DOCUMENT RESUME

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| TITLE | Military Curricula for Vocational & Technical Education. Continuous Photoprocessing Specialist, 16-4. |
| INSTITUTION | Air Force Training Command, Lowry AFB, Colo.; Ohio State Univ., Columbus. National Center for Research in Vocational Education. |
| SPONS AGENCY | Bureau of Occupational and Adult Education (DHEW/OE), Washington, D.C. |
| PUB DATE | Oct 77 |
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| DESCRIPTORS | Behavioral Objectives; Chemistry; Course Descriptions; Curriculum Guides; Equipment Utilization; High Schools; Learning Activities; Lesson Plans; Light; Mathematics; Optics; *Photographic Equipment; *Photography; Postsecondary Education; *Production Techniques; Semiskilled Occupations; Study Guides; *Vocational Education; Workbooks |
| IDENTIFIERS | Aerial Photography; Military Curriculum Project |

ABSTRACT

These lesson plans and student study guides and workbooks for a secondary-postsecondary-level course in continuous photoprocessing are one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. Purpose stated for the course is to expose students to fundamental concepts of the photographic process, chemistry, optics, exposure, light, and processing of color and black-and-white film; train them to use equipment and operations involved in photographic processing laboratories; and provide fundamental training in sensitometric and densitometric process control techniques and photographic reproduction. The plan of instruction, which suggests number of hours of class time devoted to each course objective, is based on the following outline allowing for six units of instruction (blocks): Photographic Fundamentals (5 lessons), Continuous Processing Fundamentals (5 lessons), Aerial Film Processing (2 lessons), Aerial Film Duplication (2 lessons), Aerial Select Printing (4 lessons), and Continuous Color Processing (3 lessons). The lesson plans contain course outlines, objectives, and information on support materials and guidance. Contents of the study guides and workbooks include objectives, informative material, study questions, and exercises. Media materials are suggested, but not provided. (YLB)


# Military Curricula for Vocational & Technical Education

CONTINUOUS PHOTOPROCESSING SPECIALIST

THE NATIONAL CENTER FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

This military technical training course has been selected and adapted by The Center for Vocational Education for "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education," a project sponsored by the Bureau of Occupational and Adult Education, U.S. Department of Health, Education, and Welfare.

## MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

CONTINUOUS PROCESSING SPECIALIST

G 3ABR23330 001

Classroom Course 16-4

**Developed by:**

United States Air Force

**Development and Review Dates:**

October 1977

**Occupational Area:**

Photography

**Target Audiences:**

10 - Adult

**Print Pages:** 612

Microfiche: 11

**Availability:**
Vocational Curriculum Coordination Centers

| Contents: | Type of Materials: | Lesson Plans: | Programmed Text: | Student Workbook: | Handouts: | Text Materials: | Audio-Visuals: | Instructional Design: | Performance Objectives: | Tests: | Review Exercises: | Additional Materials Required: | Type of Instruction: | Group Instruction: | Individualized: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Blocks: | | | | | | | | | | | | | | | |
| I Photographic Fundamentals | | ● | | ● | | | x | | | | | | | ● | |
| II Continuous Processing Fundamentals | | ● | | ● | | | x | | | | | | | ● | |
| III Aerial Film Processing | | ● | | ● | | | x | | | | | | | ● | |
| IV Aerial Film Duplication | | ● | | ● | | | | | | | | | | ● | |
| V Aerial Select Printing | | ● | | ● | | | | | | | | | | ● | |
| VI Continuous Color Processing | | ● | | ● | | | x | | | | | | | ● | |

X Materials are recommended but not provided.

**Course Description:**

This course includes fundamental concepts of the photographic process, chemistry, optics, exposure, light, and processing of color and black-and-white film; equipment and operations involved in photographic processing laboratories; fundamental training in sensitometric and densitometric process control techniques; and photographic reproduction.

The instructional design for this course is Grop/Lock Step. The course is based on the following units of instruction:

- Block I Photographic Fundamentals
  - Basic Theory of Light and Optics (3 hours)
  - Exposure Theory and Film Characteristics (14 hours)
  - The Developmental Process (12 hours)
  - The Printing Process (10 hours)
- Block II Continuous Photoprocessing Fundamentals
  - Introduction to Aerial Photography (2 hours)
  - Continuous Photoprocessing Fundamentals (6 hours)
  - Mathematics Used in Photography (14 hours)
  - Chemical Mixing and Certification (14 hours)
  - Sensitometry and Densitometry (18 hours)
- Block III Aerial Film Processing
  - Continuous Processor Operation (48 hours)
  - Titling and Cleaning Aerial Film (20 hours)
- Block IV Aerial Film Duplication
  - Nondodging Continuous Printing (32 hours)
  - Automatic Dodging Continuous Printing (20 hours)
- Block V Aerial Select Printing
  - Manual Contact Printing (16 hours)
  - Copying Techniques (16 hours)
  - Projection Printing (16 hours)
  - Step-Mode Printing (30 hours)
- Block VI Continuous Color Processing
  - Color Theory (16 hours)
  - Color Chemistry (8 hours)
  - Processor Operation (43 hours)

This course contains materials for both student and teacher use. Instructor materials include a plan of instruction for each block and lesson plans for each lesson. Student materials consist of study guides and workbooks. Media materials are suggested but not provided.

## CONTINUOUS PHOTOPROCESSING SPECIALIST

### Table of Contents

POI G1ABR2311 [illegible]
(PDS Code YAA)

# PLAN OF INSTRUCTION

(Technical Training)

## CONTINUOUS PHOTOPROCESSING SPECIALIST

16-4

LOWRY TECHNICAL TRAINING CENTER

1 October 1977-Effective 17 October 1977 with class 771017

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214 MAY 69, 5-2 NOV 63 AND 523, MAY 71 STANDARD COVERSHEET

DEPARTMENT OF THE AIR FORCE
3400 Tech Tng Wg (ATC)
Lowry Air Force Base, Colorado 80230

PLAN OF INSTRUCTION G3ABR23330 001
(PDS Code YAA)
1 October 1977

## FOREWORD

1. PURPOSE: This publication is the plan of instruction (POI) when the pages shown on page A are bound into a single document. The POI prescribes the qualitative requirements for Course Number G3ABR23330 001, Continuous Photoprocessing Specialist, in terms of criterion objectives and teaching steps presented by units of instruction and shows the correlation with the training standard, and support materials and guidance. When separated into units of instruction, it becomes Part I of the lesson plan. This POI was developed under the provisions of ATCR 50-5, Instructional System Development, and ATCR 52-7, Plans of Instruction and Lesson Plans.

2. COURSE DESIGN/DESCRIPTION. The instructional design for this course is Group/Lock Step. The course trains airmen to perform duties prescribed in AFR 39-1 for Continuous Photoprocessing Specialist, AFSC 23330. Training includes fundamental concepts of the photographic process, chemistry, optics, exposure, light, and processing of color and black-and-white film; equipment and operations involved in photographic processing laboratories; fundamental training in sensitometric and densitometric process control techniques; and photographic reproduction; and operator knowledges associated with photographic laboratories. In addition, related training is provided on driver education, mission application seminar, troop information program, commander's calls/briefings, etc.

3. TRAINING EQUIPMENT. The number shown in parentheses after equipment listed as Training Equipment under SUPPORT MATERIALS AND GUIDANCE is the planned number of students assigned to each equipment unit.

4. REFERENCES. This plan of instruction is based on Specialty Training Standard 233X0, July 1977 and Course Chart G3ABR23330 001, 3 August 1977.

FOR THE COMMANDER

EDWIN D. BOGGIE, Colonel, USAF
Commander, 3430th Tech Tng Gp

Supersedes Plan of Instruction G3ABR23330 000/G3AZR23350 000, 1 November 1976
OPR: 3430 TCHTG
DISTRIBUTION: Listed on Page A.

MODIFICATIONS

Block I - Lesson 1 of this publication has (have) been deleted in adapting this material for use in Vocational and Technical Education. Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

**PLAN OF INSTRUCTION/LESSON PLAN PART I**

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |
| **BLOCK NUMBER** | **BLOCK TITLE** |
| 1 | Photographic Fundamentals |

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 2. Career Progression, Security, and Safety | 6 (4/2) |

a. List the five primary duties of a continuous photoprocessing specialist and define career ladder progression procedures. STS: 1a, 1b, 5b(1) Meas. W

(1) Air Force classification system

(2) Specialty description

(3) Specialty Training Standard (STS)

(4) Upgrade training

(5) On-the-job training

(6) Career development course

(7) Skill level progression

b. Given information pertaining to security classification and essential elements of friendly information, identify terms, definitions or classifications as they relate to COMSEC. STS: 2a(1), 2a(2). Meas: W

(1) Three types of information: classified, unclassified and unclassified but of possible intelligence value.

(2) Security classification guide.

(3) Proper use of MAJCOM/SOA essential elements of friendly information (EEFIs).

c. Given information relating to communication modes, security risks and nontechnical procedures designed to prevent security violations, identify terms, definitions, risks and corrective actions as they relate to COMSEC. STS: 2a(3), 2a(4) Meas: W

(1) Communication modes which will provide the security, reliability and speed required.

**SUPERVISOR APPROVAL OF LESSON PLAN (PART II)**

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(2) Security risks that exist when using unsecured communication systems.

(3) Security risks that exist in attempting to disguise classified or unclassified information of intelligence value.

(4) Procedures designed to prevent security violations and practices dangerous to security.

d. Given an example of an operational security violation in your career field, identify the cause of the violation. STS: 2b(2), 2b(3), 2b(4), 2b(5), 2b(6) Meas: W

(1) Purposes and objectives of OPSEC.

(2) Relationship to other security programs.

(3) OPSEC vulnerabilities of this specialty.

e. List two safety precautions you should observe for each of the following potential hazards: electrical, mechanical, chemical, and compressed gases. STS: 3a, 3b, 3c(1), 3c(2), 3d Meas: W, PC

(1) Warning signs

(2) Illumination

(3) Chemical hazards

(4) Compressed gases

(5) Electrical hazards

(6) Mechanical hazards

(7) Fire prevention

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-I-2, Career Progression, Security, and Safety
ATC SG E3ABR/OBR00001, Communications Security

Audio Visual Aids
Film TF 6650, COMSEC and You
Film SFP 1872, Alone, Unarmed, and Unafraid

Training Methods
Discussion and Demonstration (3 hrs)
Performance (1 hr)
CTT Assignment (2 hrs)

Instructional Guidance
Relate continuous photoprocessing to the Photographic Career Field and aerial reconnaissance. Stress the importance of Safety and Security. Give CTT assignment.

PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| I | Photographic Fundamentals |

| 1 COURSE CONTENT | 2. TIME |
|---|---|
| 3. Publications | 3 |

a. Using appropriate technical order files, publications, and a research exercise, locate required technical order information.
STS: 4a, 4b, 4c, Meas: W, PC

(1) Technical manuals

(2) Preliminary technical orders

(3) Automatic technical orders

(4) Time compliance technical orders

(5) Methods and procedures technical orders

(6) Abbreviated technical orders

(7) Index type technical orders

(8) Technical order numbering system

(9) Air Force regulations

(10) Air Force manuals

(11) Pamphlets

(12) Publications numbering sytem

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

**Student Instructional Materials**
SW G3ABR23330 001-I-3, Publications
ATC IG 52-4, Air Force Technical Order System
ATCPT 52-4, Air Force Technical Order System

**Audio Visual Aids**
Film TF 1-5105, The Air Force Technical Order System

**Training Methods**
Discussion and Demonstration (2 hrs)
Performance (1 hr)

**Instructional Guidance**
Technical publications will be limited to TOs and will be covered by discussion and demonstration. Check CTT assignment.



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PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
| --- | --- |
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
| --- | --- |
| I | Photographic Fundamentals |

| 1 COURSE CONTENT | 2 TIME |
| --- | --- |
| 4. Basic Theory of Light and Optics | 3 |
| a. Identify the five characteristics of light and their relationship with optics. STS: 13c, 17b, 17c Meas: W, PC | |
| (1) Characteristics of light | |
| (2) Behavior of light | |
| (3) Design of a lens | |
| (4) Lens characteristics | |
| (5) Lens types | |
| (6) Lens aberrations | |

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-I-4, Basic Theory of Light and Optics

Audio Visual Aids
Film MN 2449, Introduction to Optics
Film TVL 23-3, Fundamentals of Optics and Photography

Training Methods
Discussion and Demonstration (2 hrs)
Performance (1 hr)

Instructional Guidance
Apply optical principles to photographic use. Explain the relationship between emulsion sensitivity and various types of light.

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| I | Photographic Fundamentals |

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 5. Exposure Theory and Film Characteristics | 14<br>(12/2) |
| a. Name the five principal parts of a camera and define the function of each part. STS: 13b Meas: W | (3) |
| (1) Body | |
| (2) Lens | |
| (3) Viewing system | |
| (4) Focusing system | |
| (5) Shutter | |
| b. Define the major characteristics of photographic film. STS: 7g(1), 13c, 15f, 15g Meas: (W) | (3) |
| (1) Film structure | |
| (2) Black-and-white emulsion characteristics | |
| (3) Specialized emulsions | |
| (4) Aerial film classifications | |
| (5) Storage and handling of sensitized materials | |
| c. Provided a 35mm camera and film, photograph several scenes as directed by your instructor. STS: 13b, 13c Meas: W, PC | (6) |
| (1) Exposure theory | |
| (2) Exposure and film | |
| (3) Camera operation | |

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COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-I-5, Exposure Theory and Film Characteristics

Audio Visual Aids
Film MN 5383, Fundamentals of Photography--Basic Camera
Trainer, Iris Diaphragm

Training Equipment
35mm Camera (1)

Training Methods
Discussion and Demonstration (6 hrs)
Performance (6 hrs)
CTT Assignment (2 hrs)

Instructional Guidance
Provide a basic introduction to the functions of the camera and film. Have each student expose one roll of 20 exposure film during an on base photographic mission. Give CTT assignment.

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**PLAN OF INSTRUCTION/LESSON PLAN PART I**

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| 1 | Photographic Fundamentals |

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 6. The Development Process | 12 |
| a. Identify the chemical properties of black-and-white processing solutions. STS: 3b, 5a(20), 15a(2), 15c(1), 15c(2) Meas: W, PC | (6) |
| (1) Developer | |
| (2) Stop bath | |
| (3) Fixing baths | |
| (4) Wash | |
| b. Process previously exposed film using manual processing facilities. Processed negatives must be free of physical defects and have acceptable density and contrast. STS: 3a, 3b, 5a(21)(a), 5a(21)(b), 9a, 9b, 9c, 9d, 9f, 9g, 9h, 9i, 9j(1), 9j(2), 9j(3) Meas: W, PC | (6) |
| (1) Preparing for processing | |
| (2) Processing 35mm film | |
| (3) Time-temperature processing | |
| (4) Archival quality | |

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COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-I-6, Basic Photo Chemistry

Audio Visual Aids
Film MN 6673, What Happens During Processing

Training Equipment
Timer, Continuous (1)
Thermometer (2)
Laboratory Facilities (8)
Film Dryer (8)
Processing Tank and reels (1)

Training Methods
Discussion and Demonstration (6)
Performance (6)

Instructional Guidance
Provide a basic introduction to photographic processing principles and stress chemical safety. Check CTT assignment.

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## PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| I | Photographic Fundamentals |

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 7. The Printing Process | 10 |
| a. Identify the major characteristics of photographic paper. STS: 7g(1), 8d, 15f, 15g Meas: W | (4) |
| (1) Paper structure | |
| (2) Emulsion characteristics | |
| (3) Storage and handling | |
| b. Using previously exposed negatives and a projection printer, expose and process projection prints. Prints must be free of exposure and processing defects. STS: 3a, 3b, 5a(21)(a), 5a(21)(b), 8a(2), 8c, 8d, 8e, 8f, 8g, 8h, 9a, 9b, 9c, 9d, 9f, 9g, 9h, 9i, 9j(1), 9j(2), 9j(3), Meas: W, PC | (6) |
| (1) Projection printing principles | |
| (2) Types of printers | |
| (3) The EN-52B projection printer | |
| (4) EN-52B operating procedures | |
| (5) Negative evaluation | |
| (6) Projection printing steps | |
| (7) Print processing | |
| (8) Print finishing | |

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COURSE CONTENT

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-I-7, The Printing Process

Audio Visual Aids
Slide Tape, EN-52A Projection Printing

Training Equipment
Projection Printer (1)
Timer, Interval (1)
Timer, Continuous (1)
Thermometer (2)
Laboratory Facilities (8)
Print Washer (8)
Print Dryer (8)

Training Methods
Discussion and Demonstration (4 hrs)
Performance (6 hrs)

Instructional Guidance
Discuss and demonstrate proper projection printing techniques. Emphasize chemical and electrical safety.

8. Related Training (identified in course chart) 12

9. Measurement and Critique 2

a. Measurement Test

b. Test Critique

| BLOCK NUMBER | BLOCK TITLE |
| --- | --- |
| II | Continuous Photoprocessing Fundamentals |

| 1 COURSE CONTENT | 2 TIME |
| --- | --- |
| 1. Introduction to Aerial Photography | 2 |

a. List and explain the four phases of the intelligence cycle. STS: 14a Meas: W

(1) Requirements

(2) Collection

(3) Production

(4) Dissemination

b. Define fundamental techniques and terms used in optical reconnaissance. STS: 1b, 14a Meas: W

(1) Cartographic photography

(2) Reconnaissance photography

(3) Reconnaissance missions

(4) Aerial cameras

(5) Camera positions

c. List the capabilities and limitations of nonoptical imagery systems. STS: 1b, 14a Meas: W

(1) Side looking airborne radar (SLAR)

(2) Infrared (IR)

(3) Laser

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COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-II-1, Introduction to Aerial Photography

Audio Visual Aids
Film SFP 1327, Tactical Air Reconnaissance
35mm Slides and Script, The Intelligence Cycle

Training Methods
Discussion and Demonstration (2 hrs)

Instructional Guidance
Motivate students and establish the place of the 23330 in Aerial Photo Reconnaissance.

PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |
| BLOCK NUMBER: II | BLOCK TITLE: Continuous Photoprocessing Fundamentals |

| 1. COURSE CONTENT | 2. TIME |
|---|---|
| 2. Continuous Photoprocessing Facilities | 6 (4/2) |

a. Describe the operating principles of a precision processing laboratory. STS: 14a, 5a(21)(a), 5a(21)(b) Meas: W

(1) Environmental design

(2) Machinery

(3) Personal hygiene

(4) Employee discipline

(5) Visitors

(6) Security

(7) Maintenance and inspection

(8) Safety

(9) Adjacent areas

b. Describe the mission and organization of the Photographic Processing and Interpretation Facility (PPIF), WS-430B. STS: 14a Meas: W

(1) Mission

(2) Organization

c. List the basic responsibilities of the Production Control unit, the Imagery Interpretation unit (II), and the Imagery Processing unit (IP) within the WS-430B complex. STS: 14a Meas: W

(1) Production control

(2) Imagery processing

(3) Imagery interpretation

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d. List the functions of the individual shelters contained in the WS-430B. STS: 14a Meas: W

(1) Expandable Final Edit and Inspection Labs, ES-60B and ES-61B.

(2) Continuous Processing Lab, ES-59A

(3) Expandable Film Titling and Cleaning Lab, ES-63A

(4) Expandable Interpretation Lab, ES-64A

(5) Series I Printing Lab, ES-57B

(6) Series II Printing Lab, ES-58B

(7) Series III Printing Lab, ES-73A

(8) Chemical Mixing and Distribution Lab, ES-65A

(9) Sensitized Materials Storage Shelter, FS-6A

(10) Expandable Maintenance Shelter, FS-7A

e. Explain the steps necessary for maintaining a mobility capability. STS: 14a, 14b, 14c, 14d, 14e Meas: W

(1) Deployment preplanning

(2) Mobility responsibilities

(3) Facility preparation and setup

(4) Mobility exercises

f. State the purpose of the Dual Basing Program. STS: 14a Meas: W

(1) Mission requirements

(2) Operational flexibility

(3) Training

g. Explain the major causes of corrosion within the WS-430B complex. STS: 14a Meas: W

(1) Climatic conditions

(2) Corrosive chemicals

21

h. List the general responsibilities of all personnel assigned to a WS-430B complex in supporting an effective corrosion control program. STS: 1b Meas: W

(1) Identification

(2) Correction

(3) Prevention

i. Describe the responsibilities of the OIC and the Logistics Officer in a WS-430B facility. STS: 14a Meas: W

(1) OIC responsibilities

(2) Logistic officer responsibilities

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-II-2, Continuous Photoprocessing Facilities

Audio Visual Aids
35mm Slides, WS-430B Orientation
35mm Slides, Mobilizing the WS-430B
35mm Slides, WS-430B Corrosion Control

Training Methods
Discussion and Demonstration (4 hrs)
CTT Assignment (2 hrs)

Instructional Guidance
Ensure that students have a basic understanding of the processing facilities that they will probably encounter in this career field. Emphasis should be placed on strategic and tactical processing functions. Give CTT assignment.

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| 11 | Continuous Photoprocessing Fundamentals |

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 3. Mathematics Used in Photography | 14 (12/2) |

3. Mathematics Used in Photography

a. Given photographic related math problems and log tables, solve 80% of the problems correctly. STS: 16a, 16b, 16c Meas: W, PC

(1) Basic arithmetic

(2) Signed numbers

(3) Logarithms

(4) Metric system

(5) Temperature conversions

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

SUPPORT MATERIALS AND GUIDANCE

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Student Instructional Materials
SW G3ABR23330 001-II-3, Mathematics Used in Photography

Training Methods
Discussion and Demonstration (6 hrs)
Performance (6 hrs)
CTT Assignment (2 hrs)

Instructional Guidance
Determine in-depth subject matter coverage by analyzing results on mathematical problems. Give CTT assignment.

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| II | Continuous Photoprocessing Fundamentals |

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 4. Chemical Mixing and Certification | 14 (12/2) |
| a. Given the necessary bulk chemicals, selected formulas, chemical mix facilities, measuring and mixing equipment, prepare black-and-white processing solutions. Solutions must meet locally prescribed standards of quality. STS: 3b, 5a(21)(a), 5a(21)(b), 15b(2), 15b(3), 15b(5), 15e Meas: W, PC | (6) |
| (1) Chemical grades | |
| (2) Mixing chemicals | |
| (3) Safety in mixing | |
| (4) Storage | |
| (5) Glassware (types) | |
| (6) Cleaning glassware | |
| (7) Glassware measurements | |
| (8) Beam balances | |
| b. Given pH meter, hydrometer set, and photographic solutions, determine the pH and specific gravity of the photographic solutions. Students value for pH must be within ± 0.10 and specific gravity value must be within ± 0.015 of the class standard. STS: 6b(2)(b), 15c(1), 15c(2) Meas: W, PC | (6) |
| (1) Purpose of specific gravity analysis | |
| (2) Use of the hydrometer | |
| (3) Temperature compensation | |
| (4) Reading the hydrometer | |
| (5) Purpose of pH measurement | |
| (6) Electrodes | |

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(7) Buffers

(8) Operation of pH meters

(9) pH measurement precautions

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-II-4, Chemical Mixing and Certification

Audio Visual Aids
Slide Tape, Mixing Photographic Solutions
Slide Tape, pH Meter

Training Equipment
Chemical Laboratory Facilities (8)
Assorted Laboratory Glassware (8)
Triple Beam Balance (Scales) (2)
pH Meter (2)
Hydrometer (2)
Thermometer (2)

Training Methods
Discussion and Demonstration (6 hrs)
Performance (6 hrs)
CTT Assignment (2 hrs)

Instructional Guidance
Students are introduced to chemical laboratory apparatus and procedures. Stress chemical safety throughout the lesson. Give CTT assignment.

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| II | Continuous Photoprocessing Fundamentals |

25

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 5. Sensitometry and Densitometry | 18 (16/2) |
| a. Using unexposed original film, sensitometer, previously mixed processing solutions, and manual processing facilities, expose and process sensitometric strips. Processed sensitometric strips must be of acceptable density and be free of chemical and physical defects. STS: 11a, 11c, 17c, 17d Meas: W, PC | (6) |
| (1) Sensitometry | |
| (2) Classification of sensitometers | |
| (3) Light sources | |
| (4) Exposure modulators | |
| (5) Kodak Model 101 sensitometer | |
| (6) EG & G Mark VI sensitometer | |
| (7) Sensitometric processing methods | |
| (8) Safety precautions | |
| b. Using a densitometer and previously processed sensitometric strips, measure and record each density step to within ± 0.02 of the actual density. STS: 11b Meas: W, PC | (6) |
| (1) Transmission, opacity and density | |
| (2) Densitometry | |
| (3) Classification of densitometers | |
| (4) Common densitometers | |
| (5) Operating procedures | |

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c. Using densitometric readings from a previously processed sensitometric strip, plot a sensitometric curve and determine gamma. Gamma must be computed to within ± 0.10 of the class standard. STS: 11d Meas: W, PC (4)

(1) Parts of a characteristic curve

(2) Plotting the curve

(3) Determining gamma

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-XI-5, Sensitometry and Densitometry

Training Equipment
Sensitometer (2)
Densitometer (2)
Manual Processing Facilities (8)
Neutral Density Filters (8)
Graphing Implements (8)

Training Methods
Discussion and Demonstration (6 hrs)
Performance (10 hrs)
CTT Assignment (2 hrs)

Instructional Guidance
Emphasize intensity scale sensitometers, safety and cleanliness. Cover the densitometer as a basic tool of sensitometry. Stress all five parts of the curve and how each can be used to control the process. Check CTT assignment.

6. Related Training (identified in course chart) 8

7. Measurement and Critique 2

a. Measurement Test

b. Test Critique

## PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |
| BLOCK NUMBER: III | BLOCK TITLE: Aerial Film Processing |

27

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 1. Continuous Processor Operation | 48 |
| a. Identify the basic operating principles of continuous processors. STS: 5a(20), 6a, 6b, 6c, 6d, 6e, 6f Meas: W | (36/12) |
| (1) Film drives and transport systems | (3) |
| (2) Machine-threading systems | |
| (3) Developing and fixing systems | |
| (4) Recirculation systems | |
| (5) Squeegees | |
| (6) Drying systems | |
| (7) Safety | |
| (8) Silver-recovery methods | |
| (9) Silver-recovery equipment | |
| (10) Fultron | |
| (11) H.T.A. 3CM | |
| (12) Ektachrome RT Processor Model 1811 | |
| b. Identify and locate the major components, systems, and controls of a Versamat 11C-MW Processor. STS: 3a, 3b, 3d, 6a(1)(a), 6a(1)(b), 6a(1)(c), 6a(1)(d), 6a(1)(e), 6a(1)(f), 6a(3), 6a(5), 6a(6), 6a(9) Meas: W, PC | (3) |
| (1) General description | |
| (2) Standard equipment | |
| (3) Accessory and optional equipment | |
| (4) Operating principles | |
| (5) Functional description | |
| (6) Operating controls | |

### SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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COURSE CONTENT

c. Provided a Versamat processor, setup and systems clean the processor while observing all safety precautions. STS: 3a, 3b, 3d, 5a(21)(a), 6d(2), 6f(1), 6f(2), 6f(3)(b) Meas: W, PC (6)

(1) Initial setup

(2) Systems cleaning

d. Using specified packaged chemicals, mix and certify the chemical solutions. Mixed solutions must meet local certification standards. STS: 3a, 3b, 6a(2), 15a(2), 15(b)(1), 15b(3), 15b(4), 15b(5), 15c(1), 15c(2) Meas: W, PC (6)

(1) Mixing chemistry

(2) Certifying chemistry

(3) Filling processor tanks

e. Using a Versamat processor and operating checklists, startup and shutdown processor IAW the checklists. STS: 3a, 3b, 3d, 5a(21)(a), 5a(21)(b), 6a(1)(a), 6a(1)(b), 6a(1)(c), 6a(1)(d), 6a(1)(e), 6a(1)(f), 6a(3), 6a(5), 6a(6), 6a(9), 6d(2), 6f(1), 6f(2), 6f(3)(b) Meas: W, PC (6)

(1) Preoperational check

(2) Daily startup

(3) Daily shutdown

(4) Preventive maintenance

f. Provided a Versamat processor, certify the processor mechanically, chemically and sensitometrically. The processor will be certified to meet local certification standards. STS: 3a, 3d, 6b(1)(b), 6b(2)(b), 6b(3), 6e(2), 11a, 11b, 11c, 11d Meas: W, PC (6)

(1) Mechanical certification

(2) Chemical certification

(3) Trouble shooting

(4) Sensitometric certification

(5) Process control

g. Explain the need for a quality assurance program within continuous photoprocessing laboratories. STS: 6b(2)(b) Meas: W (1)

(1) Laboratory quality assurance

(2) Central calibration program

COURSE CONTENT



(3) Sensor system evaluation program

h. Using a preinspection table and a Versamat processor, preinspect and process exposed aerial film, processed film must be free of processing defects. STS: 3a, 3d, 6c(2), 6c(4), 6c(5), 6c(7), 6c(9), 6c(10)(a), 6c(10)(b), 10a(1), 10a(2) Meas: W, PC (5)

(1) Preinspection and makeup

(2) Processing

(3) Processing defects

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-III-1, Continuous Processor Operation

Audio Visual Aids
Film MN 10302A, The EH-38 Film Processor
Film MN 10302C, The EH-38 Processor Quality Control
Silver Recovery Cartridge Trainer

Training Equipment
Preinspection Table (4)
Versamat Model 11CMW Processor (4)
Processing Support Equipment (8)
Cleaning Supplies and Equipment (8)

Training Methods
Discussion and Demonstration (6 hrs)
Performance (30 hrs)
CTT Assignments (12 hrs)

Instructional Guidance
Emphasize checklist procedures and safety. Give individual instruction on startup, certification, operating, troubleshooting, and shutdown procedures. Ensure that students save their processed film for use in the next SW. Check CTT assignments.

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| III | Aerial Film Processing |

30

| 1. COURSE CONTENT | 2. TIME |
|---|---|
| 2. Titling and Cleaning Aerial Film | 20 (16/4) |
| a. Using an editing table, postinspect and attach head and tail friskets to a roll of processed aerial film. All defects must be recorded. STS: 10b, 10c, 10e, 10h(1), 10h(2), 10i Meas: W, PC | (3) |
| (1) Postinspection | |
| (2) Primary breakdown | |
| b. Using a Dual Head film titler, title processed aerial film. Type must be correctly positioned and transfer to the film must be legible without flow or embossing. STS: 3a, 3c(1), 3c(2), 3d, 12a(1)(a), 12a(1)(b), 12a(1)(c), 12a(1)(d), 12a(2), 12a(3), 12a(4), 12c, 12d Meas: W, PC | (6) |
| (1) Titling principles | |
| (2) General description | |
| (3) Detailed description | |
| (4) Preoperation procedures | |
| (5) Operation | |
| (6) Shutdown | |
| (7) Preventive maintenance | |
| c. Using a Delaware portable film titler, title processed aerial film. Type must be correctly positioned and transfer to the film must be legible without flow or embossing. STS: 3a, 3d, 12a(1)(a), 12a(1)(b), 12a(1)(c), 12a(1)(d), 12a(2), 12a(3), 12a(4), 12c, 12d Meas: W, PC | (3) |
| (1) General description | |
| (2) Detailed description | |
| (3) Preoperation procedures | |

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(4) Operation

(5) Shutdown

(6) Preventive maintenance

d. Using a film cleaner, clean processed aerial film. Cleaned film must be free of objectionable dirt, [illegible] and other foreign matter. STS: 3a, 3d, 5a(21)(a), 5a(21)(b), 12b(1)(a), 12b(1)(b), 12b(1)(c), 12b(2)[illegible], 12c, 12d Meas: W, PC (4)

(1) Taconic tacky roll cleaner

(2) Tacky roller film cleaner

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-III-2, Titling and Cleaning Aerial Film

Training Equipment
Editing Table (8)
Dual Head Film Titler (8)
Delaware Film Titler (8)
Tacky Roller Film Cleaner (8)
Taconic Tacky Roll Cleaner (8)
Allen Wrenches (2)

Training Methods
Discussion and Demonstration (4 hrs)
Performance (12 hrs)
CTT Assignments (4 hrs)

Instructional Guidance
Check film to ensure that titling is complete and legible. Stress the importance of proper film cleaning techniques. Ensure that students save their titled film for use in the next block. Observe compressed gas safety precautions. Check CTT assignments.

3. Related Training (identified in course chart) 2

4. Measurement and Critique 2

a. Measurement Test

b. Test Critique

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| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| IV | Aerial Film Duplication |

32

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 1. Nondodging Continuous Printing | 32 (24/8) |

a. Using an EN-86A Niagara Continuous Printer and Versamat 11CM Processor, duplicate a roll of previously processed film. Finished product must be free of chemical and physical defects and have acceptable density and contrast. STS: 3a, 3b, 3d, 5a(21)(a), 5a(21)(b), 6c(4), 6c(5), 7a(2), 7b(1), 7b(2), 7b(3), 7b(4), 7c(2), 7d(2), 7e(2), 7f(2), 7g(1) Meas: W, PC

(1) Description of printer

(2) Preoperational procedures for the Niagara Printer

(3) Printer operation

(4) Preventive maintenance

(5) Printer certification

(6) Printer correlation

(7) Materials for photographic duplication

(8) Tone reproduction

(9) Trigradient tone control system

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-IV-1, Nondodging Continuous Printing

Training Equipment
EN-86A Continuous Contact Printer (8)
Versamat Model 11CM Processor (8)

Training Methods
Discussion and Demonstration (12 hrs)
Performance (12 hrs)
CTT Assignments (8 hrs)

Instructional Guidance
The dupe positive produced in this unit of instruction will be used for printing a dupe negative in the next study guide/workbook. Stress electrical and mechanical safety. Check CTT assignments.

PLAN OF INSTRUCTION/LESSON PLAN PART I

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|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| IV | Aerial Film Duplication |

34

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 2. Automatic Dodging Continuous Printing | 20 (16/4) |

a. Using an SP 10/70 Continuous Contact Printer, and Versamat 11CM Processor, duplicate a roll of previously processed film. Finished product must be free of chemical and physical defects and have acceptable density and contrast. STS: 3a, 3b, 5a(21)(a), 5a(21)(b), ____, 6c(5), 7a(2), 7b(1), 7b(2), 7b(3), 7c(2), 7d(2), 7e(2), 7f(2), 7g(1) Meas: W, PC

(1) General description

(2) Detailed description

(3) Control panel description

(4) Accessories

(5) Initial setup and certification

(6) Operational printing

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## SUPPORT MATERIALS AND GUIDANCE

**Student Instructional Materials**
SW G3ABR23330 001-IV-2, Automatic Dodging Continuous Printing

**Training Equipment**
SP 10/70 Continuous Contact Printer (8)
Versamat Model 11CM Processor (8)

**Training Methods**
Discussion and Demonstration (6 hrs)
Performance (10 hrs)
CTT Assignments (4 hrs)

**Instructional Guidance**
Ensure that students save their dupe negatives for use in the next block. Stress electrical and mechanical safety. Check CTT assignments.

3. Related Training (identified in course chart) 2

4. Measurement and Critique 2

   a. Measurement Test

   b. Test Critique

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PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTION | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

36

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| V | Aerial Select Printing |

| COURSE CONTENT | TIME |
|---|---|
| 1. Manual Contact Printing | 16 (12/4) |

a. Using manual contact printers, laboratory facilities, aerial negatives, and printing materials, produce black-and-white prints which are free of exposure and processing defects. STS: 3a, 3b, 3d, 5a(21)(a), 5a(21)(b), 8b, 8c, 8d, 8e, 8f, 8g, 8h, 9a, 9b, 9c, 9d, 9f, 9g, 9h, 9i, 9j(1), 9j(2), 9j(3), 17c Meas: W, PC

(1) Principles of contact printing

(2) Manual contact printers

(3) Printing materials

(4) EN-22A, Manual Contact Printer

(5) Contact printing controls

(6) Safety

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## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-V-1, Manual Contact Printing

Audio Visual Aids
Film MN 5387, Fundamentals of Photography Printing the Positive

Training Equipment
EN-22 Contact Printer (1)
Timer, Interval (1)
Timer, Continuous (1)
Thermometer (2)
Laboratory Facilities (8)
Print Washer (4)
Print Dryer (8)

Training Methods
Discussion and Demonstration (2 hrs)
Performance (10 hrs)
CTT Assignments (4 hrs)

Instructional Guidance
Stress electrical safety. Use previously produced aerial duplicate negatives. Give individual assistance on dodging techniques. Emphasize contrast and density controls. Check CTT assignments.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
| --- | --- |
| | Continuous Photoprocessing Specialist |

38

| BLOCK NUMBER | BLOCK TITLE |
| --- | --- |
| V | Aerial Select Printing |

| 1 COURSE CONTENT | 2 TIME |
| --- | --- |
| 2. Copying Techniques | 16 (12/4) |

a. Given mosaics, copy equipment, processing and printing facilities, produce a scaled reproduction of the mosaic. The size of the reproduction must be within ± 5 percent of the desired size. STS: 3a, 3b, 5a(21)(a), 5a(21)(b), 13a, 13b, 13c, 17c Meas: W, PC

(1) Mosaic production

(2) Fundamentals of copying

(3) Lighting for copying

(4) Filters

(5) Film selection

(6) Copy camera operation

(7) Laboratory safety

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-V-2, Copying Techniques

Training Equipment
Copy Camera (2)
Copy Equipment (8)
Copy Room Facilities (8)
Laboratory Facilities (8)
Timer, Continuous (1)
Print Washer (4)
Print Dryer (8)

Training Methods
Discussion and Demonstration (3 hrs)
Performance (9 hrs)
CTT Assignments (4 hrs)

Instructional Guidance
Make this SW slanted toward field operations. Check CTT assignments.

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PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| V | Aerial Select Printing |

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| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 3. Projection Printing | 16 (12/4) |

a. Using manual projection printers, laboratory facilities, aerial negatives and printing materials, produce black-and-white prints which are free of exposure and processing defects.
STS: 3a, 3b, 3d, 5a(21)(a), 5a(21)(b), 8a(2), 8c, 8d, 8e, 8f, 8g, 8[illegible] 17b. Meas: W, PC

(1) Principles of projection printing

(2) Types of projection printers

(3) Projection printer models

(4) EN-52B projection printer

(5) Projection printing procedures

(6) Projection printing controls

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-V-3, Projection Printing

Training Equipment
Projection Printer (1)
Laboratory Facilities (8)
Timer, Interval (1)
Timer, Continuous (1)
Thermometer (2)
Print Washer (4)
Print Dryer (8)

Training Methods
Discussion and Demonstration (3 hrs)
Performance (9 hrs)
CTT Assignments (4 hrs)

Instructional Guidance
Stress chemical and electrical safety. Use previously produced duplicate negatives. It may be necessary to remove selected frames from the roll of film. If frames are removed, the students will splice the film back together properly. Check CTT assignments.

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| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Phetoprocessing Specialist |
| BLOCK NUMBER: V | BLOCK TITLE: Aerial Subject Printing |

42

| 1. COURSE CONTENT | 2. TIME |
|---|---|
| 4. Step-Mode Printing | 30 (22/8) |

a. Using a Mark IIR5A printer, Versamat 11CM processor, negatives, and printing materials, produce prints in the contact and projection modes of operation. Prints must be free of physical and chemical defects and must have acceptable density and contrast.
STS: 3a, 3b, 3d, 5a(21)(a), 5a(21)(b), 7a(2), 7b(1), 7b(2), 7c(2), 7c(3), 7d(2), 7e(2), 7f(2), 7g(1), 8f Meas: W, PC

(1) Description

(2) Exposure and dodging systems

(3) Controls and indicators

(4) Operation of the Mark IIR5A

(5) Safety precautions

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-V-4, Step-Mode Printing

Training Equipment
Mark IIR5A (8)
Versamat 11CM Processor (4)
Exposure Index Calibration Sheet (4)

Training Methods
Discussion and Demonstration (6 hrs)
Performance (16 hrs)
CTT Assignments (8 hrs)

Instructional Guidance
Stress electrical safety. Use duplicate negatives from previous block.
Check CTT assignments.

5. Measurement and Critique 2

a. Measurement Test

b. Test Critique

NAME OF INSTRUCTOR

COURSE TITLE: Continuous Photoprocessing Specialist

BLOCK NUMBER: VI

BLOCK TITLE: Continuous Color Processing

44

| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 1. Color Theory | 16 (12/4) |
| a. Provided exercises pertaining to the function of white light in forming colors, identify colors formed by additive and subtractive means. STS: 17a(1), 17a(2) Meas: W | (3) |
| (1) Electromagnetic spectrum | |
| (2) Visible spectrum | |
| (3) Trichromatic systems | |
| (4) Additive color process | |
| (5) Subtractive color process | |
| (6) Additive and subtractive printer systems | |
| b. Using provided diagrams, write the names of dyes formed in various color film emulsions when exposed to given colors. STS: 13c, 15f, 15g, 17a(1), 17a(2) Meas: W, PC | (3) |
| (1) Dye couplers | |
| (2) Standard reversal process | |
| (3) Color negative process | |
| (4) Storage | |
| (5) Illumination | |

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U.S. G.P.O. 1975-671-586/42 ATC 76-27001

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

c. Describe the major characteristics of motion picture sensitized materials. STS: 13c Meas: W, PC (6,

(1) Requirements of motion picture film

(2) Motion picture film configurations

(3) Spooling

(4) Reversal films

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 C...-VI-1, Color Theory

Audio Visual Aids
Color Charts on Characteristics of Light
Color Star

Training Methods
Discussion and Demonstration (6 hrs)
Performance (6 hrs)
CTT Assignments (4 hrs)

Instructional Guidance
Students are authorized a six hour field trip to expose film for later use in this block. Check CTT assignments.



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ATC FORM APR 73 133A — REPLACES ATC FORMS 337A, MAR 73, AND 770A, AUG 72, WHICH WILL BE USED.

**PLAN OF INSTRUCTION/LESSON PLAN PART I**

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| VI | Continuous Color Processing |

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| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 2. Color Chemistry | 8 (6/2) |

a. List the major processing steps that are required for processing different types of color film. STS: 15a(1) Meas: W

(1) Negative/positive process

(2) Reversal process

b. List the components of the ME-4 process in order and explain the purpose of each component. STS: 3b, 15a(1) Meas: W

(1) Prehardner

(2) Neutralizer

(3) First developer

(4) First stop

(5) First wash

(6) Color developer

(7) Second stop

(8) Second wash

(9) Bleach

(10) Fix

(11) Final wash

(12) Stabilizer

(13) Dry

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

| SIGNATURE AND DATE | SIGNATURE AND DATE |
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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

c. Using packaged ME-4 color chemicals, chemical mixing facilities and equipment, mix ME-4 color chemicals following the manufacturer's instructions. STS: 3a, 3b, 3d, 5a(21)(a), 5a(21)(b), 15a(1), 15b(1), 15b(3), 15b(4), 15b(5) Meas: W, PC

(1) Handling color chemicals

(2) ME-4 chemical handling precautions

(3) Mixing solutions

(4) Certification of mixed solutions

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-VI-2, Color Chemistry

Audio Visual Aids
Slide Tape ME-4 Color Chemistry

Training Equipment
Hydromixer (8)

Training Methods
Discussion and Demonstration (3 hrs)
Performance (3 hrs)
CTT Assignment (2 hrs)

Instructional Guidance
Insure thorough understanding of the sequence of each processing step. Emphasize safe handling precautions and cleanliness. Check CTT assignment.

**PLAN OF INSTRUCTION/LESSON PLAN PART I**

| NAME OF INSTRUCTOR | | COURSE TITLE |
|---|---|---|
| | | Continuous Photoprocessing Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| VI | Continuous Color Processing |

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| 1 COURSE CONTENT | 2 TIME |
|---|---|
| 3. Processor Operation | 43 (27/6) |
| a. Identify the functions of motion picture processors. STS: 3a, 3b, 3d, 6a(2), 6c(7), 6a(8) Meas: W, PC | (2) |
| (1) Black-and-white processors | |
| (2) Difference between black-and-white and color processors | |
| (3) ME-4 processing design considerations | |
| b. Identify and locate the major components, systems, and controls of the Colormaster Mark II processor. STS: 3a, 3b, 3d, 6a(1)(a), 6a(1)(b), 6a(1)(c), 6a(1)(d), 6a(1)(e), 6a(1)(f) Meas: W, PC | (4) |
| (1) General description | |
| (2) Detailed description | |
| c. Using a Colormaster Mark II processor and an operating checklist, start up, certify and shut down the processor IAW the checklist. STS: 3a, 3b, 3d, 6a(1)(a), 6a(1)(b), 6a(1)(c), 6a(1)(d), 6a(1)(e), 6a(1)(f), 6a(3), 6a(4), 6a(5), 6a(6), 6a(7), 6a(9), 6b(1)(a), 6b(2)(a), 6b(3), 6d(1), 6f(1), 6f(2), 5a(21)(a), 5a(21)(b), 6f(3)(a) Meas: W, PC | (12) |
| (1) Preoperational procedures | |
| (2) Startup | |
| (3) Operation | |
| (4) Certification procedures | |
| (5) Shut down | |
| (6) Preventive maintenance | |

**SUPERVISOR APPROVAL OF LESSON PLAN (PART II)**

| SIGNATURE AND DATE | SIGNATURE AND DATE |
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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

d. Make up previously exposed motion picture film and process on the Colormaster processor. Film must be free of processing defects. STS: 3a, 3b, 3d, 6a(1)(a), 6a(1)(b), 6a(1)(c), 6a(1)(d), 6a(1)(e), 6a(1)(f), 6c(1), 6c(3), 6c(8), 6c(9), 6c(10)(a), 6c(10)(b), 6e(1), 10c, 10e, 10h(1), 10h(2), 10i Meas: W, PC (9)

(1) Film makeup

(2) Load station change over

(3) Takeup station change over

(4) Systems monitoring

(5) Processor malfunctions

(6) Postinspection

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SW G3ABR23330 001-VI-3, Processor Operation

Training Equipment
Colormaster Mark II Processor (8)
Staple Gun and Staples (8)
Makeup Table (8)
Splicer (8)

Training Methods
Discussion and Demonstration (6 hrs)
Performance (21 hrs)
CTT Assignments (6 hrs)

Instructional Guidance
Stress importance of constant monitoring for any malfunctions during equipment operation. Also insure that thorough equipment shutdown and cleanup procedures are followed. Insure students observe safety practices at all times during processor operation. Check CTT assignments.

4. Related Training (indicated in course chart) 4

5. Measurement and Critique 2

a. Measurement Test

b. Test Critique

6. Course Critique and Graduation 1

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Technical Training

Continuous Photoprocessing Specialist

# PHOTOGRAPHIC FUNDAMENTALS

October 1977

3400th TECHNICAL TRAINING WING
3430th Technical Training Group
Lowry Air Force Base, Colorado

Designed For ATC Course Use

DO NOT USE ON THE JOB

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# MODIFICATIONS

Block I, section 1 and parts of section 2 of this publication has (have) been deleted in adapting this material for use in Vocational and Technical Education. Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

## SAFETY

Accidents happen without cause. Accident records show that of all accidents, 88 percent are caused by unsafe acts of people, 10 percent by unsafe conditions which people allow to exist, and only 2 percent by natural disasters. The identification, isolation, and control of these causes form the backbone behind accident prevention programs.

Some phases of photographic work have a potential for producing accidents. Some of the work is performed in total darkness or under extremely low levels of illumination. Some of the photographic processes require the use of chemicals that, if used improperly, can cause serious injuries. However, if you are aware of the potential danger and exercise the safety precautions covered in this text, the chances of your being involved in an accident are extremely limited.

You should begin to develop good safety habits now. Accidents result in pain and suffering, needless waste of manpower and materials, and could result in failure to carry out the assigned mission of the unit. For this reason, safety is stressed throughout the course. Protect yourself from possible accidents by paying close attention to the prescribed safety policies and procedures.

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The following information is provided to help you deal with some of the more common safety problems you may encounter.

Warning Signs

Observing posted warning signs and complying with directed procedures help establish safe working habits. Signs such as INFLAMMABLE, HIGH VOLTAGE, TOXIC CHEMICALS, and POISON are there to identify potential hazards and to help you avoid accidents. Observe the signs and comply with recommended procedures for handling these items. If in doubt as to what action to take, check with your instructor. Don't become an accident statistic through ignorance.

Illumination

Photo darkrooms require the use of little or no illumination. This provides an excellent environment for accidents. Organization is the key to accident prevention here. If you work in the dark, you must know by memory, where everything is located. Everything has its place in the darkroom and should be properly stored when not in use. Check your darkroom before turning out the lights. This little tip can save you many bumps and bruises. Small quantities of luminous paint or tape are helpful in identifying hazards or orienting yourself in the dark.

Chemical Hazards

Almost any chemical, if misused, constitutes a hazard of some sort. Generally, photo chemicals present no more of a hazard than some of the common cleaning products found around the home. However, to avoid any chance of an accident, you should follow the following procedures in handling the storage of chemicals.

1. Strict adherence to the manufacturer's recommendations for mixing and use of the chemistry is mandatory. Because of the research involved, the manufacturer is the most informed source concerning the necessary safety precautions.

2. Make sure that your laboratory has adequate ventilation. Vents should be installed to insure that vapors are quickly removed from the work area. Some of the photographic chemistry contains Formalin, the liquid formula for formaldehyde. This chemical is a nose and throat irritant. If the worker is exposed to its vapors for prolonged periods of time, he will develop severe headaches. Proper ventilation eliminates this problem.

3. Never sniff a container or opened bottle to determine its contents. Sniffing concentrated ammonia could damage your lungs. If it is necessary to identify a substance by smell, cautiously sniff the lid instead.

4. When necessary, proper protective equipment and clothing should be worn. Working with caustic chemicals or acids requires that you use a rubber apron, rubber gloves, and goggles. If you are mixing chemicals in a powder form, a respirator is advised to prevent inhaling the dust. Again, adequate ventilation is required. When diluting acids with water, remember this rule, ALWAYS ADD ACID. Adding water to concentrated acid can cause it to boil and splatter. This could result in severe burns and possible damage to the eyes. Always add acid to water. When diluting sodium hydroxide in water, always use cold water. Sodium hydroxide raises the temperature of the water. If warm water is used, it will boil and splatter. In case you didn't remember, sodium hydroxide is commonly called lye and can produce very severe burns.

Other chemicals used to compound photographic solutions can cause skin irritation. This is not a common occurrence, but it does happen. Generally, the person involved has a record of problems pertaining to skin sensitivity. One of the best ways to avoid problems like this is to wash the exposed area as soon as possible after exposure. If you are hand processing prints, periodically rinse your hands in the stop bath or fixer to neutralize the effects of prolonged contact with the developer. Proper application of soap and water also helps to lessen the chances for irritation.

5. Make certain that solutions are stored in properly labeled containers. When these containers are not in use they should be stored in a safe place. Avoid storing acids and other hazardous chemicals on high shelves. This precludes the possibility of their being knocked off and causing an accident. Corrosive chemicals, such as color bleach, should be stored in hard rubber tanks or glass bottles. Amber colored bottles or tanks with floating lids may be used where appropriate.

Compressed Gases

The most frequently used form of compressed gas is nitrogen. It is used to provide agitation during film and print processing. Nitrogen is an odorless, colorless, tasteless, and chemically inert gas which is neither corrosive, explosive, nor flammable.

After what has just been said, you might wonder how this compressed gas could produce a situation that could be hazardous to you. Actually, it can be dangerous in two ways. First, since it is in a compressed form, there is quite a volume present in the container. If it were used in a confined area and there were a lack of adequate ventilation, the gas could easily asphyxiate the worker. Because it is odorless, colorless, and tasteless, it would be almost impossible to identify the hazardous situation until too late. Good ventilation and careful inspection to insure that hoses and fittings are in good condition and properly connnected will eliminate this potential hazard.

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Secondly, because the gas is in a compressed form, the container itself is a source of danger. The container must be handled carefully to avoid damage. If the top were cracked or broken the escaping gas would turn the cylinder into a deadly projectile. Although these types of accidents occur infrequently, the possibility exists, so remember to handle the gas cylinders with care.

Electrical Hazards

A great many items of equipment used in the photographic processes are electrically powered. You should take special safety precautions to reduce the possibility of electrical shock, burns, and equipment damage when using this equipment. Check power cords for worn or frayed insulation, loose connections and broken parts to minimize accidents. See that electrical equipment is properly grounded, and all power cords have polarized, three-prong plugs attached. You can reduce your chances of being shocked by removing items of jewelry such as rings, watches, and bracelets while operating machines.

Overloading electrical circuits is extremely dangerous and is not permitted at any time. All systems installed in Air Force installations must be equipped with fuses, circuit breakers, or other approved means to prevent accidental overloading. Only fuses of the proper capacity should be used and tinfoil, solder, or other materials should never be used in place of a fuse.

Machine Operation

With any type of equipment there is always an inherent safety problem to be coped with. Trimmers have sharp edges that can cut; processing machines have gears that can pinch. The list of potential dangers is limitless. An alert individual, following the established safety practices, can avoid becoming a victim of these hazards. Remember, most safety rules are established as a result of someone's unfortunate experience. Don't you provide a reason for making a new rule.

The following procedures will help to insure safe operation of equipment.

1. Make certain that no loose clothing, such as neckties, unbuttomed lab coats, wrist watches, or rings can become entangled in the machine's drive mechanism.

2. Print trimmers and scissors are used to cut film and paper. They can also slice fingers. When not in use, these items should be properly stored and the trimmer blade left in the down position.

3. Avoid the possibility of accidental burns. Display a "HOT" warning sign after using a dry mounting press, tacking iron, or film splicer.

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4. Perform prescribed operator maintenance only. Don't be a "Do it yourself" statistic. Many automated processors or printers have complex mechanical or electrical components and require the services of a maintenance technician.

**Fire Prevention**

To produce a fire, three things must be present: fuel, heat, and oxygen. If any one of the three is missing, a fire cannot start, or, if any one of them is removed, the fire will go out. Good housekeeping is essential to effective fire prevention. Accumulation of rubbish, waste, and residue are all sources of fuel. Concentration of flammable or explosive gases and vapors can be destructive. Fires are commonly started by people dumping cigarettes and ashtrays into waste paper receptacles. Avoid this practice.

Since fires may occur unexpectedly, you must be ready to fight them quickly and effectively. This means that you should know the telephone number of the base fire department (117 on Lowry). Prompt reporting of fires can limit the damage. You should know the location of fire extinguishers, the type of extinguisher required to fight the fire, and the proper method for using the extinguisher.

Fires are grouped into four general classes, each of which can be extinguished by a particular action, agent, or extinguisher. Because all fire extinguishing agents cannot be used on all types of fires, this classification makes it possible to determine the agent best suited for fighting a particular type of fire.

CLASS A. Fires in this classification can be extinguished effectively and safely by water, or solutions containing water. Fires occurring in wood, paper, and rags, are typical Class A fires.

CLASS B. Fires caused by flammable liquids, such as gasoline and other fuels, solvents, greases, or similar substances are termed Class B fires. Agents like $CO_2$, which dilute or eliminate air by blanketing the fire, are effective on this type of fire.

CLASS C. Electrical fires comes under Class C. Extinguishing agents, such as $CO_2$, which are nonconductors of electricity and work principally on smothering the fire can be used. Extinguishers containing carbon tetrachloride must not be used on electrical fires.

CLASS D. Fires that occur in combustible metals, such as magnesium, potassium, powdered aluminum, zinc, sodium, titanium, zirconium, and lithium are Class D fires. Dry powder extinguishers should be used on all Class D fires.

Exercise 3

PROCEDURES

Answer the following questions and record your answers on a separate sheet of paper. DO NOT WRITE IN THIS STUY WORKBOOK.

1. What is the chief cause of accidents?

2. List two safety precautions you should observe for each of the following potential hazards:

a. Electrical.

b. Mechanical.

c. Chemical.

d. Compressed gases.

3. List the four classes of fires and give an example of each.

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# MODIFICATIONS

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Sciences Branch
Lowry Air Force Base, Colorado

SW G3ABR23330 001-I-4
October 1977

# BASIC THEORY OF LIGHT AND OPTICS

## OBJECTIVE

Identify the five characteristics of light and state their relationship with optics.

## INTRODUCTION

While the photoprocessor need not make an extensive study of the physics of light, he should nevertheless be acquainted with certain aspects of its behavior that are of importance because of their relation to his work.

## INFORMATION

### THEORY OF LIGHT

Light is usually described as a form of radiant energy. It is a form of wave energy that radiates from its source in all directions. Other forms of radiant energy include radio waves, infrared, ultraviolet, x-rays and gamma radiations. A simple example of wave motion can be demonstrated by dropping a pebble into a pool of water. As the pebble hits the water it causes waves that spread in every expanding circles. The light waves from the sun travel in much the same manner.

### Characteristics of Light

WAVE LENGTH AND FREQUENCY. Different forms of radiant energy are distinguished from each other in two ways. They differ in (1) wavelength and (2) frequency. Wavelength is the distance from the crest of one wave to the crest of the next. Frequency is the number of waves that pass a given point in one second. The product of waveleagth and frequency is called velocity or the speed of light. Figure 4-1 illustrates the parts of a wavelength.

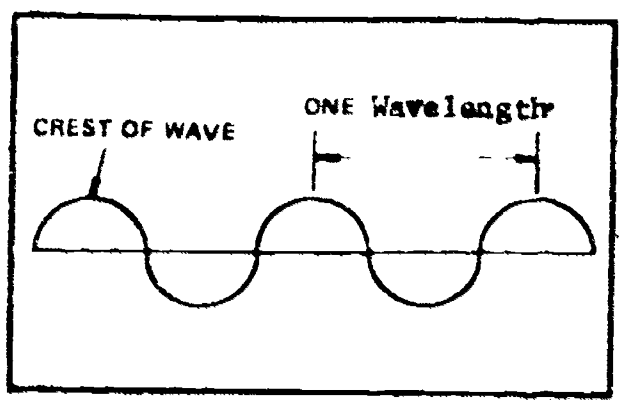


Figure 4-1. Parts of a Wavelength

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Light travels at approximately 186.000 miles per second. The speed of light is constant for any given medium, but it varies as it enters a medium of a different density. For example, the speed of light in ordinary glass is only about two thirds of its speed in air. Since frequency remains constant, the change in speed is due to a change in wavelength.

ELECTROMAGNETIC SPECTRUM. The various forms of radiant energy form a continuous series of wavelengths, each differing from the adjacent wavelength by an extremely small amount. This grouping of wavelengths is known as the electromagnetic spectrum. Figure 4-2 illustrates the electromagnetic spectrum.

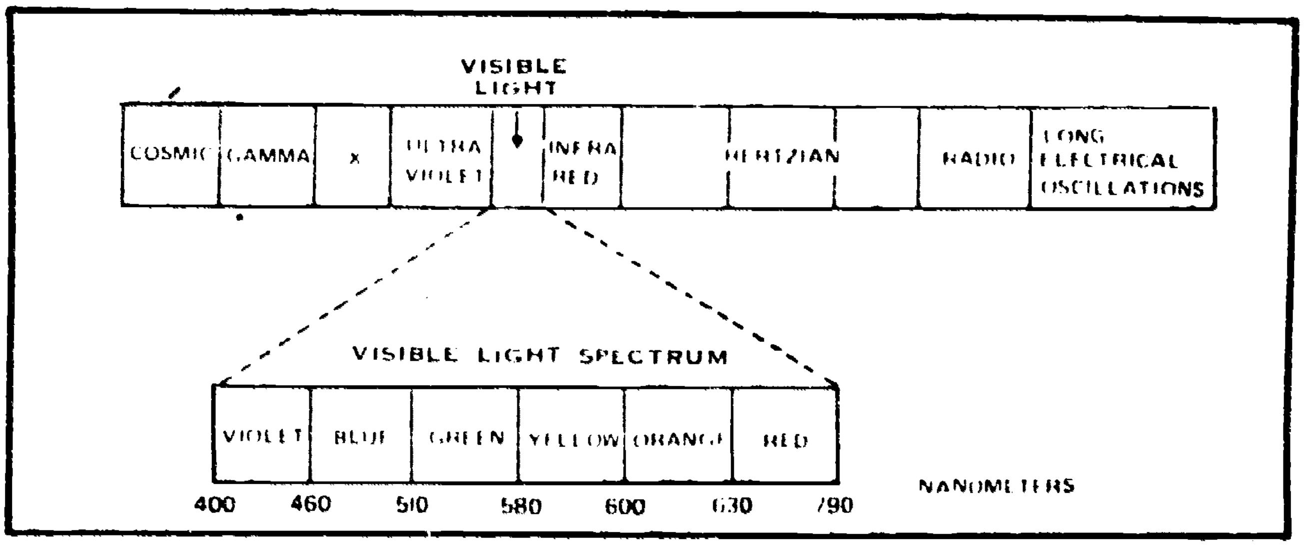


Figure 4-2. The Electromagnetic Spectrum

Visible light occupies just a small part of the total spectrum and consists of wavelengths from about 400 to 700 nanometers. The 700 nanometer dimension is extremely small. A micron is one-thousandth of a millimeter; thus a nanometer is one-millionth of a millimeter.

If you view the entire range of visible spectrum (from 400-700nm), you get the sensation of seeing white light. However, if you see only a small portion of the visible spectrum, or a particular wavelength, you get the sensation of seeing one color. For example, light with a wavelength of 450 nanometers appears blue, 500nm appears green, and 650nm appears red.

If you see various combinations of wavelengths, you get the sensation of seeing different colors. The red, blue, and green colors mentioned above are called primary colors. All other colors are combinations of varying amounts of equal primary colors. For example, equal amounts of red and green gives yellow. If there is more red than green the color becomes orange.

Behavior of Light

Because light is necessary to make a photographic exposure you must know something of reflection, transmission, absorption, refraction, and dispersion. To become a good laboratory technician, it is essential that you understand these terms and their principles. Once you know them, you can then effectively use light, the basic tool of your profession.

REFLECTION. The casting back, or the change in direction, of light after striking a surface is called reflection. Light striking a surface is called incident light. If the surface upon which the light falls is smooth and polished, reflected light bounces off of the surface in the same plane and at the same angle as the incident light. The reflections from smooth, highly polished surfaces are said to be specular. However, if the surface is rough and irregular, the light is reflected in more than one plane and direction. This reflected light is diffused.. Study the differences between specular and diffused reflections in figure 4-3.

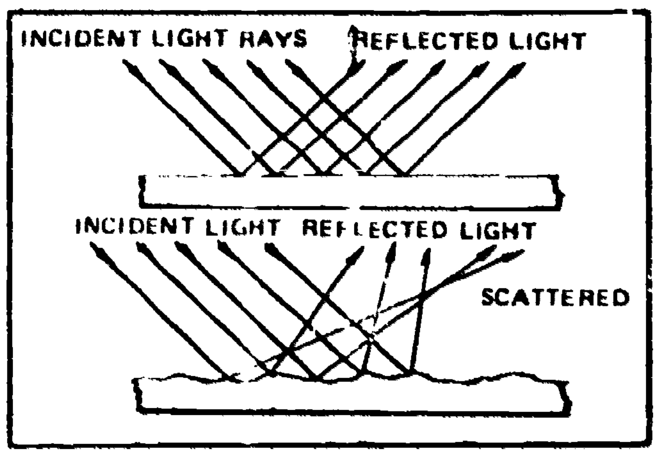


Figure 4-3. Reflection

TRANSMISSION. The term that describes the passing of light through a medium is transmission. For transmission to take place, the medium must be either transparent or translucent. A transparent medium will transmit rays of light through its substance and any object beyond or behind the medium can be distinctly seen. Translucent mediums transmit rays of light but alter their direction of travel. An object behind a translucent medium can not be clearly seen. Transmitted light passing through a translucent medium is diffused. Figure 4-4 illustrates transmission through transparent and translucent mediums.

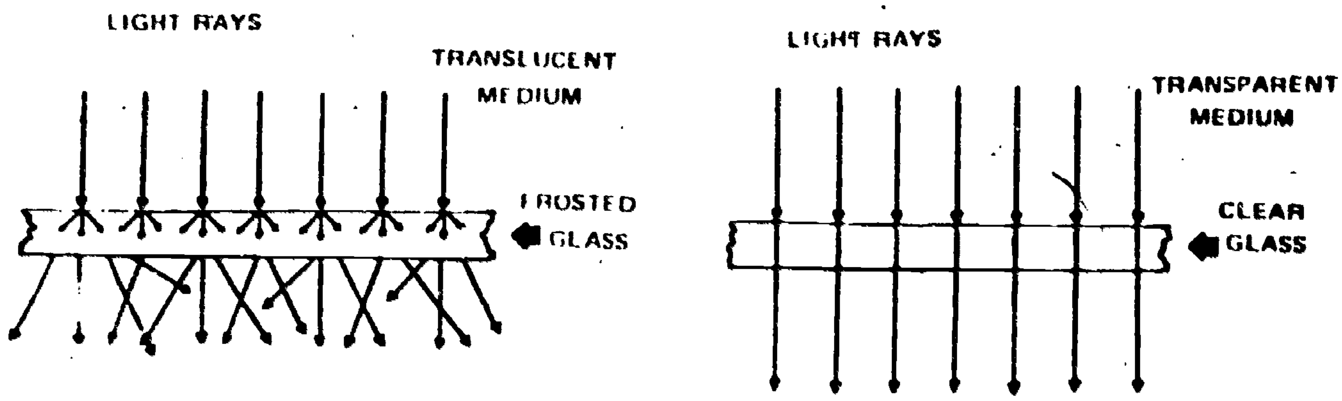


Figure 4-4. Transmission Through Transparent and Translucent Mediums

ABSORPTION. When light is neither transmitted nor reflected by a medium, it is absorbed. Black objects, such as a black cloth, black ink, black paint, appear black because they reflect very little of the light that falls on them. On the other hand white objects such as white paper and snow appear white because they reflect most of the incident light.

Objects appear as a specific color because of their powers of absorption and reflection. When light falls upon a medium, some absorption and some reflection always takes place. No known medium completely absorbs or reflects all of the incident light. Figure 4-5 illustrates this phenomenon.

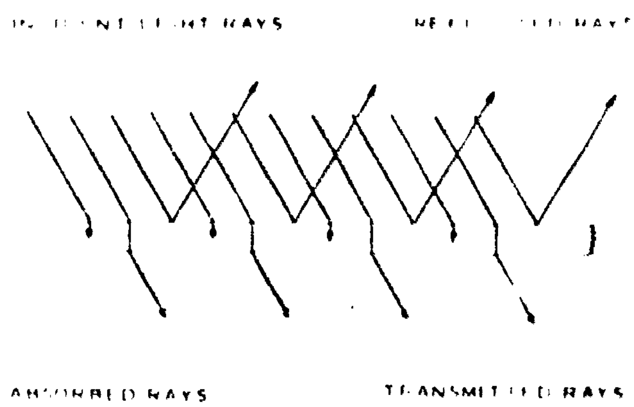

Figure 4-5. Transmission, Reflection and Absorption of Light Rays

REFRACTION. The bending of a light ray is called refraction. As light passes from a medium of one density to a medium of another density, its speed is altered. If the ray strikes the new medium at a 90°

angle to its surface, it passes through with no appreciable change in direction. This type of ray is called a normal ray. The angle the ray makes with the surface is called the normal angle, or simply, the norm.

If the ray of light enters the new medium at an oblique angle, it is bent or refracted. The law of refraction states that if light enters a medium of a different density at an oblique angle, its direction is changed so that the light is bent toward the norm if the new medium is more dense; and away from the norm if the new medium is less dense.

Refraction makes it possible for a lens to form a sharp, clear image of an object. Light can be bent and directed in any direction and to any degree by (1) controlling the shape of the surfaces of the medium (flat, convex, or concave), (2) calculating the correct relationship of the surface of the mediums or (3) choosing mediums which have the correct density to accomplish the desired effect (flint, glass, air, crown glass, etc.).

DISPERSION. While the various colors produced when sunlight passes through jewels or transparent crystals have been observed for centuries, it remained for Newton, in 1766, to explain the phenomenon. It was once believed that the colors were produced by the crystals, but Newton, using a prism, demonstrated that the colors were present in the light rather than the crystal. The separation of the white light into several colors is the result of differential refraction of the light by the prism. The angular spread of the light rays by the prism is called dispersion, and the band of colors produced is called the spectrum. Figure 4-6 illustrates the dispersion of light through a prism.

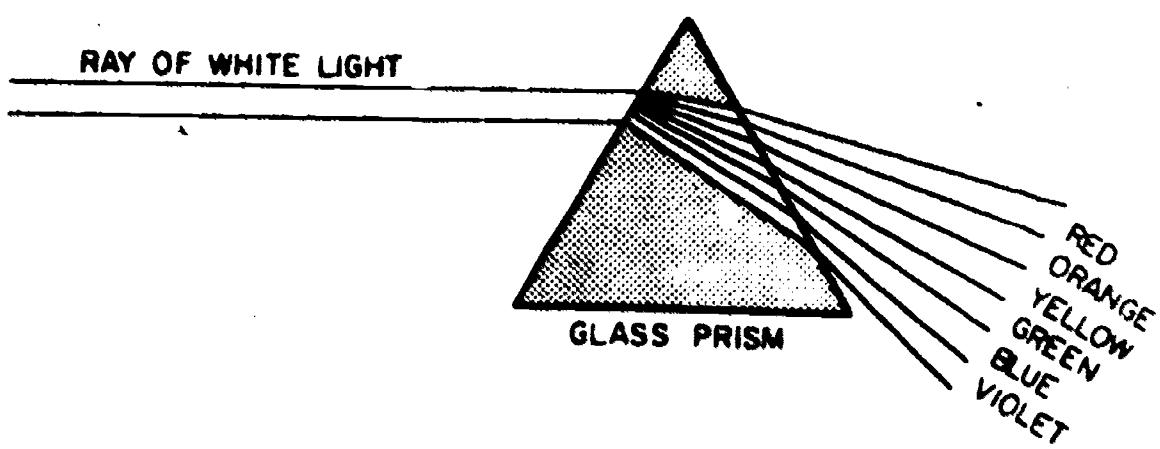


Figure 4-6. Dispersion of Light Through a Prism

## OPTICS

Since the functions of optics and light are interdependent, our discussion of optics really began when we first considered the nature of

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light. However, since the word optics usually implies the use of some system of reflecting and refraction devices to control the behavior of light, we will discuss it in terms of those systems.

Design of a Lens

To understand the design and function of a lens, we must return our thoughts to the prism. As you recall the prism has the ability to bend or refract light rays. If two prisms are placed one on top of the other, bases touching, the light rays passing through the prisms will converge at a point on the other side. Conversely, when prisms are arranged in an opposite manner, points touching, the light will diverge.

A lens is a solid piece of glass (or other transparent material) that is a refinement of two prisms. There are two basic types of lenses: positive and negative. A lens that causes light rays to converge is a positive lens; one that causes light rays to diverge is a negative lens. The determining factor is the thickness of the lens in the center as related to the thickness at its edges. A positive (convex) lens is thicker in the center and thinner at the edges. A negative (concave) lens is thinner at the center and thicker in the edges. Lens shapes are not limited to these two basic shapes mentioned. Figure 4-7 illustrates some of the most common lens shapes. Very often, two or more types of lenses are cemented together to form a complex lens system.

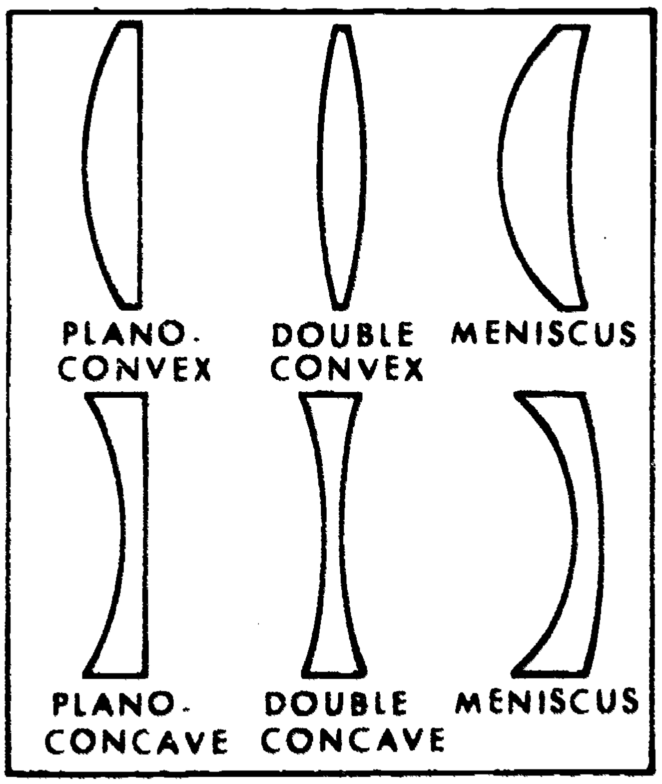


Figure 4-7. Common Lens Shapes

SW G3ABR23330 001-I-4

Lens Characteristics

There are many items that must be included when we consider the characteristics of a lens. To perform well as a photographic workman, you must be able to recognize the effect of these lens characteristics on the photographic product. You must also learn how some of the lens characteristics may limit your photographic operation capability as well as improve your work.

FOCAL LENGTH. The term "focal length" is defined as the distance between the optical center of the lens and the image produced by the lens, when the lens is focused on infinity. To understand this definition, it is essential to understand the terms "optical center" and "infinity."

The optical center of a lens is a point usually (although not always) within a lens, at which the rays of light from two different sources entering the lens are assumed to cross. The "infinity" is not so easy to define. When light is reflected from a point of an object through a lens, the closer the point is to the lens, the greater is the angle of the spread of the light rays from the object to the lens. As the point gets farther away from the lens, the angle of spread becomes less and less until a distance is reached at which the rays from a single point striking top and bottom of the lens, for all practical purposes, can be considered parallel. This distance is "infinity."

Photographic lenses are measured according to their focal length, and the focal length is usually imprinted somewhere on the lens mounting. This focal length information is measured in millimeters for short lenses and in both millimeters and inches for long lenses.

Two factors directly related to focal length are (1) image size and (2) subject coverage. These two factors vary inversely; i.e., image size would increase and subject coverage would decrease as the focal length is increased. Conversely, when the focal length is decreased, the image size is decreased and the subject coverage is increased. Figure 4-8 illustrates this.

LENS SPEED. One major characteristic of a lens is its speed. The term "lens speed" refers to the largest possible aperature of a lens—the maximum amount of light that a lens allows to pass to the focal plane and form the image. The lens speed is indicated by a numerical value termed an "f/number." It is dependent upon two factors and their relationship. These factors are (1) the maximum aperture of the lens and (2) the focal length of the lens. The relationship between focal length (FL) and diameter (D) in determining lens speed is expressed as

$$\text{lens speed} = \frac{\text{FL}}{\text{maximum D}}$$

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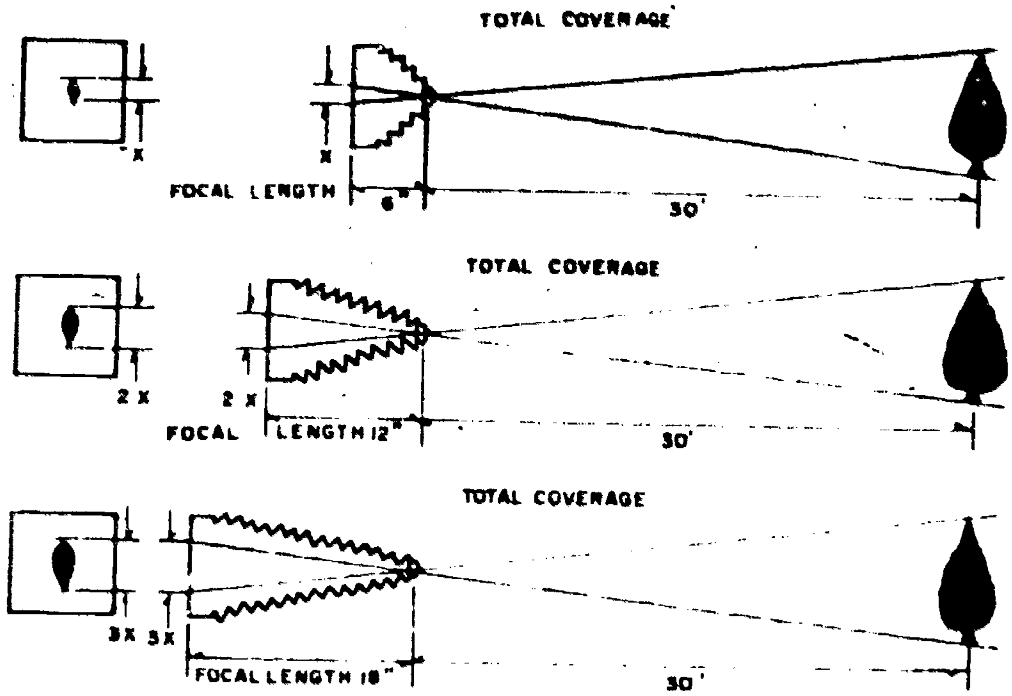


Figure 4-8. Image Size Related to Focal Length

Observe figure 4-9. You can easily see from this figure that if focal length remains constant, a lens having a larger opening allows more light to reach the focal plane than does a lens having a smaller opening. The lens with the larger opening is capable of producing a brighter image than the lens with the smaller opening and is, therefore, termed a "fast" lens. Conversely, the lens with the smaller opening is termed "slower."

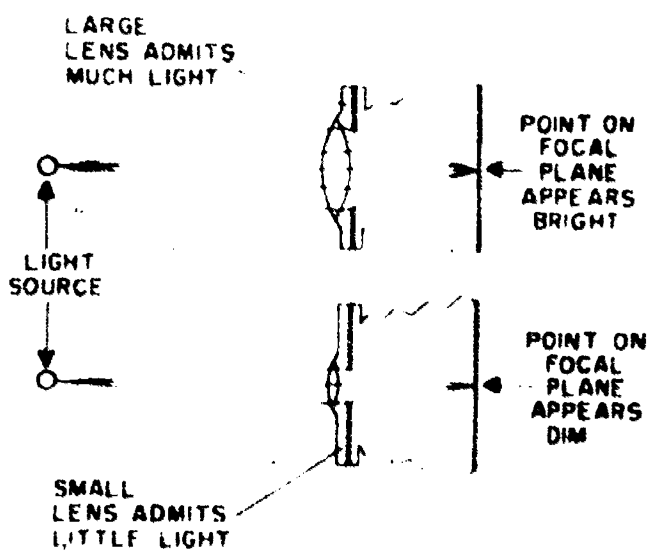


Figure 4-9. Effect of Lens Aperture on Image Brightness

RESOLVING POWER. The term "resolving power" refers to the ability of a photographic lens or material to form an image of, or record, fine detail. The normal method of measuring this quality is to photograph a suitable test pattern at a greatly reduced scale and then examine the developed image under adequate magnification to determine the smallest detail that is resolved. Resolving power should usually be considered with respect to a lens-film combination. The resolving power of a lens by itself, or a film by itself, indicates little, as the final photographic product is necessarily a result of the lens-film combination.

PHOTOGRAPHIC DEFINITION. The term "photographic definition" refers to the quality aspect of a photograph that is associated with the clarity of detail. Since photographic definition is an impression made on the mind of an observer when he views a photograph, the concept of definition becomes subjective and depends on the viewer. In common terms, definition is a composite effect of at least four subjective factors: resolving power, sharpness, graininess, and tone reproduction.

Lens Types

NORMAL LENS. The normal focal length lens for a camera is approximately equal to the diagonal dimension of the film being used to record the image. This lens coverage is an angle that is very near the angle covered by the human eye; i.e. 45°. For standard film sizes, the following focal lengths are considered approximatley "normal."

| FILM SIZE | NORMAL FOCAL LENGTH |
|---|---|
| 35mm | 50mm |
| 120 (producing 2 1/4 x 2 1/4) | 80mm |
| 120 (producing 2 1/4 x 2 3/4) | 100mm |
| 4 x 5 | 150mm |
| 8 x 10 | 300mm |

NOTE: The same approximate focal lengths are considered "normal" for enlarging lenses when printing the different film sizes.

WIDE ANGLE LENS. The wide angle lens has a shorter-than-normal focal length. That is, the focal length is less than the diagonal dimension of the film being used.

In terms of focal length for 35mm cameras, wide angle lenses start at 35mm and typically go to 28mm and then to 21mm or shorter. These lenses give an angle of view from 70° to 180° for a "fisheye" lens. A wide angle lens offers greater subject coverage with a smaller image size.

LONG FOCAL LENGTH LENS. "Long focal length" refers to any lens that has a focal length greater than the diagonal dimension of the film being used.

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The advantages of a long focal length lens are that it has a narrower angle of coverage (35° or narrower), and produces a larger image size than does a normal lens under the same lens-to-subject distance. This makes the lens ideal for portraits and photographs of faraway subjects.

Lens Aberrations

The inability of a lens to project an image that is a faithful reproduction of the original is called an aberration. It has been found that by combining lenses of different shapes and refractive indices, aberrations can be reduced to tolerable limits. Such is the case in the well-corrected lens used in cameras today.

CHROMATIC ABERRATION. The term "chromatic aberration" describes the inability of a lens to bring all the colors of the visible spectrum to the same plane of focus. In figure 4-10 you can see how a lens that is not corrected for chromatic aberration focuses the various colors of the spectrum at different planes even though they originate from the same source. The aberration forms color fringes around the image points, which represent points of the subject if the subject reflects complex light.

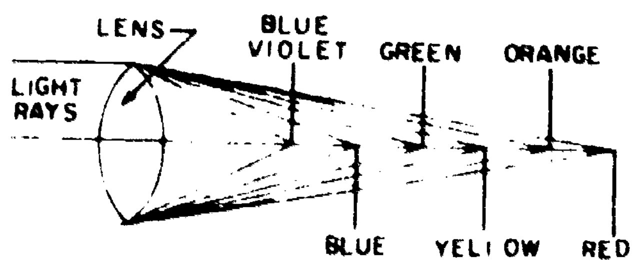


Figure 4-10. Chromatic Aberration

The term "apochromat" is applied to a lens which is corrected for three colors. Generally apochromatic lens are used by photoengravers and copy personnel working with color separation and similar work.

ASTIGMATISM. The aberration in a lens that is characterized by its inability to bring together at a common plane of focus both horizontal and vertical lines is known as astigmatism. This aberration is especially noticeable at the outer edges of the image. Figure 4-11 is a graphic representation of the problem. When the vertical lines are brought into focus, the horizontal lines are out of focus. Conversely, when horizontal lines are brought into focus, the vertical lines are out of focus.

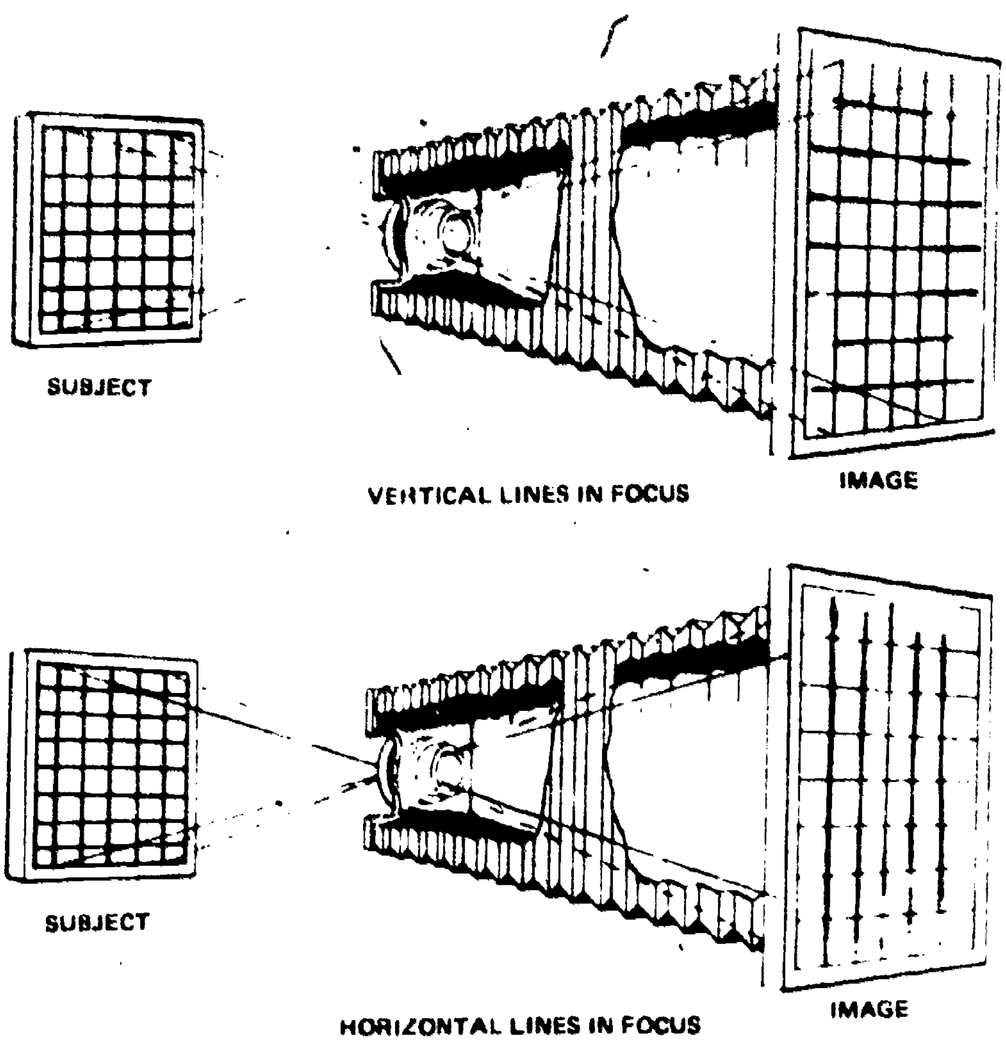


Figure 4-11. Astigmatism

When a lens has been corrected for astigmatism, it is given the term "anastigmat." Anastigmatic lenses are used in copy work.

COMA. The aberration caused by the inability of a lens to bring an oblique ray to a common point with equal magnification and brightness is termed "coma." Light rays in passing through a single lens at an oblique angle come to focus in the same plane, but fall at different points, rather than being superimposed. The image formed by the ray which strikes nearest the center of the lens produces the smallest, brightest point. The rays striking the lens toward the edges produce images which are increasingly larger and dimmer. The total effect is an image of a point that is smallest at its brightest end and grows larger toward its dimmest end. Because the image of the point tends to resemble that of a comet, the aberration was named coma. You can best understand the appearance of this aberration by studying figure 4-12.

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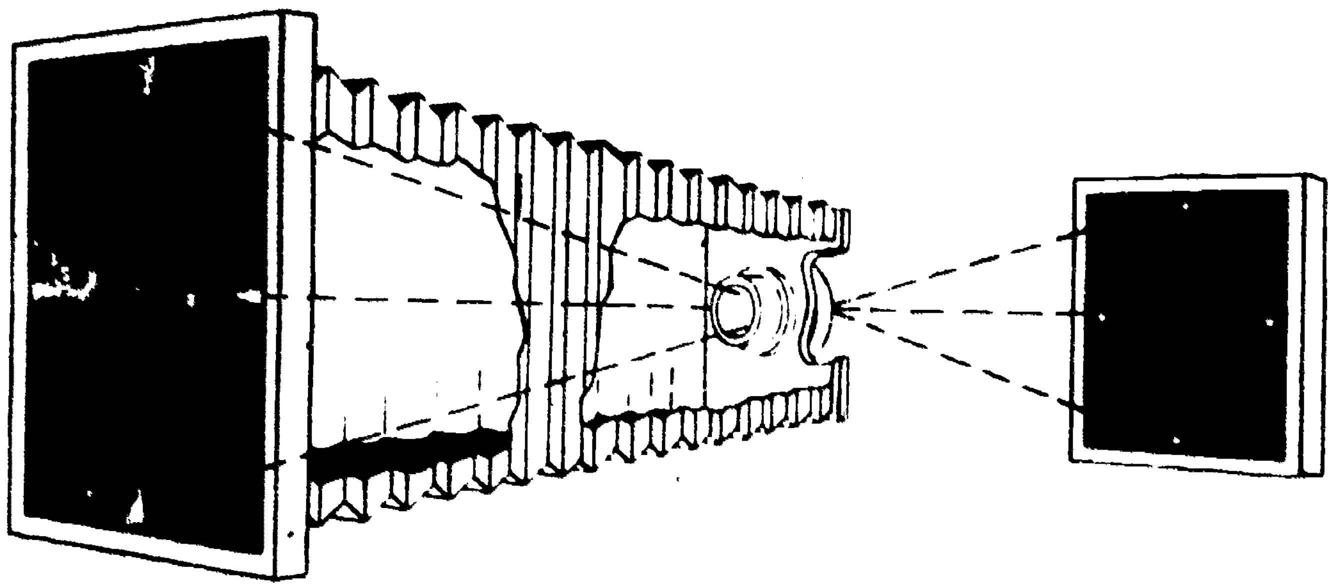


Figure 4-12. Coma

SPHERICAL ABERRATION. Spherical aberration occurs when light rays that enter the outer portions of a lens fail to reach the same focal point as those entering the center of the lens. You can understand this problem better if you study figure 4-13. This problem can be partially overcome by stopping down the aperture, but ideally the lens should be constructed to contain the elements necessary to prevent its occurring.

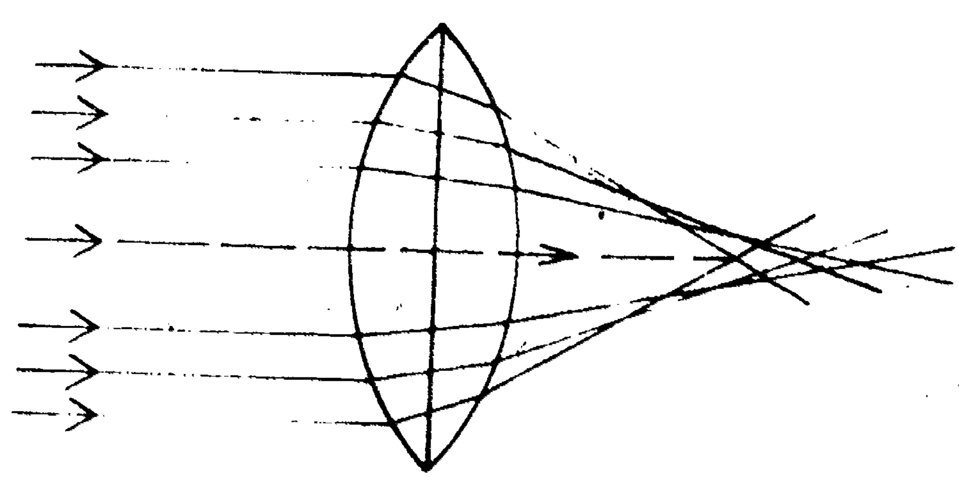


Figure 4-13. Spherical Aberration

FLARE. There are two general types of flare: mechanical and optical. Mechanical flare is the term given to the flare caused by reflections that occur because of reflective surfaces on the inner side of the lens barrel, the camera, or anywhere else near the lens. Normally mechanical flare is not an inherent characteristic of the lens, but it is a result of a damaged or burnished surface. Such flare can be eliminated by coating the damaged surface with a nonreflective coating.

Optical flare is the term given to flare that results from internal reflections from the glass-to-air surfaces of the lens itself. Optical flare is not really classified as an aberration, and it is present, to some extent, in any lens that has more than one element. A technique, known as coating, minimizes this problem. The various elements of the lens are coated with a material that helps reduce internal reflections. In addition to reducing the internal reflections, coating a lens also increases the lens transmission. Because the front surface of the lens is also coated, one must be very careful in cleaning the lens, since too vigorous rubbing can remove the coating.

QUESTIONS

<u>DO NOT WRITE IN THIS STUDY GUIDE/WORKBOOK</u>. <u>USE A SEPARATE SHEET OF PAPER</u>.

1. What is light?

2. How fast does light travel?

3. Define wavelength.

4. Define frequency.

5. What is the product of wavelength and frequency?

6. Compare the speed of light in glass with the speed in air.

7. What is the electromagnetic spectrum?

8. The visible radiation ranges from approximately what frequency to what frequency?

9. Why are lenses coated?

10. Define reflection.

11. Objects appear as specific color because of their powers of ___________ and ___________.

12. Define refraction.

13. The separation of white light into several colors is the result of __________.

14. Describe a positive lens.

15. Define focal length.

16. What two factors are directly related to focal length?

17. How is lens speed determined?

18. How is a normal lens for a camera determined?

19. The term __________ describes the inability of a lens to bring all the colors of the visible spectrum to the same plane of focus.

20. Describe astigmatism.

21. Describe coma.

22. List the two types of flare.

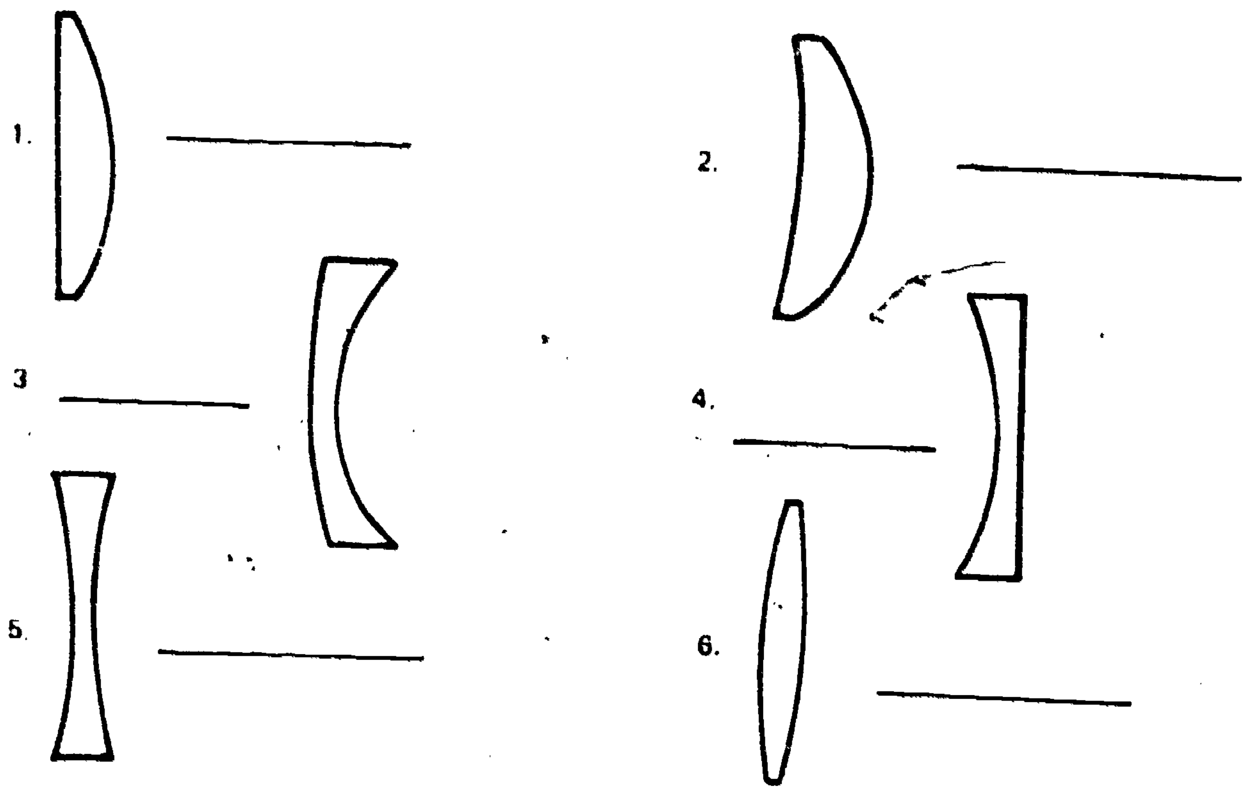
23. What causes mechanical flare?

24. What effect does coating the lens have on the lens?

## Exercise 1

PROCEDURES

1. Identify the following lens shapes. State if they converge or diverge the light waves.




2. Match the following terms with its proper definition.

| | |
|---|---|
| ____1. Transmission | a. The angular spread of light rays by a prism. |
| ____2. Reflection | b. When light is neither transmitted nor reflected. |
| ____3. Absorption | c. The casting back, or the change in direction, of light after striking a surface. |
| ____4. Refraction | d. The bending of a light ray. |
| ____5. Dispersion | e. The passing of light through a medium. |

Sciences Branch
Lowry Air Force Base, Colorado

SW G3ABR23330 001-I-5
October 1977

# EXPOSURE THEORY AND FILM CHARACTERISTICS

## OBJECTIVES

Explain the principle parts of a camera.

Define the major characteristics of photographic film.

Provide a 35mm camera and film, photograph several scenes as directed by your instructor.

## INTRODUCTION

The term "photography" is derived from two Greek words meaning light (phos) and writing (graphein). Light is the essential element in photography for it possesses two properties that combine to create a permanent image. The first is that light, when passed through a lens and focused on some field, such as paper or glass, can produce an image. The second is the ability of light to physically alter some materials. The first property was discussed in the previous study guide. The second property of light and how it is used to produce an exposure on sensitized materials is the subject of this study guide. The discussion also concerns the basic camera; the tool used with light to make photographic exposures.

## INFORMATION

### THE CAMERA

No one knows when man first constructed a device that would project images of light. An old legend tells of a certain Arab who awoke one morning to find a vision on the wall of his tent. After his first astonishment had passed, he realized that his "vision" was actually an inverted image of a group of people outside. A tiny hole in the opposite wall of the tent had acted as a crude lens. This phenomena was later called "camera obscura."

This principle was exploited during the Renaissance as a means to achieve correct perspective in painting. It was not until later in the 18th century that this principle was used to record images on glass.

Despite striking differences in physical appearance, all cameras are fundamentally the same. The camera consists of a light tight box with a hole at one end and light sensitive material at the other. The hole or aperture admits light into the box. The light sensitive film receives the light and records an image in response to it.

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Every camera, however inexpensive or costly, is equipped with five basic features: the body, the lens, the viewing system, the focusing system, and the shutter. Differences between one model and the next depend upon the relative simplicity or sophistication of these features.

Body

The body of the camera is a light-tight box. Its major function is to keep light from striking the sensitized material when the shutter is closed. The body also houses the lens, the mechanical and electrical operating devices of the camera.

Lens

The lens gathers the light rays reflected from the scene being photographed and projects them onto the film surface. A camera, whatever the quality of its other features, is only as good as its picture-taking lens. No other aspect can be considered so important as the lens. A good lens is capable of producing sharpness and accuracy in the image projected upon the film. The lens consists of several layers of different kinds of optical glass. All are ground to extremely fine tolerances and combined to adjust smoothly for exact focus. Lenses were discussed in study guide 4. It may be beneficial to review that section of the study guide.

Viewing System

The viewing system normally consists of a lens that permits viewing the scene the camera will record on film. Early box cameras did not have a special viewing system. Instead, the instrument was held at waist level and pointed. This method was quite inadequate. A viewfinder was then devised and fitted to later cameras. A viewfinder permits one to look through the camera and see the approximate area it will record. This arrangement is perfectly adequate for the ordinary snapshot, and the viewfinder is still used on some inexpensive cameras. However, the viewfinder has one major drawback--parallax.

Parallax is a defect inherent in the viewfinder that prevents it from revealing with accuracy the area actually recorded by the camera. This discrepancy occurs because the viewfinder and the lens do not sight from the same position. Usually, the viewfinder is located slightly higher than the lens and off to one side. See figure 5-1.

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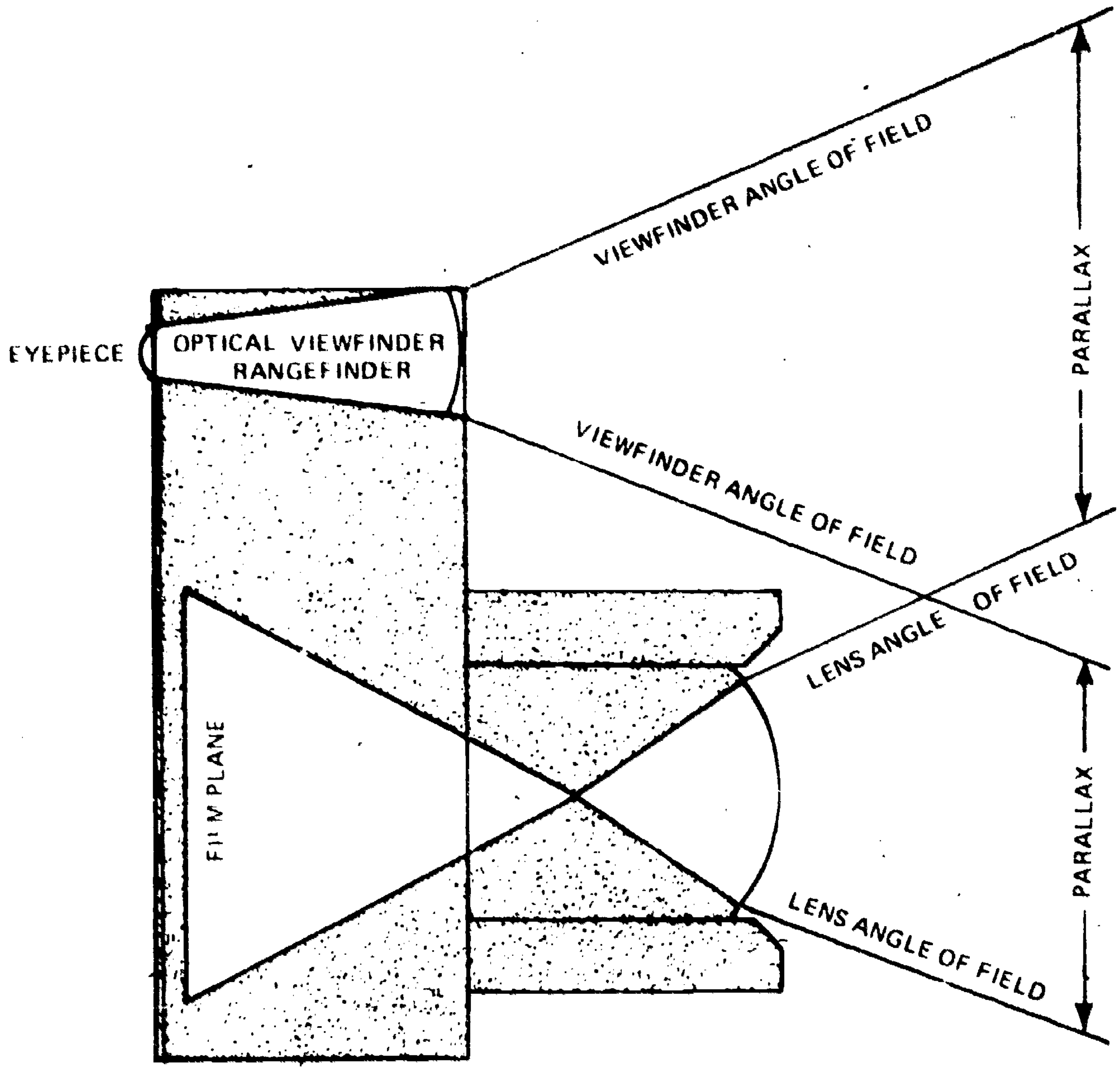


Figure 5-1. Camera Using an Optical Viewing and Focusing System

Parallax can be eliminated with the use of a single lens reflex camera that has through-the-lens viewing. This camera uses a system of mirrors and prisms which enables the photographer to see exactly what the lens will record. See figure 5-2.

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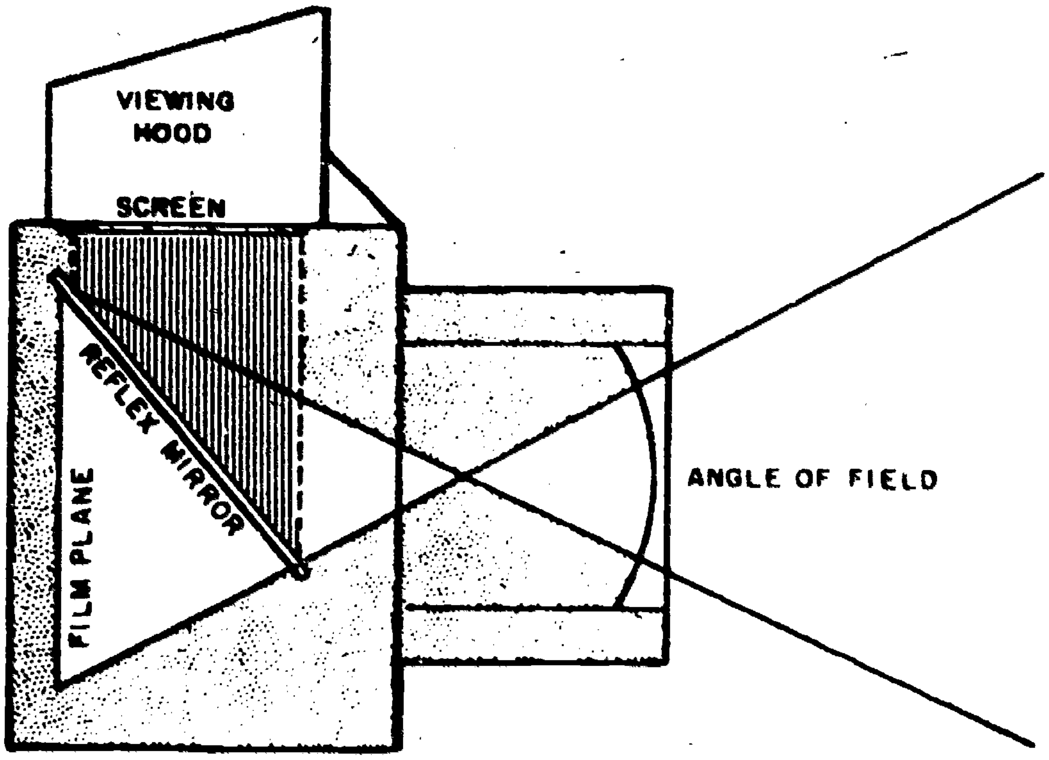


Figure 5-2. Principles of Typical Single Lens Reflex Cameras

Focusing System

The focusing system works mechanically to move the lens closer to or farther away from the film. This makes the image sharp or blurred as it strikes the film surface. Not all cameras have a built in mechanism for making this adjustment. Early box cameras and some contemporary models are designed to produce a relatively sharp image as long as the subject is at least six feet away.

To achieve really sharp photographs, it is essential to have some dependable means for relating the distance between camera and subject to the distance between lens and film. Two principle focusing devices have been developed for accomplishing this end: the rangefinder and the ground-glass viewing screen.

RANGEFINDER. The rangefinder is an optical-mechanical focusing device that produces in the viewfinder a double image of the subject to be photographed. When the two images coincide exactly, the camera is in focus.

GROUND-GLASS VIEWING SCREEN. An older device for focusing the camera is the ground-glass viewing screen. In this system, light reflected from the subject passes through the camera lens and projects onto a piece of ground glass. This produces an image that can be viewed. Thus, you see what the lens "sees." You can bring the image into focus

by watching it on the etched glass screen as the lens' focusing mechanism is manipulated.

## Shutter

The shutter and the aperture of the lens controls the amount of light that reaches the film. By adjusting these mechanisms, the exposure of the film is varied according to the requirements of the subjects.

Many kinds of shutters have been developed, but today most cameras employ either the leaf shutter or the focal plane shutter.

LEAF SHUTTER. The leaf shutter is also called a between-the-lens shutter, because it is located between the lens elements. This device consists of a series of tiny metal blades which, when closed, overlap to prevent light from entering the camera. See figure 5-3. The opening and closing of the blades are controlled by a gear and a spring mechanism. For the shutter to open, the spring must be cocked and subsequently tripped by the shutter release button. Some cameras cock the spring automatically. Others require that it be done manually.

FOCAL PLANE SHUTTERS. The focal plane shutter operates near the focal plane of the camera--directly in front of the film. This type of shutter consists of an opaque curtain with a slit. A spring mechanism pulls the slit past the film. In doing so, it exposes the film to light. By combining a wide slit with a low spring tension, a long exposure is produced. A narrow slit and a high spring tension produces a short exposure. A wide range of shutter speeds are therefore available. See figure 5-4.

# PHOTOGRAPHIC FILMS

When the shutter operates, it allows light to strike the film. The film records the scene as the light strikes it. All conventional photographic films are made up of several layers. Each layer is made of a given material to serve a specific function. The following paragraphs describe the functions of each layer. See figure 5-5.

## Film Structure

OVERCOATING. The overcoating is a gelatin layer which protects the emulsion beneath it during normal handling. Without this protective overcoating, the mere act of placing films on top of one another would be sufficient to cause minor scratches and abrasions which show up after processing.

EMULSION COATING. The emulsion is the light-sensitive layer consisting of millions of microscopic silver halide particles suspended in

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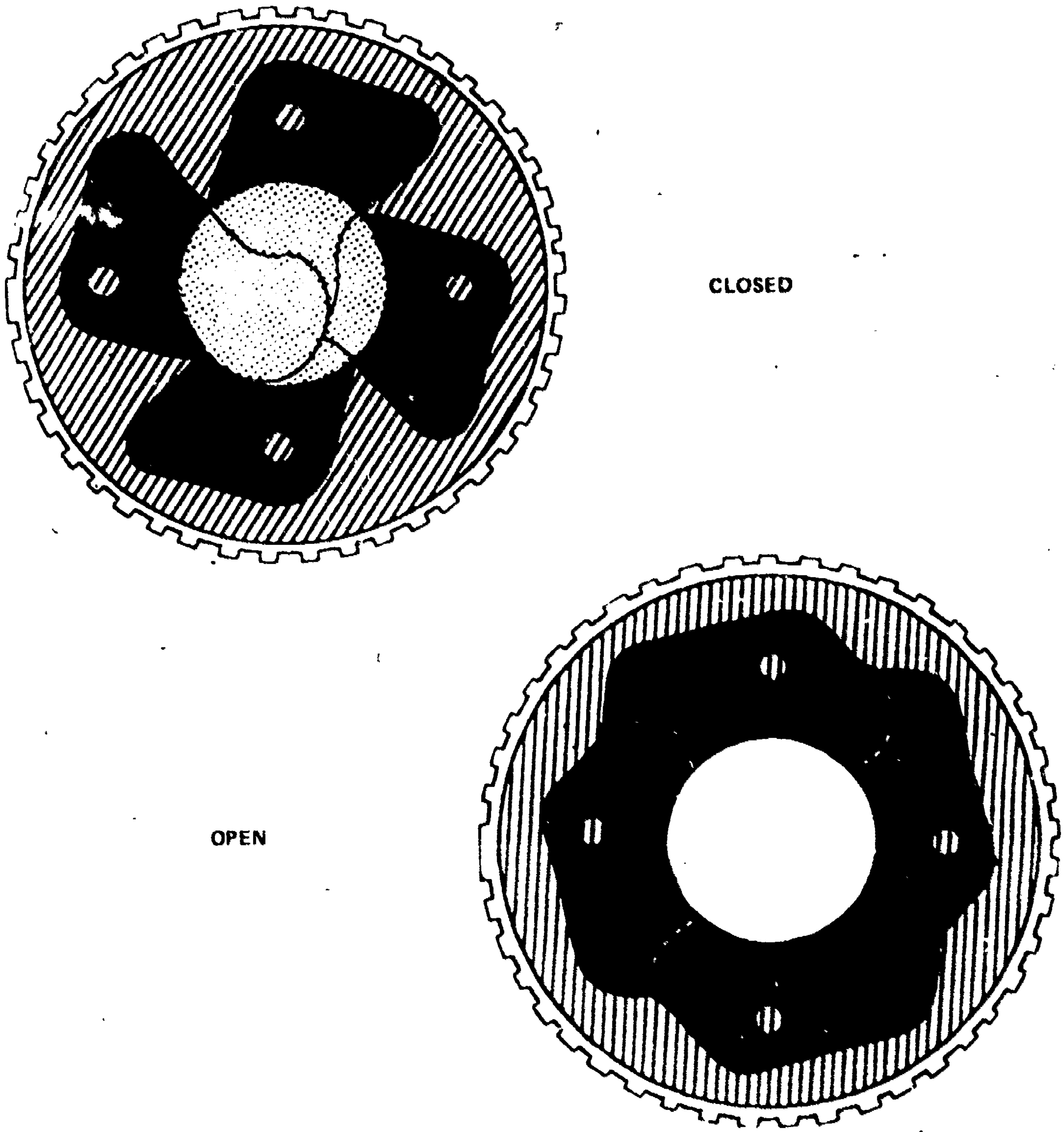


Figure 5-3. Simplified Leaf Shutter Mechanism

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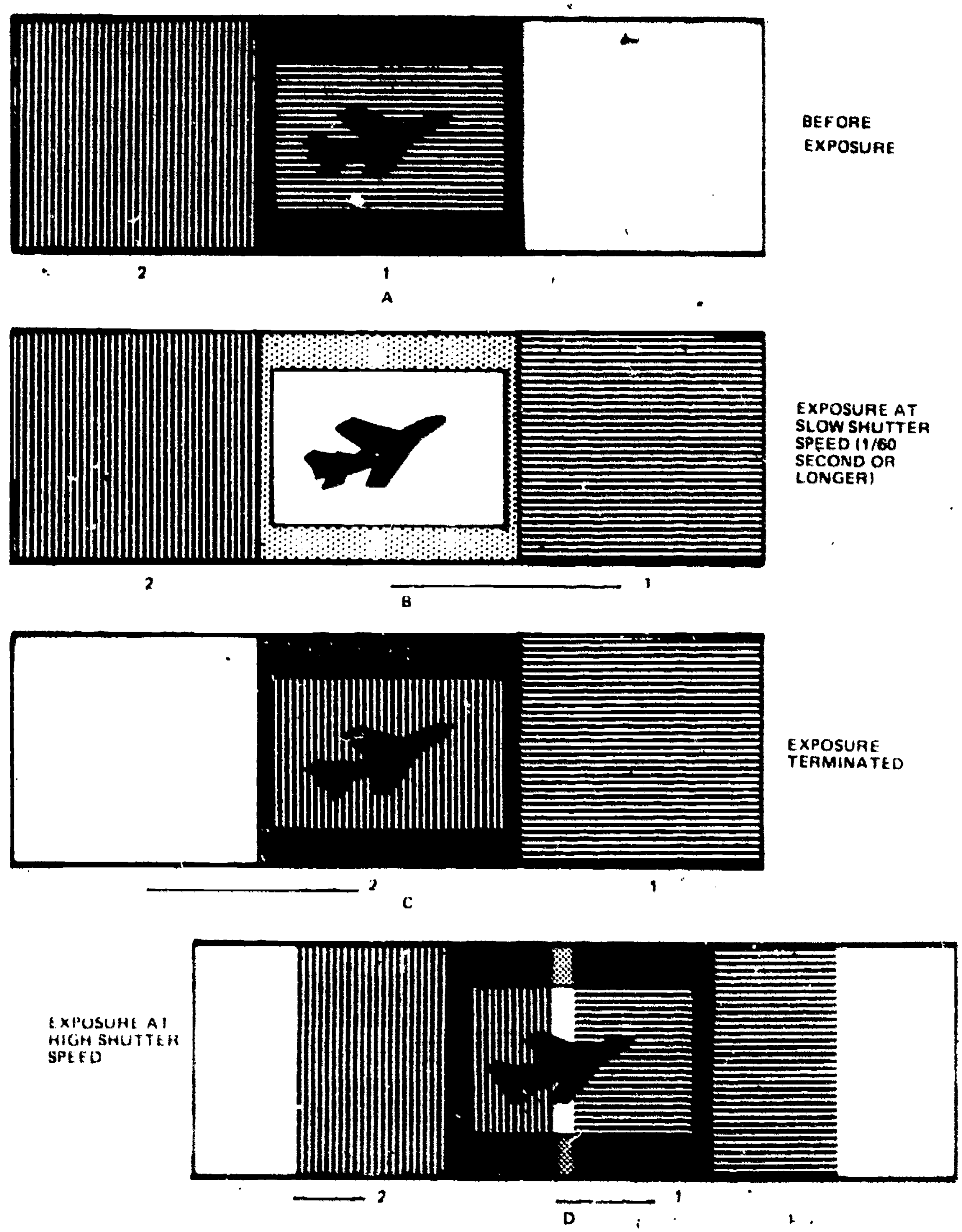


Figure 5-4. Focal Plane Shutter Principle

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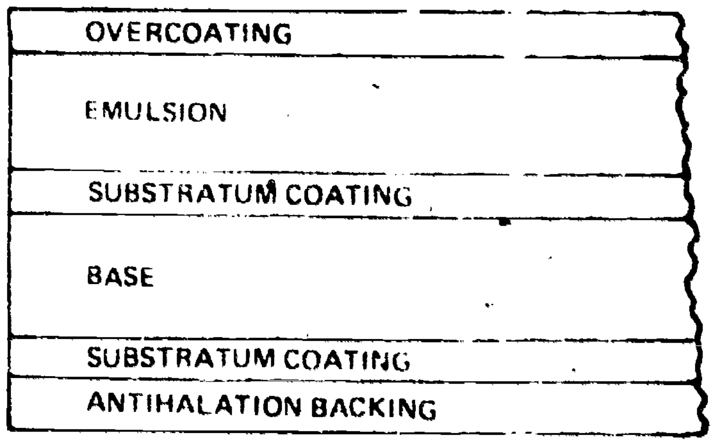


Figure 5-5. Cross-Section of Film Structure

gelatin. The emulsion characteristics are determined by the kind and combination of silver halides, the size of the silver halides, and how evenly distributed they are in the gelatin. Also the addition of dyes and other chemicals along with the quality of the gelatin itself effect emulsion characteristics.

SUBSTRATUM COATING. The gelatin containing the light-sensitive particles does not adhere to the base without a bonding material. A coating spread over the base provides the bond between the base and the emulsion. The bonding coat is a very exact formula consisting of a cellulose acetate solvent, gelatin and gelatin solvent.

FILM BASE. At one time the only support used for negative emulsions was glass. These glass plates were heavy, bulky and easily broken. Eventually, research proved cellulose nitrate was suitable as a base material for the emulsion. It was light weight, chemically inert, transparent when free from impurities and flexible. However, it was extremely flammable. It would burn with almost explosive force. Present film design now gives fire-resistant plastic base materials with great resistance to shrinking and tearing. Some of the more common film bases used today are made of cellulose acetate or cellulose tri-acetate.

ANTIHALATION BACKING. The antihalation backing is usually a layer of dyed gelatin on the back side of the film. This backing serves two purposes. One of these is countering the curling tendencies of the film due to the contracting of the emulsion layer when it sets and dries. The other purpose is to absorb as much light as possible which goes through the film during the exposure. This light would otherwise be reflected back into the emulsion layer causing a halo around brilliant highlights. Such unwanted effects are called halation.

Black-and-White Emulsion Characteristics

The photographic emulsion (or light-sensitive layer) is a result of many years experimentation and research. There are very few light-sensitive substances which will respond proportionately to light intensities in the same manner and effectiveness as the silver halide crystals. Although you are unable to detect this response to light until after development of the film or paper, the change caused by the action of light on the silver halide crystals, which forms the latent image, will remain relatively stable for a given time before the image is processed and made visible. (It is best to process the film as soon as possible after exposure.) With many other light-sensitive substances, the reaction or change caused by light disappears as soon as the light is removed.

The action of light on the silver halide crystals also is progressive. This means that with prolonged exposure to light, you can see a darkening of the emulsion layer (without processing) due to the physical release of metallic silver within the silver halide crystals.

SILVER HALIDES. There are three silver halides which are used, either separately or in combination, for most of the sensitized photographic materials on the market today. They are silver iodide, silver chloride, and silver bromide.

1. Silver iodide is seldom used by itself, due to its extremely slow response to light. However when it is added to silver bromide in small quantities (from three to five percent), it increases the "speed" or response of the silver bromide to light. This combination of silver bromide and silver iodide therefore, is used in many film emulsions.

2. Silver chloride is used by itself for making contact paper emulsions.

3. Silver bromide is the fastest of the silver halides, and its response to light is increased even more by the addition of a small quantity of silver iodide. Therefore, this silver bromide-iodide combination is used for fast film emulsions. Silver bromide by itself is used in some of the slower film emulsions.

These three silver halides, silver iodide, silver chloride and silver bromide are controlling factors in the formation of other emulsion characteristics. The six remaining emulsion characteristics are: color sensitivity, contrast, light sensitivity, grain, resolving power, and accutance.

COLOR SENSITIVITY. Visible light which appears white, is a mixture of the primary colors red, blue and green. When photographic emulsions were first made, the silver halides used were sensitive only to blue

light and somewhat to invisible ultraviolet radiation. These films were affected only by the blue portion of light. Thus, the blues in a scene were reproduced too light and the other colors were reproduced too dark.

The blue sensitive emulsions were also slow. Refer to figure 5-6 for the reason. This shows how the color sensitivity of typical films compares to the human eye. Blue sensitive film is sensitive to about one third of the total visible spectrum, which accounts for its slow speed. In other words, to make a good exposure on this film, a lot of

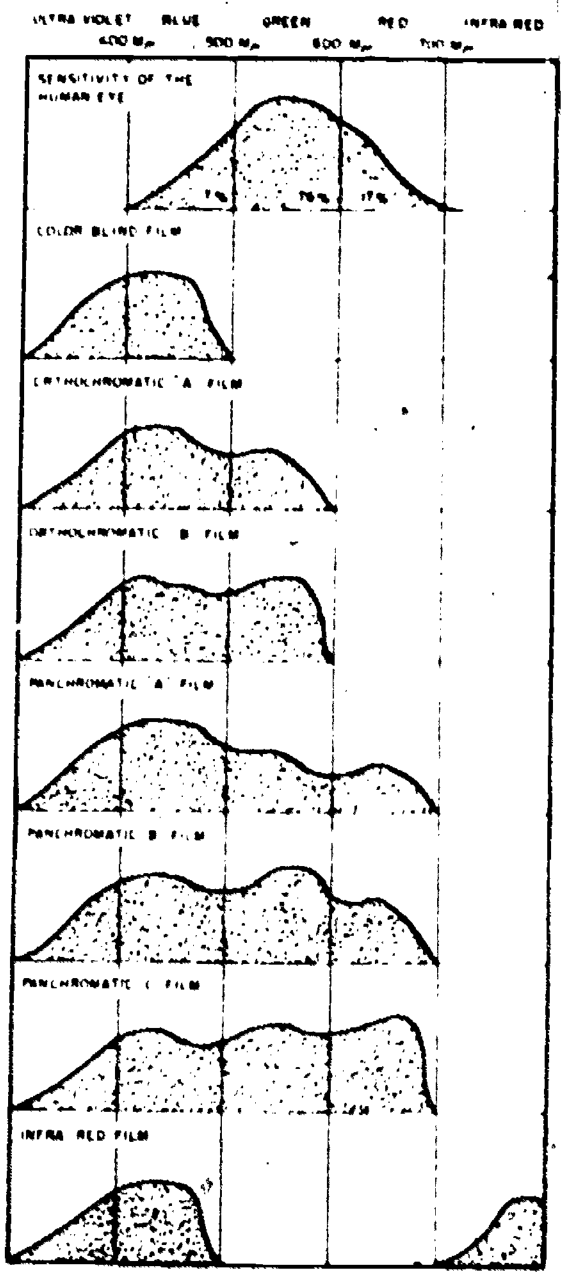


Figure 5-6. Color Sensitivity of Film

light or long exposure is needed. However, this type of emulsion is useful. It is still manufactured because it yields the high contrast results needed for copying black and white line drawings, charts, book pages, etc.

Eventually, dyes were added to blue sensitive emulsions to sensitize the silver halides to green light as well as blue light. This film was named orthochromatic (true color) because it was believed that the ultimate in color sensitivity was reached. The term was incorrect, however, since the emulsion was not sensitive to red and would not reproduce red in the correct shade of gray. Ortho films, as they are often called, are made in several speeds and variations. They are excellent for many uses, provided that their incorrect rendition of red is considered when the scene is photographed. Since they are not sensitive to red, red light does not (for practical purposes) make a latent image on the film. Therefore, after processing, red objects are relatively transparent on the negative. This means they are quite dark on the print.

As an example, ortho film is good for a portrait of a man; but not for photographing a woman wearing makeup. If used for the woman, the light reflecting from her red lipstick would not expose the film and her lips would look too dark (almost black) on the print.

Years after the design of orthochromatic film, additional dyes were added to emulsions to make silver halides sensitive to red light also. The term "panchromatic" (meaning all-color) was given to this new film. Panchromatic films record most colors in their relative tones or shades of gray. Even though panchromatic film is sensitive to all colors, it does not reproduce them in the same tonal values seen by the eye. Of the three primary colors, green appears brightest to the eye. Yet, green photographs darkest on the majority of panchromatic films. This effect can be modified to some extent through the use of photographic filters. Filters change the sensitivity of the film by allowing only certain portions of the visible spectrum to strike the film.

CONTRAST. Some photographic densities are black in areas, some are white (or transparent) and in between, there are many shades of gray. Closely associated with density is the characteristic known as contrast. Contrast is the difference between the high and low densities.

A light subject area reflects a great amount of light, causing a heavy density in the negative, called a highlight. A dark subject area reflects little light, resulting in a thin density in the negative, called a shadow.

The subject brightness between these light and dark areas also registers as corresponding densities, called middle tones. Normal contrast is represented by a full range of densities, including highlights,

middle tones and shadows. High contrast does not have a full range of densities and consists only of highlights and shadows with little or no intermediate graduations. Low contrast has very little difference in densities.

Emulsions are manufactured with varying degrees of inherent contrast. High contrast (process) film is used to record a short range of tones such as black and white line drawings. Medium and low contrast films are used to record a longer range of tones such as might be found in a portrait. Therefore, the selection of the film should be governed by the subject contrast and the desired rendition.

Usually, the emulsions which have the slowest speed (react slower to light) have the highest inherent contrast. Fast films respond to light much more rapidly than the slower films. This tends to flatten out or lower the contrast of these films.

Many other factors influence the contrast of the final result. Development has an effect. So do the lighting conditions of the original scene and the contrast ratio of objects in the original scene. Normally a contrasty film is not used for a portrait or similar subject when the intermediate tones must be retained. Conversely, do not use a low contrast film for a reproduction of a black and white line drawing where the intermediate tones are undesirable.

LIGHT SENSITIVITY. The size of the silver halide crystal in a film emulsion determines other major characteristics of that particular film. Among them is its light sensitivity or "speed." The larger the crystals are, the greater the sensitivity and vice versa, see figure 5-7. This means that a film with high sensitivity (a fast film) requires less light to produce an image than one with low sensitivity (a slow film). The various speeds available to the photographer are indicated by ASA numbers established by the American National Standards Institute.

The major classifications of film speed, by average ASA ratings are:

Slow films, about ASA 32, which require a highlight level.

Medium films, about ASA 125, which are used in average or normal light situations.

Fast films, about ASA 400, which are needed when the light level is low or when a fast shutter speed is required to stop action.

Extra fast films, some well above ASA 800, are used only when the other types of films are too slow, under the dimmest light levels or when the highest shutter speeds are necessary.

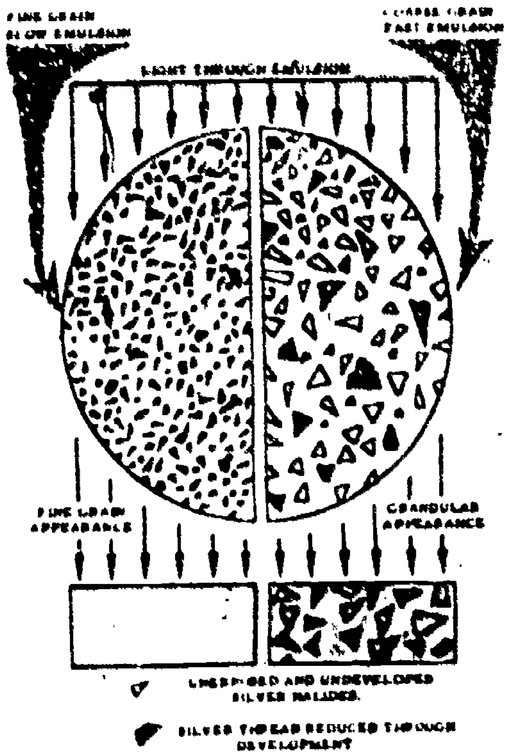


Figure 5-7. Size of Silver Halides

GRAIN. In addition to speed, the size of the light sensitive crystals in a film emulsion determines the nature of its grain, see figure 5-7. Grain is the texture quality of tones in a print that is produced when microscopic particles of silver clump together during processing. A fast film, though highly sensitive to light, is grainier and less sharp than a slow, fine grain film. When choosing the best film for a particular situation, consider not only whether it will give satisfactory exposure under the conditions, but also the kind of image it will create. Since it is impossible to attain both maximum speed and the finest visual quality simultaneously, photographers often compromise by using a medium speed film.

In addition to the inherent grain size, processing also has a great effect on the grain size. By using special processing techniques, excessive clumping of silver crystals can be prevented during development. When the grain becomes apparent in the image, it is said to be grainy.

RESOLVING POWER. The resolving power of a film is its ability to distinguish between closely spaced lines. A technique for determining the extent of this ability is to photograph a chart that consists of areas of parallel lines. The distance between the lines ranges by degrees from rather far apart to very close. At some point on the negative, the lines can no longer be distinguished as lines, but are seen as a tone of gray. This indicates the limit of resolving power for a particular film. The resolving power is expressed in lines per millimeter and, in general, the slowest films have the highest resolving power.

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ACUTANCE. Acutance describes a film's sharpness. It is accurately gauged by placing a knife edge on the film, then exposing and processing it. The silhouette of the knife edge on the negative is examined by a microscope. Because light scatters when it strikes the silver halides in the emulsion, there is always some gradation of white to black at the boundary between bright and dark areas. The narrower this gradation is, the higher the acutance of the film.

Specialized Emulsions

INFRARED. Infrared film is sensitive to the infrared region of the electromagnetic spectrum (700 to 900nm wavelengths) which is invisible. Even though infrared is invisible to the human eye, this film can "see" it; therefore, an exposure can be made.

Infrared film has many uses in scientific, investigative and aerospace photography. One outstanding use for this film is in aerial reconnaissance photography. It gives sharp definition and good tone differentiation of distant objects under adverse climatic conditions. It penetrates haze since infrared is scattered considerably less than visible light. Additionally, the film is useful in document photography, microphotography and in many other scientific fields.

ULTRAVIOLET FILM. All films are sensitive to ultraviolet radiations. With normal and infrared films, the ultraviolet radiations are eliminated by filters. With ultraviolet film, the ultraviolet radiations must be allowed to reach the film in order to produce an exposure. In most cases, photography using ultraviolet is confined to scientific work and many of the emulsions are designed for a specific purpose.

The most widely known application of ultraviolet photography is in the area of detection. Altered documents can be identified, paintings can be verified, etc. This technique is also used in investigative photography, since invisible ink and finger prints are readily detected.

Aerial Film Classification

There are several methods of classifying films. You have, or probably will hear such classifications as Type V Class L film or Class A film, Class N film, etc. These designations come from Federal Specification L-F-330, dated December 17, 1956, amended April 20, 1962. Most still photography film is designated this way. However, Federal Standard 170a, dated March 31, 1967, specified a new designator system for Federal agencies in its application to the purchase of such films. Military Specification MIL-F-32F, dated 22 March 1965, amended 2 March 1967, uses the same designator system as Federal Standard 170a. MIL-F-32F is mandatory for use by all departments and agencies of the Department of Defense. This specification covers the detail requirements for black-and-white photographic film for use in, and duplication of, aerial photography.

In the designator system, outlined by these two documents, all films sold to the Federal Government through GSA (General Services Administration) are classified according to: (1) product, (2) type of material, (3) base material, (4) base thickness, (5) spectral sensitivity, (6) gamma range, and (7) relative sensitivity. The designator is written in the format of XX-XX-XXX. An explanation of each digit follows:

1. The first digit refers to the product relative to its use. All aerial film has the number one as its first digit.

2. The second digit refers to the type of material. Most aerial film will be either 1 negative, or 4 duplicating. 5 is never used as aerial film, and 2 is seldom used.

3. The third digit refers to base type of material.

4. The fourth digit refers to the thickness of the material.

5. The fifth digit refers to the spectral sensitivity; that is, whether it is blue sensitive, orthochromatic, panchromatic, infrared, etc.

6. The sixth digit refers to the gamma range obtained when this film is processed in accordance with applicable specifications.

7. The last digit is actually a lower case letter which refers to the relative sensitivity obtained when using the appropriate method and processing standard from the specification. This relative sensitivity does not bear a relationship to the manufacturer's published exposure index number or any other established film speed methods.

Figure 5-8 gives a complete listing of each designator and all possible values for each.

One purpose of using the designator system is to enable manufacturers to produce a film meeting a certain specification. Therefore, if Kodak, DuPont, and GAF all produced a film having the same designator number, a laboratory could use them interchangeably. In fact, most procurement of films is now based on designator numbers exclusively.

Some of the more common films you will use in this career field and their designators are:

## FILM CLASSIFICATION SYSTEM

Designator 11 — 25 — 24a

| Product D[1] | Type D[1] | Support type D[1] | Total thickness (mils.) D[1] | Spectral sensitivity D[1] | Gamma D[1] | Relative sensitivity D[1] |
|---|---|---|---|---|---|---|
| 1 Aerial film | 1 Negative | 1 Cellulose-ester regular | 1 1.0 1.9 | 1 Extended ultra-violet | 1 0.10 0.50 | a— 0.8 — .57 1.1 |
| | | | | | | b— 1.5 — 1.2 2.1 |
| 2 Motion picture film | 2 Positive film | 2 Cellulose-ester low shrink | 2 2.0 3.8 | 2 Blue sensitive | 2 0.51 1.00 | c— 3 — 2.2 4.2 |
| 3 Roll and film pack | 3 Reversal | 3 Synthetic resin | 3 3.9 5.1 | 3 Orthochromatic | 3 1.01 1.50 | d— 6 — 4.3 8.5 |
| | | | | | | e— 12 — 8.6 17 |
| 4 Sheet film | 4 Duplicating | 4 Polystyrene type | 4 5.2 6.5 | 4 High green | 4 1.51 3.00 | f— 25 — 18 35 |
| 5 Photo-mechanical | 5 Sound recording | 5 stripping base | 5 6.6 8.2 | 5 Panchromatic | 5 3.01 5.00 | g— 50 — 36 71 |
| | | | | | | h— 100 — 72 140 |
| 6 Microfilm | | | 6 8.3 10.0 | 6 Panchromatic extended red | 6 5.01 Above | i— 200 — 141 280 |
| | | | 7 10.1 12.0 | 7 Infrared | 0 Other | j— 400 — 281 570 |
| | | | | | | k— 800 — 571 1100 |
| | | | 0 Other | | | l—1600 — 1101 2300 |
| | | | | | | m—3200 — 2301 4500 |

¹ Designator

Figure 5-8. Film Classification System

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| Designator Number | Manufacturer's Name and Number | |
|---|---|---|
| 14-33-23d | Kodak Aerographic Duplicating Film | 2420 |
| 14-33-23d | Kodak Aerographic Duplicating Film | 2427 |
| 14-33-23c | DuPont Cronar Aerial Duping Film | 228R |
| 14-24-24d | Kodak Aerographic Duplicating Film | 5427 |
| 14-35-23d | Kodak Aerographic Duplicating Film | 4427 |
| 14-33-24a | Kodak Fine Grain Aerial Duping Film | 2430 |
| 14-14-24d | Kodak Aerial Recon Duping Film | 8427 |
| 14-32-23d | Kodak Aerographic Duplicating Film | SO-122 |
| 11-33-64i | Kodak Plus-x Aerographic Film | 2401 |
| 11-33-64i | Kodak Plux-x Aerographic Film | 2402 |
| 11-33-64k | Kodak Tri-x Aerographic Film | 2403 |
| 11-33-63i | Kodak Double-x Aerographic Film | 2405 |
| 11-32-64g | Kodak Panatomic-x Aerial Film | 3400 |
| 11-32-64i | Kodak Plus-x Aerial Film | 3401 |
| 11-32-64d | Kodak High Definition Aerial Film | 3404 |
| 11-24-74o | Kodak Infrared Aerographic Film | 5424 |
| 11-14-64i | Kodak Plus-x Aerocon Film | 8401 |
| 11-12-64i | Kodak Plus-x Aerocon Film (thin base) | 8402 |

Storage and Handling of Sensitized Materials

Photosensitized materials deteriorate rapidly when exposed to very high temperatures (even for short periods of time) or when exposed to extremely high relative humidities or to radioactivity. As a result there may be a loss of light sensitivity, a change (usually a loss) in contrast, a loss of emulsion speed, an increase in fog level, or varying degrees of all four conditions may be present. The two prim factors which affect deterioration are heat and humidity.

The effects of moisture can be controlled by the use of vapor-resistant packaging, desiccants, or humidity controlled environments. The effects of heat can be minimized by proper control of temperature during storage. AFM 67-9, Storage Manual, lists the procedures for storing photographic film, paper, and chemicals. The following information has been extracted from AFM 67-9, paragraph 5-12.

o The required relative humidity for sensitized materials ranges from 30 percent to 60 percent with 50 percent considered ideal. A constant relative humidity level shall be maintained.

o Photosensitive materials shall be stored at temperatures of 50°F (10°C) or lower. Constant temperature shall be maintained.

o Photosensitive materials will be protected from harmful gasses. High concentrations of formaldehyde, hydrogen sulfide (sewer gas), ammonia, mercury vapor, etc., can damage photographic emulsions.

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o Adequate thickness of lead or other shielding material will be used to protect sensitized materials from X-rays, radioactive and atomic fission radiation if present.

o Photosensitive materials shall be issued according to the expiration date shown on the package. Earliest expiration date material is used first. If the material has been properly stored, upon reaching the expiration date, the expiration date can be automatically extended according to the following table:

| Material Type | Stateside | Overseas |
|---|---|---|
| Black-&-White Films | 12 months | 6 months |
| Graded Paper | 12 months | 6 months |
| Variable Contrast Paper | 12 months | 6 months |
| Color Film | 6 months | 0 months |
| Infrared Film | 6 months | 0 months |
| Camouflage Detection Film | 6 months | 0 months |
| Polaroid Materials | No extension permitted | |

When the new expiration date is reached, the material should not be used until it is tested. The material should meet standards established by TO 10J-1-4, Storage, Issue, and Shipment of Film, Paper and Chemicals. If the material does not meet the required standards, action must be taken to dispose of it. Should the material meet the standards, the expiration date can be extended up to 12 months.

If a lab has adequate testing facilities it will be responsible for testing supplies stored at the base. If the testing capability is not present, the responsibility shifts to the command. Because of the cost involved in testing, evaluation is usually restricted to emulsion batches, on a sampling basis.

TO 10J-1-4 lists the various types of tests that can be used to determine the usability of outdated materials. Refer to this TO if required to evaluate expired materials.

## PHOTOGRAPHIC EXPOSURE

One can have the best camera, the finest lens, the greatest film and total control of the lighting, but without proper exposure one still will not have a good photograph. One must be able to control the amount of light reaching the film and the amount of time it exposes the film. Without this control, results would be haphazard at best, if not totally useless.

## Exposure Theory

Accurate exposure is essential if negatives are to record faithfully the wide range of tones in a scene. About fifty basic and distinct tones of gray can be rendered in a photograph, but the range of tones in nature far exceeds this. For every photograph, then, a choice must be made between tones to be neglected and tones to be emphasized. How well the choice is represented in the final print depends largely upon how the negative has been exposed.

The term "exposure" means the amount of light which is permitted to act upon a photographic emulsion. A light of high intensity may be permitted to act for a short time, or one of lesser intensity for a greater time. Both exposures produce the same photographic effect on the film. The exposure formula which applies to most practical work is:

Exposure = Intensity x Time (E = I x T)

Intensity in this case refers to the brightness of the image on the film. This intensity depends on the lens aperture in conjunction with the light reflected from the subject. Time is the interval during which the shutter remains open to permit light to reach the film.

For example, three different exposures of one scene were made. The first exposure is a product of a shutter speed of 1/125 second and a lens aperture of f/11. The second is 1/60 second at f/16 and the third is 1/250 at f/8. All three were developed exactly alike. All the negatives will have the same equivalent amount of exposure. In this demonstration, the exposure (E) has remained constant while both intensity (I) and time (T) have varied. When the intensity was reduced, the time was increased to keep the exposure constant.

Thus, the lens aperture works with the shutter to control the exposure. The exposure formula could be rewritten as:

Exposure = Lens Aperture times Shutter Speed

Here the lens aperture relates to the intensity and the shutter speed to the time needed to produce the exposure.

It was stated that the three example exposures were equivalent. This formula can be used for these or any given exposures. As the shutter speed changes so must the f/stop. However, this must be done according to the formula.

Each f/stop changes the intensity of the light by a factor of two from the f/stops on either side of it. Changing the f/stop from f/8 to f/5.6 will double the intensity of the light striking the film. Changing the f/stop from f/11 to f/16 will cut the intensity in half. The

same relationship is true with shutter speeds. Each shutter speed changes the length of exposure by a factor of two from the speeds on either side of it. Changing the shutter speed from 1/60 of a second to 1/30 will double the time the light strikes the film. Changing from 1/125 to 1/250 will half the time.

Because of this, f/stops or shutter speeds can be changed in order to match the scene being photographed—to stop action, blurr action, inc... or decrease depth of field.

Exposure and Film

To record an image, insert a piece of photographic material into the back of the camera. The image is recorded during the time the shutter is open. No matter how the light-sensitive material is altered under the influence of the light falling on it, assume that there is one correct exposure giving the best results. Underexposure means that only the brightest parts of the subject are recorded, if at all. The amount of light reflected from the darker parts of the subject is too weak to effect the senstive material. Overexposure means that the brighter parts of the subject will appear the same—the light sensitive emulsion being incapable of separating or grading the bright tones of the subject.

A negative is said to be correctly exposed when it gives a satisfactory rendition of detail in both the deepest shadows and brightest highlights. Fortunately, in many cases there is more than one single exposure which will produce such a result. There is a wide range of possible exposures within which satisfactory tone separation is possible. The minimum satisfactory exposure is one in which good tone separation is just attained in the deepest shadow areas. The maximum satisfactory exposure is one in which detail is just retained in the brightest highlight. Any additional exposure causes this highlight detail to become flattened out or "blocked up."

The range between the minimum and maximum satisfactory exposures is called latitude. This latitude may be either narrow or wide, depending upon the subject matter, lighting conditions, type of film and degree of development of the negative. Generally speaking, black-and-white films have a wider latitude than color films.

An exposure meter is used to help determine the exposure required in a given situation. The reading that the light meter gives is translated in terms of lens aperture and shutter speed in correlation with the speed of the film used.

Camera Operation

After the film and camera have been selected and a basic knowledge of exposure learned, then you must learn to operate the particular

camera to be used. Many different cameras exist and many operate slightly different (although the basic design is similar). In order to get the best photographic results, learn to use the particular camera properly. Never try to guess how to use an expensive camera. Follow the instruction booklet, study guide or TO carefully.

The following is a discussion of the Topcon Super D, a 35mm single lens reflex camera. Refer to figure 5-9, 5-10, and 5-11 while studying this information.

GENERAL CHARACTERISTICS OF THE TOPCON SUPER D. Focusing and framing with the Topcon is done through the lens. The image is reflected from a 45° mirror, located behind the lens, into a pentaprism which shows an unreversed image at eye level.

The image seen is 97 percent of the final negative. It is identical to the image that will appear on the film, so there is no parallax. What is shown on the focusing screen is what the camera records.

The focusing screen has a full area ground glass field plus a split-image rangefinder spot surrounded by a fine focus ring. The penta-prism and focusing screen are removable. To avoid the possibility of dirt and fingerprints in the viewing system, they should NEVER be removed unless absolutely necessary.

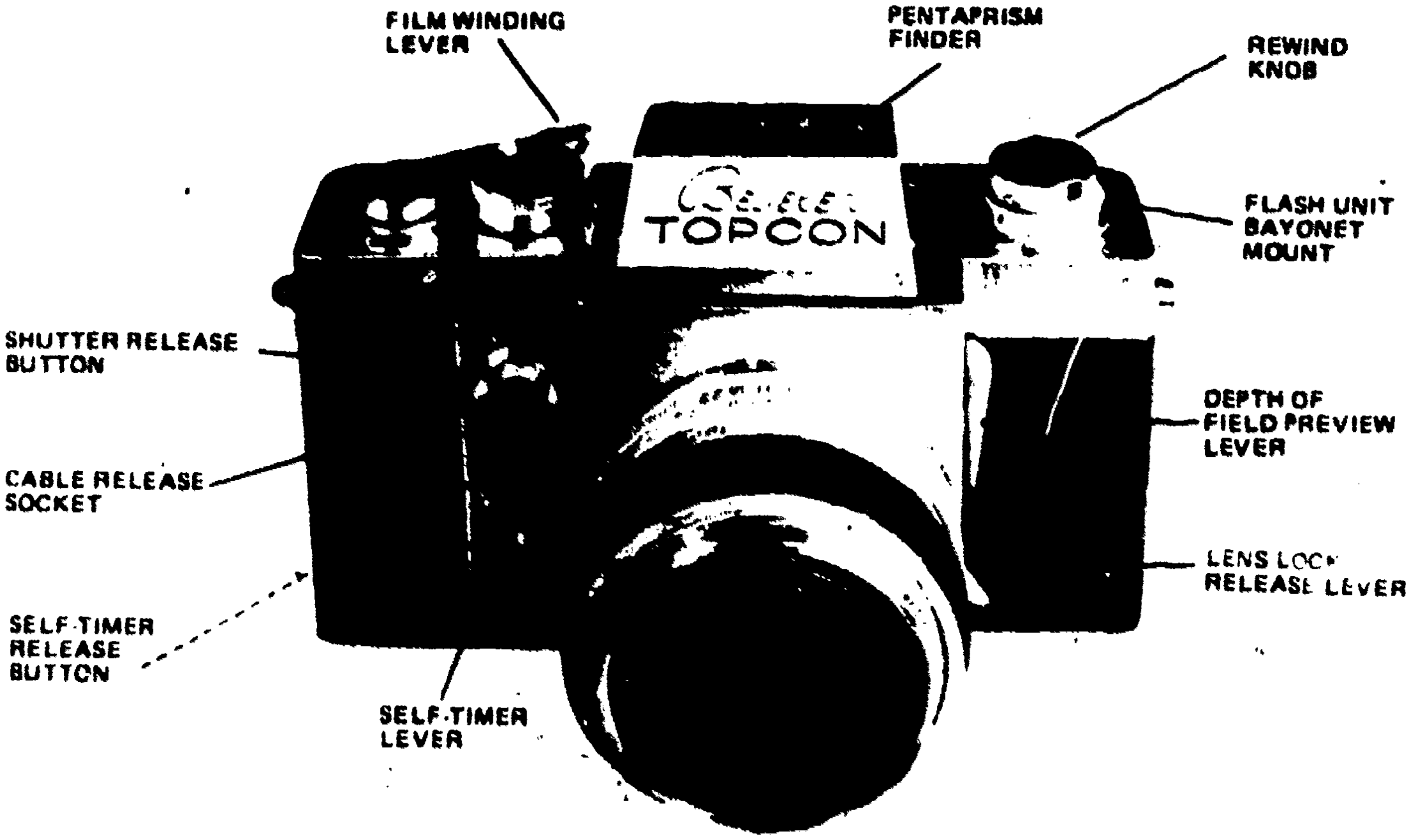


Figure 5-9. Camera Controls and Indicators, Front View

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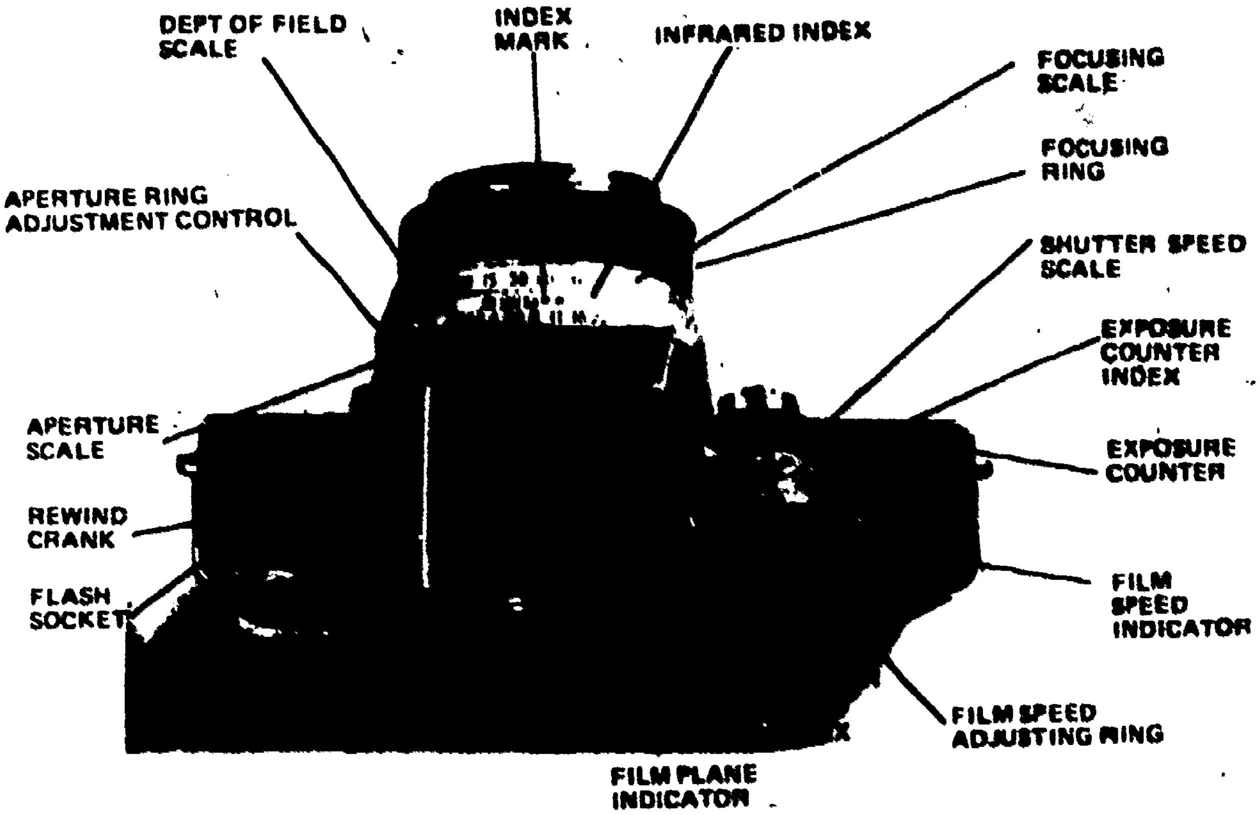


Figure 5-10. Camera Controls and Indicators, Top View

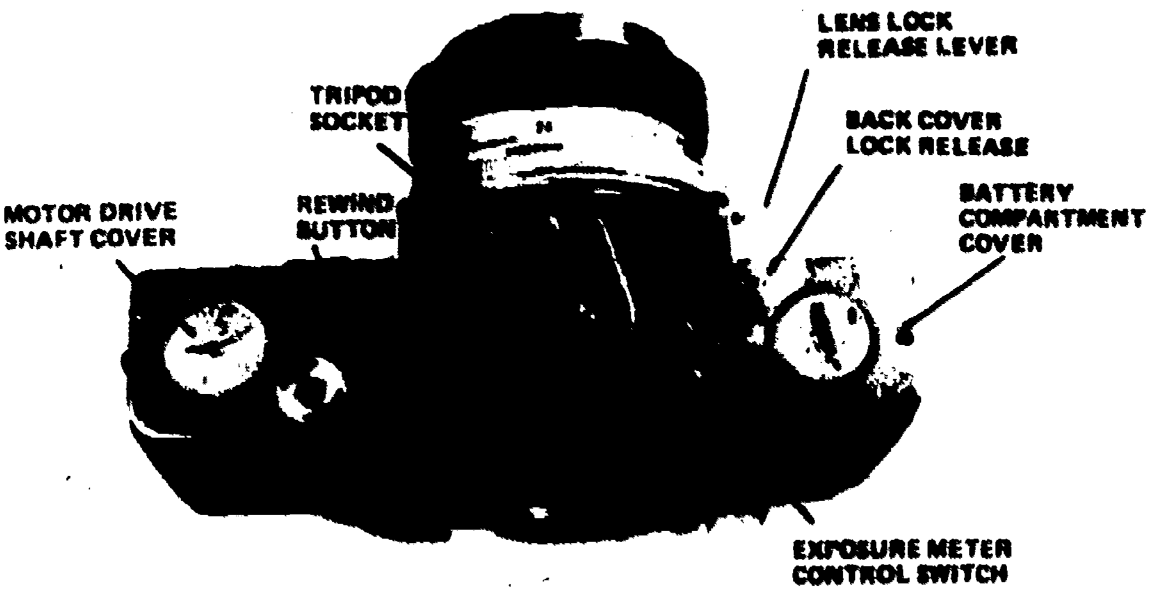


Figure 5-11. Camera Controls and Indicators, Bottom View

While viewing, the lens is at maximum aperture and automatically closes to the predetermined aperture immediately prior to exposure.

OPERATING CONTROLS. The standard Topcon lens is the f/1.8 Auto-Topcon. The f/stop range is from f/1.8 to f/22. Apertures are controlled by a ring on the lens barrel closest to the camera body. The aperture index mark is a dot in the center of the depth-of-field scale. The "R" beside the index dot is for focusing with infrared film.

The shutter speed dial is located on the right of the camera beside the penta-prism. Shutter speeds are selected by revolving the dial in either direction. The dial will not revolve beyond the ASA window. Speeds are 1 sec. to 1/1000 sec. plus "B."

Focusing adjustments are made by revolving the rubber distance focusing ring on the forward part of the lens barrel. Distances can be read off the indicator mark which also doubles as the aperture mark. The camera focuses from 18 inches to infinity.

The shutter release is located on the front right of the camera. The sequence which occurs after release of the shutter is: the mirror swings up, the diaphragm closes to the present aperture, the shutter releases, the mirror returns and the diaphragm reopens.

Film advance is accomplished as follows: after making an exposure, use the right thumb to push the film-advance lever as far as it will go. It is possible to make several short strokes, but it must always advance until it comes to a full stop. The advance lever advances the film one frame, advances the exposure counter, cocks the shutter, changes the mirror-raising mechanism and releases the shutter lock.

The Topcon has a depth-of-field preview lever. It is located on the left side of the lens mount. Depressing the lever closes the aperture to the preselected f/stop to permit visual check of the depth of field on the ground glass.

AUTOMATIC OPERATION. The Topcon's built-in CdS exposure meter is internally coupled to both shutter speed and to the lens diaphragm. Since this is behind the lens it automatically compensates for filter factors, bellows extension, etc. Operating power for the meter is provided by a round mercury 1.3 volt battery installed in the base of the camera. Battery life is about one year.

Before using the meter, set the camera to the ASA of the film that will be used. This is accomplished by lifting and revolving the milled ring that is around the shutter speed dial. Revolve the ring until the desired speed is seen in the window. Speeds range from 10 to 800. After selecting the proper ASA, push the switch on the bottom of the camera to "on." This switch is located just to the left of the battery

compartment. With the subject carefully framed in the viewfinder, adjust EITHER the shutter speed dial or the aperture ring, or both, until the T indicator seen just below the focusing screen is aligned correctly with the apex of the V-index mark. The extended legs of the V-index indicate 1/2 stop over or under exposure. An indicator is also visible on top of the camera beside the rewind knob and is used to check meter operation without having to look into the viewfinder. Turn the meter off when not in use to avoid battery drain.

LOADING PROCEDURE. To load film into the Topcon, first open the camera back. This is done by push-turning the back cover lock that is located on the bottom of the camera. Pull the back open all the way. Now pull up the rewind knob as far as it will go and insert the film cartridge into the empty chamber. The leading end of the film points towards the take-up spool. Push the rewind knob down. Now insert the film leader as deep as possible into the slit on the take-up spool. Be sure a perforation on the film engages the screw head protruding at the lower end of the slit. If the slit is not visible, revolve the take-up spool by grasping it by its serrated flange. Revolve the serrated flange slowly until the perforations at both top and bottom fully engage the film sprockets. Now push the back cover closed until it catches, then turn the rewind knob clockwise to tension the film. Next, trip the shutter and advance the film twice, until the "0" appears beside the dot in the exposure counter window. The exposure counter indicates the number of exposures already made, not the number remaining.

UNLOADING PROCEDURE. After shooting the final exposure on a roll, depress the rewind button on the bottom of the camera. Unfold the rewind crank from its storage position and revolve it clockwise. Rewind the exposed film into its cartridge. Now all that remains is to open the back cover, pull out the rewind knob and lift out the cartridge.

QUESTIONS

DO NOT WRITE IN THIS SW. USE A SEPARATE SHEET OF PAPER.

1. What is meant by the term parallax?

2. What are the two main types of focusing systems?

3. List the 5 layers in black-and-white film.

4. What is the purpose of the overcoating?

5. What is the purpose of the substratum?

6. What is the purpose of the antihalation backing?

7. How are films sold to the federal government designated?

8. What is the ideal relative humidity level for storing photographic materials?

9. Exposure is a product of ________ times ________.

10. Define latitude.

11. The Topcon camera focuses from ________ to ________.

12. How is it possible to preview the depth of field with the Topcon?

Exercise 1

PROCEDURE

Answer the following questions and record your answers on a separate sheet of paper. DO NOT WRITE IN THIS SW.

1. What are the 5 principle parts of a camera?

2. List the basic function of each of the 5 principle parts of a camera.

Exercise 2

PROCEDURE

Answer the following questions and record your answers on a separate sheet of paper. DO NOT WRITE IN THIS SW.

1. List the 3 silver halides used in most of the sensitized photographic materials.

2. Which silver halide is the most sensitive to light?

3. What two silver halides are used in combination to produce fast film emulsions?

4. What accounts for the slow speed of the blue sensitive films?

5. What is the name given to film that is sensitive to blue and green light only?

6. Which of the three colors--red, green, or blue--photograph the darkest on panchromatic films?

7. The difference between high densities and low densities is called ________.

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8. When would you use a film that has a high contrast?

9. Which films have the highest inherent contrast?

10. What is meant by the term "film speed"?

11. What is meant by the term "grain"?

12. What is the term used to describe the ability of a film to distinguish between closely spaced lines?

13. The term used to describe a film's sharpness is called ______.

Exercise 3

EQUIPMENT

| | Basis of Issue |
|---|---|
| Topcon camera outfit | 1/student |
| Film | 1 roll/student |

PROCEDURE

1. Observe the instructor's classroom demonstration of the Topcon Super D camera.

2. Follow the instructor's directions as you expose the film.

3. Photograph several scenes around the school.

Sciences Branch
Lowry Air Force Base, Colorado

SW G3ABR23330 001-I-6
October 1977

# THE DEVELOPMENT PROCESS

## OBJECTIVES

Identify the chemical properties of black-and-white processing solutions.

Process previously exposed film using manual processing facilities. Processed negatives must be free of physical defects and have acceptable density and contrast.

## INTRODUCTION

In one sense, the moment the camera shutter clicks, the photograph has been made. Yet nothing shows on the film: the image is there but it is invisible—a latent image. To make this latent image visible and permanent, the film is processed in chemical solutions. The following discussion describes the various chemical solutions used to develop film.

## INFORMATION

### PROCESSING SOLUTIONS

#### Developer

The first of these processing solutions in the development process is the developer. The developer creates density in those areas of the film that were exposed to light. Actually, this is a process of reducing the exposed silver halides (the latent image) to black metallic silver. There are many chemicals used in a single developing solution and each one has a definite function. Common developers generally contain the following components:

1. Solvent (water)

2. Developing agent (reducer)

3. Accelerator

4. Preservative

5. Retainer

6. Special additive ingredients

SOLVENT. Tap water is used as the solvent for mixing the chemical components to a developing solution. Without water, the dry chemicals could neither soften the emulsion nor reach the exposed halides.

REDUCING DEVELOPING AGENT. The most important chemical in a developing solution is the reducing agent, which actually reduces or changes the exposed halides to black metallic silver, making the image visible. There are several chemicals which may be used as reducing agents; but only two, hydroquinone and metol are found in most standard developing solutions.

Hydroquinone is a slow-working, high-contrast reducing agent. It becomes inactive at temperatures lower than 50°F (10°C), and has a tendency to produce fog at temperatures over 80°F (26.7C). Hydroquinone has good keeping qualities, is nonstaining, and produces a cold, blue-black tone.

Metol and hydroquinone are generally used in combination. The resultant (MQ), metol-hydroquinone, developer has the desired characteristics of both reducing agents and is superior in many ways to a solution containing either agent by itself.

ACCELERATORS. The solution must be in an alkaline state so that the developing agent will be active. Most agents are either neutral or slightly acid, making it necessary to add an alkali to the developing solution. The alkali, called an accelerator, energizes the developing agent and also causes the emulsion to soften and swell, thus allowing the developing agent to penetrate more rapidly.

Accelerators fall into three general classifications--mild, moderate, and strong. Sodium borate (borax) is a mild alkali and is used in low-contrast, fine-grain developers for negatives only. Sodium metaborate (Kodalk) is slightly stronger than borax, but is similar in action. Sodium carbonate is a moderately strong alkali and is the accelerator used in most developers, both film and paper. Sodium hydroxide, a very caustic alkali, is extremely active and is used in high-contrast film developers only.

The activity of a developer can be changed to a considerable extent by varying the amount of alkali included. Because the accelerator is a determining factor in the activity of a developing solution, it has a marked influence upon the degree of graininess produced in a negative. Graininess is caused by the clumping together of the silver halides during development. The more active the developer, the greater the clumping action; the milder or less alkaline the developer, the finer the grain.

PRESERVATIVES. A solution containing water, a developing agent and an alkali can develop an emulsion. However, such a solution would oxidize very quickly, resulting in rapid deterioration. It would also

fog and stain the emulsion. In order to prevent excessive oxidation, a chemical used as a preservative is added. The preservative retards the oxidation of the developing agent, making the solution more stable and preventing stains. The chemical most commonly used as a preservative is sodium sulfite.

RESTRAINERS. A developing solution containing only a reducer, accelerator, and preservative has a tendency to reduce the unexposed silver halides. Such unrestricted developing action results quickly in chemical fog. To prevent this action, a restrainer, which makes the developer more selective by restraining developing action in the unexposed areas of the emulsion, is added. The restrainer also permits longer development and, consequently, greater contrast can be obtained. An excessive amount of restrainer greatly retards development and, unless developing time is increased, may produce greenish-brown tones in prints.

The chemical most commonly used as a restrainer is potassium bromide. Other chemicals which can be used are potassium iodide and sodium chloride (table salt), although they are not entirely satisfactory.

SPECIAL ADDITIVE INGREDIENTS. Common developer solutions contain a solvent (water), a reducing agent, a preservative, an alkali, and a restrainer, although the last two are not absolutely required. However, in continuous photoprocessing you will very seldom use one of the common developers. You will probably use one of the newer proprietary developer solutions which contain other compounds in addition to the ones listed above.

Within the past twenty years a variety of organic compounds has been shown to possess important antifoggant properties. Not only do they inhibit fogging to the same degree as bromides, but they do not cause as great a loss in film speeds in doing so. At the elevated temperatures in use today, antifoggants must be used since bromide is not very effective at these higher temperatures. Some examples of antifoggants in use are Kodak AF#1, AF#2, AF#6, AF#7, benzotriazole, and 6-nitrobenzimidazole.

When there is a high concentration of compounds dissolved in a developer solution, there is a tendency for sludging and precipitation. Sequestering agents, which act as protective colloids, keep the developer by-products in solution preventing sludging and precipitation. Examples of sequestering agents are sodium metaphosphate, sodium tetraphosphate, calgon, quadrafos, and EDTA.

Wetting agents facilitate the absorption of developing solution into the emulsion. Examples are ethyl alcohol, butyl alcohol, benzyl alcohol, ethylene discloride, and tri-ethanolamine.

Stop Baths

A stop bath is needed for the three following reasons:

1. To interrupt development instantly by neutralizing the alkali of the developer that is trapped in the emulsion, or more slowly by diluting the developer.

2. To prolong the life of the fixing bath.

3. To prevent the fixing bath from staining the photographic emulsion.

There are three general types of stop baths: water, acid, and hardening. Each has a specific purpose and should be used accordingly.

1. Water, as a stop bath, helps to retard development and washes excessive developer from the emulsion thereby minimizing contamination of the fix.

2. An acid bath stops all development by neutralizing the action of the developer. This definitely prolongs the life of the fixing bath and aids in preventing stains.

3. A hardening stop bath (usually chrome alum) is used when the emulsion is processed in high temperatures or tropical climates. If you cannot keep the developer temperature below 86°F (30.0°C) a hardening stop bath should be used.

Fixing Baths

When a negative or print is removed from the developer and rinsed, there are silver halides in the emulsion which have not been developed. These halides are made soluble (can be dissolved) in a solution called a fixing bath. The chemicals and agents most commonly used in a fixing bath are:

1. Silver Halide Solvent (Fixing Agent) - The silver halide solvent is the agent which changes the undeveloped silver halides to a water-soluble salt. The salts are then removed, thereby making the image permanent. The chemical most commonly used as a halide solvent is sodium thiosulfate (hypo).

2. Acid or Neutralizer - After development, the softened emulsion retains considerable amount of developer. If this developer is allowed to remain, it will continue its reducing action. Even though an emulsion is thoroughly rinsed in water before it is placed in the fixing bath, enough of the developer remains to continue developing action. The result would be stains, making the negative unfit to print. To

stop development and prevent staining, acetic acid is added to the fix. This neutralizes the alkalinity of the developer and stops its action.

3. Preservative - When acid is added to the fixing bath, the sodium thiosulfate decomposes into free sulphur and sulphurous acid. To offset decomposition, a preservative, sodium sulfite, is added. Sodium sulfite acts as a preservative by combining with free sulphur and forming new sodium thiosulfate. It also prevents discoloration of the solution which could cause stains.

4. Hardener - During development, the emulsion becomes soft and swollen. If processing is continued without hardening the gelatin, frilling, scratching, and other undesirable effects may occur. The most common hardening agent used is potassium alum, and is added to the fixing bath to allow the film or paper to fix and harden at the same time.

TYPES OF FIXING BATHS. Some common fixing baths are listed below.

1. Plain fixing bath - A plain fixing bath contains nothing more than sodium thiosulfate (hypo) and water. It is very seldom used except for special purposes, such as fixing prints that are to be toned.

2. Acid fixing bath - A solution of sodium thiosulfate combined with the proper proportions of acetic acid and sodium sulfate is an acid fixing bath. This type of bath is unsatisfactory for negatives because it has no hardening qualities. It is primarily intended for prints.

3. Acid hardening fixing bath - An acid bath contains a hardening agent, making the solution suitable for both negatives and prints.

Wash

The purpose of washing negatives and prints is to remove the soluble salts left in the emulsion after fixing. An unwashed, or improperly washed emulsion may stain, change color, and fade. Therefore, the washing of the photographic emulsion is just as important as any other part of the development process.

How long should you wash your materials? An idea may be gained if you realize that the hypo remaining in the sensitized materials is continually halved in equal periods of time. That is, if the average negative gives up half of its hypo in 15 seconds of time in direct contact with running water, after 30 seconds, only one fourth of hypo will remain, and so on. The exact washing time depends on many things including:

1. The efficiency of the washing method.

2. The chemical composition of the fixing bath.

3. How long the emulsion remained in the fixing bath.

4. The temperature of the wash water.

5. The degree of hypo removal required.

WASHING IN TRAYS. There are three methods of washing negatives and prints in trays. The simplest is to place the material in a tray full of water and change the water at least once every five minutes. A second method is to have a continuous stream of water running into the tray for a minimum of 20 minutes. The third and most efficient method of washing in trays uses a device attached to the tray which siphons the water from the bottom of the tray while fresh water is being run in at the top. In any method, care must be taken to separate the negatives or printes to insure that sufficient fresh water reaches all areas of each emulsion.

WASHING IN TANKS. A very satisfactory method of washing negatives is the tank method. Metal or plastic frames hold the negatives and suspend them in the tank. Water is then allowed to run into the tank and the negatives are washed for the required time.

MECHANICAL WASHERS. A convenient method of washing a large number of small and medium size prints is by the use of a mechanical washer. These washers spray fresh water onto the prints and at the same time siphon off the contaminated water. This type of washer sometimes has a large tray or basket which is revolved either by the force of the water spray or by a separate motor. The rotation, together with the spray of fresh water, gives constant agitation and the water is changed every few minutes.

## DEVELOPING TECHNIQUES

### Preparing for Processing

The processing of photographic emulsions is done best in a properly equipped laboratory. At this time we will not go into complete detail on the laboratory layout, but we will familiarize you with a few of the essentials. These factors are important, whether the darkroom is large or small, if quality work is to be produced.

LAB SET UP. It is impossible to turn out good photographic work in a dirty laboratory. At all times the laboratory must be maintained in a spotless clean condition. Shelves, bottles, walls, floor, and sinks should be cleaned thoroughly and checked frequently. Chemicals that might get into the air from dried spillage or other careless techniques can be detrimental to your health and will lower the quality of the photographic product.

Always check the lab for cleanliness before beginning work. Take a few minutes and wipe off the surface of the area where film is handled. Then after you've finished processing for the day, clean all the equipment used, clean and dry the sink, and mop the floor. Always leave the lab cleaner than you found it.

Imagine the laboratory as being divided into two sections—a wet section and a dry section. Make it a habit to take nothing that is wet into the dry section, and also never take anything that must be kept dry into the wet section. This prevents the dry negatives from becoming spotted with water or fixer. It also prevents water from getting onto the printer or easel. Sloppy darkroom techniques always result in poor quality work. Be neat. Wear an apron to prevent chemistry from getting on your clothes and keep a dry towel handy. Always rinse and dry your hands thoroughly before going from the wet section to the dry section. When it becomes necessary to go into the dry section from the wet section, rinse and dry your hands.

Every laboratory should have a standard rule of "a place for everything and everything in its place." This is important for finding items in total darkness and for moving about safely.

ILLUMINATION. Safelights are designed to produce illumination which will not affect light sensitive materials. The proper safelight is necessary for the materials being handled. Different emulsions are sensitive to different colors of light. Orthochromatic emulsions are not sensitive to red light, therefore a red safelight filter would not expose the film. Panchromatic film is sensitive to all colors of light and must be developed in total darkness. However, some panchromatic emulsions may be viewed under a dark green safelight for short periods of time after processing is partially complete.

The safelight illumination must be the proper color plus it must be the proper intensity and the proper distance from the film. Check the film data sheet for safelight illumination used with the film being processed.

EQUIPMENT. The basic equipment needed to process a roll of 35mm film is a developing tank with lid, developing reel, interval timer, scissors, film cassette opener, thermometer, graduates and chemistry. Arrange the equipment in an orderly manner. The graduates and chemistry are placed on a wet side of the darkroom while all other equipment is placed on the dry side. While arranging the equipment, always keep in mind that the lights will be turned off, leaving total darkness. Place the items so they can easily be located.

PREPARING THE CHEMISTRY. After the equipment has been arranged on the dry side of the darkroom, begin organizing the wet side of the darkroom. The first step is chemistry preparation.

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Photographic processing solutions are prepared as either stock solutions or working solutions. Stock solutions are prepared in a concentrated form. Stock solutions require dilution prior to use. Working solutions have the correct concentration for use. When properly diluted, the stock solution becomes a working solution. The label on each container of photographic solutions should contain the following information: the type of solution and its strength.

The developer that will be used to process the film in this section is a stock D-76 solution. This solution will need to be diluted to a ratio of 1:1. This means, mix one part developer to one part of water. For the developing tanks that will be used, a total working solution of eight ounces is needed. To achieve this volume, dilute four ounces of developer with four ounces of water.

The stop bath also comes in a stock solution. Again a total of eight ounces is needed. The dilution ratio for the stop bath is 1:32.

When diluting a stock solution, measure the liquids carefully. Be careful with the solutions as some are hazardous to health.

CAUTION

> The stop bath contains acetic acid. Fill the graduate with water first then add the acid to it. Remember: Always add acid (AAA)!

Prepare the proper dilutions of chemistry before loading the film reel. Measure the temperature of the solutions. The ideal temperature for processing film manually, is between 68° and 72°F. (20° and 22.2°C) As has been stated before, temperature greatly affects development. Correct temperature is extremely important.

PREPARATING THE FILM FOR PROCESSING. After the solutions are mixed and at the proper temperature, prepare the film for processing. At this point recheck the arrangement of the equipment since the next steps will be done in total darkness.

With all lights off, open the roll of film. To remove film from a standard 35mm cassette, find the spool end protruding from one end of the cassette. Pick up the cassette by this end. Pry off the other end with the cassette opener or a soft drink bottle opener, see figure 6-1A. Slide the spool out.

With the scissors, cut off the protruding end of the film to square it off, see figure 6-1B. Do not try to tear the film. Besides injuring the emulsion, the friction of tearing could cause a flash of static electricity, creating enough light to streak the film. Put the scissors where they can be found and where the blades or points cannot scratch the film.

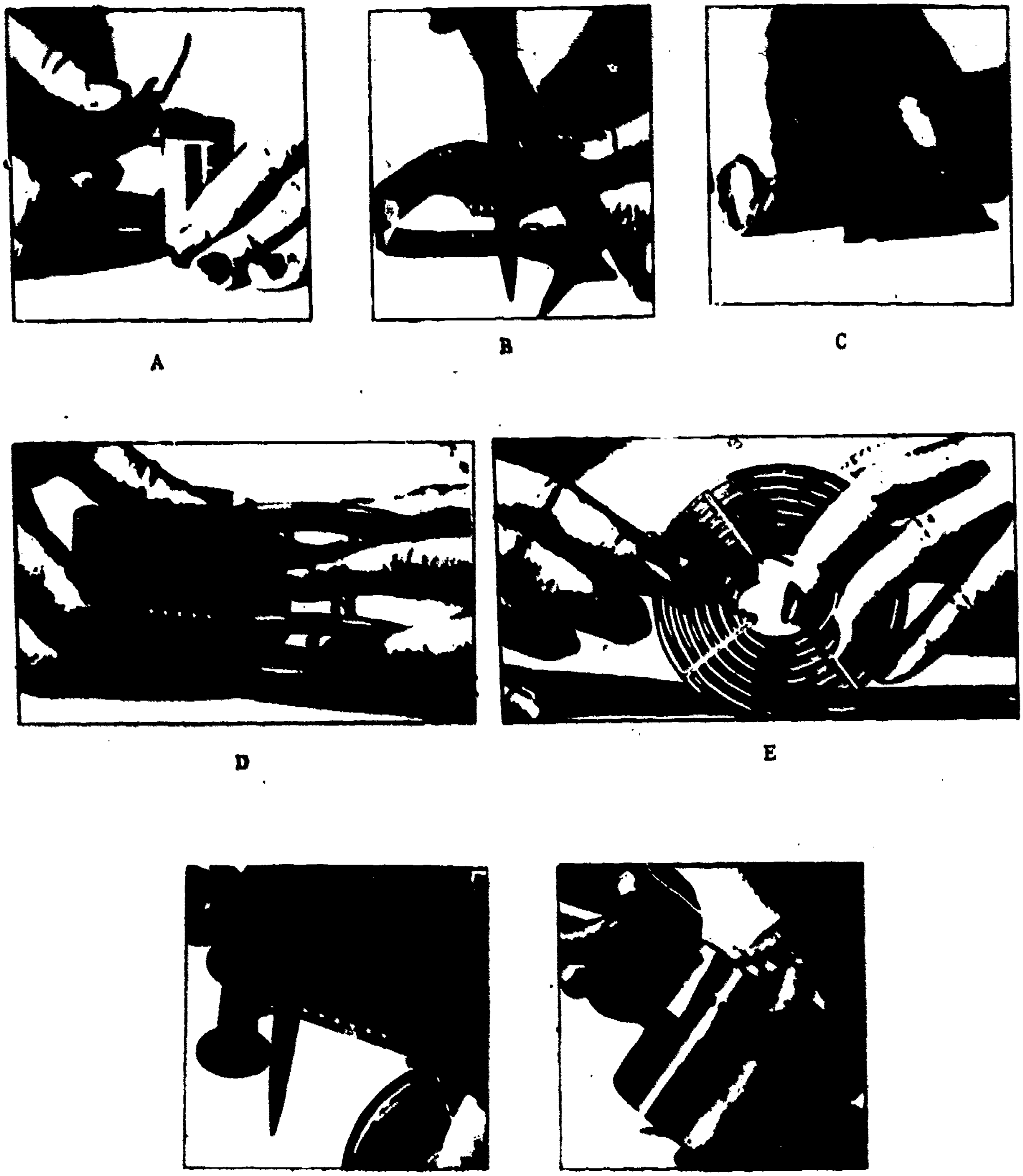


Figure 6-1. Loading 35mm Film

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Hold the film spool in either hand so that the film unwinds off the top. Unwind about three inches and bow it slightly between thumb and forefinger, see figure 6-1C. The reel must be oriented properly in the other hand or the film will not slip into the grooves. Each reel is made of wire in a spiral starting at the core of the reel and running to the outside. The space between the wire spirals forms the groove that holds the film edges. Hold the reel so that the sides are vertical and feel for the blunt ends of the spirals. Rotate the reel until the ends are at the top. If the ends then face the film, the orientation is correct. Insert the squared-off end into the core of the reel, see figure 6-1D. Rotate the reel away from the film to start the film into the innermost groove.

To finish threading the reel, place it edgewise on the flat surface, see figure 6-1E. Hold the film spool as before, with thumb and forefinger bowing the film slightly. Unwind three or four inches of film and push the film so that the reel rolls forward. As it rolls, it will draw the film easily into the grooves. When all the film is wound on the reel, cut the spool free with the scissors, see figure 6-1F. Check that the film has been wound into an open spiral. Unless the reel is correctly loaded, sections of film may touch, stopping development at those points.

After properly winding the film on the reel, place it into the developing tank and cover with the lid, see figure 6-1G. After the lid is on the tank, turn on the light and process the film. Do not remove the lid until the process is completed. Practice the film loading procedure a few times with dummy film while the lights are on. Refer to figure 6-1 for an illustration of the steps.

Processing 35mm Roll Film

PRESOAKING. Before starting development, run tap water in the vented top of the tank. Prewetting the film causes the emulsion to soften and swell. This allows the developer to be absorbed more quickly. It also reduces the shock to the emulsion of being thrown into a strong alkaline bath. Agitate the tank continuously for 30 seconds. Pour out the water.

DEVELOPER. In addition to exposure there are four factors in development that control the density of the negative. These four factors are:

- o Development time.
- o Temperature of the developer solution.
- o Degree of agitation.
- o Activity of the developer used.

Time of Development. When the exposed material is placed in the developer, the solution penetrates the emulsion and begins to reduce the exposed silver halides to metallic silver. The longer the development time, the more silver is reduced, and the denser the image becomes.

If development is carried too far, the density may become too high. Then the developer may begin to act on the unexposed silver halide crystals. This causes "chemical fog," which tends to veil the shadow detail.

Temperature of Developer Solution. The rate of development is affected by the temperature of the developer solution. As the temperature rises, the rate of development increases. Thus, when the developer temperature is low, the reaction is slow. The development time recommended for the normal temperature would then give underdevelopment. When the temperature is high, the reaction is fast and the same time would give overdevelopment. Within certain limits, these changes can be compensated for by increasing or decreasing development time.

Agitation of the Developer. If exposed photographic materials are placed in a developer solution and allowed to develop without any movement, the action soon slows down. This is because the developing power of the solution in and around the emulsion becomes exhausted. If the material is agitated, fresh solutions are continually brought to the emulsion surface and the rate of development remains constant. Therefore, agitation has an important effect on the degree of development obtained.

MOTTLE. An even more important effect of agitation is prevention of uneven development or mottle. Without agitation, the exhausted solution, loaded with developer by-products, may flow across the emulsion from the dense areas producing uneven streaks. Agitation keeps the solution uniform throughout and prevents uneven development.

Activity of the Developer Solution. The rate of development is also affected by the chemical activity of the developing solution. This depends upon the composition, nature and concentration of the developing agent and the alkalinity of the solution. The stronger the developing agent, the faster the developing solution reacts with the exposed silver crystals. Likewise, the stronger the alkali in the solution, the faster the development rate. The dilution of the developer in water will also affect its activity.

EXHAUSTION. In addition, the exhaustion of the developer affects the activity of the solution. As the developer is used, its developing power decreases. Even when the developer is not used, its activity may decrease because of aerial oxidation of the developing agent.

There is a right developer for each emulsion. The film data sheet in the film carton will list the preferred developer.

As soon as the presoak water has drained from the tank, pour the developer into the vented top of the tank. Agitate the tank five to ten seconds every minute of development time. Develop the film for the recommended time for its temperature. Pour out the developer.

AGITATION. During development, to achieve desired results, use proper agitation. For consistent results, keep the rate and method of agitation constant. One method of agitating is by turning the tank back and forth through a 45° arc, as if turning a key in a lock. Another method is by firmly gripping the tank and lids and completely inverting the tank. Remember that agitation is an essential part of the developing process.

STOP BATH. [illegible] the developer has drained from the tank, pour the stop bath into t[illegible]ed top. Agitate continuously for 30 to 60 seconds. Pour out the stop bath.

FIXER. After draining the stop bath, pour the fixer into the vented top of the tank. It is necessary to agitate the film in the fixing bath because gases are released and gas bells may form on the film surface. If these gas bells form, they will cause dark spots on the film. Agitate the film continuously for 60 seconds. Let the tank sit for another minute. Remove the top of the tank and check the back of the film. The milky appearance on the back of the film should have disappeared. If the back of the film still has a milky appearance, leave the film in the fixer another couple of minutes. Pour the fixer back into its bottle at the end of the fixing time.

NOTE: NEVER DISCARD THE FIXER!

WASH. After the fix is complete, wash the film under a stream of running tap water for 10 to 30 minutes. Leave the film on the reel while it washes. The washing of photographic emulsions is just as important as any other part of the development process.

WETTING AGENT. After the film has washed sufficiently, pour out the water and pour a wetting agent into the tank. Let the film sit in the wetting agent for 30 seconds.

The term "wetting agent" is used to describe a class of agents which reduce the surface tension or increase the wetting properties of water. Wetting agents act primarily as water spot inhibitors. They speed up the drying time by softening the water so that it runs off the negative without beading. Wetting agents are used highly diluted (approximately 1:600 or one ounce to five gallons of water).

DRYING. When the film has remained in the wetting agent for 30 seconds, remove the reel from the tank and carefully remove the film from the reel. Remember that the emulsion is still wet and soft and easily scratched. Attach a clip to one end and hang it in a dust free place where the room temperature will remain constant during the drying period. Pull the film taut and remove excess water from the surface by gently drawing a damp viscous sponge or damp cotton ball down both sides of the film. This pulls away tiny particles of grit and any isolated water drops which did not drain away.

It is best to let the negatives air dry at room temperature. If the drying rate is increased by using extremely hot air, the outer film surface may dry and harden before the moisture contained within the gelatin can diffuse out. This might cause surface ruptures. The use of moderate heat is tolerable if short processing time is important. If the emulsion is dried too completely, it becomes dry and brittle and will easily crack. The ideal situation is one in which the film dries uniformly until it is in equilibrium with the surrounding air.

LAB CLEAN UP. Before any session in the darkroom is terminated, the equipment and lab must be cleaned. Thoroughly wash and dry the developing tank and reel. Any chemicals left on these items can contaminate the chemicals used to process the next roll of film. Wash the graduates and thermometer and dry them. Rinse and dry the sink and mop the floor. A little time spent cleaning now will prevent large clean ups later and will assure the production of quality work.

SUMMARY OF DEVELOPMENT PROCESS. The following is a step-by-step breakdown of the development process. Study the steps and keep them handy for use in the lab.

ROOM LIGHT

1. Clean area and arrange equipment so it can be found in total darkness.

2. Mix chemistry according to instructions. (Remember AAA.)

3. Use thermometer to measure temperature of solutions. Consult time/temperature chart for correct time.

TOTAL DARKNESS

4. Wind film onto film reel, taking care to keep fingers off the emulsion.

5. Place reel into tank and secure the lid. Do not remove the lid until film is in the fixer.

ROOM LIGHT

6. Presoak film in tap water for 30 seconds with agitation. Pour out water.

7. Pour developer into vented top and start timer. Develop for recommended time with agitation. Pour out developer.

8. Pour stop bath into vented top. Agitate for 30 to 60 seconds and pour out.

9. Pour fixer into vented top and agitate continuously for 60 seconds. Check film after another minute in the fixer.

10. Wash the film under running water 10 to 30 minutes. Pour out water.

11. Pour wetting agent into tank and let sit for 30 seconds. Pour out.

12. Hang film for drying.

13. Wash and dry tank and reel. Clean other equipment in the lab and mop the floor.

Time-Temperature Processing

For correct development, both time and temperature must be accurately controlled—such techniques are known as time-temperature processing. Within limits, time can be adjusted for a given time. Normally, temperature is maintained as a constant at 68°F (20°C), and time of development is varied to produce the desired results. There are several reasons for this standardization. First consider the temperature at 68°F (20°C). The gelatin in the emulsion swells sufficiently to provide adequate penetration of the solution without oversoftening the emulsion to the point where it becomes dangerously soft (which it does at higher temperatures). Temperatures lower than 68°F (20°C), tend to slow development excessively and may even cause chemicals to crystallize out of the solution. Only when time is of utmost importance are temperatures above 68°F (20°C) used. In most instances when very high temperatures are used, special chemical treatment is given the film, or the film is handled by machine where it is less subject to handling damage.

The time element is seldom of sufficient importance, except under emergency conditions, to become significant. Since a several-degree rise in temperature will shorten the developing time only a relatively short amount, there is little to be gained and much to be lost by changing the temperature from the standard 68°F (20°C).

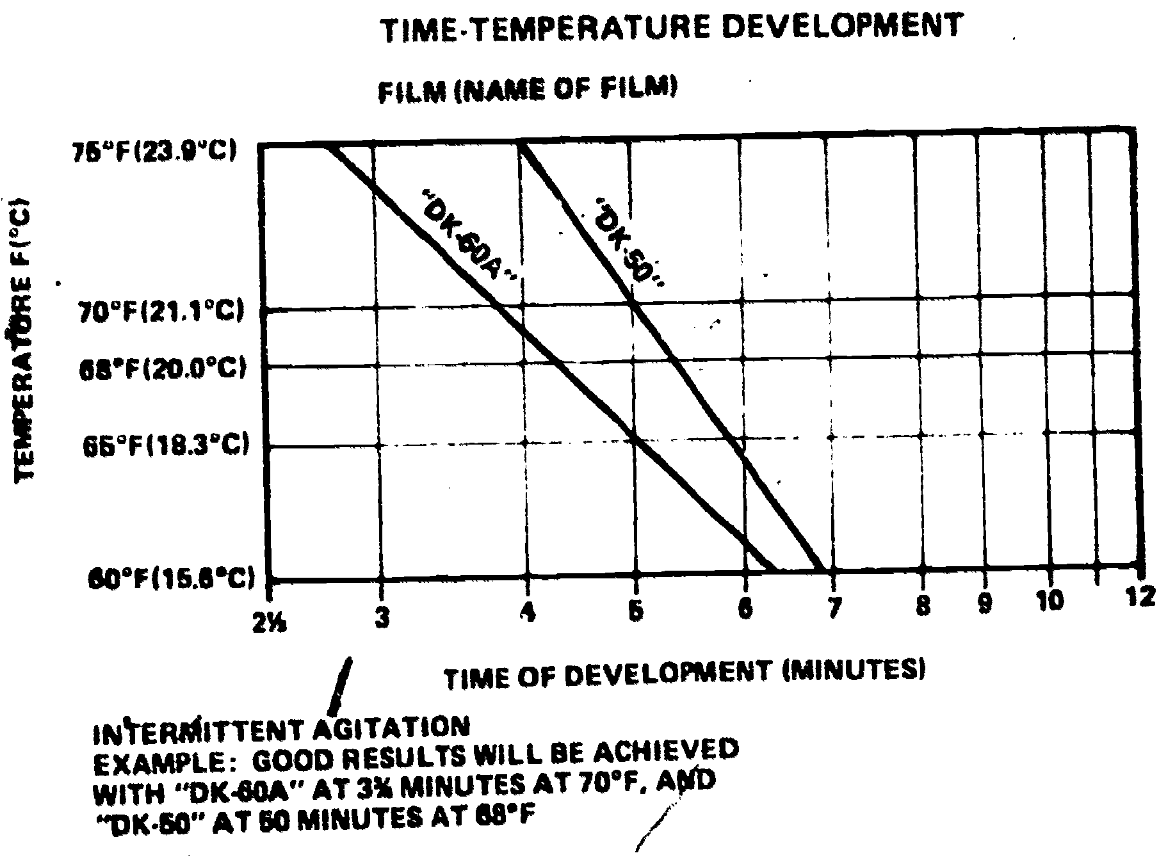


Figure 6-2. Time-Temperature Table

There is a definite correlation between time and temperature as shown on the sample time-temperature graphs in figure 6-2. When it is impossible to maintain solution temperature at the desired level, time can be shortened or lengthened to compensate. As the temperature rises, developing time must be decreased to provide equivalent development. As the temperature drops, developing time must be increased to provide equivalent development.

RETICULATION. At this time, it is important to recognize a problem related to solution temperature. The temperature of all solutions (developer, rinse, fixing bath, and wash) should be as near to each other as possible. If there is considerable difference in the temperature between the solutions, the emulsion is subjected to excessive expansion and contraction which may cause it to wrinkle and/or crack. This effect is known as reticulation and gives the negative surface a leather-like appearance. Normally, it renders the negative useless for printing, since reticulation is not correctable.

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Archival Quality

Archival quality in photography means the "keeping property of the final photographic product"—not for days or weeks but for many, many years. This means that, if a photographic material has been processed to archival quality, the material will not deteriorate with the passing of years.

Every step in the photographic process must be given careful consideration to produce materials of archival quality. Normally, the composition of the developer will have no effect on archival quality.

However, fixing in a fresh fixing bath is a must in the "keeping quality" of your final product. When washing this final product, use properly conditioned water in an adequate flow across the surface of the emulsion. There will always be some residual hypo left in the emulsion no matter how long it is washed. When this residual hypo has been reduced to 0.005 milligram per square inch or less, it is generally considered that it will do no damage to the emulsion.

QUESTIONS

DO NOT WRITE IN THIS SW. USE A SEPARATE SHEET OF PAPER.

1. What is meant by the term latent image?

2. What four factors in development control the density of the negative?

3. What are the primary reasons for using a stop bath?

4. What effect does the fixer have on the silver halides in the emulsion?

5. What will happen to the emulsion if the fixer is not removed?

6. What is the difference between a stock solution and a working solution?

7. What is the ideal temperature for processing negatives manually?

8. How often should the film be agitated while it is in the developer?

9. Why is it necessary to agitate the film while it is in the fixer?

10. How long should negatives be washed?

11. What is the purpose of using a wetting agent?

12. What is the relationship between time and temperature in the development process?

13. What causes reticulation?

14. What is meant by the term archival quality?

15. What factors affect archival quality?

16. List the six main components of a developer.

17. What two reducing agents are found in most standard developing solutions?

18. What is the function of the accelerator?

19. The chemical most commonly used as a preservative is ________.

20. List the three general types of stop baths.

21. List the chemicals most commonly used in a fixing bath.

22. List the three common fixing baths.

Exercise 1

PROCEDURES

Using a separate sheet of paper, match the following terms. DO NOT WRITE IN THIS SW.

a. solvent

b. developing agent

c. accelerator

d. preservative

e. restrainer

f. metol

g. stop bath

h. plain fixing baths

i. acid fixing baths

j. silver halide solvent

k. hydroquinone

____ 1. A soft, quick working, low constrast reducing agent.

____ 2. Energizes the developing agent.

____ 3. Changes the unexposed silver halides to a water soluble salt.

____ 4. Water.

____ 5. Makes the developer more selective.

____ 6. Prevents excessive oxidation.

____ 7. Neutralizes the developer.

____ 8. A slow working, high contrast reducing agent.

____ 9. Changes the exposed silver halides to black metallic silver.

____10. Contains nothing more than sodium thiosulfate.

____11. Contains sodium thiosulfate and acetic acid.

Exercise 2

| EQUIPMENT | Basis of Issue |
|---|---|
| 35mm developing tank | 1/student |
| 35mm reel | 1/student |
| Interval Timer | 1/2 students |
| Scissors | 1/student |
| Film Cassette Opener | 1/student |
| Thermometer | 1/2 students |
| Graduates | 3/student |
| Laboratory Facilities | 1/class |
| Film Dryer | 1/class |

PROCEDURES

1. Set up processing lab as described in SW.
2. Dilute chemistry to the proper dilution as given by instructor.
3. Process film following the procedures described in SW.
4. Clean lab.

Sciences Branch
Lowry Air Force Base, Colorado

SW G3ABR23330 001-I-7
October 1977

# THE PRINTING PROCESS

## OBJECTIVES

Identify the major characteristics of photographic paper.

Using previously exposed negatives and a projection printer, expose and process projection prints. Prints must be free of exposure and processing defects.

## INTRODUCTION

You have learned two fundamental steps in the photographic process. However, taking the photograph and developing the film are only two of the necessary steps. To complete the process, it is necessary to print the negative and produce a positive image having approximately the same tones as the original. This positive image is usually made on sensitized paper and is called a photographic print.

The quality of the image on a print can be varied by the choice of printing material, exposure and processing. Many of the deficiencies which may exist in the negative can be corrected in the print. Because of this, it is important to have a working knowledge of all the materials, equipment and procedures necessary to produce the desired results.

## INFORMATION

### PRINT MATERIAL

The following information describes conventional printing papers used in printing black-and-white negatives. See figure 7-1 for a cross-section of paper structure.

#### Paper Structure

THE PAPER BASE. The paper used as a base supporting the emulsion must have specific properties. It must be of the highest quality and purity, free from any foreign or metallic particles which might react with the emulsion or the solutions. Chemicals used in the manufacturing of the paper stock must be neutralized, or they will affect the permanency and quality of the photographic image. The paper must be strong and resilient to withstand prolonged immersion and handling in the various solutions. It must be as white as possible (bleached), opaque and evenly flexible. Usually, the paper base is made from a very pure sulfite pulp stock and comes in three weights—light, single, and double weight.

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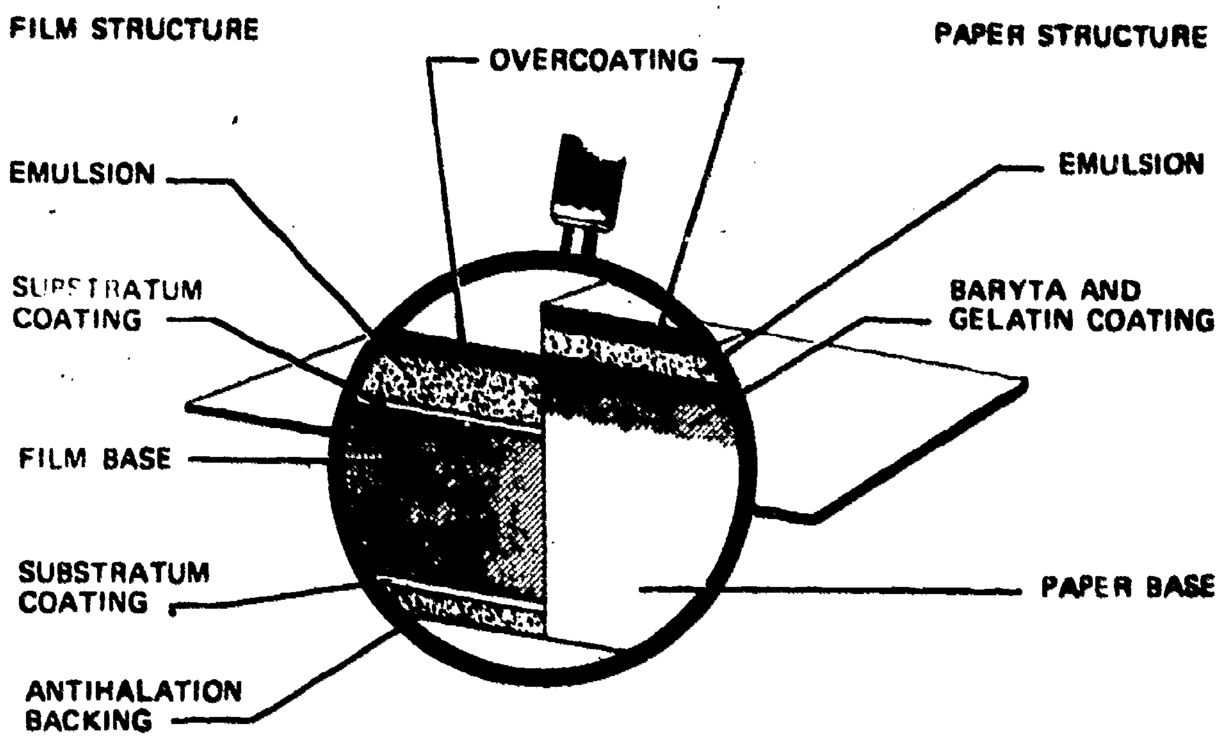


Figure 7-1. Cross-Section of Film/Paper Structure

THE BARYTA AND GELATIN COATING. If the emulsion were coated onto the paper base without the baryta (barium sulfate) and gelatin coating, the emulsion would soak into the paper fibers. The resultant image would be extremely weak unless a large quantity of emulsion were used. Not only does the baryta and gelatin coating act as a "filler," it also aids the reflecting ability of the paper.

The Armed Forces use another paper treated with a solution of cellulose acetate which makes the paper water resistant and requires a substratum coating, the same as for film bases. This paper is used for rush printing assignments calling for rapid processing in conventional chemistry.

THE EMULSION COATING. The emulsion coating is a light sensitive layer. It consists of millions and millions of tiny microscopic silver halide particles imbedded or suspended in gelatin. The characteristics of the emulsion are determined by the kind and combination of silver halides, the size of the silver halides, how evenly distributed they are in the gelatin, and the addition of dyes and other chemicals in the emulsion along with the quality of the gelatin itself.

THE OVERCOATING. The overcoating consists of a thin layer of gelatin which acts as a protector to the emulsion underneath, during normal handling and use of the material. Without this protective overcoating, the mere act of placing one sheet of paper on top of another would be sufficient to cause minor scratches and abrasion marks. These would show up after processing. However, this overcoating will not protect the emulsion under rough or abusive handling.

PAPER SURFACES. The surface of a paper is a combination of texture and finish. The texture may be smooth, fine grained or rough. In addition, there are many artificial textures such as silk, canvas, suede, etc.

Glossy, semiglossy, semimatte and matte are the most used finishes. However, these may be described by other names such as, half-matte, lustre, semilustre, velvet, etc.

Enlarging papers, and to a lesser extent, contact papers, are made with a variety of surfaces. This variety offers the technician and photographer the opportunity, through selection, to improve the photograph. He can choose the paper most suitable to match the mood or character of the subject.

The foregoing information covers the physical makeup of the paper. This will give you a better understanding of how this material is constructed. Next you will delve into the characteristics of various paper emulsions to discover how they react to light.

Emulsion Characteristics

SILVER HALIDES. There are three silver halides which are used, either separately or in combination, for most of the sensitized photographic materials on the market today. These are silver iodide, silver chloride and silver bromide.

- Silver chloride is used by itself for making contact paper emulsions. It is also added to silver bromide to make the popular "chlorobromide" projection papers. Since silver chloride is slower in its response to light than silver bromide, the greater the percentage of silver chloride to silver bromide in the emulsion, the slower the emulsion will be. The so-called warm-toned slow projection papers have a greater percentage of silver chloride than silver bromide.

- Silver bromide is the fastest of the silver halides, and its response to light is increased even more by the addition of a small quantity of silver iodide. Silver bromide is slowed down by the addition of silver chloride, which makes it suitable for projection paper emulsions. Usually, when there is a greater percentage of silver bromide than of silver chloride, it is called bromide paper.

EMULSION TYPES. There are four types of emulsions used in coating paper that include the above silver halides separately or in combination; silver chloride for contact paper, slow chlorobromide for warm tone contact paper, silver bromide for projection paper and fast chlorobromide for warm tone projection paper.

o Silver Chloride Paper (Graded Contrast). These paers have only siver chloride in the emulsion. The senstivity of these papers is comparatively slow, making them suitable for contact printing. This low sensitivity under artificial light permits handling with bright yellow safelight (Wratten 00) or safelights intended for other conventional papers. Development takes about 45 to 90 seconds in AFD #25, (D-72) diluted 1:2, at 70°F (21.4°C). This produces blue-black tones.

o Slow Chlorobromide Paper (Graded Contrast). Emulsions of this type contain, primarily, silver chloride, combined with small portions of silver bromide.

Sensitivity of this paper is about 10 times faster than chloride papers. This makes it ideal for faster contact printing and sometimes for enlarging. The increased sensitivity makes it necessary to use a yellow-green safelight (Wratten OA) or safelights designed for use with equally fast or faster papers.

o Silver Bromide Paper (Graded Contrast). These papers are frequently referred to as bromide papers. The emulsion contains only silver bromide, though frequently a trace of silver iodide will be added.

Bromide papers, being the most sensitive of the printing materials, are 100 to 1000 times more sensitive than chloride or contact papers. These papers are used mainly for enlarging due to the lower intensity of the printing light and the distance between the light source and the paper. The sensitivity of bromide paper is such that even a very weak light will fog it; therefore, they should be handled under a yellow-green safelight (Wratten (OA) using a bulb of no more than 15 watts at a distance of about 4 1/2 feet. Development in AFD #25 (D-72) for two minutes produces very deep and pure blacks.

o Fast Chlorobromide Papers (Graded Contrast). Fast chlorobromide papers have an emulsion consisting of silver bromide and smaller amounts of silver chloride. Occasionally, small portions of silver iodide is also used. These papers are not quite as fast as plain bromide emulsions. Even though they are used mainly for projection printing, they require as much as four times the exposure as bromide papers.

CONTRAST. Density can be referred to as the amount of metallic silver deposited in any area of an emulsion. The difference between the densities of the various areas of the emulsion is called contrast.

A bright area of a subject reflects the greatest amount of light and, therefore, called the highlight. Conversely, any area reflecting little or no light can be called the shadow area. The subject brightness between these highlights and shadows are known as the middle tones. The difference in brightness, from highlights through the middle tones to the shadows, is referred to as the subject contrast. Normal image contrast is represented by a full range of densities, including highlights, middle tones, and shadows. High image contrast does not have a full range of densities and consists only of highlights and shadows with little or no gradation between. Low image contrast has very little difference in densities.

Graded Contrast Papers. Most papers are made in several contrast grades. This range of contrast is essential for the photographer who wants to produce the best possible print from any type of negative--from soft to hard. Graded contrast emulsions are primarily sensitive to blue light.

Each manufacturer of photographic printing paper has classified the range of contrasts according to his own standards. Therefore, the paper of a particular grade number and description may not agree with that of another carrying the same description. However, papers currently available conform in a broad sense to the following scale.

No. 0 -- Extra Soft
No. 1 -- Soft
No. 2 -- Normal or Medium
No. 3 -- Hard or Contrasty
No. 4 -- Extra Hard or Extra Contrasty
No. 5 -- Ultra Hard or Ultra Contrast

Grades 0 and 5 are not available through normal military supply channels.

A normal or medium grade paper is accepted as the one giving the best print from an average negative.

Using a soft paper, with an average negative, will yield a print without much tone gradation. The entire picture would be shades of gray, with no real blacks and no light highlights. Low contrast papers are used with high contrast negatives to produce prints with normal or near normal contrast. Printing an average negative, on hard paper, will be over-contrasty. All the light tones would be white, while the darker areas will be solid black. High contrast papers are used with low contrast negatives to produce prints with normal or near normal contrast.

Variable Contrast Papers. Variable contrast papers offer several advantages over graded contrast papers. Probably the first is that of economy, since fewer boxes of paper would be required. Secondly, as

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many as 10 grades of contrast are available, through the use of filters, compared to four or five with graded contrast. To permit this function, variable contrast emulsions must be sensitive to both blue and green light. Another advantage is in the amount of storage space needed. With variable contrast it is considerably less than with graded contrast paper.

The structure, surfaces, and finishes of variable contrast papers compare favorable with those of graded contrast papers, with this exception--the emulsion or sensitized coating.

Most variable contrast papers are coated with a single layer of emulsion in which the larger, faster halides are sensitized to green light to produce the low contrast component. The remaining halides respond only to blue-violet light. It is obvious that green light will produce minimum contrast while maximum contrast will be derived from the blue-violet. Intermediate degrees of contrast are obtained by combining varying amounts of blue and green. The lower the amount of green, the higher the contrast, the lower the amount of blue, the lower the contrast.

All variable contrast papers are sensitive to blue and green light in varying degrees. It is easy to see that high contrast filters are bluish in color, but you may be puzzled by the fact that low contrast filters are yellow. Why? A filter has two functions to perform; it must transmit the color of light desired and it must absorb those colors not desired. The low contrast filter must transmit green and absorb blue-violet. A green filter that would absorb the blue-violet would have to be very dense. Therefore, your exposures would be rather long. Since yellow is very efficient in absorbing blue, a medium yellow filter will do a very good job. Yellow is a combination of red and green. The paper, being insensitive to red, will only be affected by the green portion. By using yellow instead of green for low contrast filters, long exposures can be avoided.

Most variable contrast papers will produce a normal contrast, equal to a #2 graded paper, when exposed without a filter.

Variable contrast printing filters are available in two sets, one made by DuPont and the other made by Eastman Kodak Company. DuPont filters are made of an optical grade plastic and will withstand continuous heat up to 140°F.(60°C), without warping. These filters are numbered from #1 (low contrast) through #10 (high contrast), #5 is considered to be equivalent to contrast 2 graded paper. Kodak "Polycontrast" filters are made of optical grade plastic too and have the same qualities of DuPont filters, except for the number of filters per set. Kodak filters are numbered to correspond with a similar graded contrast paper, thus 1, 1 1/2, 2, 2 1/2, 3, 3 1/2, and 4.

Variable contrast papers, unlike graded contrast papers, cannot be handled under Wratten 00 or 0A safelights without fogging. However, both types of paper may be handled under DuPont's S55-X or Kodak's Wratten OC safelight filters. These filters are brownish yellow in color and afford excellent light for judging print quality. See figure 7-2 for proper safelight/paper combinations.

| SAFELIGHT FILTERS | PAPERS | | | |
|---|---|---|---|---|
| | GRADED CONTRAST | | VARIABLE CONTRAST | |
| | CONTACT | PROJECTION | CONTACT | PROJECTION |
| Wratten 00 | X | | | |
| Wratten 0A | X | X | | |
| Wratten OC | X | X | X | X |
| DuPont S55-X | X | X | X | X |

Figure 7-2. Safelight - Paper Combination Chart

Storage and Handling

Manufacturers package their produce either for domestic use or for export. Materials intended for export or for use wherever high relative humidity is prevalent are packaged in moisture-proof containers which are vapor tight and water tight. Packaging for export is so labeled on the individual units as well as on the shipping cartons. Materials intended for normal domestic use may be packaged in moisture-resistant, but not in water tight and vapor tight containers. You should assume that any unlabeled package is intended for domestic use, and handle it accordingly. Do not keep sensitized papers under refrigeration once the sealed packages have been broken, unless the refrigerator can be held at 50 to 60 percent relative humidity.

Store individual packages of film and paper on end so that the weight of the contents is on the edges of the film and paper. You should also store material with the earliest expiration date to the front of the stack. This enables you to use the material with the earliest expiration date first. However, when it is known that the paper that is due to be used next has been stored or shipped under unfavorable conditions, and a highly critical mission is to be printed, use the fresh material.

Paper removed from cold storage areas must be adjusted to room temperature before the packages are opened. This will prevent moisture condensation on the paper. Bring the paper to room temperature over a period of at least eight hours prior to use. Longer times are required for warm-up if the packages are stacked.

# FUNDAMENTALS OF PRINTING

Photographic printing is the process of permitting light to pass through a negative to expose sensitized material (photographic paper). The exposure can be made either by placing the negative in contact with the sensitized material (contact printing) or by projecting the negative image onto the material (projection printing).

## Projection Printing Principles

The process of projection printing, also known as enlargement printing, enables the photographer to produce prints scaled larger than the negatives. In contact printing there is a one-to-one relationship between the size of the print and the size of the negative. That is, the print is the same size as the negative. Today's precision instruments--cameras and enlargers--are capable of transforming small negative images into large prints of good quality.

PRINTERS. An enlarger is capable of producing only enlarged prints, while a projection printer can produce enlargements one-to-one prints or even reductions. The proper nomenclature for the printer used in this course is projection printer.

PRINCIPAL PARTS OF A PRINTER. The printer head contains a light source, negative holder and lenses and is connected to a rigid vertical column. The head can be adjusted higher or lower on this column to increase or decrease image size. The light source can be an incandescent bulb or a tubular fluorescent lamp. Most often it is an incandescent bulb.

The light from the lamp falls upon a condenser system, which distributes light evenly over the negative thus giving uniform illumination. The condenser is arranged as a pair of convex lenses or as a flat piece of frosted (diffusing) glass. The negative carrier, located between the condenser system and the main lens below, holds the negative flat and level.

A bellows is located under the negative holder. It permits more refined distance adjustments from the main lens to the printing paper. The bellows serves to focus the image clearly upon the printing paper. (It is focused by turning a knob.) Like a camera lens, the enlarger lens bends light rays to project an image to the focal plane, which in projection printing is the printing paper. The lens also contains a diaphragm, which regulates the amount of light passing through the lens.

At the base of the vertical column, a platform supports the structure of the enlarger and the easel. The easel holds the paper flat, level and in proper position to record the image projected from the enlarger lens.

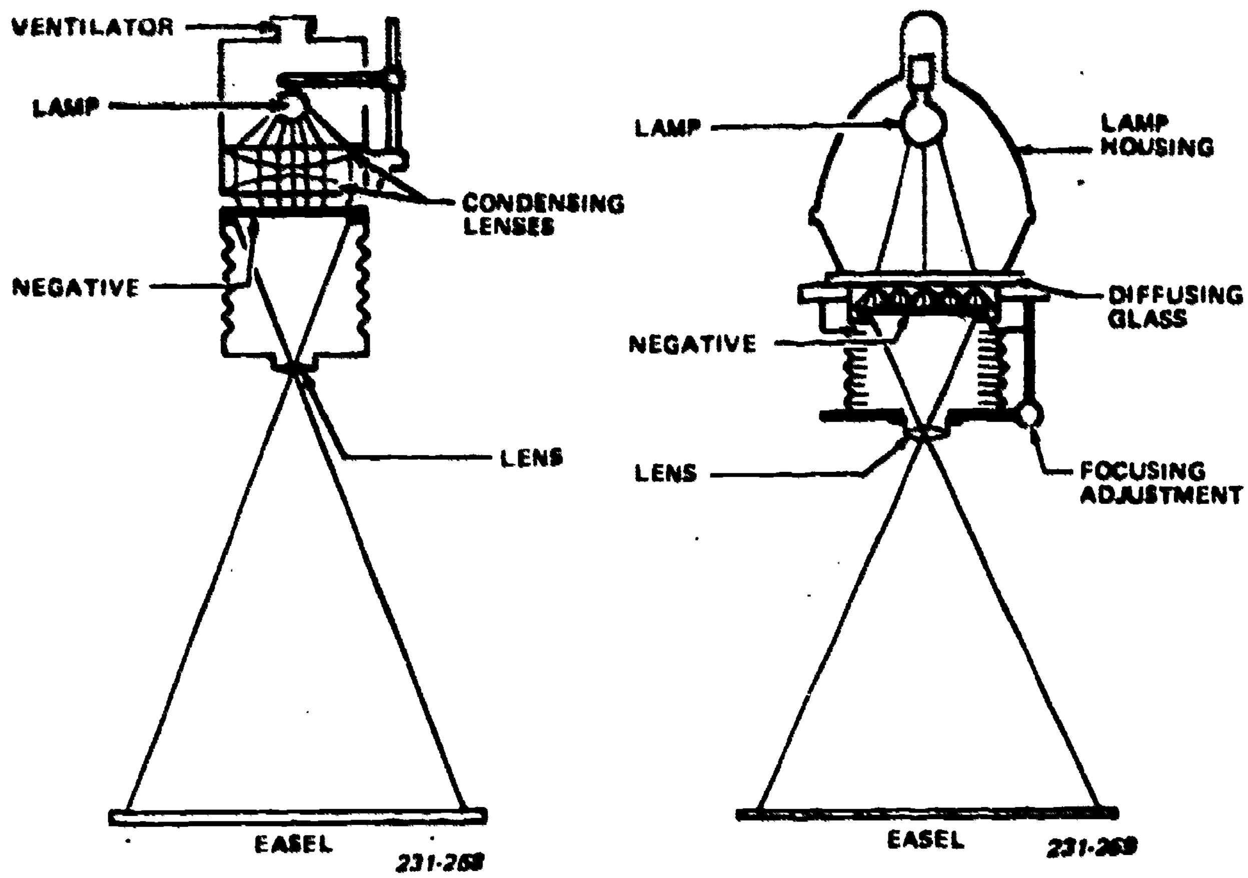


Figure 7-3. Condenser and Diffusion Printers

Types of Printers

Printers exist in many different brands with a variety of control mechanisms. They can be classified according to two basic optical systems; one is the diffusion enlarger, the other is the condenser enlarger. See figure 7-3.

DIFFUSION ENLARGER. In a diffusion optical system a sheet of frosted glass scatters the light rays from the lamp over the entire negative. Because the light rays scatter in all directions, some light rays never reach the negative. Other rays overlap and the result is an overall loss of light before it enters the main lens. Therefore, prints made by a diffusion enlarger tend to have softened details and a rather diffused appearance. Because of the loss of a certain amount of image quality, the diffusion system is not recommended for ae ial work. In aerial work image sharpness is the utmost concern.

CONDENSER ENLARGER. A superior system for directing light from its source through the negative and into the enlarging lens is the condenser system. It is based upon two saucer-shaped lenses whose convex sides are interfaced. This arrangement gathers light and spreads the beams uniformly and directs them through the negative. This system loses little light and directs more light to the printing paper. The straight line of the projection minimizes the overlapping of light rays.

The condenser enlarger reproduces the maximum amount of detail in the print. For this reason, negative defects, such as surface scratches, often become apparent on the print. With the condenser enlarger, the projected image is contrastier than with a diffusion type printer.

The EN-52B Projection Printer

The EN-52B, a condenser-type projection printer, is used in this course. The main features are:

1. Lens and Mount Assemblies - f/3.5, 50mm; f/4.5, 105mm and f/4.5, 150mm focal lengths; all mounts are equipped with an f/number illuminator.

2. Heat Absorbing Glass - 5-inch (12.7cm) diameter.

3. Condenser Lens Assembly - two, 7-inch (17.78cm) diameter plane convex lens.

4. Spool type Photographic Negative Carriers - six, consisting of 30mm single frame glassless, 70mm glassless, 70mm (120 aperture) glassless, 2 1/4 x 3 1/4 inch, (5.72 x 8.25cm), glass and a 4 x 5-inch (10.16 x 12.70cm) glass.

The operating controls and principal parts of the EN-52B are listed in figure 7-4.

The projection printer may be rotated on its base to permit the negative to be projected onto the floor or at an intermediate level in order that enlargements of a size greater than 11 x 14 (27.94 x 35.56cm) inches may be made. Hold the carriage and girder securely, loosen the three cap screws, and secure the three rotary clamping pads. Rotate the girder 180° on the base and secure it in this position with the cap screws.

CAUTION

Before rotating the girder and carriage for projection to the floor, you must secure the base board to the table with "C" clamps to prevent the projection printer from overturning.

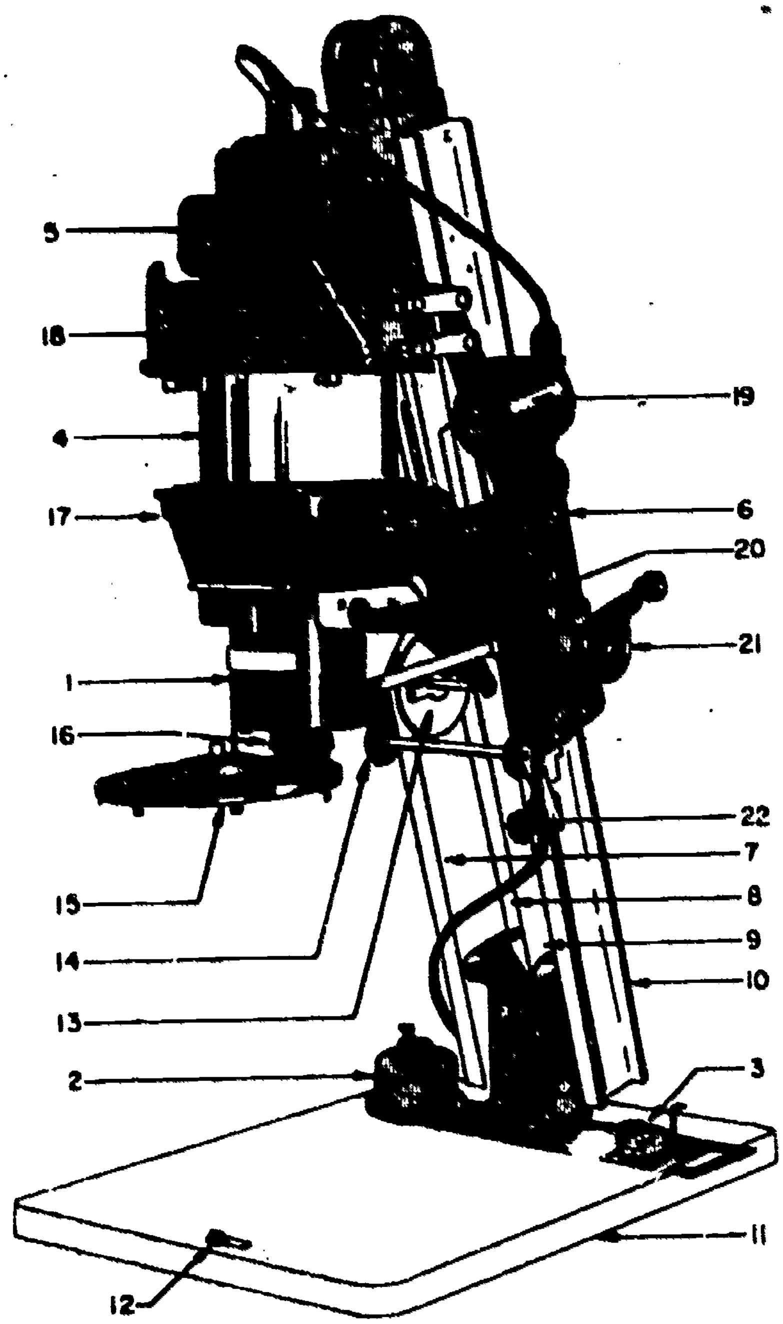


Figure 7-4. Photographic Projection Printer, EN-52B

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The Photographic Projection Printer, EN-52B is very similar to the Type B-15B Photographic Projection Printer. In fact, most of the parts and accessories are interchangeable. The major differences are:

o Condenser spacer retainers must be in the center of the film stage opening to avoid possible cutoff of the projected image.

o Heat absorbing glass is inserted into top of variable condenser lamp house after removing lamp house and condenser assembly and disconnecting the cable from the elapsed time indicator.

o The plug from the lamp house cable must be connected to the receptacle of the elapsed time indicator and the cable of the elapsed time indicator must be connected to the power source. This assures time-in-use record when feed through switch is ON.

The accessory carrying case and the elapsed time indicator are exclusive items with the EN-52B.

EN-52B Operating Procedures

Operate the projection printer as follows:

1. Check the condenser lens to see that it is properly positioned in the lamp house assembly. Set the cam follower wheel on the cam so that it is matched with the proper lens.

NOTE: Matching cam and lens are identified by the matching part number inscribed on the lens and cam identification plate.

2. After an initial manual adjustment, the lens is kept in proper focus for all magnifications by an auto-focusing device. This device consists of a special cam cut to match the characteristics of the lens and a cam follower. The cam follower changes the lens to object (negative) distance as the printer housing is moved up or down, changing the lens to image distance. When lenses are changed, the cam follower must be changed to the matching cam.

3. Select the appropriate size negative carrier for the negative being printed, raise the lamp house assembly; install the negative carrier on the film stage.

a. Insert negative with emulsion (dull) side down on the bottom plate of the carrier.

b. For aerial roll film, insert the film in the left bracket assembly of the spool-type carrier, thread and attach it to the empty spool in the right bracket assembly, rotate the crank handle of the right bracket assembly to bring the desired negative into position.

c. Lower the lamp house assembly.

d. Set the variable contrast filter turret assembly so that the blank opening is below the lens. Set the lens aperture wide-open by turning the diaphragm control counterclockwise, and snap the feed-through switch to ON.

e. Place a sheet of white paper in the projection printing easel, loosen the brake knob, and raise the carriage assembly to its highest position by turning the handwheel knob. Focus by making adjustments with the focusing knob until a sharp image is obtained. Adjust the projection printing easel by using the margin control knobs to set each of the masking blade arms. The margin width markings on the masking blade arms must line up to the dimension of the photographic paper being used.

NOTE: After a sharp image has been obtained, subsequent raising and lowering of the carriage assembly to vary the size of the desired enlargements do not affect the sharpness of the image.

f. Lower the carriage assembly by turning the handwheel knob until the desired enlargement size is projected on the white paper in the projection printing easel. Tighten the carriage break knob.

CAUTION

To avoid damage to the carrier gears, always loosen the brake knob before turning the handwheel knob.

g. Set the diaphragm ring to the desired f/stop.

h. Position the easel to assure that the desired image is composed within the area indicated by the masking blades.

i. Turn the time switch from focus to time and replace the white paper in the projection easel with a sheet of sensitized paper. The sensitized side must be up with the top and left edges tight against the margin guides. Lower the hinged frame and make certain that the position of the easel is not disturbed.

NOTE: If variable contrast paper is to be exposed, set the turret assembly to position the required filter below the lens.

j. Set the desired time on the timer, snap the toggle switch to the start position and make the exposure. The exposure time must be determined by the f/stop setting, the type of paper being used, the density of the negatives, and the degree of magnification desired.

k. After the desired time has elapsed the timer will automatically terminate the exposure. Raise the hinged frame of the easel to remove the exposed print for processing.

Negative Evaluation

Unfortunately, there is no simple answer to the question of what is a good negative. Yet we know that you need good negatives before you can make good prints. We know that you should aim toward producing negatives of consistent quality. In this section, we discuss some of the more important factors, other than development, which determines whether or not your exposures will develop into quality negatives. We'll start by discussing the finished product--the finished negative.

How should you look at your negatives to determine if they are quality negatives in terms of density and contrast? Don't try to judge a negative by holding it up to a window or an ordinary room light source. This procedure will give you a false impression of negative quality. View your negatives by reflected light, light which is reflected from white paper. Another way to view your negatives properly is to place them on a well-diffused light box designed for that purpose. A very practical method of judging negative quality is to place your negatives directly over a newspaper or magazine page or to view the negative by the light reflected from the magazine or newspaper page.

A quality negative has a wide range of tones--a real variety of grays with areas that will make rich blacks and brilliant whites on the final print if they are supposed to be there. The variety of tones should be suitable to the nature of the original subject. The film should have been exposed enough to record all the important shadow details. On the other hand, the highlight areas must not be too dense. You should be able to read magazine or newspaper type through the densest parts of the negative if viewed as discussed above. By practical definition, a quality negative is one which, when enlarged during the printing process, easily prints with the normal grade of enlarging paper. This negative has a wide range of nicely separated tones all the way from the shadows to the highlights.

An underexposed negative can never produce prints to match the quality of those from the normal negative. An underexposed negative has only a small range of tones, and the highlight areas are too transparent. The shadow areas are almost clear and contain no detail.

A negative gets very dense from heavy overexposure. Again, you have a negative displaying only a small number of separate tones. There is very little difference between any two adjacent tone values. Enlarged prints from these negatives are very low in quality and require very long printing exposures.

Projection Printing Steps

Follow this procedure when making projection prints.

1. Clean the working area thoroughly. Be sure that your laboratory and equipment are free of dust, dirt, and other foreign materials. Because minor dust particles on the negative or on the glass plates of the negative carrier become extremely noticeable when enlarged, cleanliness is especially important.

2. Prepare the solutions.

3. Select, very carefully, the negative to be printed. There is a rule which states: "If it isn't in the negative, you can't expect to produce it in the print." Moreover, if it is in the negative, it will also show up in the print. To make a good print, especially an enlargement, you must start with a good negative. A good negative is one free from surface scratches, moderate in density and contrast, and adequate in detail.

4. Position the negative in a clean negative carrier with the emulsion side of the negative facing the lens. Insert the negative carrier in its proper position into the projection printer.

5. Turn on the projection lamp and, while viewing the image, adjust the masking devices to eliminate extraneous light which may come from around the outer edges of the negative. Position the masking arms on the easel to produce the correct size of opening for the print being made. Adjust the paper positioning devices of the easel to make the correct size borders to the print.

6. Place a piece of white paper (the same size and weight as the printing paper) in the easel. Turn the printing light on and open the diaphragm to its maximum aperture.

7. Adjust the position of the printer head to give the correct image size. (If the projection printer is not equipped with an automatic focusing device, it will be necessary to focus. This may change the image size sufficiently so that the printer head must be repositioned. Repositioning the head may necessitate refocusing. Continue this procedure until the image is correct in size and is in critically sharp focus.)

8. Adjust the position of the easel to produce the desired composition in the photograph.

9. Judge the contrast of the image and the density of the negative. (If you have not developed the ability to do this, assume that the contrast is average and give an average exposure.)

10. Stop the diaphragm down to the desired opening. The exact amount that the lens diaphragm should be closed is difficult to determine without experience. Try to control the illumination so that the exposure requires from five to ten seconds. For the beginner, it is suggested that the printer lens be stopped down to three stops from the maximum aperture. This should produce a long enough exposure with an average negative to allow for accurate timing.

11. If graded paper is being used, select a grade which you consider to be of the proper contrast. If variable-contrast paper is being used, position the correct filter in front of the lens. (In lieu of experience, assume that the negative has normal contrast.)

12. Under safelight conditions, cut the sheet of projection-printing paper into test strips about two inches (5 cm) wide.

CAUTION

When you finish using a paper trimmer, always leave the blade in the lowered position.

13. Remove the white paper from the easel and place a test strip in the easel with the emulsion facing the lens. Be sure to include highlight, middle tone, and shadow areas in the test. Make a series of exposures on individual test strips on one test strip.

14. Process the test strip or strips. Be sure to use a 68°F (20°C) solution temperature and from 1 to 2 minutes developing time.

15. Judge the test strip for contrast and exposure. If the test does not fall within the desired range of tone and contrast, make additional test until both the correct contrast and the correct exposure have been determined. Use the same processing time for all tests.

16. Using the exposure and contrast determined by the test strip, make the desired number of prints on full-sized paper. Be sure to position the paper in the easel so that borders and composition are correct. Process the prints for the same time you used for your tests.

Print Processing

Processing prints is very similar to processing film. Many of the steps are the same and the same principles of time/temperature/agitation apply to development. Of critical importance are the principles of cleanliness and the wet and dry divisions of the lab.

The developer used will have a different formula, but its function is the same as for film developing. The developer will also have a

different dilution. The dilution will be 1:2, or one part of developer stock solution to two parts of water. Developer formula D-72 will be used.

One major difference in the processing of prints compared to processing film will be the use of safelights and the use of trays instead of tanks. Prints will be exposed and processed under safelight illumination.

DEVELOPING. As soon as the printing paper has been exposed, immerse it quickly, gently and completely in the developer solution. To keep fresh solution washing over the print throughout development, rock the tray. The agitation must be easy enough not to splash any chemicals. Development should be timed carefully. One could follow the process visually and make a judgement of the print as it emerges. However, in the dim illumination of a safelight, an image looks darker and appears fully developed before it is. A good indication of correct development is the evidence of clear detail in deep shadows and bright highlights.

If left in the developer for less than one minute, a print typically looks underexposed and mottled with a limited tonal range. Developing beyond two minutes could cause staining of the print. The print that appears too light after two minutes in the developer should be discarded and a new print made with a longer exposure.

STOPPING. When development is completed, the print must be transferred to the stop bath. (Before placing the print in the stop bath, hold it above the developer tray and allow the excess developer to drain back into its tray.) Submerge the print into the stop bath solution.

The stop bath neutralizes the developer, halting its chemical action. Usually the developed print is placed in the stop bath with slight agitation for 10 to 15 seconds. Next, the print is lifted and excess solution is allowed to drain into the stop bath tray. The print is then transferred to the fixer.

FIXING. Immersion time in the fixer can last from three to ten minutes, depending on the type of paper and fixer used. It is a good idea to agitate the print from time to time while it is in the fixer. This keeps fresh fix in contact with the print surface thus assuring proper fixation. A print exposed to white light before adequate fixing is likely to have veiled highlights and poor tonal qualities. If exposed to white light before fixing, it will immediately turn black. Prolonged immersion in the fixer can also destroy a print by causing the image to disappear.

After fixation, one may examine the print by placing it in an empty, clean tray and taking it out of the darkroom into a fully illuminated area.

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Print Finishing

The process of preparing prints for delivery to the requestor is called "print finishing." Finishing begins at the point where darkroom handling of the material is no longer required. Once the prints have completed their necessary fixation, the finishing procedures are started. These procedures are not limited to only the washing and drying steps. Rather, they often require correction of certain faults in their quality, mounting and toning. In some cases, you may need to completely eliminate the fixer from the prints to achieve archival quality. We can begin a discussion of the print finishing process with a study of the two basic steps, washing and drying.

WASHING. Unless all residual chemicals are removed from photographic emulsions, they will eventually fade and yellow. Normal washing procedures are sufficient to remove enough of these chemicals to preserve the image for many years. Therefore, thorough washing will be satisfactory for the majority of photographs.

There are several factors which determine how rapidly the materials can be washed. One of these factors involves the structure of the base material. Light weight printing paper has far less capacity for retaining chemicals than does single weight material. Double weight paper retains chemicals longer than single weight materials do. When properly processed, water resistant papers contain very little chemistry in their base.

Another factor in determining washing rates is the frequency of water change. A good rate of flow will remove fixer chemicals in a relatively few minutes. This of course depends on the number of prints being washed. But even the good water flow will not do a satisfactory washing job if the prints are not agitated properly. Water temperatures are not as critical to washing as the chemical solution temperatures are to processing. However, you should use water as close to normal room temperature as possible. Very low water temperatures will reduce the effectiveness of the washing process. High temperatures increase the possibility of damage to the emulsion during agitation and handling before drying.

Normal print washing procedures are satisfactory for the majority of purposes providing fresh fixer has been used. Although complete fixing is possible with moderately aged chemicals, the time must be extended for that step. Washing becomes less effective when fixing times have been longer than normal or when aged chemistry is used. Either trays or mechanical washers can be used for washing prints. The adequacy of their performance can be checked with other chemical solutions.

Mechanical Washers. A convenient method of washing large numbers of small and medium size prints is by the use of a mechanical washer. Average washing time for single-weight prints is 50-60 minutes, double-

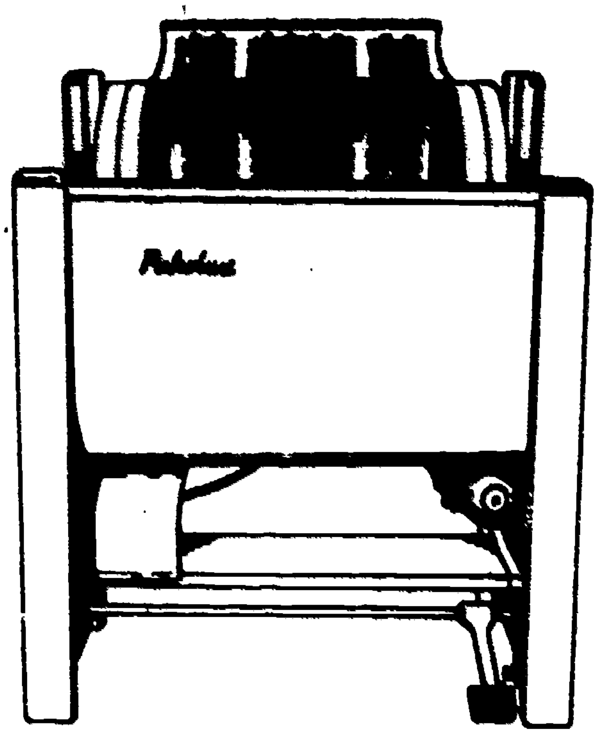

Figure 7-5. Mechanical Print Washer

prints 120 minutes. These washers spray fresh water onto the prints and at the same time siphon off the contaminated water from the bottom. This type of washer sometimes contains a large tray which is revolved either by the force of the water spray or by a motor. The rotation, together with the spray of the water, gives constant agitation to the prints. In these washers the water is completely changed every few minutes. A typical mechanical print washer is shown in figure 7-5.

Washing in Trays. Although most prints are washed in mechanical washers, it is often necessary to wash prints in trays without the assistance of running water. However, this type of washing is not recommended, but it can be used as a temporary expedient when absolutely necessary. Two deep trays should be used for the washing process. The size of the trays is determined by the size of the prints and by the number of prints that are to be washed at one time. Both trays should be almost completely filled with fresh water, and the prints placed emulsion side up in the first tray. After five minutes of soaking, each print should be drained, then transferred, one at a time, to the second tray. When all of the prints have been transferred, the first tray is emptied and refilled with fresh water. Allowing five minutes between changes, six complete changes from one tray to the other are considered the minimum for single-weight prints. Double-weight prints should be given at least eight to ten changes.

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A second way of tray washing is to utilize running water and submerge the hose in the wash tray. This system is adequate for washing a few prints, but it is not recommended as an ideal procedure. There is a tendency for the contaminated water to sink to the bottom of the tray and remain there. When this method of washing is used, the flow of fresh water must be sufficient to thoroughly circulate the water in the tray. Prints should be agitated frequently.

A third method of washing involves the use of trays and a specially designed tray siphon.

DRYING PHOTOGRAPHIC PRINTS. When washing has been completed, dry the prints between blotters especially designed for photographic work, on drying racks, on ferrotype plates, and on belt driers. The drying method depends on the purpose of the prints and the availability of the various types of drying equipment.

Drying Prints Between Blotters. Occasionally, it is considered advantageous to dry prints between photographic blotters. These blotters are made so that they will not leave lint on the print. The method used is to drain the prints well, place them between two blotters, and remove all of the surface water. After this treatment, they are placed between two dry blotters. They are then weighted or placed in a press that is capable of holding them flat until they are dry. When several prints are to be dried in this manner, it is advantageous to use corregated cardboard between each combination of two blotters and a print. Air can then circulate through the stack, and drying will be speeded up. This method of drying is relatively slow, but does produce a nice flat print.

Drying Prints on Racks. The procedure for drying prints on racks has the big advantages that no change in print tone occurs and both stretching and shrinking are minimized. For these reasons, the rack-drying procedure is normally used when prints are being prepared for a controlled, photographic mosaic.

Drying Prints on Belt Dryer. The majority of prints (other than those made for mapping purposes) are dried on the motor-driven belt-type dryer. A belt dryer consists of a drum over which a wide endless cloth belt or apron travels. The drum is motor driven and is usually heated by electricity. The rate that prints dry is regulated by the temperature of the drum and the speed at which the drum rotates. The drum temperature is controlled by a thermostat, while the drum rotating speed is regulated with a variable speed motor and a speed reduction system. The prints are held in contact with the drum by means of the endless belt and are dried during one revolution of the drum.

Place the prints on the apron, allowing 1/2-inch (1.27cm) between prints and not less than 1/2-inch (1.27cm) from the edge of the apron. Glossy prints are positioned face up on the table or apron portion of

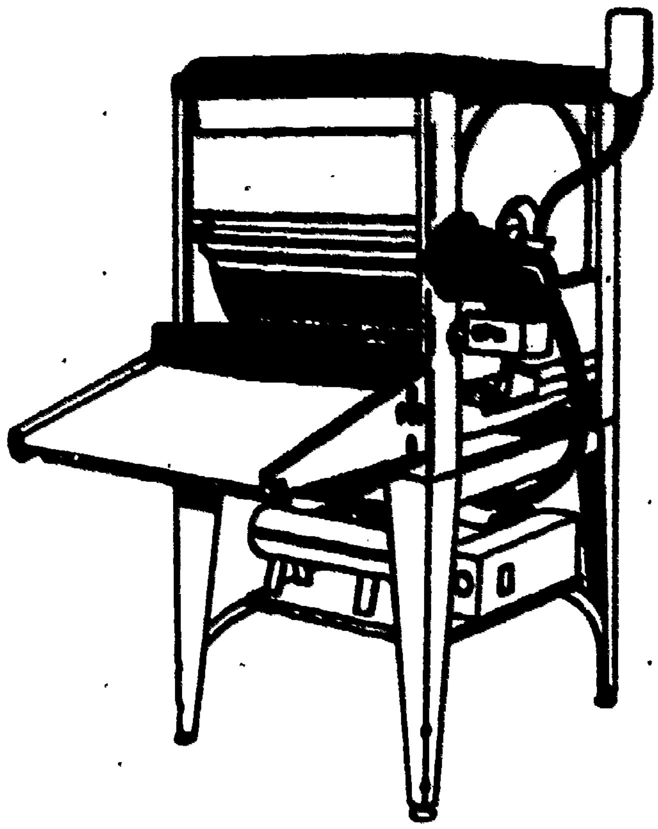

Figure 7-6. Print Dryer

of the belt; matte prints are positioned with the emulsion toward the apron.

Belt dryers have a capacity for drying 100 single-weight 8 X 10-inch (20.32 X 25.40cm) prints per hour. If double-weight prints are being dried, the rate is 50 8 X 10-inch (20.32 X 25.40cm) prints per hour. Prints up to 24 inches (60.96cm) in width may be dried on this machine. A typical belt dryer is shown in figure 7-6.

To stop the dryer, first turn off the heaters. The apron should be allowed to move for 15 minutes to allow the drum to cool. When the drum has cooled, place the motor in the OFF position.

QUESTIONS

DO NOT WRITE IN THIS SW. USE A SEPARATE SHEET OF PAPER.

1. What is the baryta and galatin coating?

2. What is the purpose of the overcoating?

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3. The surface of a paper is a combination of _________ and _________.

4. List the three silver halides used in making paper emulsions.

5. Graded contrast papers are primarily sensitive to _____ light.

6. Variable contrast papers are sensitive to _________ light.

7. How long should papers be allowed to warm up before use?

8. List the two types of projection printers.

9. Define "quality negatives."

10. How long sh· ıld the print remain in the developer?

11. What is the function of the stop bath?

12. What will happen to the print if it is left in the fixer too long?

13. What is the result if prints are not washed sufficiently?

14. List three methods of drying prints.

15. Describe the operation of a belt print dryer.

Exercise 1

PROCEDURES

Match the following items, etc.

a. silver chloride

b. silver bromide

c. contrast

d. graded papers

e. variable contrast papers

_____ 1. Sensitive to b e and green light.

_____ 2. Difference between densities.

_____ 3. Used by itself for making contact paper emulsions.

_____ 4. Sensitive to blue light.

_____ 5. Fastest of the silver halides.

a. slow chloride papers

b. slow chlorobromide papers

c. silver bromide papers

d. fast chlorobromide papers

____ 1. Sensitivity is 10 times faster than chloride papers.

____ 2. Used mainly for enlarging.

____ 3. Requires as much as 4 times the exposure as bromide papers.

____ 4. Produces blue-black tones.

Exercise 2

| EQUIPMENT | Basis of Issue |
| --- | --- |
| Negatives From Previous SW | 1/student |
| Projection Printing Laboratory facilities | 1/class |
| Projection Printers and Timers | 1/student |
| Projection Printing Paper | As needed |
| Print Washer | 1/class |
| Print Dryer | 1/class |

SAFETY PRECAUTIONS

1. Make sure electrical equipment is provided with ground attachments.

2. Keep electrical equipment away from wet sinks.

3. Do not handle electrical equipment (printers, timer, etc.) with wet hands.

4. Use extreme caution when using the paper trimmer. Never place your fingers in the cutting area. After using the trimmer, always leave the cutting blade in the lowered position and locked.

PROCEDURES

1. Obtain the necessary chemicals for processing paper from chem mix. Make your tray set up using 8 x 10-inch (20.32 x 25.40cm) trays and AFD No. 25 (D-72) solution 1:2 (16 ounces of developer to 32 ounces of water) (473ml of developer to 946ml of water).

2. Check out the projection printer as follows:

a. Inspect the printer for cleanliness and ease of operation.

b. Clean the lens. If necessary, dust it with a camel's hair brush.

c. If the printer has interchangeable condensers, insure that the set matching the lens' focal length is clean and properly installed.

d. Check the cam follower wheel to make sure that it is on the proper track to match the focal length of the lens.

3. Adjust the printing easel to give 8 x 10-inch (20.32 x 25.40cm) prints with a quarter inch border (7 1/2 x 9 1/2-inch inside dimensions) (19.05 x 24.13cm inside dimensions).

4. Select the negative to be enlarged.

5. Place the negative in the carrier and insert into the printer.

6. Check to make sure that the cam follower is on the cam corresponding to the lens you are using, and that the condenser assembly is positioned properly.

7. Raise the lamp housing to the top of its travel. Open the lens diaphragm wide open.

8. Turn on the projection printer lamp and focus on the easel. Arrange the desired composition at this time also.

9. Close the lens diaphragm down two clicks and turn off the lamp.

10. Refer back to Projection Printing steps in the SW and follow steps 12 through 16 using a normal, dense and a thin negative respectively.

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STUDY GUIDE AND WORKBOOK

G3ABR23330 001-II

Technical Training

Continuous Photoprocessing Specialist

# CONTINUOUS PROCESSING FUNDAMENTALS

October 1977


3400TH TECHNICAL TRAINING WING
3430th Technical Training Group
Lowry Air Force Base, Colorado


Designed For ATC Course Use

DO NOT USE ON THE JOB

Sciences Branch
Lowry Air Force Base, Colorado

SW G3ABR23330 001-II-1
October 1977

# INTRODUCTION TO AERIAL PHOTOGRAPHY

## OBJECTIVES

List and explain the four phases of the intelligence cycle.

Identify fundamental techniques and terms used in optical reconnaissance.

List the capabilities and limitations of non-optical imagery systems.

## INTRODUCTION

Since primitive man first realized the advantage of an elevated, unobstructed view of his enemy, the concept of reconnaissance has been part of physical combat. With the advent of the balloon, man no longer was dependent upon terrain to provide a vantage point. Furthermore, with the introduction of photography, he was no longer dependent upon his memory to relay his observations to his comrades on the ground. Thus, in the past century and a half, a new dimension has been added to reconnaissance. With man's conquest of the air and, more recently, of space, the scope of reconnaissance has leaped forward. An aircraft can reconnoiter hundreds of miles within a few hours. Space vehicles can do the same over thousands of miles within minutes.

Significantly, with this vast increase in coverage there is also an increase in the minuteness of detail which can be obtained. Through the use of one or more sensors, it is possible to detect virtually any movement of an enemy or a potential enemy, provided the sensor can be brought within range. An enemy, fully aware of this potential, must exercise elaborate precautions to hide or camouflage his moves from observation. The expanding array of sensors available makes this increasingly difficult. No longer is it possible to hide behind the hill, under cover of darkness, or poor weather. These defenses have been penetrated by airborne day and night optical sensors, infrared, radar, and electronic reconnaissance.

This vastly increased ability to gather reconnaissance information means an increased amount of information about any enemy or potential enemy. Add to this reconnaissance information, all the other information gathered by national intelligence agencies and information about an enemy is even greater. This is an age of instantaneous attack capability. A nation cannot depend on tell-tale signs of impending attack

Supersedes SW 3ABR23330, October 1973

such as massive military mobilization. The deployment of weapons of mass destruction signaled an end to international isolationism. The United States intelligence community must be constantly aware of the capabilities of all potential opponents. The nation's policy makers must never be surprised by an unfriendly nation.

INFORMATION

## THE INTELLIGENCE CYCLE

Intelligence is the best possible knowledge, of a known degree of truthfulness, of one's opposition. It is the best knowledge possible in light of all available information. Intelligence deals with external information. That is, information about an enemy or potential enemy. Internal information is termed operational information.

There are four intelligence phases based on the need of a user of intelligence. The four phases are:

- Requirements. The recognition and the validation of a need for intelligence.

- Collection. The systematic procurement of information for intelligence purposes.

- Production. The transformation of collected information into intelligence.

- Dissemination. The timely distribution of intelligence in suitable form to agencies needing it. See figure 1-1.

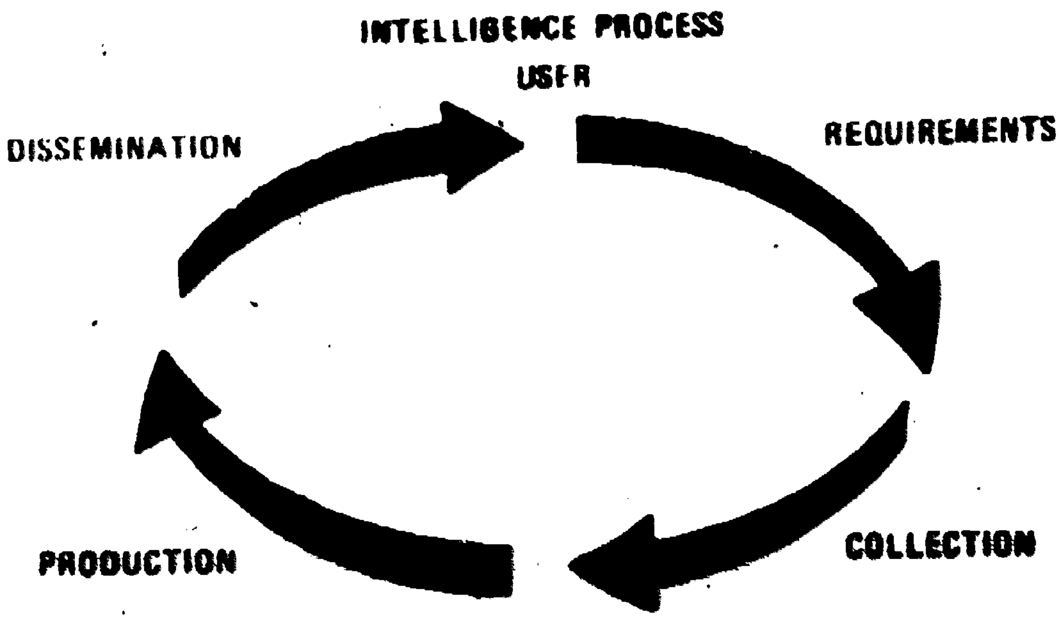


Figure 1-1. The Intelligence Cycle

SW G3ABR23330 001-II-1

Requirements

There are many reasons why intelligence information may be required. However, the two most important reasons that concern a continuous photo-processing unit are immediate battlefield needs and long range strategic planning.

IMMEDIATE BATTLEFIELD NEEDS. Military forces under combat situations need up-to-the-minute information about the enemy. Enemy troop movements, concentrations and capabilities are some examples of the information needed. The information must be accurate but it must also be gathered quickly.

LONG RANGE STRATEGIC PLANNING. In order for military and civilian policymakers to make plans for the future, information must be obtained about any potential enemy. Some examples of this information might include military hardware, troop movement and locations, production capability, and transportation.

Collection

After a need has been established, the information must be collected. Many sources and methods are used to collect the information.

SOURCES. Among the many sources available to the intelligence collector are aerial reconnaissance, electronic imagery, and communication monitoring. (The use of aerial reconnaissance and electronic imagery are directly a part of this career field.) Also, the collector can use foreign news reports, civilian reports to foreign governments, and individuals.

METHODS OF OPERATION. There are three methods of operation: overt, covert, and clandestine. Overt operations are conducted openly. Overt operations are often done discretely, however, to avoid unwanted interference. Covert operations are conducted to keep the collector or user secret. They also are used to keep the information gathered secret. Clandestine operations are intended to keep the existance of the operation itself secret.

Production

Once the information is gathered it must be put in a usable form. In the case of aerial reconnaissance, the images must be processed and interpreted. Other types of information must also be interpreted and conclusions drawn from the knowledge. In this manner, the policymakers can make the best decisions.

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Dissemination

Once the information is collected and put into a logical form, it must be given to the agencies that can best use it. Usually the information is returned to the controlling authority for formal dissemination. The controlling authority then distributes the intelligence to th agencies that requested the information.

## AERIAL PHOTOGRAPHIC SYSTEMS

Aerial photographic systems are generally placed in two categories: reconnaissance and mapping. Mapping and cartographic photography place more demands upon the system in the areas of accuracy in optical linearity, altitudes and flight attitude. Critical measurements are made from cartographic photographs of terrain features over large areas. For this reason, prescribed conditions must be strictly adhered to.

### Cartographic Photography

This type photography is performed whenever it is necessary to obtain aerial photographs to be used in compiling maps, charts, photo mosaics, and similar cartographic materials. Such a photographic mission differs from the other reconnaissance missions previously described. The mapping mission usually consists of several parallel flight lines with prescribed overlap between photographs, flown at a specified altitude above the terrain. It is evident that optimum photographic coverage cannot be procured under combat conditions because the aircraft must fly at maximum altitudes and speeds, using evasive action whenever necessary. The photographic squadron, therefore, has the problems of (1) selecting the most suitable camera installation for any given situation, and (2) developing photographic reconnaissance techniques that will insure procuring the best possible photographic coverage of the terrain.

### Reconnaissance Photography

Reconnaissance photography can be largely categorized into strategic and tactical areas, each having a different set of rules. Tactical reconnaissance is usually done under more time-demanding conditions and is accomplished to provide information for combat organizations in the field. This photography is usually accomplished from faster fighter type aircraft, often over hostile terrain, and loses its value quickly. Since the need is immediate, it is usually accomplished on a day-to-day or even hour-to-hour basis. Strategic reconnaissance, on the other hand, is used for more long-range planning. Of a surveillance nature, it may or may not be accomplished over hostile terrain and can be accomplished from higher altitudes with a higher degree of accuracy. Where cartographic photography may deal with terrain features primarily, strategic reconnaissance deals with terrain in addition to minute man-made features-weapons installations, under water obstacles, industrial

features, transportation capabilities, and other information valuable in determining the capability of a potential enemy to sustain combat.

## Reconnaissance Missions

Reconnaissance missions have one primary purpose. This is to provide information to intelligence and planning agencies. The information requirements determine the type and time of the mission. The broad categories of aerial photo reconnaissance missions and their definitions are closely related to the information requirements.

The reconnaissance cycle is a comprehensive and constant program of initial, periodic, and thorough survey of the enemy and his targets. Initial pioneer search reconnaissance is made of an area to determine its military value and potential. Specific objective reconnaissance obtains pre-strike information to obtain the most current information about the target and surrounding territories. The bomb impacts are recorded photographically on the spot by strike photos. As soon as the smoke has cleared sufficiently to permit acceptable photography, a post-strike mission is flown by the reconnaissance aircraft to give a positive evaluation of the attack. Sometimes, these post-strike photographs serve as pre-strike information for the next strike force action. If not, the reconnaissance crew makes periodic surveillance missions to check on enemy buildup, concentration, and movements. Still another phase of the reconnaissance cycle is cartographic photography to obtain photographs to be used in preparing maps for ground operations and navigational and target charts.

## Aerial Cameras

In principle, the aerial camera is essentially similar to its ground-photo counterpart. Its three basic components are the lens, the shutter, and the film support mechanism. Aerial cameras are classified as motion picture, single frame, and special purpose such as the strip camera. It is the single frame camera which is used the most, and it is in the area of adaptation that the aerial camera becomes unique. Although some cameras are built and used as a single unit, most are considered to consist of three basic units. The lens cone normally contains both the lens and shutter, serving essentially the same purpose as the bellows in a ground camera. The aerial camera, however, seldom has any provision for focusing since it is normally assumed that the lens to subject distance in aerial work will be greater than the hyperfocal distance of the lens at maximum aperture. The body, or case drive, is the chassis which supports the other components and contains film drive motors, shutter tripping mechanisms, and electrical connections. The magazine contains the film and platen. Depending upon the design, it may also contain heaters and mechanisms for image motion compensation. Some cameras consist of an integrated magazine and case drive, while others have the lens cone integrated with the case drive.

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Some of the more commonly used cameras for aerial work are the 9 x 9-inch (229 x 229mm) KC-1A and KC-1B which were designed for mapping; the 9 x 9-inch (229 x 229mm) K-17C, designed for mapping; the 9 x 9-inch (229 x 229mm) K-17, designed for reconnaissance; the KA-55, KA-56, KA-90 and KA-91 panoramic cameras; and the KS-72C-1 and KS-87A cameras which produce 4.5 x 4.5-inch (114 x 114mm) negatives. The K-18A strip camera is still used, though not very often, and the K-38 and KA-1 9 x 18-inch (229 x 457mm) cameras are used to some extent.

The 9 x 9-inch (229 x 229mm) format is used in high-altitude search reconnaissance and in precision mapping. This format is used in some tactical applications along with the 9 x 18-inch (229 x 457mm) format. Smaller cameras, capable of extreme resolution, are used in some high-altitude strategic applications, and exposure and process specifications must be highly controlled if optimum results are to be obtained.

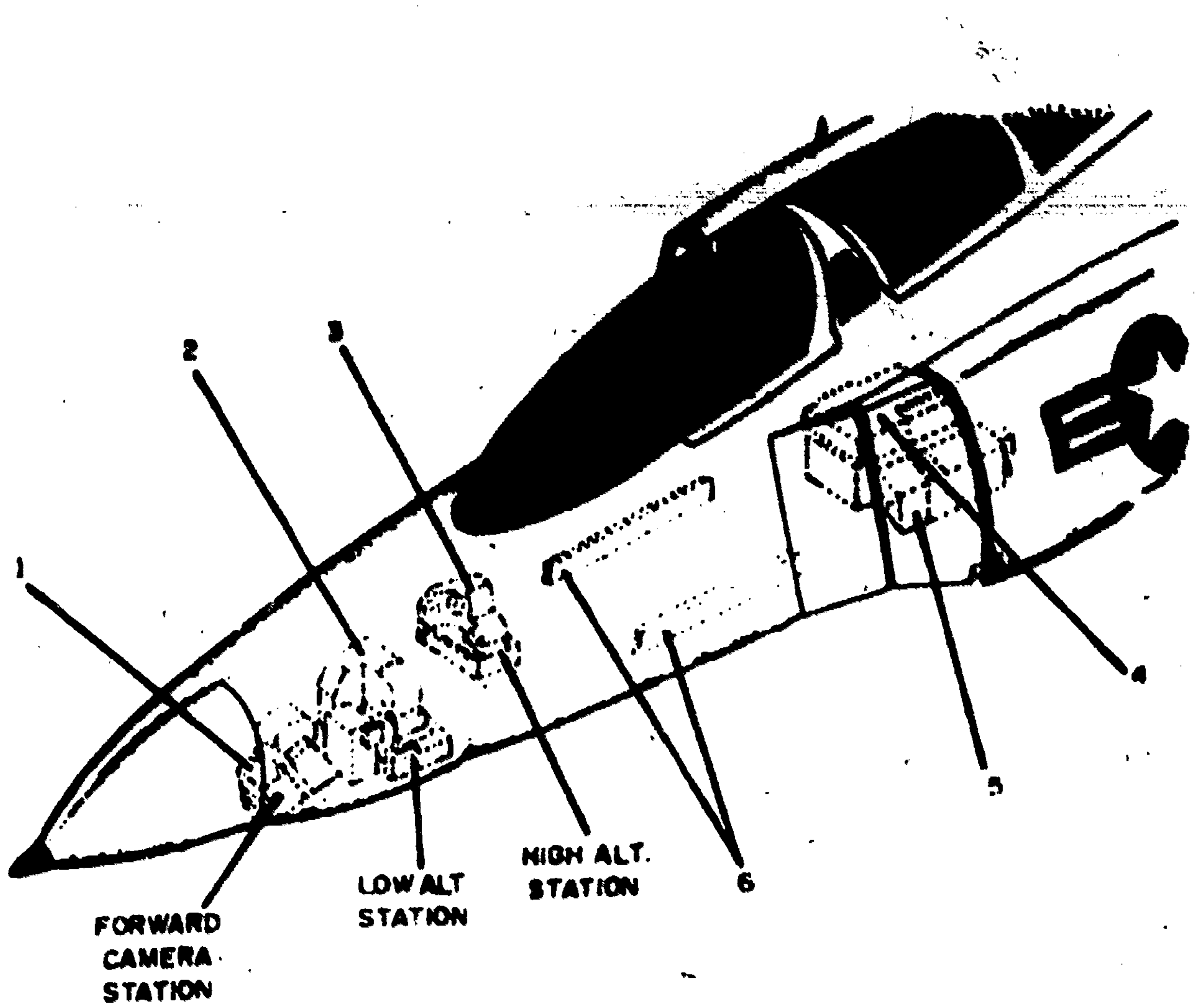
Camera Positions

Although a limited amount of aerial photography is accomplished with hand-held cameras, the practice is considered impractical for most purposes. Most aerial cameras are somewhat heavy and cumbersome to begin with. When this factor is combined with even minor G-forces, a considerable strain is placed upon the photographer. For stability required in most applications, aerial cameras are placed in fixed mounts in the aircraft, and systems have been devised for this type of mission. Also systems are designed today which include the aircraft itself, with the camera system being designated a subsystem. For tactical reconnaissance, particularly, these are usually modifications of conventional fighter type aircraft. They normally carry no armament, and the basic fuselage may be extended or enlarged to accomodate the camera subsystem. Depending upon the number of cameras and the positions, focal lengths, etc., the system offers a great number of combinations, or configurations, for various mission requirements. See figure 1-2.

There are three main types of installations: the vertical, the oblique, and the fan.

VERTICAL PHOTOGRAPHY. A vertical photograph is an aerial photograph taken with the camera axis perpendicular to the earth's surface. Ground features appear in perspective and with minimum distortion of their horizontal dimensions.

Vertical photographs have relatively small errors in scale, in relief features, and in optical distortion. Measurements may be accomplished easily and with moderate accuracy. Scale is fairly constant throughout the photo. Verticals provide excellent aids to crews accomplishing high altitude missions.




| INDEX NO | | |
|---|---|---|
| 1 | KS87 OR KS 72 | FORWARD OBLIQUE OR NOSE VERTICAL |
| 2 | KS87 OR KS 72 | L & R OBLIQUES OR/AND LOW PANORAMIC KA 56 |
| 3 | KS87 OR KS 72 | R & L Split SPLIT VERTICALS OR KA [illegible]/KA [illegible] PANORAMIC |
| 4 | AN/AAS 18 | INFRARED MAPPING RECORDER |
| 5 | AN/APQ 102 | SIDE LOOKING RADAR RECORDER |
| 6 | APQ 102 | RADAR ANTENNA |

Figure 1-2. RF-4C Sensor Positions

A disadvantage of vertical photography is that it presents an image which is seen from an unfamiliar point of view and shows a limited field of view.

OBLIQUE PHOTOGRAPHY. Oblique photography is an aerial photograph taken with the camera axis directed intentionally between the horizontal and vertical. Therefore, the aircraft does not have to fly directly over the area to be photographed. A high oblique shows the horizon; a low oblique does not. A high oblique photo shows much more area than a vertical photo with the same focal length and from the same altitude. However, the images grow smaller toward the horizon. Objects in the background tend to lose their proper perspective proportionate to the

obliquity of the camera angle, to the extent that the correct horizontal plane of individual object cannot be determined.

In oblique photos, the terrain appears as a conventional image rather than the map-like presentation of the vertical. Since oblique photos are more pictorial and more readily read, they provide excellent briefing aids for crews accomplishing low-level missions.

One disadvantage of oblique photography is that scale diminishes from foreground to horizon. Calculations are also difficult and must be accomplished by the use of trigonometry. Observation is limited to line of sight. In addition, oblique photography is not very effective at night.

FAN PHOTOGRAPHY. There are three types of fan installations used: the split-vertical, the tri-metrogon and the multi-camera.

The split-vertical installation, shown in figure 1-3, consists of two oblique cameras operating simultaneously. They are mounted in such a manner as to provide a small amount of sidelap.

Tri-metrogon photography is used in search reconnaissance. It requires three cartographic cameras with 6-inch (152mm) wide angle lenses. One vertical and two oblique cameras are mounted as shown in figure 1-4. The center camera is vertical, and the oblique cameras are opposing each other at 30° depression angles. This gives horizon to horizon coverage.

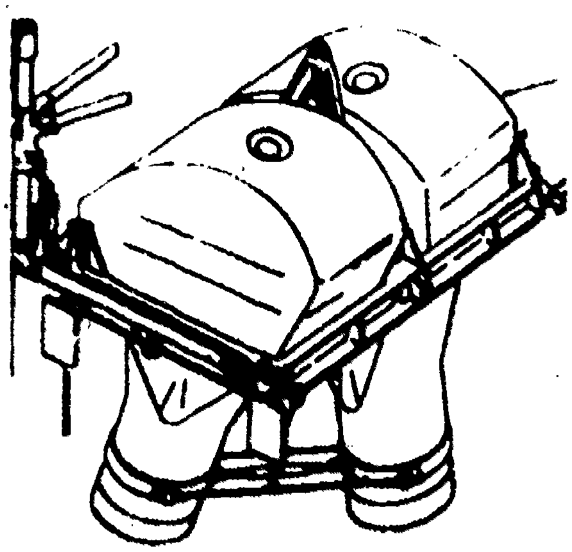


Figure 1-3. Split-Vertical Aircraft Camera Installation

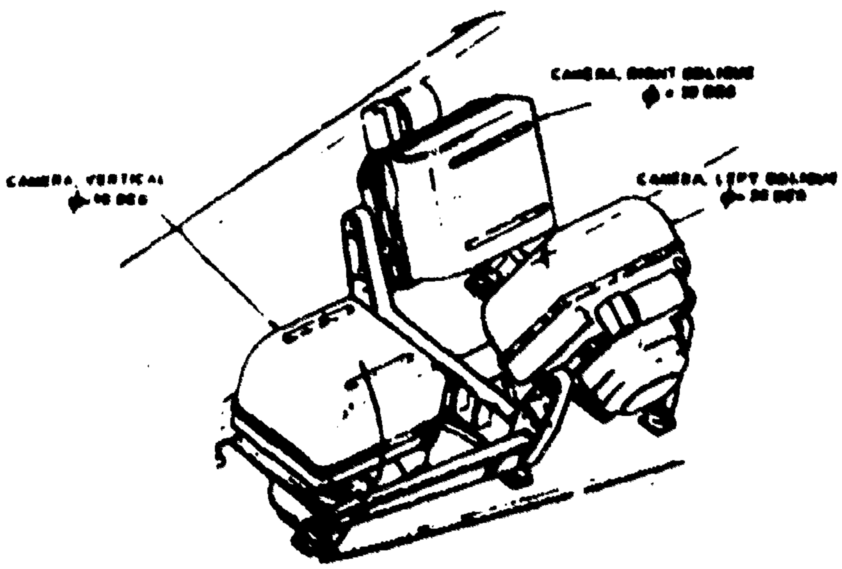


Figure 1-4. Tri-Metrogon Aircraft Camera Installation

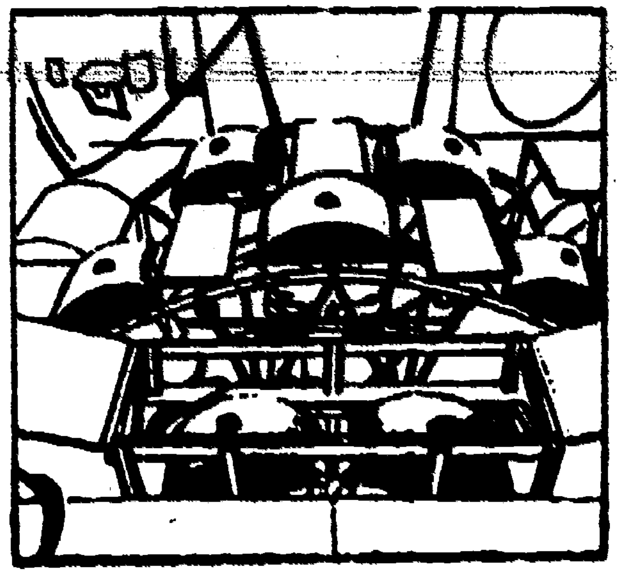


Figure 1-5. Multi-Camera Installed With Split-Vertical Installed in Foreground

The multi-camera installation consists of three or more cameras mounted so as to provide a small amount of interlock between each adjacent photograph for the purpose of providing continuous extended lateral coverage. Installations with an odd number of cameras include a vertical in the center. Those with an even number fan out from the split-vertical. A typical multi-camera installation is shown in figure 1-5.

## NON-OPTICAL IMAGERY SYSTEMS

Besides the camera systems, there are other sensors installed in the reconnaissance aircraft. These supplement the optical sensors and provide information that aerial cameras cannot produce. The three main non-optical sensors are side-looking airborne radar (SLAR), infrared sensors, and lasers.

### Side-Looking Airborne Radar

Side-looking airborne radar (SLAR) produces radar imagery whose range and ground resolution is far superior to earlier airborne radars. Its high resolution capabilities make it a useful all weather, day or night mapping and reconnaissance tool. (The term "high resolution" is used in comparison to common bomb radars and not to photography.)

This type of radar is termed "side-looking" because it transmits the radar beam at right angles to the aircraft. Thus, the radar antennas "look" to the sides of the aircraft (see fig. 1-2).

A radar beam is sent from the aircraft to the ground and bounces back according to the ground features. This returned signal is converted into light by the means of a cathode ray tube (CRT) which is similar to a TV picture tube. A photographic data film is passed over the CRT and exposed. At the completion of the flight, the data film is processed.

Then the data film is placed in an optical correlator. This machine acts as a printer and unscrambler of the information recorded on the data film. This optical correlator uses the data film to expose a final image map film which is then processed and used normally.

### Infrared

A combination of the optical and radar sensors studied so far does not fulfill all the requirements for an ideal reconnaissance system. An additional sensor system is available which makes use of natural infrared radiation. This system helps to cover some of the missing requirements.

All objects radiate infrared energy. There are many sources for this energy with the sun being the prime one. The infrared sensor can record this radiation. As an object radiates infrared, the airborne sensor picks up the radiation and focuses it into an electronic unit. This unit converts the infrared into an electronic signal which is projected onto panchromatic film through a CRT. The film is then processed normally at the completion of the mission.

It takes a skilled interpreter, however, to use the images recorded by the sensor. The interpreter must understand the nature of infrared energy and the physical laws which govern its behavior. Also, the image is greatly affected by natural, mechanical, and environmental factors.

### Lasers

Lasers are electro-optical recording sensors, not light recording cameras. Visible laser light is beamed to the ground and reflected back to the aircraft. The reflected optical energy is converted into electronic impulses. These electronic impulses can then be amplified, recorded as a video signal or handled with other electronic techniques and devices.

The laser has rather poor weather penetrativeness and works poorly at high altitudes.

### QUESTIONS

DO NOT WRITE IN THIS SW, USE A SEPARATE SHEET OF PAPER.

1. List and explain the four phases of the intelligence cycle.

2. What are some sources of intelligence information?

3. What is the difference between tactical and strategic aerial reconnaissance?

4. What is a disadvantage of vertical photography?

5. What is the difference between high and low oblique photography?

6. Why is SLAR called "side-looking"?

7. What are disadvantages to the use of lasers?

8. List the capabilities and limitations of non-optical imagery systems.

EXERCISES

Exercise 1

PROCEDURES

On a separate sheet of paper, match the intelligence cycle in column A with its definition in column B.

| COLUMN A | COLUMN B |
|---|---|
| Requirements | 1. The transformation of collected information into intelligence. |
| Collection | 2. The recognition and the validation of a need for intelligence. |
| Production | 3. The timely distribution of intelligence in suitable form to agencies needing it. |
| Dissemination | 4. The systematic procurement of information for intelligence purposes. |

Exercise 2

1. Answer the following questions on a separate sheet of paper.

   a. What is oblique photography?

   b. What is a tri-metrogon installation?

   c. What is the primary purpose of reconnaissance?

2. Match the aerial camera in column A to its description or purpose in column B. Use a separate sheet of paper.

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| COLUMN A | COLUMN B |
|---|---|
| K-17 | 1. Panoramic camera. |
| K-17C | 2. Produces 4.5 x 4.5 inch (114 x 114mm) negatives. |
| KS-72C-1 | 3. Produces 9 x 9 inch (229 x 229mm) reconnaisance negatives. |
| KS-18A | 4. Produces 9 x 9 inch (229 x 229mm) mapping negatives. |
| KA-91 | 5. A strip camera. |

3. Match the reconnaissance mission in column A with its description or purpose in column B. Each answer may be used once, more than once or not at all.

| COLUMN A | COLUMN B |
|---|---|
| Pre-strike reconnaissance | 1. Used in preparation of maps. |
| Strike reconnaissance | 2. Gives positive evaluation of the attack. |
| Post-strike reconnaissance | 3. Made to determine an area's military value. |
| Pioneer search reconnaissance | 4. Used to determine the most current information about the target. |
| | 5. Made as the bombs hit the target. |

Exercise 3

PROCEDURES

Match the terms in column A with the phrase in column B that describes it.

| COLUMN A | COLUMN B |
|---|---|
| SLAR | 1. Is greatly affected by natural, mechanical and environmental factors. |
| Infrared Sensor | 2. Has poor weather capabilities. |
| Laser | 3. Utilizes a correlator after the film is processed. |

Sciences Branch
Lowry Air Force Base, Colorado

SW G3ABR23330 001-II-2
October 1977

# CONTINUOUS PHOTOPROCESSING FACILITIES

## OBJECTIVES

Describe the operating principles of a precision processing laboratory.

Identify the mission and organization of the Photographic Processing and Interpretation Facility (PPIF), WS-430B.

List the basic responsibilities of the Production Control Unit, the Imagery Interpretation Unit (II) and the Imagery Processing Unit (IP) within the WS-430B complex.

List the functions of the individual shelters contained in the WS-430B.

Identify the steps necessary for maintaining a mobility capability.

State the purpose of the Dual Basing Program.

Identify the major causes of corrosion within the WS-430B complex.

List the general responsibilities of all personnel assigned to a WS-430B complex in support of an effective corrosion control program.

Define the responsibilities of the OIC and the Logistics Officer in a WS-430B facility.

## INTRODUCTION

Once the reconnaissance information is recorded, it must be processed in order to be of value. Often the images lose value as time goes by, such as in an intense battle situation. At other events, there is more time for processing but the requirements for exactness and quality are extremely high. There are laboratories designed to handle any type of situation that might be required to gain the most valuable information from the reconnaissance mission.

Most Air Force photographic processing takes place in a reconnaissance unit. There are labs which support other photographic aspects of the Air Force mission, but most continuous photoprocessing personnel are assigned to a reconnaissance unit sometime during their career.

In any photographic laboratory, certain prescribed requirements must be met. Cleanliness and safety are two aspects which must always

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be considered. As work becomes more critical, and equipment more sophisticated, these two aspects become of primary importance. Also with the possibility of conflict, a world-wide capability is necessary.

At present the two main types of reconnaissance labs are the Precision Processing Lab (PPL) and the mobile Photographic Processing and Interpretation Facility (PPIF).

INFORMATION

## PRECISION PROCESSING LABORATORY

Strategic reconnaissance materials may account for a large volume of intelligence information within a relatively few square millimeters of image area. Any degradation of the image area may mean the loss of vital information. Even a tiny speck of dust or lint could hide valuable intelligence information. In recognition of this, the trend in strategic laboratories has for many years been toward a clean lab.

### Environmental Design

The largest single factor in achieving and maintaining an acceptable cleanliness level is the physical design of the work area. Since a great amount of strategic reconnaissance is high altitude, small format photography, it is usually done in a specifically designed, fixed facility. These are controlled areas designed to create a suitable environment for highly sophisticated and precise photographic equipment.

AIR CONDITIONING. Air conditioning will be of standard commerical design with thought given to dust particulate removal of one (1) micron. Where feasible, thought should be given to installing equipment capable of supplying enough air flow whereby high efficiency particulate air (HEPA) type filters could be installed if required. All air handling equipment will be run 24 hours a day.

PRESSURE DIFFERENTIAL. A pressure differential will be maintained at all times sufficient to prevent infiltration of contaminated air. (Air lock will be required.) Air handling unit will be designed to provide 5 - 10 air changes an hour.

AIR FILTRATION. Stage one will consist of a rough filter (washable or disposable type); 50 - 60percent (NSB). Second stage or final filter will be rated at 80 - 85 percent efficient at 1.0 micron and larger (disposable type).

TEMPERATURE TOLERANCE. Temperature in normal shop areas will not exceed 80°F (26°C) or drop below 70°F (21°C). If calibration type work is to be accomplished within controlled areas, limits will be 72°F (22°C) plus or minus 5°F (2.5°C). Temperature recorders shall be provided with a chart read-out.

HUMIDITY TOLERANCE. Humidity will be 40 percent plus or minus 10 percent unless otherwise noted. Humidity recorders shall be provided with chart read out. Photo labs will be 50 percent plus or minus 10 percent.

PARTICULATE COUNT TOLERANCE. Operational tolerance will be no more than 300,000 particles per cubic foot of air 0.5 microns or larger, no more than 72,000 particles per cubic foot of air 1.0 micron and larger, no more than 2,200 particles per cubic foot of air 5.0 microns and larger.

MONITORING. Contamination levels may be monitored by automatic light scattering equipment or by the manual method.

FLOOR. The floor will be finished with grease resistant material. Care must be taken to insure that permanent bond between floor covering and subfloor is made. All corners should be coved (rounded).

WALLS AND CEILING. Walls and ceiling will be painted or covered with material that can withstand constant cleaning. As with the floors, all corners should be rounded.

UTILITIES AND FIXTURES. Utilities and fixtures will be installed with the thought of cleaning in mind. Utilities will be recessed where possible and fixtures to be slim line and easily cleaned.

LIGHTING. Lighting will be designed to 100 foot candles (30.48 meter candles) at bench level. Where additional lighting is required, supplemental lighting will be provided, bench mounted.

Machinery

Machinery and equipment used in the clean lab should be kept to the minimum. It should be installed so that vibration is held to the minimum. Also, it should be located so that it is easily accessible for cleaning. Processing machines should be filled, replenished, and drained by a system of pipes installed to feed directly in and out of the machine. These pipes should not pass through the room. Wherever possible, all valves and switches should be located outside the area. Both white light and safelight illumination should enter the room through a translucent ceiling. These lighting fixtures should be serviced from catwalks above the ceiling.

Personal Hygiene

Personnel with skin or upper respiratory diseases will not be allowed to work in the clean room. Some examples of physiological problems that are detrimental to clean room operations are:

1. Allergies to synthetic fabric.

2. Allergies to type solvents being used in various clean rooms.

3. Profuse nasal discharge.

4. Skin conditions which result in above-normal skinshedding, dandruff, or skinflaking.

5. High amounts of acid found in the moisture of hands.

6. Severe nervous conditions, itching, scratching, or claustrophobia.

All personnel will receive periodic indoctrination on the importance of personal hygiene in clean room operations.

All clean room personnel will practice clean habits and observe regulations to maintain a healthy environment. Personnel with colds, temporary coughing and sneezing, and severe sunburn will be assigned to jobs outside the clean room until they are sufficiently recovered. Personnel will take all necessary precautions against receiving severe cases of sunburn. This precaution is necessary to prevent peeling skin from contaminating the area. The high degree of cleanliness required necessitates that the personnel develop the following habits:

1. Bathe daily.

2. Shampoo hair often and take action against heavy dandruff.

3. Wear clean under and outer garments to insure maximum cleanliness.

4. Avoid scratching or rubbing exposed areas of the body.

5. Wear gloves if hands are severely chapped.

6. Male personnel are to shave daily.

7. Personnel having sideburns or beards will wear a cover of some type. This can be either a face mask or hood with eye opening.

8. All large or busy mustaches must be covered or removed.

9. Keep hair confined under a cap, hood, or snood. The tuft of hair on the back of a person's neck that cannot be covered by a head piece (when properly worn) is acceptable. However, hair that is not covered on the front of the head at the foreline is not acceptable. If difficulty is encountered, a combination of cap, hood, or snood may be used.

Employee Discipline

The precision processing lab must be restricted to authorized individuals. Protective clothing must be used at all times and by all individuals entering the room. This clothing is not to be worn outside the clean room or in the contaminated section of the change room. Smoking and eating in the lab is forbidden. Paper material will not be allowed within the lab until an analysis has been made to determine its particulate count.

Employees' attitudes are of prime importance. They must be prepared to meet the challenges of the lab's work before being allowed to work in it. They are to consider everything but their immediate work area as being contaminated. Also, they should be able to recognize the common types of contamination (lint, paper chips, etc.). They will be advised to report any such contamination to their supervisor. They will also consider any work or tools dropped on the floor as being contaminated. Any work (or tools) which they consider to be contaminated will be reported to their supervisors. Lab personnel movement is to be restricted as much as possible to prevent the settled particulate matter on the floor from being stirred up.

Visitors

Visitors to the precision processing lab must observe all the rules which the employees must observe. This includes top management as well as supervisors.

Security

Because of the nature of photographic intelligence data, precision labs are usually highly sensitive areas. All materials must be handled in accordance with AFR 205-1. The plant, as well as all materials are given maximum protection. All personnel connected with the operation are required to have security clearances.

Maintenance and Inspection

Routine inspections usually made in photo labs become more critical in high acutity labs. They must be inspected frequently to insure the proper performance of the equipment. Furthermore, they must be made by personnel who are authorized access to the room. Also, servicing and alignment of equipment must be performed to precluded contamination. Detailed inspection check lists should be used and complete records of inspection and maintenance should be kept. Inspection reports should be certified by the inspector and given to the supervisor for review. Critical film should not be processed until the area and equipment are certified as completely operational. Otherwise, vital information might be lost. If new installations are made, or components of the equipment repaired, a sufficient number of trial runs must be made to guarantee

proper operation. All equipment used to produce the final product must be tested and certified before being used. If unsatisfactory conditions exist, they should be discovered before production work begins.

## Safety

Although every photographer knows the hazards of working in total darkness, it is well to reemphasize them here. When work is extremely critical, or when many hours of continuous work is required, it is natural for the worker to be under greater pressure than is normally experienced. Working with machinery in darkness does increase the possibility of accidents. Danger areas include gears, drives, and clutches of machinery, as well as electrical and electronic circuitry. Other danger areas exist in chemical mix and chemical analysis laboratories. However, work in these areas is carried out under normal room illumination.

## Adjacent Areas

The clean room in a high acuity lab is usually adjoining other work areas in which the environmental control is less stringent. More temperature and humidity latitude is allowed, and larger dust particles are tolerated. Outside the control area, perhaps only ordinary air conditioning will be necessary.

# THE WS-430B

Because of the ever-changing world situation and the vast commitments of the United States, a totally mobile processing facility is needed. The WS-430B fulfills this need.

## Mission

The WS-430B, Photographic Processing and Interpretation Facility (PPIF), provides tactical reconnaissance units with a self-contained capability to process, print and interpret tactical reconnaissance imagery. The WS-430B complex consists of 25 air-transportable units called shelters. The complex can be deployed worldwide in part or in whole. The operation of the facility is outlined in AFR 55-19, Organization, Operation and Management of the WS-430B.

## Organization

The basic function of the WS-430B is to process and exploit tactical reconnaissance imagery. All functions are directed toward the timely accomplishment of that end.

Figures 2-1, 2-2, and 2-3 show the organizational structure of the WS-430B required for imagery exploitation.

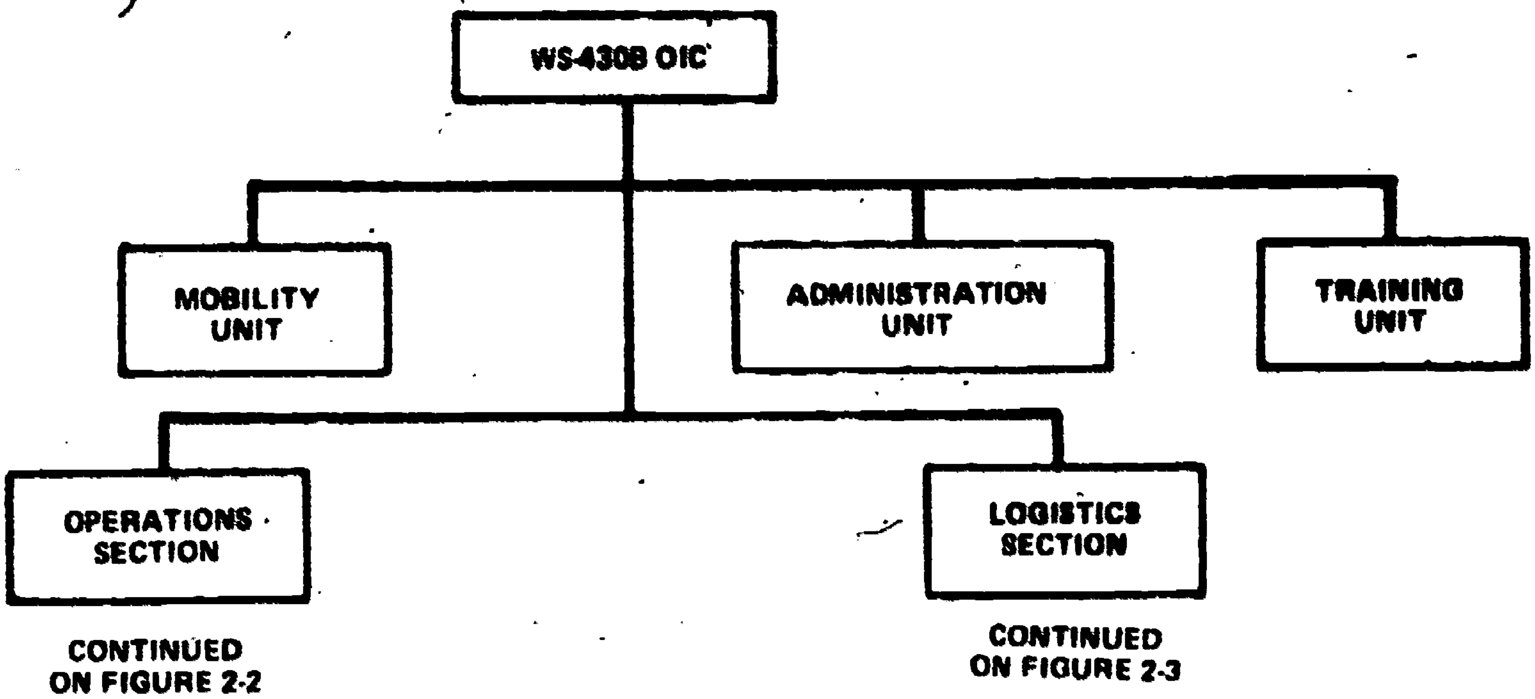


Figure 2-1. Organizational Structure of the WS-430B

OIC. The officer in charge of the WS-430B complex has a knowledge of processing and interpretation. He is directly responsible to the squadron commander for the operation and control of the complex.

MOBILITY, ADMINISTRATION AND TRAINING UNITS. The mobility section insures compliance with mobility manuals and operations plans. This section directs mobilization of the complex when it is to be deployed. The administration unit does all typing and controls classified documents. It also maintains required manuals, regulations and operational instructions. The training unit monitors all training programs in the complex. The personnel in this unit work with the squadron training NCO and section supervisors to comply with required training specified in AFR 55-19.

OPERATIONS SECTION. The operations section consists of a production control unit, the imagery processing unit and the imagery interpretation unit. The production control unit coordinates the work between the processing and interpretation units. More detail will be given to this section in another part of this SW.

LOGISTICS SECTION. The logistics section is basically in charge of the maintenance of the equipment in the complex. These personnel maintain the photographic systems, refrigeration, power, electrical systems, and plumbing in the complex.

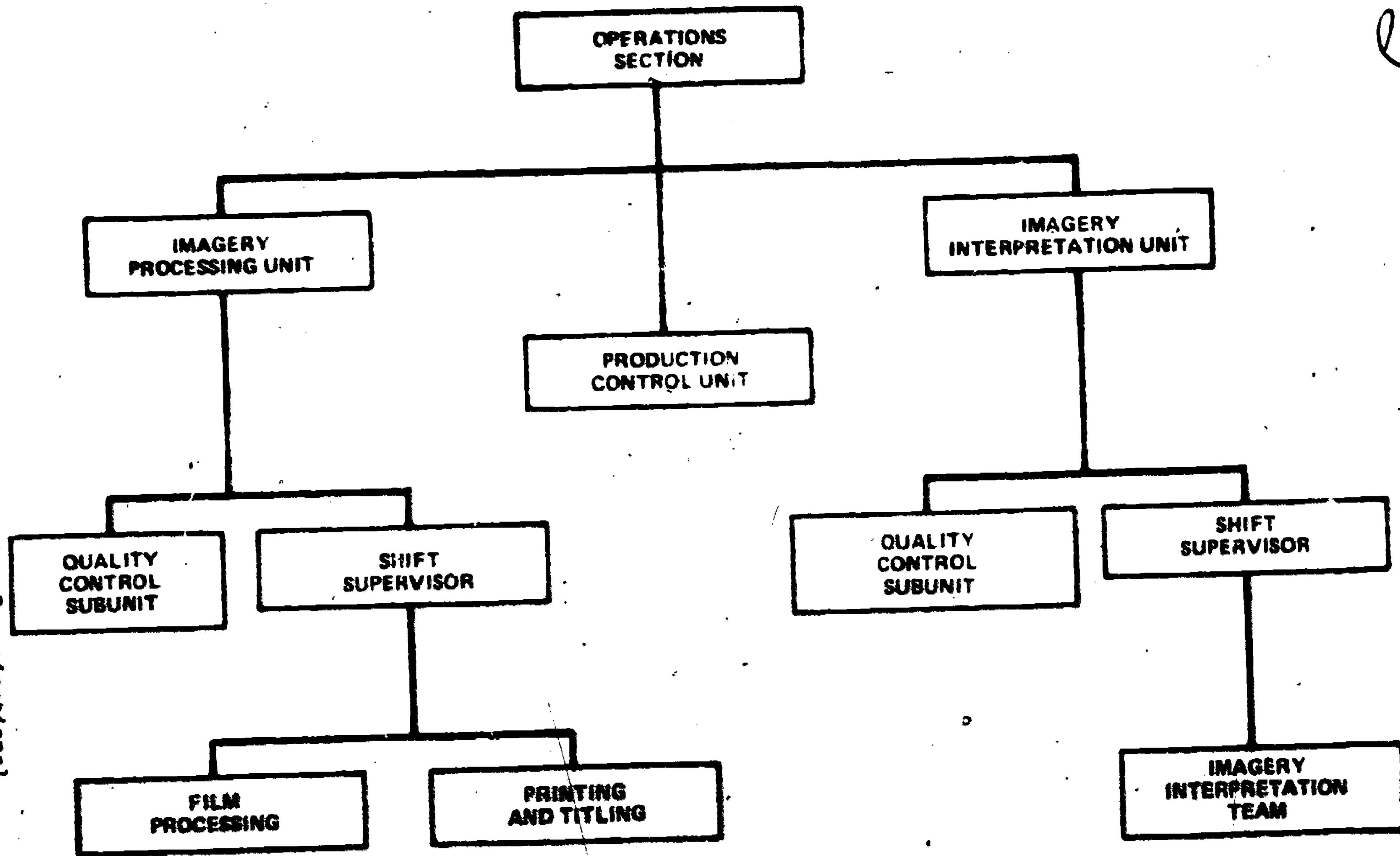


Figure 2-2. Operations Section Organizational Structure in a WS-430B

SW G3ABR3330 001-II-2

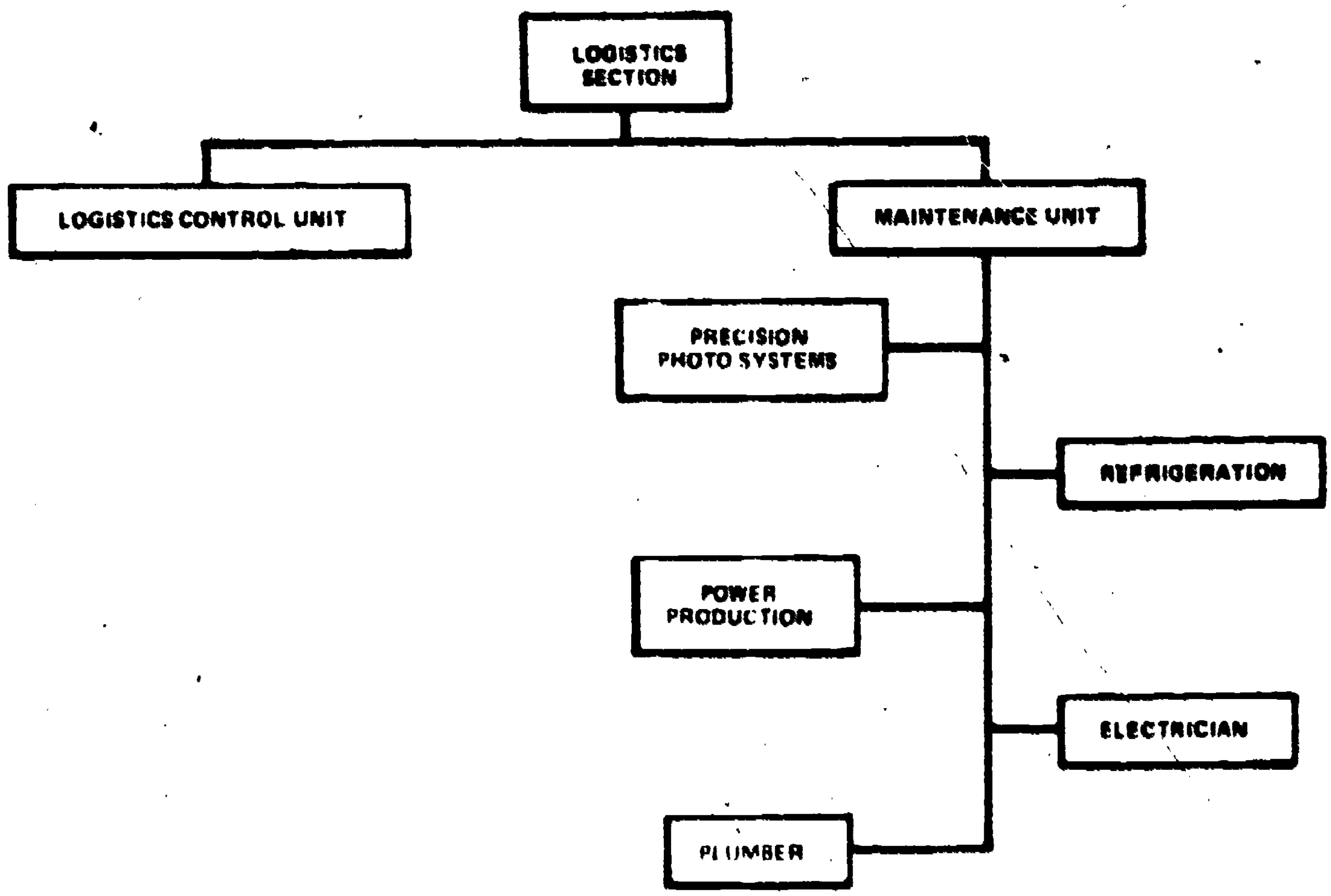


Figure 2-3. Organizational Structure of the Logistics Section of a WS-430B

## DETAILED FUNCTIONS OF THE OPERATIONS SECTION

### Production Control Unit

The production control unit has four main functions. These are production of the daily production/sortie log, record equipment status, logistics coordination, and corrosion control. The daily production/sortie log (AF Form 2598) is a permanent record of the mission as the film moves through processing and printing. The production control unit maintains a record of each roll of film, the time it entered the lab, where it is in production, and its due out time.

The production control unit keeps a record of each piece of equipment and its functional status. When maintenance is needed for any piece of equipment, the production control unit coordinates with the logistics section for the maintenance. It also works with logistics to insure adequate supplies. The unit monitors corrosion control (along with the maintenance unit) and schedules maintenance on corroded units according to mission requirements.

### Imagery Processing Unit

The imagery processing unit has the responsibility of film processing, printing, titling, and quality control. The personnel assigned to this section process the mission film and clean it. They also make reproductions of the film and control quality to the limitations of the WS-430B complex.

### Imagery Interpretation Unit

Personnel in the imagery interpretation unit examine images on aerial photography and airborne sensors. They identify objects and deduce their significance. The timely and accurate reporting of intelligence information taken from the imagery is the primary mission of this unit.

## DESCRIPTION OF SHELTERS

Each shelter in the WS-430B complex is designed to perform a specific function and to contain certain pieces of equipment. In addition, each unit is designated by a number. Each unit has an assigned location as well. (See fig. 2-4.)

### Expandable Final Edit and Inspection Labs, ES-60B and ES-61B

The ES-60 and ES-61 shelters provide the work space and equipment required for final editing and inspection of film which has been processed and printed in the facility's other laboratories. The ES-60B and ES-61 laboratories also serve as the central access to the remainder of the facility and as central control points for power distribution to specific areas of the facility. In addition, they provide storage space, administrative areas, and personnel rest areas. The ES-60B laboratory also functions as a command post for the facility.

### Continuous Processing Lab, ES-59A

The ES-59A shelter provides the primary roll-film and paper processing capability of the facility and can be used separately to fulfill a similar need at a remote site if required. In all, a total of six ES-59A laboratories are used in a complete facility (three in each half-facility). Processing is done in a Versamat Model 11CMW Film Processor.

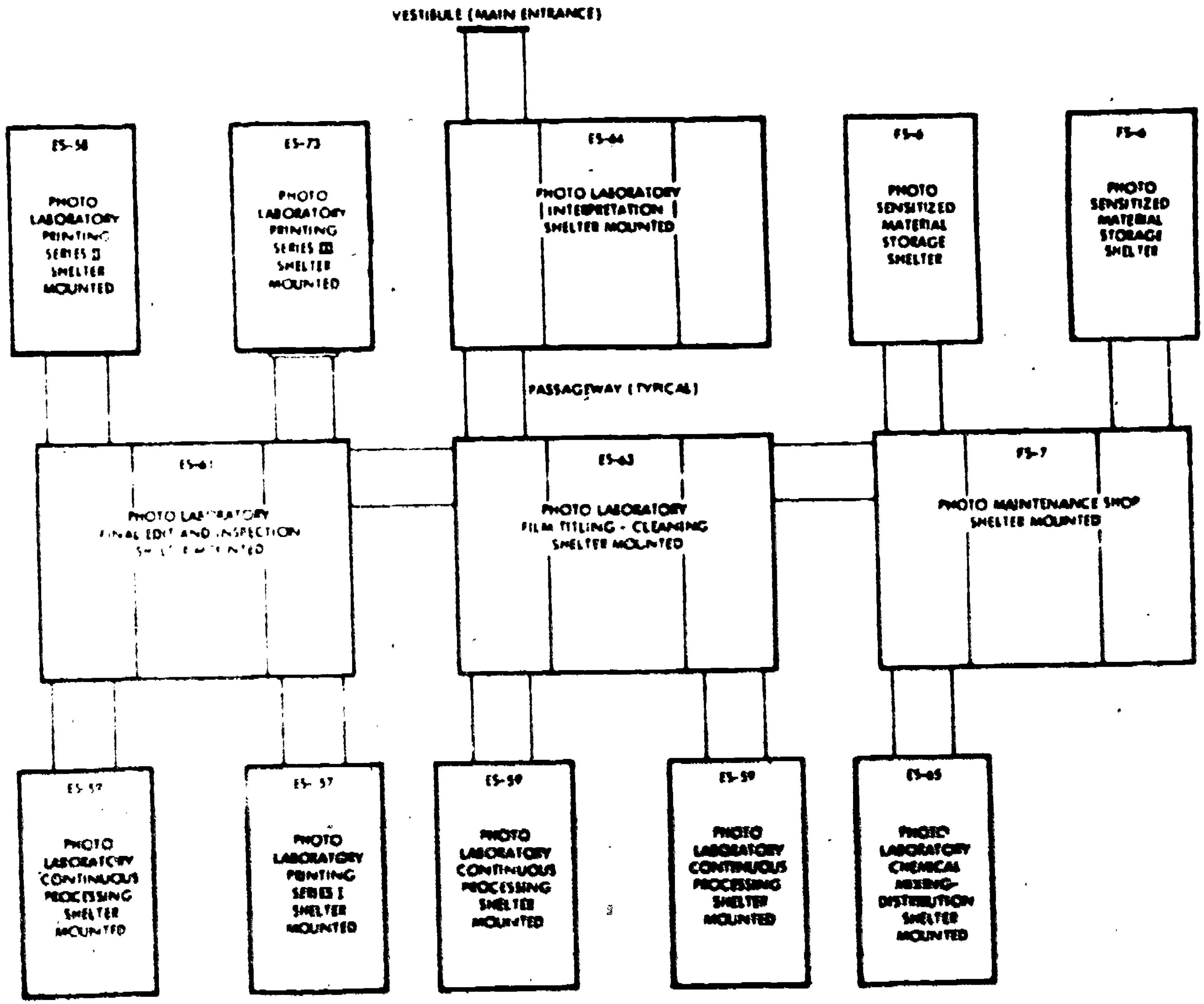


Figure 2-4. PPIF Facility Layout and Arrangement
(One-Half of a Complex)

Expandable Film Titling and Cleaning Lab, ES-63A

The ES-63A shelter provides the equipment and controlled environment necessary for film titling operations and for production control of photographic film processed in the facility. In addition, the ES-63A laboratory includes film cleaning equipment and permits interim storage of in-process film.

Expandable Interpretation Lab, ES-64A

The ES-64A shelter provides the needed capabilities for support of normal tactical interpretation functions. Specifically, the laboratory is used in initial screening, detailed interpretation, indexing, and plotting of tactical reconnaissance information. It also provides a capability for storage of maps and other related data as required. A security file (safe) is included in these storage provisions. In normal situations, an ES-64A laboratory is installed in and used with each half of a facility. The laboratory is also capable of operation as a unit, independent of the facility. In such remote applications, only its connection to an electrical power source is required for normal operation of the laboratory.

Series I Printing, ES-57D

The ES-57D shelter has capabilities for both continuous and step-and-repeat printing. Film to be printed here is normally processed in one of the ES-59A shelters. Continuous contact printing is done on the EN-6A(2) printer and manual contact printing is done on the EN-22 printer. Step-and-repeat printing is done on a Mark IIR5 printer.

Series II Printing, ES-58D

The ES-58D shelter has the capabilities of producing projection prints. It is divided into a darkroom and a finishing room. Printing is accomplished on an EN-52A projection printer. A sink, print washer and print dryer are also provided.

Series III Printing, ES-73A

A Niagara Continuous Contact Printer provides the highspeed continuous printing capabilities of the ES-73A shelter. The Niagara is the major piece of equipment in this lab, but it also has work space and film storage facilities. Although designed for use with the entire WS-430B complex, this unit can be used separately at a remote site when electrical power is provided.

Chemical Mixing and Distribution Lab, ES-65A

The ES-65A shelter provides a capability for mixing, temporary storage, and distribution of the developer and fixer solutions required

in the facility for normal film processing. The laboratory also includes
provisions for mixing and storage of chemical solutions required by the
radar film correlator-processor(s) sometimes installed in one or more of
the facility's ES-59A laboratories. Correlator-processor chemicals
would, however, have to be handcarried to the ES-59A laboratories,
whereas the chemical solutions for normal film processing can be dis-
tributed by the facility chemical supply system. Two ES-65A laboratories
are normally installed in a complete facility: one in each half-
facility. Each ES-65A laboratory normally services the three ES-59A
laboratories in its half of the facility.

Major elements of the ES-65A laboratory include four Pako Hydro-
mixers; two mixing valves (one for each two hydromixers); two plastic,
five-gallon mixing and storage tanks for the correlator-processor
chemicals; and a portable mixer for utility purposes.

Sensitized Materials Storage Shelter, FS-6A

The FS-6A provides refrigerated storage space for the photographic
materials. Up to 4000 pounds (118 kg) of material can be stored in this
shelter. Materials can be transported in this shelter if precondition-
ing is given to them but only for certain specified times. This shelter
can be used by itself when electrical power is supplied.

Expandable Maintenance Shelter, FS-7A

The FS-7A photographic maintenance shop contains the tools and
associated equipment required for maintenance of the various laboratories
and related facility-level interconnect equipment. The shop also includes
storage provisions for necessary maintenance equipment, records, and
spare parts. In addition, the shop includes an air compressor and tank
which serves as the compressed air source for facility's "wet shelter"
laboratories. It also serves as an electrical power control and distri-
bution center for the ES-65A laboratory and for the FS-6A storage
shelters in that half-facility of which the shop is a part. Although
normally used as part of a WS-430B facility (one shop in each half-
facility), the FS-7A maintenance shop can also be used as an independent
unit, if desired. In such an application, only connection of electrical
power to the shop is required for normal operation.

MOBILITY

The WS-430B complex must be maintained in a high state of readi-
ness. The complex must be ready to deploy anywhere in the world at any
time. Because of this requirement, personnel must be ready to dis-
assemble, help deploy and reassemble the complex wherever needed.

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Deployment Preplanning

In or'er to deploy at any time, plans must be made in advance of any situation. Recall rosters must be up-to-date so personnel can be notified to report to the complex at once. As the shelters are being disassembled, these personnel must also be out-processed. In addition, the transportation squadron must supply the needed equipment. As each shelter is made ready and the transportation is made available, checklists must be kept to insure proper handling of the shelters.

The other preplanning step is for a person knowledgeable of WS-430B's to survey the new site for the complex.

Mobility Responsibilities

The WS-430B OIC has overall responsibility for mobility. He attends all deployment briefings and gathers as much information as possible concerning the deployment. The NCOIC is responsible for supervising all portions of a mobility exercise or actual deployment. He reviews all procedures and checklists for accuracy, completeness, and compliance with directives. He coordinates all deployment activities and resolves problems.

The mobility NCO is responsible for developing mobility procedures and checklists for any operational requirement. He assigns personnel to mobility crews, sets up personnel processing schedules and maintains a status roster for personnel immunizations. Each packing and mobilizing team chief is responsible for seeing that each shelter is packed, inspected and marshalled on time. He insures that crews have the proper tools and e pment for mobilizing the shelters.

The maintenance NCO monitors the mobilization of the electrical generators and supervises maintenance personnel in disconnecting power and intercom cables and water, drain, and air lines. The area marshalling coordinator controls the WS-430B area checkpoint. As equipment passes this area, it is checked off on copies of the load lists.

The final inspector insures that shelters have been properly placed. He signs appropriate forms certifying this action. The WS-430B NCOIC or a designated alternate is the final inspector.

Facility Preparation and Stepup

Upon arrival at the deployment site some preparation and planning is necessary before setup begins. Some considerations are the source of water, drain point, power sources, surface conditions, and the number of shelters deployed. After the plans are made, the shelters are moved to the site. The shelters are placed on the site in the proper sequence and order. Finally, the shelters are connected to the power, intercom, water, drain, and air lines.

## Mobility Exercises

In order for all personnel to be ready for instant deployment, each WS-43QB complex will exercise a deployment at least once each year. This means that the complex is mobilized and reassembled at least once each year. In addition, the personnel must process actual mission or previously exposed film during any such exercise.

## THE DUAL BASING PROGRAM

The concept of dual basing means that a squadron which is physically assigned to one location supports another command in a different location other than their home base. This means that a stateside unit will be ready to move to an overseas base to support the mission of that base.

The purpose of this program is to support US commitments to European allies. No special training is required for photographic personnel except that they must remain proficient in mobilizing shelters.

## CORROSION CONTROL

Because of the large amount of metal used to construct the WS-430B complex, corrosion is a constant problem. The two main causes of corrosion are climatic conditions and the use of corrosive chemicals.

### Climatic Conditions

The metal in the WS-430B complex is highly affected by weather. Not only does rain and humidity affect outside portions of the facility, but personnel tracking in water contribute to corrosion inside the units. When the complex is located in a humid climate, corrosion becomes an even bigger problem than when it is located in a dry climate.

### Corrosive Chemicals

The main source of corrosion is the chemical laden atmosphere inside the wet processing facilities and water splash from cleaning attempts. The chemicals used in photography are highly corrosive. Special care must be taken to insure that all chemical leaks and spills are properly cleaned up.

### Identification

No corrosion control program can work without the full cooperation of all personnel. Everyone must constantly be aware of the formation of corrosion. The people most likely to notice corrosion build up will be those individuals who work daily in a particular shelter. Those personnel in the wet processing shelters must continually watch for any signs of corrosion since it is more likely to occur there.

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## Correction

Correction must be made quickly to any corroded area before the problem accelerates. If allowed to remain, the corrosion can cause major damage to the shelter thus hindering the mission of the complex. Report any signs of corrosion immediately to a supervisor. Do not wait for periodic maintenance or an inspection. It may be too late then.

## Prevention

There are two [illegible] steps in [illegible] corrosion according to AFR 55-19. The first is to reduce the concentration of corrosive vapors. To do this, a ventilating fan is [illegible] over chemical tanks and the air conditioning does not [illegible] only fresh outside air. The other step is to [illegible] coating on surfaces that might corrode. Also, clean the shelter often but do not splash water on equipment. Keep the floors dry.

# THE OIC AND THE LOGISTICS OFFICER

Of the many personnel [illegible] WS-430B complex, two of the most important are the [illegible] (OIC) and the logistics officer.

## OIC Responsibilities

Many responsibilities of the [illegible] have already been mentioned. He is directly responsible [illegible] operation of the WS-430B complex. He also has the prime responsibility for mobility. His duties include coordination of all functions between operations and logistics as well as the other units in the complex, as they apply to the mission of the squadron.

## Logistics Officer Responsibilities

The OIC is responsible [illegible]. He manages this area through the logistics [illegible] officer is responsible to the WS-430B OIC for the effective management of all maintenance and logistics support for the facility. He is assigned maintenance and logistics control unit to fulfill these responsibilities.

# THE ES-85 COMPLEX

The WS-430B complex provides a mobile capability for processing reconnaissance films, but is not designed to process motion picture film. The ES-85 complex is designed to give the Air Force the same mobile capability with a motion picture laboratory.

The ES-85 complex consists of eight shelters. These shelters can be air lifted or moved by sea or ground transportation. The facility is

used for tactical strike photography support. The facility's mission is to produce motion pictures of strike photography as soon as possible after the aircraft has landed. This film (commonly called gun-camera film) is used to brief the combat crews. Color and black-and-white motion pictures can be processed and printed in this facility.

QUESTIONS

DO NOT WRITE IN THIS SW, USE A SEPARATE SHEET OF PAPER.

1. What is the largest single factor in achieving and maintaining an acceptable level of cleanliness in a photographic laboratory?

2. How many shelters are in a complete WS-430B complex?

3. Which unit in the WS-430B complex directs mobilization of the complex when it is deployed?

4. Which shelter can perform continuous and step-and-repeat printing?

5. What are the duties of the NCOIC of the WS-430B complex during a mobility exercise?

6. What special training is required for photographic personnel concerning the dual basing program?

7. What is the main source of corrosion in the WS-430B?

8. What can be the results of not reporting corrosion immediately?

9. What are the two main steps in prevention of corrosion in the WS-430B?

10. Who has the prime responsibility for mobilization in the WS-430B?

11. Describe the operating principles of a precision processing laboratory.

EXERCISES

Exercise 1

PROCEDURES

1. List on paper six examples of physiological problems that are detrimental to clean room operations.

2. Write the mission of the WS-430B on paper.

3. List the basic responsibilities of the Production Control Unit.

4. List the basic responsibilities of the Imagery Interpretation Unit.

5. List the basic responsibility of the Imagery Processing Unit.

6. Match the WS-430B shelter in column A with the phrase in column B that describes the unit, its function or equipment it contains.

| Column A | Column B |
|---|---|
| ES-59A | 1. Can produce projection prints. |
| ES-73A | 2. Contains an EN-22A printer. |
| ES-57D | 3. Provides primary roll-film and paper processing. |
| ES-6A | 4. Provides refrigerated storage space. |
| | 5. Contains the Niagara printer. |

7. List the steps for maintaining a mobility capability.

8. Write the purpose of the dual basing program.

9. Write two major causes of corrosion in the WS-430B complex.

10. List the three general responsibilities of all personnel assigned to a WS-430B complex in supporting an effective corrosion control program.

11. Write the main responsibilities of the OIC and the Logistics officer in a WS-430B.

Sciences Branch
Lowry Air Force Base, Colorado

SW G3ABR23330 001-II-3
October 1977

# MATHEMATICS USED IN PHOTOGRAPHY

## OBJECTIVE

Given photographic related math problems and log tables, solve 80 percent of the problems correctly.

## INTRODUCTION

At first thought, it may seem unnecessary or even useless to study math in a photography field. However, upon closer examination, one will see that many common every day functions in photography are based on mathematical principles.

Measuring chemical characteristics, determining development time, and measuring negative densities are all based on mathematical functions.

## INFORMATION

### MATHEMATICS REVIEW

This section is intended as a basic review of mathematics with an emphasis on those functions used most often in photography. Depending on your background, this may be a simple review, but be aware that most mistakes are made by carelessness during these basic operations.

Accuracy is most important. A wrong answer has no value. In fact, a wrong answer can be worse than no answer at all, if it causes you to damage valuable mission film. Learn the mathematical processes so that accuracy and speed become standards for you.

#### Basic Arithmetic

There are four fundamental operations in arithmetic: addition, subtraction, multiplication, and division. All other arithmetical operations are either derived from one of these four or a combination of two or more of them. You may know all of these operations, but in a precision laboratory even the simple things should be reexamined with a view toward improvement.

ADDITION. Addition is the operation of finding the sum of two or more numbers. When adding several numbers, place the numbers in a vertical column so that the decimal points are all in the same vertical line. Be sure to do this accurately. If no decimal point is indicated, the point is assumed to follow the last digit to the right. Be

especially careful that the operation of carrying is accomplished. Failure to do this, other than incorrect addition, is probably the most common error.

When adding, be careful that all numbers are in like units. Almost all numbers which arise in practical arithmetic are concerned with definite amounts such as a 100 feet, 25 miles, 10 milliliters and so on. These are called units. In addition, all the units must be the same.

SUBTRACTION. This is the operation of finding the difference between two numbers. As in addition, it is necessary to subtract like units. Once again, it is important that decimal points be properly aligned. Be especially careful during any "borrowing" process.

Subtraction is a simple process and because of this simplicity, errors can be made through carelessness. In a precision photography lab, these errors could prove disastrous. With this in mind, it would pay to reexamine your own methods with a view toward improving them, if necessary.

MULTIPLICATION. This is probably the most common process used in arithmetic. It is a short method of adding a number to itself as many times as indicated. The numbers which are to be multiplied are called the multiplicand and the multiplier. The answer is called the product. In the expression 7 times 3 equals 21 7 is the multiplicand, 3 the multiplier, and 21 the product.

Be sure to locate the decimal point at the proper position. When there are decimal points in the multiplicand, multiplier or both, they are ignored until the final product is obtained. To place the decimal point in the final product, count off the number of digits to the right of the decimal point in both the multiplicand and the multiplier. Next, count from right to left in the product for an equal number of digits and insert the decimal point.

Unlike addition and subtraction, multiplication of different units can be performed. However, not just any or all units can be multiplied. There must be a relationship between them such as watt-seconds, feet per minute, man-hours, etc.

DIVISION. This operation is the reverse of multiplication. It is the process of finding how many times one number is contained in another. The number to be divided is called the dividend and the number by which it is to be divided is the divisor. The answer is the quotient. In the expression 8 divided by 4 equals 2, 8 is the dividend, 4 the divisor and 2 the quotient.

Correct placement of the decimal point is as important in division as in any other process. If decimals are present in either the divisor or the dividend, it will become necessary to place the decimal in its

proper place in the quotient. To do so, move the decimal in the divisor to the extreme right of the last figure in the divisor. Then move the decimal point in the dividend to the right of its present location the same number of places. (It may be necessary to add zeros to the right of the dividend in order to place the decimal correctly.) The decimal in the quotient will now be in a direct line with the new position of the decimal in the dividend.

Another time that decimals are encountered in division is in dealing with remainders. It is very uncommon in division to have the divisor go into the dividend exactly even. When this happens, a remainder is indicated. Most often the remainder is indicated as a decimal. To do this, zeros are added to the right of the dividend and division is continued three to four more places. This many places is usually sufficient for most photographic problems.

Signed Numbers

The sign before a number merely indicates whether the number is positive (greater than zero) or negative (less than zero). One must not confuse the sign before a number with the functional signs of addition (+) and subtraction (-) even though they look identical. Solving the problem 4 minus 3 will give a much different answer than will the problem 4 minus -3. The first will be 1 while the second will be 7.

LIKE SIGNS. When adding numbers with like signs, that is, all are positive or all are negative, the sum will have the same sign as the numbers that are added together.

To subtract numbers with like signs, first change the sign of the bottom number. If it is positive change it to negative and if it is negative change it to positive. Second, find the difference between the numbers and third, give the answer the sign of the larger of the two numbers.

The rule in multiplication is very simple. When numbers of like signs are multiplied together, the product is always positive. Similarly, when numbers of like signs are divided, the quotient is always positive.

UNLIKE SIGNS. Addition with unlike signs (one number is positive and the other is negative) is similar to subtraction of like signs. Find the difference between the two numbers and then give the answer the sign of a larger of the two numbers.

To subtract numbers of unlike signs, change the sign of the bottom number. Then add the numbers following the rule given for addition of like signs.

Once again, multiplication and division rules are easy. If numbers of unlike signs are multiplied or divided, the answer will always be negative.

Here are some examples:

| | Like Signs | | Unlike Signs | |
|---|---|---|---|---|
| addition: | 4 | -4 | -4 | 4 |
| | 3 | -3 | -3 | -3 |
| | 7 | -7 | -1 | 1 |
| Subtraction: | 4 | 4 | -4 | 4 |
| | 3 | -3 | 3 | -3 |
| | 1 | -1 | -7 | 7 |
| Multiplication: | 4 x 3 = 12 | | -4 x 3 = -12 | |
| | -4 x -3 = 12 | | 4 x -3 = 12 | |
| Division: | 12 ÷ 4 = 3 | | -12 ÷ 4 = -3 | |
| | -12 ÷ -4 = 3 | | 12 ÷ -4 = -3 | |

## Logarithms

Of all the mathematical processes, the use of logarithms is the one most often used in photography. Exactly how they are used will be taught later in this block; but first a working knowledge of logarithms must be learned.

A logarithm is simply the number of times that a number must be multiplied by 10 to equal a given number. Stated another way, a logarithm is the exponent, or power, to which a number must be raised in order to equal a given number. To understand this better, examine the following chart.

| Given Number | Powers of Ten | Logarithm |
|---|---|---|
| 10,000 | $10^4$ | 4.000 |
| 1,000 | $10^3$ | 3.000 |
| 100 | $10^2$ | 2.000 |
| 10 | $10^1$ | 1.000 |
| 1 | $10^0$ | 0.000 |
| 0.1 | $10^{-1}$ | $\bar{1}.000$ |
| 0.01 | $10^{-2}$ | $\bar{2}.000$ |
| 0.001 | $10^{-3}$ | $\bar{3}.000$ |
| 0.0001 | $10^{-4}$ | $\bar{4}.000$ |

All of the above are exact powers of ten. However, logarithms can be used to equal any number. In this case the digits to the right of the decimal point will not be zero as they are in the chart. Instead, they will be a set of digits found on a logarithm chart.

For those numbers that are not exact powers of ten, the logarithm consists of two parts. The part to the left of the decimal is called the characteristic and the part to the right of the decimal is the mantissa. For example, the log of 595 is 2.7745. The characteristic is 2 and the mantissa is .7745. The characteristic is found by inspection and the mantissa is found from a log table.

CHARACTERISTIC. The characteristic tells which power of ten is used. It is determined by the placement of the decimal in the given number. The characteristic can be found by following the following rules.

When the given number is a whole number or a whole number and a decimal fraction, the characteristic will be positive and will be one LESS than the number of figures to the LEFT of the decimal point in the given number.

| | | |
|---|---|---|
| Whole number | 687 | Characteristic 2 |
| Whole number and fraction | 687.42 | Characteristic 2 |

(NOTE: If a given number is between 1 and 10, the characteristic will be zero.)

When the given number is a decimal fraction, the characteristic will be negative and will be one MORE than the number of zeros between the decimal point and the first significant figure in the given number.

| | | |
|---|---|---|
| Decimal fraction | .4820 | Characteristic $\bar{1}$ |
| Decimal fraction | .00395 | Characteristic $\bar{3}$ |

MANTISSA. The mantissa denotes the digits in the number. The mantissa is found in a logarithm table. Numbers which have the same digits in the same order but only differ in the position of the decimal have the same mantissa. The mantissa for 595 is .7745 and the mantissa of 59.5 is also .7745. The logarithms will differ only in their characteristics.

Regardless of the sign of the characteristic, the mantissa is always positive.

To find the logarithm of a number, first determine the characteristics by using the above rules. Next, find the mantissa from the table. (Ignore the decimal place temporarily.) In the logarithm table, (see fig. 3-1) the left-hand column contains the first two digits of the numbers whose mantissas are given in the table, and the top row contains the third digit. Thus, to find the mantissa of 595, find 59 in the left-hand column and 5 at the top. In the column under 5, and opposite 59, is 7745, the mantissa. (This is similar to using a mileage chart on a road map.) Therefore, following the rules for finding the characteristic and the log table for the mantissa, the log of 595 would be 2.7745.

This means that $10^{2.7745}$ equals 595. Another way of expressing this is log 595 = 2.7745.

ANTILOGS. To find the number that corresponds to the logarithm, you perform a reverse operation. This is called finding the antilogarithm or antilog.

Looking in the body of the common logarithm tables you note that the four-digit figures (the mantissas) increase from the left to right, line by line, down the page, and from page to page. To find the antilog 1.7582, the mantissa, or .7582, is located and found to be line 57 under column "N," to the left, and under column 3. Therefore, the digits in the number are 573. Since the characteristic of the log is 1, there must be two digits preceding the decimal point in the number. Therefore, the number is 57.3. To determine the location of the decimal point, reverse the rule for finding a characteristic. That is, the number must be a whole number, having one more digit to the left of the decimal point than the value of the characteristic.

After the antilog has been found, the decimal must be placed in the proper place. To accomplish this, observe the following rules.

# Common Logarithms

| N | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 0000 | 0043 | 0086 | 0128 | 0170 | 0212 | 0253 | 0294 | 0334 | 0374 |
| 11 | 0414 | 0453 | 0492 | 0531 | 0569 | 0607 | 0645 | 0682 | 0719 | 0755 |
| 12 | 0792 | 0828 | 0864 | 0899 | 0934 | 0969 | 1004 | 1038 | 1072 | 1106 |
| 13 | 1139 | 1173 | 1206 | 1239 | 1271 | 1303 | 1335 | 1367 | 1399 | 1430 |
| 14 | 1461 | 1492 | 1523 | 1553 | 1584 | 1614 | 1644 | 1673 | 1703 | 1732 |
| 15 | 1761 | 1790 | 1818 | 1847 | 1875 | 1903 | 1931 | 1959 | 1987 | 2014 |
| 16 | 2041 | 2068 | 2095 | 2122 | 2148 | 2175 | 2201 | 2227 | 2253 | 2279 |
| 17 | 2304 | 2330 | 2355 | 2380 | 2405 | 2430 | 2455 | 2480 | 2504 | 2529 |
| 18 | 2553 | 2577 | 2601 | 2625 | 2648 | 2672 | 2695 | 2718 | 2742 | 2765 |
| 19 | 2788 | 2810 | 2833 | 2856 | 2878 | 2900 | 2923 | 2945 | 2967 | 2989 |
| 20 | 3010 | 3032 | 3054 | 3075 | 3096 | 3118 | 3139 | 3160 | 3181 | 3201 |
| 21 | 3222 | 3243 | 3263 | 3284 | 3304 | 3324 | 3345 | 3365 | 3385 | 3404 |
| 22 | 3424 | 3444 | 3464 | 3483 | 3502 | 3522 | 3541 | 3560 | 3579 | 3598 |
| 23 | 3617 | 3636 | 3655 | 3674 | 3692 | 3711 | 3729 | 3747 | 3766 | 3784 |
| 24 | 3802 | 3820 | 3838 | 3856 | 3874 | 3892 | 3909 | 3927 | 3945 | 3962 |
| 25 | 3979 | 3997 | 4014 | 4031 | 4048 | 4065 | 4082 | 4099 | 4116 | 4133 |
| 26 | 4150 | 4166 | 4183 | 4200 | 4216 | 4232 | 4249 | 4265 | 4281 | 4298 |
| 27 | 4314 | 4330 | 4346 | 4362 | 4378 | 4393 | 4409 | 4425 | 4440 | 4456 |
| 28 | 4472 | 4487 | 4502 | 4518 | 4533 | 4548 | 4564 | 4579 | 4594 | 4609 |
| 29 | 4624 | 4639 | 4654 | 4669 | 4683 | 4698 | 4713 | 4728 | 4742 | 4757 |
| 30 | 4771 | 4786 | 4800 | 4814 | 4829 | 4843 | 4857 | 4871 | 4886 | 4900 |
| 31 | 4914 | 4928 | 4942 | 4955 | 4969 | 4983 | 4997 | 5011 | 5024 | 5038 |
| 32 | 5051 | 5065 | 5079 | 5092 | 5105 | 5119 | 5132 | 5145 | 5159 | 5172 |
| 33 | 5185 | 5198 | 5211 | 5224 | 5237 | 5250 | 5263 | 5276 | 5289 | 5302 |
| 34 | 5315 | 5328 | 5340 | 5353 | 5366 | 5378 | 5391 | 5403 | 5416 | 5428 |
| 35 | 5441 | 5453 | 5465 | 5478 | 5490 | 5502 | 5514 | 5527 | 5539 | 5551 |
| 36 | 5563 | 5575 | 5587 | 5599 | 5611 | 5623 | 5635 | 5647 | 5658 | 5670 |
| 37 | 5682 | 5694 | 5705 | 5717 | 5729 | 5740 | 5752 | 5763 | 5775 | 5786 |
| 38 | 5798 | 5809 | 5821 | 5832 | 5843 | 5855 | 5866 | 5877 | 5888 | 5899 |
| 39 | 5911 | 5922 | 5933 | 5944 | 5955 | 5966 | 5977 | 5988 | 5999 | 6010 |
| 40 | 6021 | 6031 | 6042 | 6053 | 6064 | 6075 | 6085 | 6096 | 6107 | 6117 |
| 41 | 6128 | 6138 | 6149 | 6160 | 6170 | 6180 | 6191 | 6201 | 6212 | 6222 |
| 42 | 6232 | 6243 | 6253 | 6263 | 6274 | 6284 | 6294 | 6304 | 6314 | 6325 |
| 43 | 6335 | 6345 | 6355 | 6365 | 6375 | 6385 | 6395 | 6405 | 6415 | 6425 |
| 44 | 6435 | 6444 | 6454 | 6464 | 6474 | 6484 | 6493 | 6503 | 6513 | 6522 |
| 45 | 6532 | 6542 | 6551 | 6561 | 6571 | 6580 | 6590 | 6599 | 6609 | 6618 |
| 46 | 6628 | 6637 | 6646 | 6656 | 6665 | 6675 | 6684 | 6693 | 6702 | 6712 |
| 47 | 6721 | 6730 | 6739 | 6749 | 6758 | 6767 | 6776 | 6785 | 6794 | 6803 |
| 48 | 6812 | 6821 | 6830 | 6839 | 6848 | 6857 | 6866 | 6875 | 6884 | 6893 |
| 49 | 6902 | 6911 | 6920 | 6928 | 6937 | 6946 | 6955 | 6964 | 6972 | 6981 |
| 50 | 6990 | 6998 | 7007 | 7016 | 7024 | 7033 | 7042 | 7050 | 7059 | 7067 |
| 51 | 7076 | 7084 | 7093 | 7101 | 7110 | 7118 | 7126 | 7135 | 7143 | 7152 |
| 52 | 7160 | 7168 | 7177 | 7185 | 7193 | 7202 | 7210 | 7218 | 7226 | 7235 |
| 53 | 7243 | 7251 | 7259 | 7267 | 7275 | 7284 | 7292 | 7300 | 7308 | 7316 |
| 54 | 7324 | 7332 | 7340 | 7348 | 7356 | 7364 | 7372 | 7380 | 7388 | 7396 |
| 55 | 7404 | 7412 | 7419 | 7427 | 7435 | 7443 | 7451 | 7459 | 7466 | 7474 |
| 56 | 7482 | 7490 | 7497 | 7505 | 7513 | 7520 | 7528 | 7536 | 7543 | 7551 |
| 57 | 7559 | 7566 | 7574 | 7582 | 7589 | 7597 | 7604 | 7612 | 7619 | 7627 |
| 58 | 7634 | 7642 | 7649 | 7657 | 7664 | 7672 | 7679 | 7686 | 7694 | 7701 |
| 59 | 7709 | 7716 | 7723 | 7731 | 7738 | 7745 | 7752 | 7760 | 7767 | 7774 |
| 60 | 7782 | 7789 | 7796 | 7803 | 7810 | 7818 | 7825 | 7832 | 7839 | 7846 |
| 61 | 7853 | 7860 | 7868 | 7875 | 7882 | 7889 | 7896 | 7903 | 7910 | 7917 |
| 62 | 7924 | 7931 | 7938 | 7945 | 7952 | 7959 | 7966 | 7973 | 7980 | 7987 |
| 63 | 7993 | 8000 | 8007 | 8014 | 8021 | 8028 | 8035 | 8041 | 8048 | 8055 |
| 64 | 8062 | 8069 | 8075 | 8082 | 8089 | 8096 | 8102 | 8109 | 8116 | 8122 |
| 65 | 8129 | 8136 | 8142 | 8149 | 8156 | 8162 | 8169 | 8176 | 8182 | 8189 |
| 66 | 8195 | 8202 | 8209 | 8215 | 8222 | 8228 | 8235 | 8241 | 8248 | 8254 |
| 67 | 8261 | 8267 | 8274 | 8280 | 8287 | 8293 | 8299 | 8306 | 8312 | 8319 |
| 68 | 8325 | 8331 | 8338 | 8344 | 8351 | 8357 | 8363 | 8370 | 8376 | 8382 |
| 69 | 8388 | 8395 | 8401 | 8407 | 8414 | 8420 | 8426 | 8432 | 8439 | 8445 |
| 70 | 8451 | 8457 | 8463 | 8470 | 8476 | 8482 | 8488 | 8494 | 8500 | 8506 |
| 71 | 8513 | 8519 | 8525 | 8531 | 8537 | 8543 | 8549 | 8555 | 8561 | 8567 |
| 72 | 8573 | 8579 | 8585 | 8591 | 8597 | 8603 | 8609 | 8615 | 8621 | 8627 |
| 73 | 8633 | 8639 | 8645 | 8651 | 8657 | 8663 | 8669 | 8675 | 8681 | 8686 |
| 74 | 8692 | 8698 | 8704 | 8710 | 8716 | 8722 | 8727 | 8733 | 8739 | 8745 |
| 75 | 8751 | 8756 | 8762 | 8768 | 8774 | 8779 | 8785 | 8791 | 8797 | 8802 |
| 76 | 8808 | 8814 | 8820 | 8825 | 8831 | 8837 | 8842 | 8848 | 8854 | 8859 |
| 77 | 8865 | 8871 | 8876 | 8882 | 8887 | 8893 | 8899 | 8904 | 8910 | 8915 |
| 78 | 8921 | 8927 | 8932 | 8938 | 8943 | 8949 | 8954 | 8960 | 8965 | 8971 |
| 79 | 8976 | 8982 | 8987 | 8993 | 8998 | 9004 | 9009 | 9015 | 9020 | 9025 |
| 80 | 9031 | 9036 | 9042 | 9047 | 9053 | 9058 | 9063 | 9069 | 9074 | 9079 |
| 81 | 9085 | 9090 | 9096 | 9101 | 9106 | 9112 | 9117 | 9122 | 9128 | 9133 |
| 82 | 9138 | 9143 | 9149 | 9154 | 9159 | 9165 | 9170 | 9175 | 9180 | 9186 |
| 83 | 9191 | 9196 | 9201 | 9206 | 9212 | 9217 | 9222 | 9227 | 9232 | 9238 |
| 84 | 9243 | 9248 | 9253 | 9258 | 9263 | 9269 | 9274 | 9279 | 9284 | 9289 |
| 85 | 9294 | 9299 | 9304 | 9309 | 9315 | 9320 | 9325 | 9330 | 9335 | 9340 |
| 86 | 9345 | 9350 | 9355 | 9360 | 9365 | 9370 | 9375 | 9380 | 9385 | 9390 |
| 87 | 9395 | 9400 | 9405 | 9410 | 9415 | 9420 | 9425 | 9430 | 9435 | 9440 |
| 88 | 9445 | 9450 | 9455 | 9460 | 9465 | 9469 | 9474 | 9479 | 9484 | 9489 |
| 89 | 9494 | 9499 | 9504 | 9509 | 9513 | 9518 | 9523 | 9528 | 9533 | 9538 |
| 90 | 9542 | 9547 | 9552 | 9557 | 9562 | 9566 | 9571 | 9576 | 9581 | 9586 |
| 91 | 9590 | 9595 | 9600 | 9605 | 9609 | 9614 | 9619 | 9624 | 9628 | 9633 |
| 92 | 9638 | 9643 | 9647 | 9652 | 9657 | 9661 | 9666 | 9671 | 9675 | 9680 |
| 93 | 9685 | 9689 | 9694 | 9699 | 9703 | 9708 | 9713 | 9717 | 9722 | 9727 |
| 94 | 9731 | 9736 | 9741 | 9745 | 9750 | 9754 | 9759 | 9763 | 9768 | 9773 |
| 95 | 9777 | 9782 | 9786 | 9791 | 9795 | 9800 | 9805 | 9809 | 9814 | 9818 |
| 96 | 9823 | 9827 | 9832 | 9836 | 9841 | 9845 | 9850 | 9854 | 9859 | 9863 |
| 97 | 9868 | 9872 | 9877 | 9881 | 9886 | 9890 | 9894 | 9899 | 9903 | 9908 |
| 98 | 9912 | 9917 | 9921 | 9926 | 9930 | 9934 | 9939 | 9943 | 9948 | 9952 |
| 99 | 9956 | 9961 | 9965 | 9969 | 9974 | 9978 | 9983 | 9987 | 9991 | 9996 |

Figure 3-1. Common Log Table

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When the characteristic is positive, the number of digits to the left of the decimal point in the antilog will be one MORE than the numerical value of the characteristic.

| | |
|---|---|
| Log 3.5490 | Antilog 3540 |
| Log 1.7168 | Antilog 52.1 |

When the characteristic is negative, the antilog will have one LESS zero between the decimal point and the first significant figure than the numerical value of the characteristic.

| | |
|---|---|
| Log $\bar{2}$.8609 | Antilog 0.0726 |
| Log $\bar{4}$.7388 | Antilog 0.000548 |

MULTIPLICATION USING LOGARITHMS. When multiplying numbers which contain several digits, it is often easier to use logarithms. Not only is this method easier, but the chance of making a simple mistake in arithmetic is lowered. The process is easier because instead of multiplying large numbers together, the logarithms of these numbers are simply added.

After the logarithms are added, the antilog of the sum is found. This will then be the product of the original multiplication problem. Occasionally, it may become necessary to round off the numbers before the logarithms are determined. For example:

| | |
|---|---|
| Multiply 6952 x 437 | (Round 6952 to 6950.) |
| Log 6952 = 3.8420 | (Changing 6952 to a log.) |
| Log 437 = 2.6405 | (Changing 437 to a log.) |
| 6.4825 | (Addition of logs.) |
| Antilog 6.4825 = 3,040,000 | (The product of the original problem) |

Actual multiplication of 6952 by 437 would give the product of 3,037,842. This error is due to rounding and to the fact that the log table used is only accurate to three significant figures. More accuracy could be obtained by using an expanded log table. However, for most of the photographic uses, this table will be sufficient.

DIVISION USING LOGARITHMS. Since division is the inverse of multiplication, it holds true that the inverse operation will be used when dividing with logs. So instead of adding the logarithms, the logarithms will be subtracted. First, the logarithms of the numbers to be divided are found. Second, the logarithms are subtracted and the antilog of the difference is found. For example:

| | |
|---|---|
| Divide 249 ÷ 0.9628 | (Round 0.9628 to 0.963.) |
| Log 294 = 2.3926 | (Changing 249 to a log.) |
| Log 0.9628 = $\bar{1}.9836$ | (Changing 0.9628 to a log.) |
| 2.4090 | (Subtraction of logs.) |
| Antilog 2.4090 = 256 | (The quotient of the original problem.) |

Once again this is an approximate answer. However, it is accurate enough for most photographic applications.

The Metric System

Throughout your career as a Continuous Photoprocessing Specialist, you will be concerned with using mathematical formulas. Often times these formulas are used with different physical measurements. Chemical formulas, replenishment rates, development times and quality control analyses are few examples. In dealing with these situations, you will sometimes need to use a system of weights and measures.

In the United States there are two systems, the US Customary and the metric systems. The US Customary is probably the most familiar, however the metric system is used to a great extent in the photosciences.

The metric system was invented for its simplicity and has been adopted in most countries. The simplicity of the metric system results from facts; it is a decimal and therefore fits our decimal notation. Also, its units for lengths, area, volume and weight are all dependent on one unit, the meter. In the US Customary system of weights and measures, there are about 150 different terms and 50 different numbers. Some of the more common measures are committed to memory--5280 feet to a mile, 36 inches to a yard and 16 ounces to the pound--however, there are too many to learn them all. Also, seldom do these units have any relation to each other.

UNITS. In the metric system there are only three units and all of these are related to each other through the meter. These units are the meter for linear measure, the liter for volumetric measure and the gram for weight. To denote the different amounts of these units, a prefix is attached to each one. These prefixes are:

1. Mega--which denotes 1,000,000

2. Kilo--which denotes 1,000

3. Hecto--which denotes 100

4. Deka--which denotes 10

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5. Deci--which denoted 0.1

6. Centi--which denotes 0.01

7. Milli--which denotes 0.001

8. Micro--which denotes 0.000001

9. Nano--which denotes 0.00000001

Ability to handle the metric system depends on a ready understanding of the terms used. For instance, the word kilometer should mean, at once 1000 meters and the word milliliter should, at once mean, one-thousandth of a liter. After the terms are learned, converting from one unit to another is simple. This is the greatest advantage to this system. This simplicity is due to the decimal relationship among the units. To change to a larger unit, divide by 10, 100, 1000, etc., by moving the decimal point the correct number of spaces to the left. To change 3768 centimeters to meters, move the decimal point two places to the left which gives 37.68 meters. To reduce to a smaller unit, move the decimal to the right the correct number of spaces. Thus, 0.5 liter will equal 500 milliliters.

Since both the metric system and the US Customary system are in use in this country, it may be necessary at times to convert from one system to the other. In order to do so, a conversion factor is used. The conversion factors for some of the more common units are given in figure 3-2.

Temperature Conversions

Most people are familiar with the thermometer, the instrument used to measure temperature. Temperature is a measure of the INTENSITY of heat, not the quantity of heat in a substance. There are three different temperature scales and all three are used in the photographic sciences at different times. These scales are the Fahrenheit, Celsius and Kelvin scales.

The most familiar scale in the United States is the Fahrenheit scale, which was first crudely defined by taking the temperature of the human body as being 100°. The lowest temperature obtainable with a mixture of ice and salt was set as 0°. The Celsius scale (also called the centigrade scale) was invented through more precise scientific methods. On this scale, water freezes at 0 and boils at 100°.

If we compare the two scales, we note that there are 100° between the freezing point and the boiling point of water on the Celsius scale. This corresponds to 180° on the Fahrenheit scale (freezing point 32°, boiling point 212°). Therefore, the Celsius degree equals 9/5 of a Fahrenheit degree.

## CUSTOMARY TO METRIC

| TO CONVERT FROM | TO | MULTIPLY BY |
|---|---|---|
| INCHES | CENTIMETERS | 2.54 |
| FEET | METERS | 0.3048 |
| YARDS | METERS | 0.9144 |
| MILES (STATUTE) | KILOMETERS | 1.6093 |
| OUNCES (FLUID) | LITERS | 0.02958 |
| QUARTS (FLUID) | LITERS | 0.9463 |
| GALLONS | LITERS | 3.7853 |
| GRAINS | GRAMS | 0.0648 |
| OUNCES (DRY) | GRAMS | 28.3495 |
| POUNDS | KILOGRAMS | 0.4536 |

## METRIC TO CUSTOMARY

| TO CONVERT FROM | TO | MULTIPLY BY |
|---|---|---|
| CENTIMETERS | INCHES | 0.3937 |
| METERS | INCHES | 39.37 |
| KILOMETERS | MILES | 0.621 |
| MILLILITERS | OUNCES ~~(FLUID)~~ | 0.338 |
| LITERS | QUARTS (FLUID) | 1.0567 |
| GRAMS | GRAINS | 15.432 |
| KILOGRAMS | POUNDS | 2.2046 |

Figure 3-2. Conversion Tables

To change from Fahrenheit to Celsius use this equation:

$$°C = 5/9\ (°F - 32)$$

To change from Celsius to Fahrenheit use this equation:

$$°F = (9/5)\ (°C) + 32$$

The Kelvin scale is used in photography to measure the color temperature of light. Therefore, conversion to or from the Kelvin scale is seldom necessary.

QUESTIONS

DO NOT WRITE IN THIS SW, USE A SEPARATE SHEET OF PAPER.

1. How is the decimal point located in the product of a simple multiplication problem?

2. What is the rule for subtracting numbers of unlike signs?

3. What are the two parts of a logarithm?

4. What part of a logarithm is always positive?

5. Explain the procedure for locating the decimal point when going from a logarithm to the antilog.

6. Explain how to use logarithms in multiplication.

7. What is the basic unit of measure in the metric system?

8. How does one convert from meters to kilometers?

9. What is temperature?

10. How is the Kelvin used in photography?

Exercise 1

PROCEDURES

Solve the problems using a separate sheet of paper.

1. Perform the following additions.

| | | | |
|---|---|---|---|
| a. 467 | b. -1640 | c. 320 | d. -12 |
| 894 | 292 | -92 | -783 |

2. Perform the following subtractions.

a. 991 minus 428 b. 62 minus -121 c. -516 minus 29

d. -11,243 minus -696

3. Perform the following multiplications.

a. 6.5 x 19.8 b. 173.1 x -0.048

c. -6.85 x -10.1 d. -231 x 0.0086

4. Perform the following divisions.

a. -4.292 ÷ 0.418 b. 7.552 ÷ -0.128

b. 0.9245 ÷ 0.43 d. -22.8 ÷ 9.6

5. Determine logarithms of the following numbers using log tables.

| | | | |
|---|---|---|---|
| a. 7 | b. 9 | c. 16 | d. 3785 |
| e. 56 | f. 12 | g. 92 | h. 1725 |
| i. 1/2 | j. 25% | k. .20% | l. .0033% |
| m. 1.558 | n. 1 | | |

6. Determine antilogs of the following numbers.

| | | | |
|---|---|---|---|
| a. 2.8470 | b. 0.7235 | c. $\bar{6}$.0043 | d. 2.8494 |
| e. $\bar{1}$.4900 | f. 0.0009 | g. 3.444 | h. 1.9996 |
| i. $\bar{2}$.8808 | j. 1.0000 | k. 2.8543 | l. $\bar{3}$.2201 |
| m. $\bar{1}$.5666 | n. 2.5098 | | |

7. Solve the following multiplication problems using logarithms.

a. The first thing to do in solving these problems is to change each quantity to logarithmic form. In some cases, rounding off must be used to obtain the correct logarithm.

b. The multiplication procedures when using logarithms are to add the logarithms of the individual quantities.

c. This sum of the two logarithms is used to find the answer of the problem by determining its antilog. Again, if the mantissa cannot be found in the tables, find the antilog by using a mantissa that is listed, which has a numerical value closest to the one you are looking for.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (1) | 496<br>768 | (2) | 2111<br>533 | (3) | 0.0764<br>99 | (4) | 3.001<br>0.006 |
| (5) | 7563<br>6355 | (6) | 9268<br>8420 | (7) | 396<br>65 | (8) | 2008<br>0.94 |
| (9) | 7254<br>6450 | (10) | 0.004<br>0.4657 | (11) | 756<br>756 | (12) | 8355<br>94 |
| (13) | 9001<br>7564 | (14) | 7358<br>2959 | | | | |

8. Solve the following division problems using logarithms.

a. After changing all quantities in each problem to logarithmic form, the logarithm of the divisor must be subtracted from the logarithm of the dividend.

b. Again, in these problems, some quantites must be rounded off before the logarithm can be obtained.

c. After subtraction, the antilog of the difference is the final answer.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (1) | $\frac{3847}{46}$ | (2) | $\frac{756}{0.01}$ | (3) | $\frac{0.7563}{876}$ | (4) | $\frac{8674000}{6453}$ |
| (5) | $\frac{0.001}{0.001}$ | (6) | $\frac{6579}{85}$ | (7) | $\frac{8675}{648}$ | (8) | $\frac{75620}{80}$ |
| (9) | $\frac{56.47}{8.46}$ | (10) | $\frac{0.005735}{0.5683}$ | (11) | $\frac{56.04}{5.006}$ | (12) | $\frac{5.009}{1.001}$ |
| (13) | $\frac{6730000}{756}$ | (14) | $\frac{0.00000005768}{0.00000675}$ | | | | |

9. Convert temperatures from one scale to the other by computing the equivalent temperatures in the following problems.

| | Celsius | Fahrenheit |
|---|---|---|
| a. | ______ | -40 |
| b. | 25 | ______ |
| c. | ______ | 86 |
| d. | ______ | 50 |
| e. | ______ | 0 |
| f. | 4 | ______ |
| g. | 50 | ______ |
| h. | -20 | ______ |

10. Convert the measurements from one system to the other by computing the equivalent measure in the following problems.

| | Metric | Customary |
|---|---|---|
| a. | _____ kilometers | 3.5 miles |
| b. | 250 milliliters | _____ ounces |
| c. | 178 kilograms | _____ pounds |
| d. | _____ liters | 15 gallons |
| e. | _____ meters | 16.5 yards |
| f. | _____ kilograms | 12 pounds. |

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Sciences Branch
Lowry Air Force Base, Colorado

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# CHEMICAL MIXING AND CERTIFICATION

## OBJECTIVES

Given the necessary bulk chemicals, selected formulas, chemical mix facilities, measuring and mixing equipment, prepare black and white processing solutions. Solutions must meet locally prescribed standards of quality.

Given pH meter, hydrometer set and photographic solutions, determine pH and specific gravity of the photographic solutions. Value for pH must be within $\pm 0.015$ of the class standard.

## INTRODUCTION

The saying goes that a chain is only as strong as its weakest link. Producing aerial photo-intelligence can be compared to a chain. Each step in the process is a link--from preplanning the flight, to flying the mission, to processing and on to interpretation and usage. Each phase is important and if a break occurs in any of these "links," then the entire mission might result in failure.

Each person associated with any part of the mission must insure that the links do not break. One of the links in processing is mixing of chemicals and their certification. Should a mistake be made in this step, the valuable mission film could be degraded severely or even totally lost. So the importance of this study section is very high.

The chemicals and formulas that are used in today's Air Force have been the result of years of research and usage. They have been designed to give the best results with the highest quality possible. Used in conjunction with the highly sophisticated camera systems, and high quality films, these formulas will give the utmost in photo-intelligence information.

However, there is a catch! These formulas must be mixed properly, kept within standards and used correctly. In order to avoid costly and embarrassing errors, a brief study in chemical mixing and the certification of photographic solutions is in order. The better this area is known, the less likely a "break" will occur in the "chain."

INFORMATION

# CHEMISTRY FOR BLACK-AND-WHITE PROCESSING SOLUTIONS

## Chemical Grades

When selecting chemicals for any photographic purpose, two factors must be considered. One of these is the purity of the chemical used. Chemicals with too many impurities will not give desirable results. The other consideration is cost. Although some chemicals are nearly perfectly pure, the results they give may not be much different from a less pure and less expensive chemical. Chemicals are available in many concentrations and many grades of purity. Some of these chemical grades are as follows:

TECHNICAL. The least pure of the chemical grades, technical chemicals are used primarily in manufacturing processes, for washing and cleaning compounds, soil conditioners, insecticides and other similar uses.

PHOTO GRADE. These chemicals are designed especially for photographic uses. Although these chemicals contains some impurities, these impurities have been tested and are determined to cause little if any effect on the photographic materials.

UNITED STATES PHARMACOPOEIA (USP). These chemicals meet very high standards set by the United States Pharmacopoeia. They are used in the preparation of medicines.

ANALYTICAL REAGENT (AR). These chemicals are used primarily for chemical analysis. They are the most pure and have been analyzed by the manufacturer to show known impurities.

While USP and AR grade chemicals can be used in photographic solutions, they usually are not used because of their high cost. Technical grade chemicals are the least expensive, but their impurities make their results undependable. Therefore, considering the quality desired and the cost involved, the use of the photo grade chemicals would be the best choice.

## Mixing Chemicals

After the developer formula has been chosen, the next step is to mix the developer from bulk chemicals. Mixing instructions are usually given with the photographic formulas. Always read these instructions and follow them carefully. The metric system is used for measurements.

It is very important that chemicals be mixed in the proper order and that each one is thoroughly dissolved before the next is added. If the next chemical is added too soon, before the preceding one is dissolved,

an adverse reaction could occur. This reaction might lower the solution's developing capabilities. It is also important that the chemicals be sifted into the water slowly; otherwise, they may cake and then they would be difficult to dissolve. Unless some other temperature is recommended, water should be 100 - 120°F. (38 - 50°C).

The solution should be stirred gently so that introduction of air into the solution is avoided. Violent stirring should be avoided. Also, when using a magnetic or other type of automatic mixer, a spinning vortex in the solution must not be allowed. These practices will cause the solution to oxidize more rapidly.

Safety in Mixing

WARNING

Caustic alkalies and strong acids generate considerable heat and can react violently when added to water. When mixing very strong acids or alkalies, always use the exhaust hood and appropriate safety clothing. Wear a plastic or rubber apron, rubber gloves and a face mask or goggles. If the chemical gives off toxic fumes, use a gas mask as well. Remember the rule: ALWAYS ADD ACID. It holds true with alkalies--ALWAYS ADD ALKALIES. Never add water to an acid or alkali; add the acid or alkali to the water.

Be aware of the hazards of the other chemicals, too. Many photographic chemicals are toxic if swallowed. Many can cause skin burns or damage to the eyes. Know where the safety shower and eye wash is located. Avoid contact with the chemicals. If accidents do occur, take immediate steps. Get medical help, if necessary.

Storage

Once the solutions are ready, they must be stored in proper containers. In the chemistry laboratory, chemicals are usually stored in glass containers. If the solutions are affected by light, they should be stored in amber bottles away from the light. In general photographic laboratories, however, solutions are also stored in stainless steel or polyethylene containers. Polyethylene is the most common material because of its lower cost and inertness to most photographic chemicals.

The most important thing to remember about storing photographic solutions is to exclude air. Air causes the solution to oxidize rapidly. Therefore, solutions should be kept in full, tightly stoppered bottles. If partially used bottles are to be kept for any length of time, their contents should be transferred to smaller bottles so that excess air may be excluded. In larger containers used for mixing and storing large amounts of processing solutions, a floating lid is often provided. This

lid fits snugly into the tank and floats on top of the solution, thereby keeping air from the solutions.

Glassware (Types)

Besides storing chemicals, glass containers are also used for mixing and transporting chemicals. Glass is durable and is inert to photographic chemicals. However, be careful when using glassware as it is brittle and easily broken. Excess breakage is costly and broken glass is dangerous. Basically, there are two kinds of glassware used in the laboratory. These are volumetric and mixing.

VOLUMETRIC GLASSWARE. The manufacturer of volumetric glassware calibrates the glassware to measure a specified volume. This calibration is certified to conform to tolerances set by the National Bureau of Standards. This glassware gives very accurate measurements of volume when used properly.

Volumetric glassware is calibrated at 68°F. (20°C). Extreme deviations from this temperature will affect the capacity of the glassware and the volume of the solution being measured. To attain very high accuracy, the solution must be at 20°C ±2°C. At no time should volumetric glassware be heated or rinsed with hot water. Heating can cause a permanent change in the glassware and will result in inaccurate measurements.

GLASSWARE FOR MIXING. Glassware for mixing is not calibrated for a specific measurement. It is designed to withstand temperature changes and for heating solutions. The volumetric changes caused by heating these pieces is not important since they are not used for measuring any way.

In the laboratory there is a variety of glassware. Each piece is designed for a specific purpose. Although one piece may be substituted for another at times, it is best to use each piece for the job it was designed. The glassware that will be used in this unit is listed below. (See fig. 4-1).

Beaker--A beaker is an ungraduated utility cup with a wide mouth. It is used for mixing solutions and for holding the solution during the pH reading of the solution.

Funnel--A funnel is used to pour liquids in containers with small openings. There are many different types.

Hydrometer--A hydrometer is a highly calibrated instrument used to determine specific gravity. It has a graduated stem and is weighted with lead at the bottom.

Graduated Cylinder--This is a cylinder graduated for accurate volumetric measurements.

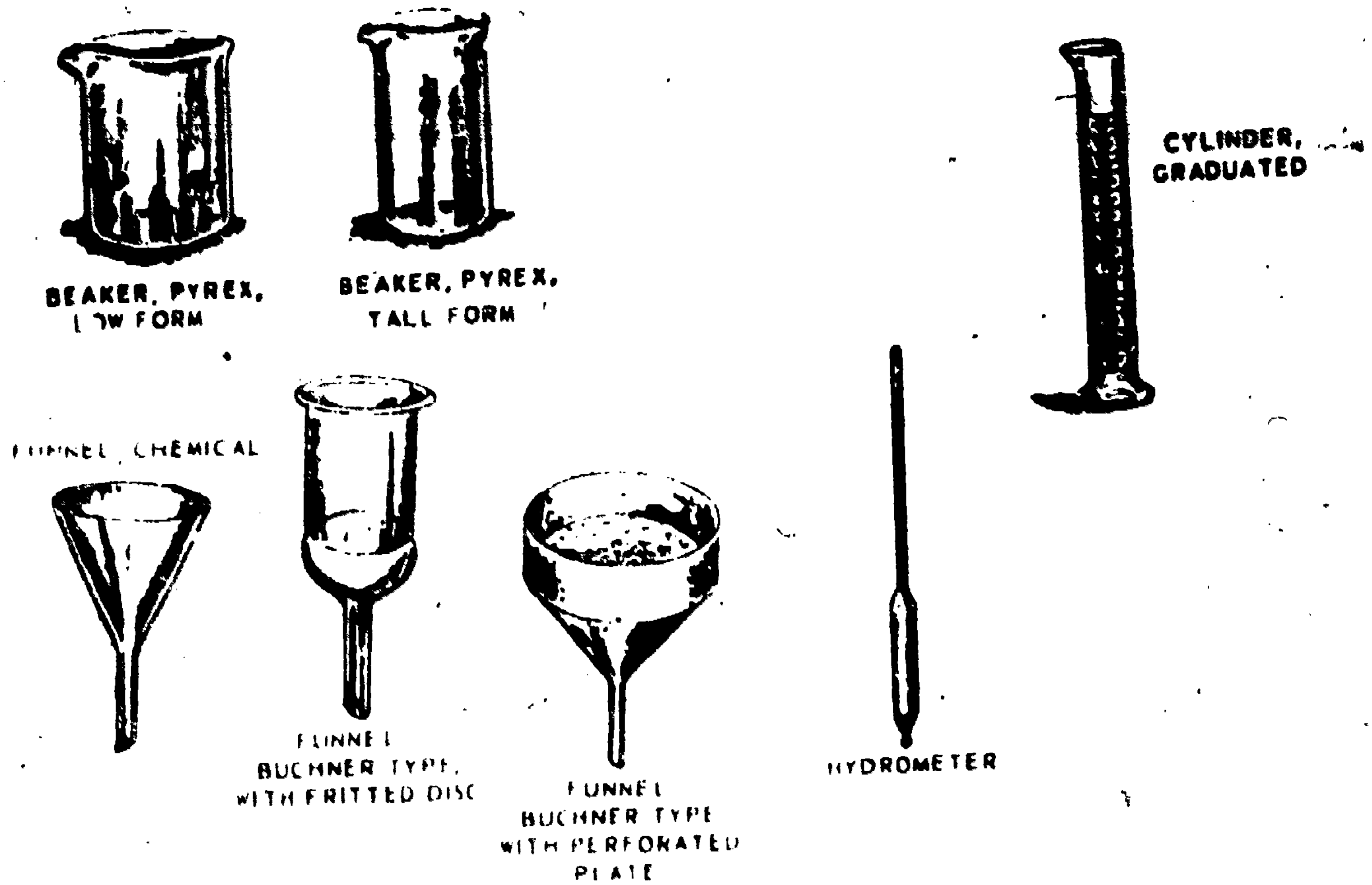


Figure 4-1. Laboratory Glassware

Cleaning Glassware

Before any piece of glassware can be used, it must be cleansed of all residue. Contamination from previous work must be totally removed. Otherwise, it will affect the results of the new solution being mixed. Three types of cleaning solutions are recommended to keep glassware clean.

DETERGENT. This is a very effective, inexpensive material for most cleaning problems. However, it must be a nontoxic and noncorrosive type.

SULFURIC-DICHROMATE. This is a mixture of sodium or potassium dichromate in concentrated sulfuric acid. This mixture is very effective against grease, but it is dangerous because of its strong acid, oxidizing and dehydrating properties.

ACID-ALCOHOL. This cleaner is made by mixing one volume of 3N hydrochloric acid with one volume isopropyl or methyl alcohol. This cleanser is very effective in removing dye stains.

NOTE: Detergent will be used exclusively in this course!

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When preparing glassware for use, rinse it a total of four times after cleaning. Rinse twice with tap water and twice with distilled water or deionized water. If, after rinsing, drops adhere to the walls of the glassware, it is not sufficiently clean. There should be a solid film of water remaining for at least one minute.

When preparing glassware for storage, DO NOT rinse with distilled water. This is to conserve the distilled water. After cleaning, glassware should be stored in such a position that it will drain.

Glassware Measurements

Solution quantities are determined from the meniscus of the solution. The meniscus is the curved upper portion of a column of liquid. As a result of capillary action, the meniscus is concave when the liquid wets the walls of a container. (See fig. 4-2A.) If the liquid does not wet the glass, the meniscus is inverted. (See fig. 2B.)

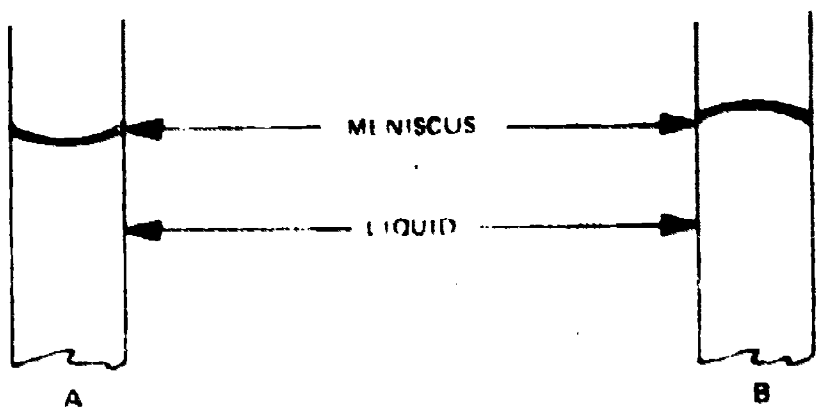



Figure 4-2. Meniscus - Normal and Inverted

Measurements of clear liquids in most containers are taken from the lowest point on the meniscus. Exceptions to this are the measurement of opaque liquids, the measurement of specific gravity and when the meniscus is inverted. In these cases the measurement is taken from the top of the meniscus.

Beam Balances

After the glassware is arranged for use and liquids have been measured into them, the dry chemicals must be weighed carefully before they are added to the liquid. The instrument used for weighing these chemicals is the beam balance. Photographic formulas are quite exact,

therefore, accuracy is very important. Do not take short cuts when weighing these chemicals.

The following procedures are specifically for the OHAUS triple beam balance but they also apply in general to all beam balances. There are two models of the OHAUS in common use. They are the Model 311 (with a maximum capacity of 311 grams) and the Model 2610 (with a maximum capacity of 2610 grams).

ZEROING THE BALANCE

1. Slide all poises to zero.

2. Make sure the balance is level.

3. Place a sheet of protective paper on the weighing pan.

4. Rotate the knurled compensator knob until the pointer lines up with zero.

WEIGHING UNKNOWN SPECIMENS

1. With the balance beam arrested in locked position, place the specimen on the weighing pan.

2. Unlock the arrest and allow the beam to swing.

3. Move the heaviest poise to the right to the first notch which causes the pointer to drop, then move it back one notch causing the pointer to rise.

4. Repeat this procedure with the next lighter poise.

5. Repeat this procedure with each succeeding lighter poise.

6. With the lightest poise, slide it to a position which brings the pointer to zero.

7. The weight of the specimen is the sum of the values of all poise positions; read directly from the graduated beams.

WEIGHING PREDETERMINED AMOUNTS

1. Zero balance with weighing pan in place. Large amounts of chemical can be weighed in a beaker if the beaker has been "tared out" as follows:

a. Remove weighing pan and replace with the beaker.

b. Zero the beam by adding tare weights (counterweights) to the beam to bring to approximately zero.

c. With the knurled balance compensator knob, bring the beam to final zero.

2. Set all poises to total the amount desired.

3. Add the bulk chemical slowly until the beam just starts to rise, then stop.

4. From this point on, add very small amounts of the chemical and check the position of the pointer after each addition.

5. If too much chemical is added and the pointer comes to rest above zero, remove a small amount of chemical and slowly add part of this back until the pointer comes to zero.

The beam balance is a simple instrument to use but it must never be abused. Handle it carefully and keep dust off of it. When preparing the beam balance for storage, remove the tension from the weighing pan by raising the resting shoe and setting the pan on it. Return all poises to zero and remove the beams from the fulcrum. If the balance has proper care, it will always give easy and accurate measurements.

## SOLUTION CERTIFICATION

Just because the formula was followed correctly and measurements made correctly, it cannot be assumed that the chemical solutions will perform correctly. Precautions must be taken to assure that the chemical solutions do the work they are designed to do. Tests must be run, also, to assure that the solutions will process the film suitably. There are three basic tests for certifying photographic solutions--specific gravity, pH and a sensitometric test. (The sensitometric test will be discussed in a later SW.) All tests are important and must be made before the solutions can be certified for use.

## SPECIFIC GRAVITY

### Purpose of the Specific Gravity Analysis

The first check made on all solutions is the specific gravity test. It is a quick check to determine if the mix is complete. Specific gravity is the ratio of the mass of a given volume of a substance to an equal volume of distilled water at 60°F (15.6°C). Distilled water is assigned the specific gravity of 1.00. The specific gravity of each element is known, so from these facts, the specific gravity of any combination of elements in any ratio can be determined. The specific gravities for all processing solutions have been determined through years of use and testing and remains constant. The solution being

tested will have the same specific gravity provided it has been mixed in the proper proportions.

Specific gravity will, however, vary from one batch of solution to another because of various factors involved (quality of chemicals, inaccurate scales used in measuring chemicals, etc.). Because of these factors, upper and lower control limits must be set. If specific gravity is made to determine the cause. If the specific gravity goes beyond the upper control limit, it might indicate that more than the formula amount of an ingredient has been used, a foreign ingredient has been used, or the solution has not been diluted properly. A specific gravity which is below the lower limit might indicate that an ingredient has been left out of the solution, or that too much water has been added.

Use of the Hydrometer

To aid in the determination of specific gravity, the hydrometer is used. The hydrometer is a highly calibrated instrument with a stem and a lead weight at the bottom. When used, it gives a direct reading of a solution's specific gravity.

Be careful while using the hydrometer as it breaks easily. While handling the hydrometer carefully, gently lower it into the proper graduated cylinder. Be sure that the cylinder is wide enough so that the hydrometer does not become stuck. Be careful, too, when placing the hydrometer into the solution, that it does not drop quickly to the bottom and break. If the hydrometer seems too heavy for a particular solution, use a lighter hydrometer. This simply means that the wrong hydrometer was used, since each one is calibrated to measure only a certain range of specific gravities.

As the correct hydrometer is lowered into the solution, give it a gentle spin. This will prevent the hydrometer from clinging to the sides of the cylinder. The hydrometer should bob only slightly and spin only for a few seconds. After it has come to rest, the reading may be made.

Reading the Hydrometer

With the cylinder on a level support, the hydrometer will float vertically in the liquid. The reading can be taken from the emerging portion of the stem. The hydrometer is calibrated along the stem. This scale is calibrated to read the ratio of the submerged volume of the hydrometer in the liquid to the submerged volume when it is floating in water.

Make the reading at the top of the meniscus (fig. 4-3) on a level even with the meniscus. The hydrometer will give a reading of 1.00 in distilled water. For liquids heavier than water, the hydrometer has a scale reading downward from 1.00 to 2.00 or more. For liquids lighter

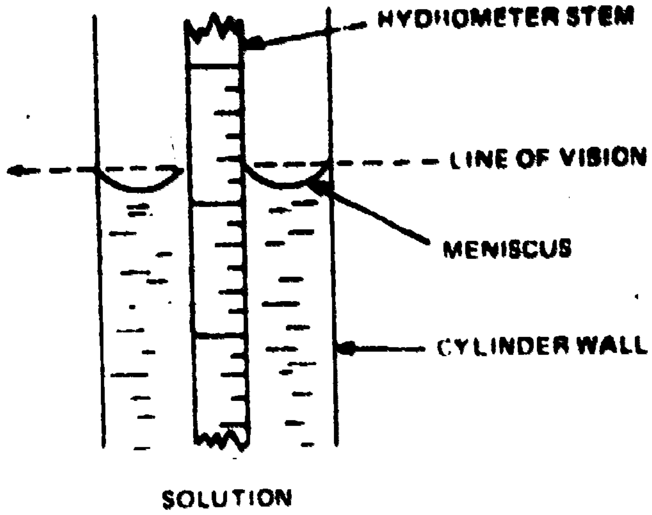



Figure 4-3. Section of Hydrometer Stem

than water, the hydrometer is adjusted to a scale reading from 1.00 to 0.7.

Temperature Compensation

The hydrometer is also calibrated at 60°F (15.6°C) in distilled water. A temperature change will have a direct effect on the specific gravity reading. In the case of water, 0.001 must be added to the reading for every 5°F (2.5°C) increase in temperature. For every 5°F (2.5°C) decrease in temperature, 0.001 must be subtracted from the reading.

Since most photographic solutions contain several solids dissolved in water, their density is not the same as the density of distilled water. Because the photographic solution is denser than water, the solution will expand more for each degree of temperature change. The temperature correction for most photographic solutions whose specific gravity falls between 1.100 and 1.200 is 0.003 for each 10°F (5°C) temperature change. Laboratory research indicates this fact. Therefore, after taking the reading it is necessary to find the temperature of the solution and apply this correction factor.

SOLUTION pH

Purpose of pH Measurements

Specific gravity is the first and quickest test given to a photographic solution. However, even if the solution has the right specific gravity, it must not be assumed that it will perform as desired. The alkalinity or acidity of a solution will also affect its ability to process photographic materials. The amount of alkalinity or acidity is determined by measuring pH. This amount will vary from solution to solution. Figure 4-4 shows the pH values of some common substances from the most acidic to the most alkaline.

| SOLUTION | pH |
|---|---|
| GASTRIC FLUID | 1.6 |
| VINEGAR (4% ACETIC ACID) | 3.1 |
| ORANGE JUICE | 3.8 |
| MILK | 6.9 |
| "PURE" WATER | 7.0 |
| BORAX (9.0%) | 9.3 |
| AMMONIA (10%) | 11.8 |

Figure 4-4. pH Values of Common Substances

The pH of a solution can be described as a measure of its alkalinity or acidity. Such a figure is necessary when making various photographic formulas, for predicting its effectiveness, etc. Certain indicators, such as litmus paper, can establish the fact that a solution is acidic, alkaline or neutral. However, they do not indicate how much. A pH meter will tell how acidic or alkaline a solution is.

The pH value has a scale of zero to 14 with 7 being the neutral point of pure water at 77°F (25°C). Numbers less than 7 indicate a degree of acidity and numbers greater than 7 indicate a degree of alkalinity. Liquid solutions are acid or alkaline according to their ratio of hydronium ($H_3O+$) to hydroxyl (OH-) ions. Acidic solutions have more hydronium ions than hydroxyl ions while alkaline solutions have more hydroxyl than hydronium ions.

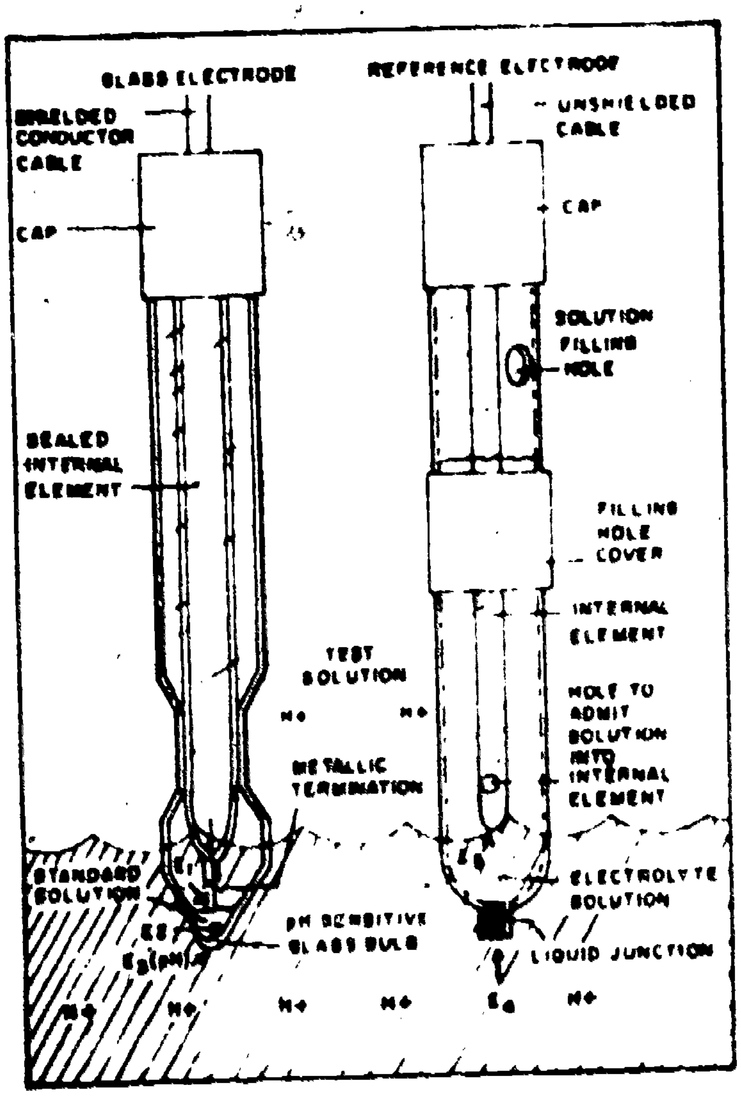
Hydronium ion concentration is used to express both acidity and alkalinity. This is because an electrode that will sense hydronium ion concentration is much more stable than one which will sense hydroxyl ion concentration. Since numerical values for the hydronium ion concentration often are extremely small fractions (for example, 1/10,000,000) the pH unit is used instead. The pH unit is defined as the negative of the logarithm of the hydronium ion concentration.

# pH METERS

Basically, a pH meter is a device which measures an electrochemical potential. To perform this function the pH meter is composed of many subsystems including the electrodes which generate a minute electrical potential. It also includes an amplifier to amplify the minute potential from the electrodes and a scale to indicate the pH of the solution.

## Electrodes

The electrodes develop an electrical potential when immersed into a solution. In most cases two electrodes are used: a glass electrode to generate an electrical potential of the test solution and a reference electrode to generate a constant potential against which the glass electrode is measured. (Refer to Fig. 4-5.)




$E_1$ - potential between internal element and standard solution

$E_2$ - potential between standard solution and innersurface of glass membrane

$E_3$ - potential between outer surface of pH-sensitive glass bulb and test solution. this is the only potential in electrode system that varies in accordance with change in hydrogen-ion concentration, or pH, of test solution

$E_4$ - potential of liquid junction between electrolyte and test solutions

$E_5$ - potential developed at internal element in electrolytic solution

Figure 4-5. Electrode System

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GLASS ELECTRODE. The basic purpose of the glass electrode is to measure the hydronium ion concentration of the sample. The electrical potential developed at the glass electrode is proportional to the pH of the solution. The measurement of the electrical potential, developed at the glass electrode, is accomplished with the pH meter.

In some types of electrochemical potential measurement, such as oxidation reduction, a metallic electrode is substituted for the glass electrode. Then the readout is in millivolts instead of pH units. NEVER USE METAL ELECTRODES TO DETERMINE pH OF DEVELOPERS!

REFERENCE ELECTRODE. The purpose of the reference electrode is to provide a constant reference voltage. This permits measurement of the potential at the glass electrode. The reference electrode is filled with a saturated solution of potassium chloride (KCl). The constant voltage is supplied by this KCl. A small, but constant, flow of KCl solution is maintained through a liquid junction in the tip of the reference electrode. The KCl solution forms a conductive salt bridge in the sample solution between the two electrodes.

Buffers

When making a pH measurement, the electrodes are first immersed in a buffer solution. A buffer is a solution whose exact pH is known. The meter is calibrated so that the reading shown is the exact pH of the buffer. Following this calibration, unknown pH values will be in a direct readout when the electrodes are immersed in the test solution.

Normally there are three buffers in the lab--pH 4, pH 7 and pH 10. For accuracy, always select the buffer that would correspond closest to the pH of the solution being tested. For example: When testing developers, use buffer 10 and with fixing baths, use 4. When the test solution is unknown, use buffer 7 or use litmus paper for a quick test of acidity or alkalinity. The use of litmus paper is normally preferred.

Operation of pH Meters

After the buffer is selected, taking the pH measurement is a simple operation. However, be careful. The pH meter is an expensive, precise instrument. Follow the directions carefully and observe all safety precautions.

In this course, there are three different models of pH meters. These are the Beckman Expandomatic, the Expandomatic Model SS-2 and the Model 3500. Each meter will give accurate pH readings and operating principles are basically the same.

The first ten steps in operation of the pH meters are the same for each different model and will generally hold true for any other meter. The other steps merely allow for the different designs of the meters.

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GENERAL OPERATING PROCEDURES. Follow these steps when taking a pH measurement.

1. Depress Standby Push Buttom. (Press the STANDBY pushbutton to the in position on the Model 3500.)

2. Select three 25( ml beakers.

3. Wash and rinse glassware properly.

4. Label each beaker as either test solution, buffer, or trash water.

5. Select the proper buffer which corresponds with the solution being tested. (Alkali/Acid)

6. Using proper solutions, fill beakers marked buffer and test. (Approximately 1 1/2 to 2 inches (3.8 to 5.1 cm) of solution.)

7. Slide rubber sleeve from the orifice of the reference electrode.

8. Insure that the KCl is at proper level in the reference electrode. (If not, notify your instructor.)

9. Using the trash water beaker, rinse electrodes and thermometer with distilled water and blot off excess water with lint free absorbent tissue.

10. Gently lower the electrodes into the buffer.

From this point, follow the directions given for the particular pH meter being used. (Refer to fig. 4-5, 4-6, 4-7, and 4-8.)

BECKMAN EXPANDOMATIC. When using this meter, follow the first ten steps given above then continue with these steps:

11. Depress STD (Standard) button.

12. Depress pH button.

13. Adjust the STANDARDIZE knob until the needle matches the pH of the buffer.

14. Depress STANDBY button.

15. Lift the electrodes, replace the buffer with the trash container, rinse and blot the electrodes dry.

16. Gently lower the electrodes into the test solution.

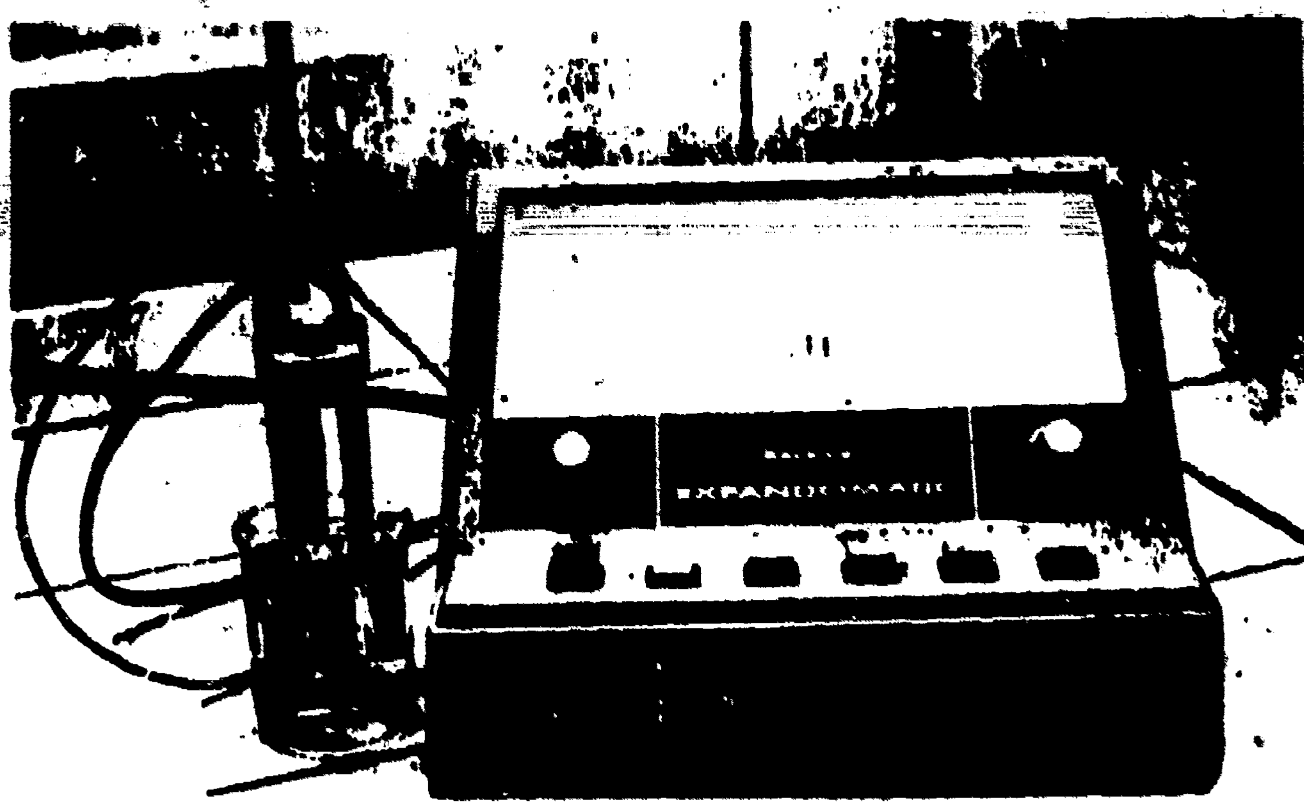

Figure 4-6. Beckman Expandomatic pH Meter

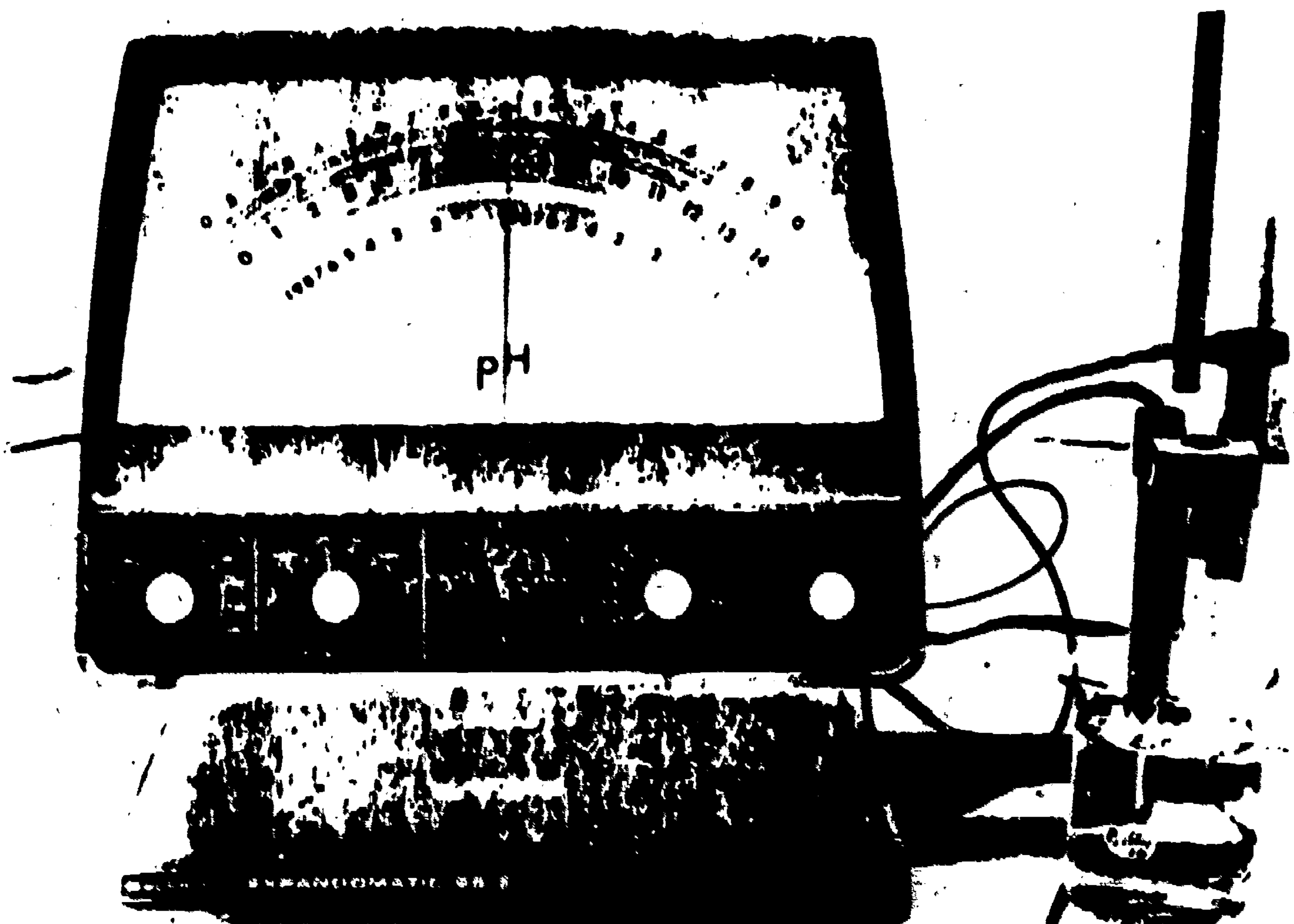


Figure 4-7. Beckman Expandomatic SS-2 pH Meter

17. Depress STD button and record pH reading.

18. Depress STANDBY button, lift, rinse the electrodes over the trash container.

19. Immerse the electrodes in a beaker of distilled water.

BECKMAN MODEL SS-2. When using this meter, follow the first ten steps given for the general operating procedures then continue with these steps:

11. Set function control to AUTO TC for automatic temperature compensation.

12. Depress the STD (Standard) button.

13. Unlock standardize knob and adjust the needle to the pH of the buffer. Relock the standardize knob.

14. Depress STDBY (Standby) button.

15. Lift the electrodes, replace the buffer with the trash water container, rinse, and blot the electrodes dry.

16. Gently lower the electrodes into the test solution.

17. Depress the STD button and record the pH reading.

18. Depress STDBY button, lift and rinse the electrodes over the trash container.

19. Immerse the electrodes in a beaker of distilled water.

BECKMAN MODEL 3500. This is a digital readout pH meter. When using it, follow the first ten steps given for the general operating procedures then continue with these steps:

11. Depress pH pushbutton to the in position (engaged). Do not adjust SLOPE control.

12. Press STANDBY pushbutton to disengage (out position).

13. Adjust STANDARDIZED control to obtain buffer pH on digital display, and then lock control.

14. Depress STANDBY pushbotton to the in position (engaged).

15. Lift the electrodes, replace the buffer with the trash container, rinse, and blot the electrodes dry.

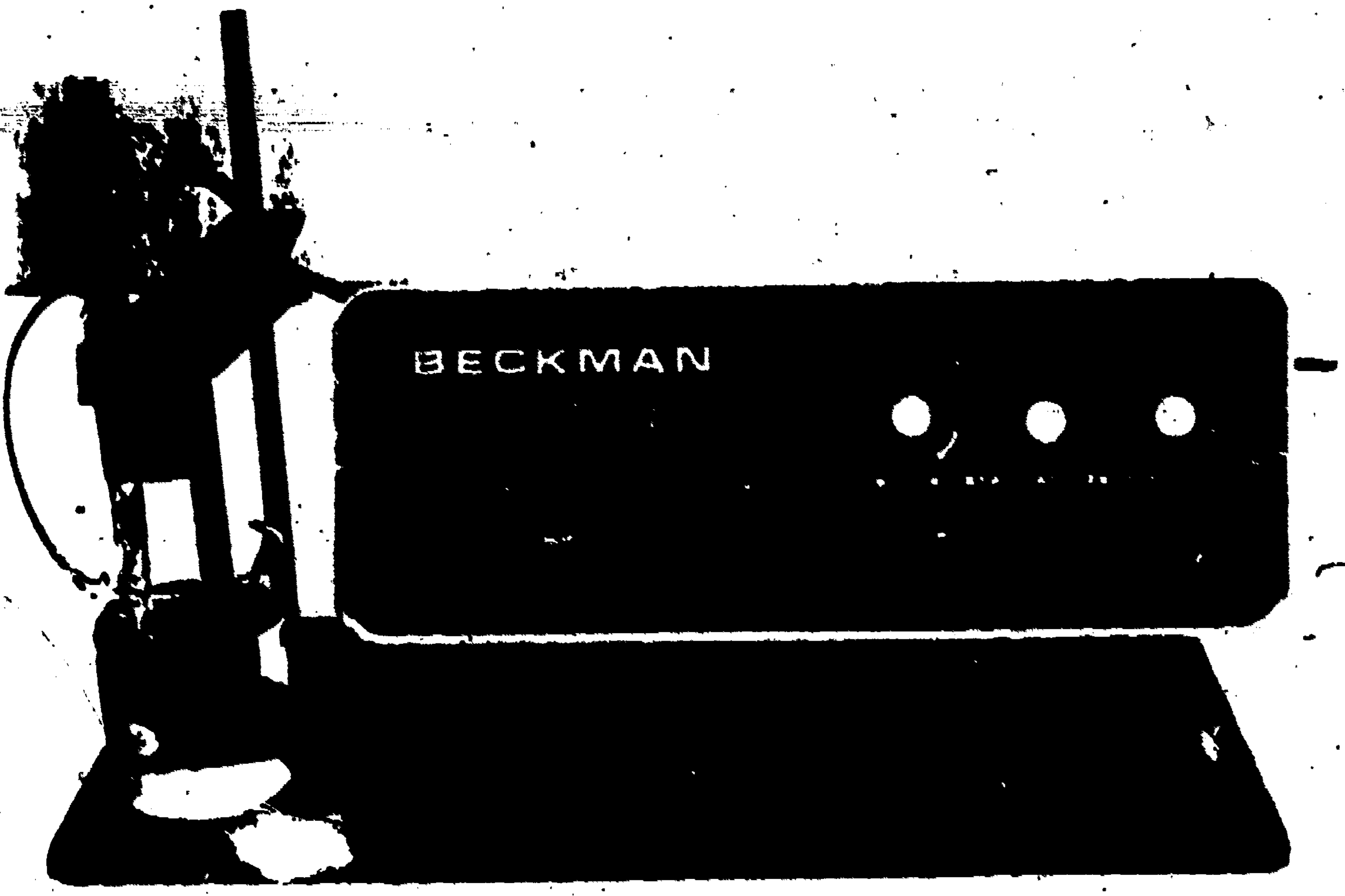


Figure 4-8. Beckman Model 3500 Digital pH Meter

16. Gently lower the electrodes into the test solution and allow them to reach thermal equilibrium.

17. Press STANDBY pushbutton to disengage (out position) and read pH value on digital display.

18. Depress STANDBY pushbutton to the in (engaged) position, lift, and rinse the electrodes over the trash water container.

19. Immerse the electrodes in a beaker of distilled water.

pH Measurement Precautions

Follow the given directions step-by-step. If they are followed precisely, exact and clear readings will be obtained. Inaccurate readings will be obtained if they are not. Besides the inaccurate readings, the meter may be damaged. To acquire good readings and avoid meter damage, observe the following precautions:

1. Electrodes are very fragile; never let the tips touch the bottom of the beaker.

206 2. NEVER REMOVE THE ELECTRODES FROM SOLUTIONS EXCEPT WHEN THE METER IS IN STANDBY!!

3. Keep the electrodes clean. Rinse them with distilled or deionized water and blot them with chemically inert absorbent tissue before immersing them in the buffer or test solution.

4. Care should be taken not to transfer body electrical charge to the glass electrode when blotting electrodes. Blot only, DO NOT WIPE. Reading drift will occur if the charge is transferred. If glass electrodes obtain a charge, wait for it to discharge before proceeding.

5. The filling hole on the reference electrode should always be covered when not in use.

6. Always check the level of the KCl in the reference electrode; if not full, notify the instructor.

7. Always leave the tips of the electrodes immersed in distilled or deionized water when not in use.

8. Do not stir the buffer or test solution with the electrodes in the beaker.

9. The pH of any given formula will vary somewhat from one container to another. Therefore, each lab will have to make a series of readings from each solution batch.

10. When using the Expandomatic or the SS-2, always observe the needle so that it covers its own reflection in the scale mirror. Otherwise parallax will cause an inaccurate reading.

Because pH measurement involves liquids plus electrical equipment, insure that the meter is grounded at all times. This will prevent any accidental damage to the meter or the operator during operation.

The pH meters used in this course are equipped with automatic temperature control. This means that the meter automatically adjusts for the temperature of the solution. Also, most pH meters in the Air Force are so equipped. However, one may have need to use a pH meter without this equipment. When this occurs, it will be necessary to take the temperature of the solution and adjust the Temperature Compensator Control manually to the temperature of the solutions. This step must be added since the pH of a solution will change with temperature variations. A label from a buffer powder package is shown in figure 4-9 to indicate how temperature effects pH of a solution.

## pH – TEMPERATURE TABLE

THE BUFFER POWDER IN THIS PACKAGE, WHEN DISSOLVED IN 500 ML OF DISTILLED WATER, WILL GIVE A BUFFER SOLUTION (ACCURATE TO ±0.01 pH) OF THE FOLLOWING.

| °C | pH | °C | pH | °C | pH |
|---|---|---|---|---|---|
| 0 | 9.46 | 25 | 9.18 | 60 | 8.96 |
| 5 | 9.39 | 30 | 9.14 | 70 | 8.92 |
| 10 | 9.33 | 35 | 9.10 | 80 | 8.88 |
| 15 | 9.27 | 40 | 9.07 | 90 | 8.85 |
| 20 | 9.22 | 50 | 9.01 | 95 | 8.83 |

THESE VALUES BASED ON COMPLETE THERMAL EQUILIBRIUM OF ELECTRODES AND BUFFER.

Figure 4-9. Changes in pH Due to Temperature Changes

QUESTIONS

DO NOT WRITE IN THIS SW, USE A SEPARATE SHEET OF PAPER.

1. What are the precautions when mixing acids?

2. Volumetric glassware is calibrated at what temperature?

3. What is the procedure for washing glassware?

4. What will be the results of mixing photographic developers violently?

5. What might happen if a chemical for a solution is added before the preceding chemical has dissolved?

6. What is the minimum number of times glassware should be rinsed after being washed with a cleaning solution before storage?

7. Measurements of clear solutions in containers are generally taken at the ______ of the meniscus.

8. What are the three basic tests given for certification of photographic solutions?

9. What is specific gravity?

10. What is the specific gravity of distilled water at 60°F (15.6°C), at 70°F (21.4°C) and at 115°F (46.1°C)?

11. What is a hydrometer?

12. Hydrometers are calibrated at what temperatures?

13. What correction factor must be applied to hydrometer readings for temperature changes when testing photographic solutions?

14. How is a hydrometer read?

15. What is a pH meter?

16. What is the definition of the pH unit?

17. What is pH?

18. What is the neutral pH?

19. What are solutions with low pH called?

20. What are solutions with high pH values called?

21. What is the purpose of the reference electrode? What is the purpose of the glass electrode?

22. What is KCl? How is it used?

23. What are buffer solutions?

24. Before the electrodes are lifted from a solution, the electrodes must be in ________.

25. Do temperature changes affect the pH of a given solution?

EXERCISES

Exercise 1

| EQUIPMENT | Basis of Issue |
|---|---|
| Chemical Mixing Facilities | 1/class |
| Assorted Laboratory Glassware | As needed |
| Magnetic Mixing Apparatus or Stirring Rods | 1/student |
| Triple Beam Balances | 1/student |

PROCEDURES

1. Observe the general safety precautions for the particular chemicals being used.

2. Remember the triple A (AAA) rule when using acids--ALWAYS ADD ACID. Add the acid or alkali to the water or other solutions. If water or other solutions are added to acid or alkali, splattering often results, endangering the eyes, skin or clothing.

3. Select proper equipment needed to mix 1.05 quarts (one liter) of AFD #1.

4. Obtain chemicals from the instructor.

5. Following the formula given below, mix the chemicals in their proper order. Take plenty of time.

6. The instructor will discuss mixing techniques during the mission.

FORMULA - AFD #1
(D-19)

| | |
|---|---|
| Water (52 C or 125 F) | 500 ml |
| Metol | 2.0 grams |
| Sodium Sulfite, desiccated | 90.0 grams |
| Hydroquinone | 8.0 grams |
| Sodium Carbonate, monohydrated | 52.5 grams |
| Potassium Bromide | 5.0 grams |
| Cold Water to make | 1.0 liter |

Exercise 2

| EQUIPMENT | Basis of Issue |
|---|---|
| Hydrometer Set | 2/class |
| Graduated Cylinder | 1/student |
| Processing Solution | 1/student |
| Glassware Washing Iacilities | As needed |
| Thermometer | 2/class |

PROCEDURES

1. Pour a sample of the developer mixed in exercise 1 into a proper graduated cylinder.

2. Use a hydrometer and take the specific gravity.

3. Take the temperature of the solution.

4. Mathematically adjust the reading according to the procedure stated in the SW.

Exercise 3

| EQUIPMENT | Basis of Issue |
|---|---|
| pH Meter | 1/student |
| Processing Solution | 1/student |
| Assorted Beakers | As needed |
| Glassware Washing Facilities | As needed |
| pH Buffer | As needed |
| Distilled (Deionized) Water | As needed |
| Chemically Inert Tissue | As needed |

PROCEDURES

1. Use the same solution mixed in exercise 1.

2. Using procedures prescribed in the SW, determine the pH of the solution.

3. Observe all personnel and equipment safety precautions.

4. Store the remaining developer in a brown stoppered bottle, as per the instructor's directions for use in the next SW. Labeling instructions: YOUR NAME
COURSE NUMBER
DATE MIXED
INSTRUCTOR'S NAME

Sciences Branch
Lowry Air Force Base, Colorado

SW G3ABR23330 001-II-5
October 1977

# SENSITOMETRY AND DENSITOMETRY

## OBJECTIVES

Using unexposed original film, sensitometer, previously mixed solutions, and manual processing facilities, expose and process sensitometric strips. Processed sensitometric strips must be of acceptable density and be free of chemical and physical defects.

Using a densitometer and previously processed sensitometric strips, measure and record each density step to within ±0.02 of the actual density.

Using densitometric readings from a previously processed sensitometric strip, plot a sensitometric curve and determine gamma. Gamma must be computed to within ±0.10 of the class standard.

## INTRODUCTION

In the early years of aerial photo reconnaissance, processing was a hit-and-miss game. However, in more recent years, research has produced means of controlling and predicting the results of photographic processing. Results that were good "sometimes" would not provide high quality intelligence information that was good enough.

One method of achieving good quality control is the use of sensitometry. Through sensitometry, a very previse control can be kept on the sensitized materials, photographic solutions, and the method of processing.

## INFORMATION

### SENSITOMETRIC FUNDAMENTALS

When a photographic emulsion is exposed to light, certain changes occur which eventually produce a series of densities. If this exposure takes place in a camera, a great many densities are created whose values are the opposite, or the negative, of the luminances in the scene. These negative densities, in turn, modulate light passing through them to produce positive densities in a print. Each density is some approximate product of the intensity of the light the emulsion was subjected to and the length of time it was exposed. Such a variety of exposures are produced in a camera that to make comparisons between exposures and densities would be extremely difficult. Therefore, an instrument capable of producing a series of known exposures over the range likely to be encountered in practice must be used. The instrument which does this is a sensitometer.

The first requirement of a sensitometer is that it conforms to practice. If the response of an emulsion to exposure is to be measured, the duration, intensity and quality of the exposure must be controlled. Also, the results must be predictable and reproducible.

Sensitometry and densitometry are terms that are closely tied together. Sometimes they are even used interchangeably. However, this is incorrect, since densitometry is merely a part of sensitometry.

Sensitometry is the science of determining the photographic characteristics and responses of radiation sensitive materials. Densitometry is just the process of obtaining data for a sensitometric calculation.

Sensitometry

As the name implies, sensitometry is concerned with the measurement of sensitivity. This does not mean just sensitivity to light, but to all forms of radiation that are used in photography. These include light, X-rays, ultraviolet and infrared radiation and so forth. Therefore, the measurement of the effect of radiation on sensitive material is perhaps a better working definition of sensitometry.

In practice, sensitometry consists of giving sensitized materials a controlled exposure of radiation. After the exposure, the sensitometric strip is processed and the densities of the exposure are evaluated.

In order for the evaluation to be valid, the exposure, materials and processing must match those in actual use. It would be useless to test a material that is not used or to test it in a manner different from its intended use.

The sensitometric strip, sometimes called a control strip or test strip, is a convenient method of producing a uniform, measurable set of densities for test purposes. These densities should progress by some predetermined multiple of exposure and should have sufficient range to be representative of any densities likely to be encountered in the photographic negative.

Sensitometry can be used to test the effectiveness of a batch of photographic chemicals. It can be used to evaluate a certain method of processing or the reliability of a processing machine. It can also be used to determine the characteristics of a particular type of film. Therefore, sensitometry can be a very important tool for the photoprocessing specialist.

Classification of Sensitometers

The instrument used to produce the controlled exposure on the sensitized material is a sensitometer. Photographic sensitometers are

designed to make controlled exposures which produce densities suitable for sensitometric testing. Sensitometric-densitometric testing requires a method of comparing the amount of exposure given to an emulsion to the amount of density which results from that exposure.

Sensitometers are grouped into two classes. If the intensity of the light is changed while the time is held constant, the sensitometer is an intensity-scale instrument. If the time varies while the intensity is kept constant, the instrument is a time-scale sensitometer.

TIME-SCALE SENSITOMETERS. There are several designs for time-scale sensitometers. One way to build such an instrument would have the material exposed in different steps. This would be similar to exposing a test strip during projection printing. In other words, one section would receive an exposure, then another section would receive a larger exposure until the entire strip had been exposed.

Another design, more commonly used, uses a rotating wheel with apertures of different lengths cut into the wheel. (See fig. 5-1.) The apertures are precisely cut in order to give an accurate exposure time. In both of these designs, the intensity of the exposing lamp remains constant.

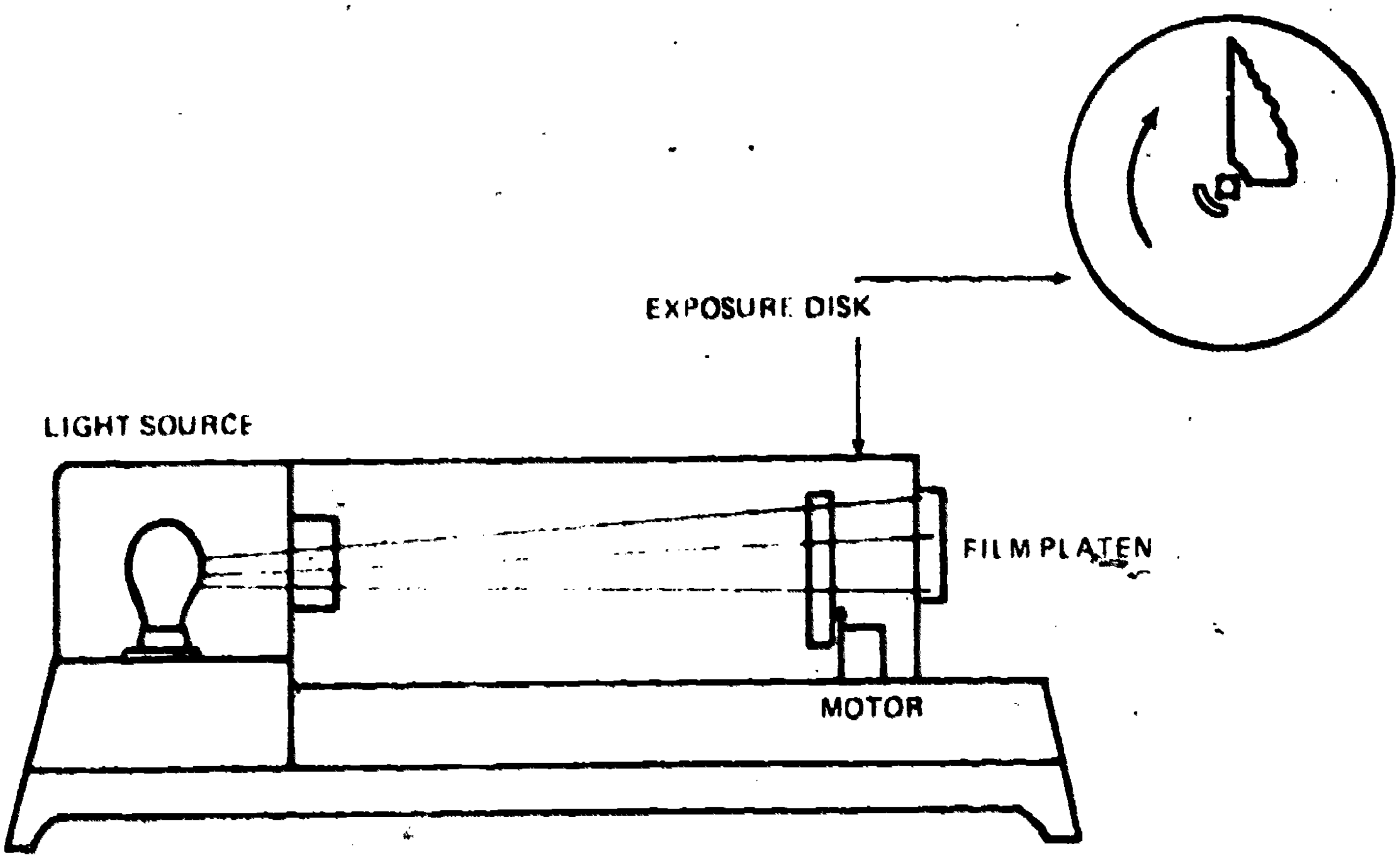


Figure 5-1. Time-Scale Sensitometer

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Until recent years, time-scale sensitometers were used for most precision work because it was easier to obtain a series of accurate exposures by varying the time than by varying the illumination. The usual method of obtaining a time-scale exposure is by means of a rotating disk with apertures of varying length. When the disk is rotated in front of the sensitive material, the time of exposure varies directly with the length of the aperture. The exposure varies by the power of two.

INTENSITY-SCALE SENSITOMETERS. Sensitometers in which the scale of exposures is produced by varying the illumination on different parts of the emulsion are preferred because, in actual practice, photographic materials are usually exposed to differences in illumination. For example, exposing negative materials in the camera subjects the emulsion to varying intensities rather than to different times. Many types of sensitometers producing illumination scales have been designed, but those using light absorbing filters, commonly known as step wedges, are the most widely used.

Light Sources

Photographic exposure is defined as the product of illumination and time (E = I x T). The unit of exposure is the meter-candle second (MCS). This is the exposure produced by a standard candle in one second, at a distance of one meter from the material. It follows then, that the two important parts of a sensitometer are the light source and the device for producing a series of graded exposure steps.

Light source lamps for a sensitometer must be carefully chosen, and their characteristics must be precisely known. The intensity of the light must be known. It must be sufficient to make the time of exposure correspond closely with actual photographic practice and it must remain constant over long periods of time. In addition, the color temperature of the light must be known. These illumination requirements are fulfilled most completely at the present time by special incandescent tungsten lamps. Both the intensity and the color quality of lamps of this kind depend on the current flowing through the filament. It is necessary to maintain proper voltage at all times. Another factor in precision sensitometry is the change in both intensity and color with the age of the lamp. A replacement lamp should be burned for a short time before using it for testing purposes. An old lamp should be discarded before any appreciable change occurs.

Incandescent lamps of the type most suitable for use as a standard light source operate at a color temperature of about 2300° K, while the color temperature of sunlight at the earth's surface has been fixed at 5400° K. Therefore, it is necessary to use a filter to alter the color temperature of the lamp so that it is equal to the color temperature of sunlight. Gelatin filters, such as the "Wratten" 78, 78A, and 79 are sufficiently accurate for practical exposures and are generally used.

Another light source suitable for use as a standard light source is a xenon flash (similar to a strobe light). Advantages of this type of light source are long life, color quality close to daylight, and little loss of color quality over the life of the lamp.

## Exposure Modulators

For a sensitometer to produce a graded series of exposures, the values of the exposure intervals must be accurately known. These intervals are generally arranged in steps increasing in order from low to high exposure. A part of the strip is left unexposed in order that the fog density of the material may be determined.

TIME-SCALE MODULATORS. First, consider the time differential used in sensitometers and see why the time intervals are figured the way they are. Consider making a test strip and that the exposure times are unknown. Assume a trail range of exposure times from 5 to 80 seconds. What intermediate steps should be used?

One answer might be to use steps, 5, 10, 15, 20, 25 seconds and so on. This might appear to be a reasonable system of exposure, but it fails to meet the requirements for an equal set of exposure changes. This can be seen by comparing the steps in the low and high ranges. The change from 5 to 10 seconds is a 100 percent increase in exposure, and the change from 10 to 15 seconds is a 50 percent increase. The change from 75 to 80 seconds would only be an increase of about 6-1/2 percent. Therefore, as the exposure time becomes greater, the effective increase becomes less.

In designing the exposure modulator, then, a set of equal changes is required. If a change from 5 to 10 is appropriate to use, the next step should be 20, then 40 and so on. Such a series of numbers would be equally spaced in a geometric progression. There is a common multiplier (2) which is used to generate each number from the preceding one. The complete series would be 5, 10, 20, 40, and 80. Notice though, that here you have exhausted the range from 5 to 80 in only 5 steps. The principle that applies here is "to produce a series of equal exposure changes, do so by repeated multiplication by some factor." (The factor need not be 2, although this is commonly used.)

Now convert the series developed above to logarithms and notice that the logs have a common difference, which is 0.30. (This is the log of the common factor 2.)

| | | | | |
|---|---|---|---|---|
| 5 | 10 | 20 | 40 | 80 |
| 0.70 | 1.00 | 1.30 | 1.60 | 1.90 |

The principle used here is: "A series of equally spaced exposures (equally spaced in that they differ by a common multiplier) when expressed

in logarithms, have a common difference." The exposure wheel on the sensitometer is designed to give these equally spaced exposures during one revolution of the wheel.

The device or method used as an exposure modulator must also meet certain requirements. First, it should be able to produce an exposure range that conforms closely to that found in actual experience. Next, it should be accurate. Also, it must be consistent. Finally, it should have no significant effect on the color quality of the light.

INTENSITY-SCALE MODULATORS. In the time-scale sensitometers, the exposure is changed (or modlated) by apertures of varying length. The modulator used in a intensity-scale instrument is commonly called a step wedge or tablet and has steps of varying densities. These densities are precisely known. This modulator changes the intensity of the light striking the film being tested. By using this modulator even exposure changes can be obtained.

Absorbing step wedges, are usually made by coating glass with a layer of gelatin containing carbon or some black pigment. For rough sensitometric work by the practical photographer, it is often adequate to use a step wedge consisting of a photographic negative made by exposing a film in steps and developing it in a developer which gives a deposit as free as possible of color other than gray.

An intensity-scale sensitometer using a step wedge is simple to construct and to use. It merely involves placing the wedge in contact with the test strip and exposing both to the light from a standard lamp through an accurately timed shutter. The intensity may be further modulated by placing neutral density filters between the light source and the step wedge. See figure 5-2.

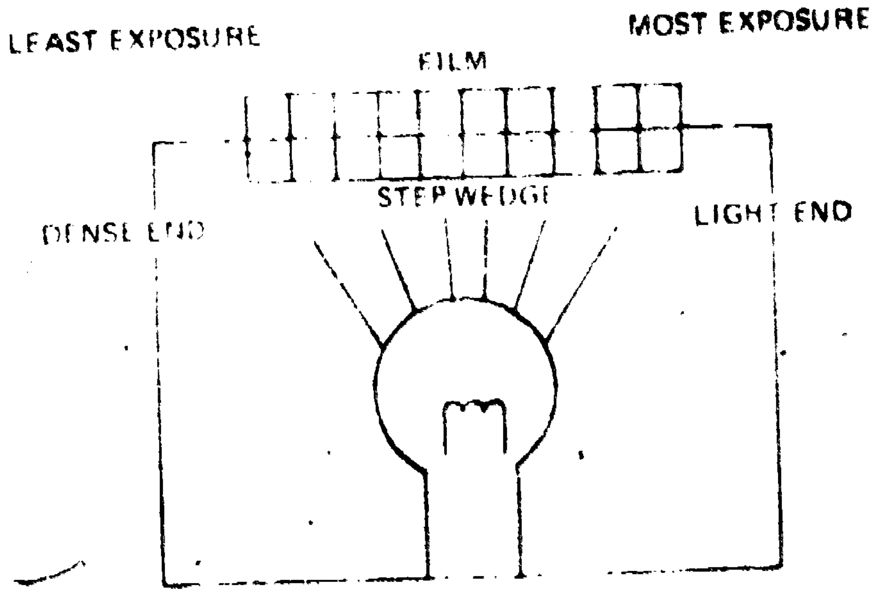


Figure 5-2. Intensity-Scale Sensitometer

There are two sensitometers in common use in the Air Force. These are the Kodak Process Control Sensitometer Model 101 and the E G & G Mark VI Sensitometer. Both of these instruments are intensity-scale sensitometers.

Kodak Model 101 Sensitometer

FUNCTIONAL DESCRIPTION. This instrument provides repeatable exposures for either black-and-white or color photographic materials for process control purposes in laboratories. The sensitometer is versatile enough to handle all commonly processed photographic materials with sufficient accuracy to provide the degree of control required.

A fixed exposure time of 1/5 second is produced by a shutter disk connected directly to a synchronous motor. Illumination of constant intensity and color quality is provided by a calibrated projection lamp mounted in a polarized 3-pronged plug. The electrical control circuit for the lamp consists of a voltage stabilizer to supply constant voltage, a variable transformer to produce the correct lamp current, and an ammeter to set and read the required lamp current. Combinations of calibrated neutral density and color-balancing filters are used in the exposing beam to convert the illumination intensity and color quality to meet requirements of the material being exposed.

During exposure, film or paper is held by a pressure pad against a step wedge. The Kodak Sensitometric Step Tablet No. 1, supplied with the sensitometer, provides 11 exposures with a 0.30-density increment between steps. Total exposed area is 7/8 by 4 7/16 inches (22mm x 113mm). Other step wedges for specialized emulsions are also provided.

This sentiometer must be used in a darkroom, but, for efficient operation, it is advisable for you to practice operating it in the light. (See fig. 5-3.)

The calibration life of the lamp is 100 to 150 hours. To conserve this, turn off the instrument when it is not in use and do not operate the lamp at a current value greater than specified on the calibration tag. As a further caution, always turn the instrument on and off with the lamp control knob, not by inserting and pulling the power cord in the outlet. This will protect the lamp and ammeter from sudden current surges.

The sides of the gate are notched to allow positioning. Strips of film or paper 35mm or 3 1/2 inches (89mm) wide can be handled by resting their lower edges on the lowest stop on the gate. The strips must be at least 6 1/2 inches (165mm) long to allow proper handling on the gate, but they can be much longer if desired.

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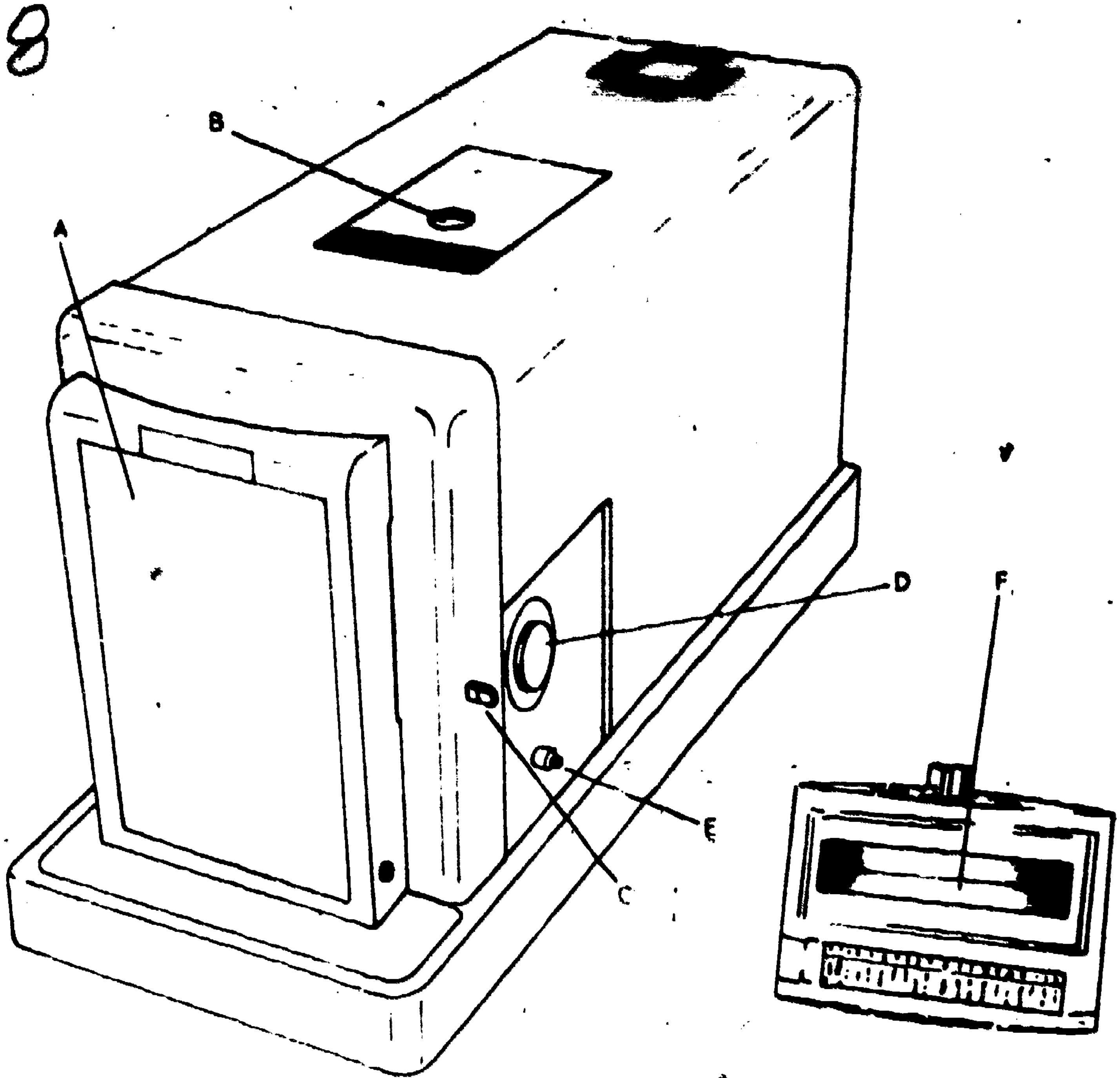



A – GATE
B – DARK SLIDE
C – GATE RELEASE LEVER
D – LAMP CONTROL KNOB
E – EXPOSURE BUTTON
F – MODULATOR WITH STEP WEDGE

Figure 5-3. Kodak Process Control Sensitometer, Model 101

The removable neutral density filter assembly contains two glass filters and allows adjustment of the light intensity to suit three general types of material. These include black-and-white negative films, color films, and most print materials. The lighter of these two filters has a density of approximately 0.80 and the darker one has a density of approximately 2.10. The filter assembly is removable for conditions where no filter is required.

The color filter holder accepts 3-inch (76mm) square filters needed to balance the color quality of the illumination for the various types of color materials.

OPERATING PROCEDURES. To operate the Kodak 101, follow these steps carefully:

1. Make certain that power cord is unplugged - lamp control knob "OFF."

2. Insert proper neutral density and color compensating filters.

3. Close dark slide door.

4. Plug power cord into 100V grounded outlet.

5. Check proper placement of exposure modulator.

6. Turn lamp control knob "ON" and adjust to bring ammeter to value given on lamp calibration tag.

7. After 2 minutes readjust lamp control knob if reading on ammeter is not correct.

8. Turn out room lights.

9. Open platen gate.

10. Place strip across pressure pad, holding the ends in appropriate notches - close platen gate.

11. Press, and immediately release, exposure button. CAUTION--Holding the button too long will result in multiple exposures.

12. Open the gate and remove the exposed strip.

13. Turn "OFF" by turning the lamp control knob counterclockwise until the switch clicks.

14. Unplug the power cord.

15. Open dark slide door and remove the filters - close the dark slide.

E G & G Mark VI Sensitometer

FUNCTIONAL DESCRIPTION. The Mark VI is a precision photographic research tool which uses a xenon flash source. Designed to be used as the exposure light source for film characteristics investigations, process control operations, and reciprocity effect studies, the Mark VI can

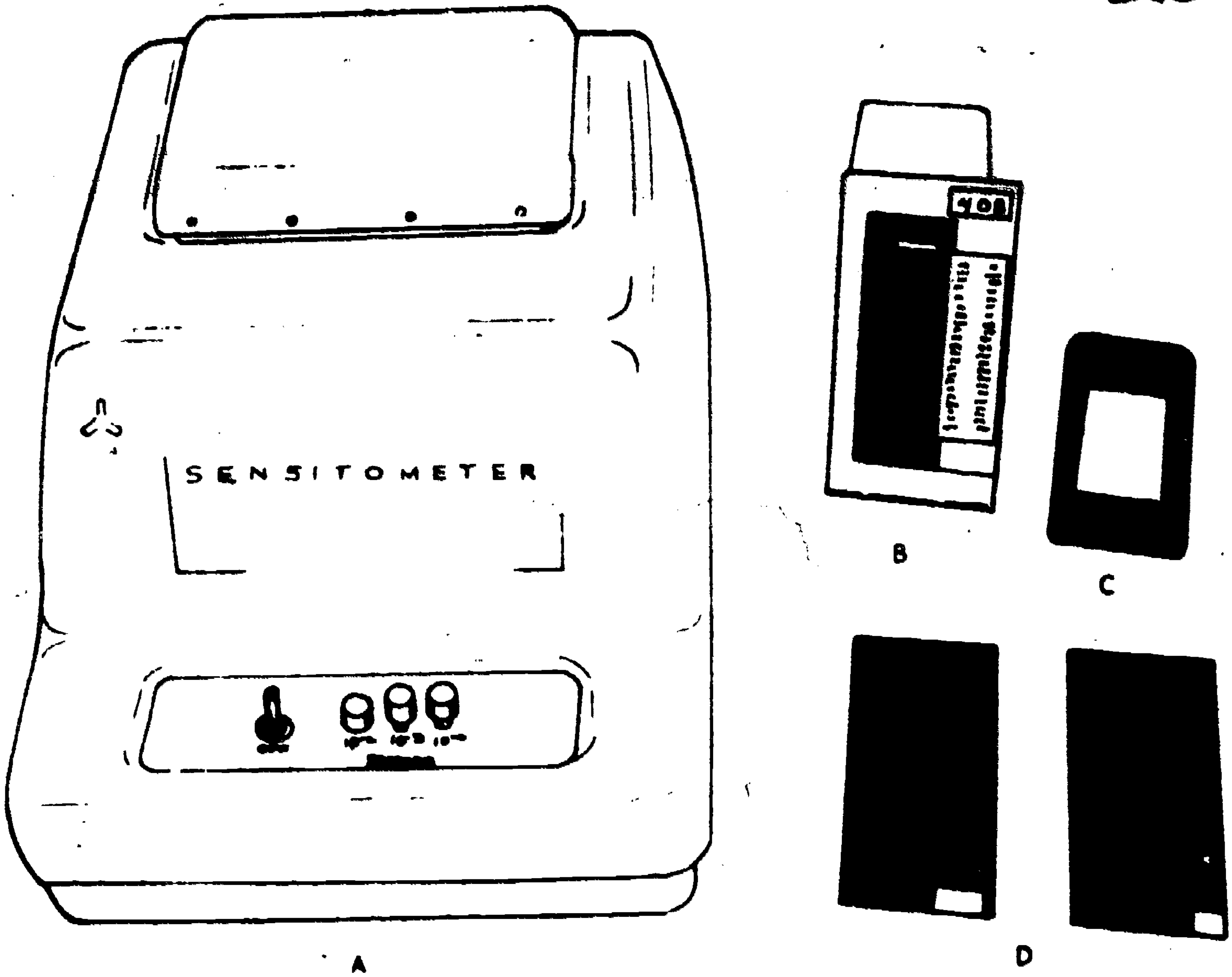
be used with all types of photographic emulsions. Since the light output approximates the color quality of daylight, no color compensation is required for testing black-and-white or daylight-type color emulsions. The Mark VI has sufficient light output to test the slowest and fastest emulsions and flash durations which approximate the exposures encountered in snapshot, electronic flash, and high speed motion picture photography.

The Mark VI Sensitometer has four operating controls (ON OFF toggle, and $10^{-2}$, $10^{-3}$, and $10^{-4}$ SECOND EXPOSURE TIME selector switches) located on the top of the instrument. Closing the cover platen triggers the exposure lamp. A socket is provided on the right of the base so that the user may also trigger the unit remotely.

The sensitometer operates on standard 115-V, 60-cycle, AC power. A built in voltage regulator circuit prevents change in light output with line-voltage fluctuations from 95V to 130V. The time constants of the three different RC circuits provide three precise duration flashes at three different energy levels. The highest output, approximately 5000 meter-candle seconds (MCS) is obtained from the $10^{-3}$ second circuit. The $10^{-2}$ and $10^{-4}$ second circuits deliver approximately 1000 and 130 MCS, respectively.

The three exposure time selector switches correspond to different shutter speeds in normal photography. The switch $10^{-2}$ equals 1/100 second exposure time; $10^{-3}$ equals 1/1000 second and $10^{-4}$ equals 1/10000 second. These exposure times are provided to allow an exposures equivalent to the exposure used during actual use.

The complete system consists of the sensitometer, a gray-scale box, flashtube shield, two variable-area filters, and an uncalibrated Kodak No. 2 Photographic 21-Step Tablet (step wedge). See figure 5-4. Calibrated photographic step tablets can be obtained, or the scale provided can be easily calibrated. The gray-scale box, which is inserted into the body cavity under the platen of the instrument, provides the exposure platform upon which the film undergoing test is exposed. The variable area filters (3-line and 19-line), which are inserted between the flashtube shield and the gray scale box, allow the user to balance the light output of the three separate circuits within ± 10 percent. The 3-line filter and the 19-line filter, which can be considered equivalent to ND 1.70 and ND 1.0 filters, respectively, are used to normalize the light output of the $10^{-3}$ and $10^{-2}$ second circuits to that of the $10^{-4}$ second circuit. Normalization of the light output of the three circuits can be useful in studying film characteristics and exposure reciprocity effects. The step tablet is supplied as an exposure modulator. Neutral density filters, such as the Wratten 96 series, can also be used to reduce the light output of the individual circuits to suit the needs of the specific film being tested. Neutral density filters are not recommended for color work however.




A – MARK VI SENSITOMETER
B – GRAY-SCALE BOX
C – FLASHTUBE SHIELD
D – VARIABLE-AREA FILTERS

Figure 5-4. Complete Mark VI System

The E G & G Mark VI Sensitometer is an instrument with which standardization can be accomplished. With it, complex photographic variables can be analyzed separately and scientifically. The precise duration and constant repeatability of the light output of the Mark VI makes it possible to consider all aspects of the photographic process from the point of view of exact, controlled exposure. Film characteristics and the effects of processing conditions can be determined easily and precisely with this sensitometer.

The foregoing information on the Mark VI sensitometer includes data only for one type (or version) of the Mark VI. There are two versions

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of this sensitometer in existence and the output varies slightly between them. To compute the exposure properly, the output of the sensitometer must be known.

These two versions are commonly referred to as the "gray model" and the "white model." The differences in output are as follows:

| | "Gray Model" | "White Model" |
|---|---|---|
| $10^{-2}$ circuit | 1300 mcs | 1000 mcs |
| $10^{-3}$ circuit | 7000 mcs | 5000 mcs |
| $10^{-4}$ circuit | 130 mcs | 130 mcs |

OPERATING PROCEDURES. To operate the Mark VI, follow these steps:

1. Plug power cord into 110 volt, 60 cycle AC outlet.

2. Switch power on.

3. Press desired exposure time selector switch.

4. Add neutral density filters or variable area filters if necessary.

NOTE: To add filters, remove the gray scale box completely from the instrument. Drop filters or area weighted attenuators into the cavity over the light source and replace the gray scale box. Make sure the curved edge is at the rear. Otherwise, the box will not seat properly and will be impossible to make an exposure.

5. Check the operation of the instrument by pressing the micro-switch located behind the gray scale box while looking into the cavity through the step wedge. If the flash is not seen, check the electrical connection and be sure the flash duration button is depressed completely.

6. Turn room lights off.

7. Position film strip on gray scale box so that it completely covers the step wedge. DO NOT allow the film to cover the microswitch.

8. Close lid of the sensitometer until the "click" of the micro-switch is heard. When this is heard, exposure is complete.

9. Allow at least 5 seconds between exposures to insure recharging of circuit capacitors.

10. Repeat steps 5 through 7 until all strips have been exposed.

11. When all exposures have been made, switch the instrument off and unplug the power cord.

## Sensitometric Processing Methods

The density of a developed image depends on the characteristics of the emulsion, its exposure and the degree of development. With any emulsion, the degree of development depends on the temperature of the developer, development time, the degree of agitation, and the activity of the developer. In order to make a usable sensitometric test, all of these variables must be the same from one test to the next test. Use the same developer/film combination at the same temperature, for the same time with the same amount of agitation. Everything must be exact.

There are 3 methods for processing sensitometric strips: The ASA tray method, the tank method, and the machine method.

ASA TRAY METHOD. For processing most test strips, the ASA tray method of agitation may be satisfactory. In this method, provide three trays of suitable size for developer, rinse or stop bath and fixer. Use solutions at 68°F (20°C). Keep the proper amount of developer in a graduate until time for processing. Place the proper amounts of rinse and fixer in their trays. Then, with the lights out, proceed as follows:

1. Tape the test strip to the bottom of the dry developer tray.

2. Start the timer and pour the beaker of developer into the tray containing the test strip.

3. Agitate continuously in the following manner:

a. Raise the left side of the tray 1/2 to 3/4 of an inch (or about 2 centimeters).

b. Lower smoothly, and immediately raise and lower the near side in a similar manner.

c. Next, raise and lower the right side.

d. Then, again raise and lower the near side.

4. Rinse the film (with agitation) for about 5 seconds.

5. Transfer the film to the fixing bath and agitate (as described for development) for about 30 seconds. Repeat the agitation several times during fixation.

6. Thoroughly wash the film, treat with a wetting agent and hang to dry.

While developers and development are of primary importance, keep in mind that all of the other steps in the processing of film are also important. If standards are to be maintained and results uniform, there must be uniformity in stop bath or rinses, fixer, and wash. Every step in the entire process, from exposure to drying the processed film, must be carried out as carefully and systematically as possible.

TANK PROCESSING. The ASA method of processing is satisfactory for some purposes. However, it is possible to process sensitometric control strips in tanks. The type of tank may vary to suit different needs, but the same processing controls must be met. The only thing that differs is the method of agitation. Conventional tank agitation methods are usually satisfactory. When extremely critical results are desired, however, a commercial tank processing unit is used.

In some commercial processors, agitation is made by a controlled burst of compressed nitrogen. This allows for more consistent and repeatable results. Other commercial processors are designed to process nothing but sensitometric strips. These sensitometric processors provide extremely accurate results.

MACHINE PROCESSING. Quite often a sensitometric strip will be processed in a production film processor. This serves two purposes. It is used to certify the processing solutions in the machine before valuable mission film is run; and it certifies the reliability of the machine itself. Although this method does not have the extremely high degree of control that a sensitometric processor would have, it proves to be a valuable and practical means of processing control strips.

### Safety Precautions

Remember the basic rules of darkroom safety when processing control strips. Beware of the chemicals used, particularly of acids. Working in total darkness presents additional hazards. Place equipment properly before turning out the lights. This will prevent needless groping and stumbling about in total darkness.

## DENSITOMETRIC MEASUREMENTS

After the control strip is exposed and properly processed, the densities must be measured accurately. Guessing has no place in the precision photographic lab. The method used to measure these densities is called densitometry and is based on the concepts of transmission, opacity and density.

### Transmission, Opacity and Density

When light strikes a negative, part of it is reflected, part of it is absorbed, and the remainder passes through. These three conditions bear a definite relationship to each other. For the present, consider

only the transmitted light and the things that affect it. Basically, transmission is the ratio of the amount of light transmitted by any one area of a negative to the amount of light falling upon that area.

$$\text{Thus, transmission} = \frac{\text{transmitted light}}{\text{incident light}}$$

For example, if two units of light strike a portion of a negative and only one passes through, the ratio would be

$$T = 1/2 \text{ or } 0.50 \text{ or } 50 \text{ percent}$$

The condition which reduces the amount of incident light to the amount of transmitted light is a degree of opaqueness or opacity of that area of the negative. This is the inverse of the ratio of transmission or:

$$\text{Opacity} = \frac{\text{incident light}}{\text{transmitted light}}$$

For instance, using the values from the preceding example,

$$O = \frac{2}{1} \text{ or } 2$$

Thus, it is apparent that the opacity is the reciprocal of the transmission and vice versa, since by dividing either value into 1, the other is obtained. For example

$$T = \frac{1}{2},\ O = \frac{1}{\frac{1}{2}} = \frac{1}{0.50} = 2$$

Since the values of transmission and opacity are reciprocal, it can be seen that as the percent of transmission diminishes, the numerical expression of opacity increases until, where extremely small transmittances are concerned, the opacity becomes uncomfortably large. (Transmittance is given here as a measure of transmission.) This could be a disadvantage. Therefore the common logarithm (to 2 places) of the opacity is used and, for purposes of differentiation, is called density.

$$\text{Thus, Density} = \log_{10} \text{Opacity}$$

To illustrate, using the values from the previous examples

$$D = \log_{10} 2 = 0.30$$

where 0.30 is the logarithmic value of 2 as obtained from a table of common logarithms.

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In summary, transmittance is a portion of the incident light. Hence, it is always less than 100 percent of 1, and normally will be shown either as a decimal fraction, or as percentage. Opacity is the reciprocal of the transmittance and will always be a number equal to, or greater than 1. Density is the common logarithm of the opacity.

The photographic image produced by exposure and development may be considered in either of two ways: (1) as the mass of silver per unit area, or (2) as the ability of the deposit of silver to absorb light. The first is useful when considering image formation as a result of chemical action. The second is important since the photographic function involves the absorption and transmission of light. Both methods can be used to evaluate the effect of exposure and development, but the first method, although it appears to be the more logical, is more difficult to measure. It is more useful to evaluate an image by measuring its absorption and transmission of light.

Of the three terms used in this lesson, transmission, opacity and density, the most important is density. However, no one of these terms can be disassociated from the other two. If the value of any one of these is known, the values of the others can be computed.

Densitometry

Densitometry provides the information needed for the practical application of sensitometry in the determination of the photographic characteristics of radiation-sensitive materials. In other words, densitometry is the portion of sensitometry when measurements are taken.

Densitometry is the measurement of density. This density can be on film or paper or any other sensitized material. Density is measured with some form of photometer which compares the light transmitted by a substance with the light incident upon it. This instrument is a densitometer.

Classification of Densitometers

A densitometer measures, in terms of density, the light stopping ability of areas of films or prints. There are several types of densitometers in use and more are being designed for future use. Although most densitometric readings will be done by the quality control section, a thorough knowledge of densitometers is helpful to the photoprocessing specialist so that the mission of the unit can be accomplished smoothly and quickly.

VISUAL COMPARISON DENSITOMETERS. Visual comparison densitometers have a field of view consisting of two concentric areas of light as shown in figure 5-5.

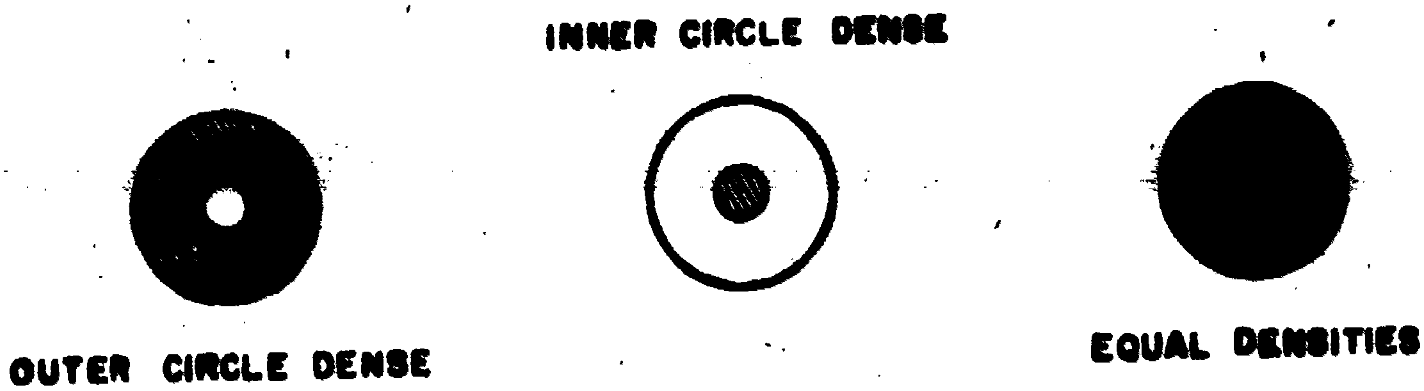


Figure 5-5. Visual Comparison Densitometer - Field of View

These two fields are compared visually as to brightness and an adjustment is made until the intensities appear equal. The adjustment knob or level is calibrated and marked in density units, and density readings are taken directly from it.

Because of their simple design, visual comparison densitometers are rather inexpensive. However, they do have some distinct disadvantages. One of these is the possibility of making erroneous measurements because of the fallability of the eye and errors in judgement. Also, if the instrument is used over a long period of time, eye fatigue usually results. Nevertheless, in spite of the disadvantages, visual comparison type densitometers serve a valuable purpose, especially when photoelectric densitometers are not available.

PHOTOELECTRIC DENSITOMETERS. Photoelectric densitometers are so named because they employ a photoelectric cell or similar detector, to determine the intensity of light. The most extensively used photoelectric densitometers are the direct-reading type. To use a densitometer of this type, the material to be measured is placed in the light beam between the source and the photocell and the density value is read directly from a meter. Photoelectric densitometers have the main advantage of eliminating errors due to poor judgment or eye fatigue, since the measurements taken are not based upon visual impressions. Some disadvantages are possible instabilities due to fluctuations in light source intensity and to the aging characteristics of photoelectric cells and meters.

Common Densitometers

MACBETH QUANTALOG DENSITOMETER, MODEL TD-100. The TD-100 is a transmission densitometer designed to measure densities of black and white materials only. It can be used in the microfilm, graphic arts, X-ray, and photographic areas where precise measurement of the diffuse transmission density of materials is needed to establish consistent product quality. It permits the operator to make rapid, accurate and reproducible measurements with a minimum of training. The mirrored meter scale and evenly spaced graduations minimize parallax errors. See figure 5-6.

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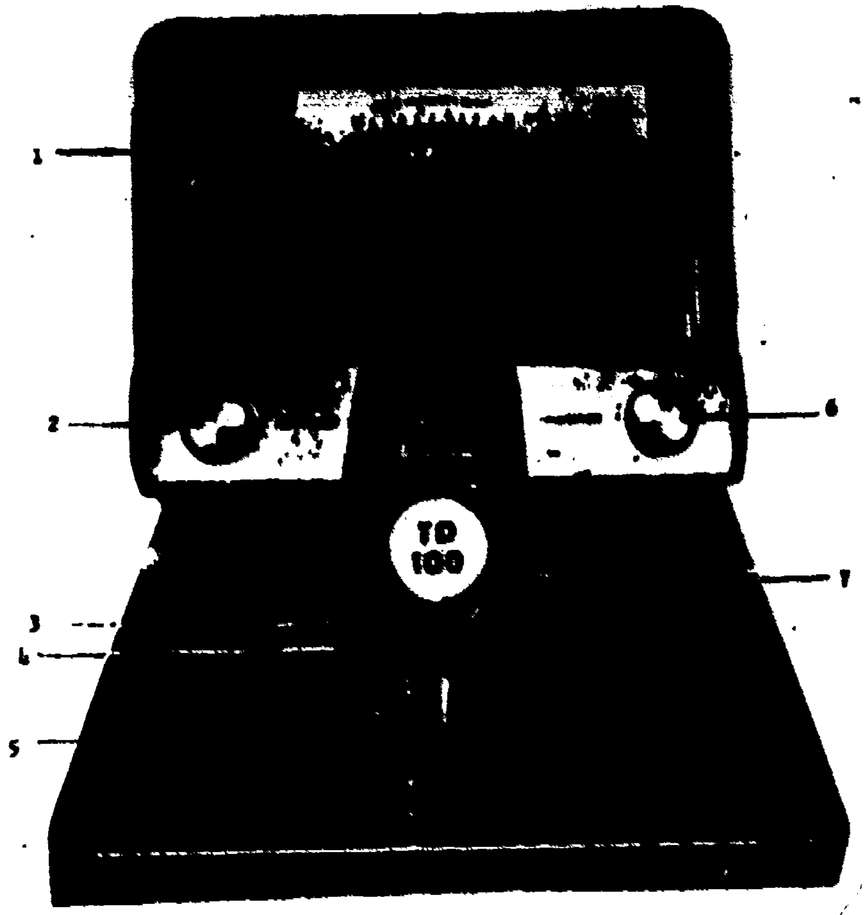



(1) Mirrored meter scale

(2) Zero adjust control

(3) Snout lever

(4) Finger rest

(5) Probe snout

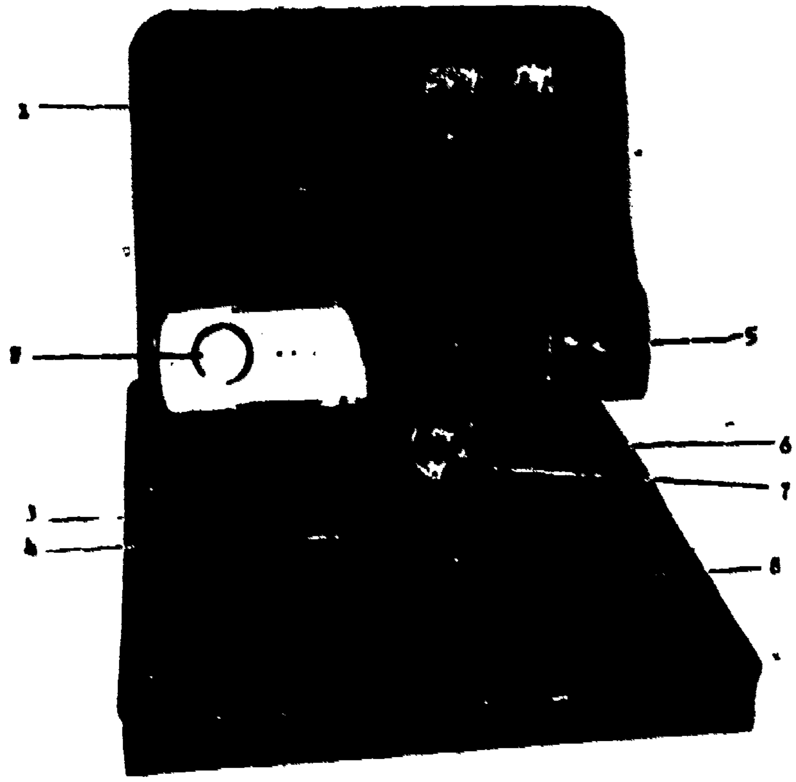
(6) Calibration control

(7) Calibration reference lever

Figure 5-6. Model TD-100 Densitometer

Because of the long warmup and stabilization period required, it is advisable to leave this machine "ON" at all times. The power supply is self-regulating, therefore, it is not affected by normal line voltage variations. However, line voltage variations do affect the stability of the energy radiated by the optical system's light source. Therefore, a voltage stabilizer must be used. This instrument may be used in room light or in a darkroom. Since the meter scale is not illuminated, some form of illumination is required when reading the scale under darkroom conditions.

MACBETH QUANTALOG DENSITOMETER, MODEL TD-102. The TD-102 is a transmission densitometer capable of measuring densities of both black-and-white and color materials. This is the major practical difference between it and the TD-100. It has adjustments for fine calibration for precise color work but is operated basically the same as the TD-100. The preceding paragraph concerning the warmup period, voltage requirements and illumination of the TD-100 also apply to the TD-102. See figure 5-7.




(1) Linear meter scale
(2) Zero adjust control
(3) Snout lever
(4) Finger rest
(5) Calibration control
(6) Calibration reference lever
(7) Filter trim controls
(8) Probe [illegible]

Figure 5-7. Model TD-102 Densitometer

A similar instrument is the Model TD-203 which is almost identical to the TD-102. The major difference is in the color filters installed in each instrument. The TD-203 has different color filters than the TD-102. These filters are used when measuring densities of color materials.

## Operating Procedures

The operating procedures for the TD-100 and the TD-102 are very similar when measuring black and white densities. Before using the TD-102, be sure that the yellow trim knob on the front of the machine is in the bottom position. The controls for the densitometers and their functions are described below. The instruments should be operated in the sequence presented:

ZERO ADJUST— This control preforms a dual purpose. It is a combined power ON-OFF switch and ZERO ADJUST control.

1. Rotating this switch clockwise supplies AC power to the instrument after it has been plugged into a suitable power line whose voltage is stabilized with a voltage regulator.

2. The zero adjust control must be rotated further clockwise to set the meter for zero scale reading. Do this with the snout lever in the depressed position. Note that the meter continues to read below zero until the snout lever is fully depressed with no sample over the aperture. This is normal and insures against an erroneous zero adjust setting.

CALIBRATION - The calibration control is used to adjust the meter pointer to read a specific up-scale density reading for which the instrument was calibrated at the factory. Set this control as follows:

1. Place the internal calibration reference in the measuring beam by moving the CALIBRATION REFERENCE control backward until you feel it "click in." This control is located on the bottom right-hand side of the photomultiplier housing.

2. Depress the snout lever.

3. Adjust the calibration control until the meter reads the density indicated on the tag adjacent to this control.

4. Remove the internal calibration reference from the measuring beam by moving the calibration reference control forward until you feel it "click out."

5. Recheck your zero adjust control and calibration control settings by repeating steps previously described.

DENSITY MEASUREMENTS. When using this instrument to make density measurements follow these operating instructions:

1. Plug the voltage regulator into a wall receptacle.

2. Plug the densitometer into the voltage regulator.

3. Turn the zero adjust control clockwise to turn power on. (The circular stage diffuser is illuminated.)

4. Allow at least 30 minutes for warmup. (As stated before, it is best to leave this machine "ON" always.)

5. With no sample over the aperture, depress the snout lever and move the zero adjust control until the meter reads zero.

6. Push the calibration reference control backward. Depress the snout lever. Set the calibration control for a meter reading corresponding to the density indicated for this control.

7. Flick the calibration reference control towards yourself out of the optical path.

8. Recheck the meter readings obtained in 5 and 6 above and reset the controls, if necessary.

9. The instrument is now ready for use. Proceed to make measurements of the densities of the samples.

READING THE STRIP. After the densitometer is adjusted, insert the control strip over the circular-stage diffuser and position the 11th step (on a 21-step strip) over the one millimeter circular aperture. (The 11th step will be marked with a small notch to one side.) Depress the snout lever, read and record the measurement. Measure, read, and record the density for each step in the same manner. Be sure that the needle on the meter scale covers its reflection in order to avoid parallax errors.

## CONSTRUCTION AND ANALYSIS OF SENSITOMETRIC CURVES

Once sensitometric data is obtained through the use of the densitometer, the data must be analyzed. The method used for analyzing this data is to plot a sensitometric curve. This curve will represent in graphic form the sensitometric capabilities of the particular film/developer/development used in the test.

The principles of plotting graphs are the same regardless of the type of graph plotted. One begins with a set of data. These data are obtained by making measurements on a process or experiment to determine the relationship between two quantities. An example is exposure and the densities produced.

Normally one quantity is changed to find what change this will produce in the second quantity. The first quantity is called the "independent" variable and the second is the "dependent" variable. In sensitometry, exposure is the independent variable and the density produced is the dependent variable. The independent variable is always plotted along the horizontal axis while the dependent variable is plotted along the vertical axis. The value assigned each block or line on the graph should be such that the values are easy to plot and read, and such that most of the paper is used. On sensitometric curves always use 0.40 units (either density or exposure) to the inch. In this course 20 X 20 to the inch graph paper will be used so each small square will equal 0.02 density units or log E units.

### Parts of a Characteristic Curve

Figure 5-8 illustrates a graph of a hypothetical curve with all of the essential parts identified. The graph itself provides two axes so that density vs relative log E plots can be located. The horizontal axis, or abscissa, is the log E axis. The vertical axis, or ordinate, is the density axis. The graph should be long enough to permit an

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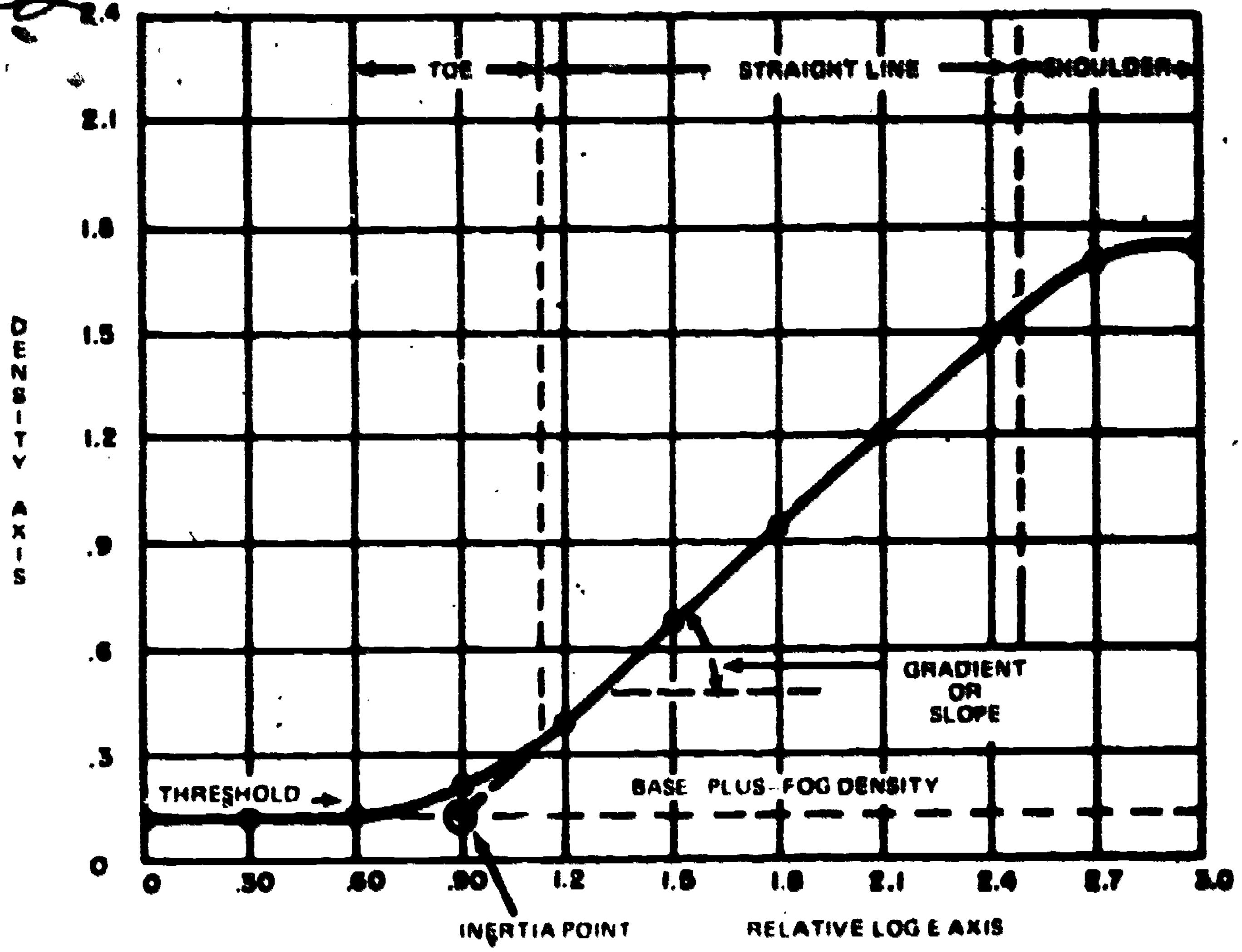


Figure 5-8. Characteristic Curve

exposure range equal to, or greater than, the range of exposures produced by the sensitometer and should be deep enough to accomodate a complete range of densities. The lower portion, or toe of the curve is the region of increasing gradient where increases in density are greater than proportional to their corresponding exposure increases. The straight-line portion is the region of constant gradient where density increases are proportional to their corresponding exposure increases. The upper portion, or shoulder, is the region of decreasing gradient where density increases are less than proportional to their corresponding increases in exposure. Finally, if the exposure continues to increase, the density values will decrease even more, and we have the region of reversal. In practice, most exposures will fall on the toe and straight-line gradients. Seldom will there be an exposure that produces densities up on the shoulder and probably never in the reversal region. It takes extremely long exposures to produce the reversal effect.

TOE. The toe is flat at its extreme end, representing the base-plus-fog density of the emulsion. The length of this flat portion of the toe is affected by the amount of overall exposure the film has received. If the exposure is low, the flat portion of the toe will be

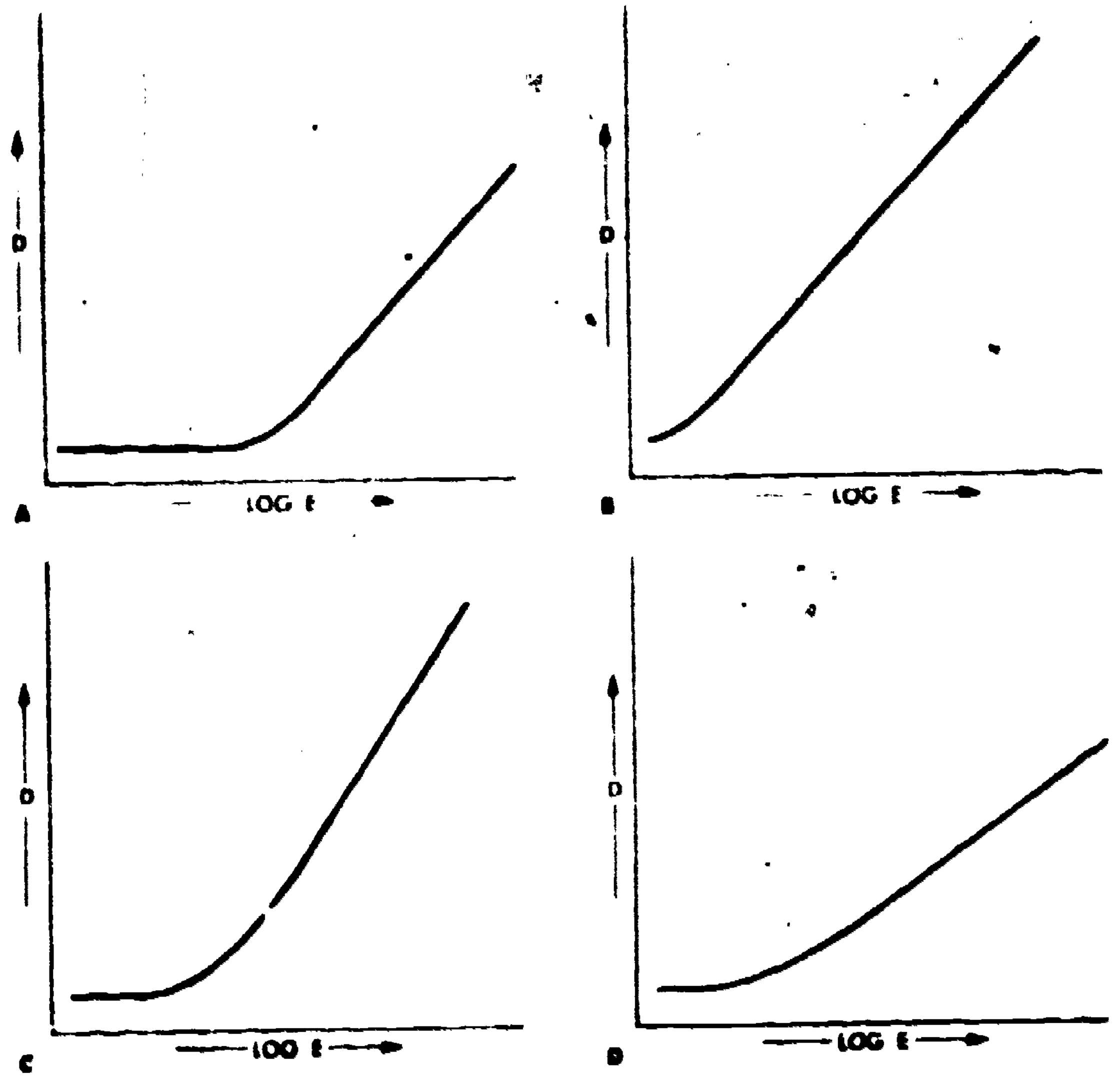


Figure 5-9. A-B. The Effect of Exposure Changes on a Characteristic Curve

C-D. The Effect of Development Changes on a Characteristic curve

longer and the straight-line portion will be moved to the right, figure 5-9A. On the other hand, increasing the exposure will shorten the flat portion of the toe and move the straight-line portion to the left figure 5-9B.

Where the toe is flat, the silver halides have not been exposed long enough to render them developable under the developing conditions used. A more energetic developer or increased developing time will shorten the fla part of the toe. However, it will also steepen the straight-line gradient and will not appreciably change the extreme end of the toe, see figure 5-9C. Shortening development in an attempt to compensate for overexposure may produce a toe but will also produce a flatter curve, see figure 9D.

INERTIA POINT. When the straight-line portion of the curve is extended to intersect the base-plus-fog density, and a line drawn vertically to the relative log E axis as shown in figure 5-8, the point of intersection is called the "inertia point." The inertia point can be used to establish an emulsion speed.

THRESHOLD. The threshold is the point on the toe of the curve where the density first comes perceptible. This varies. No two observers see exactly alike and will disagree upon the location of a threshold density. This is why some procedures for calculating film speed set a specific density above base fog as a basis for measurement.

STRAIGHT-LINE GRADIENT. On the straight-line gradient, equal changes in log E produce equal (or almost equal) changes in density. Any deviations from a straight line occuring in normally exposed and developed sensitometric strips will average out, and we can ignore them in most of our calculations. This is the most important part of the curve. The degree of processing is determined from this part of the curve.

SHOULDER. Normally, the shoulder of a characteristic curve is somewhat convex. The density changes represented in it are less than corresponding log E changes. Density is still increasing but not as rapidly as it is in the straight line or toe. It continues to increase until maximum density (D max) is reached. If the exposure continues to increase beyond this point, the reversal effect is produced. Most camera exposures avoid the shoulder. In this area, detail is lost because the density differences are not great enough to allow the viewer to distinguish between them, and the result is blocked up highlights.

Plotting the Curve

There are three means of labeling and plotting the graph. These are density versus relative log E, density versus absolute log E and density versus density. Because of its ease of use, most graphs are plotted using the density versus relative log E method.

DENSITY VERSUS RELATIVE LOG E. Follow these steps in plotting a density versus relative log E curves:

1. Label the vertical axis as density and mark each half inch as 0.20, 0.40, 0.60, etc. Start with zero as the base line and increase upward.

2. The horizontal axis will be labeled according to the method of plotting used. Start by plotting relative log E (density vs relative log E) so the horizontal axis will be labeled relative log E.

a. Start one and a half inches from the left side of the graph paper and label the horizontal base line in increments of 0.20 units per half inch starting with zero.

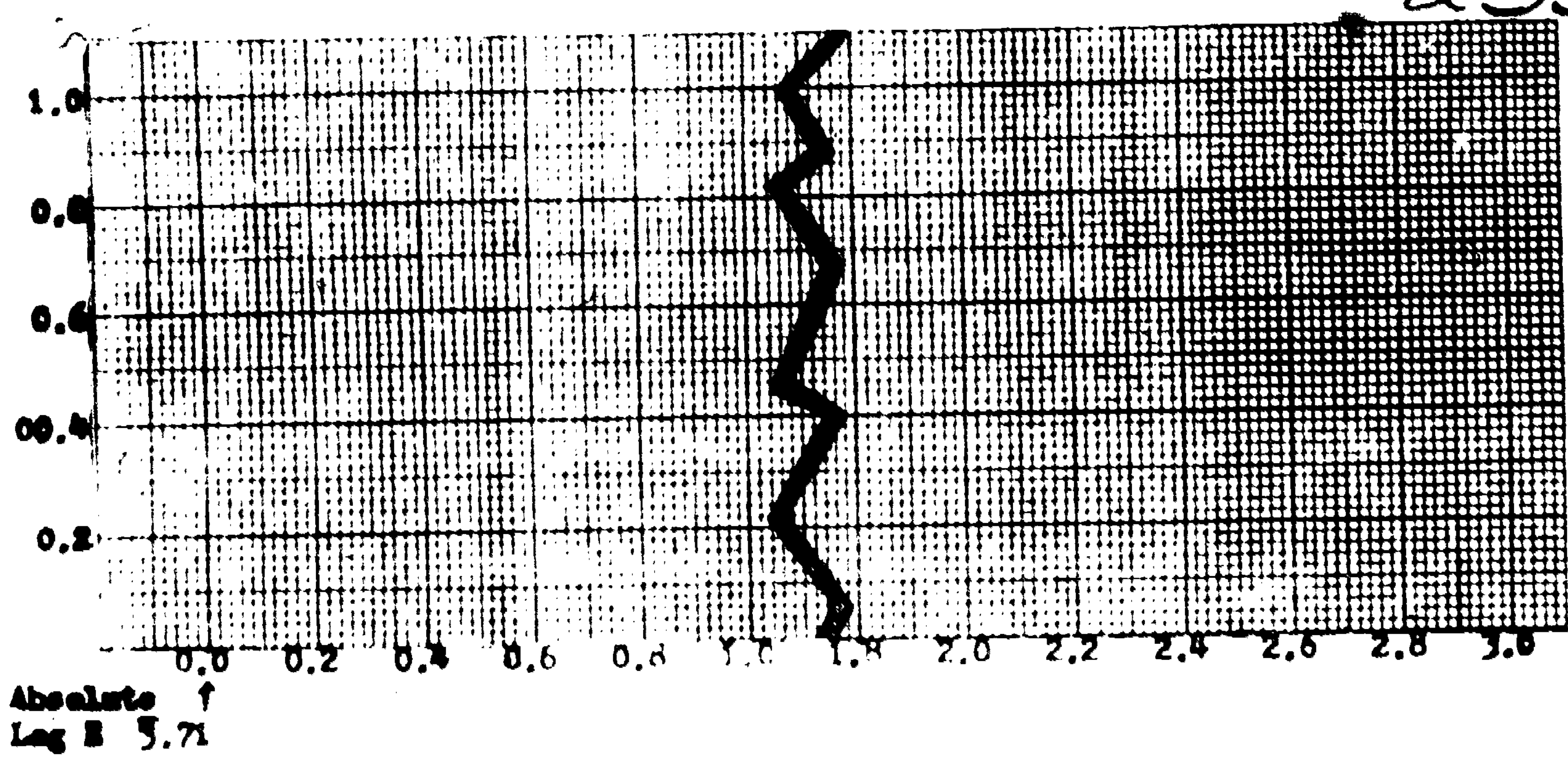


Figure 5-10. Relative log E

b. Mark off 21 steps in even increments of 0.15 starting from zero. (See fig. 5-10.)

3. Use a fairly hard pencil (4H is preferred) to make small dots where the horizontal values of the recorded densities intersect the 21 vertical points of the relative log E axis. Though these dots have been precisely placed, you realize that they are probably somewhat incorrect.

4. The next step is to connect these 21 dots with a smooth curve. This curve or line is more than just "connecting the points;" it must represent your best estimate of where all other similar sets of data would have plotted had more been available. Even though there are only 21 points, try to imagine how thousands of other intermediate points would have been placed. This is difficult to do since even the 21 points available may not be absolutely right.

COMPUTING ABSOLUTE LOG E. At times it may be necessary to compute absolute log E. Compute the absolute log E value which corresponds to zero relative log E in the following manner:

1. Determine the luminous intensity of the sensitometer in meter candles and convert to a logarithm.

2. Determine the exposure time of the sensitometer and convert to a logarithm.

3. Add these two logarithms to find the logarithm of exposure before attenuation.

4. Subtract the density of all neutral density filters and attenuators that were inserted in the light path from the above log of exposure. This is the unmodulated log of exposure.

5. Subtract the density of the densest end of the step wedge from the above value. This is the log E value of the zero relative log E point. Mark this value on the graph at the zero relative log E point, see figure 5-10.

DENSITY VERSUS DENSITY. The major difference between the density versus relative log E and the density versus density curves is in labeling the graph. A bit of arithmetic is also required on the density versus density curve. Label the vertical axis "Density of the Dupe." Label the horizontal axis "Density of the Original." Mark the density steps on the vertical axis the same as for the density versus relative log E graph.

Mark off the horizontal axis in increments of 0.20 units starting with 3.00, one and one-half inches from the left side of the graph. Count down to 0.0. Starting at 0.0 and moving to the left, place the density of each step of the modulator at the point corresponding to its density. As an example: if the first step on the modulator is labeled 0.05, place a small mark at the 0.05 point to the left of the 0.0 mark. Continue marking each step of the modulator at its corresponding point. The density measurements from the sensitometric strip will now be plotted above each of these points.

DENSITY VERSUS ABSOLUTE LOG E. In a density versus absolute log E curve, the vertical axis is labeled just as it is in a density versus relative log E curve. To label the horizontal axis, begin at the extreme right edge of the graph with 0.0. Using increments of 0.20, label each half inch up to 4.00, moving from right to left. (All of the numbers may not fit on the graph. This is normal.) Then subtract the smallest density of the modulator from 4.00 and mark the difference at its corresponding point. (4.00 is used since it is considered maximum density.) Subtract each step of the modulator from 4.00 and plot each difference at its proper point. Finally, label the horizontal axis as absolute log E.

Most related numbers, when plotted, give smooth, regular lines. This is a statement of faith, borne out of exhaustive tests in a multitude of scientific fields. "Smooth, regular lines" means straight lines, ascending or descending curves becoming gradually steeper or less steep. Sharp breaks and abrupt changes in direction are an indication of probable error and should be checked.

If a smooth curve is not evident when the points are plotted; (1) the data are actually unrelated, (2) there are serious errors in the data, (3) one or more points is incorrectly plotted. Always double

check to insure that the latter is not the case. If the first condition is present, there is no sense in drawing the line, and in the second condition, draw the best possible curve or obtain more and/or better data.

During the connection of the dots, if some of the points do not fit a smooth curve, try to average out the points, so that some of them fall on each side of the line. NEVER draw a line so that all of the points along one portion of the curve fall to one side of the line and at another place they all fall on the other side. If they do, the line is drawn improperly.

When drawing sensitometric curves, draw the straight line portion first. Place the straight edge along the series of points and shift it so the maximum number of points will fall along the straight edge. Make sure that all of the points along the toe, or left hand portion of the curve fall to the left of the straight edge and those along the shoulder or right hand portion fall to the right. Once the straight edge is aligned properly, draw a thin line through all points falling along the straight edge. Next, take an irregular curve and fit it to the points along the toe of the curve. Try various sections of the curve until the best fit is found; then draw through those points which fit. Move the curve to fit some more points and draw through them. A smooth blend of the lines is the desired result. Repeat for the shoulder portion of the curve.

Determining Gamma

Gamma ( ) is a useful measure of the degree of development and as such is a valuable tool. Gamma is determined after the curve is drawn and the curve is labeled with its gamma.

GRAPHIC METHOD OF DETERMINING GAMMA. When drawing the straight line portion of the curve, extend the line down to the horizontal axis. From this point count to the right 50 squares (1.00 log units) and extend this point upward until it intersects the straight line. Read the density of this point from the density axis. This is the gamma value.

GAMMA METER METHOD. Another way to determine gamma is to use a gamma meter. This is a piece of film with vertical scales on it. To use the gamma meter, extend the straight line portion until it intersects the horizontal axis. Place the reference point of the gamma meter at this intersection and place the horizontal line of the meter over the horizontal axis. Gamma can be read directly where the straight line now intersects one of the vertical scales. See figure 5-11.

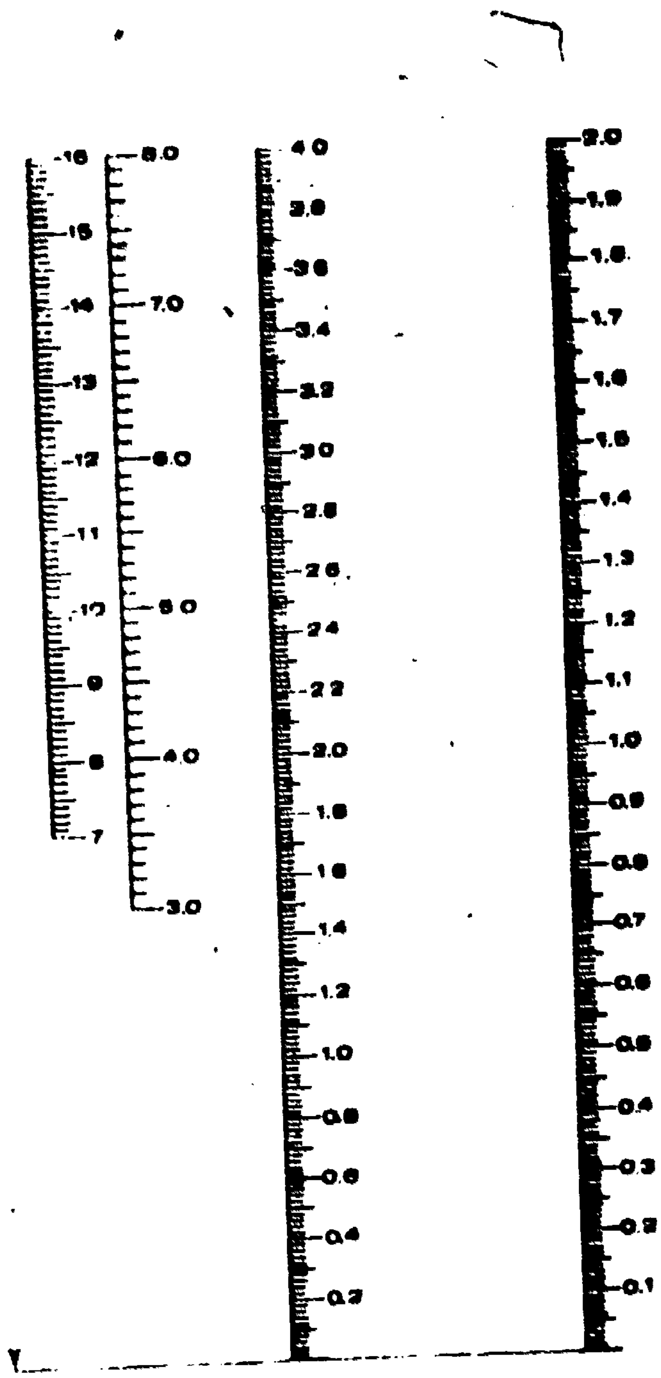


Figure 5-11. A Gamma Meter

SIGNIFICANCE OF GAMMA. An increase in gamma indicates an increase in development, all other parameters being unchanged. An increase in time, temperature, agitation, or developer activity, results in increased gamma, and a decrease in any of these factors results in decreased gamma. A moderately energetic developer can produce high gamma if the time, temperature, or both are stepped up. Moreover, the reverse is true. A high energy developer can be made to produce low gamma if the other factors are held back.

It is important to remember that gamma relates only to development--not to exposure. A photographic negative developed to a predetermined gamma will possess that gamma regardless of the exposure. The densities in the negative which correspond to straight-line densities

in the D log E curve, will have the same density differences. Of course, sensitometric curves made at different exposures would occupy correspondingly different positions on a graph.

The time of development is only one of the processing factors affecting gamma. Other factors are the type of developer used, dilution of developer, processing temperature, and the method of agitation. If the gamma is measured and found to be high, an appreciable amount of development was obtained, even though the developing time may have been short.

Gamma is one of the most important tools used in processing control. Negatives developed to the same gamma, for example, show comparable tone reproduction. If it is desired to determine that processing is constant, sensitometric strips are run along with the material being processed and the gamma plotted. If the gamma remains the same, processing is constant. Whenever practicable, the test strips should be printed on the material itself; on the edge of cut film or at the end of a roll of film.

QUESTIONS

DO NOT WRITE IN THIS SW, USE A SEPARATE SHEET OF PAPER.

1. What is a good working definition of sensitometry?

2. Name the two classes of sensitometers.

3. Describe the ASA tray method of processing.

4. What is the relationship between transmission and opacity? Between density and opacity?

5. What are some disadvantages in the visual comparison densitometer?

6. What are some disadvantages to photoelectric densitometers?

7. What values are normally plotted on the vertical axis (ordinate) of the characteristic curve?

8. List the parts of a characteristic curve.

9. How is absolute log E determined?

10. What are the two methods of determining gamma?

11. Name the parts of a characteristic curve.

12. If the exposure is low, what will happen to the flat toe portion and the straight-line portion of the characteristic curve?

EXERCISES

Exercise 1

| EQUIPMENT | Basis of Issue |
|---|---|
| Sensitometer | 1/class |
| Processing Facilities | 1/class |
| Neutral Density Filters | 1 set/class |
| Photographic Film | As needed |

PROCEDURE

1. Prepare the sensitometer and expose three sensitometric strips on the film. Your instructor will provide the necessary exposure data.

2. Develop the strips in the developer mixed earlier in the block at varying time increments. (i.e., 3, 6, 9 minutes.) Follow the processing methods outlined in the SW describing the ASA tray method.

3. Fix, wash and dry all strips.

4. Repeat the above steps using a dilution of 1:1 with the developer. Label all strips.

5. Fix, wash, dry and label all strips. Clean the processing area and return any equipment to its proper storage place.

Exercise 2

| EQUIPMENT | Basis of Issue |
|---|---|
| Densitometer | 1/2 students |
| Paper and Pencil | As needed |

PROCEDURE

1. Follow the procedures outlined in the SW text, standardize the densitometer.

2. Read the densities from each step on the test strips and record the readings. Read the density of each step at two or more different places and average the results.

## Exercise 3

**EQUIPMENT** | **Basis of Issue**

| EQUIPMENT | Basis of Issue |
|---|---|
| Graphing Implements | As needed |
| Graph Paper | As needed |

**PROCEDURE**

1. Prepare the graph paper for a density versus relative log E curve following the procedures explained in the SW.

2. Plot the densities produced for each of the 21 steps on one strip and draw the curve.

3. Plot the densities of the two other strips processed in the same developer dilution on the same graph.

4. Plot the densities of the three strips developed in the other developer dilution on another sheet of graph paper.

5. Determine gamma for each curve.

6. In the top left of each graph, enter all pertinent information. This includes:

   a. Film type.
   b. Process used (i.e., ASA tray method).
   c. Developer type.
   d. Developer temperature.
   e. Process times (or speeds if machine processed).
   f. Number of racks in developer (if machine processed).
   g. Sensitometer used.
   h. Exposure time.
   i. Log E before modulation.
   j. Any ND filter used.
   k. Date of test.
   l. Your name.

7. The instructor will check the graphs for neatness, accuracy, and completeness.

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Technical Training

Continuous Photoprocessing Specialist

# AERIAL FILM PROCESSING

October 1977

3400TH TECHNICAL TRAINING WING
3430th Technical Training Group
Lowry Air Force Base, Colorado

Designed For ATC Course Use
DO NOT USE ON THE JOB

Sciences Branch
Lowry AFB, Colorado

SW G3ABR23330 001-III-1
October 1977

# CONTINUOUS PROCESSOR OPERATION

## OBJECTIVES

Identify the basic operating principles of continuous processors.

Identify and locate the major components, systems and controls of a Versamat 11C-MW processor.

Provided a Versamat processor, setup and systems, clean the processor while observing all safety precautions.

Using specified packaged chemicals, mix and certify the chemical solutions. Mixed solutions must meet local certification standards.

Using a Versamat processor and operating checklists, startup and shutdown the processor IAW the checklists.

Provided a Versamat processor, certify the processor mechanically, chemically, and sensitometrically. The processor will be certified to meet local certification standards.

Explain the need for a quality assurance program within continuous photoprocessing laboratories.

Using a preinspection table and a Versamat processor, preinspect and process exposed aerial film. Processed film must be free of processing defects.

## INTRODUCTION

A continuous photoprocessing laboratory is charged with the responsibility of handling valuable property each time a roll of original film enters the laboratory. The cost of a roll of aerial film is only minor compared to the value placed upon it after the mission has been flown and the exposures recorded.

One duty of a Continuous Photoprocessing Specialist will be to process, or support the processing of aerial reconnaissance film. In many cases, the film may have a direct bearing on the security of the United States. For this reason, only personnel of high responsibility should be selected to operate continuous film processors.

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Supersedes SW 3ABR23330-III, October 1973

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The basic steps of development, fixation, washing, and drying are similar to those used in processing sheet film. However, in processing continuous lengths of film where each exposure must receive identical treatment, some entirely different problems are introduced. Every problem must be corrected, and each operation must be performed with utmost care to provide the desired final product.

INFORMATION

## BASIC OPERATING PRINCIPLES OF CONTINUOUS PROCESSORS

The history of using machines to process reconnaissance film dates to 1952. At that time, the Air Force first used continuous processing machines in Korea under combat conditions. This machine, known as the A-9 processing machine, could handle film 9.5 inches (24.1 cm) in width in lengths up to 1000 feet (304.8 m). Prior to 1952, all continuous processing machines were designed for narrow films such as 16mm and 35mm. Before the A-9 Machine came into existence, it was necessary for the processing technician to use a rather simple hand processor. This hand processor did not allow for repeatability.

Since the advent of the A-9 until about 1962, very little progress was made in the design of new processors. However, since 1962 rapid advances in continuous processors have been made. Equipment is now quite complicated, and the technician must be completely familiar with all systems of the particular machine he is using before he can become a qualified operator.

The basic function of a processing machine is to transport the film through the various solutions and to permit an appropriate treatment time for the film in each solution. The machine must fulfill these functions in a reproducible manner.

There are many continuous processing machines currently in use in the Air Force. During this course, it would be impractical to try to teach the operation of each machine. However, it will be helpful to learn the design of these machines. These operating procedures can be adapted to any processor.

### Film Drives and Transport Systems

One of the most important areas of machine design is the film drive system. The film must be driven through the solution tanks at a constant speed. The operator must be able to adjust this film drive speed as the situation warrants. Also, the speed must be reproducible.

That is, if the operator changes from 10 feet per minute (3 mpm) to 20 fpm (6.1 mpm) and then back to 10 fpm (3 mpm), the second 10 fpm (3 mpm) setting must produce the same speed as the first 10 fpm (3 mpm).

In the field of continuous processing, the ideal transport would be a system which moves the film through the machine without touching it (the thought being that if the film were not touched it would not be damaged), and recently a means of liquid bearing transport has been devised which purports to do just that. The ideal drive would be one that would move the film through the process at a rate both uniform and exact. That is, one that could be set with accuracy and one which would neither exert strain nor permit slack in the film. Most drives consist of a motor, some type of variable transmission, and a drive chain which produces rotation of the transport rollers through a system of clutches.

The type of transport selected is largely dependent upon the size of the film to be processed and the quality of the product required. Narrow film widths are generally transported by gangs of rollers while the larger widths pass over single rollers. Most transport rollers operate by friction although it is possible to employ sprocket drives when perforated films are to be processed. Some rollers are flanged while others depend upon alignment for accurate tracking. Some rollers are narrow while others are wide. Some are of small circumference while others are large. Each of these variables has its particular effect on the system.

Flanged rollers tend to guide the film in the desired direction provided other factors do not interfere. If misalignment occurs because of worn rollers, shafts, or bearings, the film may climb the flanges. This could cause the film to have crimped or fluted edges, or longitudinal creases, or even to run off the roller and become broken. The wide rollers depend upon their width to permit the film to find its own path without the danger of running off. This permits some lateral movement with the possibility of sidewide strain being introduced into the film. If considerable misalignment exists, one edge of the film may rise up off the roller, thus increasing the danger of the emulsion becoming damaged.

Rollers having small diameters are economical of space; however, they exert more bending strain than do rollers whose diameters are larger. Owing to size and cost requirements, the former are extensively used. Also, there are machines which have rollers of more than one size. The technician should know the diameter of the rollers and their location in his machine so that he can quickly locate troubles involving them. For instance, a repetively occurring abrasion mark might be caused by some foreign material imbedded in a roller, and the space between the marks would indicate the diameter of the offending roller. Knowing the location of rollers of that diameter would limit the search.

One type of processing machine (Versamat Model 11CMW), uses a unique method of transporting film by means of closely spaced rollers. No threading of the processor is needed. Black-and-white film is inserted into the darkroom end of the processor. The roller transport accepts the film, manipulates it through the various solutions in a zigzag motion, carries it through the dryer, and deposits it, processed and dried, at the takeup station.

The roller transport provides agitation by removing the reaction byproducts from the emulsion as fresh solution is being applied. Racks containing the rollers are arranged in a vertical path with appropriate crossover rollers to carry the film from one roller rack to another (figure 1-1).

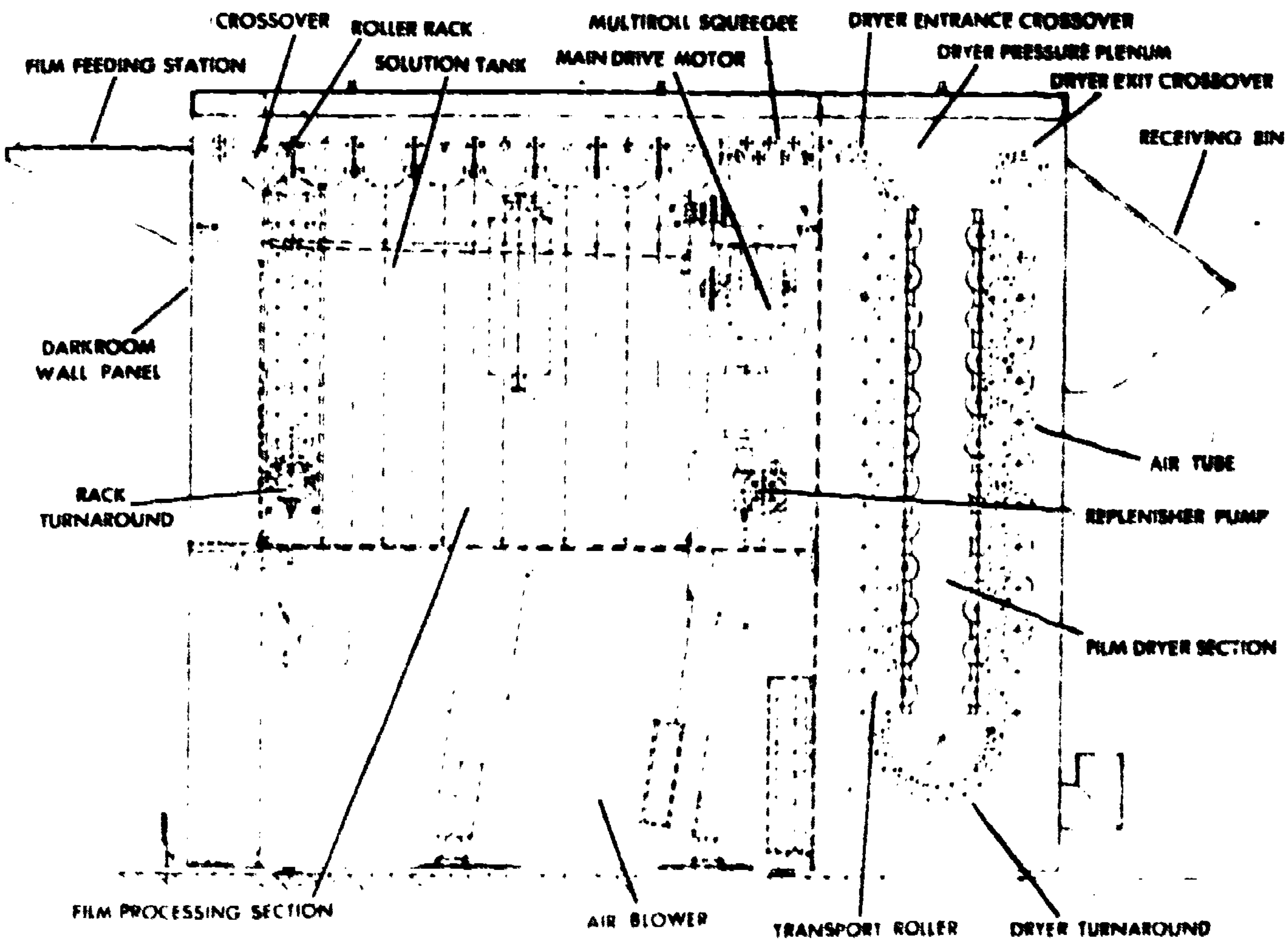


Figure 1-1. Processor Sections

Machine Threading Systems

LEADER TYPE. Most processing machines are threaded with a leader which may be a thick opaque acetate, thin opaque acetate, or clear or opaque mylar material, and in some instances, clear film. The film to be processed is then spliced to this leader. The threading pattern used most often with wide film (over 70mm wide) is the "over-under system." Normally when this pattern is used, the emulsion side of the film touches only the bottom rollers which are always wet with the processing solutions. (Refer to figure 1-2). However, one processor now being used is operated with the film emulsion down which means the emulsion side touches the top rollers and the base side touches the bottom rollers.

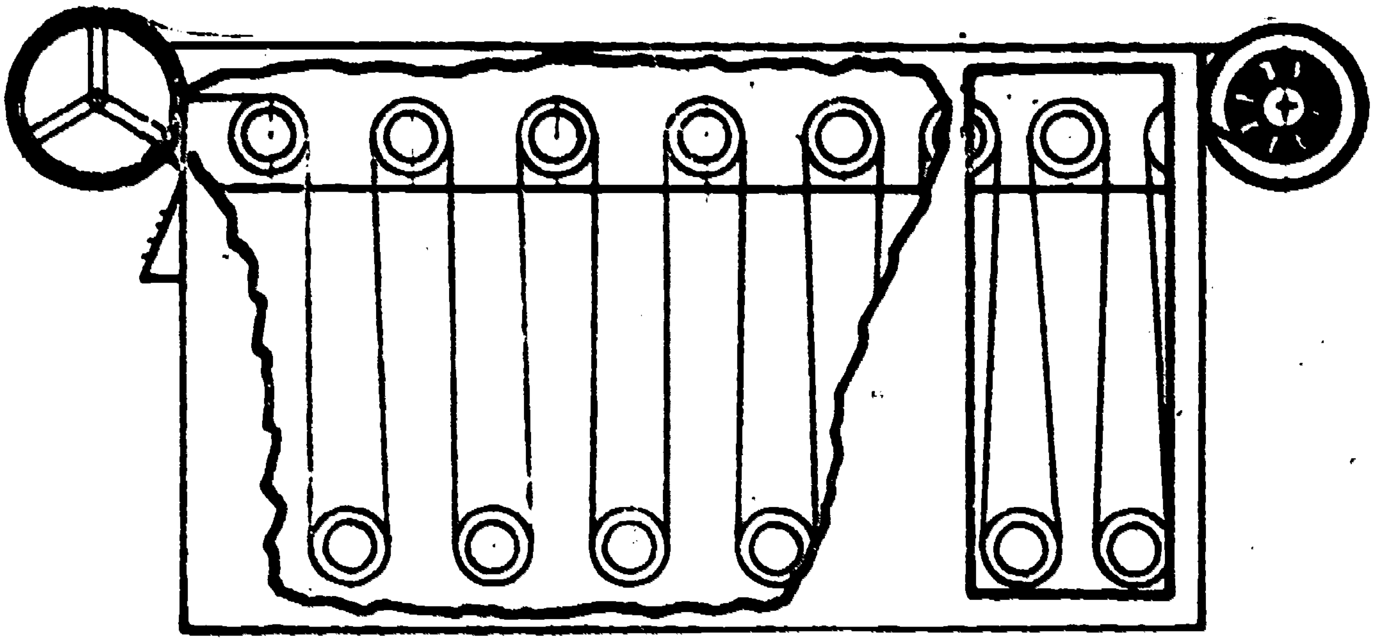

Figure 1-2. Over-Under Threading

Another threading system is the "loop" type. In this system, the film is threaded in a loop around the rollers and only the film base touches the roller. See figure 1-3.

LEADERLESS MACHINES. These machines do not require threading with a leader, but transport the film through the machine by another means. This transport method is a double row of rollers that are closely spaced to each other, and to the opposing row. The film is transported between the rows of rollers, by friction, through the machine.

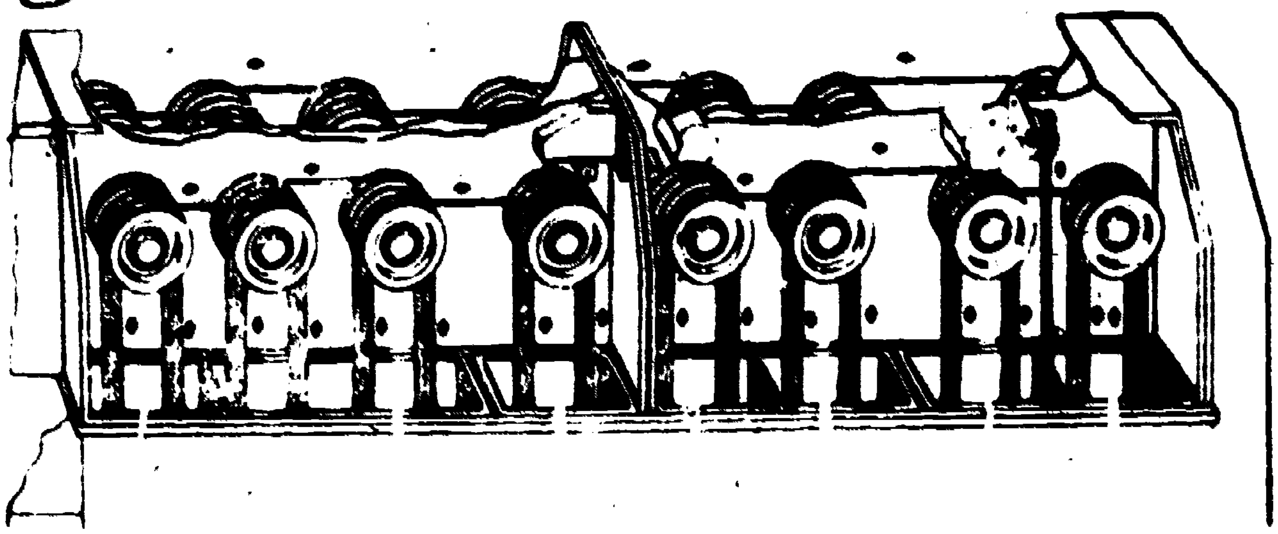

Figure 1-3. Loop Type Threading

Developing and Fixing Systems

Continuous processing machines employ three major types of developing and fixing systems.

IMMERSION. The immersion system of processing is perhaps the oldest and most widely used of the three processing systems. In this system, the film, carried on rollers, travels through various tanks containing solutions. Figure 1-4 shows how a typical tank in an immersion-type processor might appear. The film receives agitation solely by passing through the solution.

SPRAY SYSTEM. The spray processor consists of empty tanks through which the film passes. As film moves through the tanks, solution is sprayed against the emulsion. Spray heads are often mounted on both sides of the film so that spray pressures are equalized and film will not be pushed to one side. See figure 1-5.

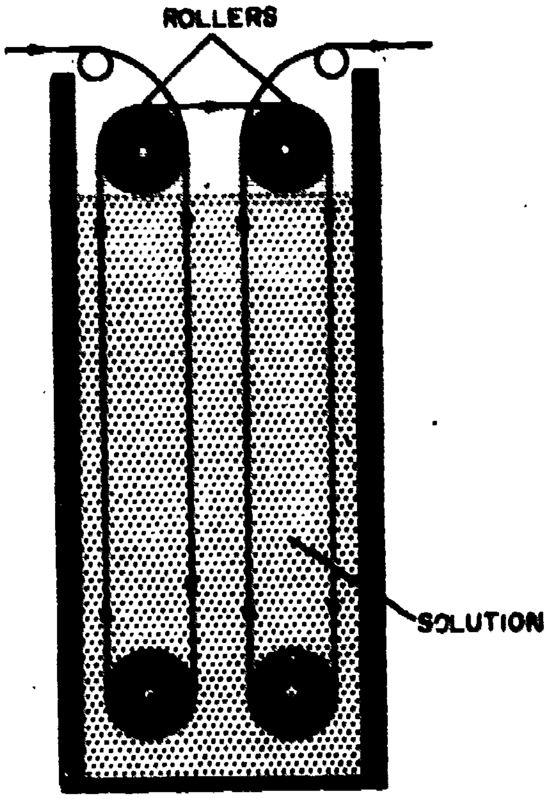


Figure 1-4.
Schematic of a Typical Immersion
Processing Tank

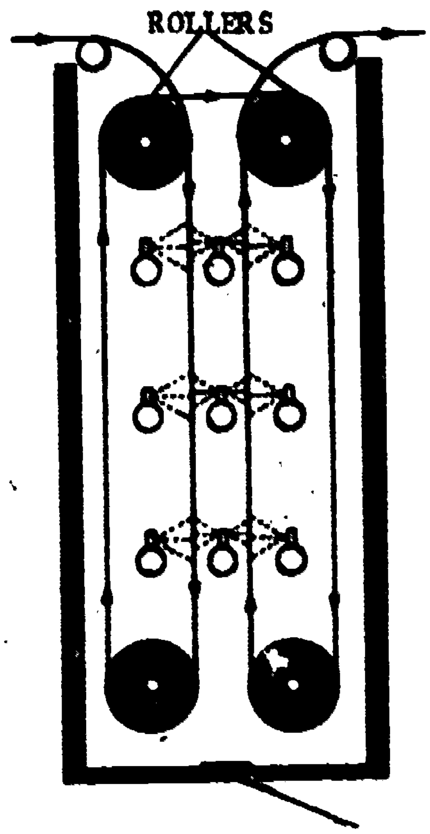


Figure 1-5. Schematic of a Typical Spray Processing Tank

There are two main spray processing configurations. One sprays fresh solution which is used once and then drained away. The other employs a sump in which the solutions accumulate to be pumped through the spray system onto the film and back to the sump. Both systems are in common use. Each has its advantages and disadvantages. When a developer solution is exposed to air, it oxidizes rapidly. During spray processing, the oxidization process is speeded up, since the exposure of developer to air is accelerated. This is why some systems use the developer only once, after which it is drained. In systems where the solution is used again, the machine is equipped with a replenishment system to offset the effects of oxidation. In either system, it helps to use a developer formula with a high preservative content. There are some complex systems in which the air within the machine developing tank is evacuated and replaced with nitrogen gas. Nitrogen gas does not support oxidation, and developer used in a nitrogen environment may be recovered and used again and again.

SPRAY IMMERSION. The third (fig 1-6), is a combination of both systems. In this system the spray bars are placed in the full developer tanks.

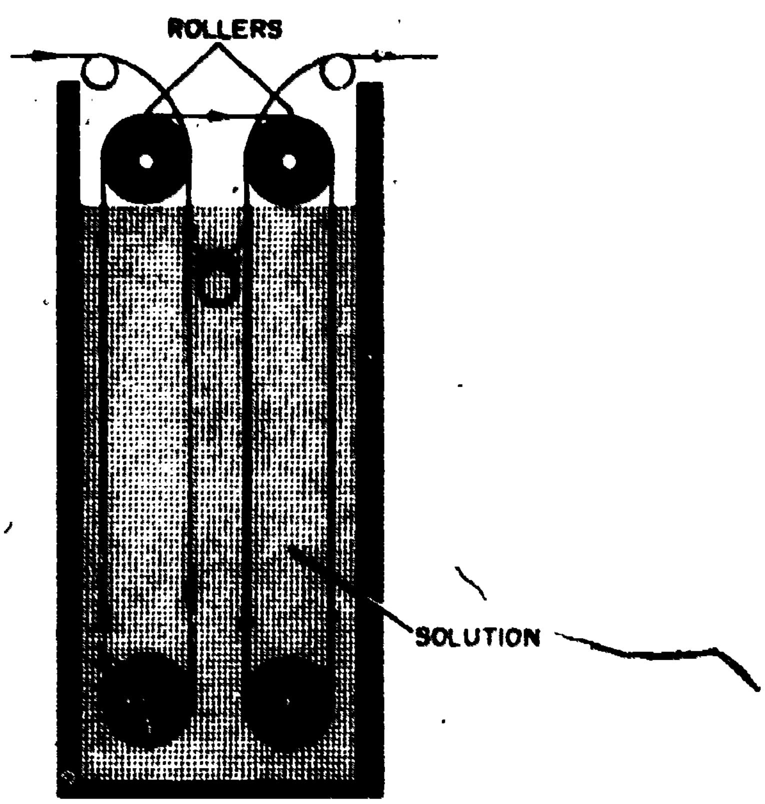


Figure 1-6.
Schematic of a Typical Spray Immersion Processing Tank

There are advantages and disadvantages to each major chemical system. The spray concept gives excellent rapid processing. However, adjustment of the spray fan to minimize streaking is critical. In the spray processor, the cabinet doors may be opened making all cabinet areas accessible for cleaning. Since solutions do not remain in the cabinets, there is no drastic build-up of chemical byproducts in the machine. Deposits which are formed can be removed by wiping with a sponge. In an immersion type system, the operator cannot reach the bottom of the tanks and must rely upon chemical cleaning agents to remove chemical deposits. When the spray machine is used, every milliliter of solution can be filtered before it is repumped into the machine. Developer, however, is oxidized rapidly and requires a large amount of replenishment. The rapid exhaustion of the developer, and consequent high rate of replenishment, makes the spray processor expensive to operate.

Other considerations are the man-hours required to mix this replenisher, and the storage space the replenisher occupies. Most processors in the Air Force are immersion machines that incorporate the spray principle. In these machines, solution is removed from the chemical tanks, and pumped back into the same tank through spray tubes that are under the maximum solution level. This type system maintains better agitation than the standard immersion machine, and the developer oxidation rate is relatively low since the developer is not sprayed into air.

Recirculation Systems

Recirculation systems in both immersion and spray processors usually perform the following functions: (See figure 1-7).

1. Provide agitation of the solutions for even development and fixation.

2. Filter solutions.

3. Control temperature of solutions.

4. Provide a logical place to introduce replenishers into the machine.

FILTRATION. Solutions are generally filtered before they are reintroduced into the machine. Continuous filtration of this type, at least during machine operation, is generally regarded as preferable to batch filtration. This filtration is usually accomplished through the use of screen or cartridge filters. The particle size passed by the filter is of prime importance. Most Air Force processors use filters that filter out all particles larger than 10 microns. Wash water must be filtered to the same degree as the chemical solutions. Instruments used on the solution filter system should include pressure gauges on the inlet and outlet of the filter to indicate the pressure drop across the filter system. The pressure drop will signal when the filters are becoming clogged and need cleaning or replacing.

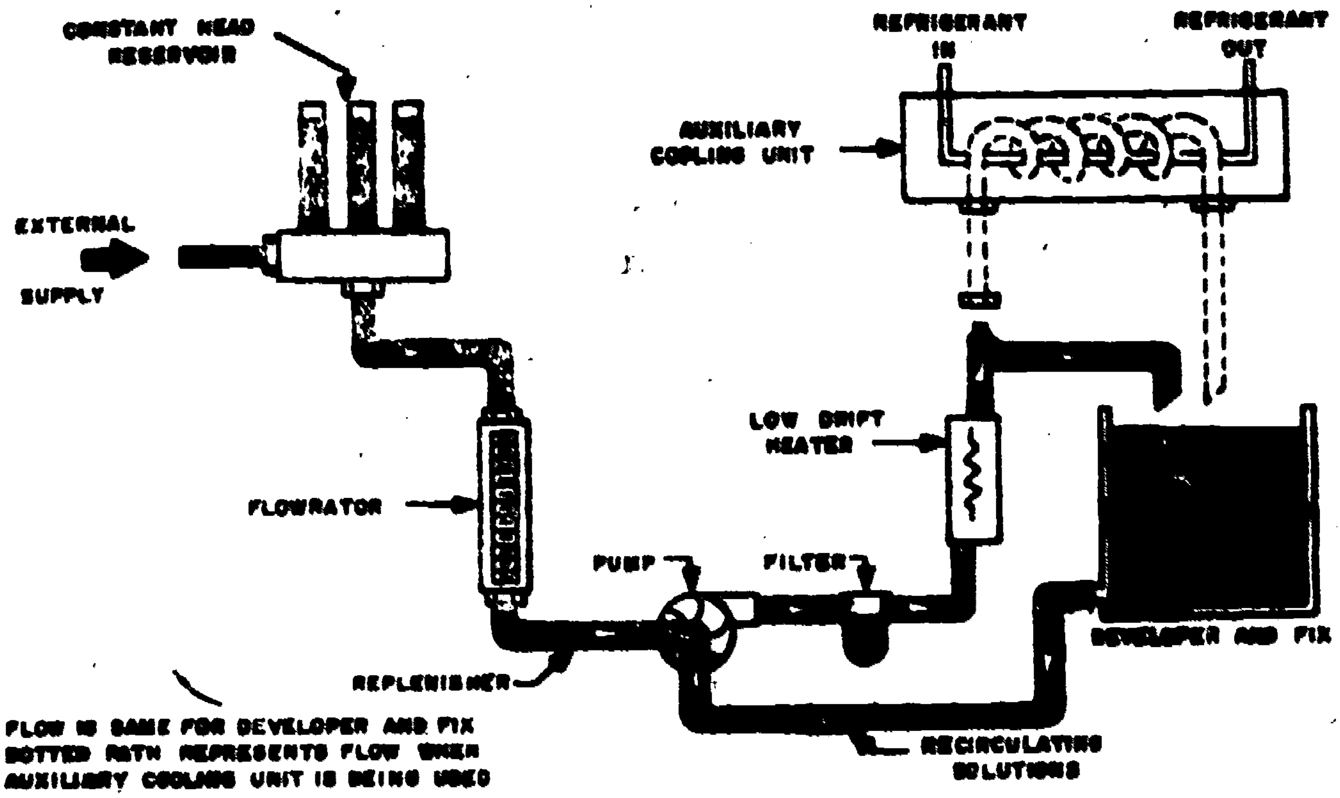


Figure 1-7. **Typical Recirculation System**

TEMPERATURE CONTROL. One of the most critical elements of the photographic process is solution temperature control. Temperature must be controlled for consistent and reproducible results. The developer is the most critical solution and should be held within $\pm$ 1/4 to 1/2°F ($\pm$0.1 to 0.25°C). Other solution temperatures are less critical, but should be controlled to within 2°F (1.1°C) of the developer temperature.

Most recirculation systems contain a heat exchanger. The heat exchanger usually incorporates refrigeration coils and electrical heating elements. The developer and fixer solutions are pumped through these heat exchangers - each through a different exchanger - adjusted to the proper temperatures, and reintroduced into the processing machine. A temperature sensing probe, located within the processing machine tank, monitors solution temperatures and transmits this information to the solution thermostats. If solution temperature is too high, the refrigeration compressor is activated, driving the refrigerant through the coils within the heat exchanger and thus cooling the solution. If the solution in the tank is too cold, the heaters located in the heat exchanger are activated; thus heating the solution.

The operator merely sets the solution thermostats at the desired temperature and the processing solution temperature is automatically controlled.

REPLENISHMENT. Replenisher is generally introduced to existing solutions in the recirculation system. During this introduction, it is mixed with the partially exhausted solutions and, therefore, does not enter the machine in its raw, undiluted state. If raw replenisher were added directly into the solution tanks, uneven development and/or fixation would occur before the replenisher thoroughly mixed with the solutions already present. The rate of replenishment is controlled by values and is incorporated within the system to allow the operator to monitor and adjust the replenisher flow.

Squeegees

As the film is transported from tank to tank, solutions are carried over which will cause contamination or dilution. A squeegee is used to remove most of the fluid from the film surfaces to minimize carry over. It is also very important to remove excess water from the film before it enters the drying cabinet. There are two general types of squeegees. The first type removes fluid by actual contact with the film. Rubber blades or rollers are employed for this purpose. This type of squeegee has the disadvantage of scratching the film if any foreign matter is trapped by the squeegee. The second type of squeegee uses compressed gas or air to blow off excess liquid. The method is considered to be one of the most satisfactory methods available.

Drying Systems

The drying of film is a complex operation. So that moisture may be removed from the thickness of an emulsion, it must first migrate to the surface and then evaporate in the air. The rate at which this takes place depends upon the thickness of the emulsion, the amount of hardening is received, the density of the developed image, the temperature, the relative humidity, and the movement of the ambient air reaching the film.

The air is heated to expand it, to lower its relative humidity, and to accelerate the evaporation of moisture. These factors are directly proportional to the temperature. The temperature must be held within certain limits. If it is too low, evaporation is slowed up; and if it is too high, the emulsion may be damaged. The exact limits are governed by the kind of material being dried, how it was processed, and the type of dryer being used.

The main reason why the air should be kept moving is that the air at the surface of the wet emulsion soon becomes saturated and will not take up additional moisture. The saturated air must be replaced by unsaturated air if drying is to continue. Of course, even still air is in constant motion, and an emulsion will dry eventually, but the drying will most likely be uneven. When warm, dry air moves slowly across a film, the film tends to dry more rapidly at the edges than in the center. Thus, any considerable change in the drying conditions that persists for a comparatively long period of time will leave visible lines at the wet-dry borders at the time of change. This condition is apt to occur in some type of parallel-flow dryers.

PARALLEL-FLOW. These dryers utilize a series of reverse-bend ducts to conduct warm dry air across the film as it moves through the drying cabinet. Figure 1-8, shows schematically a typical arrangement.

In order to prevent the drying marks mentioned above, parallel-flow dryers should be operated at rather high velocities. The temperature should not be excessive, and the relative humidity of the air should not be too low. The exact conditions must be adjusted to the climate in which the dryer is being used. Different settings would be required for coastal areas than, for example, the Arizona desert.

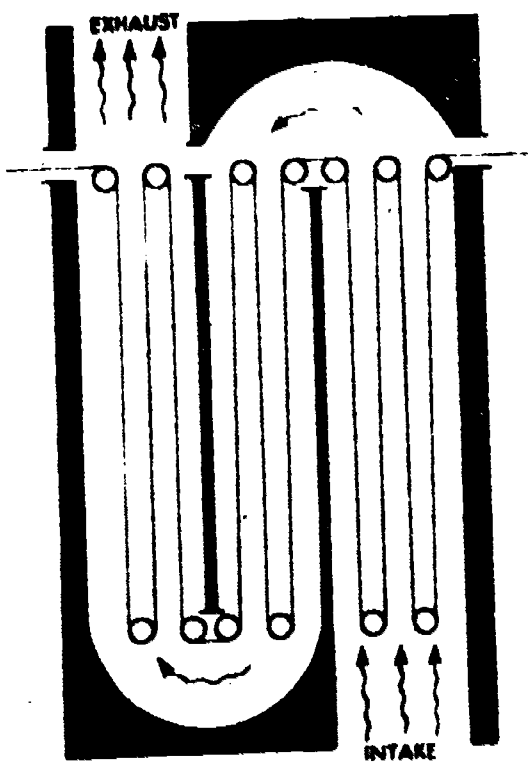


Figure 1-8. Parallel Flow Drying Cabinet

IMPINGEMENT. One of the most common methods is called impingement drying. In this method, jets of air are applied at right angles to the emulsion and base surfaces of the film simultaneously. The schematic, figure 1-9, shows the relation of the film to the air plenums in the drying compartment of a continuous processor. The air is heated to dry-bulb temperatures ranging between 100°F and 150°F (37.8°C to 65°C) and is directed against the film at velocities of from 5000 to 6000 ft/min (1524 mpm to 1830 mpm). An efficient air squeegee must be used since surface liquid remaining on the film will result in nonuniform drying. As with any other type of dryer, the condition of temperature and velocity must be adjusted to the local climate. Otherwise, the film will dry more rapidly at the edges with the usual undesirable effects.

Some types of film tend to become excessively brittle when dried rapidly by this method. This is due to reduced relative humidity rather than overdrying.

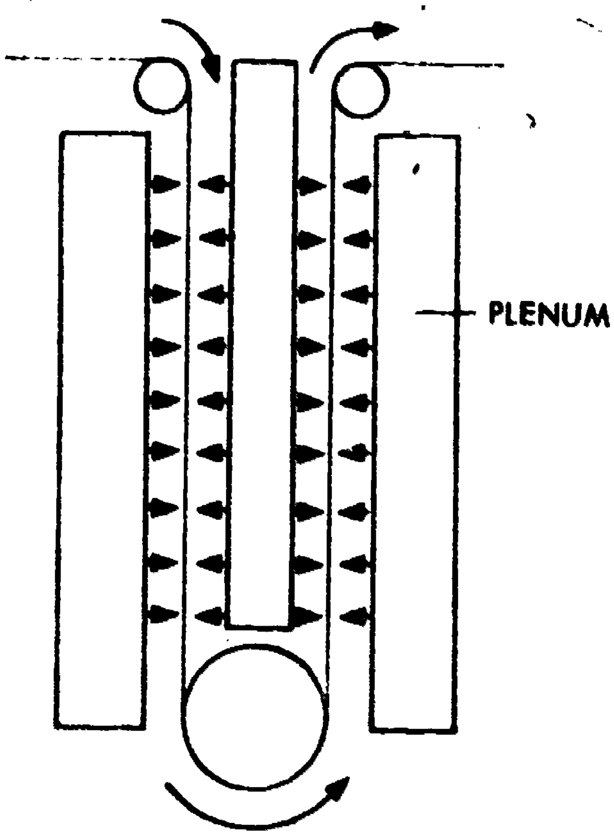


Figure 1-9. Impingement Drying Cabinet

## Safety

There are three basic areas of safety: Chemical, Electrical, and Mechanical. When dealing with any photographic solution, assume that it will be harmful. Also always remember AAA. ALWAYS ADD ACID to water. When working with any equipment that requires electricity there is always a chance of electrical shock. Before operating any equipment, make sure that is is grounded. The third type of safety is mechanical. When using machines, make sure to keep all loose fitting clothing away from gears and chains. SAFETY IS A NEVER ENDING JOB. Remember, it is better to be safe than sorry.

## Silver Recovery Methods

Photography, more than any other major profession, depends on silver-bearing materials. Films and papers contain varying concentrations of silver, which in its purest form, is valued at more than $1.75 per troy ounce. However, the diminishing reserve of US produced silver and the greater dependency on foreign silver production makes this metal even more precious. Perhaps the poorest example of conservation has been the silver which has flowed down the drain with photographic fixers. Include the silver in discarded films and papers, special batteries, electronics, missile parts, and other silver-bearing scrap, and the losses are magnified.

To reduce further waste of silver, the Department of Defense (DOD) is tasked with establishing and monitoring a silver reclamation program for government agencies. DOD Directive 4160.22, AFR 400-14, and TO 10-1-25 are designed to assure benefits from silver recovery in government operations. Whereas, AFR 400-14 details various levels of management in silver recovery, TO 10-1-25 is directed toward laboratory operations. Thus, it is the Technical Order which will be used at this level of the program.

There are three primary methods for silver recovery from used fixer solutions.

1. ELECTROLYSIS. Silver is removed by passing a controlled electrical current through electrodes placed in the solution. Silver is deposited on the cathode in the form of near pure silver plate. The cathodes are removed periodically and the silver is stripped off. To maintain the highest efficiency and recovery rates, silver content of the solution and amperage of the electrical current are constantly monitored electronically. This method is the only one that permits reuse of fixer after the silver is removed.

2. METALLIC REPLACEMENT. Insertion of a base metal, such as steel wool, into the fixing solution causes an interchange of the base metal for the silver in the solution, resulting in silver-bearing sludge. This sludge is removed after maximum exchange is accomplished and refined to reclaim the silver. The fixing solution must be discarded after silver is recovered by this method.

3. CHEMICAL PRECIPITATION. Recovery of silver is possible by adding certain chemicals to the solution. Silver is precipitated in the form of a sludge which is dried and refined to reclaim the silver. Fixing solution must be discarded after using this method. This method is not recommended for Air Force use due to facility and manpower requirements and the noxious fumes and odors generated.

There are currently two methods for recovery of silver from processed and unprocessed film/paper remnants.

1. INCINERATION. The silver in photographic film and paper can be recovered by completely burning the material in an incinerator which controls both the burning process and the fly ash. Residual ash is processed to reclaim the silver content. Special incinerator equipment is necessary to accomplish this method.

2. EMULSION STRIPPING. The emulsion layer containing the silver can be removed from the film base, using chemical or mechanical means. The resulting sludge is then refined to recover the silver. This method of silver recovery from film is still in the development stage.

Methods, procedures, and equipment are not yet available to meet production processing requirements.

Silver Recovery Equipment

METALLIC REPLACEMENT CARTRIDGE SYSTEM. Low-volume photographic/reconnaissance processing facilities, which generate less than 30 gallons (114 l.) of exhausted hypo-solution per eight-hour day, will use the metallic replacement Cartridge Recovery System. This would normally include such activities as medical/dental X-ray laboratories, photographic hobby shops, and possibly some base photographic laboratories. All mobile facilities will use the cartridge recovery system unless authorized by the Item Manager to use electrolytic equipment. (Figure 1-10)

NOTE: Operating units which generate less than 200 gallons (760 l.) of exhausted fixer solution annually will not be issued cartridges.

When economically practical, exhausted fixer solution will be transferred to a central collection point for processing.

The cartridge is a serially-numbered, plastic or plastic-coated drum which is filled with a spun metallic filler. The main top or lid is tightly crimped in place and is not intended for removal at base level. The cartridge is available in two types. The Type IP cartridge contains a coarse metallic filler and is intended for general use. The Type II/IIP cartridge is packed with a fine metallic filler and is specifically designed for use with color film and color-print fixers. These cartridges have a maximum capacity of 4.75 gallons per hour or 300 cc per minute and will process approximately 200 gallons (760 l.) of fixer before the cartridge is exhausted. The cartridge should be replaced when tests of the effluent indicate the cartridge is exhausted. The removed cartridge contains silver sludge and will be processed for shipment to the central collection point.

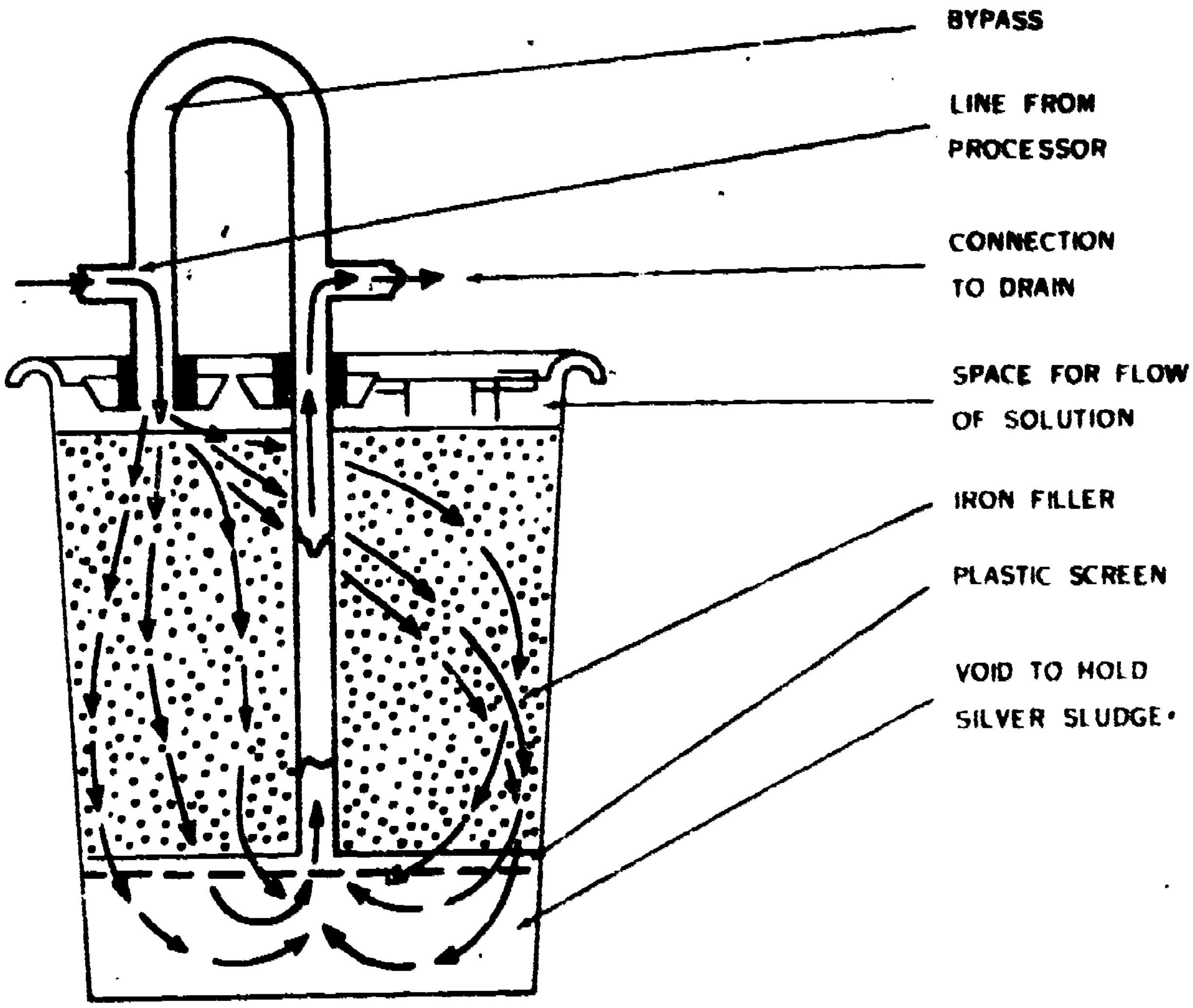


Figure 1-10. Metallic Replacement Cartridge

ELECTROLYTIC RECOVERY SYSTEM. Medium and high-volume processing facilities, which generate more than 30 gallons (114 l.) of exhausted fixer solution per eight-hour day, (except mobile laboratory facilities), will use electrolytic recovery units. (Figure 1-11). This would include activities such as Reconnaissance Technical Squadrons, Radiographic, and Base Photographic Laboratories. Electrolytic recovery units can recover approximately 2.5 troy ounces (70.8 g.) of silver per hour using a "batch" process. It will process approximately 100 gallons (378.5 l.) every twenty-four hours. Facilities which generate hypo in excess of 100 gallons (378.5 l.) per twenty-hour day will require installation of multiple units.

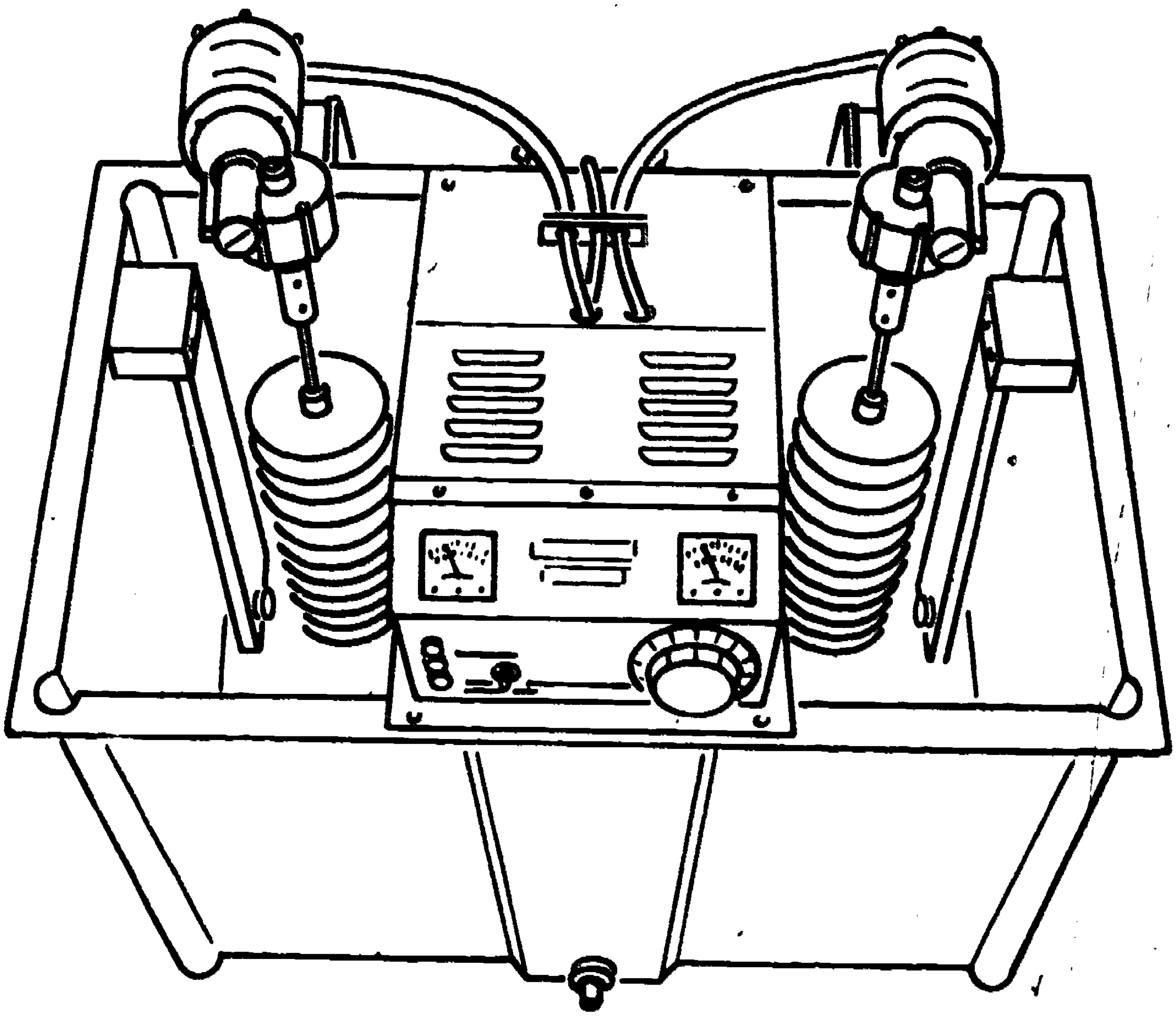

Figure 1-11. Electrolytic Recovery Unit

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This recovery unit includes an electronic sensing device which adjusts the plating current to the silver concentration in the fixing bath by reducing the current as the silver is removed. It shuts off the plating current when the recoverable silver has been extracted and turns on automatically when silver is present.

This type of equipment will be used with medium through high production operations because it is clean, reliable, efficient, and requires minimum manpower for operation and maintenance.

The silver recovery system for a high-production reconnaissance processing facility would consist of multiple electrolytic recovery units installed in a cascade arrangement. Gravity flow would be used from the processing equipment to a centrally located holding tank and also between the cascaded recovery units. Pumping from the holding tank to the first silver recovery unit would be required and the system would be sized, based on the daily generation of exhausted fixer. The determination of silver recovery equipment requirements for specific installations is based on the amount of film processed, and the quantity and type fixer (ammonium or sodium thiosulfate) used to process the film.

Silver will be harvested or stripped from the cathode plates as prescribed by the applicable equipment maintenance manual. The stripping operation will be witnessed by a designated representative of the commander. The silver will be accurately weighed, the weight annotated on the turn-in document, and certified by the witness. The silver will be placed in a metal container, secured, and turned in for shipment to the central collection point.

## TYPES OF CONTINUOUS PROCESSORS

There are many different types of continuous processors that may be encountered in the field. This discussion will be limited to four common processors:

1. Fultron
2. HTA-3CM
3. Ektachrome RT Model 1811
4. Versamat 11CM

The first three will be covered briefly and the last in detail.

### Fultron

The "Fultron" processor (Figure 1-12), is manufactured by the

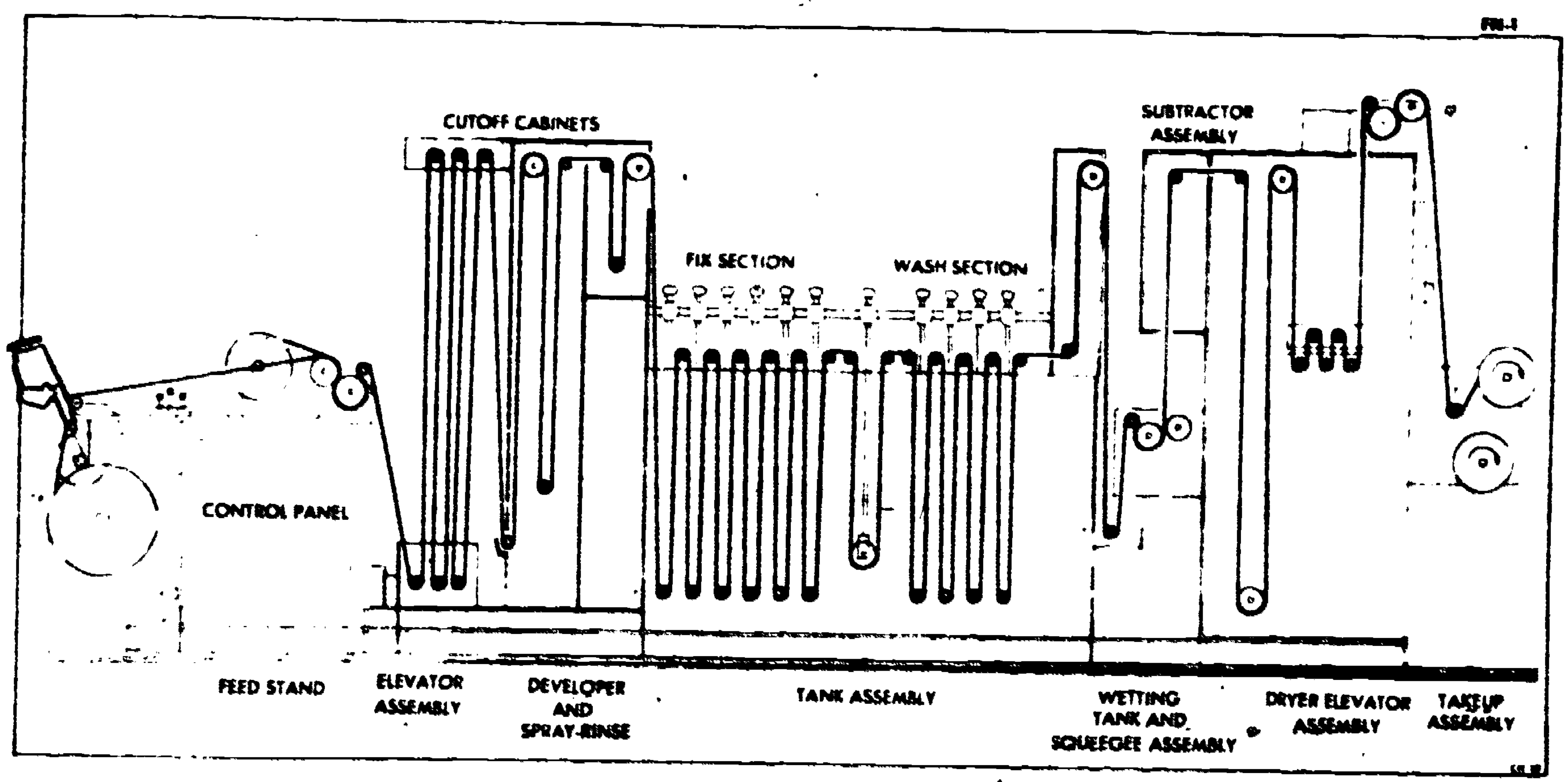


Figure 1-12. Fultron Threading Diagram

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Eastman Kodak Company. The "Fultron" is designed to process continuous lengths of original negative and aerial duplicating films with a speed range of 5 to 60 feet per minute (1.5-18.3mpm). It uses a combination spray and immersion system for processing. The four principal operating sections are described as follows:

LOAD SECTION. This section includes the following:

Feed Stand. The feed stand, located at the feed end of the processor, supports the rolls of film during processing. A heat seal splicer is mounted on top of the stand so that rolls of film can be spliced intc continuous lengths. Also, within the stand is the control panel for all aspects of operation.

Elevator Assembly. The elevator assembly consists of an upper fixed carriage with four rollers and a lower moveable carriage with three rollers. The elevator assembly is a storage device that allows time for splicing without stopping the processing operation.

WET SECTION. This section includes the following:

Developer System. The developer system consists of a developer spray cabinet, temperature control apparatus, a recirculation pump, and a filter (located on the pump stand). The stainless steel developer spray cabinet encloses two banks of nozzles to spray developer onto the emulsion. It also has a bank of nozzles positioned to spray developer onto the base to remove any antihalation coating.

Pump Stand. The pump stand (not shown) is comprised, principally, of a pressure control panel, a chemical control panel, a developer temperature control apparatus, filters, and pumps.

Cutoff-Spray Cabinet. The cutoff spray cabinet is attached to the exit of the developer cabinet. Termination of development is accomplished in this cabinet by a cutoff spray rinse of fix-laden wash water drawn from the sump of the first wash spray. This cutoff spray rinse flushes carry-over developer to the drain, thereby reducing contamination of the fix.

Tank Sections. The tank sections consists of an immersion fix section, a first wash spray section, a wash bath section wetting agent tray, and a tank drain section.

Final Wash Spray Cabinet. This small cabinet is mounted on top of the last compartment of the tank assembly. In this cabinet, a final rinse is sprayed onto both sides of the film.

Wetting Agent Tray. This shallow tank is attached to the takeup end of the tank assembly. It holds a wetting agent to disperse droplets of water evenly on the film surface which helps prevent water marks during drying. Film is submerged as it passes through the pan under the idler roller.

DRY SECTION. This section contains the following:

Squeegee Assembly. This squeegee assembly comprises an idler roller, a main drive roller, and a pressure roller. The film feeds around the idler roller and the main drive roller. The squeegee action occurs as film passes between the main drive and pressure roller.

Subtractor Assembly. Any surface moisture remaining on either surface of the film after it passes through the squeegee is removed by the subtractor assembly. This assembly consists of a series of staggered rollers and warm air ducts which remove any detectable traces of wetting agent solution.

Dryer. Two cabinets constitute the dryer section of the processor. The front cabinet houses three idler rollers and 33 slotted air tubes in the first half, and the takeup elevator in the second half. The rear cabinet contains a dryer blower, heating elements, filters, and two plenums to direct the air flow to the slotted air tubes in the front cabinet. An auxiliary control panel is located on the takeup end, at the top of the rear dryer cabinet.

Dryer Elevator Assembly. The dryer elevator assembly inside the dryer cabinet has a similar function to the elevator at the feed end of the processor. The takeup elevator collects the film strand to eliminate any need for stopping the processing operation while changing s[illegible] is on the takeup assembly.

TAKEUP SECTION. This section includes:

Antibackup Rollers. The antibackup rollers, located on top of the dryer cabinet, prevent loss of tension within the dryer cabinet when the takeup drive is stopped for changing spools, or when a break occurs between these antibackup rollers and the takeup spool.

Viewer and Cutter Assembly. The viewer and cutter assembly, at the takeup end of the processor, is designed for viewing the processed film and cutting the film for spool change over.

Takeup Assembly. Two spindles, driven by a single torque motor, comprise the takeup assembly. Only one spindle at a time actually winds film. The other spindle holds an empty spool so that film can be cut

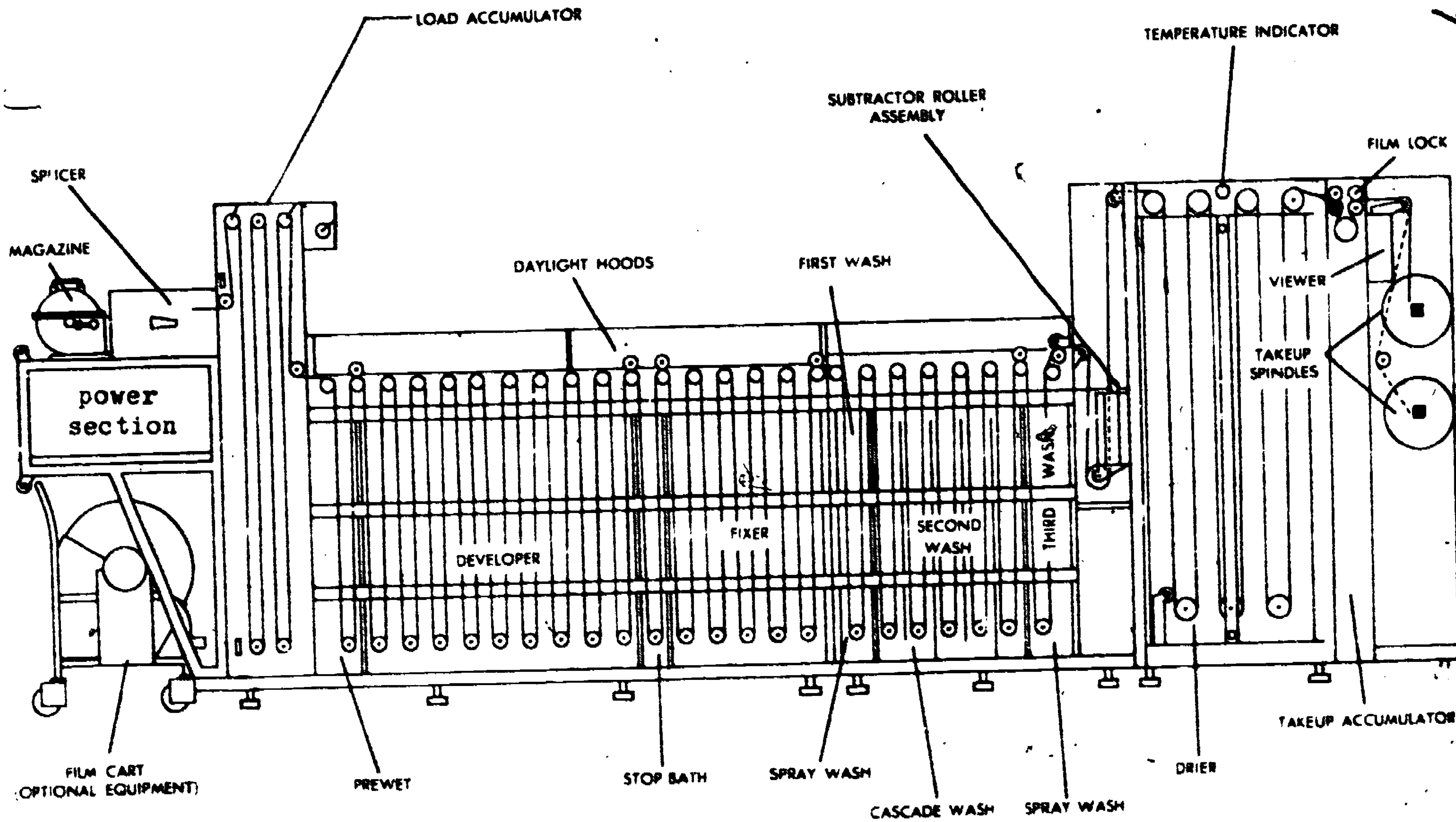


Figure 1-13. HTA-3CM Threading Diagram

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and transferred directly to the empty spool when the other spool is full. Up to 1000 feet (305 m) of standard base film can be wound on a takeup spool placed on either spindle.

## HTA-3CM

The HTA-3CM continuous film processor (Figure 1-13) is a daylight-operated machine designed to process 70 mm to 9.5 inch (24.1 cm) film, either standard base or thin base. Processing speeds are from 5 to 60 feet per minute (1.5 to 18.3 mpm).

The processor is constructed chiefly of stainless steel. All parts of the machine likely to be exposed to corrosive solutions or vapors are fabricated from Type 316 corrosion-resistant stainless steel, synthetic rubber, or inert materials.

The Houston-Fearless HTA-3CM processor consists of four principal operating sections described as follows:

POWER SECTION. The power section, located at the loading end of the processor, contains the film-loading magazine, the film splicer, the main drive unit, and the principal operating controls. The operating controls are located on the front of the upper power-compartment section. All panels enclosing the power section are removable to permit access to the power distribution and control components. The film-loading magazine guides and the film splicer are mounted on top of the power section.

LOAD ACCUMULATOR. The load accumulator, situated between the power section and the prewet tank, provides a film reserve so that film can be spliced without stopping the machine. The accumulator has three top rollers and two elevator rollers over which the film is looped. When the end of the film reaches the film splicer, the film is locked automatically, and the magnetic elevator break releases the elevator. The elevator rises as the film is pulled into the wet section. The accumulator holds sufficient film footage to permit making splices while processing at 30 feet per minute (9.1 mpm). After a splice has been completed, the film lock is released and the elevator descends to its normal operating position. If a splice is not complete within the allotted time, the processor drive shuts off. The processor can be started again after the splice has been completed.

WET SECTION. The wet section consists of the following tanks: Prewet tank, developer tank, stop-bath tank, fixer tank, and three

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wash tanks. The developing and fixing solutions can be continuously recirculated, filtered, and tempered. The developing solution is turbulated by means of pumps and submerged manifolds. Flowmeters, to meter the replenishment of the developer, stop bath, and fixing solution are provided. Wash tanks use both spray and full-immersion wash techniques and provide these options: (1) the first wash may be full spray, spray and half-immersion, or full immersion. (2) the second and third washes are a combination spray and cascade arrangement. Wash water temperature is controlled by a manually adjustable mixing valve which admits hot and cold water in the correct proportions to maintain the desired temperature.

Solution carryover into the developer, stop bath, fixer, and wash tanks is limited by roller squeegees located at the exits of the prewet, developer, stop bath, fixer, and first and second wash tanks. Carryover from the third wash tank is limited by a wringer-type roller squeegee located at the tank exit.

DRYER. The dryer section consists of an upright dryer cabinet, an accumulator, a film viewer, and a dual film-takeup section. Up to 1000 feet (304.8 m) of standard base, or 1800 feet (549 m) of thin base film can be wound on a takeup spool placed on either spindle.

Ektachrome RT Processor Model 1811

The Model 1811 Processor is designed to process and dry "Ektachrome" aerial roll film in all sizes up to 9 1/2 inches (24.1 cm) wide in EA-5 chemistry. The processor operates on the roller-transport system, and all film requires a threading leader tab for positive transport. Access time is approximately 9 minutes at 9 fpm (2.7 mpm) operation.

The processing unit is designed in two modules of 9 tanks each. The first module, containing the first developer solution, is operated at approximately 110°F (43.3°C) and the second at approximately 125°F (51.7°C).

A compact control console, separate from the processor, includes all elements for replenishment, recirculation, temperature control, and filtration of solutions. A panel, situated above the plumbing fixtures, contains all the control switches, speed meter, thermometers, flowmeters and 15 gpm (56.8 lpm) thermostatic water mixing valve (figure 1-14).

Nine 55-gallon (189.3 l.) chemical storage units, made of durable polyethylene tanks (complete with fittings, hose, dust covers, and floating lids) are provided with the processor. Replenishment tubing is also provided.

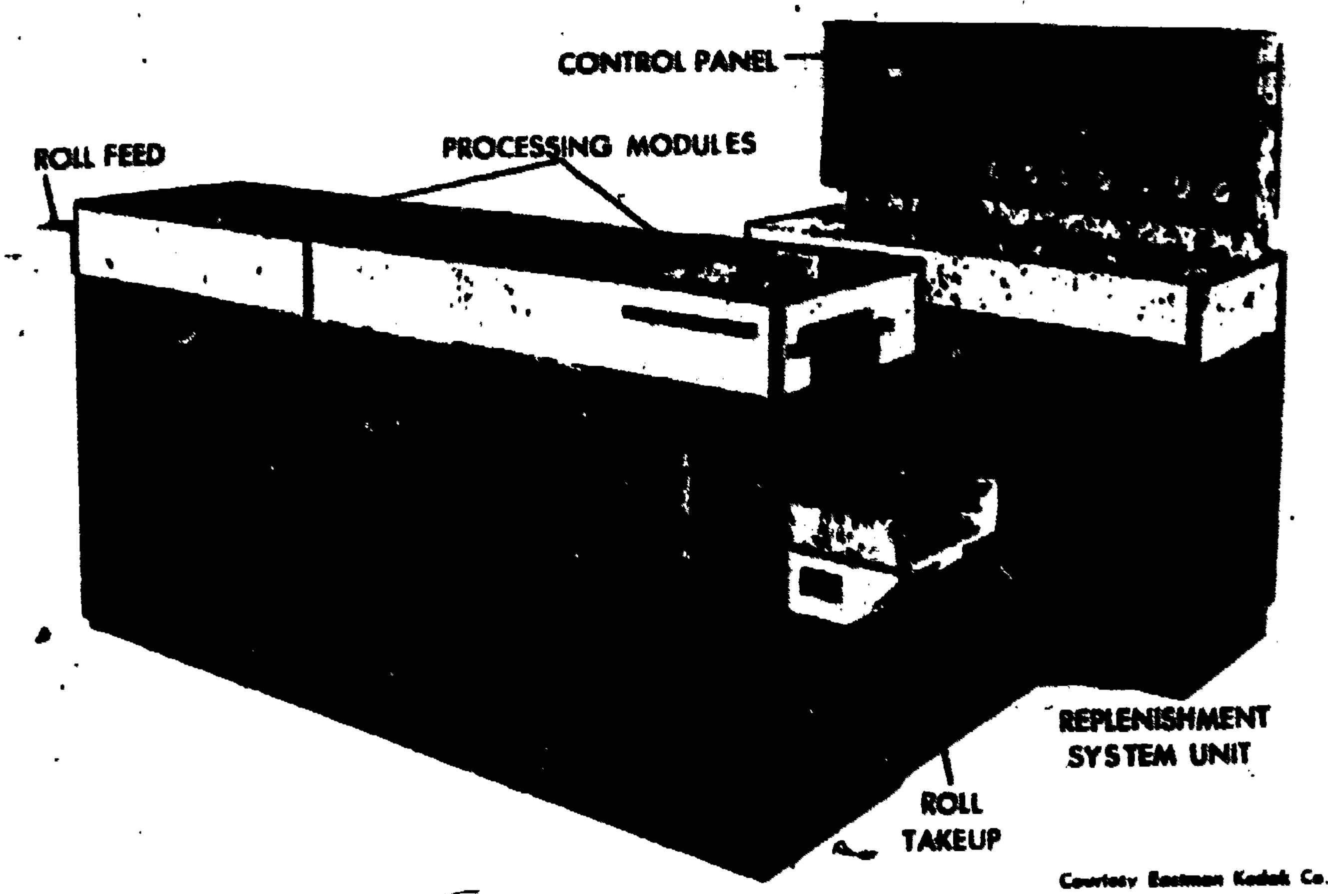


Figure 1-14. "Ektachrome" RT Processor, Model 1811

VERSAMAT FILM PROCESSOR, MODEL 11CMW

Almost every laboratory has the job of processing film of various sizes and formats. For example, routine work orders over a week's duration may include requests to process cut film, film packs, and roll film. The roll film requests may include sizes ranging from 16 mm to 9.5 inches (24.1 cm) in width. In addition to the 4-by 5-inch (100 x 125 mm) film pack processing requests, cut film in 4- by 5-inch (100 x 125 mm) or 8-by 10-inch (200 x 250 mm) formats are also processed. Ordinarily, separate processing equipment would be used to develop such a wide range of film sizes and formats. However, the Model 11CMW Versamat processor can handle all of the film sizes and formats usually found on routine work orders, on a selective basis. This processor unit can handle, at the same time, cut or sheet film in any size ranging from 4 by 5 inches to 11 by 14 inches (280 x 356 mm).

General Description

The Versamat processor is usually installed in a wall that separates the laboratory darkroom and its white-lighted finishing room.

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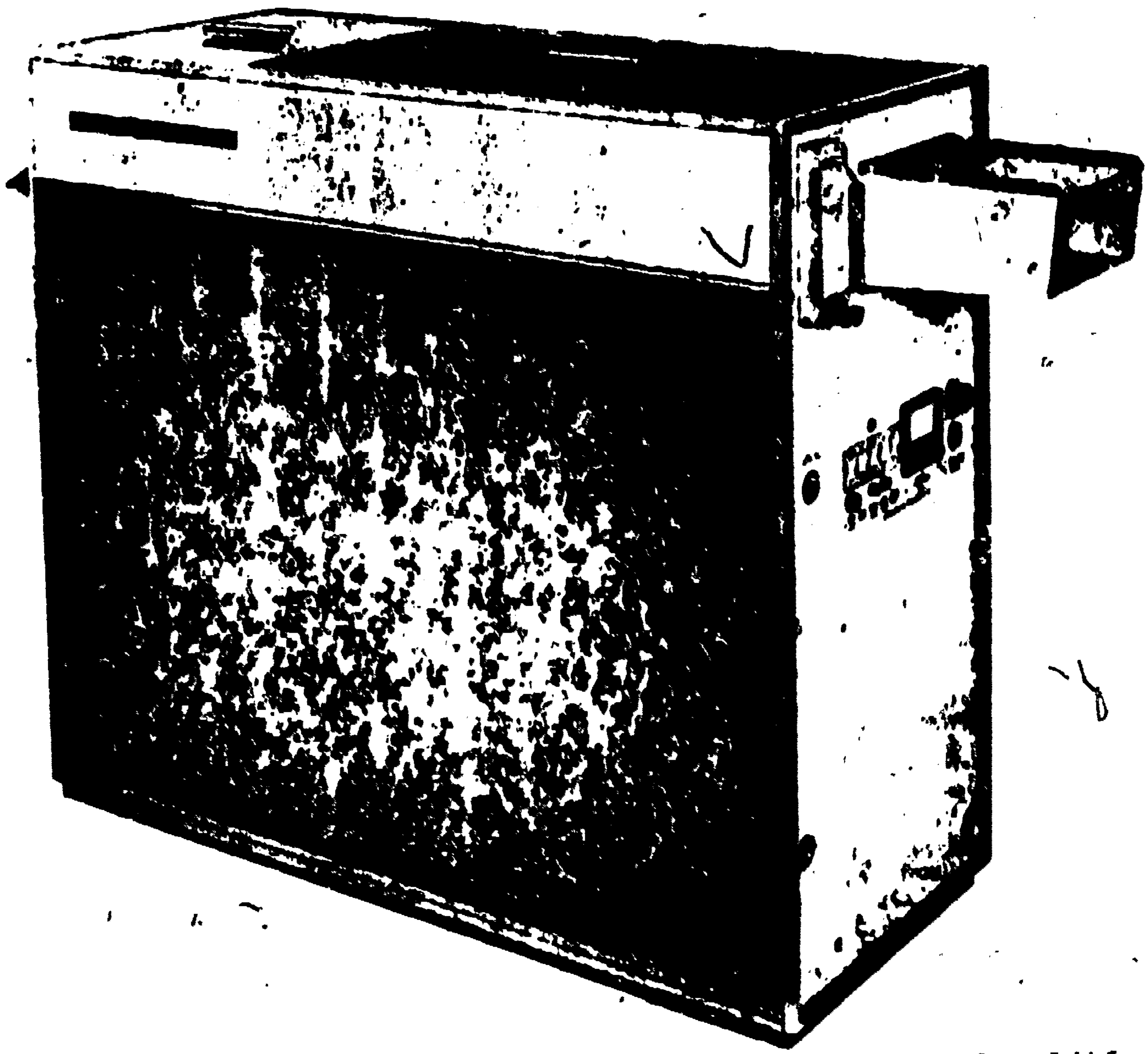

Courtesy Eastman Kodak Co

Figure 1-15. "Versamat" Film Processor

The feed end of the Versamat, which is shown in figure 1-15, is in the darkroom while the takeup end is in the lighted room.

The basic processor measures 58 inches (1.5 m) in length, 25 inches (0.6 m) in width and 54 inches (1.4m) in height. Maximum weight of the unit, without processing solutions, is 1200 pounds (540 kg). Although no more than 11 square feet (1 $m^2$) of floor space is needed for installation of the basic processor unit, additional space may be needed to accommodate floor-mounted, 25-gallon (95 l.) storage tanks for replenisher solutions. To operate and service the Versamat processor, a space requirement of two feet (0.6 m) is necessary on the control side and at both ends of the unit.

The electrical power needed by the Versamat processor is supplied by a 4-wire, 3-phase, 60-Hz, 110/208-volt source. Total electrical load required to operate the processor unit should not exceed 12 kilowatts. Unlike most equipment, the Versamat processor has no main power switch on its control panel. Instead, the electrical power supply is provided by a wall-mounted, off-on switch. When this switch is in its ON position, all components of the processor are energized up to their individual control stations.

Standard Equipment

The following equipment comes as part of the Versamat processor:

1. Two 30-gallon (114 l.) replenisher tanks for developer and fixer, complete with compression fittings, hose adapters, mixing paddle, floating lid, and dust covers.

2. Fifty feet (15.2 m) of tubing with clamps to connect replenisher tanks to processor.

3. Two strainers, one for fixer and one for developer.

4. Thermostatically controlled water mixing valve with check valve, strainers for hot and cold water, and a temperature gauge.

5. A flow control orifice.

6. Two Weir blocks to direct fixer flow for aerial-type or commercial-type chemistry.

7. One splash guard.

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## Accessory and Optional Equipment

The Versamat's accessory and optional equipment includes:

1. Roll film and takeup adapter.
2. Developer bypass to bypass the first developer tank.
3. Skip rack crossover for bypassing any tank after the first.
4. Adapter assembly for Miller-Holzwarth window attachment.
5. Silver recovery device.

## Operating Principles

Once the exposed film is placed in the feed end of the Versamat processor, its film transport system, which is self-threading, automatically takes over handling the film. Exposed film is conveyed through the various processing solutions with the aid of special racks, located in each of the seven stainless steel tanks. Each rack has a number of rollers, arranged so that a strand of roll film moves between the rollers. In addition to its transport duty, this system furnishes an effective agitation action so that reaction byproducts can be removed readily as fresh developer solution is circulated around the film.

When sheet film or roll film is attached to a leader bullet, it guides the film through the roller racks. Because the roller racks are located within the tanks, the film is completely immersed in the various processing solutions. The film is cleared by a cascade spray wash before it enters the drying compartment. As the film enters this compartment, it passes through a squeegee assembly where excess water is removed and is transported downward and then upward between air tubes, which directs hot air on both surfaces of the film.

Air within the drying compartment naturally becomes laden with moisture as the film is drying. In order to maintain the desired operating speed, the moisture-laden air must be eliminated. This is done by exhausting the air away from the drying compartment so that dry, heated air may enter and replace the moisture-laden air. Thus, the drying action is not allowed to slow down and the transport speed of the processor is maintained. The processed and dried film then passes into a receiving bin (for sheet film) or to a takeup adapter (for roll film).

Functional Description

Major parts of the Versamat are identified in Figure 1-16 and the following paragraphs describe the various processor systems.

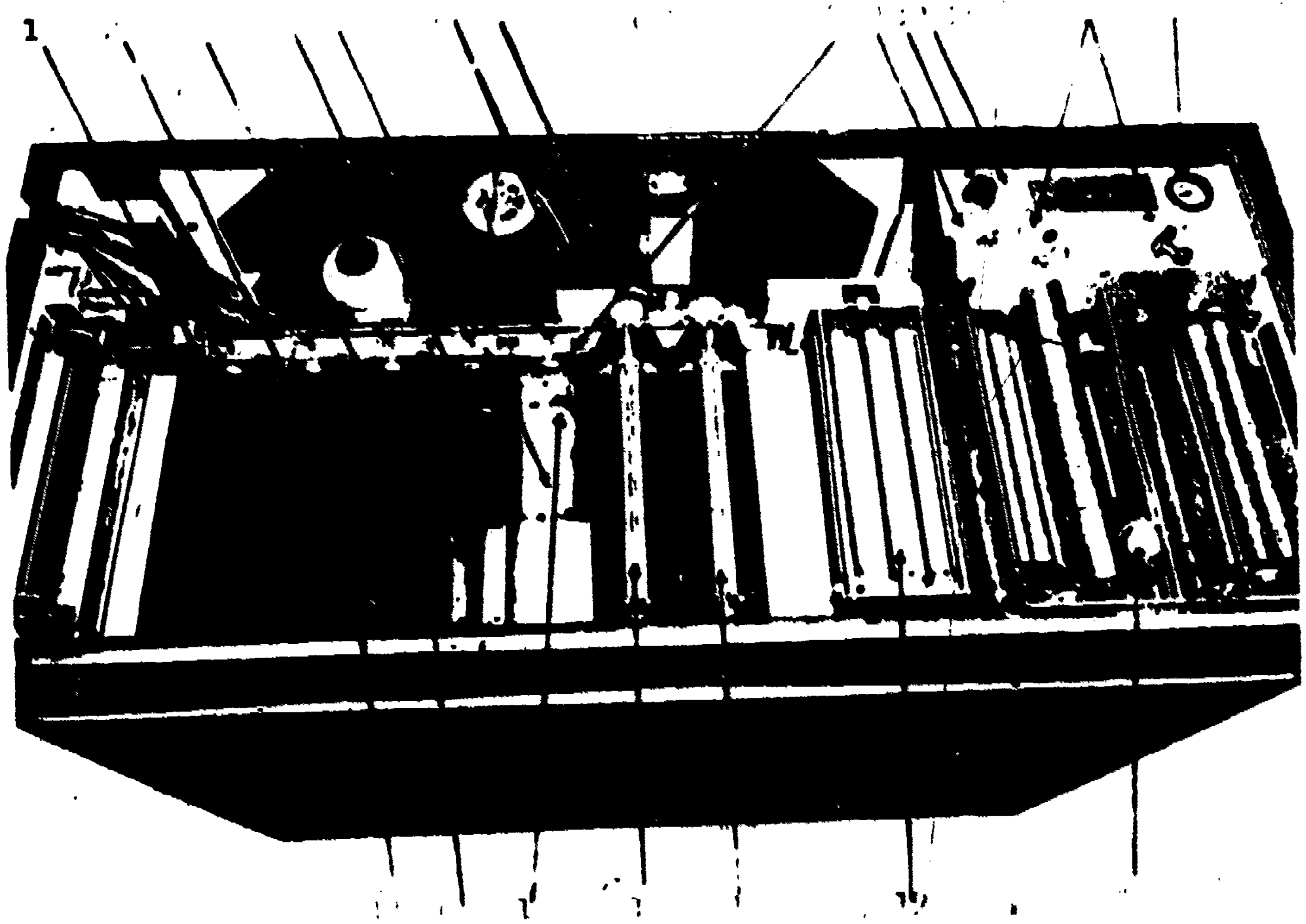


Figure 1-16. Versamat Major Parts

1. Number 1 Developer Tank
2. Number 2 Developer Tank
3. Number 1 Fixer Tank
4. Number 2 Fixer Tank
5. Number 3 Fixer Tank
6. DEV Thermostat Pilot Lamp
7. Developer Thermostat
8. Weir Block
9. Dryer Flood Light Switch
10. Dryer Thermostat
11. Dryer Thermostat Pilot Lamp
12. Damper Control Knobs
13. Dryer Temperature Gauge
14. Overflow
15. Fixer Inlet (A type Chemistry)
16. Fixer Inlet (B type Chemistry)
17. Number 1 wash tank and rack
18. Number 2 wash tank and rack
19. Squeegee Assembly
20. Dryer Flood Light

**RECIRCULATION SYSTEM.** The developer recirculation system (figure 1-17) continuously pumps the developer from developing tanks through a filter, heat exchanger, thermostatically controlled electric heater, and back to the developing tanks. An ON-OFF rocker switch operates the pump and energizes the thermal control system.

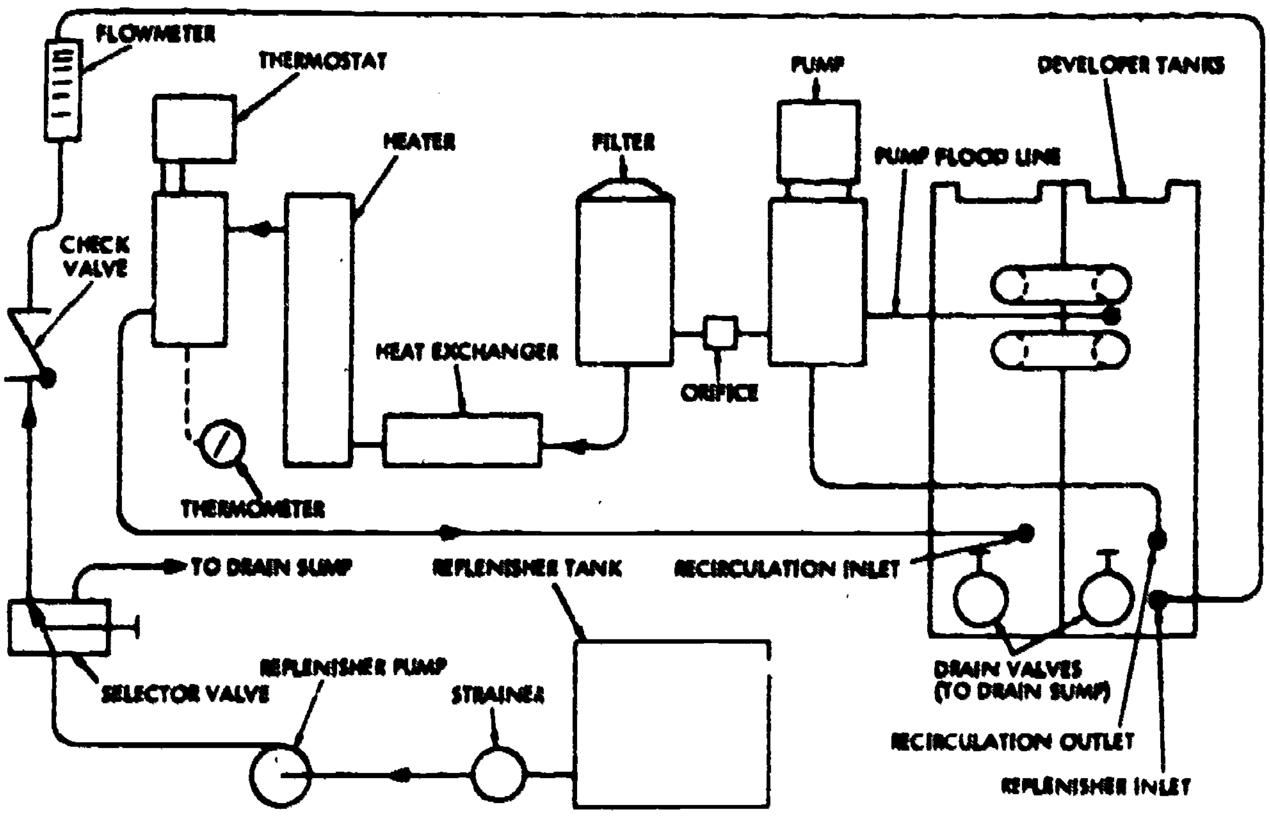



Figure 1-17. Developer Recirculation Flow

NOTE: Fixer solution is not recirculated.

The water circulation system operates from line pressure to provide water to the cascade spray wash tanks through the jacket side of the developer heat exchanger. Water temperature is regulated by an externally mounted, thermostatically controlled mixing valve. The temperature should be adjusted 5° F (2.8°C) less than the desired developer temperature.

**REPLENISHMENT SYSTEM.** The fixer and developer replenishment systems pump fixer and developer to the processing tanks from the replenishment tanks. Both replenishment pumps are operated automatically by a switch in the film detector assembly. The pumps start when film is detected passing through the rollers and stop when no film is passing through. Both replenishment systems are energized by an AUTOMATIC-OFF-MANUAL rocker switch. The manual setting allows operation with thin base films that may not actuate the switch.

FIXER REPLENISHMENT FLOW. The fixer, unlike the developer, is not recirculated, but it must be replenished. Figure 1-18 shows how this replenishment system works. Fixer replenisher starts with the replenishment tank then flows through a strainer, the fixer replenisher pump, the selector valve, a check valve, the flowmeter, and into the fixer tank (tank #3 on the Versamat). The selector valve is used to remove any air in the replenishment system. Both the fixer and developer have their own check valve.

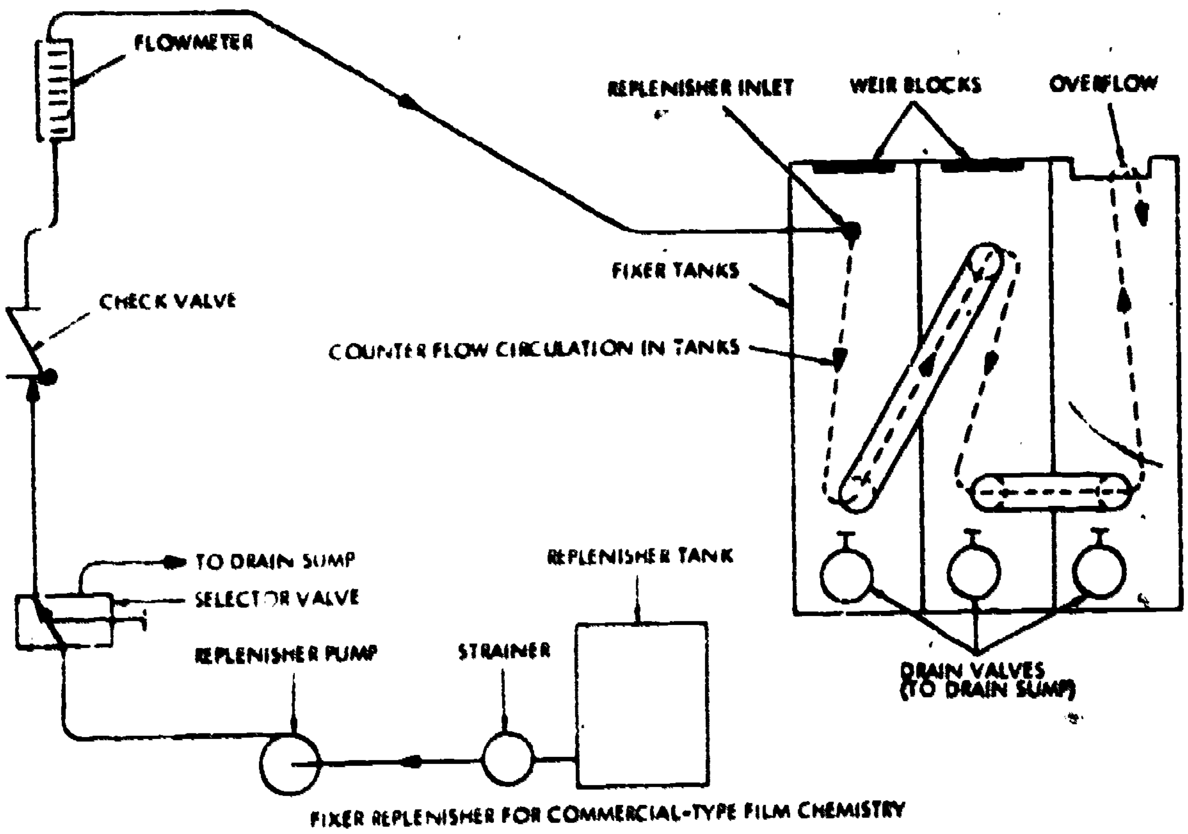



Figure 1-18. Fixer Replenishment Flow

DRAINAGE. The drainage system, which continuously gravity-drains the wash tanks and the overflow from the process tanks, is also used during cleaning to completely drain the process tanks.

MAIN DRIVE. The main drive system, consisting of a single, variable-speed motor, sprockets, chains, and gears which drive the entire roller transport system, is actuated by an ON-OFF rocker switch. The desired speed (0-25 feet per minute) (0-7.6 mpm) is set with a speed control potentiometer. The set speed is automatically kept constant by a drive control as electrical loads vary.

AIR CIRCULATION. The air circulation system is designed to circulate heated air through the dryer section of the processor. A blower, located beneath the processing tanks, continuously recirculates air through the dryer and heater sections. Makeup air is added through the grille opening in the dryer end panel and an equivalent amount is discharged through the dryer exhaust, thereby maintaining proper relative humidity in the dryer. Approximately 250 cfm is replaced in this manner. The blower motor and dryer heaters are controlled by an ON-OFF rocker switch located on the front panel.

WARNING: Do not operate dryers for more than a brief period of time with side panels removed.

ROLLER TRANSPORT SYSTEM. This system consists of:

1. A film detector assembly.

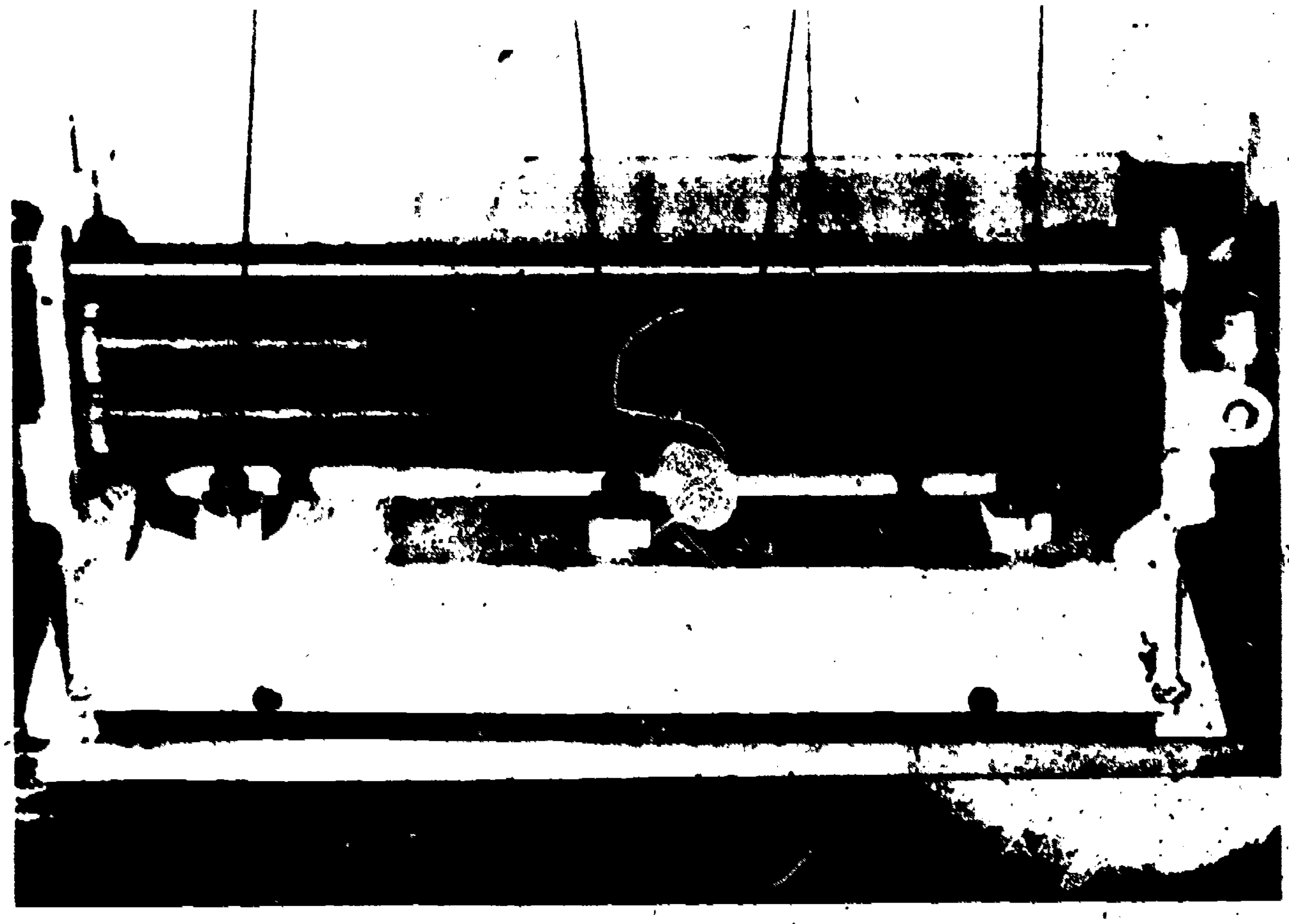
2. Seven racks.

3. Eight crossovers.

4. A squeegee assembly - all in the processing section.

The film detector assembly (Figure 1-19) consists of the following: two rollers and three micro switches. The film passes in between these two rollers and a buzzer sounds indicating a double thickness of film (film spliced onto a bullet). This buzzer is activated by the two outside micro switches. The center micro switch operates the replenishment pumps when the replenishment switch is in the automatic position. Three seconds after the trailing end of the film has passed the detector rollers, a bell sounds. This bell indicates that the end of the film is in the processor. This also indicates that another roll of film can now be processed.

Each roller rack consists of a series of chain-driven rollers mounted in a staggered path. As the rollers rotate, the film is conveyed from roller to roller throughout the system. When the film reaches the bottom of each rack, it is turned 180 degrees to complete its course through the rack by a turn-around assembly mounted at the bottom of each rack. When the film reaches the top of a rack, it enters a crossover assembly similar in design to the turn-around assembly, which conveys it to the next rack. There are eight crossover assemblies: one for the entrance to the first rack, one between each of the seven racks, and one at the exit of the last rack. To minimize surface deposits, certain rack transport rollers are covered with polyethylene.



1. Thickness Detection Switches 2. REPLEN Pump Switch
3. Detection Rollers

Figure 1-19. Detection Switches, Top View

FEED TRAY. The purpose of the feed tray is to guide the film into the processor and to keep the film from drifting from side to side during processing.

DRYER TRANSPORT SYSTEM. This system consists of:

1. Entrance and exit crossovers.

2. Two vertical rows of belt-driven rollers mounted in a staggered path.

3. A turnaround.

4. Air tubes mounted between the transport rollers.

The air tubes direct air onto both surfaces of the film. An additional air tube is located above the dryer entrance crossover to remove excess moisture prior to drying. Guide pins, mounted on the

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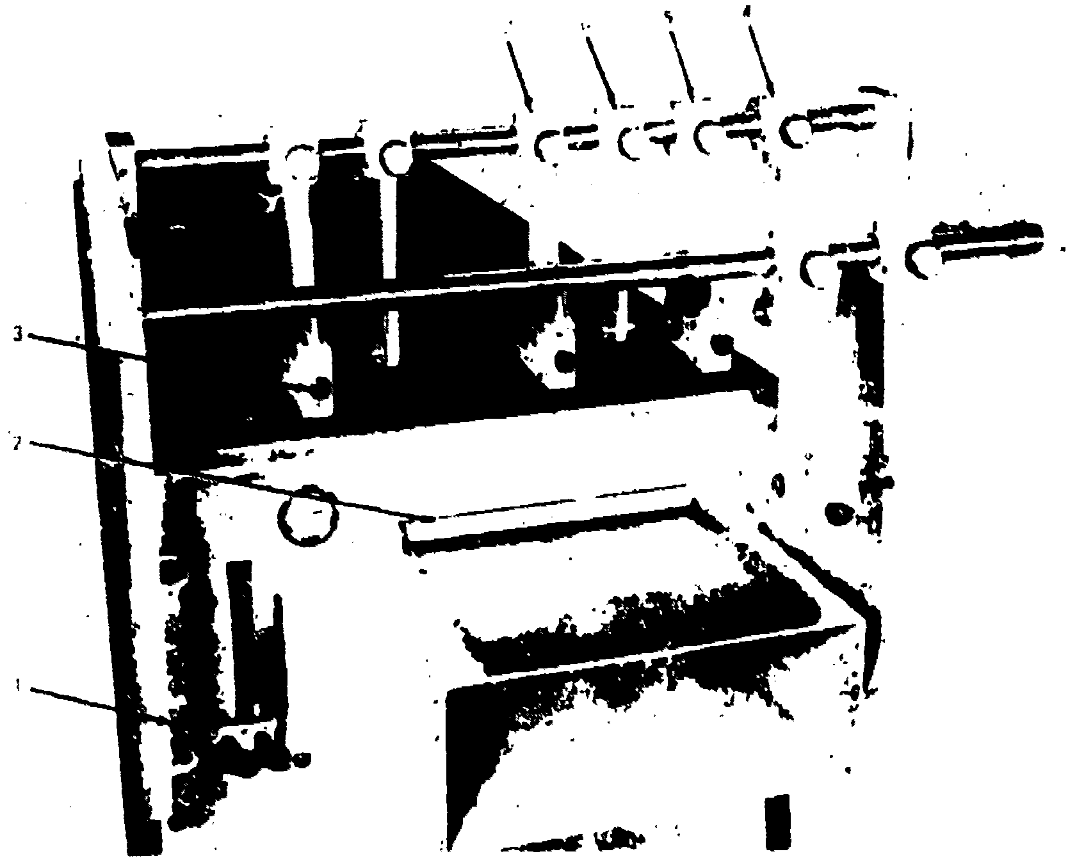



1. Pan Head Screw
2. Entrance Roller
3. Tension Adjusting [illegible]
4. [illegible] Arm
5. [illegible] Arm
6. [illegible] Arm
7. [illegible] Arm

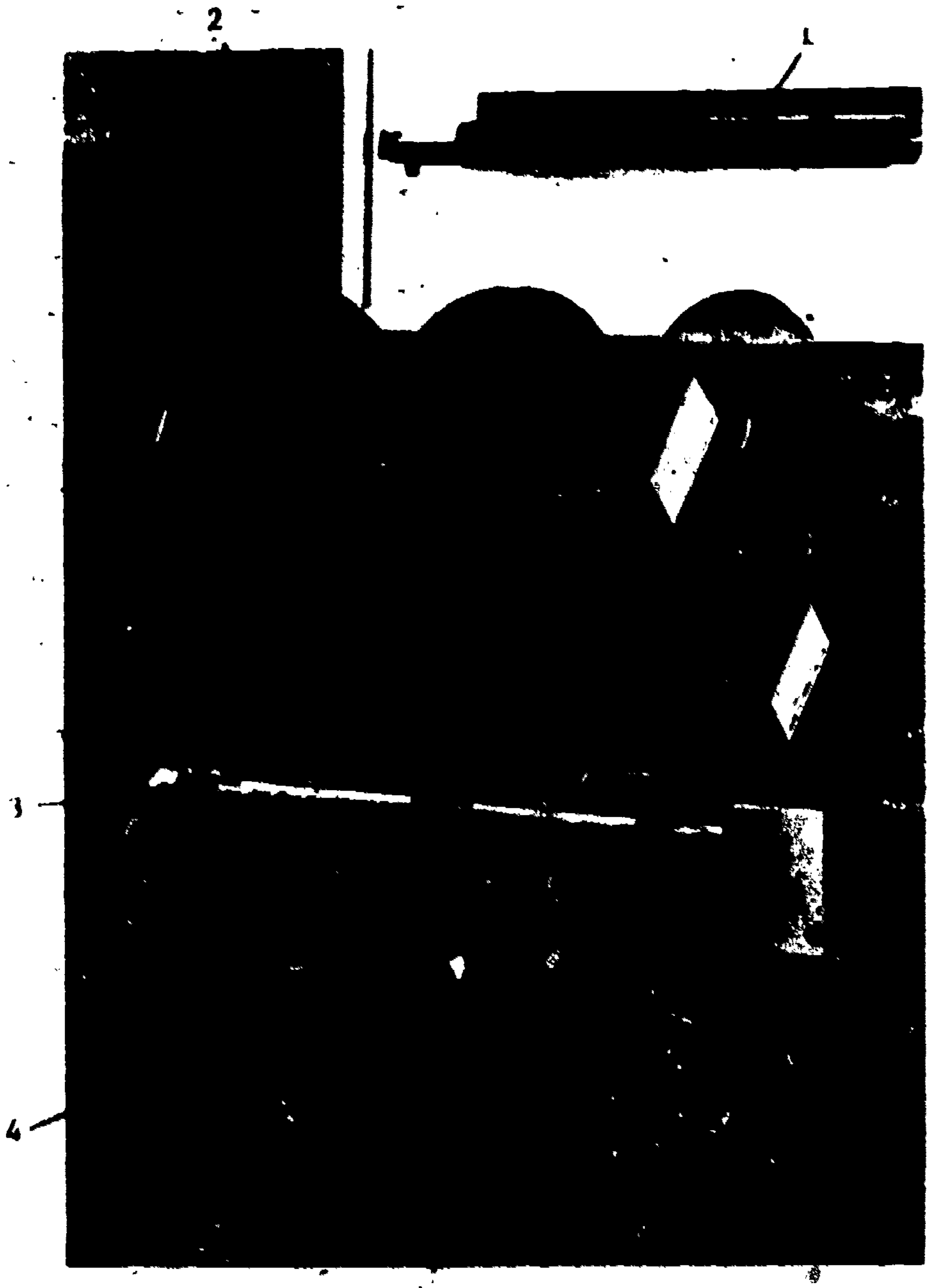
Figure 1-20. Roll Film Feed Adapter Installation

air tubes, direct the film from one transport roller to the next.

CAUTION: Handle tubes with care to prevent misalignment of guide pins.

NOTE: The down-path film transport rollers are identified by a smooth surface at the end of pulley, while the up-path transport rollers are identified by a grooved surface at the end of the pulley.

ROLL FEED ADAPTERS. When the Versamat is to be used to process




1. Dryer Exit Roller
2. Windup Reels
3. Collars
4. On-Off Switch

Figure 1-21. Roll Film Takeup Adapter Installation

aerial roll film, a roll feed adapter must be installed. The roll feed adapter consists of two metal rods that support the roller and clutch arms (Figure 1-20). The roll of film is placed between an idler arm and a clutch arm and fed into the processor. A tension-adjusting thumbscrew is used to keep proper tension on the film as it is being processed.

In place of the roll feed adapter, a Miller-Holzwarth Magazine Adapter is often used. (Figure 1-22). This adapter allows for white light operation at the feed end of the processor. You may find either the roll feed adapter or the magazine adapter used in the field as well as here in the school. The magazine and the roll feed adapters both allow for various widths of film to be processed.

ROLL TAKEUP ADAPTER. The roll film takeup adapter is installed in place of the receiving bin. A dryer exit roller and takeup reels then provide continuous takeup of roll films. The outer rims of each reel rest on a motor driven drive shaft by moveable collars. The drive shaft turns the reel, and the idler shaft permits it to slip, ensuring that the reel will takeup all slack, but will slip as necessary to avoid overstressing and tearing of the film. The motor is plugged into the accessory outlet at the dryer end of the processor (Figure 1-21).

## Operating Controls

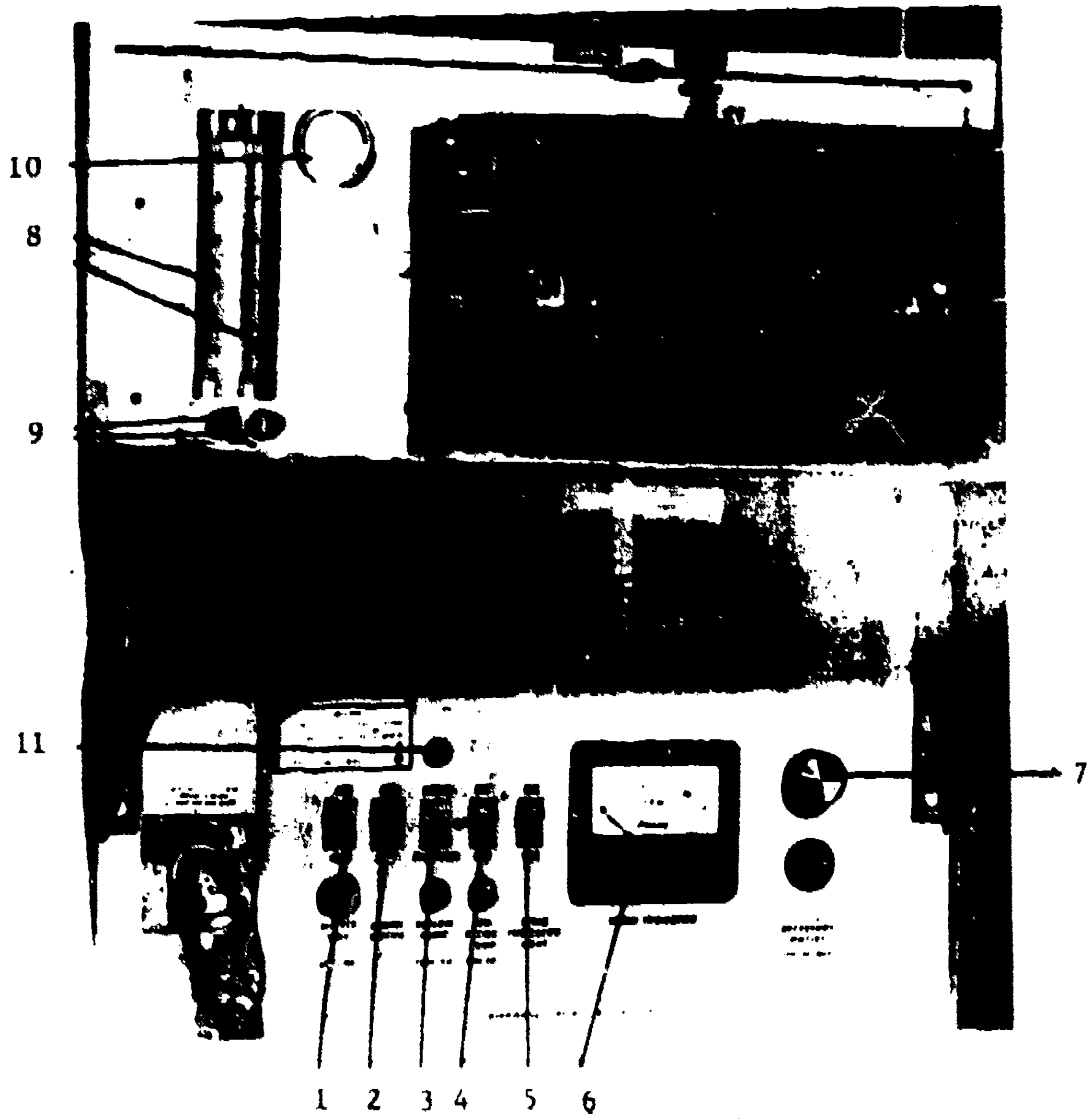
FEED END CONTROLS. Following is a list of the feed end controls and the function of each. (See Figure 1-22).

| CONTROL NOMENCLATURE | | FUNCTION |
|---|---|---|
| 1. DRYER FAN SWITCH | | Controls dryer fan and heater circuits. |
| 2. MAIN DRIVE SWITCH | | Controls main drive motor. |
| 3. REPLEN PUMP SWITCH | Manual | -Provides continuous operation of replenisher pumps. |
| | Automatic | -Provides automatic operation of replenisher pumps by the thickness detector switches. |
| 4. DEV RECIRC PUMP SWITCH | | Controls developer recirculating pump and heater circuit. |
| 5. SPEED INDICATOR LIGHT SW | | Controls illumination of the speed indicator and flowmeters. |

| | | |
|---|---|---|
| 6. | SPEED INDICATOR | Provides visual indication of processor speed in feet/minute. |
| 7. | SPEED CONTROL KNOB | Allows adjustment of the speed of the film transport system. |
| 8. | FLOWMETER TUBES | Indicate the flow rate of the developer and fixer replenishment to the processor. |
| 9. | FLOWMETER CONTROL VALVES | Controls the flow rate of the fixer and developer replenisher. |
| 10. | DEV TEMPERATURE GAUGE | Visual indication of the developer temperature in degrees F. |
| 11. | REPLENISHMENT PUMPS INDICATOR LAMPS | Indicates that the replenishment pumps are on when glowing. |

DRYER END CONTROLS. The following is a list of the dryer end controls and the function of each. (See Figure 1-23).

| | | |
|---|---|---|
| 1. | DRYER FLOOD LIGHT SWITCH | Controls dryer section flood light. |
| 2. | DRYER THERMOSTAT | Allows selection of air temperatures in dryer section up to 155°F (68.3°C). |
| 3. | DRYER SECTION PILOT LAMP | Provides visual indication that dryer heaters are in operation. |
| 4. | DAMPER CONTROL KNOBS | Controls amount of air in dryer. |
| 5. | DRYER TEMPERATURE GAUGE | Provides visual indication of air temperature in dryer section. |
| 6. | DRYER FLOOD LAMP | Lights up dryer. |




1. DRYER FAN Switch
2. MAIN DRIVE Switch
3. REPLEN PUMP Switch
4. DEV RECIRC PUMP Switch
5. SPEED INDICATOR LIGHT Switch
6. SPEED INDICATOR
7. SPEED CONTROL KNOB
8. FLOWMETER TUBES
9. FLOWMETER CONTROL VALVES
10. DEVELOPER Temperature Gauge
11. REPLENISHER PUMPS INDICATOR LAMP

Figure 1-22. Feed End Controls

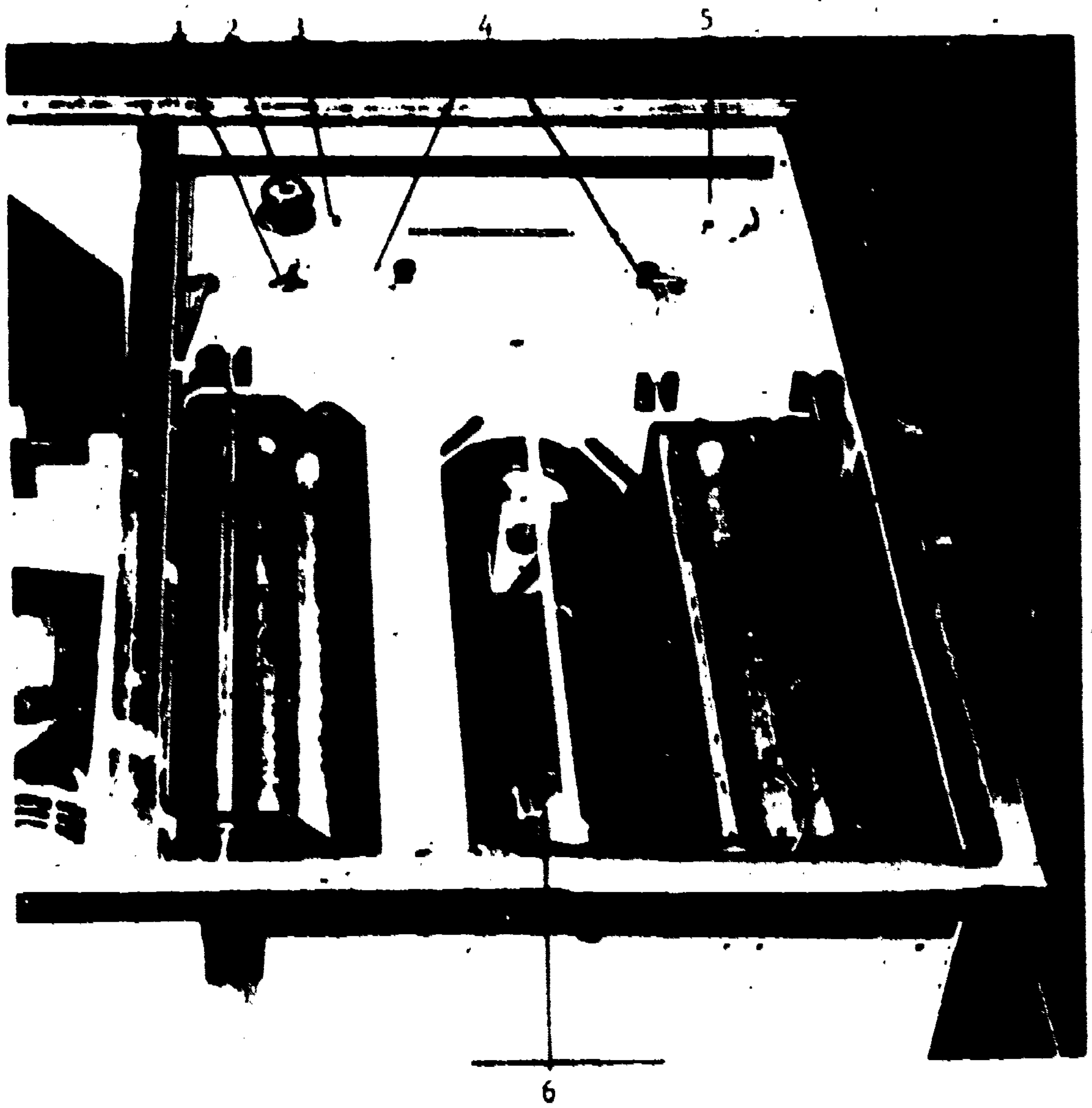
## INITIAL PROCESSOR PREPARATION

Before the Versamat can be operated, initial setup must be performed. There are two steps for this setup: Water supply and power supply.

WATER SUPPLY. Each Versamat has its own water supply and mixing valve. The water must be turned on and adjusted to 5°F (2.8°C) less than the developer temperature. Turn on the water and adjust the temperature. Before the power can be applied, the last wash tank must be at least half full.

CAUTION: TURN ON WATER BEFORE POWER.

POWER SUPPLY. Each Versamat has its own circuit breaker. Turn off ALL switches on the feed end dryer section of the processor, THEN turn on this main circuit breaker.




1. Dryer Flood Light Switch
2. Dryer Thermostat
3. Dryer Thermostat Pilot Lamp
4. Damper Control Knobs
5. Dryer Temperature Gauge
6. Dryer Flood Light

Figure 1-23. Dryer Section Controls

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## Systems Cleaning

The physical quality of processed film will be acceptable only if care is exercised to keep equipment and processing solutions clean and uncontaminated. Frequency of use and the environment in which the equipment is used will affect the type and amount of cleaning required.

PROCEDURES. Follow these steps to clean the developer tanks.

1. Drain all developer from the processing tanks by opening the drain valves on the developer tanks.

2. Remove all crossovers.

3. Position the splash guard on the partition between the developer and fixer tanks (tanks 2 and 3) to protect the fixer. Remove racks 1 and 2 from the developer tanks.

4. Remove the developer filter cartridge and replace the cover on the filter holder.

WARNING: System Cleaner contains Sulfamic Acid, causes burns. Do not get in the eyes, on skin, or clothing. In case of contact, flush skin or eyes with plenty of water for at least 15 minutes. For eyes, get medical attention.

5. Fill the two developer tanks with approximately 10 gallons (37.9 l.) of premixed Kodak developer systems cleaner.

To make a stock solution of systems cleaner, dissolve the contents of its container in three gallons (11.4 l.) of water at 100°F (38°C). Prepare a working solution by diluting one part of stock solution with three parts of 90°F (32°C) water. This will give 12 gallons (45.5 l.) of working solution.

6. Run the recirculation pumps for at least 15 minutes.

7. For normal cleaning, place the developer racks in a sink and rinse with warm water. The temperature must not exceed 120°F (49°C). NEVER IMMERSE THE RACKS IN SYSTEMS CLEANER!

8. Discoloration of the rollers is not harmful, but built-up deposits should be removed. In case of extreme encrustation, a plastic abrasive material may be used. Never use steel wool on

any processor parts. Abrasive cleaners should not be used on polyethylene-covered rollers. A rough towel or cloth should be used.

9. If stubborn chemical deposits remain, rotate the rack drive gear in a clockwise direction and apply systems cleaner to all rollers and side plates. Use a soft brush or rough cloth. CAUTION: Wear goggles or other eye protection and a plastic apron when using a brush.

10. Flush the racks with warm water and wipe them with a damp sponge to remove all the cleaner.

11. Repeat steps 7, 8, and 9 as necessary for thorough rack cleaning. Rack cleaning can usually be done during the time the cleaner is circulating through the developer tanks.

12. After 15 minutes, stop the recirculation pump and open the drain valves. Empty and flush the tanks.

13. Replace the developer racks and fill the tanks with water. Turn on the recirculation pump and the main drive. (The water must be on in the machine when the main drive is on). Allow them to run for about five minutes. Repeat flushing and dumping until the water shows no discoloration.

14. Clean all crossovers using the same method described in steps 7, 8, and 9.

15. If the processor is to be returned to service right away, the Versamat must be filled with chemistry. The developer tanks and racks must be seasoned before film can be run. This prevents "dichroic fog" from forming on the film. Dichroic fog is a two color sheen resembling grease or oil on the film. Dichroic fog can be removed by rinsing the negative(s) in a neutral solution of Potassium Permanganate (1/2 gram per liter) until the fog has disappeared. Then immerse in a 5% solution of Sodium Bisulfite until the brown permanganate stain is removed. The above procedure may not be feasible with continuous lengths of aerial film, but could be used when select prints are required. Season the tanks by filling them with half water and half developer and recirculate for five minutes. After this, drain the tanks and remove racks. Refill the tanks with fresh, certified developer following the procedures listed in this SW for Filling Processor Tanks.

## PREPARING PHOTOGRAPHIC SOLUTIONS

### Mixing Chemistry

Photographic solutions must be prepared in a systematic manner

dictated by the chemical formula or package instructions. Usually the order in which the ingredients are added to the solution serves to protect the integrity of other ingredients and of the solution itself. A developer, for instance, whose constituents are added in an order other than that prescribed could become discolored and practically inert due to aerial oxidation or an undesirable reaction. The temperature of the solution and the stirring method are of equal importance and are generally specified with the mixing order. Each constituent must be thoroughly dissolved before the next is added. Usually the instructions will specify "mix until clear" but there are exceptions.

Mixing and storage equipment must be nonporous and inert to photographic solutions. Glass, hard rubber, polyethylene, enameled steel and polyvinyl chloride (PVC) which all meet these requirements are used in smaller labs or where cost is important. Most large processing facilities, however, use AISI (American Iron and Steel Institute) Type 316 stainless steel for all solutions except "color bleach" solution which requires the use of "Hastaloy C" stainless steel. (Type 302 stainless steel is not acceptable for use in a processing lab).

Mix tanks should be equipped with a mechanical stirring device to obtain efficient mixing without causing excessive oxidation of the solution during the mixing operation. Some labs mount the stirrer so that the impeller shaft is at an angle with the vertical. With baffles along the outer edge of the tank, there is no beating of the air into the mix or vortexing of the liquid which will cause oxidation.

If it is necessary to use the same mix tank to mix more than one solution, it is desirable to mix them in the order they are used in the process. For example, developer, short stop, fixer, etc. In this manner, if traces of the chemical remain in the mixing tank after it has been cleaned, their effect on the following solution is minimized. The mix tank and stirring apparatus should be rinsed thoroughly after each solution use. All equipment must be thoroughly cleaned after a fixer solution is mixed, particularly before mixing another developer solution. After cleaning, mixing equipment should be rinsed three times with tap water.

Mix tanks must be calibrated so that the volume is accurately known. The most common method employed by labs is to use a measuring device, such as a graduated cylinder, with a capacity of between 4 and 10 percent of the capacity of the mix tank. The container is filled to the graduated line with water and emptied into the mix tank. This

procedure is repeated until the desired volume is achieved. The solution level is then marked, either on the side of the tank or on a special calibration indicator. This is generally satisfactory for most solutions since the solution will be diluted to the same level every time, therefore, achieving a good degree of precision.

Certifying Chemistry

Certification tests are conducted after the solution has been brought to final volume at room temperature. The solution is then remixed and samples taken. To eliminate as much variability as possible, the sample will be withdrawn in the same manner, from the same place in the tank and at the same point with each batch.

There are three basic tests used in certification of processing solutions.

o Physical Properties, consisting of specific gravity test.

o Chemical Properties, consisting of pH

o Processing Properties, (Sensitometric) consisting of a test that evaluates the solution's affect on a piece of photographic material.

The specific gravity test is the first test and serves as a quick check to determine whether the solution appears to be complete as to its density. The pH test can tell what the overall activity of the solution is. Other tests can be performed if these are inconclusive. However, if a solution is of substandard quality, it will normally be detected by the combination of the specific gravity, pH, and processing properties test. Therefore, performing a complete chemical analysis on solutions that have been certified by the above tests will net little useful information. If the normal certification tests are inconclusive, or if the solution is believed to be of substandard quality, it may be desirable to perform additional tests. The additional tests may provide sufficient information to pinpoint the deficiency, and thus, enable the solution to be brought into standard by corrective additions rather than to be dumped. Personnel in Quality Assurance should maintain their ability and state-of-readiness by periodically practicing all of the analysis procedures on solutions known to be certified.

DEVELOPER CERTIFICATION. A specific gravity test is accomplished by a measurement that is indicative of the total amount of dissolved solids contained in the developer. By definition, specific gravity is the ratio between the weight of a given volume of a substance and the weight of an equal volume of pure water at 60°F (15.6°C).

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The use of the hydrometer to measure specific gravity has already been taught. In Block II it was stipulated that a correction factor of 0.001 units would be added for each 5°F (2.8°C) temperature change above the standard. This correction applies to pure water only. The coefficient of expansion of a solution heavier than water is greater than the coefficient of water. The solution expands more on heating, resulting in a greater change in specific gravity per unit of temperature change. Laboratory research indicates that the thermal correction factor for most photographic developers, stop baths and fixers is very close to 0.003 per 10°F (5.6°C).

Temporary standards for the specific gravity tests, the mean and control limits (eg. 1.103 ± 0.003), can be based upon the first 15 batches of certified solution. These standards are then refined periodically as additional data is collected.

When the upper control limit is exceeded, the indication is that more than the specified amount of an ingredient was added, a wrong ingredient was added, or the solution was not diluted to the proper amount. Conversely, when the measurement falls below the lower limit, the indication is that one of the ingredients may have been left out, a wrong ingredient was used, or the solution was diluted to too great a volume.

The purpose of the pH test is to determine whether the developer has the proper alkalinity to produce the proper rate of development. The pH value of developing solutions is extremely critical since it is directly related to the ability of the developer agent to reduce the silver halide to metallic silver. The pH values of freshly mixed developing solutions will generally fall in close agreement with one another. If the evaluation of a solution sample proves to be out of control on two consecutive tests, it is a strong indication that a major error has been made in measuring one or more of the constituents or in the mixing or dilution of the solution.

The processing properties test of a developer is a sensitometric test performed to determine if a freshly mixed developer solution will produce the desired photographic effect. The test consists of carefully developing a sensitometric strip in a sample of the developer being evaluated, and comparing the results against a test standard to determine if the solution meets the certification requirements. A highly repeatable processing technique is mandatory. The evaluation will frequently detect faults that may or may not be indicated by the other tests.

The processing is performed in one of three different ways. The most common is the ASA tray method which has been covered in the last block. Probably the method used most frequently is to use an actual processor with a sample of the fresh mix. Some of the larger labs

have a special processor called a "Dip Test" or "Sensitometric" processor which they use for this purpose.

**CERTIFICATION OF FIXING BATHS.** Large quantities of unexposed, undeveloped silver halides remain in the emulsion upon termination of development. In order to obtain a permanent image, they must be removed. A fixing agent chemically reacts with the silver halide, which is not soluble in water, and converts it to a water soluble complex.

The specific gravity test is used primarily to detect gross mixing errors, improper dilution, and inadequate mixing. It is quite sensitive to deletions or incorrect amounts of sodium or ammonium thiosulfate since they constitute a major portion of the solution.

The pH of fixing solutions is indicative of the concentrations of acetic acid, boric acid and other buffering agents. If the pH of a fixer is too low, colloidal sulfur will be formed which causes stains on the emulsion. If the pH is too high, a sludge of aluminum phosphate will be formed, decreasing the hardening properties of the solution.

The processing properties test of fixing baths is simply a check of the time required to fix a sample of raw stock material properly. This test is based upon the clearing time which is defined as the time required for the film to be fixed to a point where there is no visible sign of silver halide remaining. Actually, 5-10% of the silver halide remains invisible at this point. The general rule used in most labs is that the total fixing time be twice that of the clearing time.

Filling Processor Tanks

To prepare the tanks for filling with chemistry, the following steps must be taken.

1. Close the drain valves (five in all) located at the bottom of the fixer and developer processing tanks.

2. Install the Number 1 rack in the Number 1 developer tank. Fill the Number 1 and 2 developer tanks with developer to the fill line visible in the Number 2 tank, using a suitable container. Carefully lower the Number 2 rack in the Number 2 developer tank. Install a new developer filter in the filter holder.

3. Place the splash guard between the Number 2 developer tank

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and the Number 1 fixer tank to help prevent contamination of the developer solution when filling the fixer tanks.

4. Install the Number 3 rack in the Number 1 fixer tank. Fill the fixer tanks with fixer solution to the fill lines visible in the Number 2 and 3 fixer tanks using a suitable container. Carefully lower the Number 4 and 5 racks in their respective tanks.

5. Install the Number 6 and Number 7 racks in their respective tanks. Be sure all racks are firmly seated. Remove the splash guard.

6. Install the entrance, intermediate, and exit crossovers working from the feed end. Make certain that the positioning studs are properly located in the tops of the racks and that the gears are engaged. Install the squeegee assembly and fasten in place with the spring clip provided.

The preceding procedures for filling the processor tanks are appropriate after system cleaning or when the chemistry has been dumped.

## PROCESSOR OPERATION

### Preoperational Check

A preoperational check must be conducted before machine startup is accomplished. Failure to make proper startup checks could result in damage to the processor or give a false indiction of the machine's reliability. Preoperational checks will vary from one machine to another. Here are some of the major points that should be considered for any machine.

1. Make certain that equipment is grounded properly.

2. Check for any obstructions that could damage such moving parts as gears, drive belts, [illegible] chains, etc.

3. Check solution levels in processing machine tanks and replenishment tanks.

4. Check cleanliness of all rollers and squeegees that normally operate in the dry state - clean if dirty.

5. Check machine racks and/or elevators for cleanliness - clean if dirty.

6. Check to insure that all rollers and other moving parts are free running.

Daily Startup

1. Remove crossover racks and check for cleanliness. If necessary, clean with warm water (not over 120°F or 49°C).

2. Check racks, gears, chains, and the general cleanliness of the machine. Clean as required.

3. Check solution levels in replenishment tanks. Fill if needed.
4. Replace crossover racks - seat properly. (Entrance crossover must be dry before film is processed).

5. Make sure silver recovery cartridge is in place.

6. Make sure all switches are in the OFF position. Turn the speed control full counterclockwise.

7. Turn on water, adjust to 5°F (2.8°C) less than the desired developer temperature (developer temperature - 85°F or 29.4°C).

8. Turn ON main power.

9. Turn main drive switch ON (CAUTION - Make sure speed control is full counterclockwise before turning on main drive). Adjust speed to five fpm (1.5 mpm). Check all moving parts for proper operation.

10. Turn dryer ON, adjust thermostat to required temperature.

11. Turn ON developer recirculation switch.

12. Turn replenisher pump switch to AUTO. (Set flow rate with the switch in the MANUAL position first).

13. Check solution temperature with a process thermometer. When correct temperature is reached, certify the chemicals.

In addition to the above daily startup procedures, the film detector/replenishment system and the feed-tray alignment should be checked.

FILM DETECTOR/REPLENISHMENT SYSTEM CHECKS. Proceed as follows to check the thickness detection switches and the replenisher pump switch and, if necessary, have maintenance technicians adjust these

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switches:

1. Place the REPLEN PUMP switch in the ON AUTO position.

2. Insert a single piece of normal thickness film (approximately 0.008 inch or 0.2 mm) approximately 2 inches (5.1 cm) wide between the detector rollers.

3. The replenisher pumps should start when the film is inserted and the "feed" bell should ring approximately 3 seconds after the trailing edge or end of film has passed the detector rollers. If the pumps and bell are not working properly, adjust the replenisher pump switch by inserting the film strip at one end of the detection rollers and turning the square adjusting nut slowly until the pumps just operate. Move the film to the other end and readjust if necessary.

> NOTE: The switch adjustment is maintained by spring tension. Turn the nut clockwise to raise the switch.

4. Check the thickness detection-switch adjustment by inserting a double thickness of film between the detection rollers, first at one end, and then the other. The detection buzzer should sound at both film positions. If the buzzer is not working properly, adjust the detection switches by inserting the double-film thickness at one end of the detection rollers and turning the square-adjusting nut until the buzzer just operates. Then tighten the adjusting nut 1/6 of a turn. Move the film to the other end and adjust the other switch as necessary.

> NOTE: During adjustment of the thickness-detection switches, the replenisher-pump switch should be in its OFF position to avoid unnecessary starting and stopping of the pumps.

FEED-TRAY ALIGNMENT. Check the feed-tray alignment with an 8 x 10 inch (200 x 250mm) sheet of film. Place the film on the feed tray and slide it forward until it contacts the detection rollers. Check that the film squarely contacts the rollers. If not, loosen the thumb screws holding the feed tray end, with the film held firmly against the side guide, square the leading edge of the film with the detection rollers and tighten the thumb screws.

Daily Shutdown

1. Decrease machine speed to 5 fpm (1.5 mpm).

2. Turn dryer thermostat OFF, remove top and side covers of processor.

3. Replenisher pump switch OFF.

4. Developer recirculation switch OFF.

5. Remove and clean all crossovers. (Water not over 120°F or 49°C).

6. Wipe down machine thoroughly with a damp sponge.

7. Replace crossovers.

8. Dryer fan switch OFF.*

9. Main drive switch OFF.**

10. Water OFF.**

11. Main power switch OFF.

12. Check machine for cleanliness. Replace all sides and covers.

* Dryer temperature should be 100°F (37.8°C) or less.

** Do not turn water off with main drive on. Damage to pump of water conservation kit will result.

Preventive Maintenance

The Technical Manual for operation and service of the Versamat Film Processor, Model 11C-M, is TO 11E5-2-12-1. This publication covers the daily, weekly, and monthly maintenance routines, along with periodic cleaning and lubrication.

The following items are listed as areas of CAUTION and WARNING during various machine functions:

1. The Kodak Developer Systems Cleaner contains sulfamic acid. Avoid contact while using this chemical.

2. A 10 percent solution of sulfuric acid is used to remove chemical deposits from the flowmeter and check valve. Mix in an open, uncongested area, and avoid contact.

3. Take extreme care not to get any oil or grease on the crossovers, racks, in the solution tanks, or on dryer-transport rollers and air tubes.

4. Chain tension is important and may be adjusted by loosening the chain idler stud and relocating the assembly.

DAILY MAINTENANCE. Essentially, the bulk of the maintenance responsibilities centers about keeping the Versamat processor clean. For some parts of the processor, cleanliness is a daily task. Each time the processor is shut down, remove all crossover assemblies in the processing section and wash them with warm water. When deposits are seen, use a soft brush to remove them. Wipe down all rack rollers, above the level of each solution, with a clean damp sponge. Finally, wipe clean the feed rollers in the entrance roller assembly.

In addition to the cleaning chores just described, check the following items daily:

- Flowmeter settings.
- Temperature of the developer solution.
- Wash water temperature.
- Replenishment level in the storage tank.
- Leader material for excessive wear or tears.

WEEKLY MAINTENANCE. After one week's production runs are completed, shut down the Versamat processor and remove the roller racks and crossover assemblies for washing and wiping down. Be sure to remove all chemical deposits from the sides of each rack, around the gears, and from the chain tighteners. Turn each roller by hand to see if they rotate freely. Remove any slack by adjusting the chain tighteners. After checking each rack for twists or bends, replace them and check the gears to make sure of proper seating.

Examine all chemical solutions in the processor for clarity. Determine if any foreigh particles are present. To see whether the solutions are being recirculated, turn on the pumps and watch the surface of solution for turbulence which indicates that the pumps are operating properly. Next, inspect the air tubes to the dryer compartment to see whether any clogging has occurred. Call the maintenance section if any of the slits are plugged. At this time, it would be wise to examine the screen covering the air intake for the dryer compartment to see whether the screen is clear of any obstructions.

Both the daily check and the weekly cleaning are important tasks which are routinely assigned to the operator of the Versamat processor. The operator also maintains a log sheet of minor difficulties that he may have experienced either during the shutdowns or during production runs. Purpose of this log is to acquaint

maintenance personnel with these difficulties which would then aid in the repair or adjustment of the processor.

MONTHLY MAINTENANCE. Monthly maintenance is performed concurrently with the weekly maintenance. Monthly maintenance will also include cleaning the processor tanks (if necessary) and cleaning the replenisher and recirculation system. Any scheduled maintenance should be performed at this time also.

## PROCESSOR CERTIFICATION

Processing facilities are entrusted with the critical responsibility of processing films in a manner that will minimize the possible loss or distortion of the informational content. Because the facility often has only one chance to process the material, it is essential that all possible precautions be taken to ensure that the material is competently handled. The premission certification of processors is performed prior to processing any original or duplicate film to detect conditions which will tend to degrade the informational content of the processed imagery. Machine certification consists of three major areas: mechanical, chemical, and sensitometric certifications.

### Mechanical Certification

There is no room for error in any operation conducted by a continuous photoprocessing laboratory. Much of the laboratory equipment used is highly sophisticated and complex, specific procedures must be followed carefully, and personnel must be proficient. If you were the pilot of an aircraft, you would follow a preflight checklist to make sure that all instruments read normal values and that all controls are operable. During flight, you would continuously monitor your instruments to minimize the possibility that something could go wrong. During and after landing, you would follow another checklist to land and shut down the aircraft. Such techniques are also appropriate to photographic equipment and procedures. Mechanically certifying a processor requires that you process a scratch test and verify all functions before mission film is processed.

SCRATCH TEST PRODUCTION. During machine startup, you are in reality, certifying that all processor systems are operating properly. If unusual noises, or inoperative pumps, motors, etc., are found, they are repaired or replaced before processing begins. But just because all processor systems operate properly does not guarantee that the product will be free of physical defects produced by the processor.

Basically, mechanical certification consists of processing a quantity of flash film. Flash film is raw stock that has been exposed

to simulate the overall density of mission film (usually, a density of 1.00 to 1.20). If any defect that could have been produced by the machine is evident upon examination of the flash film, the machine is shut down until the cause of the defects can be found and corrected.

EXAMINATION OF THE PROCESSED FLASH FILM. It is checked for developing and drying streaks, developing mottle, scratches, abrasions, pinholes, etc. The presence of any such defect indicates that the processor is not operating as it should. As an example, drying streaks could result from two common sources. These are improper squeegeeing or blocked airflow in the drying compartment.

SCRATCH TEST ANALYSIS. The defect most often found during mechanical certification is scratches. The cause of scratches is also the most difficult to find. After processing, the scratch test could contain scratches from a number of sources. Some of these are the printer used to expose the film, cinching the film, the processing magazine, and the processor itself, only to name a few.

The method most often used to determine if the scratches are produced by the processor is quite simple. This method consists of cutting a short length of the flash film from the center of the strip, turning it, and resplicing it into the strip before processing. The degree of turn may be either 90° or 180°. There is one disadvantage to both turns, however. On the 90° turns, the length of film that is spliced back into the strip must be the exact width of the flash film. During analysis of the 180° turn, some scratches not produced by the processor may match perfectly and falsely indicate that they were produced by the processor. In most cases, however, scratches on both turns that are continuous might have been produced by the processor. All others may be ignored during processor certification.

Another certification function that must be performed prior to processing mission film deals entirely with the quality of the processing solutions. While the analysis of the chemical certification data is the responsibility of quality assurance personnel, you, as the operator are responsible for providing the necessary input data.

Chemical Certification.

Both the developer and fixer must be certified prior to processing mission film. Such checks as pH and specific gravity may be made each day during startup. Some laboratories also perform these checks at regular intervals during the day or after a given quantity of film has been processed.

Table 1-1. Troubleshooting the "Versamat" Film Processor

| TROUBLE | POSSIBLE CAUSE | REMEDY |
|---|---|---|
| Film twisted or cocked in processing section. | Film not feeding square. Chemical or other deposits on rack rollers. | Adjust feed tray. Remove with cleaning solution. |
| | Double the thickness switches on roller incorrectly set. | Adjust detector roll assembly. |
| Film fails to be transported in processing section. | Rack chain too loose. | Tighten. |
| | Developer solution temperature too high. | Correct by:<br>1. Reset thermostat.<br>2. Tighten thermostat mounting screws.<br>3. Free thermostat plunger.<br>4. Monitor thermometer.<br>5. Check solution and water temperature with long stemmed thermometer.<br>6. Allow fresh solutions time to cool.<br>7. Turn on water supply. Check if valves are open. |
| | Solutions improperly mixed. | Correct by:<br>1. Draining and refilling with properly mixed solutions.<br>2. Checking for leaks in heat exchanger. |
| | Foamy developer solution. | Check:<br>1. Pump intake for obstructions or leaks.<br>2. Solution levels in tanks before machine startup.<br>3. Tubing of recirculation system for kinks or obstructions.<br>4. Bearings of recirculation pump impeller for wear. |
| Film does not transport in dryer compartment. | Tacky film surfaces caused by excessively high temperatures of processing solutions or wash water. | See corrective remedies for thermostat adjustments above. |
| | Improperly mixed or diluted processing solutions. | Check for leak in heat exchanger. Drain and refill with fresh properly mixed solutions. |
| Low recirculation rate. | Obstructions in solution pump, heat exchanger, or tubing of recirculation system. | Remove foreign particles or clean with system cleaner. |
| | Leaks in recirculation pump, tubing, or connections. | Contact maintenance shop. |
| Scratches on film. | Dryer air tubes not seated. Guide pins for air tubes are misaligned or loose. | Snap into locking position. Straighten bent pins and cement loose pins in place with epoxy. |

**Table 1-1. Troubleshooting the "Versamat" Film Processor (Continued.)**

| TROUBLE | POSSIBLE CAUSE | REMEDY |
|---|---|---|
| Streaks on film. | Dirty slits on air tubes. Dryer compartment temperature too high. | Clean tubes with warm water. Adjust temperature setting. |
| Fogged film. | Light leaking through cover on processing section. | Seat cover tightly. |
| | Developer contaminated by fixer. | Drain, rinse tanks and refill with developer. |
| Excessive film density. | Replenishment rate slightly high. | Check rate. |
| | Developer temperature too high. | Check and adjust thermostat setting. |
| | Developer replenisher incorrectly formulated. | Drain and refill storage tank with solution mixed according to directions on package. |
| Insufficient film density. | Developer temperature too low. Developer exhausted. | Check and adjust thermostat setting. Check replenishment rate and/or mix fresh solution. |
| | Diluted or improperly mixed developer solution. | Check for leak in heat exchanger. Drain and refill with developer mixed according to package directions |
| | Old or exhausted replenishment solution. | Drain and refill with fresh solution, mixed according to package directions |

Troubleshooting

To salvage the film when trouble occurs while the Versamat is operating, do not turn off the power. Instead, follow these procedures:

1. Pull a crossover assembly just ahead of the malfunction.

2. Remove the film(s) at this point to prevent further pileup. The films are collected and placed in a tray of water which prevents their sticking to each other.

3. Clear the processor.

4. Reintroduce the film into the processor at the point of interruption.

Any malfunction in the Versamat processing system may cause a failure of film to be transported not only at the source of trouble but at any location beyond. This is true particularly when the malfunction is caused by chemical action as, for example, high temperature of processing solutions. When this situation is present, the film fails to be transported in the fixer tack assembly since the softened emulsion becomes tacky. Or, improperly mixed replenisher or fixer solutions may cause a film transport failure in the drying compartment. Table 1-1 lists some of the common troubles that can occur while operating the Versamat processor. Because some of the malfunctions can be attributed to mechanical rather than chemical causes, study the manufacturer's instructions. When mechanical trouble sources are identified as causing a particular malfunction, notify maintenance personnel immediately.

Sensitometric Certification

Sensitometric strips are also processed at the time of certification, and at regular intervals during the day. Data from these checks are maintained on control charts for each processor. If the first sensitometric strip falls within the control limits, but is near one of the control limits, do not assume that the machine is chemically certified. A second, and even a third strip should be processed depending on criticality of mission film. Most laboratories process flash film during machine certification with sensitometric strips spliced within the flash film at regular intervals. Each laboratory has its own chemical certification standards. However, if the required footage of flash film has been processed, and the sensitometric strips are within control standards, and if chemicals meet pH and specific gravity standards, the machine can be said to be chemically certified.

At times, the operator may not be able to bring his machine into chemical control. When this happens, the only alternative is to drain the chemicals, refill the machine with fresh chemicals, and restart the chemical certification. If replenisher solutions have been stored for some time, they should be recertified before the machine is considered chemically certified.

Process Control

Once the processor is certified, process control can begin. Process control is knowing the capabilities of the machine. In other words, being able to state what the machine can do. The primary control available to the technician is GAMMA.

The gamma value of a photographic material is not fixed. It

can often be varied within wide limits by the choice of developer and the methods of development.

Gamma has been defined as the slope of the straight line portion of the characteristic curve. This is the only part of the curve where significant changes in density are obtained by changes in development. For this reason, gamma is useful as a measure of the degree of development. Gamma varies directly with development; the greater the development, the higher the gamma up to gamma infinity.

The time of development is only one of the processing factors affecting gamma. Other factors are the type of developer used, dilution of developer, processing temperature, and the method of agitation. If the gamma is measured and found to be high, an appreciable amount of development was obtained, even though the developing time may have been short.

Gamma is one of the most important tools used in processing control. Negatives developed to the same gamma, for example, show comparable tone reproduction. If it is desired to determine that processing is constant, sensitometric strips are run along with the material being processed and the gamma plotted. If the gamma remains the same, processing is constant. Whenever practicable, the test strips should be printed on the material itself; on the edge of cut film or at the end of a roll of film.

To summarize, the behavior of any film-developer combination, time-gamma or machine speed-gamma curves can be plotted. This discussion will be geared to machine speed-gamma curves. These machine speed-gamma charts are plotted on density versus density curves.

DENSITY VERSUS DENSITY CURVES. While not a true D log E curve, an understanding of the similar density - density plot is desirable at this point. Figure 1-24 shows how a test strip printed through a standard Eastman Step Tablet No. 2 would be plotted. This tablet consists of 21 steps, ranging in density from approximately 0.05 to approximately 3.05. The density difference between each step is about 0.15. A step-by-step procedure for plotting a curve from a test made in this manner is as follows:

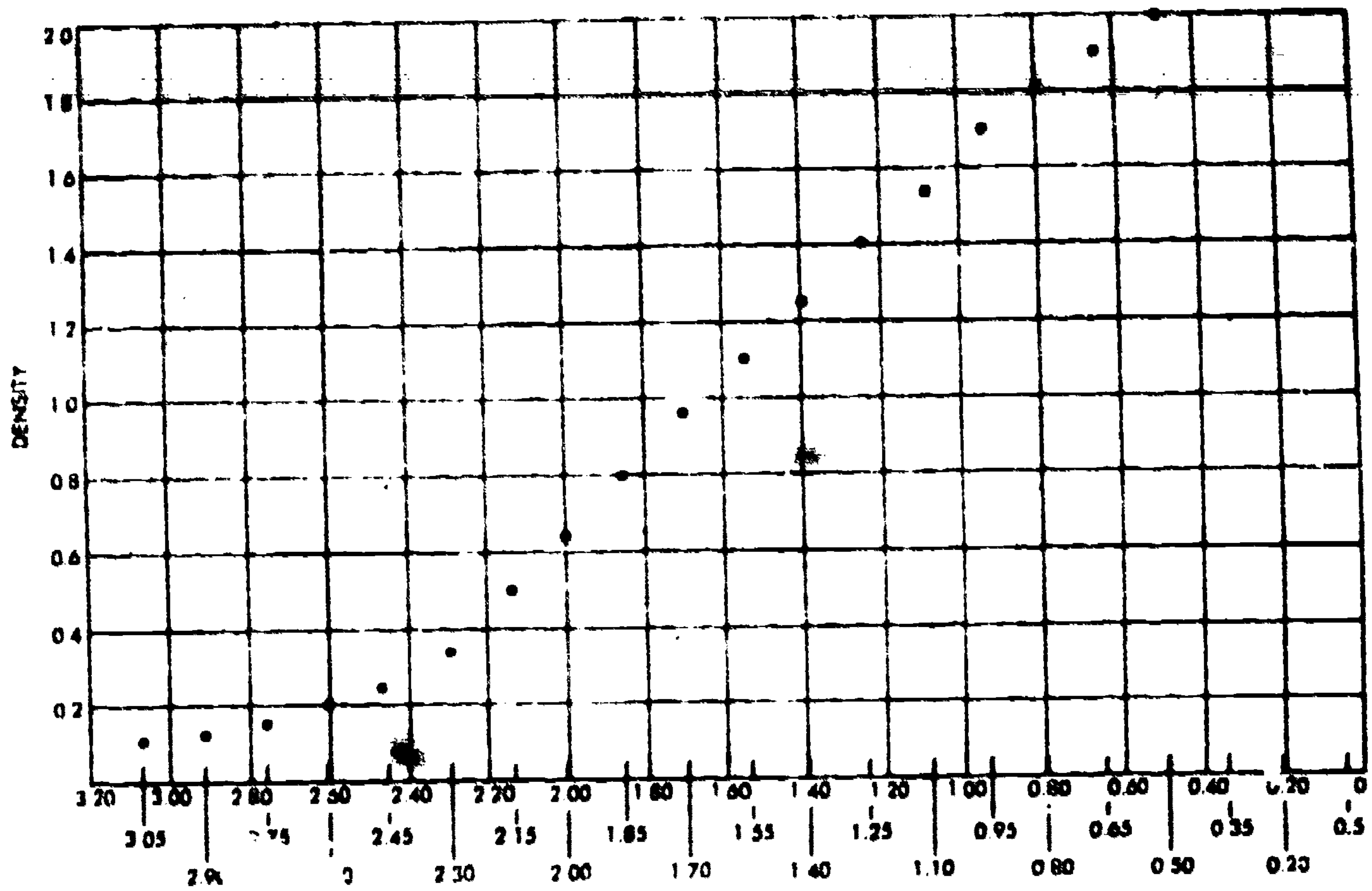


Figure 1-24. Density of Original, Plotting Density vs Density

1. The densities of the original step tablets are read and recorded.

2. The densities obtained in the test strip are read and recorded in a column beside the densities of the original (Figure 1-25).

3. A graph sheet having 20 squares to the inch is marked off in periods of 0.20 density units to the half inch, starting with zero in the lower right-hand corner and moving to the left along the abscissa (horizontal axis) and upward along the ordinate (vertical axis).

4. The densities of the original step tablet are then plotted across the base line with step 1 located near the right end and step 21 located near the left end of the line.

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**Density of Test Compared to Density of Original Step Tablet**

| Step Nr | Density of Original | Density of Test |
|---|---|---|
| 1 | 0.05 | 2.15 |
| 2 | 0.20 | 2.12 |
| 3 | 0.35 | 2.06 |
| 4 | 0.50 | 2.00 |
| 5 | 0.65 | 1.92 |
| 6 | 0.80 | 1.82 |
| 7 | 0.95 | 1.70 |
| 8 | 1.10 | 1.55 |
| 9 | 1.25 | 1.40 |
| 10 | 1.40 | 1.25 |
| 11 | 1.55 | 1.10 |
| 12 | 1.70 | 0.95 |
| 13 | 1.85 | 0.80 |
| 14 | 2.00 | 0.65 |
| 15 | 2.15 | 0.50 |
| 16 | 2.30 | 0.37 |
| 17 | 2.45 | 0.27 |
| 18 | 2.60 | 0.20 |
| 19 | 2.75 | 0.15 |
| 20 | 2.90 | 0.13 |
| 21 | 3.05 | 0.10 |

Figure 1-25

5. The density of each step of the test is then plotted by placing a dot on the graph opposite its value on the vertical axis and above its axis. This is continued until all 21 steps are plotted.

6. The dots are then connected with a best fit curve using a straightedge and French curve, and the result will be a characteristic curve in relative D log E values.

MACHINE-SPEED GAMMA CHART. Use the same basic procedures for the machine-speed gamma (MSG) chart as those used for plotting density vs. density. The procedures for constructing MSG charts are as follows:

1. Print 10 sensitometric strips on a sensitometer.

2. Record the density values of the exposure modulator on the sensitometer. These readings will be used at a later time.

3. Using one developer rack on a Versamat, process one sensitometric strip at five fpm (1.5 mpm), one at 10 fpm (3.1 mpm) and so on through 25 fpm (7.6 mpm).

4. Using both developer racks, repeat step #3.

**NOTE: Be sure to mark the strips for one rack or two and their machine speeds.**

5. All 10 strips must be read out and all readings recorded.

6. Plot the five strips (family of curves) that were processed in one rack on one sheet of graph paper. Plot the five strips processed in two racks on another sheet of graph paper.

7. In the upper left hand corner of each graph, construct a small speed gamma chart. Gamma is plotted on the ordinate and machine speed is plotted on the abscissa.

From these machine speed gamma charts, the proper machine speed for a particular gamma can be found.

After the density vs. density curves are constructed, information provided by the curve is transferred to various control charts. This information often includes gamma, D-min (the minimum useful density on the curve), D-avg (an average, middle tone density, usually step 11), and D-max (maximum useful density).

Control charts of pH and specific gravity are also kept for the chemicals. Control of developer pH is of particular importance since an increase in pH results in an increase in activity and a decrease in pH results in a decrease in activity.

Control charts provide the operator with a graphic record to compare what is happening now with what has happened before. They contain aim points and control limits so the operator can actually see how his machine is running compared to how it should run. Control charts also enable the operator to predict possible problems and correct them before they can occur. In this respect a control chart can be considered to be an "action" chart.

QUALITY ASSURANCE PROGRAMS

Imagery-recording systems continue to provide one of the major sources of information to satisfy intelligence requirements. The maximum information must be obtained from the imagery produced. This means that each component of the reconnaissance cycle must be controlled.

The levels of quality obtainable from reconnaissance missions vary with the sensor system, the operating conditions, recording

media, processing, and printing characteristics and other related factors. The capabilities of the supporting facilities also vary according to their assigned mission. Therefore, variations must be identified in order to establish quality controls and to insure that the maximum imagery information is obtained.

Laboratory Quality Assurance

There is no single quality assurance specification covering ALL reconnaissance programs. Instead, "quality goals" are set for each type of reconnaissance system in accordance with AFR 96-1, Evaluation and Quality Assurance for U.S. Air Force Reconnaissance Imaging Systems. Once this "quality goal" is set, very specific steps are taken to reach this "goal." Any quality assurance program must maintain this high "quality goal" in order to retain as much intelligence information as possible. Otherwise, vast amounts of information will be lost due to poor handling, bad chemistry, poor processing techniques, and other means.

If all variables are under control, the reliability of the laboratory production is assured. This is very important. In this way, no matter where or when a mission is flown, the results can be predicted beforehand. Regardless of the lab's mission or the duties of its personnel, quality control applies to all personnel in that laboratory.

LABORATORY QUALITY ASSURANCE FUNCTIONS. The laboratory quality assurance program can be separated into four specific steps. They are:

1. Identifying variables.

2. Using instruments. Whether these devices are simple or complex, their repeatability and accuracy must be known. They will be calibrated periodically.

3. Collecting and presenting data. Quality assurance data will be collected and recorded accurately and uniformly. The data will be recorded on specific Air Force forms.

4. Analyzing and intergrating data. Analysis of data begins by examining control charts for abnormal results. All variables are examined before any changes are made. If a process correction is made, more data must be collected to analyze the results of this correction. If the corrective action fails to restore control, the operation is suspended until a complete analysis is made and further corrections made.

If these steps are to work, all continuous photoprocessing laboratories must maintain minimum standards for equipment certification and calibration. Certification, standardization, and quality assurance will be performed at, or exceeding, the frequency stated in AFR 96-1.

Central Calibration Program

This program was established to insure that all sensitometers and densitometers (and any future designated devices) in the Air Force meet certain specifications.

The responsibilities for this program start at USAF Central Calibration Facility (USAF/CCF) and follow the chain of command downward to each laboratory.

Sensor System Evaluation Program

Sensor system evaluation program is the Air Force effort to determine the performance of specific imagery systems. The sensor system includes such variables as aircraft, camera, film, processing and environmental conditions. The sensor system evaluation program provides a measure of the quality of the reconnaissance information. The degree of evaluation can range from limited visual inspection to indepth documentation requiring sophisticated instruments. The sensor system evaluation program allows one to identify problems and causes and provides for corrective action. The key element in this program is the Nominal Performance Standard (NPS). This standard provides a common base line for Air Force organizations. It tells the minimum standard for any set of conditions.

## FILM PROCESSING

Once the quality of the processor, chemicals, and processing methods have been assured, the film may be processed. However, two other steps are necessary. Before a roll of film is processed, it must be preinspected for torn or crimped edges which might cause a processor malfunction. Also, the film must be made-up for processing. Both of these steps are normally accomplished at the same time.

Preinspection and Makeup

Since the film is exposed and unprocessed, visual inspection by ordinary means cannot be made. It is possible, however, to use an infrared light source and an image convertor to view the film.

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This method is satisfactory provided the film is not sensitive to IR. If equipment of this type is not available or if the film is sensitive to IR, preinspection must be made by touch in total darkness.

PREINSPECTION STEPS.

1. Set up the preinspection table to handle one width of material.

2. Procure adequate amounts of exposed step wedges, heat splicing tape and "Mylar" tape.

3. Inspect the film for edge tears, holes, creases, and splices. Perform these operations by touch while wearing gloves. Record all noted defects.

4. Repair torn edges with "Mylar" tape.

5. Cut out any torn area deemed to be hazardous to machine operation and make a heat splice.

6. Save the cut out portion to be developed later.

7. Carefully check and repair, or cut out, all splices as required. Factory splices are usually safe, but must be checked.

8. Exercise extreme caution at all times, particularly while transporting material across the preinspection table. Transport the material across the table at a slow, steady speed to minimize static electricity discharge, pressure, and abrasion marks.

MAKEUP. Before film can be processed it must be made-up. Film makeup may vary from lab to lab. Here in the school, your film makeup will be as follows:

1. To a bullet, attach a head sensitometric strip.

2. To the head sensitometric strip, attach the Original Negative (O.N.).

3. To the O.N., attach a tail sensitometric strip.

Both preinspection and film makeup must be accomplished before processing.

## Processing

During film processing, the operator must remain alert at all times. Film, whose length is less than 5 inches (12.7 cm) should not be fed into the processor. The replenishment flow meters must be constantly monitored to assure proper flow rate. The flow meters should be read at eye level to avoid parallax distortion and the bottom of the ball is used as the reference point. If air bubbles appear in the flow meter tubes, this is an indication of improper replenishment rates. Machine speed indicators must be monitored since line voltage fluctuations may change the drive speed, necessitating a machine speed adjustment. Film drying must be monitored at all times and the dryer thermostat adjusted to control drying. Solution temperatures must also be checked periodically to assure proper processing temperature.

The machine operators must be prepared to correct any machine malfunction that occurs. Often this must be done in total darkness. These, and many other operations, must be done while the film is being processed. By now, you can see that there are too many operations for one technician. Two or more people should be assigned to each processing machine. Where only two people are available, one should operate the feed end, while the other operates the takeup end of the machine. Responsibilities for each function should be well defined so that all functions are monitored.

## Processing Defects

The processed film should be monitored for physical or image defects. These are then reported to the operator's supervisor. The following list gives some of these defects and their descriptions.

| | |
|---|---|
| Abrasion | A scuff. A series or group of very light scratches; caused by rubbing of two reasonable smooth surfaces together under pressure. |
| Banding | A series of varying densities of different widths across the width of the film. The edges of the bands may be either sharp or soft. Usually caused by improper spray pressure, clogged spray nozzles, improper spray angle, or nonuniformity in printer illuminance. |
| Brittleness or Buckled Film | Brittleness or wavy buckle are both caused by drying at exceptionally high temperature or in |

| | |
|---|---|
| Bromide Drag | Uneven densities seen extending from dense areas on film "flow." Appears in longitudinal direction on film. |
| Chemical Stain | Discoloration of portions of the imagery caused by contamination of developer, fixer, or improper washing. |
| Cinch Marks | Similar to abrasions in appearance; caused by excessive tension of takeup or sudden stops or starts during rewinding of film. |
| Creased Film | A single or multiple elongated bending of the film. Usually along the edges caused by improper takeup or tracking in the machine. |
| Crimped Film | A small cresent shaped distortion in the base of the film caused by wrinkling of the film from improper handling. |
| Deckled Edges | A rippling of the edge of the film caused by poor tracking in a machine or improper torque and/or alignment during takeup. |
| Developer Sprayback | Developer spraying back in droplets onto the undeveloped portion of film before reaching the first spray nozzle, causing high density spots. |
| Dimples | Indentations which are the result of winding film over a piece of embedded particle or any other protrusion. These may be transferred through several layers of film. |
| Double Exposure | Two separate exposures having been recorded on the same piece of film. Usually causes a double image. |
| Embedded Dirt | Any particle which has become embedded into the film base or emulsion. |
| Finger-Prints | Marks showing the lines of the fingertips; frequently caused by handling the dry negative with dirty, moist, or greasy fingers. If the fingermarks are dark, contamination with developer is indicated. If marks are light, hypo on the fingers is the probable cause. |
| Hypo Sprayback | Hypo spraying back onto film that is being developed, causing thin density spots. |

| | |
|---|---|
| Improper Takeup | When film is improperly aligned on takeup spool causing indentations, stretched, creased, or torn film. |
| Light Fog | A density of varying size or shape which may or may not remain within the frame limits; caused by film being exposed to an uncontrolled light source at any time up to the time of fixation. |
| Mottle | An appearance of unevenness in density in irregular form caused by improper development. Normally caused by improper spray pressure, clogged spray nozzles, or improper spray angle. Not to be confused with Newton Rings. |
| Newton Rings | Irregular shaped, varied densities throughout the film. This is an effect of interference between light rays reflected from adjacent surfaces during printing. NOTE: Not cause for reject. |
| Oil Spots | Chain of small gray areas; irregular light gray areas; mottled areas; black spots, with or without white centers; strippled streamline effects. Caused by oil adhering to the surface of the film prior to processing or during processing. |
| Overdevelopment/Underdevelopment | Heavy or light D-max/min returns. Processing limits not within standards. |
| Pressure Streaks | A sheen on the emulsion side of the film normally running in parallel lines lengthwise along the film. Intermittent; caused by excessive tension before the film is dry or during drying. |
| Pin Holes | A small clear hole in the emulsion caused by trapped alkali solution placed in a strong acid solution, causing a gaseous discharge through the emulsion; or fine particles printed in from the preceding generation. |
| Reticulation or frosty-wrinkled appearance of emulsion | Sudden temperature change from solution to solution or to wash of different temperature. Driving in too much heat. |

| | |
|---|---|
| Scratch | An indentation of varied length, width, and depth either on the base or emulsion side of the film; caused by a sharp protrusion being scraped across the surface. Emulsion abrasions on the original negative often appear as emulsion scratches on a dupe positive. |
| Scum | A thin layer of impurities found on the emulsion or base of the film. |
| Static Marks | Forked, branching, tree-like marks on the film, darker than the imagery; usually caused by static electricity discharges, created by rapid winding of the film in an exceptionally dry (low humidity) area. |
| Stopped in Processor | Extreme overdevelopment, spotting, and streaking in large areas of processed film. |
| Uncleared Film | Film with a milky appearance from lack of fixation. |
| Uneven Density | Unevenness of density across the width of the film. Usually caused by improper spray pressure, clogged spray nozzles, improper spray angle, or nonuniformity in printer illuminance. |
| Water Spots | Intermittent spots of varying size and density; caused by irregular drying or improper squeegeeing prior to drying. A 12X magnifier should be used to insure that the material is free of water spots during processor certification and production runs. |

REVIEW QUESTIONS.

DO NOT WRITE IN THIS SW - USE A SEPARATE PIECE OF PAPER.

1. At what point is replenisher generally introduced to existing solutions in a film processor?

2. What effect does overdrying have on film?

3. Why is a spray-processing machine expensive to operate?

4. Explain the over-under threading system; the loop-type threading system.

5. How is even-film tension achieved in most processors?

6. Describe how self-threading machines transport the film.

7. Why are squeegees employed on continuous processing machines?

8. List the functions that the recirculation system performs.

9. List some of the factors which affect replenishment rate.

10. Are silver recovery programs optional, desired, or required in a photographic operation?

11. What is the basis for your answer to the previous question?

12. Why are silver recovery programs included as part of laboratory operations?

13. List three primary methods of silver recovery from fixer solutions.

14. Which combination of a silver recovery system and fixer solution permits reuse of the solution?

15. Which silver recovery system is used by Air Force photo labs to produce refineable sludge?

16. How is silver normally recovered from processed film and paper?

17. Which type of recovery system is intended for use by faciliities using less than 30 gallons (114. l.) of fixer per eight-hour day?

18. What recovery system is basic in medium and high-volume processing laboratories?

19. What types of facilities use cartridge as their standard silver recovery systems?

20. What do air bubbles in the flowmeter tubes indicate?

21. What type of threading is used on the Versamat 11CM?

22. What is the maximum speed that the Versamat can be run at?

23. What film can be run on the Versamat?

24. How many tanks comprise the wet section of the Versamat?

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25. At what temperature should the water be adjusted to on the Versamat?

26. What causes a buzzer to sound when the operator is feeding film into the Versamat?

27. Where is replenisher introduced into the Versamat?

28. What is the developer temperature on the Versamat?

29. What is the developer temperature tolerance range on the Versamat?

30. How does the temperature control system operate on the Versamat processor?

31. What is the dryer temperature range on the Versamat?

32. What must the dryer temperature be before the Versamat can be shut down?

33. Why must the cover on the Versamat be left slightly ajar after shutdown?

34. What could be the cause, if the film fails to transport through the dryer section of the Versamat processor?

35. What solution(s) are filtered on the Versamat?

36. What is a developer bypass?

37. What is a skip-rack crossover?

38. When cleaning the crossovers and racks on the Versamat, what is the maximum temperature that the water can be?

39. What solution is used to clean the processor tanks?

40. Why should protective equipment be worn when system cleaning a processor?

41. How is the Versamat processor drained of its solutions?

42. What is used to season the tanks in the Versamat?

43. What might happen if the tanks in the Versamat were not seasoned after cleaning?

44. If it is necessary to mix more than one solution in the same mix tank, how should they be mixed?

45. Name the three basic tests used in certification of processing solutions.

46. What is the thermal correction factor for most photographic solutions?

47. List the major points on a processor preoperational check.

48. What are the two types of machine certification?

49. What is flash film and what is it used for?

50. Why is film given a preinspection before processing?

51. Describe the preinspection procedures.

52. How may a small tear in film be repaired during preinspection? A large tear?

53. How are defects on the edge of film detected during preinspection?

54. Describe some of the operator's functions which must be accomplished during film processing.

55. Why must the processor be certified before processing sensitometric strips for process control?

56. How is process control achieved?

57. What is the purpose of process control?

58. How are sensitometric strips plotted for process control?

59. List the basic steps in determining the proper machine speed for processing to a specific gamma.

60. Describe four common processing defects found on processed aerial film.

PRACTICAL EXERCISES

EXERCISE I

PROCEDURES

1. On a separate sheet of paper, match the principles of

continuous processors in column "A" with the correct responses in column "B." The items in column "A" may have more than one response.

| A | B |
|---|---|
| 1. Film Drives | a. Rubber |
| 2. Threading | b. Mechanical |
| 3. Developing and Fixing | c. Impingement |
| 4. Recirculation | d. Electrical |
| 5. Squeegees | e. Agitation |
| 6. Drying | f. Chemical |
| 7. Safety | g. Loop |
| 8. Silver Recovery Methods | h. Air |
| 9. Silver Recovery Equipment | i. Over and Under |
| | j. Parallel Flow |
| | k. Rollers |
| | l. Liquid Bearings |
| | m. Electrolysis |
| | n. Spray |
| | o. Cartridge |
| | p. Filter Solutions |
| | q. 70mm maximum |
| | r. Metallic Replacement |
| | s. Electrolytic Recovery Unit |
| | t. Immersion |

EXERCISE II

PROCEDURES

1. On a separate sheet of paper, identify the items listed as numbers 1 through 20 in Figure 1-26.

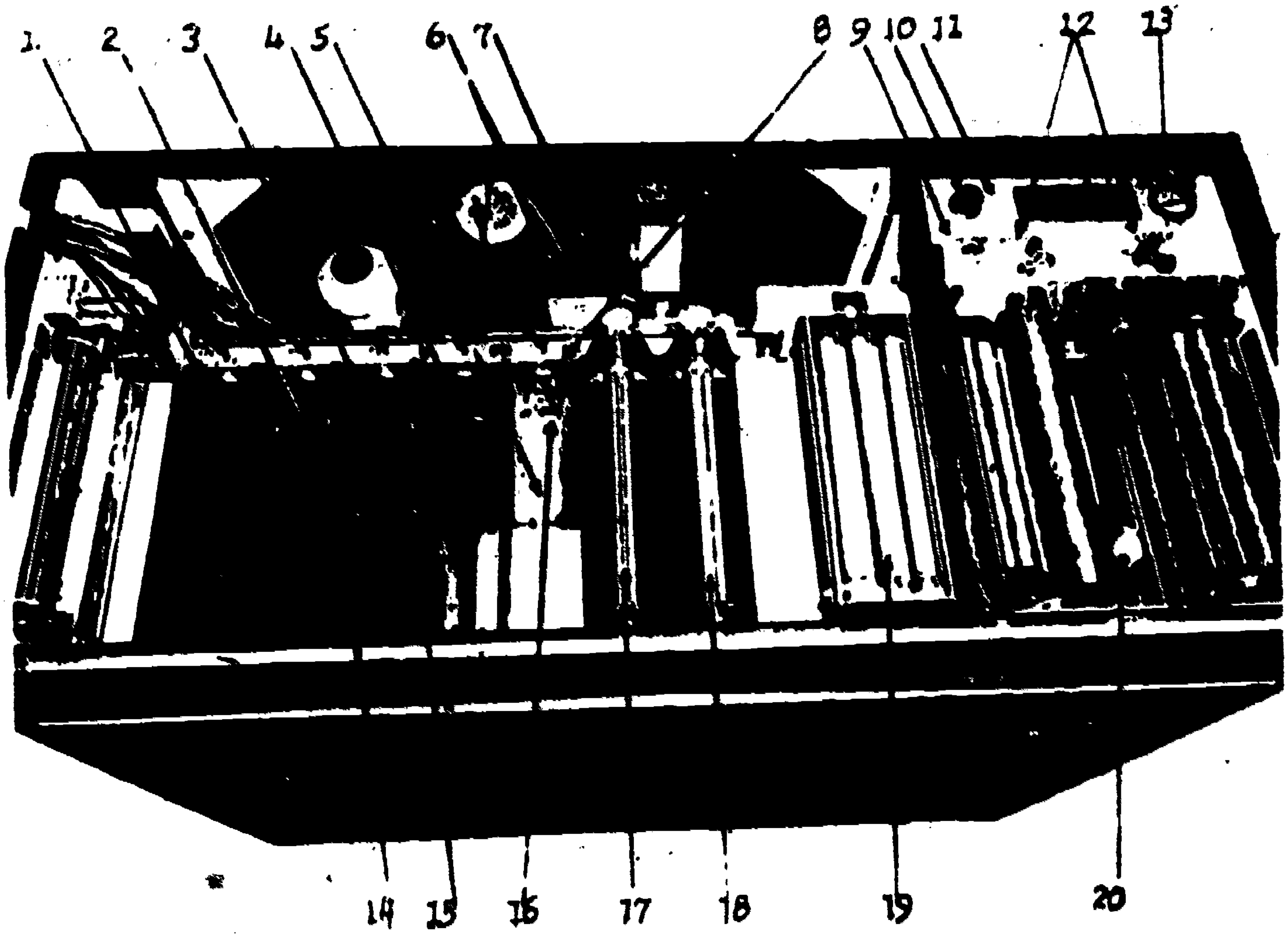


Figure 1-26. Parts of a Versamat

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2. On a separate sheet of paper, identify the items listed as numbers 1 through 11 in Figure 1-27.

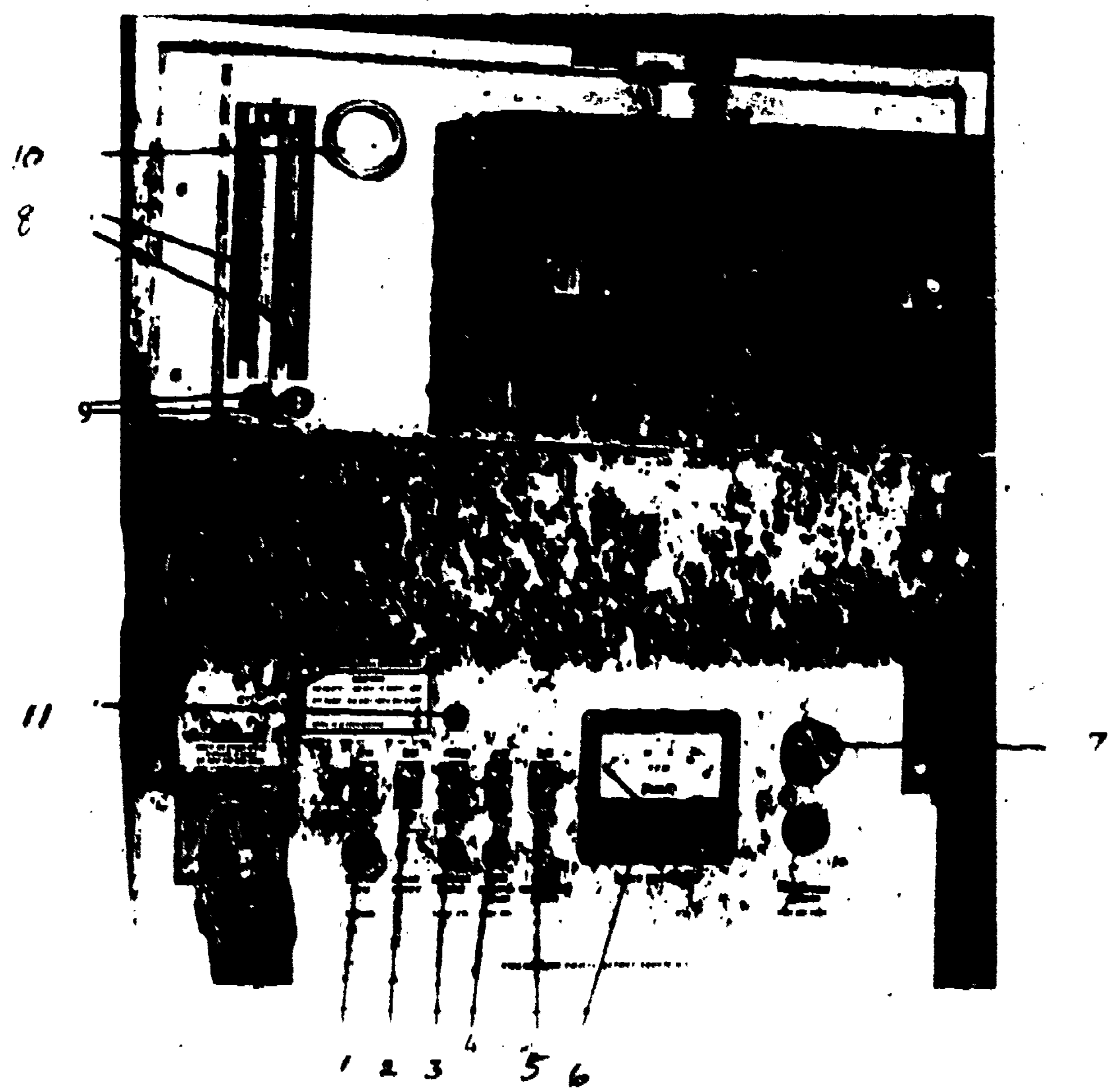


Figure 1-27. Versamat Controls

EXERCISE III

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Versamat Processor | 2/class |
| Systems Cleaner | 2/class |
| Cleaning Supplies and Equipment | As needed |

PROCEDURES

1. Using procedures outlined in this SW, systems clean the processor. Observe all safety precautions.

EXERCISE IV

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| Mixing Facilities | 1/4 students |
| Prepackaged Developer Mix | 1/4 students |
| Prepackaged Fixer Mix | 1/4 students |
| pH Meter | 2/class |
| Hydrometers (set) | 1/class |

PROCEDURES

1. The instructor will assign the specific prepackaged solutions to be mixed.

2. Make sure the mixer is clean. If it is not, clean it before proceeding.

3. Mix the developer, following the manufacturer's instructions.

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4. Withdraw a sample of the developer for certification.

5. Determine the pH and specific gravity readings of the developer. Check with your instructor to see if these readings meet certification standards.

6. Construct a control chart for pH and specific gravity values of the developer and plot these readings on the chart. Retain this chart for future use. (A chart might already be available in the machine area).

7. Transfer the developer to the proper storage and processor tanks.

8. Clean and rinse the mixer thoroughly.

9. Mix the prepackaged fixer using the same procedures as in steps 2 through 8.

## EXERCISE V

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| Versamat Processor | 2/class |
| Cleaning Supplies and Equipment | As needed |

PROCEDURES

1. Using procedures outlined in this SW, install racks, crossovers, and chemistry in the Versamat processor.

## EXERCISE VI

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| Versamat Processor | 2/class |
| Cleaning Supplies and Equipment | As needed |
| Preexposed Control Strips | As needed |
| Flash Film | As needed |

| | |
|---|---|
| Thermometer | 2/class |
| pH Meter | 2/class |
| Hydrometers (set) | 1/class |
| Densitometer | 2/class |
| Graphing Materials | As needed |

PROCEDURES

1. Following the daily startup checklist in this SW, perform a daily startup on the Versamat processor.

2. Perform mechanical, chemical, and sensitometric certification for the Versamat processor.

3. After the Versamat is certified, establish process control by making a machine speed gamma chart(s).

4. Perform any and all preventive maintenance required to insure proper Versamat operation.

5. When necessary, shut down the Versamat following the shutdown checklist in this SW.

6. Observe all safety precautions.

EXERCISE VII

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| Preinspection Table | 1/4 students |
| Lint-free gloves | 1 pr/student |
| Empty Reels | As needed |
| Exposed, unprocessed film | 1 roll/class |

PROCEDURES

1. Clean preinspection area and equipment.

2. Insure sufficient amount of splicing tape.

3. Turn on safe lights (if applicable), turn off room lights.

4. Position film on rewinder, fasten end of film to the takeup reel.

5. Start rewinder. Place gloved fingers lightly against the edges of the film as it moves from the supply to the takeup reel.

6. When damaged film is detected, stop rewinder and repair film as outlined in the text. Instructor assistance may be necessary.

7. After the film has been repaired, save it for processing.

## EXERCISE VIII

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| Versamat Processor | 1/class |
| Processing Support Equipment | As needed |
| Preinspected Film | 1 roll/class |

PROCEDURES

1. Start up the Versamat according to the checklist - developer temperature 85° (29.4°C).

2. Certify the machine according to past exercises.

3. Process the preinspected film from Exercise VIII. The instructor will give the necessary processing information. Check processed film for defects.

4. When finished, clean the area and equipment and return everything to its proper place.

## EXERCISE IX

PROCEDURES

1. Answer the following questions on a separate sheet of paper. Do NOT write in this SW.

a. Why is there a need for a quality assurance program in a photoprocessing laboratory?

b. If all variables are under control, the ______________ of the production of the laboratory is assured.

c. List the four steps in the quality assurance program.

d. Why was the Central Calibration Program started?

e. What is the purpose of the Sensor System Evaluation Program?

Sciences Branch
Lowry AFB, Colorado

SW G3ABR23330 001-III-2
October 1977

# TITLING AND CLEANING AERIAL FILM

## OBJECTIVES

Using an editing table, postinspect and attach head and tail friskets to a roll of processed aerial film. All defects must be recorded.

Using a Dual Head film titler, title processed aerial film. Type must be correctly positioned and transfer to the film must be legible without flow or embossing.

Using a Delaware portable film titler, title processed aerial film. Type must be correctly positioned and transfer to the film must be legible without flow or embossing.

Using a film cleaner, clean processed aerial film. Cleaned film must be free of objectionable dirt, dust, and other foreign matter.

## INTRODUCTION

In the field of high-altitude reconnaissance photography, original negatives are priceless. They give a permanent record of a vast amount of detailed information within the view of the camera lens-information that is acquired only through careful planning and a great expense. Furthermore, the information the negatives contain may be such that it can never again be obtained. In the previous SW, film processing was discussed with an emphasis on processing original negatives. As a result of this work, there are now on hand original, one-of-a-kind films.

For various reasons, the roll of negatives can be studied and restudied. Whenever the negative roll is studied, it must be viewed, and viewing requires handling and a risk of potential damage. Additionally, it is usual to disseminate information among various Air Force organizations. With only one roll of negatives, this is impossible. Therefore, the negative roll must be reproduced. Thus, this SW concerns the inspection, breakdown, titling and cleaning of the original negatives. These operations normally precede reproduction.

INFORMATION

## INSPECTION AND BREAKDOWN

### Postinspection

Naturally, the first step after processing is inspecting the material for physical defects. During this inspection, you are required to note and record all physical defects. Use the physical inspection report procedures when recording defects.

The defects found should be checked with the results of the preinspection. For example, edge deckling caused by the processor would not have appeared during preinspection. In general, defects are listed during each step of the entire lab handling sequence, so that they can be traced to their source and eliminated. At this point the film is ready for another viewing., often referred to as the primary breakdown.

## PHYSICAL INSPECTION REPORT PROCEDURES

PURPOSE: To define specific procedures for the evaluation of mission material.

SCOPE: Applies to all personnel assigned to the Physical Inspection Section.

RESPONSIBILITY: All personnel assigned to the Physical Inspection Section must comply with these procedures.

PROCEDURES:

1. To assure that mission material is properly evaluated, accomplish the report in the following format:

   a. Mission name and number.

   b. Date of inspection.

   c. Inspector(s).

   d. General image characteristics (define causes when possible).

      (1) Density (in terms of processing and/or exposure).

(2) Evenness (in terms of processing or exposure).

(3) Contrast

(a) Extremely high-$\gamma$ = 1.60 or above.

(b) High-$\gamma$ = 1.20 to 1.60.

(c) Average-$\gamma$ = 0.80 to 1.20.

(d) Flat-$\gamma$ = 0.40 to 0.80.

(e) Extremely flat-$\gamma$ = 0.40 and below.

(4) General subject analysis.

(a) Cloud coverage (percent, approximately).

(b) Any other factor such as haze, terrain, etc.

(5) Processing deficiencies.

(a) Under or overdevelopment.

(b) Streaking and/or unevenness.

(c) Any other factor.

e. Physical defects (define cause if possible).

(1) Pinholes.

(2) Tears.

(3) Scratches.

(4) Deckling.

(5) Blistering.

(6) Emulsion pulls or stripping.

(7) Abrasions.

(8) Dirt - imbedded or loose.

(9) Creasing.

(10) Other.

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NOTE: When reporting physical defects, be specific; i.e., "numerous pinholes scattered throughout all rolls." "Tears in frames 1092, 1246." "Deep emulsion scratches in frames 510 through 640." "Dirt imbedded in frames 0010,0600."

f. The Section Supervisor accomplishes the overall subjective evaluation of the mission.

2. A sample mission evaluation follows and can be used as a guide.

SAMPLE

MISSION EVALUATION

1. Mission Name:

2. Date of Inspection:

3. Inspector(s):

4. General Image Characteristics:

a. Overall mission was extremely dense due to overexposure. Image contr. t was flat primarily because of overcast weather.

b. Cloud coverage extended over approximately 80 percent of the imagery.

c. Processing was normal with no evidence of major processing problems.

d. Physical Defects Noted: Pinholes were scattered (lightly) throughout all rolls. Light emulsion scratches throughout rolls 7L, 8L, 9L. Scattered heavy emulsion scratches, probably caused by camera throughout roll 9L. Deckled edges attributable to processing were noted on frames 600 through 610. Imbedded dirt was found in frames 0025, 0162, 1180, probably due to mishandling during original inspection.

e. Overall Subjective Evaluation of Mission: The overall quality of this mission was slightly poorer than previous missions over the last two months and can be attributed to original overexposure. Minor processing problems were noted but overall processing was above average. Informational imagery was flat but yielded good informational returns. Titling of originals continues to give us trouble since originator is using white titling instead of black.

Primary Breakdown

Primary breakdown of original negative serves one major purpose. That is, a long roll can be broken down into smaller rolls, each roll consisting of a single pass or other logical division. Each roll includes a leader and a trailer which furnishes identification information deemed necessary by the lab. Leader and trailer segments are spliced on in the usual manner. The mission log sheet should be annotated to identify the breakdown. Following this breakdown, it is necessary to add complete identification information to be printed over to the master positive.

VIEWING FILM. During this task, view the film over a light table equipped with a splicer. Since original negative processing rolls are to be cut, it is advisable that two operators be present. "Two heads are better than one."

An editing table consolidates (into a compact work center) the accessories essential to roll film editing. Diffused fluorescent light is provided for the viewing of film. Adjustable masks restrict the illuminated area to a width more suitable for the size film being viewed. These masks also block flare light at the edges where it could interfere with vision.

A splicing assembly mounted over the viewer includes a knife to square the ends of the selected film sections. A clamp holds the film ends in place as they are spliced with tape under heat and pressure.

Rewinds may be set to accept film spools in various widths. Many tables include a dual rewind assembly which is desirable in some operations. This motor-driven unit includes under-the-table spindles that hold leader and trailer material. These accessory films are fed through a slot in the table top to the splicer in approximate register with the film to which they are spliced.

A motor-driven transport system moves the film in either direction at the tension and speed selected. Tension is adjustable to high or low. Any speed, from creep to maximum, can be obtained. A manual rewind version of this same table is also available, but it does not include leader and trailer storage. With the manual unit, tension is controlled by hand-snubbing the feed roll.

UNWANTED FOOTAGE. One of the subtasks of primary film breakdown is removing the unwanted material footage from the mission film. The term "unwanted footage" is used to identify

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material that is not an actual part of the mission. To understand just what this means, trace the film from camera uploading, through mission recording, to camera downloading at the conclusion of the mission.

When the unexposed film is loaded into the camera magazine, several feet of it are used to attach to the takeup reel and to insure that the film is advancing and taking up properly. The magazine is then taken to the reconnaissance aircraft where it is positioned onto the camera. Here, the camera power supply is activated and several camera cycles are allowed to check out the camera operation. The film footage expended here is called ground clearance.

Once the aircraft becomes airborne, the pilot usually exposes several more feet of film before reaching the target area. This action serves two purposes. First, to doublecheck the operational capability of the camera and, second, to advance film footage that might have been accidentally fogged during camera uploading. This section of film is called air clearance. The pilot then proceeds to the target and records it. If two or more targets are to be photographed on the same flight, or if more than one pass must be made on any one target (such as prestrike and bomb damage assessment), the pilot might choose to expose a few more feet of film to separate one target or mission from the others.

When all targets have been recorded, the pilot returns to the base. Upon landing and parking the aircraft, the camera is again operated to insure that all valuable mission footage is on the takeup reel. This is to prevent accidental fogging of the film during downloading procedures.

Since so many extra exposures are made in the course of a mission, many feet of useless material might be contained on a roll of original negative material. To retain this unwanted footage would only extend the handling time of subsequent steps, expend more duplicating materials and chemicals, and consume additional manhours. [illegible] exercise care in sel[illegible] the [illegible] roll to be removed. In some [illegible], all frames between [illegible] of the first air clearance and the beginning of the [illegible] ground clearance are retained. In other cases, the original negative roll might be separated according to targets. This SW cannot dictate which method to use. Instead, the method is preestablished for each operating unit and mission.

Aerial reconnaissance film is not the only photography from which unwanted footage must be removed. This also occurs in motion picture work. However, the removal of material from motion picture footage is not as critical as it is in aerial reconnaissance work. One frame of aerial reconnaissance ON can contain 100 percent of the desired information - information that might be impossible to replace. Very few, if any, motion picture scenes have ever been lost because of losing one frame from the beginning or end of the sequence.

FRISKETS. Friskets are attached to roll film for two primary reasons. First, for both aerial reconnaissance and motion picture materials, when properly annotated, the friskets provide pertinent identification information that is easily accessible. Furthermore, for motion picture materials, it is the only source of this identification information. Second, when the original material is to be printed on a continuous prin . additional material other than mission footage is required to thread the printer.

In all cases, friskets are attached to both the head and tail of each roll. Even though the information that is annotated on both the head and tail frisket is the same, there are minor variations in the placement of this information preventing their interchange. The information which is annotated on the motion picture leader and trailer varies considerably, and again they are not interchangeable.

When attaching friskets to the original negatives, the negatives must be wound so that the first exposure made is on the outside of the roll, emulsion down. This roll should then be positioned on the left-hand side of a splicer/rewinder or a viewing ta that has a motor rewind. The head frisket is then placed so that the imprinted information can be easily read. Both the film and frisket ends are cut squarely and joined, usually with "Mylar" type tape. (In some cases, and usually in all situations concerning motion picture materials, the film cement or heat splicing methods are used). The film is then wound to the right side and the tail frisket attached in a similar manner. When the friskets are properly attached, the imprinted information should be near the mission footage with a substantial quantity of clear leader material on the extreme ends of the combined roll.

Once the friskets are attached to the mission film, they must be annotated with the appropriate information.

FRISKET ANNOTATION. The minimum entries made on the head and tail friskets of aerial reconnaissance film are established in Defense Intelligence Agency (DIA) Manual 55-5, Aerial Photography

**Airborne Sensor Imagery (Forwarding, Titling, and Plotting).** As prescribed by this manual, the following information must be included:

- o Camera position (depression angle).
- o Taking unit.
- o Sortie/mission number.
- o Date (followed by double hyphen [ = ]).
- o Focal length and enlargement coefficient.
- o Project name and/or number.
- o Security classification and downgrading group number.
- o Release instructions, if applicable.

If space on the friskets permits, the following information is also included:

- o Service.
- o Time group and zone letter.
- o Altitude.
- o Kind of photography or imagery.
- o Geographic coordinates.
- o Descriptive title (if applicable).
- o Sensor type or [illegible] identification.

## TITLING AERIAL FILM

### Titling Principles

Since aerial reconnaissance film must be identified, special equipment is needed to title the rolls of film. Titling is the process of printing information, such as frame numbers, date, and other information related to the mission film, onto the film.

Usually this is accomplished by heating a type holder and pressing it onto the film through pigment impregnated tape. Two common titlers are the Dual-Head Film Titler, Model 1-A, and the Delaware Portable Film Titler, Model II.

Titling information is usaually placed on the film base (glossy surface of the film). However, film exposed by cameras using mirrors or prisms are usually titled on the emulsion. All titling will be uniformly located to minimize obstruction of image detail. Title data will be in upper case letters or numerals.

Most aerial cameras are equipped with data recording chambers, designed to expose pertinent data outside the image area. Examples of this data are as follows:

1. Lens serial number and calibrated focal length.

2. Time of flight.

3. Flight altitude.

4. Exposure counter reading.

5. Aircraft number.

6. Date.

7. Mission name or number.

8. Type of film.

In addition to the data provided by the data chamber, the minimum titling requirements lettered next to each exposure are as follows:

1. Negative number
2. Camera position
3. Taking unit
4. Service
5. Sortie/mission number
6. Date (followed by a double hyphen [ = ])
7. Time group and zone letter (GMT)
8. Focal length
9. Altitude
10. Security Classification and Downgrading Instructions

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Negatives are titled by mechanical or manual methods. Titling is not to exceed two lines.

A sample titling strip:

121/F21/325 RTS/USAF/109/25 Jan 67 - 1630Z/36 in/12,000 ft/ Unclassified

Explanation of items used in titling strip:

1. Negative number. Numerical identification is applied to each frame in a sequence of exposures.

2. Camera position. This entry identifies the camera position in a single or multiple camera installation (camera fan). In the example above, the letter "F" is followed by 2 digits. The first digit to indicate the number of cameras in the fan and the second digit to indicate the camera position, i.e.,

| | |
|---|---|
| Split Fan | - F21 F22 |
| 3 Camera Fan | - F31 F32 F33 |

3. Taking Unit. Entry identifies the unit which flew the photography.

4. Service. Entry identifies the DOD service of the taking unit.

5. Sortie/Mission Number. Numerical designation to identify the sortie or mission.

6. Date. Day, month, and year the photography was flown.

7. Time group and zone letter. Show Greenwich Mean Time (Z). Time will denote beginning of the flight.

8. Focal length. Show [illegible] focal length in inches, centimeters, or millimeters.

9. Altitude. Show barometric altitude in feet or meters.

10. Kind [illegible] Photography or [illegible] the following symbols to show type of photography.

a. IR - Infrared airborne thermal sensor imagery

b. RC - Reconnaissance, continuous strip

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c. RK - Reconnaissance, color

d. RD - Reconnaissance, day

e. RN - Reconnaissance, night

f. RP - Reconnaissance, panoramic

g. SLAR - Side looking airborne radar

11. Geographic Coordinates. The geographic coordinates of the first and last exposure will be entered in the leader (head frisket) and trailer (tail frisket) of a continuous roll or negatives. Degrees of longitude will be stated in 3 digits, using zero (0) before longitude entries less than 100 degrees.

12. Descriptive Title. Identifies approximate place or the subject of the photograph.

13. Project Name or Number. Included in the assignment generating the flight(s).

14. Camera Type and Serial Number. Alpha/numeric designation and serial number assigned to the type of camera used to expose the film.

15. Security Classification. The security classification assigned the photographic coverage by the responsible security authority. DOD Instruction C-5210.52, "Security Classification of Airborne Sensor Imagery (U), " 25 October 1966, provides instructions and guidance. "Downgrading and Declassification of Classified Defense Information," will be an integral part of the security classification and is covered in DOD Directive 5200.10. These are categorized as group numbers, i.e., GP-1, GP-3, etc.

Other information pertaining to titling can be found in Defense Intelligence Agency Manual (DIAM) 55-5; Aerial Photography and Airborne Electronic Sensor Imagery (Forwarding, Titling, and Plotting).

## DUAL-HEAD FILM TITLER, MODEL 1-A

The Dual-Head Film Titler, Model 1-A (figure 2-1), imprints coded title information in the clear border of processed aerial reconnaissance film. It can accommodate film in widths from 70mm to 9.5 inches (22.1 cm). The title consists of a 6-digit number which can advance consecutively or repeat from frame to frame, and one or two lines of fixed alphanumeric type. Two title heads are available.

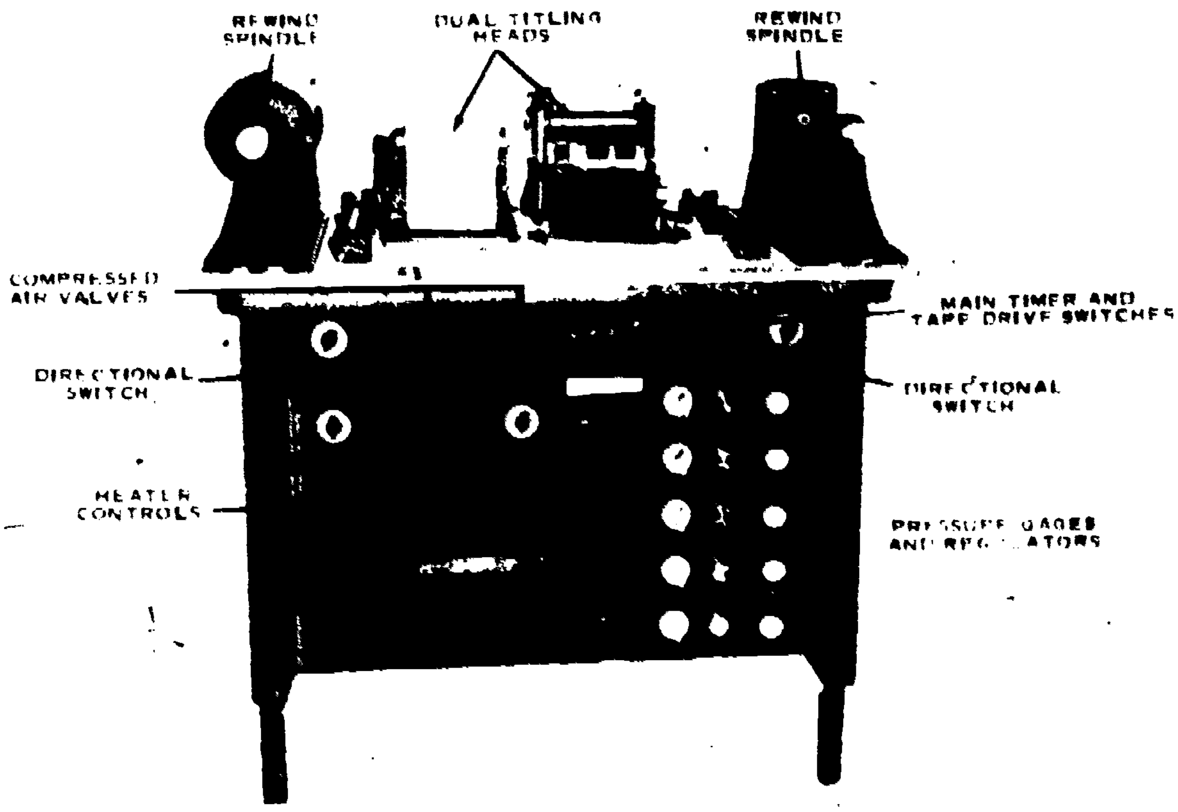


Figure 2-1. Dual-Head Titler, Model 1A

General Description

The Dual-Head Film Titler prints frame titles along the edge of processed reconnaissance aerial film by transferring pigment from a coated tape. The back side of the tape is struck by a preheated bar of type as the film is supported by a hard rubber pad or platen. The coated side of the tape is forced against the film in the configuration of the letters and numbers of the type bar. The pigment is transferred to the surface of the film in the form of opaque alphanumeric characters.

The pigment has adhesive characteristics that enable it to stick to the photographic film surface. Transfer of pigment strips the tape.

Therefore, the tape feed is indexed to advance 1/4" (6.4 mm) after each print cycle to make available a solid strip of pigment for the next impression.

Two title heads are provided. Either one can be used, or both can be operated in conjunction. Each head contains a serial numbering head and room for 4-3/16" (113.8 mm) of type which can contain alphanumeric information set from commercially available type fonts in a variety of faces and sizes. The numbering heads can be adjusted to repeat or to advance serially. In the serial mode, frame numbers can be sequentially printed automatically with the rest of the title.

The film transport is driven by two torque motors, controlled in either direction. Film travel is stopped momentarily by hand for the print cycle, which is activated by a foot switch. Holding the switch down will produce one print cycle every 4 seconds for volume production. Controlled compressed air resets the counters and drives the printing heads.

Standard or thin base film can be titled on either the base or the emulsion side.

Detailed Description

The Dual-Head Film Titler, a pneumatic-electrical device, was designed to apply coded-title information, which repeats frame after frame, and sequential frame numbers in the clear, unexposed area of processed film. Film sizes from 70mm to 9.5 inch (24.1 cm) can be titled. The sequential or indexing counter will print up to and including a 6-digit number or any combination of numbers and spaces totaling six. This 6-digit combination may be sequential or repetitive.

For the repeated, coded-title information, characters in 6, 8, 10, or 12 point lead type can be set up with the total number of characters restricted only by the six-inch (15.2cm) printing block space. The lead type is set in a holder held in place on the printing head by two retaining screws in the top plate. Type can be changed easily in this holder when the holder is removed from the printing head. During the titling operation, the code letters or words are repetitive on each frame while the counters are consecutive or repetitive as desired.

Although the machine is equipped with two titling heads, it is possible to use only one head by turning off the controls to the head that is not being used.

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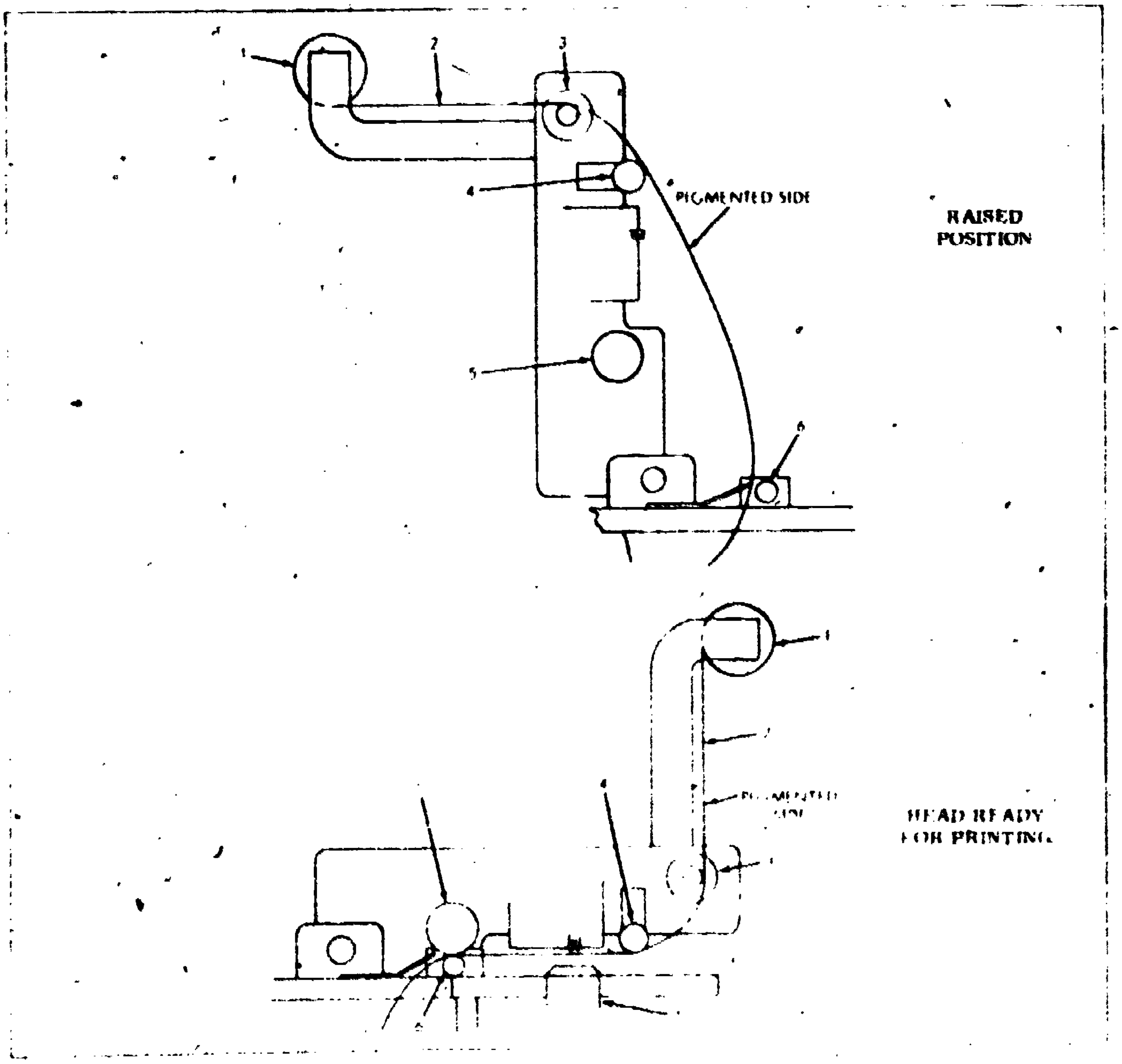
"Cello" tape (black, white or brown) is used as the transfer medium and is fed between the film and the lead type and counter (figure 2-2).




1. Supply Spindle
2. Titling Tape
3. Tape Reel Shaft
4. Tape Idler Roller
5. Pressure Roller (Rubber Covered)
6. Tape Advance Roller Block and Pad Assembly

Figure 2-2.
**Pigmented Tape Setup**

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The lead type and counter must be heated and proper pressure applied to transfer the material to the edge of the film properly. To heat the counters to the proper operating temperature, two 50-watt heating elements are installed in each counter nest. The temperature of these heating elements is controlled individually by the "Variac" control knobs labeled No. 1 COUNTER HEATER and No. 2 COUNTER HEATER. The No. 1 COUNTER HEATER is the temperature control knob for the counter in Printing Head 1 (left-hand head) and the No. 2 COUNTER HEATER is the temperature control knob for the counter in Printing Head 2 (right-hand head).

To heat the lead type to the proper operating temperature, a 240-watt heating element is installed in each of the two blocks. The temperature of these heating elements is controlled by the "Variac" control knobs labeled No. 1 TYPE HEATER and No. 2 TYPE HEATER. The No. 1 TYPE HEATER is the temperature control knob for the type in Printing Head 1 (left-hand head) and the No. 2 TYPE HEATER is the temperature control knob for the type in Printing Head 2 (right-hand head). During operation, adjustment to these "Variac" controls depends upon characteristics of the material to be titled. If the temperature of these heating elements is too high, the transfer medium will flow, and if the temperature is too low, improper or illegible transfer will result.

To obtain the proper printing pressure, adjustments can be made to change the readings on the gauges labeled No. 1 COUNTER PAD, No. 1 TYPE PAD, No. 2 COUNTER PAD, and No. 2 TYPE PAD. Readings on these gauges are changed by manipulation of the two control knobs to the right of each gauge. The extreme right control knob should be fully open for each gauge and then the proper pressure achieved by turning the control knob nearest the gauge counterclockwise to decrease the gauge reading or clockwise to increase it. Proper pressure is achieved when the film is not embossed and the title is clear and legible. Each counter stamp pad and each lead type stamp pad its own pressure gauge so that the pressure for each counter or lead type stamp pad can be adjusted individually.

The pressure gauge labeled COUNTER AIR and the control knobs to the right of this gauge are used to control the pneumatic system for indexing the counters.

Too high a pressure on the COUNTER PAD and TYPE PAD gauges will cause embossing of the film and too low a pressure will result in light or possibly illegible titles and reference numbers. Too low a pressure on the COUNTER AIR gauge will result in improper indexing of the counters.

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PHYSICAL CHARACTERISTICS. The pneumatic and mechanical assemblies that make up the Dual-Head Film Titler are mounted on a rigid metal frame. The upper portion of the unit consists of the printing table, the film handling mechanism, the titling heads, and the rubber covered stamp pads. The lower portion of the machine consists of the pneumatic and electrical components required for machine operation.

AIR REQUIREMENTS. A constant air supply of 40 psi should be available for operation of the pneumatic portion of the machine. The air supply is then reduced by the pressure regulating valves in the machine to the proper operating pressure. It is recommended that this air be clean and dry. A compressor capable of delivering 3 cubic feet of free air 40-50 psi is suitable as the source of compressed air.

ELECTRICAL REQUIREMENTS. The machine is designed to operate on 110-volt, 60-cycle, single phase ac. Power consumption is 1,000 watts. A three-wire grounded receptacle must be provided.

CONTROLS. All machine controls for operation of the Dual-Head Film Titler are located on the front of the machine within easy reach of the operator. The "Variac" control knobs for regulating temperature of the lead type and the counter as well as the pressure control valves for regulating and turning off the incoming air supply for the pneumatic stamp pads and counters are located in the lower portion of the machine.

The Dual-Head Film Titler, designed to be used in normal room light, can be installed in any clean work area equipped with proper electrical outlets and with connections to a suitable air supply. A work space of three feet (.9 m) should be allowed at the front of the machine and a space from one to three feet (.3 to .9 m) should be allowed at each end of the unit.

Preoperation Procedures

Before operating the Dual-Head Film Titler, perform the following steps:

1. SETUP OF PRINTING HEAD 1 (LEFT-HAND HEAD). With the printing head in the raised position, set the counter in Printing Head 1 to the proper digit or digits for the first frame of the film to be numbered. To set these counters, rotate each row of numbers using a wood stick, until the proper digit is reached.

To set up the proper title in the type block of Printing Head 1, remove the type holder from the printing head by loosening the two retaining thumbscrews. Loosen the socket set screw at the end of

each row in the type block and insert the lead type to a bottomed position. (Notched side of the type faces the front of the type block). Secure the type by tightening the socket setscrew. This must be flush or below the surface of the type block. Proofread by placing the type block in front of a mirror, then replace the block and secure with the two retaining thumbscrews.

Turn the MAIN switch ON and set the No. 1 COUNTER HEATER and the No. 1 TYPE HEATER "Variac" control knobs at their maximum settings for 10 minutes. Then return them to a predetermined setting (see NOTE) allowing heating elements to heat the counter and the lead type to the proper temperature. Then reset the "Variac" control knobs lower on the dial until tests made with a piece of scrap film show satisfactory results.

> NOTE: Proper Settings for pressure and heat are best determined by adjusting the appropriate controls while printing on scrap pieces of film. If possible, the scrap pieces should be of the same material as that to be titled. These tests should be run only after all preparatory steps noted in the operating portion of this section are completed.

Adjust the incoming air pressure with the machine pressure control regulators so that the gauge labeled No. 1 COUNTER PAD reads 10 psi and the gauge lebeled No. 1 TYPE PAD reads 15 psi. Open the valve labeled COUNTER SEQUENCING AIR No. 1, and close valve labeled COUNTER SEQUENCING AIR No. 2.

Place the "Cello" tape on the printing head supply spindle so that the tape coating is next to the film when the printing head is lowered to the titling position. Thread this tape over the guide roller, in front of the upper phenolic roller and the rubber-covered drive roller, behind the lower phenolic roller and into the exit slot so that some tape extends into the exit chute.

2. SETUP OF PRINTING HEAD 2 (RIGHT-HAND HEAD). Setup the counter and type block for this printing head as described above. Adjust incoming air pressure with the machine pressure control regulators so that the gauge labeled No. 2 COUNTER PAD reads 10 psi and the gauge lebeled No. 2 TYPE PAD reads 15 psi. Open the valve labeled COUNTER SEQUENCING AIR No. 2. Set the No. 2 COUNTER HEATER and the No. 2 TYPE HEATER "Variac" control knobs at their maximum settings for 10 minutes. Then return to

the previously determined settings to allow the heating elements to heat the counter and lead type to the proper temperature.

If it is not in the raised position, raise Printing Head 2 (right-hand head), place the "Cello" tape on the printing head supply spindle, and thread in the manner described in step 1.

3. SET UP OF PRINTING HEADS 1 AND 2. Set up the counter and type block for both printing heads as described in step 1. Regulate incoming air pressure with the machine pressure control regulators so that the gauges labeled No. 1 COUNTER PAD and No. 2 COUNTER PAD read 10 psi and the gauges labeled No. 1 TYPE PAD and No. 2 TYPE PAD read 15 psi. Set the four "Variac" controls labeled No. 1 COUNTER HEATER, No. 1 TYPE HEATER, No. 2 TYPE HEATER, and No. 2 COUNTER HEATER at 40. If not already in the raised position, raise both printing heads, place the "Cello" tape on the printing head spindles, and thread in the manner described in step 1.

4. THREADING FILM FOR TITLING. The machine is designed so that either spindle can be used as a supply spindle.

If the left-hand spindle is to be used as the supply, place the material to be titled on this spindle so that the film comes off the top of the roll. Then thread it under the left guide roller, across the printing table, under the right-guide roller, and onto the top of the takeup spool on the right-hand spindle.

Both left and right-guide rollers are pivoted for convenience during threading. When the hook clamps on the front of these rollers are released, the rollers can be raised and the film threaded. After threading is complete, lower the rollers and clamp them in place to keep the film at the proper height above the stamp pads.

When titling other than 70mm film, the special 70mm guide roller shown between the two printing heads is removed. To do this, loosen the two screws in the mounting block and lift the entire unit off the printing table.

When titling dupe film, a special nylon roller must be used to prevent curl. Clamp this roller to the edge of the cutoff for Printing head 2 (right-hand head) so that the roller is positioned between the two printing heads. The back edge of the nylon roller must be even with the edge of the film. Thread the dupe film under this roller as it passes from Printing Head 1 to Printing Head 2.

WARNING

> **Both the counter and the type block are hot and contact with either could cause a burn. Be careful to keep any part of the hands or arms from coming in contact with the type blocks or counters.**

When threading is complete, lower Printing Head 1 or Printing Head 2, or both, to the printing position and lock in place with the clamps provided on each side of the printing head. Turn the knurled knobs for these clamps clockwise or counterclockwise to lock the head in place.

Turn the No. 1 TAPE DRIVE switch for Printing Head 1 or the No. 2 TAPE DRIVE switch for Printing Head 2, or both, to the ON position and adjust the speed control knob on the right front of the machine (above the Directional Switch) to read between 70 and 80. This setting should provide sufficient forward torque for windup. Adjust the speed control knob on the left front of the machine to read between 40 and 50. This setting will provide sufficient reverse torque to keep proper tension on the film during the printing operation.

If the supply roll is on the right-hand spindle and the takeup roll is on the left-hand spindle, adjust the speed control knob on the left front of the machine to read between 70 and 80. Adjust the speed control knob on the right front of the machine to read between 40 and 50.

5. PRINTING HEAD ADJUSTMENT. Both printing heads can be adjusted front and back to accommodate any variations in the unexposed areas of the film to be titled. Printing Head 2 (right-hand head) can also be moved left or right to provide for perfect placement of the title on the film.

6. TAPE ADVANCE. To prevent a flowing imprint of characters from heat softened "Cello" tape, when starting a titling operation, move the TAPE ADVANCE switch to the ON position until unmarked tape is under the counter and lead tape.

7. LIGHT. The machine is equipped with illuminated viewing areas to the front of the printing heads to allow the operator to determine whether the titling operation is being performed satisfactorily.

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Turn the light switch to the ON position to turn on the lights in the viewing area.

Operation

After accomplishing the preoperational steps in the previous section, the following steps are ready to be performed.

1. SWITCH POSITIONS. After the machine has been set up for operation, using Printing Head 1, Printing Head 2, or both, turn the timer switch to the ON position.

If the film to be titled is on the left-hand spindle and is fed from the top of the spool, turn the film direction-toggle switch below the supply spindle (left-hand spindle) to L to apply reverse torque to the supply roll. This keeps tension on the film during the titling operation. Turn the film direction-toggle switch below the takeup spindle (right-hand spindle) to R to apply forward torque for windup of the titled film.

If the film to be titled is on the right-hand spindle and fed off the top of the rpool, turn the film direction-toggle switch below the takeup spindle (left-hand spindle) to L to apply forward torque for windup of the titled film.

In some titling operations, it is necessary to unwind the film from the bottom of the supply roll and wind the titled film onto the bottom of the takeup roll.

When unwinding from the bottom of the supply of the left-hand spindle, turn the film direction-toggle switch under the supply spindle to R to apply reverse torque to the supply roll. This keeps tension on the film during the titling operation. Turn the film direction-toggle switch under the takeup spool to L to apply forward torque for windup of the titled film.

2. TITLING. Stop the film movement by applying pressure with a gloved hand to the large knob on the supply spindle. The frame to be titled should be stopped directly under the printing head or heads, or as called for by the titling requirements. These requirements also delineate whether one or both titling heads shall be used, the method of using the titling heads, and the manner in which the titling is placed on the film.

After stopping the film movement, depress and release the

foot switch to operate the "Meadmatic" Timing Unit which allows air to go to the lower cylinders on each printing head.

> **NOTE: This timing unit is present at the factory and the set of the cams should not be changed except for the cam on the extreme left which controls the tape advance. See step 3.**

Application of air to these cylinders raises the rubber-covered stamp pads to press against the counter and lead tape.

The pads are automatically held against the counter and lead type for the time limit set in the timing mechanism and then lowered to the rest position. After the stamp pads are lowered, the "Cello" tape is advanced 1/4 inch (6.4mm) automatically and the counter is indexed to the next digit.

A titling cycle takes about 4.5 seconds to complete. If the operator fails to release the foot switch as soon as he hears the lower cylinders advance, the entire cycle will be repeated.

3. ADJUSTMENT OF TAPE ADVANCE CAM. If the tape does not advance sufficiently to prevent superimposition of characters on the "Cello" tape, move the stops on the cam located at the extreme left of the "Meadmatic" Timing Unit slightly farther apart. Select a position to permit advancing only sufficient tape to prevent superimposition, being careful to prevent tape waste. To gain access to the "Meadmatic" Timing Unit, turn the knob below the "Variac" control knobs counterclockwise and open the hinged door.

Shutdown

When shutting the machine down, move the printing heads to the raised position to keep from forming a flat spot in the rubber-covered tape drive roller.

Turn OFF both the Main switch and the air supply.

If the machine is to be idle for even a short period of time, it is good practice to turn the Timer switch OFF.

Preventive Maintenance

All good housekeeping procedures that are normal for photographic equipment apply to the Dual-Head Film Titler. In addition, the following special maintenance services should be scheduled.

1. **DAILY.** Brush all flakings from the "Cello" tape off of the printing table, the counters, and the lead type. Vacuum all surfaces around the printing areas to remove flakings. Exercise extreme care to be sure that the flakings do not become wedged in the roller bearings.

Wipe off all rollers on the printing heads to prevent a buildup of flakings on the rollers. The rollers should be wiped off with solvent periodically.

2. **PERIODIC.** The counter should be lubricated every 2 months. If atmospheric conditions in the area where the Dual-Head Film Titler is installed are conducive to rust, the counters should be lubricated more frequently than at 2 month intervals. It is recommended that the counters be removed from the printing heads and returned to the contractor for lubrication. If it is deemed necessary to lubricate the counters at the site, instructions for lubrication will be furnished by the manufacturer upon request.

The cylinders for the stamp pads should be lubricated every 3 or 4 months. To lubricate these cylinders, put a few drops of oil in the main air line so that all cylinders and valves will receive a small amount of lubrication; or put a couple of drops of oil in the separate air line for each cylinder. A good grade of light machine oil should be used in either application.

Every 6 months, put a few drops of a good grade of light machine oil in the oil cup on the "Bodine" motor.

CHECKLIST - DUAL-HEAD, MODEL [illegible] A

[illegible]

1. A [illegible]
2. Att [illegible]
3. [illegible]
4. [illegible]
5. MAIN [illegible]
6. [illegible]
7. [illegible]
8. [illegible]
9. Set No. 1 COUNTER HEATER and No. [illegible] HEATER [illegible] to their maximum settings.
10. Set No. 2 COUNTER HEATER and No. [illegible] HEATER [illegible] to their maximum settings.

NOTE: After 10 minutes return knobs to their recommended settings (COUNTER HEATERS to 30 and TYPE HEATERS to 48) to allow heating elements to heat the counter and type to the proper temperature.

11. Adjust No. 1 COUNTER PAD to 10 psi
12. Adjust No. 1 TYPE PAD to 15 psi
13. Adjust No. 2 COUNTER PAD to 10 psi
14. Adjust No. 2 TYPE PAD to 15 psi
15. Adjust COUNTER AIR to 30 psi

NOTE: If necessary, heat and pressure can be readjusted while printing on scrap pieces of film.

16. Open COUNTER SEQUENCING AIR valves No. 1 and No. 2
17. TIMER switch ON
18. LIGHT switch ON
19. TAPE DRIVE No. 1 and No. 2 ON
20. Set COUNT on 0
21. Run PLATEN TEST for No. 1 TYPE, No. 1 COUNTER, No. 2 ~~COUNTER~~, and No. 2 TYPE
22. Set COUNT to desired number
23. Set VOLTAGE for left and right DIRECTIONAL SWITCH
24. Thread film
25. Holding hand spindles, set left and right DIRECTIONAL SWITCH

Shutdown

1. Raise titling head
2. MAIN POWER switch OFF
3. Air supply OFF
4. Heaters OFF
5. Air valves OFF
6. Close COUNTER SEQUENCING AIR
7. All switches OFF
8. Clean work area

## DELAWARE PORTABLE FILM TITLER, MODEL II

General Description

The Delaware Portable Film Titler, Model II (figure 2-3), is a pneumatic-electrical device, designed to apply coded-title information on the emulsion or base side of processed aerial photographic films. Title information can be applied along one border or within the inter-frame spacings of the film. All standard film widths between 70mm and

9 1/2 inches (24.1 cm) can be titled. The counter will print up to and including a 4-digit number. This 4-digit combination may be sequential, repetitive, or skip-numbered.

For repeated, coded-title information, a choice from two sizes of characters can be established with the total number of characters limited only by the 1 7/8 inch (48 mm) capacity of the type holder. One or two rows of type can be employed in the type holder. During the titling operation, the code letters or words setup in the type holder will be repeated on each frame.

Detailed Description

The film essentially consists of a titler mechanism, two spool drive assemblies, an air compressor, type preheater, and a footswitch. The bottom of the carrying case forms the base of the film titler.

TITLER MECHANISM. The titler mechanism consists of a support to which is attached a pivot ring. The pivot ring supports a rotating ring which holds two pneumatic cylinders; one to operate a counter. A titling tape feed and takeup mechanism, a type holder, and associated components are mounted on the titling head.

Pivot Ring. The pivot ring supports the rotating ring and allows it and components mounted thereon to be pivoted from the vertical position, where titling is performed, to the horizontal position to adjust the counter or to perform other services. Tightening a knurled thumbscrew locks the pivot ring in the operating position.

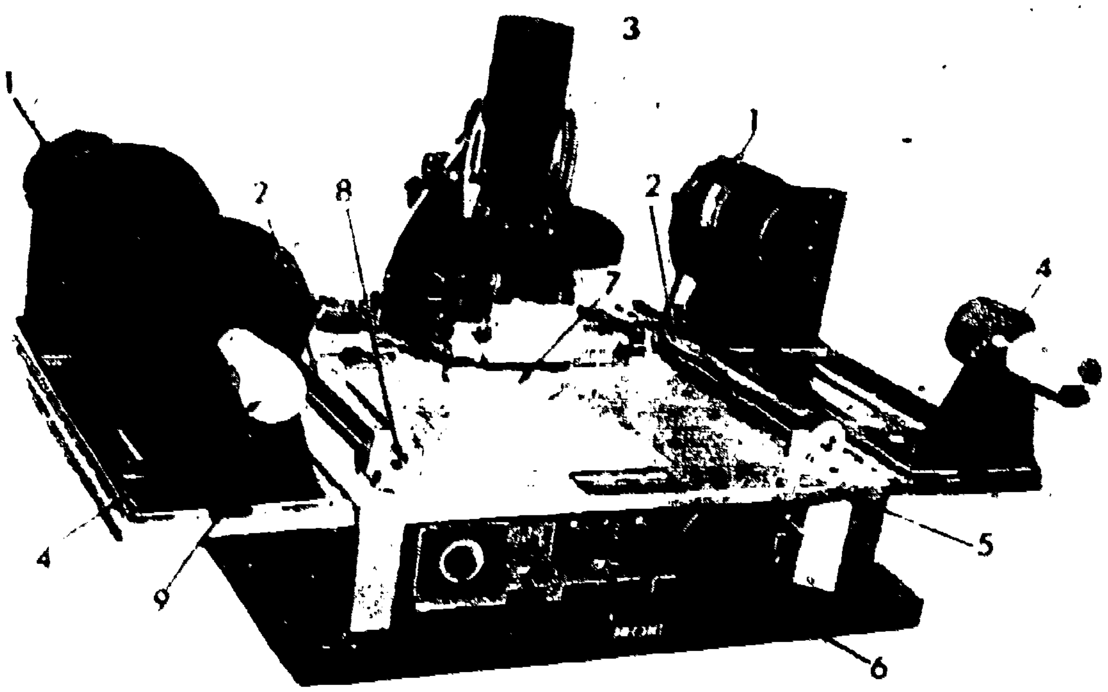
Rotating Ring. [illegible] be rotated 110 degrees in either direction [illegible] information can be applied [illegible] frames. A knurled thumbscrew [illegible] operating position.

Titling [illegible] is furnished by the titling cylinder [illegible] the typeholder, counter, and titling [illegible] by the titling [illegible] and pressure [illegible] each time [illegible] titling head.

Titling Head. The titling head [illegible] counter, operated by an indexing cylinder, [illegible], a type holder, two type heating cartridges, [illegible], and a thermometer.

Counter. The counter contains nine numbering wheels, only four of

[illegible]




1 SPOOL DRIVE ASSEMBLY
2 ROLLER ASSEMBLY
3 TITLER MECHANISM ASSEMBLY
4 ADJUSTABLE SPOOL SUPPORT ASSEMBLY
5 MAIN PLATE
6 CARRYING CASE BASE
7 RUBBER PAD
8 ROLLER LATCH
9 RULER

Figure 2-3. Portable Film Titler

which are used. The zero characters on the five unused wheels can be removed to prevent their embossing the film.

Indexing Cylinder. The indexing cylinder is a small, double-acting pneumatic cylinder that can index the counter either once or twice between each titling operation to provide sequential or skip-numbering of successive frames. The air cylinder can also be set to allow repetitious numbering.

Titling Tape Feed and Takeup Mechanism. The titling tape feed and takeup mechanism consists of tape supply and takeup spools, idler rollers, and an adjustable pawl and ratchet wheel. Titling tape feeds, dull side down, off the top of the supply spool, travels under the two idler rollers, and is wound up on the takeup spool. When the titling head moves upward, the ratchet wheel on the takeup spool shaft engages the adjustable pawl and causes the takeup spool to rotate a fraction of a turn. Thus, a fresh

area of titling tape from one-eighth to one inch (3.2 mm to 25.4 mm) per titling cycle.

Type Holder. Two sizes of type holders are furnished with the film titler; one size for 6-point type and one for 10-point type. An 8-point holder is available on order. The selected type holder, loaded with one or two lines of type, is positioned in an aperture in the titling head. An insulated handle on the type holder facilitates handling when hot.

SPOOL DRIVE ASSEMBLIES. Two spool drive assemblies (rewind units) accommodate film rolls in standard widths from 70mm to 9 1/2 inch (24.1 cm) on standard aerial film spools up to 7-5/8 inch (19.5 cm) diameter. Each unit consists of a drive assembly and an adjustable spool support assembly that face each other and traverse on a mounting plate. The position of one rewind unit can be matched to the position of the second by aligning them with the same mark on two mounted rulers. Thus, both rewind units can be adjusted for correct film width and alignment.

AIR COMPRESSOR. A piston-type air compressor supplies air through two main lines at different pressures to operate the titling cylinder and indexing cylinder. One line delivers air, at full pressure to a pressure regulator on the main plate and thence to the titling cylinder. A filter in this line removes moisture from the air. The second line has a factory-adjusted pressure regulator and a tee fitting. Two air lines, running from the tee fitting, supply air to operate the indexing cylinder.

FOOTSWITCH. A footswitch, actuated by the operator, initiates the titling operation.

TYPE PREHEATER. The type-holder preheater, [illegible] watt hot plate, is used to preheat [illegible] type holders before they are installed in the titling head. [illegible] it is nec- [illegible] preheater tempera- [illegible]

[illegible]

[illegible] SETTING [illegible] screw to allow the [illegible] Using a [illegible] the counter [illegible] numbered in the printing [illegible] position, tighten the [illegible] the INDEXING switch [illegible] (for [illegible]), DOUBLE ADVANCE (for skip numbering), or REPEAT (for repeat numbering).

2. TYPE SETUP. Select the desired type-holder and type font, loosen the type-holder screws and insert the desired characters to a bottomed position. (The notched side of type faces the front of type holder). When only one line of type is required, insert a spacer in place of the second line of type. Tighten the type-holder screws to apply light pressure against the type, proofread (hold before a mirror and read the reflected image). Check to insure the type is all the same height, and tighten the screws firmly. Insert the type-holder in the titling head making sure that it is pushed in against the stop.

3. THREADING TITLING TAPE. To install pigmented-titling tape, first pivot up the guard to gain access to the tape feed and takeup mechanism. Then push in the spring loaded cap, rotate it one-half turn, and remove it and the guide flange from the supply spool. (WARNING--If the titler has been in operation, do not touch the titling head as it is hot--250°F (121°C)--and would cause a severe burn). Remove the used tape core and place a new roll of tape on the supply spool, replace the guide flange and the spring-loaded cap. Remove the takeup spool from its brackets by pulling the spool straight towards the front of the titler and remove the used tape. Replace the takeup spool in its brackets ascertaining that the takeup spool springs snap over the takeup spool shaft. Feed the titling tape from the supply spool, dull surface down, under two idler rollers, and secure the tape to the takeup spool with the spring clip. Pivot the guard down and tighten the thumbscrew. (NOTE: After using the titler, remove the tape to prevent damage due to heat).

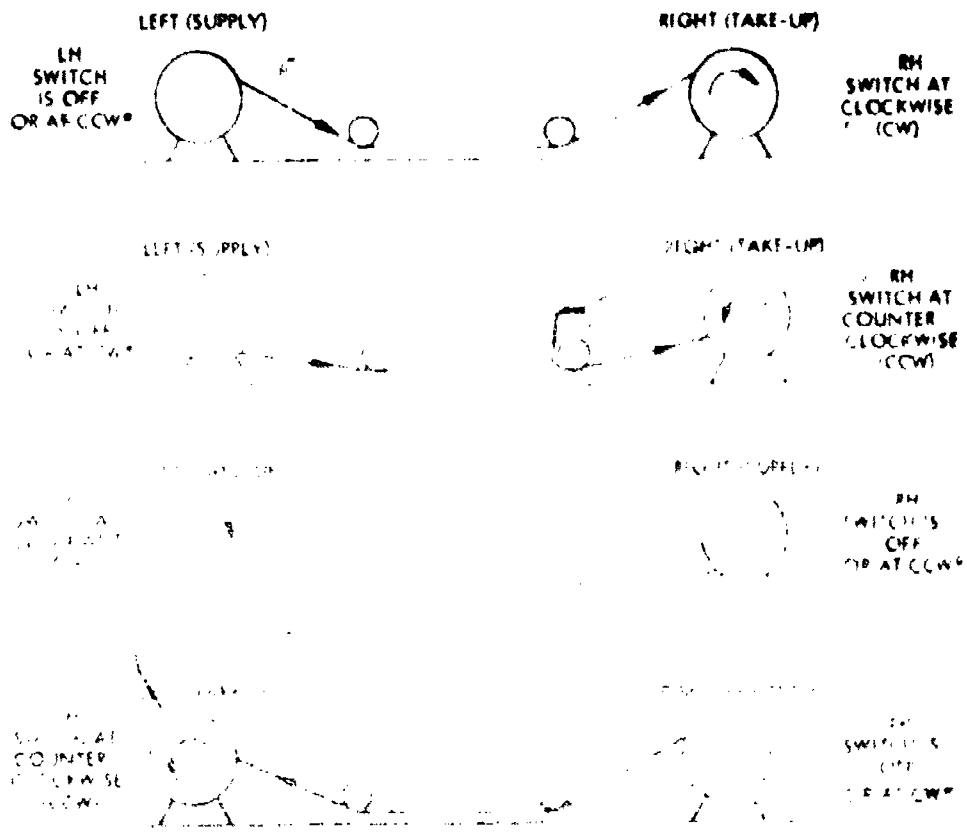
PRELIMINARY CONTROL SETTINGS. Turn the POWER switch ON. The heaters are energized at this time. If the air compressor has just been operating, wait two minutes for air to bleed from lines before turning POWER switch ON. With residual air pressure in the lines, the air compressor will not start. Set TIMER control knob at 3. This may have to be increased or decreased by one or two points to obtain the best hot-type application for various film thicknesses or materials. Next, loosen the thumbscrew and raise the plastic guard. This will facilitate accomplishing the next steps.

Fifteen minutes after turning on the power switch, check that the thermometer indicates 250°F (121°C). This may have to be increased or decreased from one to 10 degrees F (.5 to 5.5°C) to obtain optimum titling results. To increase temperature, turn thermostat adjustment screw (located directly behind the handle of the type holder) counterclockwise. Allow time for thermometer to indicate the temperature change. To decrease temperature, turn the thermostat adjustment screw clockwise. Turn the COMPRESSOR switch ON and adjust the pressure regulator knob to read 28 psi. This reading may be varied either way from 1 to 10 psi to obtain optimum titling results.

Next, loosen the pawl adjustment thumbscrew and position the pawl to advance the titling tape to the required amount. Single-line titling requires a 3/16 inch (4.8 mm) wide printing area and double-line titling requires a 1/4 inch (6.4 mm) wide printing area. (With pawl in its bottom position, the tape will advance one inch (25.4 mm) per title; in the uppermost position, 1/8 inch (3.2 mm). Tighten the pawl adjustment thumbscrew securely and carefully rotate the titling tape takeup spool a few turns by hand. This action removes the section of tape with the heat-softened pigment from under the titling head. Lower the guard and secure in place.

Operation

1. LOADING FILM FOR TITLING. The film titler is designed so that either spool drive assembly can be used as a supply spindle. The determination of which unit will hold the spool of film to be titled depends upon: (a) The side of the film to be titled (emulsion or base) must be up as it passes under the titling head. (b) When titling on the edge of the film, the film edge to be titled must be at the rear of the rewind unit so that the film edge passes under the titling head. (See figure 2-4).




* If it is desirable to have more drag on the supply spool or greater film tension, then the directional switch for the supply rewind is positioned at CW or CCW (rather than OFF) depending upon film threading.

Figure 2-4. Threading Diagram and Correct Position of Switches for Each Setup

NOTE: It is recommended that a test run, using sample film of the same thickness and type as that to be titled, be made before starting a production run in order to determine proper temperature, time, and air pressure settings.

Raise the two rollers and thread the film to be titled. Lower the rollers and make sure both spool-drive assemblies are located so that the information to be titled will be centered in the available space on the film. (NOTE--Assure that the spool-support knobs are in their detent position preventing easy axial movement). Position the LH and RH switches so that the film moves from supply to takeup (figure 2-4). Turn the REWIND MOTORS switch ON and adjust the SPEED CONTROL knob so that film moves from supply to takeup at a desirable speed. Check that the film runs without contacting the flanges of either spool. Turn REWIND MOTORS switch OFF.

2. TITLING ON EDGE OF FILM. Check that the titling head is positioned so that the titling will be parallel to the film travel. The two scribed lines on the rotating ring must align with the two lines scribed on the neck of the support. If adjustment is required then loosen the thumbscrew and rotate the titling head until the two scribed lines on the rotating ring match the lines scribed on the neck of the support arm. Tighten the thumbscrew. Turn the REWIND MOTORS switch ON and adjust the SPEED CONTROL so that the film travels from the supply to the takeup at the desired operating speed. (NOTE--The SPEED CONTROL, calibrated 0 to 100, controls the voltage applied to the spool-drive assembly torque motors.) The value to which the SPEED CONTROL is set is the direct percentage of line voltage (110) applied to the right torque motor. For the percentage applied to the left torque motor this value is subtracted from 110. For example: If the SPEED CONTROL is set to 10, then 10 percent of line voltage (11 volts) is applied to the right torque motor and 90 percent (110 minus 10) of the line voltage (99 volts) is applied to the left torque motor.

When the frame to be titled travels to the appropriate place under the titling head, halt rotation of the supply spindle by hand pressure on the spool-support knob and press down on the footswitch to initiate the titling cycle. (Once initiated, the cycle will complete regardless of the footswitch position). Release the footswitch and spool-support knob. Repeat these steps to title each successive frame. When the supply reel becomes empty, turn the REWIND MOTORS switch OFF.

3. INTERFRAME TITLING. Interframe titling is the same titling on the edge except the rotating ring is turned approximately 90 degrees to align the head with the end of the film frame. Title information is applied to the film in the same manner as outlined for edge titling.

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**Shutdown**

Upon completion of titling operations for the day, shutdown the film titler by first assuring that the REWIND MOTORS switch is OFF. Next, turn the COMPRESSOR and POWER switches OFF. Store the footswitch in a safe location, clean the work area, and return any equipment to its proper location.

## CHECKLIST - DELAWARE, MODEL II

**Startup**

1. Assure adequate tape supply
2. Attach footswitch
3. Plug in power cord to 110v outlet
4. MAIN POWER switch OFF
5. Set counter of printing head
6. Set INDEXING switch to desired setting
7. Set type block
8. POWER switch ON--after 15 minutes check for proper temperature (250°F)(121°C)
9. Set timer
10. COMPRESSOR switch ON
11. Adjust pressure regulator to 28 psi

> NOTE: If necessary, heat and pressure can be readjusted while printing on scrap pieces of film. In this case set INDEXING switch to REPEAT.

12. Assure proper tape advance [illegible]
13. [illegible] titling [illegible] film
14. [illegible]
15. Position [illegible]
16. [illegible] switch ON and adjust the [illegible]

**Shutdown**

1. [illegible]
2. COMPRESSOR [illegible]
3. POWER switch OFF
4. All other [illegible]
5. Clean work area

# AERIAL ROLL FILM CLEANING

**Cleaning is one of the most important and most often repeated tasks ever done. It is a large part of the operational cost of any industry.** In the photographic field, cleaning takes a large part of the technicians' time. With the tremendous increase in the use of photographic **intelligence in recent years, the problem of cleaning film has become staggering.**

Film can become dirty through normal handling, and without proper cleaning, this dirty film will produce prints with poor resolution and a loss in detail. In some cases, an image on the negative is so small that it can be completely obliterated by a particle of dust. Film cleaning by hand is time consuming and costly. Machines have been developed which reduce the time and therefore, the cost of cleaning.

## Taconic Tacky Roll Cleaner

The Taconic Tacky Roll Cleaner, No. [illegible], is designed to remove loose dirt from the emulsion and base sides of processed black-and-white roll film. It also retards further dirt collection on the film by eliminating any static electrical charge. The cleaner will accommodate rolls of film in standard widths between 70mm and 9.5 inches (24.1 cm) on spools up to 10.5 inches (26.7 cm) in diameter.

The cleaning is done by contact of the film surfaces with tacky rollers to which the dirt particles adhere. The static charge in the film is erased by passing the film over a static electricity-eliminator bar. This discharge occurs immediately after the film has passed the last roller and just prior to its winding up.

Both original negative and duplicating master films, either thin or standard base, are cleaned with this unit. Note that this unit cannot be used to clean color films. It is intended for black-and-white material only. The original negative is cleaned just before printing. Thereafter, it is common practice to clean the original negative after every four printings. The duplicating master is cleaned immediately after postprocess inspection and, by some users, every four printings thereafter.

After the cabinet is uncrated it should be thoroughly cleaned and installed in any white-light area where a 115-vac, 60 Hz, 1150-watt, 10-amp service outlet, is available. A working area of at least three feet (.9 m) is needed at the front of the cabinet. The relative humidity (RH) in the area should be 50 ± 5 percent. If RH is not within this range, the tacky rollers could pull the emulsion

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off the support.

The Taconic Tacky Roll Cleaner shown in Figure 2-5 has its major components described below.

CABINET. This stainless steel, floor-standing unit is 41 inches (104cm) wide, 30 inches (76cm) deep, and 70 inches (178cm) high. The cabinet houses the tacky roll cleaning assembly, a 300 CFM blower, a filter installation, a pressure gauge and the main-control panel.

The cabinet has four removeble panels; one in front, two in the back, and the fourth in the right side. The panel in front is removed to gain access to the blower and the filter installation. The lower removable panel at the back of the cabinet also gives access to the filter installation. The upper panel at the back provides access to the back of the tacky roll cleaning assembly. The small panel on the right side of the cabinet is removed to get at the rear of the pressure gauge and to make electrical connections to the control box.

TACKY ROLL CLEANING ASSEMBLY. The basic components of this assembly are the baseplate, the motorized supply and takeup spindle assemblies, two tacky rollers, and the static eliminator bar. These components shown in Figure 2-6 are described below.

Baseplate. The cleaner baseplate is made of 1/2-inch (1.3cm) aluminum jig stock and is mounted vertically to a support frame in the upper part of the cabinet.

Mounted to the front of this baseplate are the supply and takeup spindles, and two metal support plates for the tacky rollers and static eliminator bar. The power supply unit for the static-eliminator bar is mounted on the back of the [illegible].

[illegible] to be cleaned is positioned [illegible] mounted below the tacky rollers [illegible] can accept film rolls in standard [illegible] 9.5 inches (24.1cm) [illegible] type B spools [illegible]

The [illegible] on the right side of the baseplate and [illegible] that face each other. They traverse on two [illegible] which almost span the width of the [illegible] by a torque motor mounted on a support [illegible] which is secured to the bottom of the powered head. Power is transmitted from the motor to the head via a timing belt. This supply torque motor applies a "hold-back" tension to the film as it moves from the supply spindle

SW [illegible]

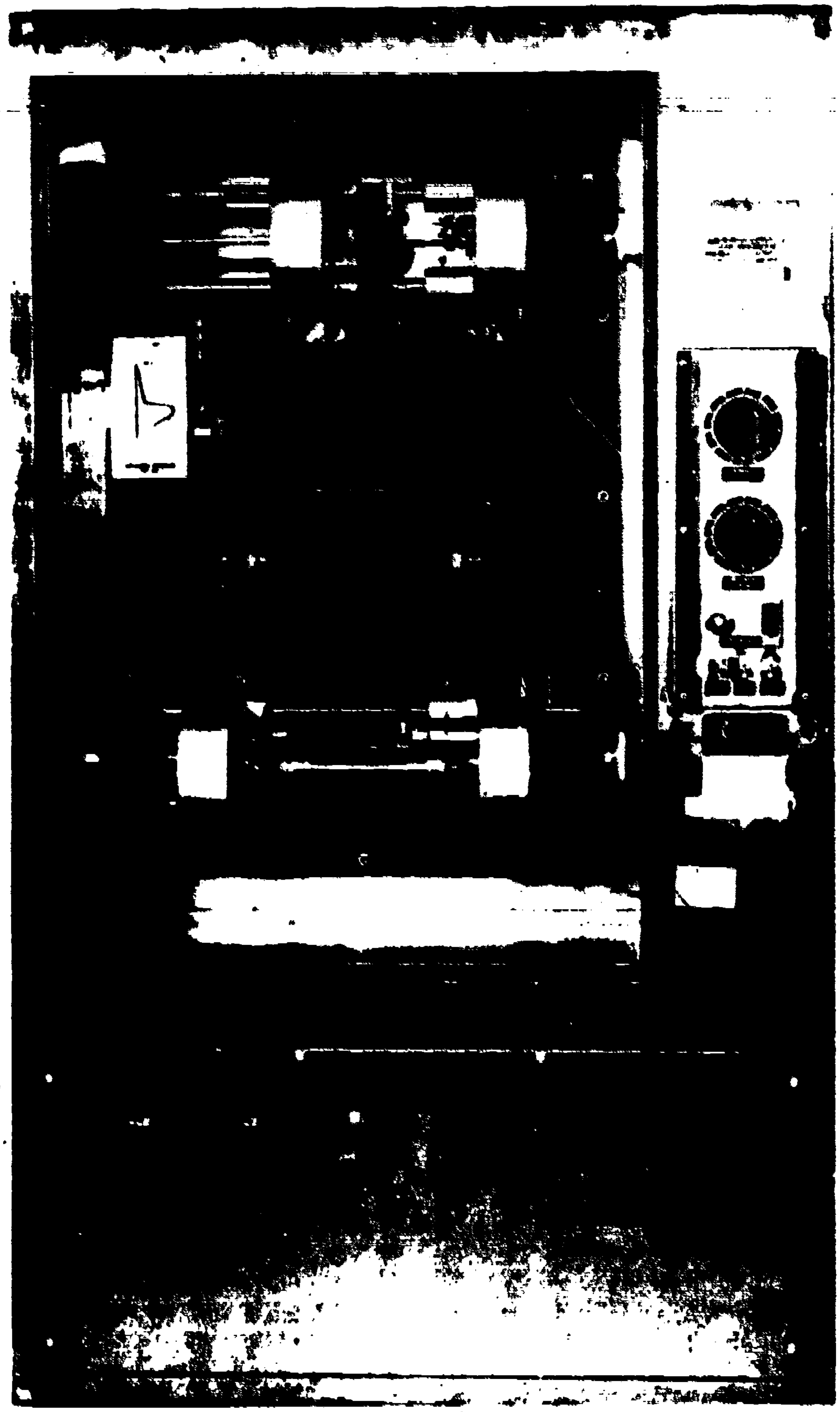

Figure 2-5. Over-All View of Taconic Tacky Roll Cleaner

to takeup spindle during the cleaning operation.

The torque motor is controlled by a variable autotransformer which is positioned behind the control panel housed in the right front of the cabinet. This autotransformer has a dial marked HOLD-BACK TENSION on the control panel. (See HOLD BACK TENSION later).

The powered and idler heads are connected by a Neg'ator spring which acts to pull the two heads together and thus hold film spools in position between the two heads. A clamp on one of the two cylindrical rails can be locked to hold the idler head from the powered head at a slightly less distance than the width of the film spool. This makes it convenient for the operator to replace spools of identical size.

Both the supply spindle and the takeup spindle can be adjusted laterally to permit film alignment between the spindles and the tacky rollers. Adjustment is effected by rotating the small handwheel centered in the right support for the cylindrical rails. This operation turns a leadscrew which engages a nut anchored in the base of the powered head. Since the heads are connected by the Neg'ator spring, they move together during this adjustment.

NOTE

> Two pointers (one secured to the powered head of each spindle assembly) and two metal rulers fastened to the baseplate facilitate alignment of the two units.

Motor driven takeup spindle. This spindle is mounted above the tacky rollers [illegible] eliminator bar; it is identical to the [illegible] larger; i.e., capable of producing more torque. [illegible] controlled by a second variable autotransformer [illegible] control panel. This transformer [illegible] dial [illegible] panel. The dial should be adjusted [illegible] sufficient to pull [illegible] rollers, to the [illegible]

[illegible] situated so that one surface [illegible] other surface contacts one other roller as the film moves from the supply spindle to the takeup spindle. [illegible] glue and glycerine mixture which picks up and retains dust particles from the surface of the film. Because of certain characteristics of glycerine,

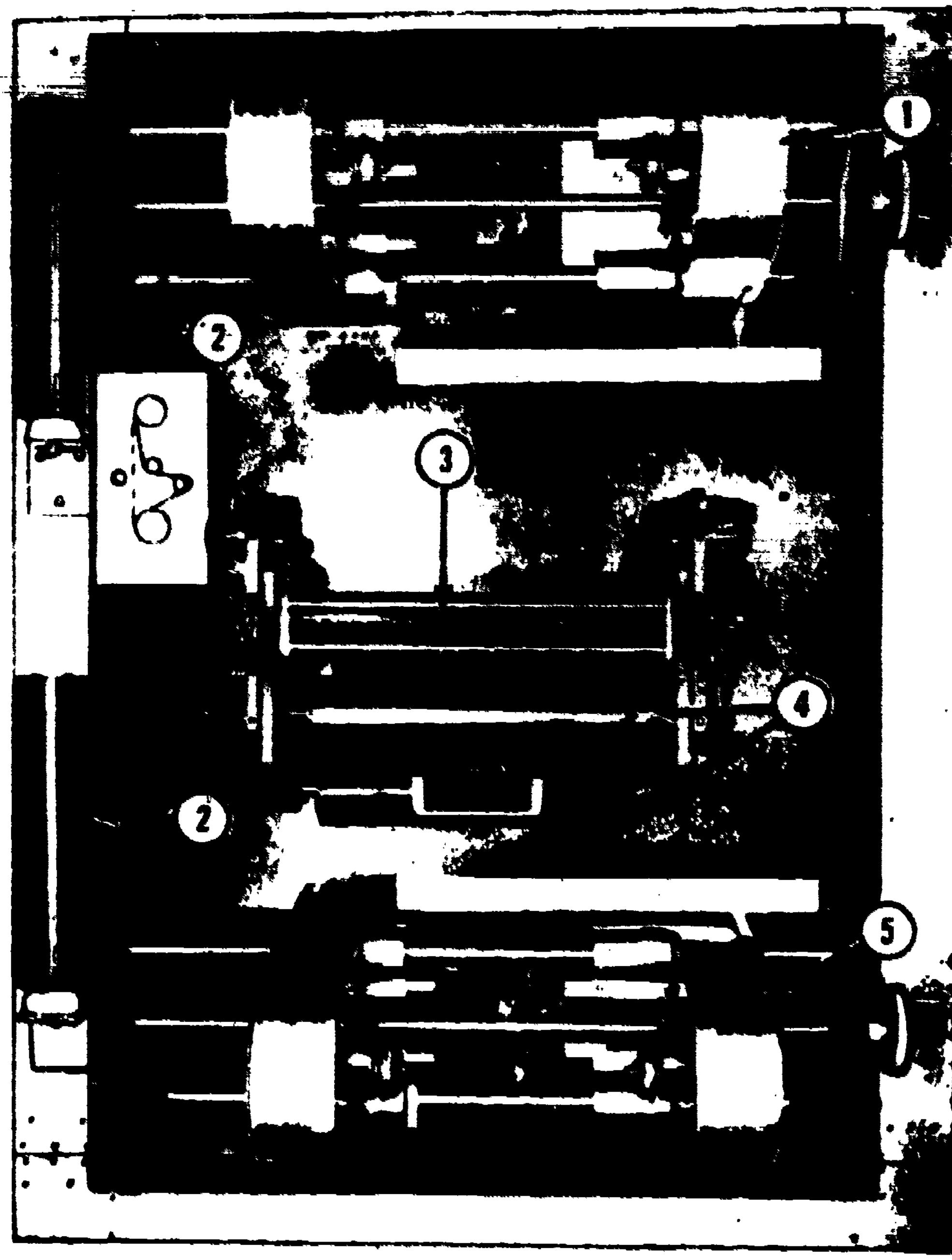


Figure 2-6. Tacky Roll Cleaning Assembly

1. Takeup Spindle Assembly
2. Place for Tacky Rollers During Time They Are Changed
3. Static Electricity Eliminator Bar
4. Tacky Rollers (Two) Used for Cleaning
5. Supply Spindle Assembly

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the Taconic Tacky Roll Film Cleaner must be operated in an area where relative humidity is controlled to 50 ± 5 percent.

One roller is supported by two shafts whose housings are secured in the metal support plates mounted to the baseplate. The outer roller is held by two shafts whose housings are mounted in an arm assembly which is attached to the metal-support plates. The left shafts for the two tacky rollers are spring-loaded enabling either roller to be replaced easily when the roller loses its tacky quality and no longer sufficiently cleans the film.

The arm assembly which supports one of the tacky rollers is movable to facilitate machine threadup; i.e., the arm can be raised and secured in the "threading" position. With the arm assembly locked in the threading position, as shown in Figure 2-7, film is simply run from supply spindle to takeup spindle. After the machine is threaded, the arm assembly is lowered and secured in one of the four "cleaning" positions shown in Figure 2-8. Film wrap and cleaning action increase as the arm assembly is moved inward toward the vertical baseplate of the tacky roll cleaning assembly.

Four locking studs are positioned in the top and bottom front corners of the two metal plates. The two studs in the bottom front corners are used to secure the arm assembly in one of the four "cleaning" positions. Both studs lock and unlock in the same manner. To secure the arm assembly, they are pushed in until seated in the respective locking holes in each arm. To free the arm assembly, they are pulled out.

Either of the two studs (one is spring-loaded) in the top front corners of the metal plates can lock the arm assembly in the "threading" position. The spring-loaded [illegible] stud [illegible] the right plate is used to [illegible] stud is released [illegible] assembly. The other [illegible] position when [illegible] and unlocks in the same [illegible] secure the arm in [illegible]

[illegible] elimination of static electricity [illegible] attraction by the cleaned film, the Taconic Tacky Roll [illegible] operates a static electricity control system. The system consists of a static-eliminator bar and high voltage power supply. The static-eliminator bar is held by the two metal plates which support the tacky rollers. The high voltage



ED 7[illegible]

power supply for this unit is mounted to the back of the cleaner baseplate. The static control system is energized when the POWER and ANTISTATIC switches are turned ON.

**The static eliminator-control system uses moderately high voltages but draws relatively low current. As installed, and if properly maintained no shock hazard exists to the operator from any exposed portion (bar, cable, etc.) of the system.**

CONTROL PANEL. The control panel shown in Figure 2-9 is located on the right front of the cabinet in full view and easy reach of the operator. The panel has the following controls:

Power Circuit Breaker. This is the primary electrical control for the cabinet. This switch must be ON to energize all controls and switches discussed below, and all circuits and electrical components (blower, two fluorescent lights within cabinet-operation interior, torque motors, etc.) in the cabinet.

Motor Power Switch. Besides the POWER circuit breaker, this switch must be ON to energize the torque motors for the takeup and supply-spindle assemblies. This switch has a guard that helps prevent accidental operation.

Holdback Tension Control. This calibrated dial (0 to 100) is coupled with a variable autotransformer that controls voltage to the supply torque motor. Depending on roll width and diameter, this dial is set to establish a satisfactory "holdback" tension on the film during the cleaning operation.

Running Tension Control. This calibrated dial (0 to 100 settings) is coupled with the variable autotransformer that controls voltage to the takeup torque motor. Since operating speed depends on certain variables (width, diameter of film rolls, tackiness of the two rollers, etc.), there is no single-dial setting. The dial should be set so that film travels from the supply spindle to the takeup spindle at a moderate, even rate.

The RUNNING TENSION control utilizes a limit relay and microswitch to prevent film snap or tear during machine startup. The limit relay must be energized to activate both the takeup and supply torque-motor circuits. This relay is controlled by a microswitch which is mechanically connected to the RUNNING-TENSION dial. If the dial is at any setting other than zero when the MOTOR-POWER switch is turned ON, the microswitch will not energize the

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relay. Thus, the operator must first turn ON the MOTOR-POWER switch and then rotate the dial <u>from zero</u> to the desired setting to energize the relay and activate both torque motors.

Antistatic Switch. In addition to the POWER-circuit breaker, this toggle switch must be ON to energize the static electricity-control system.

Blower Switch. Besides the POWER-circuit breaker, this switch must be ON to energize blower in the bottom of the cabinet.

BLOWER AND AIR FILTER. A blower rated at 300 CFM and a filter installation are housed in the bottom of the cabinet to furnish a flow of filtered air through the cleaning chamber as follows: Air is drawn through the filter installation and travels up the cabinet's back section. Then, most of it moves across the perforated plate at the top of the cabinet and exists through an adjustable baffle secured to the front of the perforated plate. This forms an air shower across the opening in the front of the cabinet to prevent dirt from entering the cleaning chamber. The adjustable baffle has been set for optimum results but it can be readjusted to regulate the air shower. The baffle is attached to the plate by three screws which can be loosened to change the baffle setting. Most of the air forming the air shower is drawn through the perforated plate at the bottom of the cleaning chamber and recirculated.

Some of the air also flows through the perforated plate at the top of the cabinet rather than across the plate and out the [illegible] This portion [illegible] which [illegible] the perforated plate moves through [illegible] plate [illegible] behind the air shower [illegible] chamber.

[illegible] front panel [illegible] through the [illegible] establish [illegible]

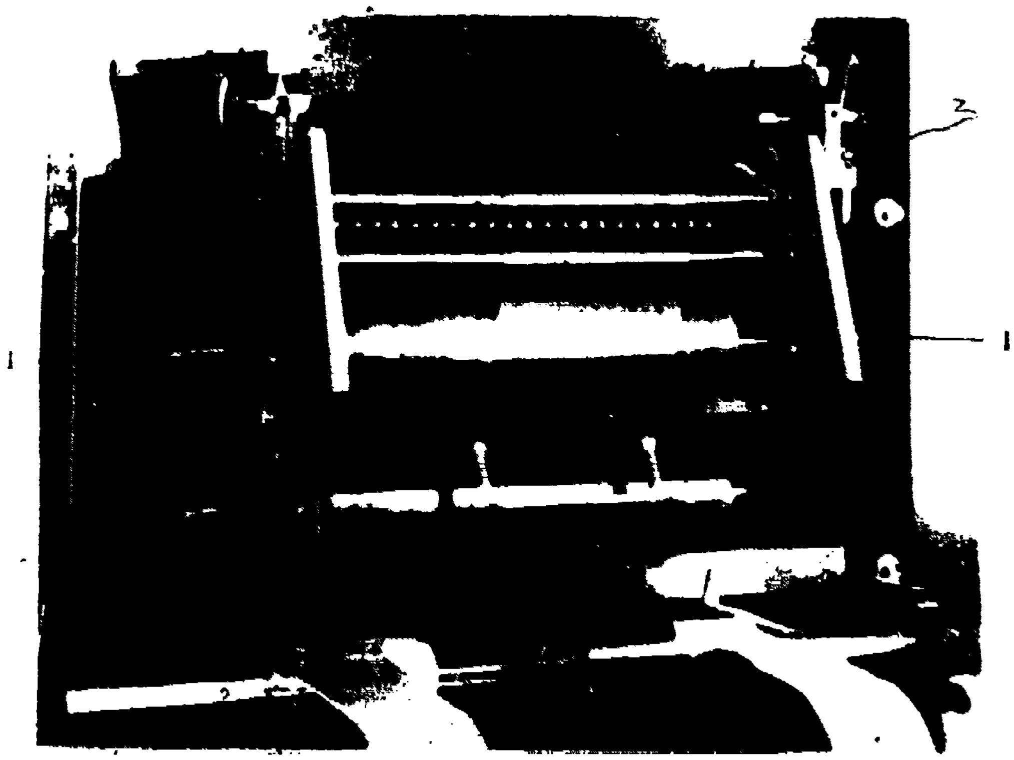
[illegible]

right wall of the cleaning chamber [illegible] one mounted before the filter, the other mounted after the filter — are [illegible] the gauge [illegible] the pressure differential [illegible] the filter [illegible]. A gauge reading of

[illegible]


1. Regular Locking Stud
2. Spring-Locking Stud

Figure 2-7. Arm Assembly Locked in Threading Position




1. Locking Studs Which Secure Arm in Cleaning Position

Figure 2-8. Arm Assembly in Cleaning Position

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Figure 2-9. Control Panel

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0.50 indicates that the filter is approximately 60 percent loaded with dirt and should be changed.

MACHINE RUNNING SPEEDS. Since running speed is dependent on many variables (e.g., diameter and width of film roll, thickness of film base, HOLDBACK and RUNNING TENSION settings, tackiness of rollers, etc.), general maximum and minimum running speeds cannot be stated. It is suggested that a sample roll of film be used to establish running speeds for the size and type of film to be cleaned.

Operating Procedures

1. Be sure and turn all three switches on the control panel to the OFF position. Check the RUNNING TENSION and HOLDBACK TENSION control dial; both should be at the zero position. Plug the power cord into a 115-vac, 60-cycle, 10-amp, properly grounded outlet.

NOTE

A trial run with scrap film of the same type to be cleaned is recommended.

2. If the film to be cleaned is titled on one edge, a film sample with titling should be tried. It may be necessary to cover the corresponding area on the tacky rollers with masking tape to prevent removal of all or part of the title.

CAUTION

Be certain that tacky rollers are dry, but tacky, before cleaning film. Damp rollers could strip the emulsion off the film.

3. Turn on the POWER circuit breaker and ANTISTATIC switch to energize the static-electricity control system. To check system operation, place fingers lightly against the needle points on the static-eliminator bar. A very slight tickling sensation will be felt at the moment of contact if the instrument is operating properly. Continued contact will produce no additional feeling.

NOTE

As installed, and if properly maintained, there is no shock hazard to the operator from any exposed portion of the instrument.

4. After energizing the static electricity-control system, turn the BLOWER switch ON to establish a constant flow of filtered air through the cleaning chamber of the cabinet.

5. To load a spool of film in the supply spindle, push the idler head away from the powered head with one hand and position the spool so its slot mates with the powered head's spindle. Then match the other end of the spool with the shaft on the idler head. Use the same procedure to position an empty spool in the takeup spindle.

a. Preliminary alignment of the takeup and supply spindles is required before film threadup. The handcrank at the right side of each spindle assembly is rotated clockwise to move the spindle assembly left to right and counterclockwise for right to left lateral movement. For 9.5 inch (24.1cm) film, use these handcranks to position the pointers at 11 3/4 inches (29.8cm) on the metal rulers.

b. After preliminary alignment of the two spindle assemblies, raise the tacky roll arm assembly and use the spring-loaded locking stud to secure it in the threading position (see figure 2-9). Slowly pull leading end of the film and thread it between the two tacky rolls, over the static-eliminator bar, and wrap it (about 2 or 3 revolutions) around an empty spool in the takeup spindle. See figure 2-10, Threading Diagram.

c. Turn ON the MOTOR POWER switch and set the HOLD-BACK TENSION knob at about 30 on its dial. Then immediately return the RUNNING TENSION knob to zero (to energize both torque motors) and increase the knob to 15 on its dial. This action establishes enough tension in the film web to prevent the film from unwinding when the tacky roll arm assembly is set in one of the four cleaning positions. [illegible] the final step of the threadup [illegible].

6. With the tacky roll [illegible] in one of the four cleaning positions, gradually turn the [illegible] TENSION control to supply power to the takeup [illegible] recheck its alignment [illegible] attention to the winding [illegible] the takeup spool. It may be necessary to readjust [illegible] the two spindle assemblies precisely, rotate the handcrank at the right side of the takeup spindle assembly. The metal rulers on the takeup and supply spindles facilitate precise alignment of the two units.

NOTE

~~Proper alignment also should include centering~~ the film in relation to the tacky rollers.

7. With the POWER circuit breaker and the MOTOR POWER switch ON, first set the RUNNING TENSION control and then the HOLD-BACK TENSION according to one of the tables below.

Be sure to set the RUNNING TENSION first. If the HOLD-BACK TENSION is adjusted first, the film threaded through the machine could be drawn back to the supply spindle and the machine would have to be rethreaded. Also, be sure to turn ON the POWER and MOTOR POWER switches before setting the RUNNING TENSION dial. If this dial is adjusted first and then the switches are turned ON, the supply and takeup torque motors will not energize.

The tables below contain recommended settings for the widest, the medium, and the narrowest width film and for three roll diameters. Settings for widths not listed and for other roll diameters can be evaluated from this data.

TABLE 2-1.

Initial Settings* for Thin Base Films

| | HOLD-BACK TENSION | | | | RUNNING TENSION. | | | |
|---|---|---|---|---|---|---|---|---|
| Film Size | 2000' 610 m | 1000' 305 m | 500' 152 m | 250' 76 m | 2000' 610 m | 1000' 305 m | 500' 152 m | 250' 76 m |
| 70 mm | 30 | 25 | 20 | 15 | 50 | 45 | 40 | 35 |
| 5" (12.7 cm) | 40 | 35 | 30 | 25 | 75 | 70 | 60 | 45 |
| 9.5" (24.1 cm) | 50 | 45 | 40 | 30 | 100 | 90 | 70 | 55 |

TABLE 2-2.

Initial Settings* for Standard Base Films

| | HOLD-BACK TENSION | | | RUNNING TENSION | | |
|---|---|---|---|---|---|---|
| Film Size | 1000' 305 m | 500' 152 m | 250' 76 m | 1000' 305 m | 500' 152 m | 250' 76 m |
| 70 mm | 30 | 25 | 20 | 50 | 45 | 40 |
| 5" (12.7 cm) | 40 | 35 | 30 | 75 | 70 | 60 |
| 9.5" (24.1 cm) | 50 | [illegible] | 40 | 100 | 90 | 70 |

* These tabulated readings are initial settings which may have to be changed as film is being transferred from supply to takeup.

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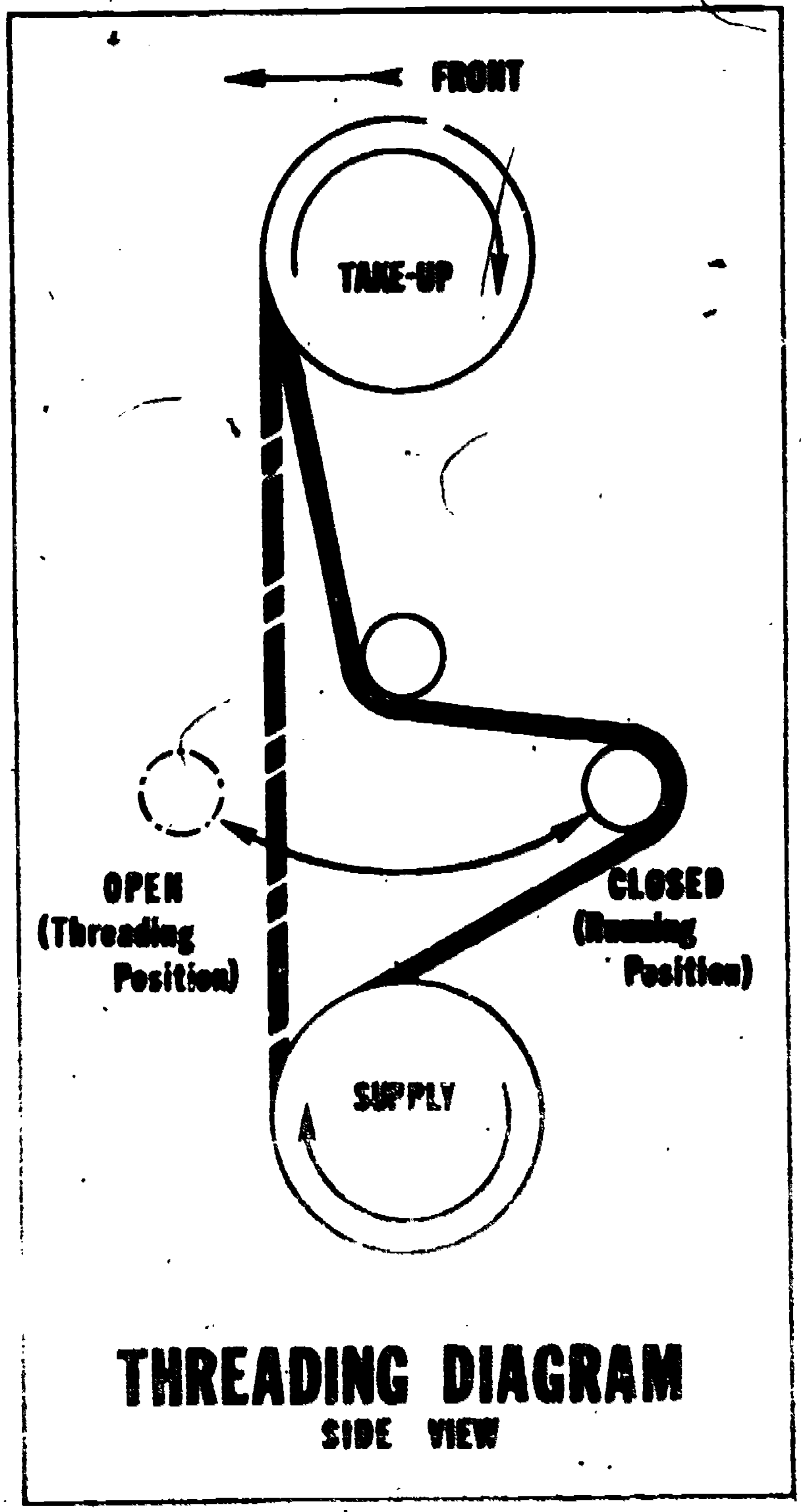


Figure 2-10.

8. After film has been cleaned, simply turn off MOTOR POWER switch and remove the film roll from the takeup spindle. Do not stop film during cleaning. If an examination of the film is required, such as examination must be done on a rewind table.

TROUBLE SHOOTING

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| Film fails to move from supply to takeup spindle. | Main power cord not plugged in | Plug cord in a 115 vac, 60 Hz, 10 amp, receptacle. |
| | POWER circuit breaker and/or MOTOR POWER switch OFF. | Be sure both switches are ON. |
| | RUNNING TENSION control dial not set high enough. | Set dial so that film moves from supply to takeup at a moderate, even rate. Refer to Tables in Section 2.5, Adjusting Tension Controls. |
| | RUNNING TENSION control was set before turning the POWER and MOTOR POWER switches ON | Turn dial back to zero and then reset. |
| Tacky rollers not picking up dirt particles. | Rollers dirty or glazed. | Wash rollers with damp cloth or replace with new rollers if washing fails to restore tackiness. |
| Excessive static electricity build-up in cleaned and rewound film. | ANTI-STATIC switch OFF. | Turn switch ON. |
| | Static eliminator bar dirty | Clean bar with soft brush or cloth. |

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| TROUBLE | PROBABLE CAUSE | REMEDY |
| --- | --- | --- |
| | ON-OFF toggle switch on power supply accidentally turned to OFF position. | Be sure switch is in ON position. The power supply unit is mounted to the base of the mechanism plate. The top panel at the back of the cabinet must be removed to get at the power unit. |
| | High voltage power supply failed. | Notify maintenance supervisor. |
| Emulsion being pulled off film. | Tacky rollers are damp. | Wipe both rollers thoroughly with soft lint-free cloth. Also, be sure machine is installed in area where RH is 50 + 5%. |

Maintenance Procedures

The tacky rollers must be inspected periodically for excessive accumulation of dirt. When this accumulation is evident, or when the cleaning they provide is unsatisfactory, they must be washed. The rollers can be cleaned [illegible] with a soft, lint free cloth. Wet [illegible] water of 60°F - 70°F (15.6°C - [illegible] [illegible] rollers to dry after cleaning.

[illegible] they fail to [illegible] two tacky rollers [illegible] rollers [illegible] either [illegible] or positioned on the roller holders in the cabinet [illegible] for easy accessibility.

To remove either tacky roller from its support shafts, simply push the roller to the left, to compress the spring-loaded shaft in its housing and to free the end of the roller from the right-support shaft. Once this end is free, remove the other end from the spring-loaded shaft. Simply reverse the above procedure to install a new roller.

CAUTION

> **Do not lay tacky rollers down for long because ~~flat spots could form on the rollers. The rollers~~ should always be stored in their shipping case but may be placed on the roller holders in the cabinet interior for short periods when immediate availability is desired.**

LUBRICATION. The bearings in the supply and takeup spindles and torque motors do not require lubrication.

STATIC CONTROL SYSTEM CARE. To obtain optimum and long life from the static electricity control system, its components (static-eliminator bar and power supply) must be given proper care.

Static-Eliminator Bar. Cleanliness is essential to good performance. Accumulation of dust and dirt on or near the bar needle points will reduce performance of the static-eliminator bar. Thus, at least once a week use a clean, soft cloth or brush to remove any accumulated dust from the bar. The static-eliminator bar must be kept dry. If the bar accidentally should become damp, it must be dried thoroughly before being operated. The bar can be dried at elevated temperatures, but not over 150°F (65.6°C). If the bar is soaked accidentally with water, return it to the manufacturer for repair.

Power Unit and Cables. The power unit and bar-feeder cables normally require very little service. However, the bar-feeder cables should be inspected occasionally for signs of abrasion or other damage. (Small cracks appearing in the outer insulation will cause no harm). Any cables with breaks or cuts extending through the outer insulation and into or through the interior metal braid sheath should be returned to the factory for repairs.

The static control power unit mounted to the back of the cleaner's vertical baseplate requires little attention other than to see that the high-voltage sockets are kept clean and dry, and closed with a blank plug when not in use.

Tacky Roller Film Cleaner

DESCRIPTION. The Tacky Roller Film Cleaner (Figure 2-11) is a compact film cleaning device designed to remove dust and lint from 70mm through 9.5 inch (24.1 cm) film. In addition to cleaning the film, the machine also removes static charges, thus retarding further collection of dust and dirt.

The cleaner accepts 70mm through 9.5 inch (24.1 cm) film in lengths to 1000 feet (305 m). The spool mandrels, which are loaded from each

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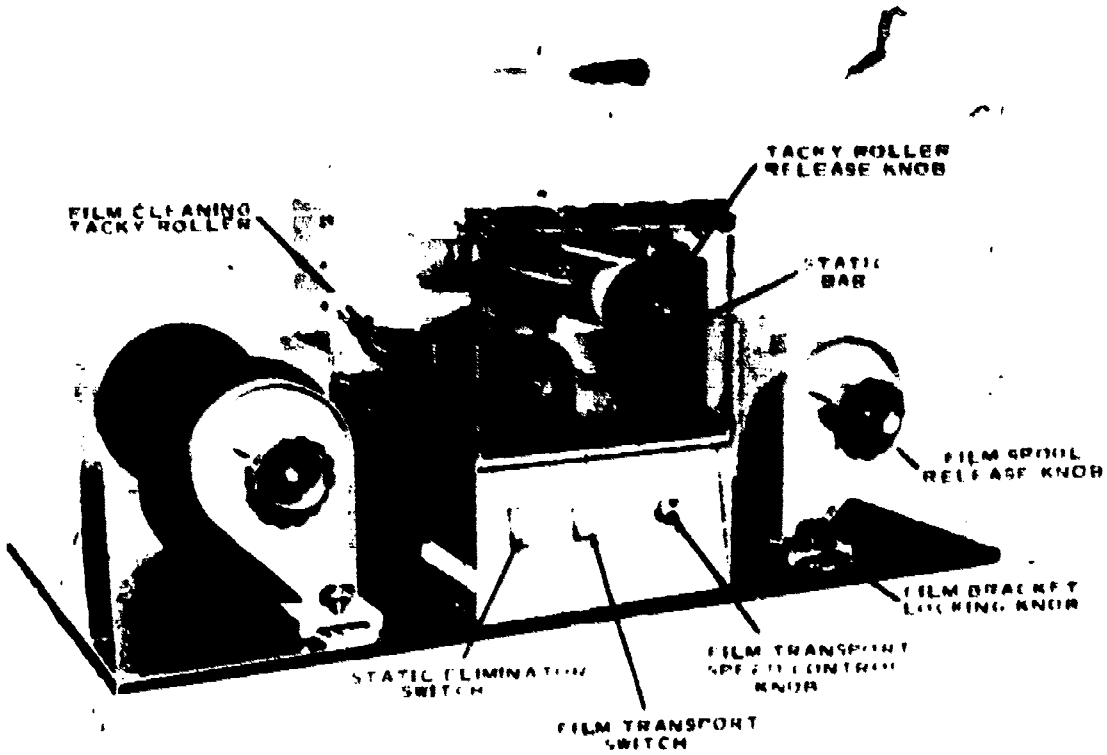


Figure 2-11. Tacky Roll Film Cleaner

end, will accommodate either standard Military Specification or Houston Fearless "B" spools. Two tacky rollers clean the film: one contacts the base side and the other contacts the emulsion side. Both rollers are enclosed in a "Plexiglas" housing to keep dust from contaminating the roller surfaces. The rollers are accessible through a door located on the front of the compartment, and they may be removed for cleaning by depressing a spring-loaded mandrel which releases both ends of the rollers.

Within the operating-speed range, the film-transport speed is variable to allow optimum setting for particular conditions. A sensing arm rides on the takeup spool to maintain speed within ± [illegible] percent of set speed. To prevent static buildup on the takeup spool, a static eliminator is mounted at the film exit of the roller enclosure. This high voltage potential static eliminator is capacitance coupled to the voltage source to prevent a shock hazard to operating personnel. A "Plexiglas" housing is provided to cover the unit.

SPECIFICATIONS. The specifications for the Tacky Roller Film Cleaner are as follows:

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1. **FILM CAPACITY:** 70mm, 5 inch (12.7 cm) or 9.5 inch (24.1 cm) film in rolls to 1000 feet (305 m) in length.

2. **TRANSPORT SPEED:** 135 feet per minute (41.1 mpm) ± 15 percent.

3. **ELECTRICAL REQUIREMENTS:** 115 volt, 60 cycle, ac, single phase, 500 watts.

4. **APPROXIMATE DIMENSIONS AND WEIGHT:** Length, 36 inches (19.4 cm); width, 20 inches (51 cm); height, 15 inches (38.1 cm) and weight, 120 pounds (54.4 kg).

PREPARATION FOR OPERATION. Before operating the Tacky Roller Film Cleaner, perform the following steps:

Setup. Place the Tacky Roller unit on a reasonable level table and plug the electrical cord into a 3-pole, grounded, 115-volt, ac single phase, 60-cycle outlet. The circuit to which the unit is connected should be capable of handling a 500-watt load.

Threading. By loosening the knob at the base of the bracket, and sliding the bracket in or out as required, adjust the film spool brackets to accept the film size being cleaned. Tighten the knob firmly when the correct spacing has been attained.

> NOTE: When using the Houston Fearless "B" type film spool, it is necessary to slide the entire spool bracket out for insertion or removal.

Place the roll of film to be cleaned on the left loading bracket by pulling the knob of the movable bracket and inserting the spool onto the pins. Then open the "Plexiglas" door on the front of the machine located on the control panel. Using the left hand, pull the film from the supply spool, pass it under the first tacky roller in the "Plexiglas" cabinet, over the second tacky roller, and onto the takeup spool (figure 7).

CAUTION

> Be sure that the film is correctly lined up from spool to spool. The "tooth" of the tacky roller prevents the shifting of the film during operation which would normally correct improper tracking.

Place the sensing-arm roller, located at the rear of the machine on the takeup end, against the film. The sensing arm controls the motor speed to insure constant driving speed.

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**OPERATION.** To operate the Tacky Roller Film Cleaner, accomplish the following steps:

1. Turn the transport speed knob counterclockwise to zero and engage the transport switch.

2. Turn the static-eliminator switch to the ON position by pressing the upper portion of the switch. This switch is interlocked with the film-transport switch and allows the static eliminator to commence operating when the transport system is energized. The cleaning unit can be operated without the static eliminator, but this is not recommended due to the intense static charge generated by the two tacky rollers.

3. Energize the transport system by pressing the upper portion of the film transport switch.

4. Turn the transport speed control knob clockwise to obtain the desired operating speed. Maximum cleaning is obtained with the slower operating speeds.

5. As a safety precaution, turn the transport speed control knob to zero before deenergizing the transport drive.

6. The cleaning unit should be covered when not in use to reduce outside contamination.

**MAINTENANCE.** The preventive maintenance outlined in this section is to be performed by the operator. All major overhaul must be done by maintenance personnel.

Lubrication. All bearings in this unit have been factory lubricated and should require no additional lubrication for approximately 1000 hours of operation. A [illegible] of graphite grease is normally [illegible] drive motor gearbox shaft should [illegible] oil such as SAE-10/20.

Cleaning. [illegible] with nonstatic [illegible]

[illegible] should be cleaned [illegible] frequently to prevent [illegible] in the roller.

CAUTION

Use extreme care when handling the tacky rollers. The material is extremely soft and can be easily

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damaged. Handle the rollers only by the outer edges to avoid damage by finger prints. Store the rollers in a vertical position. Under no condition should the rollers ever be stored horizontally, or in contact with any surface.

To remove the rollers, open the "Plexiglas" door, grasp a roller firmly by the end, pull the roller retaining knob, and lift out the roller. Clean the rollers by washing them in lukewarm water. If available, use distilled water. Do not use a soap-base cleaner. Dry the rollers with a stream of compressed air. NEVER use cloth or similar materials for drying rollers.

Removal of the "Plexiglas" Cabinet. To remove the cabinet, first disconnect the static-eliminator cable at the static bar, then remove all the round head screws which fasten the "Plexiglas" to the metal housing.

Next, remove the "Plexiglas" housing by slowly lifting it from the main frame. The base of the cleaning cabinet should remain attached to the housing.

Tracking. Tracking can be corrected by loosening the four bearing block retainer screws at the end of each tacky roller, and making adjustments in small increments.

Adjustment. A manual clutch is located under the metal housing on the supply-spool side of the machine. The clutch is adjusted at the factory and should require little or no adjustment. However, when necessary, clutch adjustment is accomplished by turning the knurled knob clockwise to increase tension and counterclockwise to reduce tension.

Fuses. A 1-amp and 2-amp "Slo-Blo" fuse are located under the floor of the cleaning compartment. To replace these fuses, remove the tacky rollers, remove the round head screws holding the compartment floor, and then lift out the floor.

REVIEW QUESTIONS

DO NOT WRITE IN THIS SW - USE A SEPARATE SHEET OF PAPER.

1. What is the purpose of primary film breakdown?

2. Why is leader and trailer material spliced on each roll after primary breakdown?

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3. How does an appropriate editing table enhance film editing?

4. Following is a list of sequences that might be found on a roll of aerial original negatives. Indicate which sequences might be considered unwanted footage.

   a. Completely fogged film.

   b. A sequence of closeup flight line exposures.

   c. A sequence of cloud cover.

   d. A sequence containing a railhead.

   e. A sequence of dense foliage.

   f. Several frames of a missile site.

   g. A sequence of closeup flight line exposures.

5. Why are ground and air clearing frames deleted from the roll during roll film breakdown?

6. Should all air clearance footage be removed from the aerial film roll regardless of the type of mission?

7. Should all ground clearance footage be removed from the aerial film roll regardless of the type of mission?

8. Operating directives require that a continuous, unspliced roll of ON containing three targets be forwarded to higher headquarters. Between targets two and three, there are approximately 100 frames of air clearance. Furthermore, a processor malfunction resulted in a three inch (7.6 cm) tear in this air clearance area. How should this situation be handled?

9. What method is used to attach leader strips to motion picture material?

10. What method is used to attach friskets to aerial reconnaissance material?

11. What are the purposes for attaching frisket or leader materials to roll film?

12. What size film can be titled on the Dual Head Titler?

13. Explain the "printing" system on the Dual Head Titler.

14. How are the counter and type heads heated on the Dual Head Titler?

15. What can happen if the type heads are too hot?

16. How fast can film be titled on the Delaware titler?

17. Explain what would cause embossing of the film during titling.

18. How much pressure is required to operate the Dual Head and Delaware titlers?

19. Why must the printer heads on the Dual Head Titler be in the raised position for shutdown?

20. How long does it take for the printer heads and the lead type to reach printing temperature?

21. On what side of the film is the titling placed, using conventional aerial photography?

22. Can the triskets be hand titled?

23. What is the maximum number of lines that can be titled on aerial film?

24. What is the purpose of the Taconic Tacky Roll Cleaner and the Tacky Roller Cleaner?

25. What size film can be cleaned on the Tacky Roller film cleaner and the Taconic Tacky Roll Cleaner?

26. Explain the method used to clean the tacky rollers.

27. Why is it undesirable to lay a tacky roller down for long periods of time?

PRACTICAL EXERCISES

EXERCISE I

PROCEDURES

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1. An RF-4C assigned to the 69th TRS took off at 0830Z on 25 October 1977. The aircraft was equipped with K-38 cameras in a split fan configuration (F-21), 24 inch (610 mm) focal length, serial number 762. It was the fifth mission flown at 15,000 feet (4,572 m). It was a clear day over the target. The target was located at 19° 05' south and 155° 10' west of Hawaii. It was an unclassified project with the code name "Pineapple."

2. List it as it would appear titled on aerial reconnaissance film. Use a separate sheet of paper.

3. List it as it would appear annotated on head and tail friskets. Use a separate sheet of paper.

## EXERCISE II

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Frisket Material | As needed |
| Splicing Tape | As needed |
| Editing Table | 2/class |
| Aerial Roll Film | As needed |

PROCEDURES

1. Annotate friskets with the proper information about the mission from Exercise I.

2. Remove unwanted footage from film.

3. Attach head frisket.

4. Postinspect film for defects.

5. Attach tail frisket.

6. Fill out the inspection report.

EXERCISE III

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Dual Head Titler | 1/class |
| Aerial Roll Film | As needed |
| Lead Type | As needed |

PROCEDURES

1. Set up titler for operation in accordance with procedures outlined in SW.

2. Set up type in accordance with the instructor's directions.

3. Title the film. Use scrap film for practice.

EXERCISE IV

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Delaware Portable Titler | 1/class |
| Aerial Film | As needed |
| Lead Type | As needed |

PROCEDURES

1. Set up titler for operation IAW procedures outlined in this SW.

2. Set up type IAW the instructor's directions.

3. Title the film.

EXERCISE V

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Taconic Tacky Roll Cleaner | 1/class |
| Aerial Roll Film | 1/student |

PROCEDURES

1. Prepare the film cleaner for operation as outlined in this SW. Accomplish mechanical inspection (certification).

2. Thread the film cleaner and clean film using this SW as a reference. Practice on scrap film before attempting the objective.

3. Shut down the film cleaner and perform cleanup using this SW for proper procedure.

EXERCISE VI

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Tacky Roller Film Cleaner | 1/class |
| Aerial Roll Film | 1/student |

PROCEDURES

1. Prepare the film cleaner for operation as outlined in this SW. Accomplish mechanical inspection.

2. Thread the film cleaner and clean film using this SW as a reference. Practice on scrap film before attempting the objective.

3. Shut down the film cleaner and perform cleanup using this SW for proper procedures.

Technical Training

Continuous Photoprocessing Specialist

# AERIAL FILM DUPLICATION

October 1977

3400TH TECHNICAL TRAINING WING
3430th Technical Training Group
Lowry Air Force Base, Colorado

Designed For ATC Course Use

DO NOT USE ON THE JOB

# NONDODGING CONTINUOUS PRINTING

## OBJECTIVE

Using an EN-86A Niagara Continuous Printer and Versamat 11CM Processor, duplicate a roll of previously processed film. Finished product must be free of chemical and physical defects and have acceptable density and contrast.

## INTRODUCTION

Continuous printing is one of the primary tasks of a continuous photoprocessing specialist. Whether you are making a positive transparency from the original negative, or a duplicate negative from the positive, it is imperative that any loss of information be held to an absolute minimum. The image must not be degraded. Printing is an exact science. Thus, utmost control must be maintained, so that little or no loss of intelligence occurs.

## INFORMATION

### THE NIAGARA PRINTER

The Niagara Printer, EN-86A, is a high resolution, low distortion printer designed to produce duplicate film at an operating speed of 100 feet per minute (30.5 mpm) of continuous rolls in lengths up to 1000 feet (304.8 m). Figure 1-1 shows an overall view of the printer. Used under darkroom conditions, this printer can reproduce any width of film 70mm to 9.5 inches (24.1 cm). It is indexed for 70mm, 5-inch (12.7 cm), 6.6-inch (16.8 cm), 8-inch (20.3 cm) and 9.5-inch (24.1 cm) film wound on standard USAF roll film aerial spools.

The Niagara is designed to print up to three widths of 70mm film on a single 9.5 inch (24.1 cm) rawstock.

### Description of Printer

LOWER CABINET. A lower cabinet supports an upper cabinet and a mechanism plate. The cabinet is mounted on four locking casters for easy mobility. A control panel (figure 1-2) containing all operating controls, is mounted on the front of the lower cabinet. The cabinet contains two drawers and a single door storage space with one adjustable shelf. Printing masks and a spindle adjusting scale are stored

Supersedes SW 3ABR23330-IV, October 1973

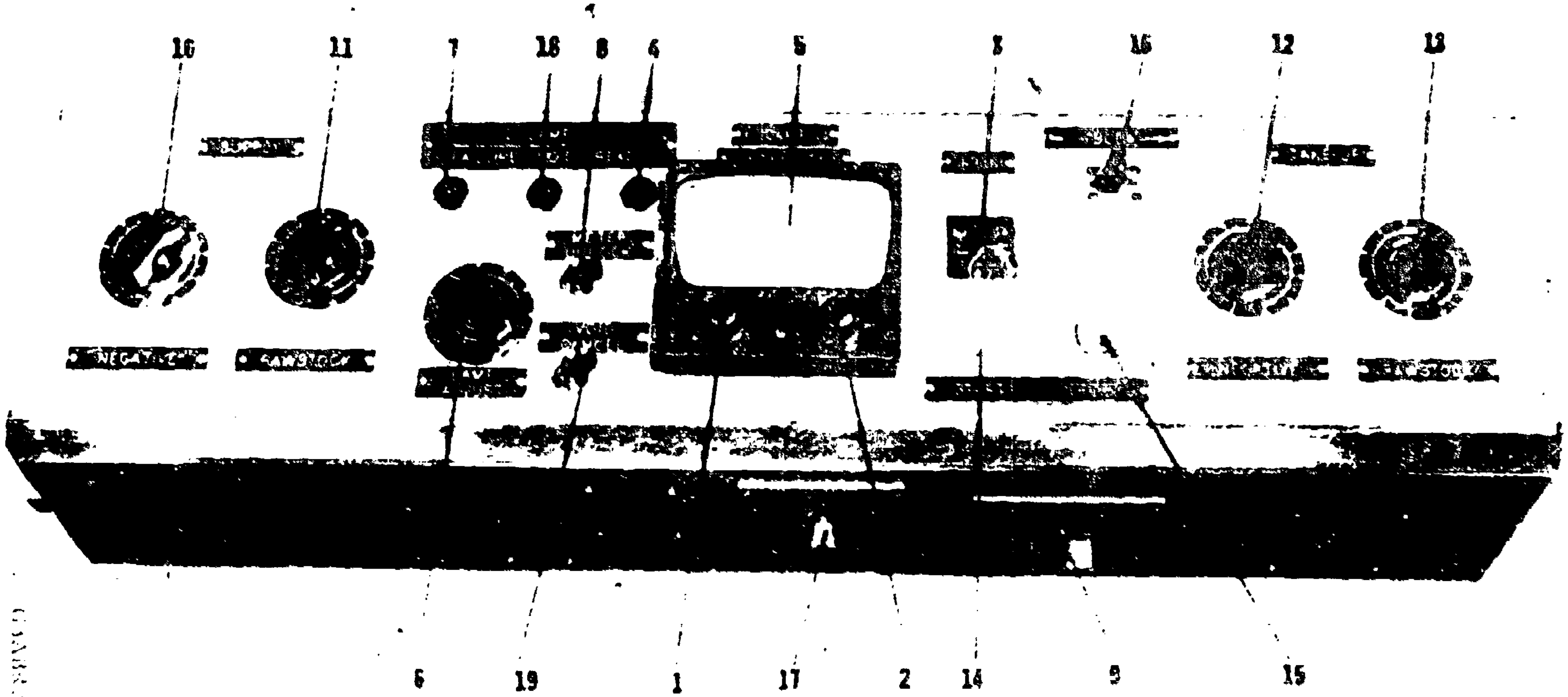

Figure 1-2. Controls and Indicators

1. Knob
2. Knob
3. MAIN Switch
4. LAMP READY Light
5. LAMP INTENSITY Meter
6. LAMP ADJUST Knob
7. LAMP FAILURE Light
8. METER UNLOCK Button
9. LAMP VOLTAGE Selector Switch
10. NEGATIVE SUPPLY Torque Motor Control Switch
11. RAWSTOCK SUPPLY Torque Motor Control Knob
12. NEGATIVE TAKEUP Torque Motor Control Knob
13. RAWSTOCK TAKEUP Torque Motor Control Knob
14. START Button
15. STOP Button
16. SLEW Switch
17. VOID Button
18. LAMP VOID Light
19. VOID CANCEL Button

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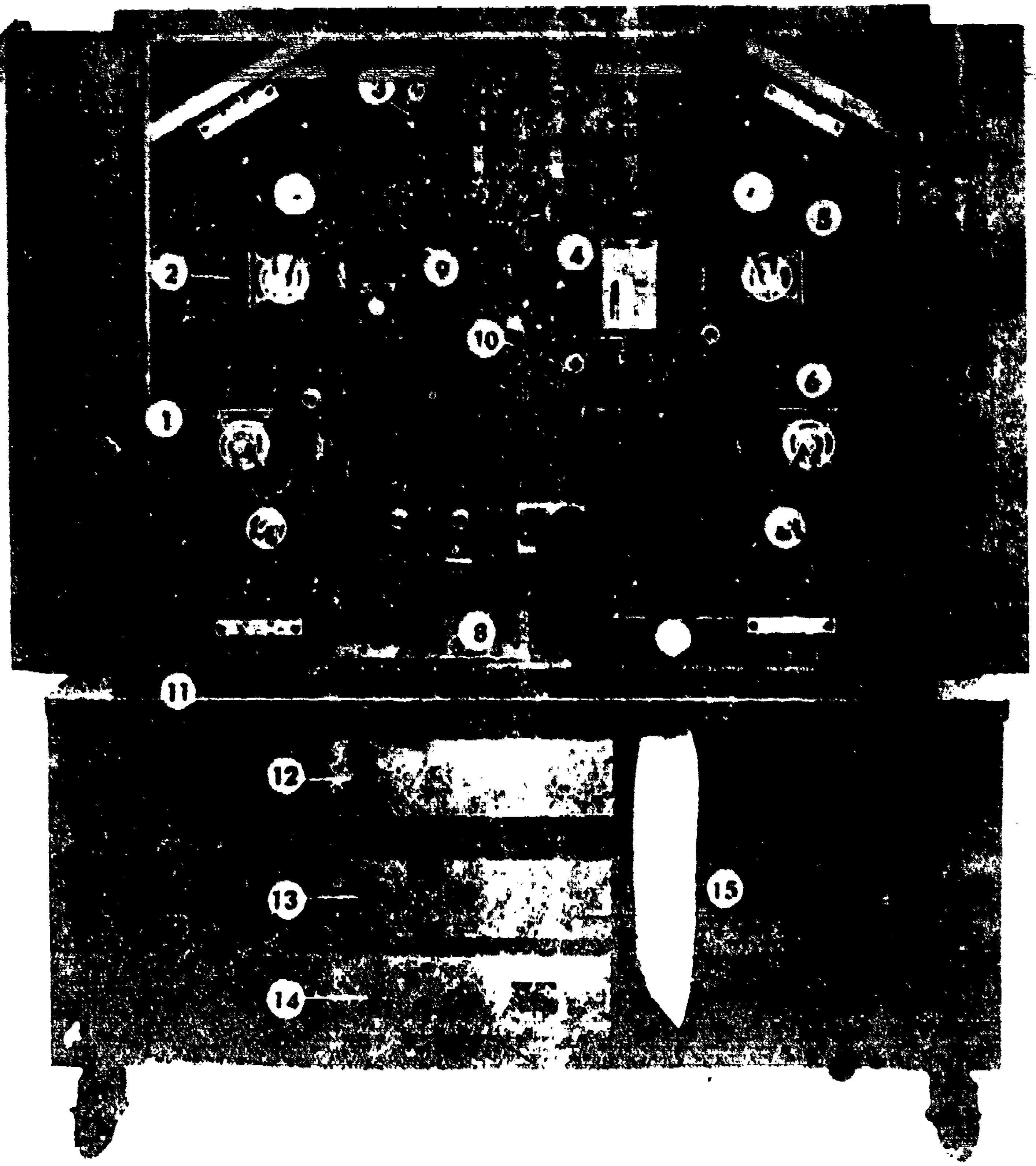


[illegible]

1. [illegible]
2. [illegible]
3. Blower for Air Cooling, Lamp [illegible]
4. Negative Static Eliminator [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible] Static Eliminator [illegible]

[illegible]

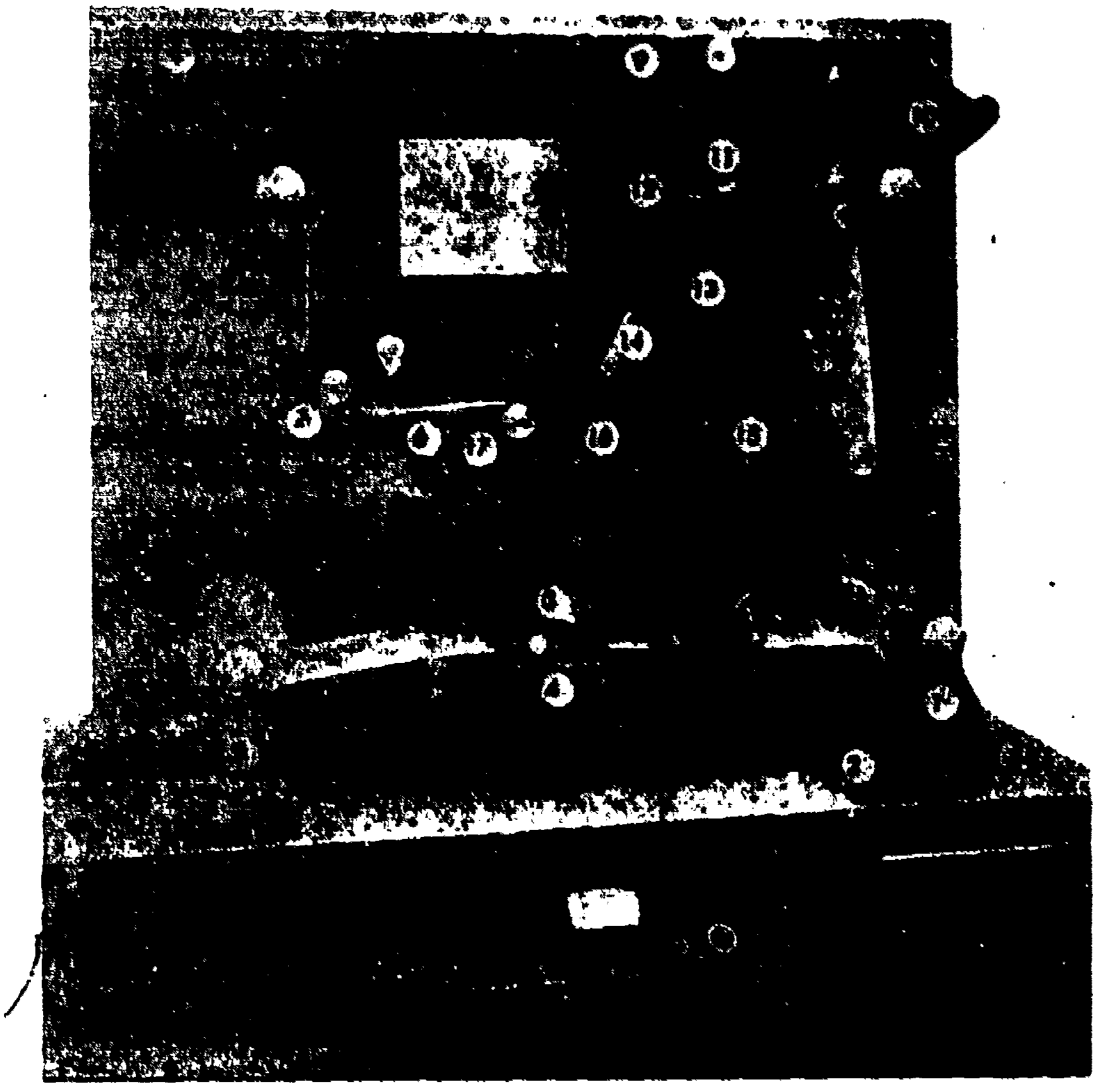


Figure 1-4. ES86A Niagara Printer

1. [illegible]
2. [illegible]
3. [illegible] Rotating [illegible]
4. [illegible]
5. [illegible]
6. Viewer [illegible]
7. Negative Dust and Static Removal Unit
8. Negative Supply Bracket
9. Viewing Guide Roller
10. Negative Takeup Bracket
11. Special Filter Positioning Lever
12. Lamp Housing
13. Variable Density Adjusting Knob
14. Pressure Roller Positioning Lever
15. Printing and Main Drive Drum
16. Rubber-Coated Pressure Roller
17. Viewer

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on the upper drawer. Three electrical control chassis and a dust collector bag for the dust and static removal units are accessible through a panel in the rear center of the cabinet. The upper chassis and its component parts which are pictured in Figure 1-3 [illegible] the light and motor control chassis and furnishes electrical power for the various motors and constant direct current voltage for the printing lamps. The lower chassis is a 1000 watt [illegible] regulator chassis which supplies [illegible]

UPPER CABINET. An upper cabinet is securely fastened to the lower cabinet. This cabinet supports the [illegible] blower for the dust and static removal units, the static [illegible] power packs, four torque motors, [illegible] and all electrical connections [illegible] Access to these components is through [illegible] cabinet. Both doors are provided with elec[illegible] cancel all power to the cabinet when [illegible]

MECHANISM PLATE. [illegible] mechanism plate are shown in figure [illegible] back of the 5/8 inch [illegible] shown in figure 1-3.

[illegible]

[illegible] side of the negative. The [illegible] [illegible] inductor bars [illegible]

... intake side of a blower which removes dirt and ... particles. The blower deposits particles in a storage bag in ...

... AND TRANSPORT SYSTEM. The film drive and transport ... components:

... spindles are driven by individual torque ... spindles for the negative are located at the top corners ... are located at the bottom ... on the left side ... the right side spindles ... adjustable to fit spool width.

... printing drum is driven ... in a clockwise ...

... on the supply ... films together ... the two ... the air is re- ... two strands of material ... during the printing opera-

... the pressure roller. With the ... drum in the printing position ... away from the drum in the ... interlock is installed in the ... mechanism to prevent printer operation if ... Also, the interlock operates ... the roller is left in the operating ... turned Off. This signal insures that ... remain in contact with ... and thereby prevents formation of

... guide the negative and

... mounted over the lamp house. This ... support when negative ... supply and takeup spools in either ... rapid movement of the ... printing. When the negative is to be ... pressure roller must be released, the negative unthreaded ... rollers and printing drum, and then placed on the slewing ... Upon completion of the slewing operation, the negative

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must be rethreaded around the idler [illegible] the printing operation can be resumed.

Preoperational Procedures for the Niagara [illegible]

To prepare the printer for operation, the MAIN POWER switch is turned to the ON position. After [illegible] minute delay which allows the printing lamp [illegible] if it is necessary to test printer operat[illegible] without waiting for the lamp to stabilize.

By pressing the lamp INTERLOCK [illegible] button, the printer [illegible] operable for test purposes. When the lamp INTERLOCK [illegible] pressed, the LAMP [illegible] light illuminates [illegible] is still in the first eight minute [illegible] operation has been performed, the LAMP [illegible] out without pressing the [illegible] warm up period is completed.

Before an actual printing [illegible] certain settings that must be [illegible]

[illegible]

shaf[illegible] the [illegible] locating [illegible] this operation, a scale is provided [illegible] mechanism [illegible] All four spindles [illegible]


[illegible] Threaded Collar
Spindle Shaft

Figure 1-5. Spindle Adjustment

Figure 1-6. Checking Position of Spool Inner Flange with Scale

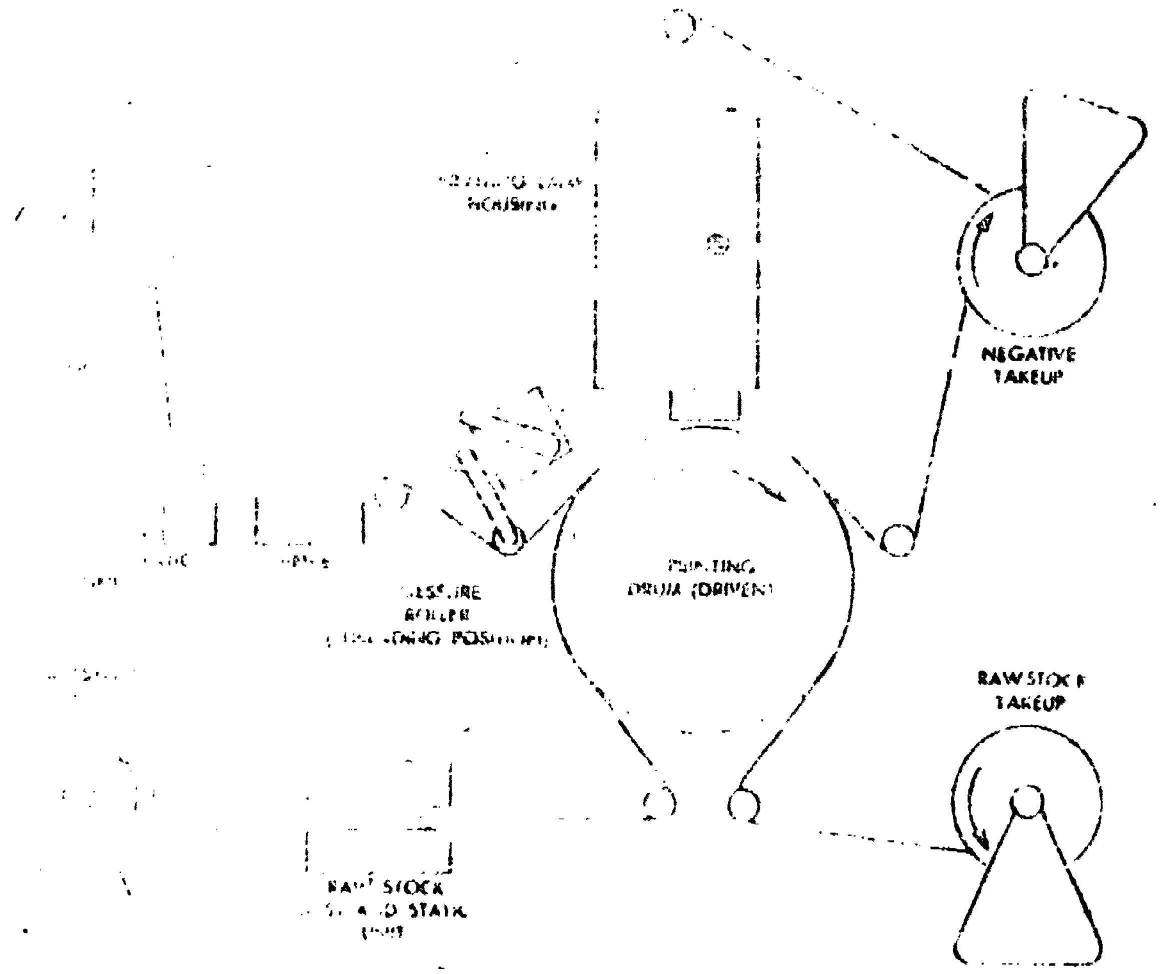
The outboard supports for all supply and takeup spools are spring loaded toward the mechanism plate and will accommodate any spool size from 70mm to 9.5 inch (241 cm). Travel of each outboard support is limited by a holding clamp on one shaft. When printing large quantities of one-width film, set and tighten the clamp about an inch (2.5cm) away from the rubber stop on the mechanism plate after a spool is placed in the spindle-support bracket. The protruding portion of this clamp must be positioned away from the spool (to avoid scratching the product). When the spool is removed, the gap between [illegible] spindle will remain just under the desired width.

ADJUST TORQUE CONTROLS. After adjusting the spindles and support brackets, the Variac control knobs must be set. This provides the proper torque for the supply and takeup spindles [illegible] and rawstock material. The torque for these supply [illegible] motors must be precisely adjusted. The use of improper [illegible] cause decreased resolution in the duplicating material [illegible] slippage. It can also cause the material to track [illegible] 1-1 for the proper settings of these control [illegible].

| [illegible] WIDTHS | RAW STOCK SUPPLY | NEGATIVE [illegible] | RAW STOCK [illegible] | [illegible] |
|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | | |
| [illegible] | [illegible] | [illegible] | [illegible] | |
| [illegible] inch ([illegible]) | [illegible] | [illegible] | [illegible] | |
| [illegible] | | | | |
| 9.5-inch (24.1 cm) | [illegible] | | | |

Table 1-1. Recommended [illegible]

... NEGATIVE AND RAWSTOCK. Referring to the Threading ... Figure 1-7, place a spool of rawstock on the lower supply ... so that it feeds off the bottom of the spool with the emulsion ... the rawstock over the left guide roller, through the dust and static eliminator unit, under the second guide roller, over the printing drum, under the right guide roller and onto the bottom of ... spool so that it is wound emulsion in.




... Threading Diagram for Niagara Printer

... negative on the upper supply spindle so that ... off of the spool with the emulsion down. Press the ... under the left guide roller, over the static eliminator unit, ... over the next guide roller, under the pressure roller, ... the printing drum (superimposed on the rawstock) under the next guide roller and onto the top of the takeup spool so that it is wound emulsion in.

The pressure roller control lever should be horizontal for threading and vertical for operation. An interlock prevents the printer from operating if the control lever is not in the vertical position.

When the printer is properly threaded, the emulsion of the negative and the emulsion of the rawstock are in contact on the printing drum. The negative is threaded emulsion [illegible], and the rawstock is threaded emulsion up.

INSERT MASKS. The printer is equipped with a set of masks which are stored in the top right drawer in the printer's base. There is a mask for each width of material for which the printer has been indexed. The sizes are marked on the front edge of [illegible] mask as follows: 9.5, 8, 6.6, [illegible] and since [illegible] three strands on 9.5-inch (24.1cm) rawstock, there are three [illegible] masks: 70-[illegible], 70-CTR, and 70 [illegible].

Select the proper mask and insert it [illegible] the lamp housing. The edge of the mask must engage the [illegible] smoothly and be shoved completely into place [illegible] the permanent magnet which holds it in position.

ADJUST VARIABLE NEUTRAL [illegible]. The variable [illegible] density [illegible] is located [illegible] lamp housing. [illegible] adjusted to [illegible] [illegible]

[illegible]

This ultraviolet transmitting [illegible] Kodak Aerial Duplicating Film 2420. This [illegible] an increase of resolution [illegible] improved image sharpness.

ADJUST PRINTING LAMP INTENSITY. Lamp intensity for optimum [illegible] is factory set and the meter is calibrated to zero at [illegible]. As the lamp is used, a gradual deposit of mercury [illegible] on the inside of the glass. This interferes with the passage of light and cuts down the available illumination. Two control knobs, one on the left of, and the other underneath the panel, can increase voltage to the lamp and bring illumination up to the required standard. [illegible] to establish the plus and minus limits [illegible] which can be tolerated and still give acceptable exposure.

[illegible] pointers in the LAMP INTENSITY meter at [illegible]. A [illegible] scale deflection indicates ap-[illegible]. The pointers are moved with the two [illegible] meter housing. [illegible] knob controls the left pointer; the right [illegible] right pointer.

[illegible] the photocell in the lamphouse and is [illegible]. If the light intensity drifts out [illegible] operation, the meter locks and the FAILURE light [illegible] can be brought up to tolerance by the lamp [illegible]. The METER UNLOCK button must be pressed before [illegible] adjusting printing lamp in-tensity.

[illegible] green LAMP READY light comes on at the end of the 8-[illegible] lamp stabilization period, the black indicating pointer/in the [illegible] should read 0. If not, adjust to 0 with the LAMP ADJUST knob.

If the lamp should drift out of tolerance any time after the [illegible] period, the red LAMP FAILURE light will come on. In this [illegible] the METER UNLOCK button and adjust the LAMP INTENSITY [illegible] 0 with the LAMP ADJUST knob. When tolerance cannot [illegible] set the LAMP ADJUST knob back to 0 and increase the [illegible] the LAMP VOLTAGE knob under the panel to [illegible] position (LOW to MEDIUM or MEDIUM to HIGH). When lamp tolerance cannot be obtained with these adjustments, replace the lamp.

[illegible]

[illegible] operation of the Niagara printer consists of [illegible]: (1) starting the printer, (2) stopping the printer, (3) three-strand printing, and (4) printer shutdown.

STARTING THE PRINTER. To start the printer, first make

sure the rubber covered pressure roller is in contact with the printing drum. Then, depress the START button. The printer will not start moving the negative and rawstock materials immediately, since there is a five-second delay before printing operation. This five-second delay is to allow the torque motors to takeup the slack. After this five-second delay, the dark shutter opens, the main drive motor starts, and the printing operation begins.

Good tracking must exist at all times during printing. The negative and rawstock materials should track properly if the spring-loaded collars are properly positioned on their respective spindles. However, a tracking problem may develop because of improperly made film splices. Therefore, the splices made in the length of film should be kept to a minimum. Where splices are necessary, they must be well aligned. Improper tracking may also occur if the torque motors are not adjusted to the correct setting.

STOPPING THE PRINTERS. While printing, it may be necessary to stop operation momentarily. To do this, depress the red STOP button. When the stop button is depressed, the torque motors do not deenergize immediately. As with the starting operation, there must be a delay to prevent film slack from developing because [illegible] slack develops, the film could be damaged. [illegible] the torque motors are deenergized [illegible] five se[illegible] [illegible]

[illegible]

[illegible] Insert the mask [illegible]

c Set the variable density filter as described in the previous section.

SW [illegible] 405

o Adjust the negative supply and takeup spindles to the [illegible] position using the procedure described in the previous [illegible]

o Adjust the rawstock supply and takeup spindles to the [illegible] inch (22.1cm) position.

[illegible] 70mm negative and 9.5-inches [illegible] as described in the previous section.

[illegible] according to instructions [illegible]

[illegible] button to stop printing.

[illegible] cut the [illegible] (24.1cm) rawstock at the [illegible] the printer.

[illegible] the 9.5-inch (24.1cm) [illegible] on its outboard portion.

[illegible] spindle positions, place [illegible] spool of [illegible]-inch (24.1cm) rawstock in the [illegible] supply bracket. The exposed strip is now in the inboard [illegible]

o Place [illegible] empty 9.5-inch (24.1cm) spool in the rawstock [illegible] bracket.

[illegible] 9.5-inch (24.1cm) rawstock through the printer [illegible] what is now the outboard portion is unexposed.

[illegible] thread the next length of 70mm negative.

[illegible]

o Push the red STOP button to stop the printer.

[illegible] 9.5-inch (24.1cm) rawstock, now exposed [illegible] from the takeup to the supply bracket.

o Exchange the mask in the lamp housing for the one [illegible]

o Adjust the negative supply and takeup spindles to the 70mm [illegible] position using the procedure described in the previous section.

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- Load and thread the next length of 70mm negative.

- Print

All three strands are not printed, and the 9.5-inch (24.1cm) film may be processed, slit, and [illegible].

PRINTER SHUTDOWN. After all the printing has been completed, shutdown of the Niagara printer must be performed.

One of the most important features of the Niagara is its uncomplicated operation. This is also true for its shutdown procedures. The first shutdown consideration is to stop the operation of the printer transport. This task can be accomplished in any one of three ways. These are: (1) depressing the STOP button, (2) disengaging the pressure roller from the printing drum, and (3) turning the main power switch off. ONLY the first is recommended. Otherwise, the torque motors are not energized for the required five seconds. Once the printer transport has been stopped, shutdown consists simply of turning the MAIN POWER switch off. However, remember that if the MAIN POWER switch is turned off and then on again immediately, an [illegible] cooling period will elapse before the printing lamp will restart. Then an eight minute lamp stabilization period is required before printing can take place. [illegible] all [illegible]

[illegible]

[illegible] printer [illegible]

Clean the camera's [illegible] removal unit in the manner described below.

Weekly. Clean the edges of the rawstock-dust-and-static removal [illegible] and remove any buildup which can trap dirt particles and cause scratches.

Monthly. Remove the covers on the rawstock-dust-and-static unit and remove any accumulation of dust from the covers or inside mechanism. [illegible] the lamp housing cover and dust all parts as required. Check the [illegible] and clean if necessary (See below).

[illegible] and check the air manifold filters. [illegible] replace both filters. Check [illegible] for proper operation. [illegible] and clean or replace.

[illegible] THE [illegible] AND STATIC REMOVAL UNITS. The power packs [illegible] require no [illegible] brushes and inductors on the [illegible] system for any unusual [illegible] particularly necessary if long [illegible] cleaned and neutralized. [illegible] rapidly passing a piece of heavy [illegible] station several times. The printer [illegible] this operation so the blower [illegible] into the filter bag. Accumulation of dust [illegible] static eliminating inductor can be removed [illegible] the brush, be careful not to bend or [illegible] the inductor points which are small, exposed pieces of wire.)

[illegible] the three electrical chassis in [illegible] should be removed and emptied periodically. [illegible] access to the bag is the same as that for the chassis.

[illegible] VARIABLE DENSITY FILTER. Remove the access plate [illegible] of the lamp housing. Turn the filter dial knob [illegible] hand and hold the filter with the left. [illegible] cleaner solution and a clean, lintfree cloth.

[illegible] the above procedure.

[illegible] dial knob must be recalibrated as follows:

[illegible] while handling the filter. Scratches on the filter will cause streaks in the photographic output.

[illegible] Turn the dial knob counterclockwise until it stops.

[illegible] Loosen the three clamping screws on the dial plate.

o Turn the dial plate until the index point above the knob on the front of the lamp housing and the punch mark beyond 1.10 on the dial are lined up.

o Tighten the three screws and the calibration is complete.

This is the extent of the maintenance to be performed by the operator. All other maintenance, including lamp replacement and calibration, should be done by the maintenance section.

Printer Certification

The primary function of any printer is to transfer, with a minimum amount of distortion, degradation, and other losses, the information content of the processed negative to a duplicating material. To insure that the losses will be held to a minimum, the certification consists of a test to insure even illumination and a constant exposure level [illegible], and a test to insure that the printer is not physically degrading the product. The Printer Standardization Master (P/N 1-008 [illegible]) furnished by the manufacturer combines all of these tests in one master so that only one test has to be run (figure [illegible]).

Using any suitable [illegible] reproduce the [illegible] Standardization Master [illegible] set at 1.00, [illegible]

[illegible]

[illegible]

[illegible] given in the specification sheet [illegible] only as a general guide.)

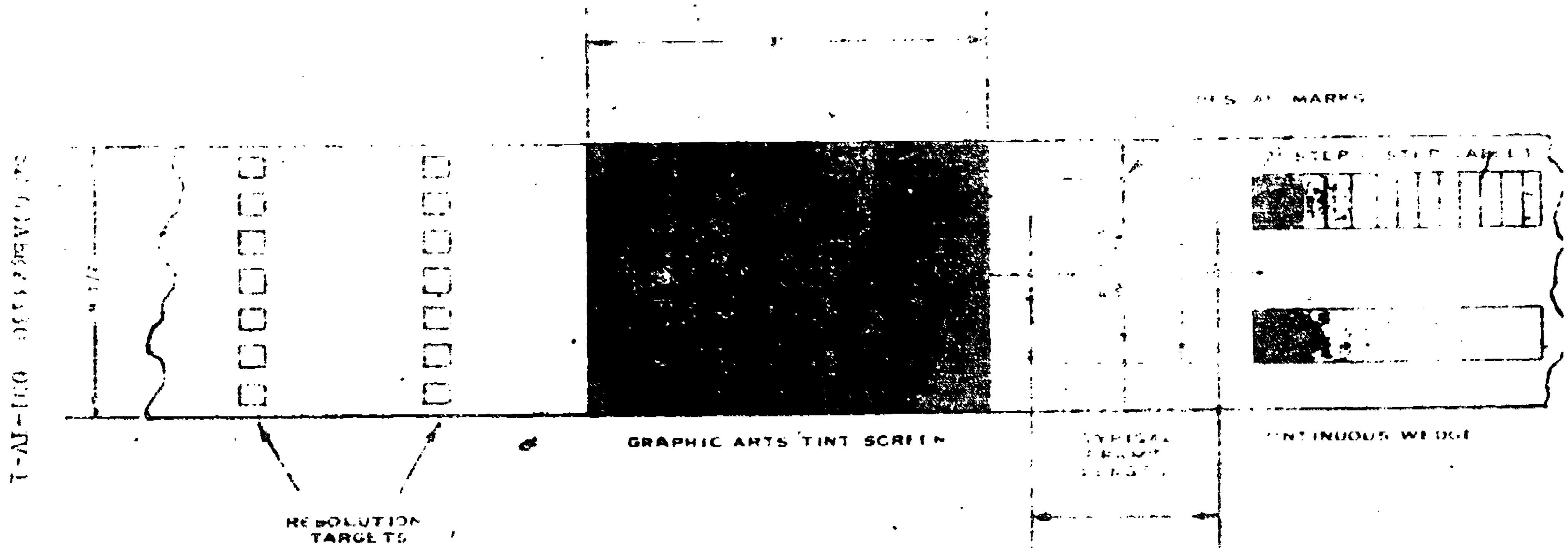



Figure 1-8. A Typical Printer Certification Frisket

If this Standardization Master has been lost or destroyed through continual use, a substitute can be made quite easily. The substitute test is as follows:

o Thread the printer in the normal manner except that a carrier material is used in place of the negative. The carrier material must be free of any physical degradations and should be as transparent as possible. Clear base leader material or processed film which has had all of the emulsion and imagery removed by immersing it in [illegible] bleach (hypochlorite solution) is frequently used for this.

o After the printer has reached its set transport rate, insert a step wedge (dense end first) between the raw stock and carrier material just ahead of the pressure roller. The operator catches the step wedge as it emerges from the [illegible]. Print the step wedge twice in the same manner as the Printer Standardization Master.

The log exposures of the result[illegible] same manner previously described.

Printer Correlation

If the production system is to meet the strict quality standards of a precision processing [illegible], all [illegible] must [illegible] produce at specific [illegible] the range and [illegible] capability of the equipment to meet this requirement [illegible] through the use of correlation.

[illegible]

To correlate [illegible] printers [illegible] procedures are as follows:

1. [illegible]

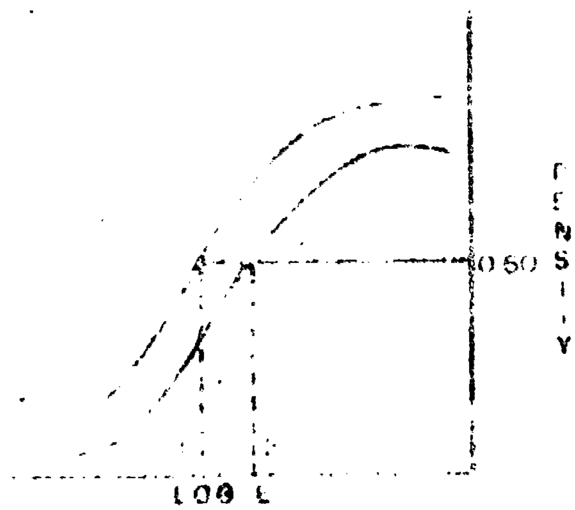
3. [illegible] the Standard Printer, print a step wedge on a roll of [illegible]. Identify this exposure.

4. [illegible] a step wedge on the same roll of rawstock, using identical settings, with each of the printers to be correlated. Identify each exposure on the roll at the time of exposure.

[illegible] roll of material [illegible] a certified processor) [illegible] high gamma (1.[illegible] to 1.25).

[illegible] of each step wedge and plot the characteristic curve for each printer on the same graph. Identify each curve.

6. To compute the [illegible] required to bring the exposure of the printer under test to the same as the Standard Printer, use a density of [illegible] and draw a line through the two curves (see figure [illegible]) [illegible] to the curves where 0.60 lines meet the curves. This will [illegible] you two log Es. Find the change by finding the difference between the two log Es. This will be your required change.




LOG $E_2$
−LOG $E_1$
Δ LOG E REQUIRED

[illegible] 9. Printer Curves

7. The LAMP INTENSITY meter scale indicates a change of + 10 percent and − 10 percent which are approximately equal to a log E change of + 0.10 and − 0.10. Turn the LAMP ADJUST knob until the LAMP INTENSITY meter pointer indicates the required setting for the desired shift in LOG E.

8. Repeat steps 2 through 5 and check to determine how close the printers now correlate. They must correlate to within a ± 0.05 density units.

9. When the printer has been correlated to within this tolerance, adjust the recessed potentiometer screw, which is located just to the left of the VOID button, until the LAMP INTENSITY meter reads zero.

## AERIAL FILM DUPLICATION

There is a continuing need in the Air Force for duplications of aerial reconnaissance film. In some labs, duplication is the major part of the work-load. The overall objective of a duplication system is to insure that a maximum amount of intelligence information is retained.

Since it is not economical to make test exposures on each roll of film, both from the standpoint of material and manhours, a method of control must be found which will produce acceptable results most efficiently. As a result, a trigradient tone control system, based on sound sensitometric and statistical methods, was developed. This SW outlines how to construct a trigradient tone control system and [illegible] use it for determining proper printing exposures.

### Materials [illegible] Photographic Duplication

[illegible] the proper [illegible] materials [illegible] photographic reproduction [illegible] be done. Also, the materials [illegible]

[illegible] variables, it must be [illegible] process variables.

A first consideration, that of materials, is treated generally [illegible]

~~OPAQUE REPRODUCTION MATERIALS. Opaque materials are available~~ in two primary mediums -- numbered or graded contrasts and variable contrasts -- each medium having certain advantages. Numbered contrasts are useful when the original negatives being produced are all of one contrast. However, since the originals are not exposed under controlled conditions, results are varied. Using a variable contrast material makes it necessary to stock only one paper. Comparing the sensitometric curve of transparency materials with that of opaque materials, it is found that the former varies with each material and gamma infinity is rather hard to obtain, while opaque materials reach gamma infinity rather quickly with less evident change in gamma.

Paper is also available in roll form and is used when prints are needed of an entire roll of film.

TRANSPARENCY MATERIALS. These cover a wide variety of photographic materials which are coated on transparent or semitransparent bases. The most common of these are coated on conventional film bases, but others may be coated on glass or other photographically inert material. Characteristics of base, as well as the physical characteristics of the emulsion, vary according to usage and manufacturing specifications. The most widely used transparency bases employ conventional acetate, triacetate or polyester materials. Emulsion types may be generally divided into two classes, normal and high definition. In the former class are materials such as Eastman Kodak Type 2427, 8427, and DuPont 228R. Their definition is adequate for all but highly specialized applications, and their characteristics lend themselves to the majority of conventional reproduction requirements. The second class of materials is that of very high definition material. At this time only one product is currently on the market--that is Eastman Kodak Type 8430 (formerly SO 278). However, there are several special-order emulsions which may be capable of even greater definition. These materials are suitable for specialized duplication of original negatives possessing very high definition and are suited to many precise reproduction functions.

The tone controls that are discussed in this SW are related to normal definition transparent materials.

Tone Reproduction

The photographic image can be seen because of the different tones that are present within the various areas. The photographic image is a copy of the original subject, due to the close relationship between the tones of the image and the luminance of the original.

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This close relationship is referred to as "tone reproduction."

A photoprocessing specialist knows that a number of steps are needed before a photographic reproduction is finished. Someone else exposes the negative of the original scene, but the photoprocessor will be called upon to process the film. Once the film is processed, either contact or projection prints must be made from the negative. In each of these steps, it must be ensured that the maximum amount of intelligence information is retained.

Two requirements that must be met, if this intelligence information is to be retained, when duplicating are:

1. The straight line portion of the characteristic curve of the printing material must be used. For most duplicating films, the straight line lies between densities of 0.40 to 1.80. Thus, in the duplicate, the minimum density should be close to 0.40 and the maximum density should be no more than 1.80.

2. The density difference between the highlight and shadow should fall between 0.80 and 1.20, ideally near 1.00.

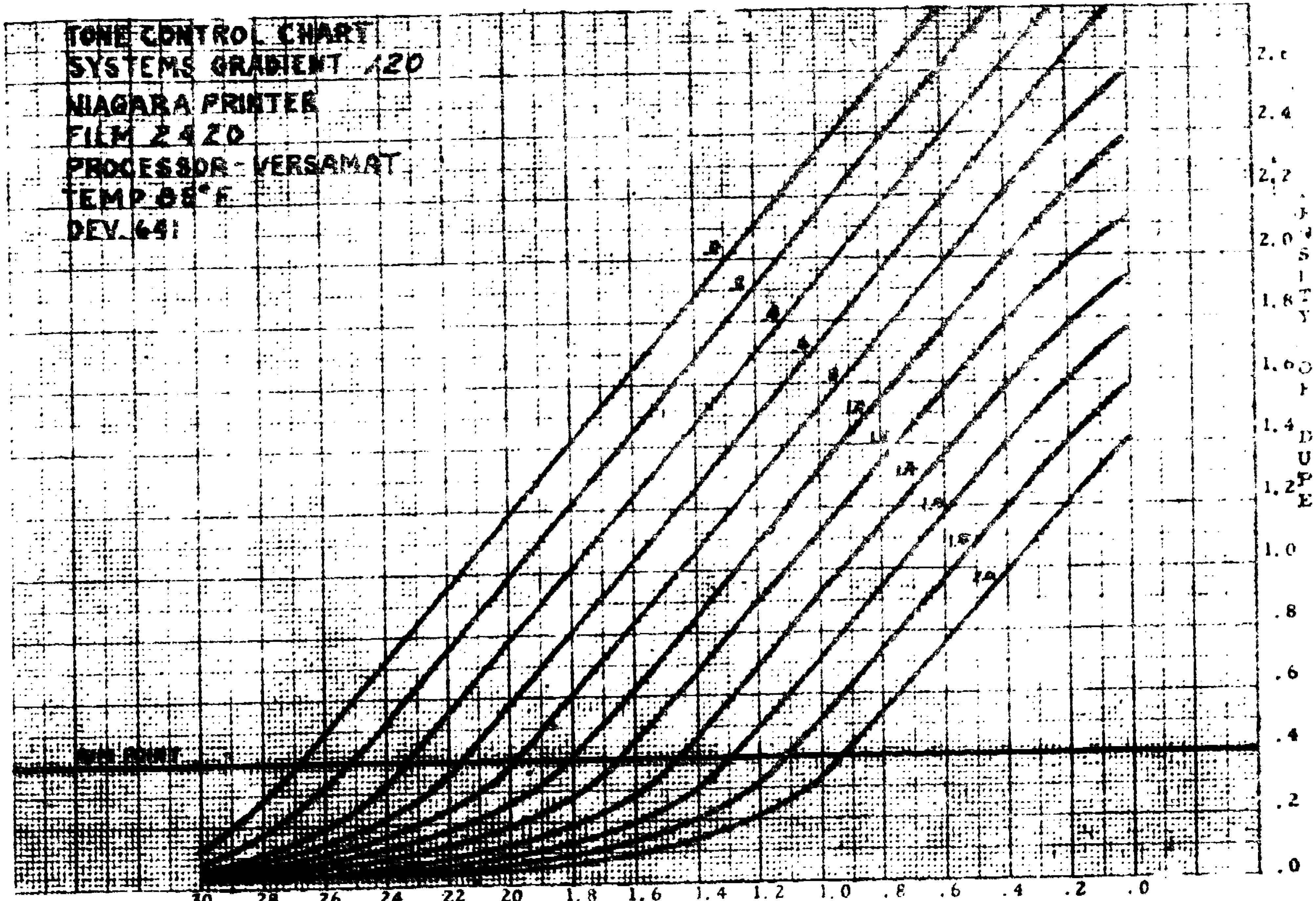
The first requirement will be met if the exposure level of the printer is correct. The second will be met if the processing is correct.

In order to achieve these goals, some form of tone control must be used to guide the printing and processing operations. The duplicating of aerial reconnaissance film requires that exacting standards and control be used to ensure that the image is of the highest possible quality.

Trigradient Tone Control System

The trigradient tone control system is considered to be a most flexible procedure for determining printing and processing requirements. As the name implies, this method enables the photoprocessor to select one of three standardized processors, each producing a different contrast. The choice of process is dependent upon whether the density range of the duplicate should be increased, maintained, or decreased. The trigradient tone control system enables one to change the density range in each generation of reproduction. In this way the final product provides the desired tonal values.

The heart of the tone reproduction method is the set of tone control curves. Each set (high, medium, and low contrast) consists of a series of characteristic curves which illustrate the tones that are produced in the duplicate image when a step wedge is printed




DENSITY OF ORIGINAL

Figure I-10. Systems Gradient 1.20

under various conditions. Figure 1-10 illustrates a set of tone control curves that has been printed, using a Niagara printer. Each curve is labeled with the amount of neutral density that was used in that particular operation. All other major variables, such as printer lamp luminance, printer transport speed, emulsion characteristics, and processing conditions were standardized.

PREPARATION OF TONE CONTROL CURVES. The preparation of a set of tone control curves must be accomplished with the utmost care. Since each set of tone control curves is valid for only one standardized process, a separate set must be prepared for each type of duplicating film, each printer, and each processor used.

Normally, these sets of tone control curves (representing low, medium, and high contrast), are prepared for each major film-processor combination.

The first task in preparing tone control curves is to select the equipment and materials to be used and to establish appropriate processing standards.

The equipment used will be the Niagara printer and the Versamat film processor. The duplication material used will either be Kodak Aerial Duplicating Film 2420 or Du Pont Aerial Duplicating Film 22SR.

After the components of the process have been selected, sensitometric tests must be conducted to determine the process gamma curve that will produce the desired sensitometric results. For the tri-gradient system, the process [illegible] must be established for each of the three tone control curves. The average gradients which [illegible] gradient [illegible] system are:

[illegible] to maintain the present density range in duplicate.

[illegible] decrease [illegible]

[illegible] High contrast [illegible] to increase the density range [illegible]

The values for each gradient (low, medium, and high) may vary from unit to unit. The desired contrasts of the three sets of tone control curves are selected on the basis of the quality of the imagery which the facility is normally called upon to duplicate. If the density range of the imagery is usually [illegible]

the average would be minor, such as gradients 0.90, 1.00, and 1.25. If the density ranges vary greatly, then the contrasts selected would produce major changes in the density range, such as 0.70, 1.00, and 1.75.

All of the sensitometric strips used in the preparation of the tone control curves and the appropriate gradients, must be exposed with the Niagara printer. Generally speaking, there is a gamma difference between sensitometric strips exposed on a sensitometer [illegible] exposed by the use of a continuous printer. [illegible] the spectral quality of the two light sources.

[illegible] using strips that have been exposed on the sensitometer because the sensitometer is more convenient for use. The gamma obtained from these sensitometer strips is called process gamma. The gamma produced from the strips printed on a continuous printer is known as the systems gradient. This is the actual output of the combined printed-processor system.

The average system gradient is determined by the use of a machine speed gradient chart. The chart is made with the printer, processor and material. To make the chart, use the Niagara as a sensitometer and then follow the same procedures for making a machine speed-gamma chart. Then use the chart to determine which machine speed will give the desired gradient (.80, 1.00, or 1.20).

After making a machine speed-gradient chart, select the machine speeds necessary to produce the three desired gradients [illegible] and high. You are now ready to print the tone controls.

The printer is threaded with a roll of clean leader, which [illegible] spliced into it, in the negative position. A [illegible] of rawstock of the specified emulsion is threaded in the lower position. The printer transport system is engaged and an exposure is made as the step wedge (inserted dense end first) and the rawstock pass under the printing aperture. The transport [illegible] stopped and the location of the exposure is marked on the roll of rawstock. This process is repeated until all of the necessary exposures for a given set of tone control curves have been made on one roll of rawstock.

When using the Niagara printer to produce the tone control curves, simply rotate the neutral density dial to vary the exposures. Begin with neutral density dial set to 0.00 (no filter

at all) and progress in increments of 0.10 until a neutral density of 1.00 has been reached. Then insert a bias filter with a value of 1.00 above the printing mask. Rotate the dial back to 0.10 neutral density and make a second set of exposures. This will give a total of 11 exposures ranging from 0.00 to 2.00 neutral density. Then process the roll of exposures.

PROCESSING TONE CONTROL CURVES FILM SAMPLES. The processing of the sensitometric images from which the tone control curves are made is indeed critical. Sloppy processing techniques could ruin the work accomplished on the printer and destroy the tone control program. Make sure the machine has been certified both chemically and mechanically. Do not begin processing until the temperature, transport rate, replenishment, etc., are set accurately. (The transport rate is determined by the machine speed-gradient chart.)

PLOTTING TONE CONTROL CURVES. The curves for the trigradient tone control system are plotted similarly to the characteristic curves used to determine gamma. The only difference is that the tone control curves are plotted as density versus density. Take a moment and study the graph in figure 1-11. Along the horizontal axis, going from right to left, find the DENSITY OF ORIGINAL. The density values marked along the horizontal axis are obtained from the step wedge used to make the exposures. Along the vertical axis at the right side of the graph, find the DENSITY OF DUPE. These densities will be those produced by the step wedge in conj[illegible] with the neutral density filter.

Plot all 11 systems gradient curves on one graph. Place the following information on each graph:

[illegible]

Printer used

[illegible]

[illegible]

[illegible]

Processing temperature

Developer used

[illegible]

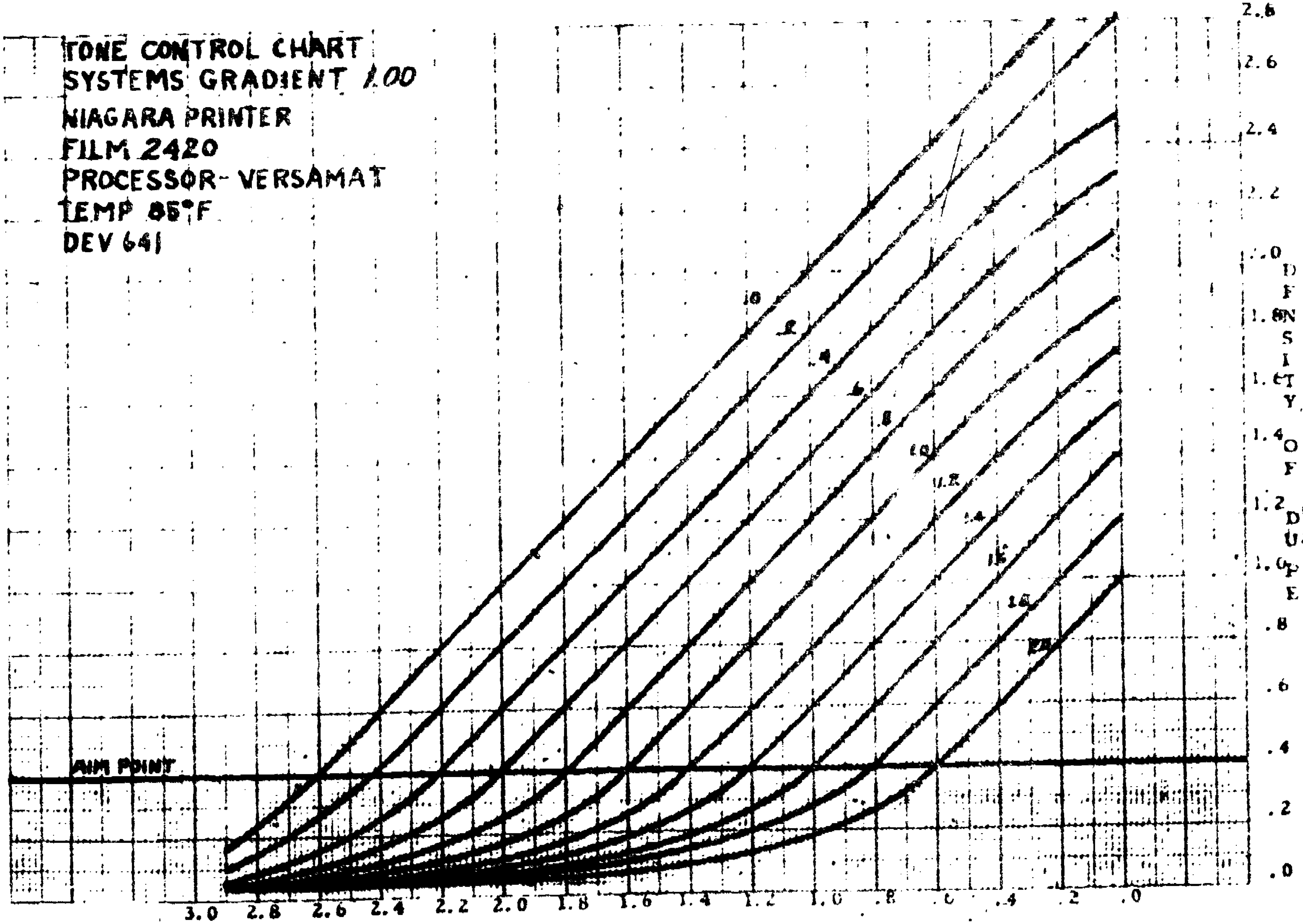



Figure 1-11. Systems Gradient 1.00

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In addition to this information, each curve must be identified by the neutral density filter used to produce that particular curve. Also, the aim point should be located. This aim point depends upon the standards of the laboratory. For most duplicating operations, a good aim point is 0.20 to 0.30 above the base-plus fog density of the duplication material. This will usually place the aim point between 0.25 and 0.40.

When the graphs have been plotted for each systems gradient they can be used to determine the exposure and process needed to duplicate a roll of aerial negatives.

USING TONE CONTROL CURVES TO COMPUTE PRINTING AND PROCESSING REQUIREMENTS. The computation of the printing and processing requirements involves the performance of three tasks:

o Densitometric evaluation of the original negative to determine the useful D-min and D-max values.

o Selection of the proper set of tone control curves based upon the density range of the original imagery.

o Computation of the printing instructions, using the appropriate set of tone control curves, based on the useful [illegible] values of the original and the desired D-min value of the [illegible]te.

DENSITOMETRIC EVALUATION [illegible] evaluation of the original [illegible] the tone [illegible] system. The values obtained from this evaluation are [illegible] [illegible]

o [illegible] D-max Values [illegible] category includes: Building roofs, aircraft, beach terrain, [illegible] runways, oil tanks, etc. [illegible] water, [illegible], etc., must be avoided, as should clouds, since these areas do not [illegible] potential intelligence information.

o Useful D-min Values [illegible]

imagery: areas of dense forrestry, asphalt runways, topographical and urban areas which are located in cloud-shadowed areas, etc. Heavily shadowed areas which contain no detail or potential information should not be used.

It is recommended that the useful D-min and D-max values be determined from eight to ten frames, selected at random. An experienced operator may require fewer than eight frames. Someone less familiar with the task may desire to take more than ten samples. Record each D-min and D-max value found within each [illegible]. The lowest D-min value is utilized as the D-min value for the roll. The highest D-max is utilized as the D-max value for the roll. [illegible] not have to be located within the same [illegible].

After the representative [illegible] and useful D-min values have been determined, compute their density difference. This density difference is known as delta (Δ-D). To compute the delta-D, subtract the useful D-min from the useful D-max. For example, if the useful D-min value was 0.35 and the useful D-max value was 1.80 the delta-D would equal 1.55.

[illegible] Control Curves. After [illegible], the density range or delta D of a roll of film, the [illegible] density range of the duplicate must be determined. The [illegible] density range for most laboratories is 1.00. This is the density range we strive for.

The unique feature of the trigradient tone control system is that the density range of the imagery can be altered so that the duplicate more nearly conforms to the desired density range. [illegible] systems gradient will lower the delta-D of the duplicate. The medium contrast chart or 1.00 systems gradient will maintain the same delta-D. The high contrast chart or [illegible] systems gradient will increase the delta-D [illegible] duplicate.

Figure 1-11A shows how three different rolls of film could be reproduced to improve the density range of the third generation. [illegible] control chart-high-medium or low contrast-as well as printing instructions are indicated.

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| **ROLL A** | | **DUPE POSITIVE** | **DUPE NEGATIVE** |
|---|---|---|---|
| ORIGINAL NEGATIVE | | HIGH CONTRAST | HIGH CONTRAST |
| | | .50N.D.+.80N.D. | .30N.D.+.80N.D. |
| D-max | 1.00 | 1.20 | 1.39 |
| D-min | 0.36 | 0.40 | 0.42 |
| Δ-D | 0.64 | 0.80 | 0.97 |

| ROLL B | | DUPE POSITIVE | DUPE NEGATIVE |
|---|---|---|---|
| ORIGINAL NEGATIVE | | MEDIUM CONTRAST | MEDIUM CONTRAST |
| | | 1.20 N.D. | 1.20 N.D. |
| D-max | 1.40 | 1.40 | 1.40 |
| D-min | 0.40 | 0.40 | 0.40 |
| Δ-D | 1.00 | 1.00 | 1.00 |

| ROLL C | | DUPE POSITIVE | DUPE NEGATIVE |
|---|---|---|---|
| [illegible] NEGATIVE | | LOW CONTRAST | LOW CONTRAS[illegible] |
| | | [illegible] N.D. | 0.40 N.[illegible] |
| [illegible] | [illegible] | [illegible] | 1.[illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |

Roll A in figure 1 [illegible] density range of 0.[illegible]. To increase the density range, [illegible] part of the 1.20 systems gradient was used. (Figure 1-10). The density range in Roll B fell within the desired [illegible] (Figure [illegible])

[illegible]

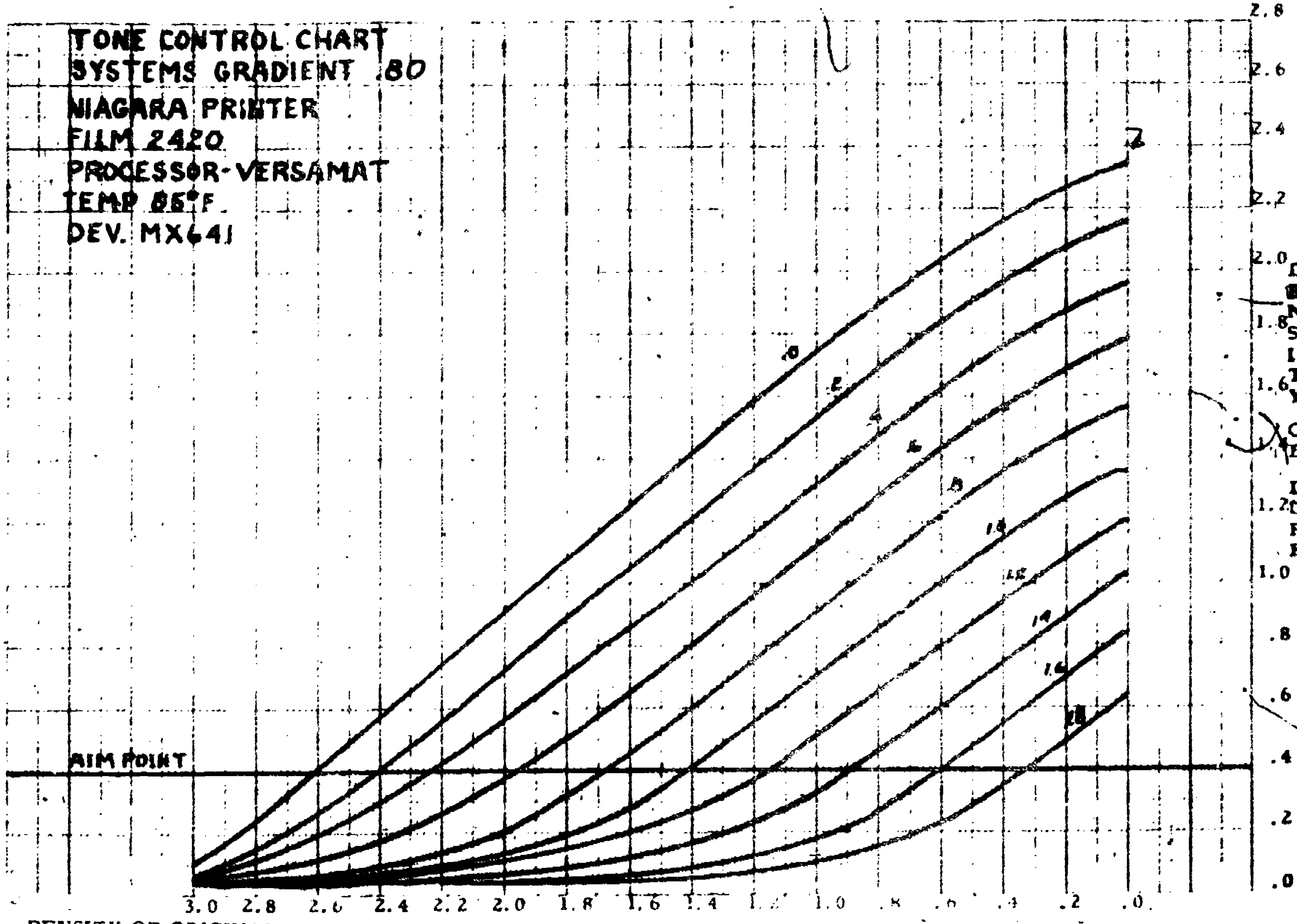


Figure 1-12. Systems Gradient .80

In Roll C the density range was too high so the low contrast chart or the 0.80 systems gradient was used. (Figure 1-12). In each case, each generation was evaluated and the necessary changes were made so that the final product conformed to the desired density range.

COMPUTATION OF THE PRINTING INSTRUCTIONS. Computation of the printing instructions is merely determining the neutral density value to be used during the printing operation. Once the proper systems gradient (low, medium, or high) has been selected, the neutral density value can be determined in the following manner:

o Locate the useful D-max of the roll of film to be duplicated on the horizontal axis of the tone control chart.

o Locate the D-min aim point (the desired D-min of the duplicate), usually 0.40 on the vertical axis.

o Locate the intersection of these two values by tracing a vertical line from the previously located D-max point and a horizontal line from the D-min aim point.

o The intersection of these two lines will fall on or near one of the tone control curves. If the point of intersection falls on a curve, the neutral density value which was used to produce this curve will then be used to print the duplicate. If the point of intersection lies between two curves, interpolate to find the proper neutral density value. For example, if the point of intersection lies one-third of the distance between the 0.50 and 0.60 neutral density curves, a neutral density of 0.53 would be used.

[illegible] the neutral density filter to be used, the [illegible] duplicated on the Niagara printer.

[illegible]

DO NOT [illegible]

1. What [illegible] printer?

2. What [illegible] printing light [illegible] printer?

3. What is used to monitor printing lamp intensity and stability?

4. When the Niagara is stopped and you hear an alarm, what is indicated?

5. When is the special filter used on the Niagara?

6. What is the warm up period for the Niagara?

7. How do you check the threading before the Niagara is warmed up?

8. What is the range of the variable density filters on the Niagara?

9. Why is there a five-second delay after the start button is pushed before printing starts?

10. Why should similar printers be correlated?

11. What two requirements must be met if we are to retain the maximum amount of intelligence information when duplicating?

12. What steps must be taken in the preparation of tone control charts?

13. What is the difference between a process gamma and a systems gradient?

14. List the three factors involved in the computation of the printing and processing requirements.

15. What is the difference between useful D-min and actual D-min.

16. How is the Delta D determined?

17. How do you determine which set of tone control charts to use?

PRACTICAL EXERCISES

## EXERCISE I

PROCEDURES

Solve the following problems using Figures 1-10, 1-11, 1-11A, 1-12, and the procedures found in the SW.

1. An original negative has a D-max of 1.70 and a D-min of .20. A duplicate positive is required, from this negative, that has a $\Delta$ D of 1.20 with a D-min of .40. What density printing filter would you use?

2. A duplicate positive has a D-max of 1.96 and a D-min of .40. If a dupe negative is needed with the range of the dupe negative being the same as that of the dupe positive, what printing filter would be used?

3: An original negative has a D-max of 2.05 and a D-min of .40. If a transparency is required having a $\Delta$D of 1.65 and a D-min of .40, what printing filter would be used?

4. An original negative contains a D-max of 1.68 and a D-min of .19. A dupe positive is required whose $\Delta$D is 1.80 and a D-min of .40. What printing filter would be used?

5. An original negative whose D-max is 1.70 and D-min is .24 has been printed with a .80 neutral density filter and processed to a systems gradient of .80 (see figure 1-12). What is the $\Delta$ D of the reproduction?

6. A dupe positive contains a D-max of 1.60 and a D-min of .40. A dupe negative is required with a $\Delta$ D of 1.45 and a D-min of .40. What printing filter would be used?

7. An original negative with a $\Delta$ D of 1.50 has a D-max of 2.15. If a positive is required from this negative and the $\Delta$ D of the positive is to be 1.20 and the D-min .40, what printing filter would be used?

8. A dupe positive has a D-max of 2.40 and a D-min of .50. A dupe negative is printed using a .20 neutral density filter, for a D-min of .40. The positive is processed to a systems gradient of .80. What is the D-max of the positive? What is the $\Delta$ D of the positive?

9. A positive is made from an original negative and the $\Delta$ Ds of both are the same. If the original negative had a D-max of 2.45 and the D-min of the positive is .40, what density printing filter was used?

10. A dupe [illegible] has been made and processed to a systems gradient of 1.2[illegible] [illegible] printing filter would be used to obtain [illegible] of .40?

EXERCISE II

[illegible]

Basis of Issue

| | |
|---|---|
| Niagara Printer | 1/class |
| Roll of Dummy O.N. Film | 1/class |
| Roll of Dummy Duplicating Film | 1/class |

**PROCEDURES**

1. Turn the Niagara main power switch ON

2. Adjust supply and takeup spindles for correct printing position. (Consult the text if necessary).

3. Place a mask in the printing aperture.

4. Adjust the variable neutral density filter to the 0.60 position and position the special filter out of the light path.

5. Adjust the torque motor "variacs" to correspond to the settings in Table [illegible], listed on page 10 of this SW.

6. Make certain that the pressure roller control lever is in the horizontal position.

7. Thread a roll of dummy film in the negative position and a roll in the raw stock position.

8. Depress the pressure roller control lever so that the roller contacts the film.

9. Set the two [illegible] tolerance pointers in the LAMP INTENSITY meter to 5 on each side of the scale.

[illegible] the green LAMP READY light is ON, adjust the LAMP ADJUST "Variac" so that the LAMP INTENSITY Meter reads "0."

NOTE

> The printer can be operated for mechanical check out only before the 8-minute warmup period has elapsed. To accomplish this, press the LAMP INTERLOCK VOID button and then the START button. When the printer is operated in this manner, the shutter does not open and exposure does not occur. The LAMP VOID light must then be cancelled by pressing the VOID CANCEL button. When the 8-minute timer runs out, the LAMP VOID light turns OFF.

11. Depress the START button. There is a 5-second delay before the transport starts.

12. If, for any reason, you wish to stop the printer during the printing cycle, press the STOP button.

13. When the dummy film has been completely "printed," press the STOP button. Rethread the negative in the SLEW position and rewind it.

14. Practice the threading and printing operations several times with the white light ON.

15. Turn off main power, clean printer and work area.

## EXERCISE III

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| Niagara Printer | 1/class |
| Versamat 11CM processor | 1/class |
| Roll of Duplication Film | 2/class |
| Step Wedge | 1/class |
| Graphing Implements | As needed |
| Sensitometer | 1/class |
| Densitometer | 1/class |

PROCEDURES

1. Prepare both the Niagara and the Versamat for operation.

2. Certify the processor and printer.

3. Construct a machine speed-gamma chart and a machine speed-gradient chart.

4. Using the two charts, establish the processing conditions (i.e., machine speed) needed to produce the low, medium, and high sets of tone controls.

5. Using a step wedge, print a full set of tone controls for [illegible] (low, medium, and high).

6. Process each set.

7. [illegible] separate set of graph paper.

8. Cleanup and shutdown the Versamat and the Niagara. Clean [illegible] and return to [illegible].

# EXERCISE IV

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| Niagara Printer | 1/class |
| Versamat 11CM Processor | 1/class |
| Roll of Aerial Negatives | 1/class |
| Roll of Duplicating Film | 1/class |
| Densitometer | 1/class |

PROCEDURES

1. Read out the negatives. Determine the "Delta-D" and average D-max.

2. Determine the proper tone control chart to use in order for your dupe positive to have a Delta-D between 1.00 and 1.20.

3. Refer to tone controls produced in the previous exercise to determine the neutral density required for printing.

4. Set this neutral density into the printer and thread the negative.

5. Print and process your dupe positive.

6. Cleanup and shutdown the Versamat and the Niagara.

7. Clean the darkroom and return to classroom for a critique by your instructor.

Sciences Branch
Lowry AFB, Colorado



# AUTOMATIC DODGING CONTINUOUS PRINTING

## OBJECTIVE

Using an SP 10/70 Continuous Contact Printer and Versamat 11CM Processor, duplicate a roll of previously processed film. Finished product must be free of chemical and physical defects and have acceptable density and contrast.

## INTRODUCTION

The previous study guide discussed how the overall density of a roll of aerial film could be improved with the use of tone controls and the Niagara printer. But, what about the roll of film that has varied densities throughout? The SP 10/70 continuous printer has one unique feature which the Niagara printer does not have. It can automatically vary its exposure from frame to frame and within each frame to ensure a uniform exposure throughout the whole roll of film.

## INFORMATION

### SP 10/70 CONTINUOUS CONTACT PRINTER

The SP 10/70 is a continuous contact printer; it prints from a roll of either positive or negative transparency onto any roll of film-base or paper-base photosensitive material. The printer features automatic control of the degree of dodging and exposure applied to the printing material as it passes through the printing area. This feature compensates for nonuniformity in the transparency. It ensures uniform exposure, from frame to frame and within each frame, for a given print material.

#### General Description

The SP 10/70B/printer (See Figure 2-1), consists of an enameled cabinet upon which is mounted a transport system, cassette, and photomultiplier box. The interior of the cabinet houses an electronic chassis, a power supply chassis, a main drive motor and control chassis. It also contains a cathode ray tube, a lens and bellows, junction box assembly, and transparency supply and takeup spools. All cabinet components are accessible when the access covers are removed. Mechanical and electronic controls, switches, and associated indicator lamps are located

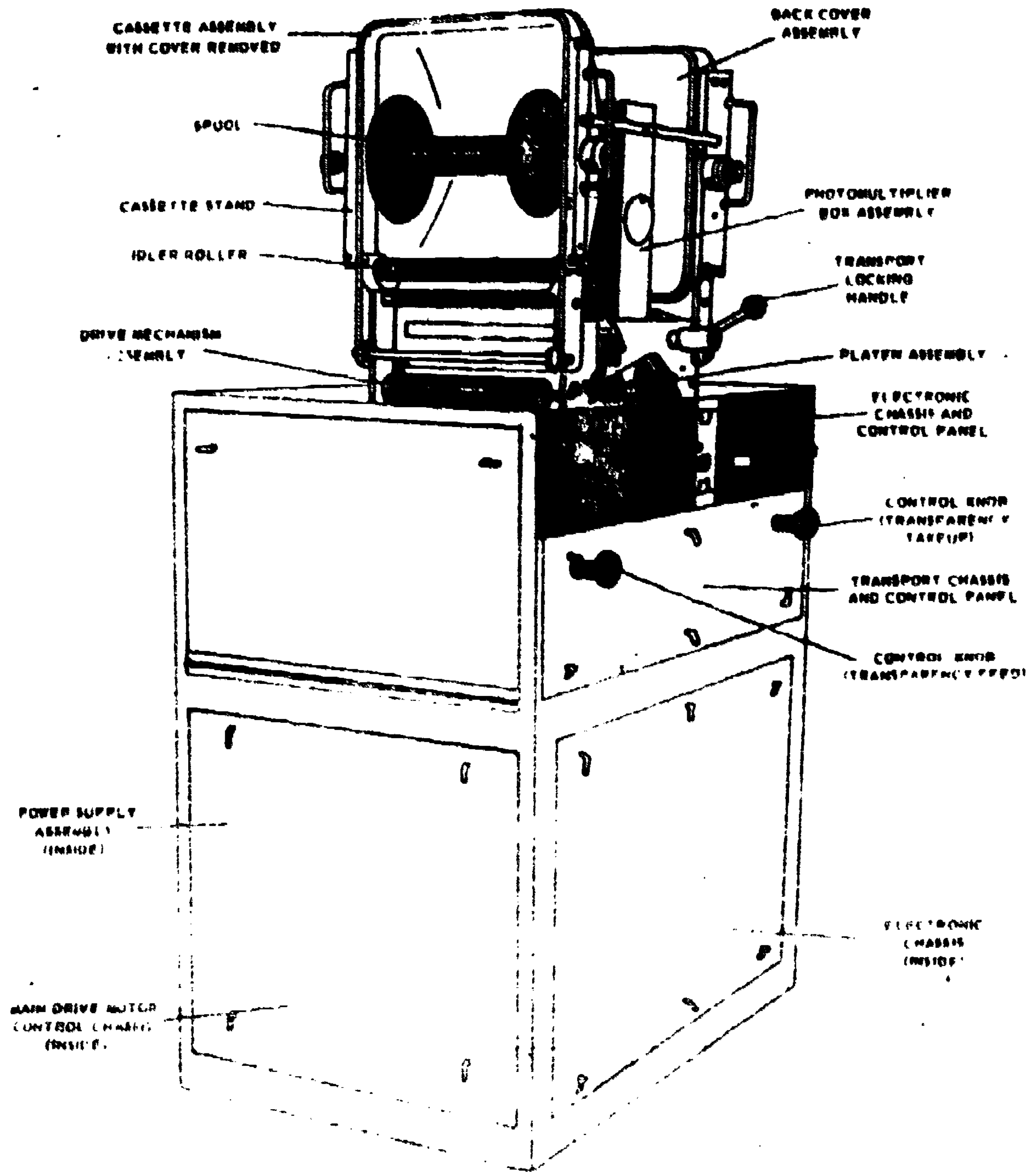


Figure 2-1. SP 10/70B Continuous Contact Printer

conveniently on the two control panels on the front of the cabinet. A transparency viewing table is set flush in the top of the cabinet.

Functionally, the SP 10/70B/ printer incorporates a transport system, printing light source, exposure level control circuits, automatic dodging circuits, and regulated power supplies. It is capable of handling material from 70mm to 9.5 inches (24.1cm) wide. The lens supplied with the SP 10/70B has a resolution capability of reproducing 200 lines per millimeter. A functional description of the SP 10/70B printer is given in the paragraphs that follow.

Detailed Description

TRANSPORT SYSTEM. The elements of the transport system are shown in Figure 2-2. The transport mechanism has two modes of operation: REWIND and PRINTING. The PRINTING system operates only when the printing stage is in the lowered and locked position.

During printing, the transparency and the printing material are drawn from their respective supply spools, driven right in a horizontal plane through the printing stage with their emulsion sides in intimate contact, and then directed to their respective takeup spools. The transparency and printing materials are maintained in an almost flat plane during transport.

Four rubber rollers are located at strategic points where the transparency and/printing material experience sharp changes in direction. On these rollers, radial slits are cut at 45-degree angles inclined toward the center of the roller. As a result of differential friction, these slits force the transparency and printing material to track along the centerline of the rollers, thereby ensuring correct registration of prints with respect to the printing material.

The drive mechanism is located in the printing area and contains a drive roller and a drag roller (Figure 2-2). The drive roller is located on the takeup side of the main frame (to the right of the printing aperture) and the drag roller is located on the supply side of the main frame (to the left of the printing aperture).

The drive roller is driven by a 1/4 horsepower variable-speed motor and reduction pulley system. The speed of the motor shaft is controlled by adjustment of its dc input voltage, derived from a magnetic amplifier in the main drive motor control chassis. This manual adjustment, from 5 to 60 FPM (1.5 to 18.3 MPM), is made by rotating the PRINTING SPEED control, located on the transport control panel. The drive roller rotates in a clockwise direction when viewed

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from the front of the printer, and provides forward motion to the transparency and printing materials. The drag roller coupled to a mechanical disc-type friction brake and also rotates in a clockwise direction, applying drag which maintains tension on the transparency and printing materials.

Two rubber rollers located on the printing stage are positioned directly above the drive and drag rollers when the printing stage is lowered and locked. These rollers exert pressure on the transparency and printing material during printing mode of operation. This pressure is sufficient to provide emulsion-to-emulsion contact, and causes these rollers to rotate with the drive and drag rollers. The braking action of the drag rollers places enough tension on the materials as they traverse the small steel rollers at the printing aperture to ensure excellent printing resolution during exposure. Each controlled exposure takes place as a frame passes over the printing aperture, which is a narrow slit positioned at right angles to the direction of transport.

The printing platen is a free-turning lucite roller located on the printing stage and positioned directly above the printing aperture. This roller presses against the nonemulsion side of the printing material and assists in maintaining intimate contact between the emulsion surfaces of the printing material and transparency. Since the lucite roller is transparent, light passing through the transparency and the printing material from the scanning spot is admitted readily for view by two photomultiplier tubes.

The [illegible] printing aperture by moving the [illegible] handle to the right, thereby breaking the emulsion-to-emulsion [illegible] between the transparency and printing material. [illegible] and [illegible] the [illegible] be shuttled back and forth [illegible] frames, or to enable [illegible] electrical interlock prevents the [illegible] source from being [illegible]

[illegible]

[illegible] wise, but is rotated counterclockwise by the material drawn from the supply spool. In attempting to rotate clockwise, it maintains tension on the transparency, between the supply spool and drag rollers.

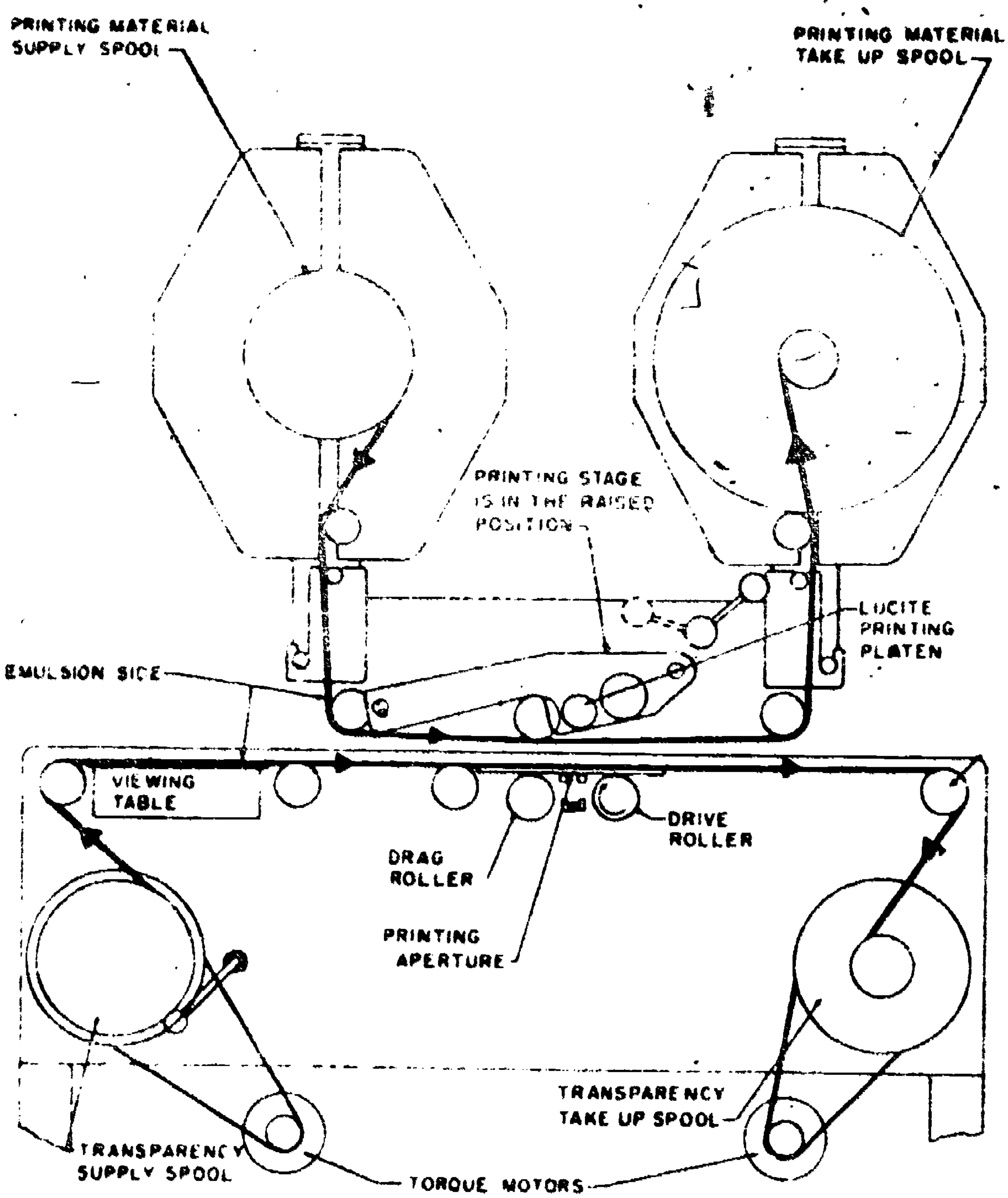


Figure 2-2. The SP 10/70B and its Transport System

The transparency takeup torque motor rotates the takeup spool in a counterclockwise direction. The torque of this motor is varied by the action of an autotorque resistor which samples the changing diameter of material on the transparency supply spool. When the supply spool is full, a reduced voltage is fed to the takeup torque motor. This voltage is increased gradually by rotation of the autotorque resistor arm as the supply empties and the takeup spool fills. Conversely, the supply torque motor receives maximum voltage when the supply spool is full, and a diminishing voltage as the supply spool empties and the takeup spool fills. During the rewind mode of operation (printing stage raised), the autotorque resistor function is replaced by that of the TRANSPARENCY REWIND SPEED AND DIRECTION control. Rotating this control counterclockwise increases the torque of the supply motor and decreases the torque of the takeup motor thereby rewinding the transparency on the supply spool. Conversely, rotating the control clockwise increases the torque of the takeup motor and decreases the torque of the supply motor. This permits the transfer of the transparency to the takeup spool without printing.

During operation, each spool is retained in position by an undriven spring-loaded spool-holder spindle which is provided with an external cam-type restrainer. This enables the spring pressure to be removed while loading or unloading materials. The SP 10/70B will hold 500 feet (152.4m) of print material and 400 feet (121.9m) of transparency.

PRINTING LIGHT SOURCE. A 10-inch (25.4cm) diameter, aluminized cathode ray tube provides the printing light source in the strip printer. The cathode ray tube operating in conjunction with the projection lens produces a scanning exposure which is [illegible] modulated by signals from the dodging and exposure level control photomultiplier tubes. As shown in the block diagram (Figure 2-3), scanning in the X-direction, or at right angles to the [illegible] of the transparency and printing material, is provided [illegible] controlled by an X-sweep generator. [illegible] is produced by the motion of the [illegible] printing aperture.

[illegible] located in the electronic chassis [illegible] by a free-running [illegible] feedback integrator which feeds a [illegible] the [illegible] output of the difference amplifier [illegible] amplifier which supplies the current required for operation of the X-deflection yoke. The repetition rate of the [illegible] approximately 1400 sweeps per second. This scanning rate is sufficiently high in terms of transport speed and spot size to eliminate any evidence of scan lines in the prints.

AUTOMATIC EXPOSURE LEVEL CONTROL. The actual exposure level depends not only upon the speed of the printing emulsion but also upon the combination of average brightness level and transport speed. Control of the average cathode ray tube brightness in the transport direction (Y-axis) is accomplished by an exposure level photomultiplier tube (PMT). This PMT is equipped with a lens and aperture plate assembly, shown in the block diagram (Figure 2-3), to restrict the field of view in the X-direction to a 1 1/2 inch (3.8cm) region at the center of the printing aperture. The photomultiplier tube measures spot brightness during a part of each scanning line. The anode current output is amplitude modulated by variations in transmission density. The ripple component is removed from this signal and a varying, negative d-c voltage is developed and fed through the d-c coupled cathode follower output stage to the grid of the cathode ray tube and controls the beam current continuously. This control maintains a constant average brightness which, in turn, produces a uniform exposure over the full length of the printing material.

When the frames of the transparency are dense, the anode current is decreased, reducing cathode ray tube bias and increasing spot brightness. Conversely, when the frames of the transparency are less dense, the spot brightness is decreased. The degree of exposure control is adjustable by varying the operating voltage for the photomultiplier tube from the negative 1000-volt supply. An exposure level meter registers the average anode current and provides a continuous of brightness control at the printing stage. Maximum printing efficiency is obtained by causing the cathode ray tube to reach peak brightness while scanning the most dense group of transparencies within a given roll. All transparencies which are less dense will be correctly exposed because the brightness level at the emulsion will be held substantially constant by the action of the exposure control negative feedback loop. This condition is achieved operationally by adjustment of the END POINT control.

AUTOMATIC DODGING. Light originating at the scanning spot on the faceplate of the cathode ray tube, shown in the block diagram (Figure 2-3), is projected by a conventional 6 inch (152mm) focal length lens through the transparency and printing material. A portion of this light, diffused after it passes through the materials, is intercepted by a 10-dynode, dodging photomultiplier tube. This tube views the entire length (X-direction) of the cathode ray tube scan in the printing aperture and monitors the transmission density of the transparency continuously at all points in the printing stage.

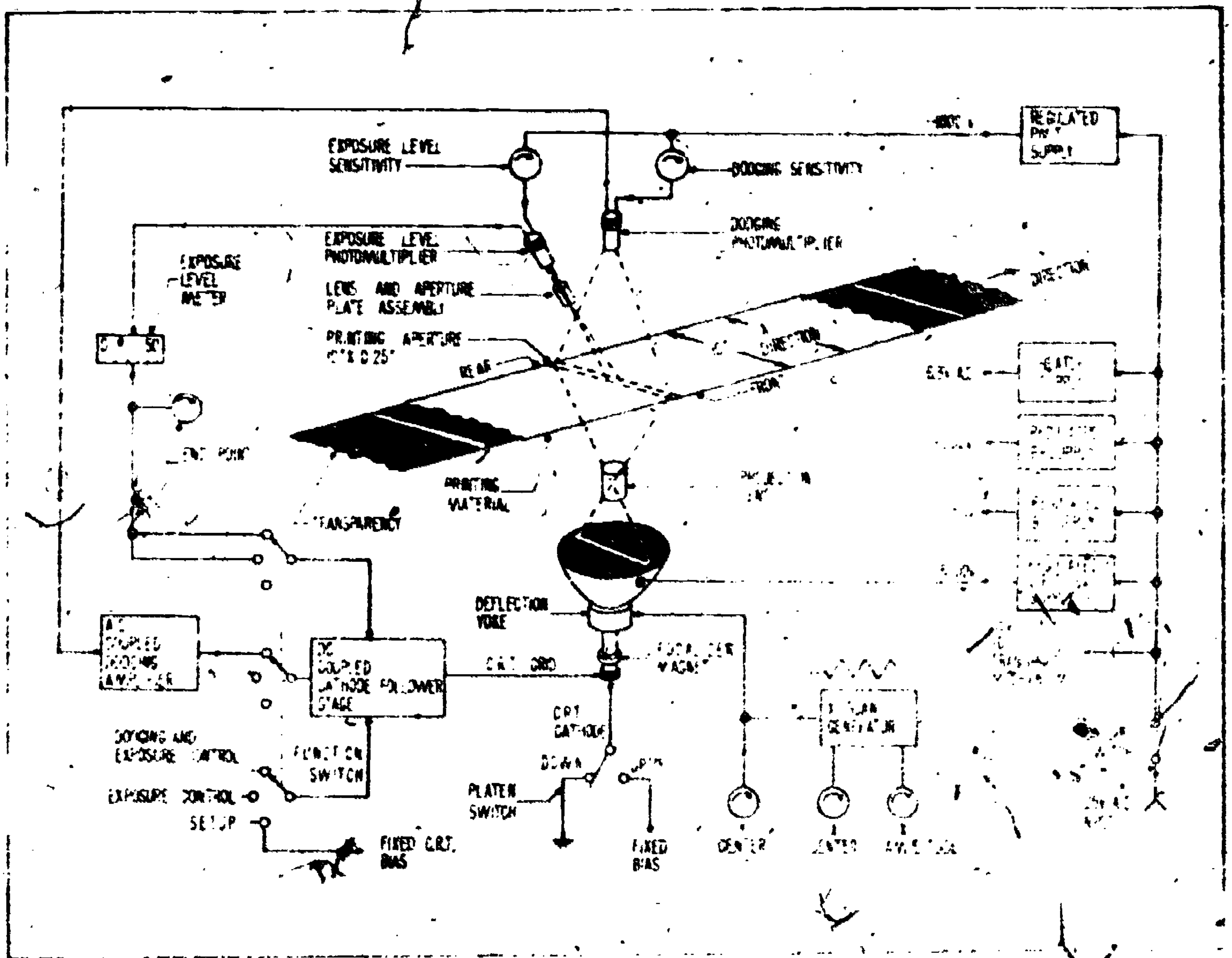


Figure 2-3. [illegible]/70B Block Diagram

SW G3ABR/3330 00X-IV-2

Variations in density of the transparency produce proportional variations in incident light intensity at the photomultiplier tube and control the magnitude of currents derived from photocathode emission. Dense areas in the transparency are represented by smaller currents and thin areas are represented by larger currents. The actual currents obtained are subjected to considerable amplification by action of the 10 dynodes. The degree of dodging is adjustable by varying the voltage applied to the dynode voltage divider network from the regulated negative 1000-volt supply. The dynode currents obtained are a-c amplified by an a-c coupled, dodging amplifier. The cathode follower output stage provides a low-impedance drive for the a-c dodging signals fed back to the cathode ray tube grid and for the d-c coupled exposure control voltage, which constitutes the working bias for the cathode ray tube during printing. The response of the feedback loop is fast, compared to the scanning rate, and enables the dodging signals to provide instantaneous, continuous control of cathode ray tube brightness. The scanning spot is brightened for dense transparency areas and is dimmed for thin transparency areas.

Control Panel Description

Most of the controls on the SP 10/70B are located on two control panels at the front of the machine, (see figure 2-4 and 2-5), or at the top of the photomultiplier box. The controls for the operation of the transport system are grouped at the left side of the machine on the TRANSPORT CONTROL PANEL. The controls for exposure regulation are grouped on the right side of the machine on the ELECTRONIC CONTROL PANEL. The functions of each control are given below:

POWER SWITCH. When the power switch is on, 115-volts, ac potential is applied to the printer circuits. When the switch is off, no power reaches [illegible].

VIEWING TABLE SWITCH. This switch operates a red safelight viewing table in the transport system. The table precedes the printing area so that transparencies may be viewed before they are printed.

[illegible] SWITCH (with indicator light). After the printing stage has been lowered and locked with its handle, this switch is pressed and released to start the printing mode of operation. When the printing stage is raised, the machine stops printing. (During printing, the indicator light glows.)

PRINTING SPEED CONTROL. This control consists of a dial that is calibrated in arbitrary units from one to ten. Transport speed is increased gradually as the dial is rotated in a clockwise direction.

TRANSPARENCY REWIND PRESS SWITCH (with indicator light). When pressed and held down, this switch applies power to the rewind circuit and the indicator light glows.

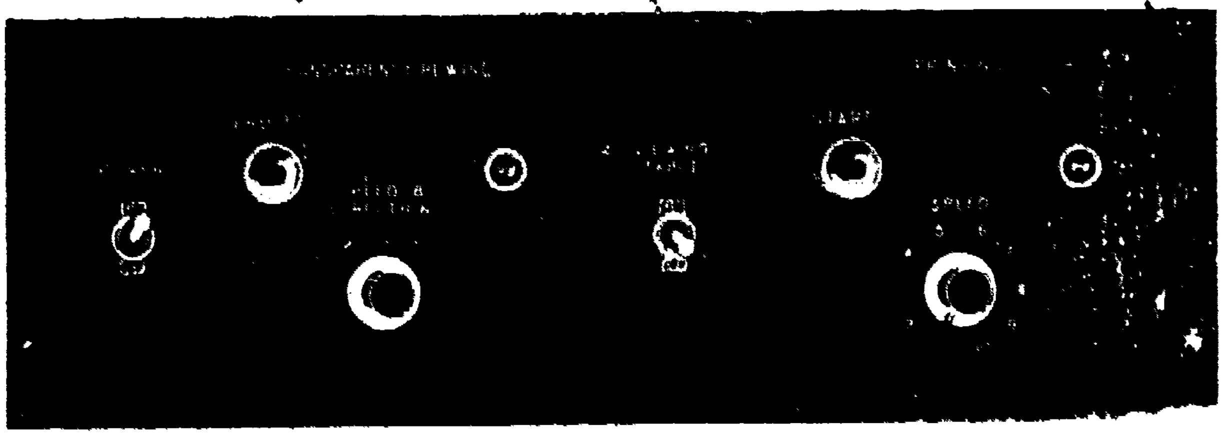

Figure 2-4. Transport Control Panel-SP-10/70P Printer

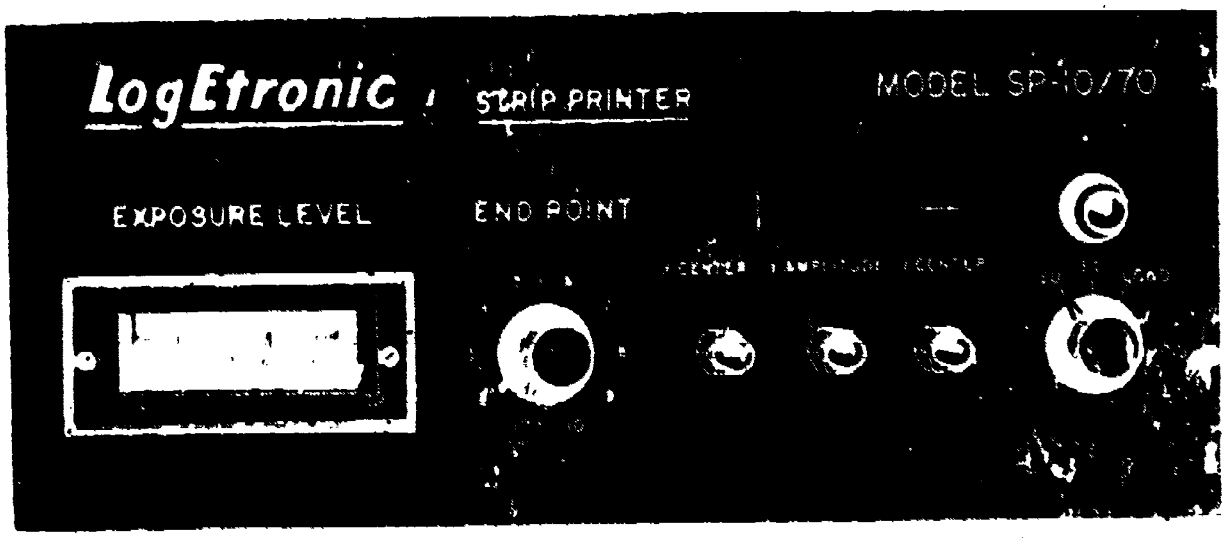


Figure 2-5. Electronic Control Panel-SP-10/70E Printer

TRANSPARENCY REWIND SPEED AND DIRECTION CONTROL. While the TRANSPARENCY REWIND PRESS SWITCH is depressed, this switch is rotated to control the speed and direction of the transparency motion.

FUNCTION SWITCH (with indicator light,) This switch operates when the printing stage is lowered and locked. When the switch is set on SU (setup), the CRT is operating at constant brightness to facilitate centering the projection scan in the printing aperture. (The exposure level meter and the indicator light do not operate at this time). When the switch is set on EC (exposure control), exposure is controlled from frame to frame, but there is no dodging within a frame. This position is used when duplicating a roll of transparencies which has already been dodged once. Redodging would produce an overly flat print. (The exposure level meter is operating at this time but the indicator lamp is not.)

When the switch is set on EC & D (exposure control and dodging), exposure control from frame-to-frame, and dodging within a frame, are accomplished. (The indicator light glows at this time.)

CAUTION: Unless the function switch is in the SU position, the rooms light should be off when the machine is operating. Failure to turn the lights off will result in damage to the PMTs.

X CENTER CONTROL. Rotating this control shifts the projected scan of the CRT in the X direction (lengthwise in the aperture) without altering the length of the scan.

X AMPLITUDE CONTROL. Rotating this control changes the CRT scan length in X direction.

Y CENTER CONTROL. Rotating this control shifts the projected scan of the CRT widthwise in the aperture (in the direction of transport motion) without altering the length of the scan.

WARNING

AT NO TIME SHOULD THE X AMPLITUDE AT THE CRT FACEPLATE BE LESS THAN EIGHT INCHES (20.3 CM). THIS COULD CAUSE PHOSPHOR BURNS ON THE CRT.

EXPOSURE LEVEL METER. This meter, calibrated in microamperes, indicates the light intensity at the printing aperture during EC and EC & D functions.

END POINT CONTROL. This control adjusts the automatic exposure

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level circuit so that the CRT reaches maximum average bri... scanning the densest transparencies of a roll. Clockwise ... creases the light intensity and the reading level on the exp... meter.

DODGING CONTROL. This control adjust the sensitivity of the dodging PMT. If too much dodging is being obtained, lower the sensitivity by turning the control counterclockwise.

EXPOSURE CONTROL. This control adjusts the sensitivity of the exposure control PMT. If increased density in the optical path is apparent (due to printing with relatively opaque materials) rotate this control clockwise to increase sensitivity.

Accessories

MASKS. The printer is installed normally with green ... positioned for printing 9 3/8 in. (23.8cm) transparencies. Alternate accessories are available to permit working with 5 1/4-inch ... and 70mm materials. These accessories consist of masks, roll paper core adapters, film spool adapters, and a +2 Portra lens.

Strips of transparent, colored acetate are satisfactory for mask material. However, neutral density strips may be used if desired or any other material that has an apparent density equal to the average density of the transparency being printed. After the masks have been correctly positioned in the mask holder, pieces of transparent, pressure-sensitive tape may be used to secure them in place. The mask aperture is a flat metal bar with an elongated slot in the center and with undercut grooves along the edges for supporting the mask material. Access to the mask aperture is gained by removing the small cover plate located between the two control panels. The mask aperture is removed from the holder by sliding the aperture out along the mounting track. The aperture has an adjustable stop and a detent at the far end which correctly positions and locks the aperture in place.

ADAPTERS. Adapters are supplied for roll paper cardboard cores that have an inside diameter of 2 1/2 inch (6.25cm) or wood cores that have a 2 inch (5.1cm) square hole. An adapter shaft fitted at one end with a flange containing a square plug accommodates either type of core. Two different threaded flanges for the other end of the shaft are interchangeable. The flange with the 2 inch (5.1cm) plug accommodates the wood core. The other flange accommodates the cardboard core.

**CAUTION**

The use of any spool with a core diameter of less than 2 inches (5.1cm) is not recommended. Excessive tension may result if transparency and printing materials are drawn onto takeup spools having smaller diameter cores.

Film spool adapters are supplied in sets of 4 for both transparency and printing material supply and takeup spools. These adapters permit centering of 5 1/4-inch (133mm) and 70mm materials in the transport system.

LENS. A +2 Portra lens is supplied for use in conjunction with the 6-inch (152mm), focal length projection lens when installed in the upper mounting position. This reduces the projected scan optically to the correct size for printing on 70 millimeter material.

Initial Setup and Certification

SETUP. The printer should be set up in a clean, dry area, with at least 4 feet (1.2 m) of working space all around the machine. The area should be remote from any electrical equipment which might have a strong magnetic field. These fields may have an adverse effect on the scanning of the transparency by the CRT. To prevent difficulties in the transport system, the printer should also be leveled by use of the screws at its base.

The power cord is connected to a 115-volt (+10%), 60-cycle, single phase outlet fused at 15 amperes. Make sure that the main power switch at the front of the machine is in the off position before connecting the power cord; otherwise the printer circuit may be damaged. Because it carries extremely high voltages (8500 volts, maximum), never operate the printer without a good electrical ground connection. If a 3-prong power outlet is available, use it. If the outlet is for a 2-prong plug, a ground wire must be connected between the machine chassis and a grounded object.

When the power cord has been properly connected, turn on the machine and let it warm up for at least 10 minutes. While the machine is warming up check to make sure that it is equipped with the proper reels, and that the proper printing mask is in the printing aperture. Check for proper mask placement by first lowering and locking the printing stage handle, and then looking down into the PMT box at the printing aperture. To see the aperture, open the porthole at the side of the PMT box.

To adjust the printing mask, remove the mask holder from the printing

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aperture. When this is done, cut two pieces of green acetate mask material. The pieces must be wide enough so that they fit snugly in the mask holder, and long enough so that they extend over the transparency border to the image. While checking the mask placement, also check to see that the X amplitude is adjusted so that the spot turns around within the mask area. Adjusting the X amplitude is a maintenance function, and should be done by maintenance personnel only.

CERTIFICATION. When the printer has been set up with the proper reels and masks, turn out the room lights and thread the machine with its printing material (emulsion down). Then select a roll of transparencies, with greater-than-average density, and thread it into the machine emulsion side up.

Now lower and lock the printing stage handle. Turn the printing speed dial to its "1" position. Rotate the end-point control until the meter reaches its maximum reading and then back off from this reading by 10 percent. Run approximately 1 foot (0.3 m) of transparency through the printing area and change the printing speed dial to its "2" position. After another foot (0.3 m) of transparency has been printed, change the dial to its "3" position. Continue until reaching the "10" position. Raise the printing stage handle to stop printing.

Process this test and look for the test which is slightly darker than desired and run the roll of transparencies at this speed. Now run another test to find the correct end point for printing. Rewind the roll to its beginning and set the printing speed dial at the speed determined from the last test. Start printing again, but this time instead of changing the speed dial, change the end point. Each time a foot (0.3m) of the transparency has passed over the aperture, rotate the end point dial in a counterclockwise direction. Decrease the end point in graduated amounts until reaching 50 percent of the original reading. Process this test. Find the best transparencies on the test and run the roll at this point. The resulting strip of dry prints consittutes the find calibration of the printer and will yield sufficient exposure data to establish suitable positions for the PRINTING SPEED and END POINT control knobs during operational printing.

OPERATIONAL PRINTING. Rewind the transparency to the beginning of the roll. Set the speed and end point dials at the settings derived from the two tests and print the roll. The exposure level meter should remain fairly steady. If it drops by a large amount, this indicates that transparencies denser than the ones used to calibrate the machine are passing the printing stage. Slow down the print speed dial and reprint the dark transparencies. When the meter returns to its original

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reading, return the print speed dial to its original position. After the roll has been printed, it is processed in the same manner as the tests.

REVIEW QUESTIONS

DO NOT WRITE IN THIS SW USE A SEPARATE SHEET OF PAPER

1. What is the minimum core diameter recommended for use with the SP 10/70B? Why?

2. Can the SP 10/70B be used in a roomlight condition? Why?

3. The Y center control moves the scan of the CRT in ______________ __________ _____ ___________________.

4. What is/are the caution/cautions that pertain to X amplitude?

5. How do you stop the SP 10/70B?

6. What is the speed range of the SP 10/70B?

7. How can you adapt the SP 10/70B to accommodate 70mm materials?

8. What is the resolution capability of the SP 10/70B?

9. What purpose do the radial slits serve in the rubber covered drive rollers?

10. Why is the platen made of clear lucite?

11. What is the light source in the SP 10/70B?

12. How many photomultiplier tubes are contained in the SP 10/70B?

PRACTICAL EXERCISES

EXERCISE I

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| SP 10/70B | 1/class |
| Roll of Dupe Positive | 1/as needed |
| Roll of Duplicating Film | 1/class |
| Versamat 11CM Processor | 1/class |

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PROCEDURES

1. Use dupe positive produced in previous SW.

2. Follow setup procedures stated in SW IV-2, Initial setup and certification.

3. Run tests to select proper printing speed and end-point setting. Testing procedures are stated in SW IV-2, Initial setup and certification.

4. Process test.

5. Inspect test material for contrast, density, and physical defects.

6. Print a duplicate negative using printing speed and end-point setting selected from your test. Use the EC + D position for a few frames and then EC position.

7. Inspect finished product for contrast, density, and physical and chemical defects.

EXERCISE II

| EQUIPMENT AND SUPPLIES | Basis of Issue |
|---|---|
| SP 10/70B | 1/class |
| Roll of dupe negatives | 1/class |
| Roll of photographic paper | 2/class |
| Versamat 11CM processor | 1/class |

PROCEDURES

1. Use dupe negative produced in Exercise I.

2. Follow setup procedures stated in SW IV-2, Initial setup and certification.

3. Run tests to select proper printing speed and end-point setting. Testing procedures are stated in SW IV-2, Initial setup and certification.

4. Process test.

5. Inspect test material for contrast, density, and physical defects.

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6. Print a positive paper print, using printing speed and end-point setting selected from your test. Use the EC+D position for 1/2 the frames and then [illegible] for the remainder.

7. Inspect finished product for contrast, density, and physical and chemical defects.

Technical Training

# Continuous Photoprocessing Specialist

# AERIAL SELECT PRINTING

October 1977

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# MANUAL CONTACT PRINTING

## OBJECTIVE

Using manual contact printers, laboratory facilities, aerial negatives and printing materials, produce black-and-white prints which are free of exposure and processing defects.

## INTRODUCTION

Using the Niagara printer and the SP 10/70 is an excellent method of printing copies of very long rolls of film. However, these machines would prove impractical if only a few copies of one or two negatives were needed. Also, the time needed to set up these printers (especially the SP 10/70) may prove to be too long for some particular mission. Where a small number of prints from a few particular frames are needed, manual contact printing is the most practical answer.

As with the other machines, local control of the printing process is necessary to compensate for poor negative quality. Many deficiencies which may exist in the negative can be corrected in the print. Because of this, it is important to have a working knowledge of the materials, equipment, and procedures used in high quality reproduction work.

## INFORMATION

### PHOTOGRAPHIC PRINTING

The formation of a latent image on light sensitive material during manual contact printing is basically the same as continuous contact printing. Light is allowed to pass through a negative to expose the sensitized material.

#### Principles of Contact Printing

Contact printing is the method of printing in which the unexposed print material is held in direct, close contact with the negative. Figure 1-1 shows a simplified diagram of contact printing.

Supersedes SW 3ABR23330, October 1973

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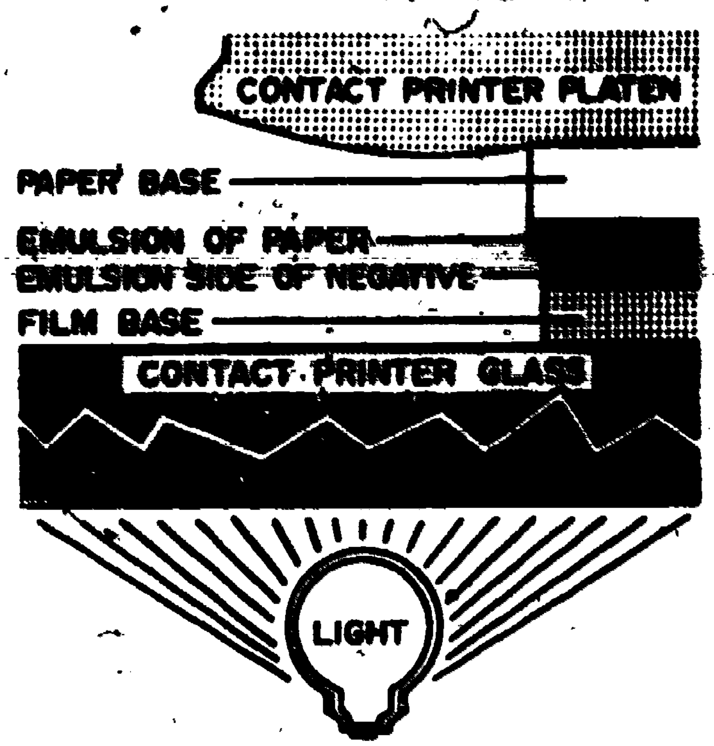


Figure 1-1. Contact Printing Schematic

A contact print is produced by placing the negative emulsion side up on a transparent surface above a light source. The rawstock is placed directly on top of the negative with the two emulsions facing each other. The negative and rawstock are held in tight contact by a pressure platen. Light then passes thorugh the transparent surface and negative exposing the rawstock.

The most light passes through the least dense areas of the negative. The least light passes through the most dense areas. Between these two extremes, varying amounts will pass. These different amounts of light striking the rawstock form the various tones in the final image.

Manual Contact Printers

A contact printer is a lighttight box with an enclosed light source. The box contains a ground glass for diffusing light, a clear glass to support the negative, and a platen to hold the negative and rawstock in tight contact during exposure. Some Air Force contact printers are quite elaborate and some are quite simple. Some have an air-filled platen bag; others use a vacuum to hold the negative

and rawstock together. Contact printers come in many different sizes. Timing can be controlled manually, by external timing devices or by a built-in timer, depending on design.

CONTACT PRINTING PROBLEMS. Certain printing problems are strictly related to contact printing. During exposure it is essential to maintain perfect contact between the negative and the rawstock. Any separation of the negative and rawstock anywhere over the image will degrade the final product.

Lack of proper contact could be the result of many contributing factors. An improperly inflated, air-filled platen could be the cause. Foreign material between the transparency and the rawstock could also cause such problems.

Figure 1-2 shows only part of the problem created by improper contact but an important part--distortion of the image. The result of this resembles a very "fuzzy" out of focus area on the print.

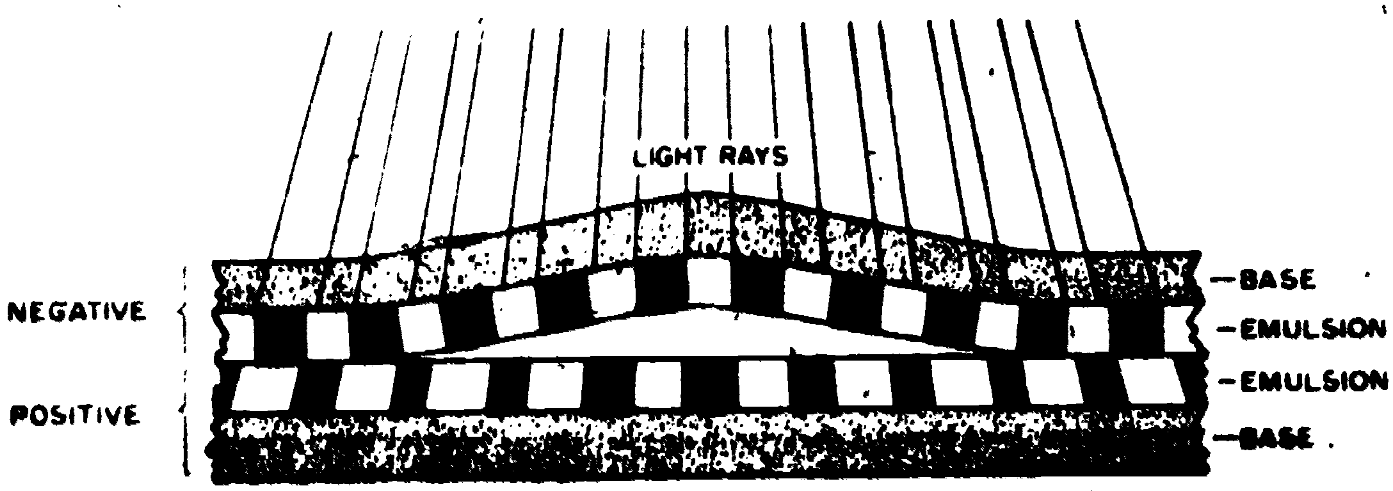


Figure 1-2. Contact Printing Problems Due to Poor Contact

Damage to either the transparency or the sensitized material could result from this problem. In all high quality control printers there is some means provided to create the proper contact. Whenever the contact is inadequate, the pressure system of the printer should be investigated. Do not rule out any possibility. Sometimes a clue to the trouble is a particular area of the print so affected. Look for repetition of the problem on other prints created by the same printing equipment.

Printing Materials

As mentioned earlier, control over the printing process can greatly enhance the final product. One method of control is the type of printing paper used. There are two means of controlling contrast during manual processing. This is done through the use of graded contrast or variable contrast papers. Regardless of the type used, the use is the same. Use a low contrast grade of paper (or a low contrast filter) with a negative of high contrast. The opposite holds true for negatives of low contrast. Negatives with normal contrast are printed on a normal grade of paper or without any filter on variable contrast paper.

In addition to knowing about graded papers and variable contrast papers, the operator must be aware of special papers used only for contact printing. These papers come in all the usual grades of contrast. Contact papers are normally slower than papers used for projection printing. However, since most contact printers produce very bright light, this slow speed is seldom a disadvantage. Note, too, that paper used for projection printing can be used in contact printing if illumination or exposure time is reduced.

Regardless of the material being used, make sure that the proper safelight is used. Each package of paper lists the manufacturer's recommended safelight.

EN-22A, Manual Contact Printer

The EN-22A is one of the most commonly used manual contact printers in the Air Force. Because of its widespread use and common operating principles, it has been selected for use in this course.

GENERAL DESCRIPTION. The EN-22A is a self-contained unit used for manual contact printing. It incorporates spot dodging features. It contains a built-in variable contrast roll filter for printing variable contrast paper. This printer can accommodate negatives up to 10 X 20 inches (25.4 x 50.8 cm). Aerial roll film sizes are printed with the aid of negative spool brackets. These brackets are completely adjustable. They will support roll film widths up to 9.5 inches (24.1 cm) and any length up to 500 feet (152.4 m) of standard base film.

The printer uses 73 individually louvered and separately switched printing lamps. The louvers control light spread and

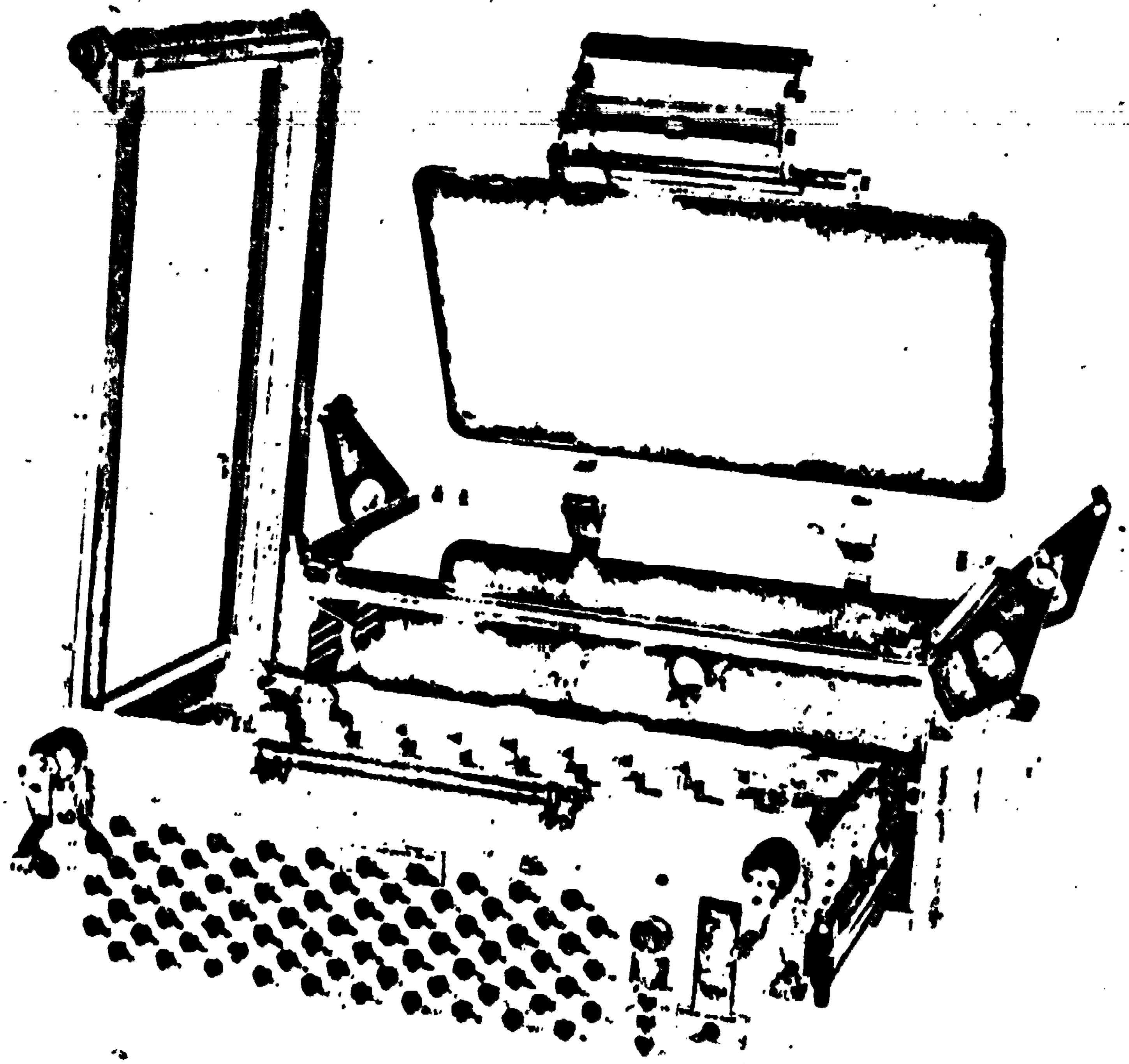

Figure 1-3. The EN-22A Showing Access to the Printing Lamps

make spot dodging practical. Eight safelights provide safe illumination levels for operator convenience and may be turned on for most printing applications.

The contrast filters are contained within a continuous roll of

acetate. The roll is divided into segments, each of which passes a different color light (comparable to the colors produced by a set of variable-contrast filters.) By turning a crank on the outside of the contact printer, the appropriate acetate filter can be placed between the light source and the printing surface.

PREOPERATIONAL CHECKS. As with any piece of Air Force equipment, there are certain preoperational checks that must be made if the printer is to produce high quality results.

Clean the printing area before starting other operations. Eliminate all dust, lint, dirt, and other foreign matter from the printing area. When possible, use a vacuum cleaner as dusting will merely cause the material to become airborne, and it settles back onto the working area. Be sure the printer and the rubber platen are clean. It sometimes becomes necessary to use a lint-free cloth and a small amount of alcohol for cleaning purposes.

Check the platen for the correct inflation. If the platen contains too much or too little air, correct the situation as outlined in TOE8-2-16-11. Improper platen inflation, either over or under, can be detrimental to both the printer and the product. In the case of overinflation, too much pressure is applied to the clear glass at the printing stage. This causes the glass to break which punctures the negative and the platen. If the platen is underinflated, there is not enough pressure to produce proper contact between the negative and the rawstock. This results in fuzzy corners on the print.

To check the inflation, lower the printer lid until the platen rests on the glass. Then release the printer handle. The platen should hold the lid so that the handle clamps are approximately 1/2 inch (1.3cm) above the clamping bar.

Connect the timer to the printer and then to the proper receptacles. Place all the printing-light switches in the ON position and check the operation of all lights. Check the viewlights and the safelights in the printer for proper operation. Place the master switch in the OFF position and check the operation of the platen-actuated, pushbutton switch.

Set up the trays for processing in the usual arrangement used for manual print processing. Fill each tray to a depth of 2.5 centimeters (about one inch) with the proper solution.

OPERATION OF THE EN-22A. After preparing the laboratory and making all necessary checks, printing may be started. Follow each

step carefully and completely before going to the next step.

1. Clean the negative to be printed -- remove all foreign matter.

2. Place the negative emulsion side up, in such a way that the image will be portrayed with the best composition possible.

3. Judge the contrast of the negative. If you do not have the ability to judge contrast, start out by assuming that the negative has normal contrast.

4. Decide what grade (contrast) of unexposed material must be used (or what filter must be used.)

5. Turn off all white room lights. Use only correct safelights.

6. Cut a sheet of the selected printing paper into test strips approximately two-inches (5 cm) wide. If narrower strips are sufficient, use them. This saves sensitized material.

7. Choose the area of the negative to be used for exposing the test strips. The area for tests should contain a highlight, middle tones and a shadow.

NOTE: Each test strip that is made should be made of the same part of the negative. Only in this way can one test strip be accurately compared with another test strip.

8. Make a series of test exposures using a systematic method of exposing. For example, start with two seconds and double it each time. Or, another method is to expose each test with an equal amount of increase. As an example, two seconds could be added to each test. Such a system would give exposures 2, 4, 6, 8, 10, etc, seconds. The main thing is to be sure to bracket the correct exposure; that is to go from underexposure to overexposure.

9. Process all test strips simultaneously for one minute and 30 seconds at 68°F (20°C), using normal agitation. Before processing, identify the tests carefully. It must be known which contrast and exposure produced the final results. Test strips must be processed with the same agitation and time of development as the final prints.

10. Inspect the test strips. Determine the best exposure for the grade of paper tested by observing useful highlight areas. The

highlight areas should be slightly darker than the same paper with no exposure. The highlight areas should contain detail. Too much exposure is indicated when the highlight areas are much darker than unexposed material. If the highlights are not correct on any of the test strips, run a new series of tests on the same paper using more or less exposure as indicated.

11. When the best exposure has been selected, determine if the correct contrast exists. Do this by examining the shadow area of the test strip that has the correct highlight exposure. If the shadow area of this test is too light, the paper (or filter) does not have sufficient contrast. Either a higher-numbered graded paper or a higher-contrast filter is needed. If the shadow is too dark, the paper (or filter) has too much inherent contrast. Either a lower-numbered graded paper or a lower-contrast filter is needed.

12. After the best exposure and contrast have been determined, print the entire negative.

Contact Printing Controls

Many aerial missions are flown under less than ideal conditions. This results in wide variations in density in different areas of a single negative. That is, the exposure in one area is greater or less than in other areas of the negative. This is often unavoidable because of a wide variation in tones or reflectance of the subject. It may be due to poor lighting or cloud shadows. Since the objective is to produce accurate, detailed representations of the subject, some of these negatives may need special treatment.

If the print is exposed long enough to bring up highlight detail, the shadow detail is lost. If the exposure is short enough to bring up shadow detail, the highlights are lost. If an exposure between these two extremes is used, some detail is lost in either the highlights, the shadows, or both.

Corrective action is taken by dodging. Dodging means controlling the exposure in specific areas of a single point. This means giving one area more exposure than another area. The techniques used in dodging vary with the type of printing being done. However, in contact printing with the EN-22A there are three methods.

DODGING METHODS. There are three methods which can be used and at times, more than one of these methods may be used in the same print.

The most common and easiest method of the contact-print dodging techniques is to turn out individual lights under parts of the negative that print too dark. This leaves the lights burning under the

areas of the negative that have the greatest density. Therefore, these areas of the print tend to get more exposure. If turning the lights off for the entire exposure time lightens the areas too much, they may be extinguished for only a portion of the total printing time. If turning the lights off for the total printing time does not hold the light back enough, those lamps surrounding the thin areas of the negative may have to be turned off in addition to those directly below the thin area.

A second method of dodging when making contact prints is by placing a translucent medium between the light source and the negative. Material such as tissue paper can be torn in the approximate shape and size of the thin area of the negative. This dodging device can be positioned on the diffusing glass directly under the thin areas of the negative. The increased density in this portion of the diffuser will reduce the light which is exposing the paper in that area.

A third method that may be considered for some negatives is to place an opaque medium between the light source and the thin portion of the negative. The procedure is the same as that given in the previous paragraph for translucent material. When this method is used, however, only the light coming through from an angle can cause an exposure through the thin part of the negative.

Whenever it is necessary to do a large amount of dodging, exposure compensation may be necessary as the total intensity of the illumination is being decreased. Thus, it is wise, whenever possible, to establish the dodging time before making the exposure test strips.

Laboratory Safety.

Even though safelights are normally used during contact printing, safelight levels are far below normal room lighting. Therefore, always exercise caution when working in the laboratory. The EN-22A and the attached timer are grounded differently. Therefore, to avoid electrical shock, never touch the printer and the timer at the same time. Never use wet hands when handling the printer or the timer. Clean all spilled solutions immediately in order to avoid slips and falls.

REVIEW QUESTIONS

DO NOT WRITE IN THIS SW-USE A SEPARATE SHEET OF PAPER.

1. Why is cleanliness so important in contact printing?

2. What are the reasons for making test strips?

3. How is a set of test strips made?

4. If a print is too dark, how can it be corrected?

5. What is the function of the platen in a contact printer?

6. How are the negative and rawstock emulsions related in their positions for contact printing?

7. What might result if the platen is overinflated on the EN-22A?

8. What are the two means of controlling contrast during manual printing?

9. Where are the contact filters located on the EN-22A?

10. What must be accomplished if projection print material is used in a manual contact printer?

PRACTICAL EXERCISES

EXERCISE I

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| EN-22A Contact Printer | 1/student |
| Printer Timer | 1/student |
| Continuous Timer | 3/class |
| Thermometer | 1/class |
| Laboratory Facilities | 1/class |
| Print Washer | 1/class |
| Print Dryer | 1/class |
| Aerial Negatives | As needed |
| Variable Contrast Paper | 20 sh/student |

PROCEDURES

1. Make sure that electrical equipment is furnished with grounding attachments and that all are properly grounded.

2. Keep electrical equipment away from wet sink areas. Do not handle any electrical equipment (printer, timer, etc.) with wet hands. Also, do not handle both the printer and the timer at the same time.

3. Obtain the necessary processing chemicals from chem mix. Use AFD #25 (D-72) diluted 1:2.

4. Check the printer platen and glass for cleanliness. Both may be cleaned if necessary.

5. Check the printer as follows:

a. Connect the cord to an electrical outlet, turn all lamp switches on and replace any burned out lamps.

b. Check the platen for proper inflation.

CAUTION: If the platen appears to be overinflated, DO NOT clamp the printer handle down. The pressure of an overinflated platen may break the printer glass, the ground glass and some of the lamps. Moreover, the broken glass may puncture the rubber platen.

c. Check the printing glass to see that it is seated properly. If it is cocked up on one corner or edge, even normal pressure may break it.

d. Turn on the safelights and check for proper filter installation.

e. Turn out the overhead lights and check to see that the printing lights operate properly when the printer lid is clamped down. The overhead lights may be turned on again.

f. If roll film is used, adjust the roll film brackets to the proper film width.

6. Select a negative of average contrast and density. Brush dust and lint from the negative using a negative brush. Clean the negative only if necessary and then very carefully. Film emulsions are easily scratched and marred. If the negative needs cleaning, use alcohol and cotton.

7. Recheck the printer glass for cleanliness. Then position the negative approximately in the center of the glass and secure it by the corners with small pieces of tape.

CAUTION: Handle negatives by the edges only.

The following steps must be accomplished under suitable safelights. Read through the entire procedure and have the steps well in mind before turning out the white lights.

CAUTION: To avoid fogging uncovered printing paper, after turning out the white lights in the lab, DO NOT turn on the printing or white lights in the printer unless the platen is lowered.

8. Cut a sheet of variable contrast paper into test strips. Use a #2 filter or white light to make a series of test exposures.

CAUTION: Use extreme caution when using the paper trimmer. NEVER place the fingers in the cutting area. ALWAYS leave the cutting blade in the lowered position after using the trimmer.

9. After exposing the strips, process them all at once, with constant agitation for 90 seconds. Rinse them and place them in the fixer tray.

10. Inspect the strips for a suitable exposure. An acceptable set of strips consists of strips ranging from too light to too dark. Be aware that prints tend to appear slightly darker under safelights than under white light.

11. In consultation with the instructor, determine the exposure time which will produce the best possible print with this filter. Save this test strip to compare it with the final print. Throw the remaining strips away.

12. Select a sheet of variable contrast paper. Using a soft lead pencil and slight pressure, record the required information on the back. For example: Name, filter used and exposure time.

13. Expose the print for the correct number of seconds and process it carefully. Compare the density of the print to the test strip. With the instructor's aid, determine if an acceptable density has been achieved. If not, repeat the process until an acceptable print is produced.

14. Determine if the contrast is correct. If not, change the filtration and repeat the process.

15. Return all unexposed paper to its box. Insure that the paper boxes are tightly closed then turn on the normal room lights.

16. At the direction of the instructor, carry the prints to the finishing room for washing and drying. Clean the lab.

Sciences Branch
Lowry AFB, Colorado

SW G3ABR23330 001-V-2
October 1977

# COPYING TECHNIQUES

## OBJECTIVE

Given mosaics, copy equipment, processing and printing facilities, produce scaled reproductions of the mosaics. The size of the reproduction must be within ±5% of the desired size.

## INTRODUCTION

After paper prints are made on the Niagara or several consecutive negatives are printed on the EN-22A, what happens to them? Often they are used as they are as single prints. They are spliced together to form one large photograph. These are called mosaics and can be used to show a large area of land in one photograph. They can also be used to make maps and other charts.

However, these mosaics are very bulky. Also, producing a mosaic can be very time consuming, particularly if several copies of one mission are needed. Therefore, once a mosaic is made, it can be copied and many copies can be made quickly and easily. The mosaic is often copied to a reduced scale for ease of handling. These prints may be used in the preparation of new maps and flight charts.

## INFORMATION

Once the mission film has been processed and printed, a mosaic is produced. While it is not the purpose of this career field to produce the mosaics, a very brief discussion of their production will aid in understanding the importance of copying techniques.

## MOSAICS

### Mosaic Production

PREPARATION OF AN INDEX. The first step to be taken when a mosaic is to be made is the presentation of a photo index. (See figure 2-1.) A photo index is a rough assembly of aerial prints made from the negatives exposed on a reconnaissance or mapping mission. As soon as the mission has been flown, the film is processed and a set of acceptable prints are made. These prints are then assembled in sequence by the use of staples. This assembly

shows:

1. Whether the desired area has been adequately photographed. This is called "coverage." If the coverage is incomplete (that is with gaps, called "holidays," between flight strips), it may be necessary to refly the mission.

2. The percentage of overlap and sidelap.

3. Which print, laying near the center of the strip, will be selected as the master print.

4. Roughly the overall size of the mosaic to be laid.

This is helpful in determining the size of the mounting board to be used.

The index is prepared by removing the black borders from the prints. The prints are assembled by matching the detail in the center portions of the overlapping print areas and fastening them together with staples. It is important that the central detail portions be matched; however matching detail in the border areas is not important as they seldom match anyway. Figure 2-1 illustrates how an index looks.

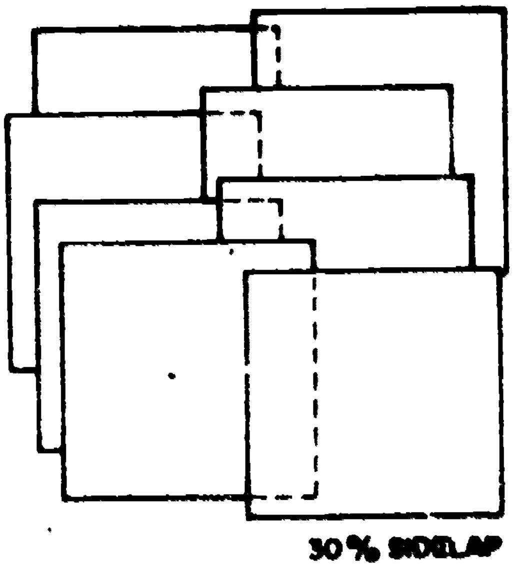


Figure 2-1. A Photo Index

Printing negatives for mosaic assembly is much the same as making prints for other purposes. There is a difference in the way the prints are processed and dried, however. Prints are made on single weight glossy paper--not on water proof paper. Uniform tone and density are vitally important if the mosaic is not to have an unpleasant patchy or checkerboard appearance. The achievement of this quality takes a little more care than is normally used in manual printing and processing.

COPYING MOSAICS TO SCALE. The completed mosaic is of little value unless reproductions of it can be made. Usually the mosaic is copied on a 24 X 30 inch (61 X 76 cm) negative for use in making contact prints and on an 8 X 10 inch (200 X 250 mm) negative for projection printing.

To compute the percentage scale of the copy or the resulting size from a given percentage, use the percentage calculator supplied with the camera. This calculator is very simple to operate. Set the desired size of the copy opposite the original size and read the percentage of the original size directly.

If a percentage calculator is not available, the dimensions can still be calculated. To find the desired dimensions from a given percentage, multiply each dimension by the percentage. Thus, a 50% reduction of a photograph of 8 units by 10 units would be 4 units by 5 units. That is: .50 (8 units) = 4 units; and .50 (10 units) = 5 units. By the same method, a 300% enlargement of a photograph of 8 units by 10 units would be 24 units by 30 units. A 100% reproduction means that the copy is exactly the same size as the original. A 100% reproduction is also called a 1:1 reproduction.

## COPY PRINCIPLES

### Fundamentals of Copying

Copy work can be done with many types of ground cameras. However, copying differs from conventional ground photography in two respects: (1) the subject to be copied is in one plane, i.e., it has only two dimensions, length and width and (2) the scale is usually much larger--very often 1:1 or larger. Because of these special differences, specialized cameras have been produced for copy work.

CHARACTERISTICS OF A COPY CAMERA. The fact that the subject is on one place eliminates any depth of field problem. This does not, however, decrease the importance of critical focusing. Because the subject to be copied is on one plane, copy cameras use a special type anastigmatic lens. This lens is highly corrected for a flat

field and has very high resolving power. It is known as a process anastigmat or process lens. Also, lenses used for copying color subjects should be corrected for chromatic aberration. A lens of this type is an apochromatic lens.

Because of the short distance from the subject to the film plane, copy cameras usually have ground glass focusing. Viewfinder focusing seldom has enough parallax correction to compensate for the distance between the viewfinder and the film plane. Also, since a specific size is usually desired in the copy negative, the use of the ground glass makes the measuring of the image size simpler. Finally, any flare from the lighting is readily seen on the ground glass and can be eliminated.

Cameras specialized for copying are designed with a long bellows extension. This long bellows allows for the production of 1:1 copies or even larger. Most of these also have both front and back focusing. These capabilities give increased control over the image size of the reproduction.

COPYING WITH NONSPECIALIZED CAMERAS. Copying can be done with ordinary ground cameras. However, special precautions must be taken. The best results will be produced with a camera designed strictly for copying.

One of the simpler methods of copying is to use a view or press-type camera mounted on a tripod, with the subject held by a copy board or easel placed in front of the camera. In such cases, the camera should be mounted firmly on the tripod. In an emergency, one can even tape the subject to a wall. The lights normally used with this setup are photoflood lamps and reflectors, which are mounted on stands. Diffusers are provided for the reflectors to obtain even illumination.

When copying with a ground camera, make sure that the ground glass is parallel to the subject being copied in order to avoid distortion. It is important to have the lens board parallel to both the ground glass and the easel. Place the camera squarely in front of the subject with the horizontal swing, vertical tilt, and rising-and-falling front in neutral positions. When using a tripod, be sure that the legs are extended evenly to prevent any tilting.

Lighting for Copying

After the camera has been selected, you must consider proper lighting. There are two important things to remember about lighting for copying. The first is to maintain an even illumination over the entire surface of the subject. This prevents hot spots (areas of

overexposure) from appearing on the copy negative.

The second is to place the lights in such a way that surface reflections do not blot out detail. For smooth, glossy surfaces, the lights provide the best illumination when placed at a 45 degree angle to the subject (See Figure 2-2.) The lighting angle should be increased to about 75 degrees to the subject for rough surfaced subjects. The greater angle will prevent the texture from casting shadows across the subject.

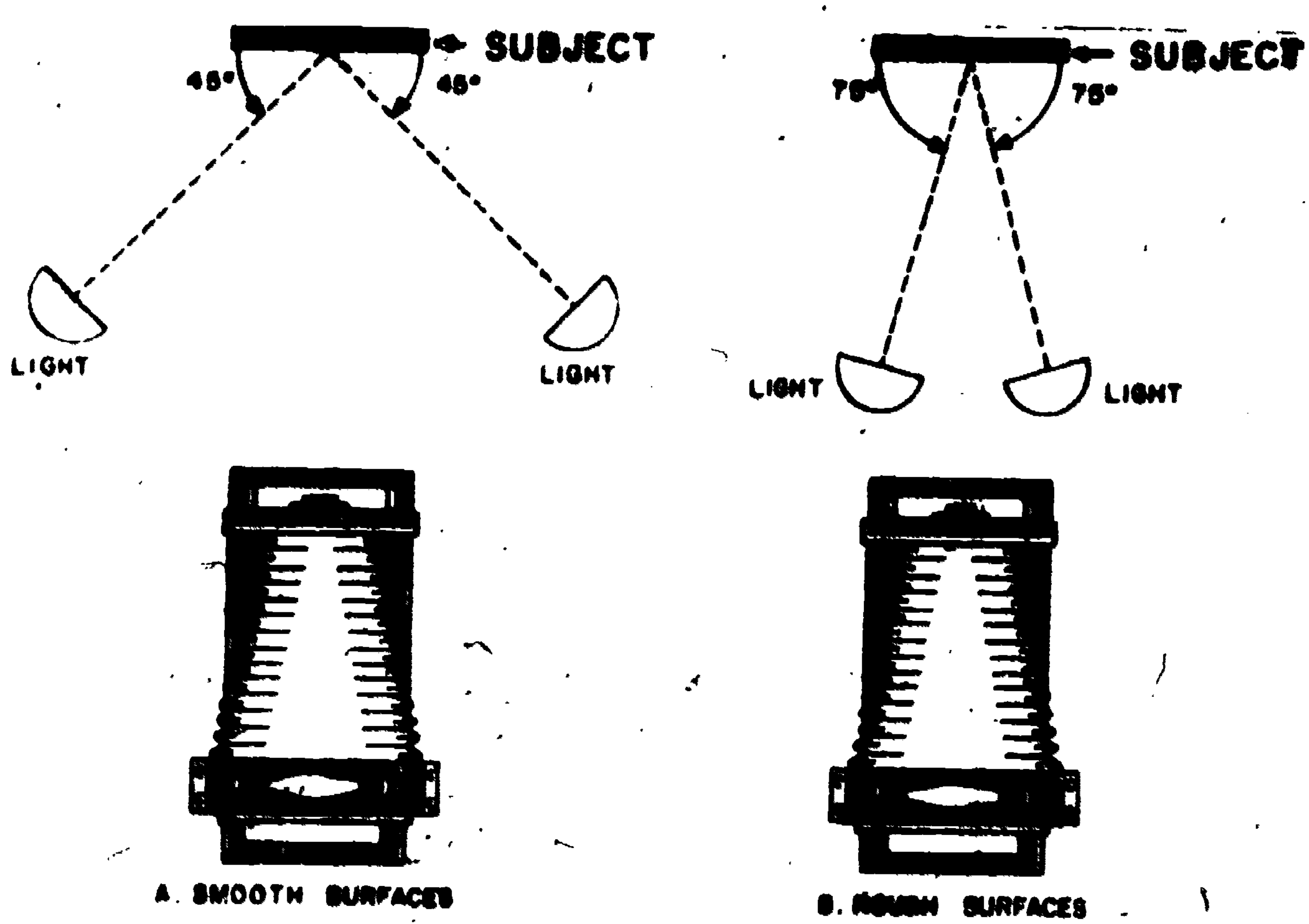


Figure 2-2. Positioning Lights for Copying

After positioning the lights to the desired angle, always check the ground glass for unwanted reflections and uneven density.

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Reposition the lights as necessary to achieve even illumination.

Bounce lighting is sometimes used in copying when the light intensity is too high. The lights may be positioned so that the light bounces off the ceiling or a wall. However, even illumination is difficult to attain and contrast is very low with bounce lighting. If the light intensity is too high, it is better to use a neutral density filter over the camera lens.

Filters

Sometimes the use of a filter can greatly improve the results during copying. Blueprints, colored line drawings, faded photographs, and photographs with transparent stains may be greatly improved if copied through appropriate filters.

A filter will transmit its own color and absorb all others. Because of this characteristic, many flaws in the copy subject can be corrected. This characteristic is also important in predicting the results that can be obtained with any particular filter.

STAIN REMOVAL. On occasion, the subject to be copied will contain a stain. This is caused by aging, spilled solutions or some other accident. When this occurs, the stain needs to be removed, if possible. If the image can be seen through the stain, the correct filter will reduce or eliminate the stain. If the stain is opaque, filtration will not remove the stain.

To remove the stain, use a filter with the same color as the stain. With this filter, only the light that is the same color as the stain will reach the film. The film will record the subject while eliminating the stain.

TONE ENHANCEMENT. Subjects with poorly saturated colors, such as blueprints, can be improved with filters. To enhance a color, do just the opposite of stain removal. Instead of using a filter of the same color, use a filter of OPPOSITE color. The filter will absorb the color to be enhanced. This causes the film to record the color as black, thus giving it more inherent contrast.

In most Air Force copy laboratories, a Type C-1 filter set is used. This filter set contains eight filters. These include a #6 (K1), light yellow filter, a #8 (K2), medium yellow filter and a #11 (X1), yellow-green filter. It also contains a #15-G, deep yellow filter, a 25-A, medium red filter, a 29-F, deep red filter, a 58-B, deep green filter and a #50 (C-5), deep blue filter.

When selecting a filter, try to previsualize the desired results. To predetermine the results on the final print, visually examine the subject through a number of different filters. Next, make a test exposure through the filter that has been selected.

POLARIZING FILTERS. Polarizing screens do three useful things. They darken a blue sky, penetrate haze, and remove or reduce reflections from nonmetallic surfaces. The last item is the one most important in copy work.

To understand how polarizing screens work, recall a few things about the nature of light. Light rays travel in straight lines. They also vibrate in all directions perpendicular to their direction of travel. When a light ray hits a nonmetallic surface, the vibration in only one direction is reflected completely. (ALL vibrations are reflected from a bare metallic surface.) Depending upon the angle at which one views the light reflected from an object, vibrations in other planes are reduced or eliminated. This reflected light--vibrating in only one direction--is called "polarized light." (See figure 2-3.)

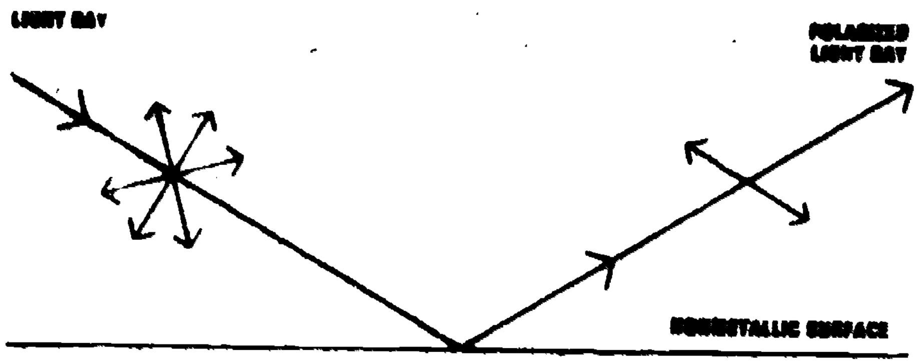


Figure 2-3. Polarization of Light

Whether or not a polarizing screen will have any effect on polarized light depends on the position of the screen. If the screen passes polarized light, no effect will happen. (See Figure 2-4.) However, if the screen is rotated 90 degrees, polarized light can be eliminated.

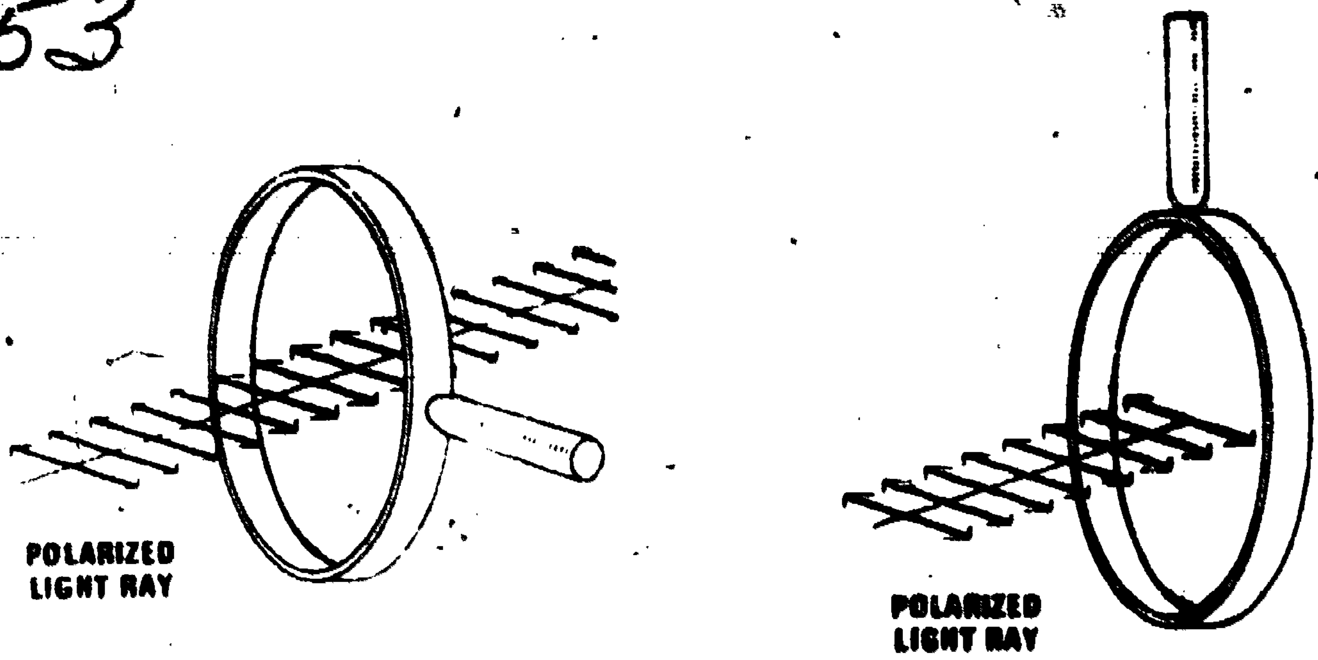


Figure 2-4. How Rotation of a Polarizing Screen Affects Polarized Light

Polarizing screens darken a blue sky since the light rays are polarized when they reflect off of dust and moisture particles in the air. This is also how a polarizing screen can penetrate haze. However, in copy work, the reduction of reflections from the copy subject or the copy board on the camera is the most useful property.

A polarizing screen, like a neutral density filter, transmits all colors of light. Therefore, a polarizing screen can be used with color rawstock materials.

FILTER FACTORS. When using a filter, note that a filter factor must be applied when computing an exposure. Since filters absorb light, the amount of exposure given with a filter must be greater than the exposure given without a filter. Exposure adjustment depends on the filter's density, the film's color sensitivity, the color of illumination and reflective properties of the subject. With the short latitude of some copy films, failing to apply a filter factor produces poor or unacceptable results.

Every filter will have a given filter factor for each film and light source combination. This factor can be obtained from the data sheet packed with the film or from the data packed with a new filter set. There are three ways to apply filter factors.

One way is to divide the factor into the film speed (ASA) and set the exposure meter for this new value. Thus, if the film speed was ASA 400 and the filter factor four, the exposure meter would be set to 100. (400 divided by 4 is 100.) Once the meter is set, it is used in the normal manner.

Another way to allow for the filter factor is to change the f/stop to compensate for the factor. The amount of f/stop change can usually be found in the film data sheet. This chart is a good example.

| | | | |
|---|---|---|---|
| Filter Factor | 2 | 4 | 8 |
| Increase f/stop by | 1 | 2 | 3 |

The third way to compensate for the filter factor is to multiply the exposure time by the factor. For example: A basic exposure without a filter might be 1/500 second at f/16. A filter with a factor of four is installed. The new exposure would be:

1/500 x 4/1 = 1/125 second at f/16.

The third method is most commonly used in copy work. As the copy camera is quite rigid, long exposures can easily be handled.

NOTE: The filter factor value depends on the light source and film type, in addition to the absorption of the filter. Therefore, a test strip is often necessary to determine exposure accurately.

Polarizing screens have a filter factor of 2.5 constantly. However, refer to the manufacturer's film data sheet for complete and accurate information concerning filter specifications for each type of emulsion.

To summarize the information about filters, read the following guidelines:

1. Filters transmit their own color and absorb all others.
2. Correction filters help balance the color sensitivity of the fil giving orthochromatic rendition.
3. Deep colored filters increase contrast.
4. Use filters only when the condition of the original requires them.

5. Expose accurately for optimum response. Do not neutralize the action of the filter.

6. Compensate for exposure with filter factors.

7. To lighten a color IN A FINAL PRINT, use a filter of the SAME COLOR.

8. To darken a color IN A FINAL PRINT, use a filter of the OPPOSITE COLOR.

9. Use a polarizing screen to reduce reflections from the copy subject or copy board.

Film Selection

Once the camera and lighting methods have been selected and any necessary filters determined, the next step is to determine the film and developer to be used.

Copy originals can be classified generally into one of four classes. These classes are black-and-white line drawings, colored line drawings, black-and-white continuous tone, and colored continuous tone. Figure 2-5 shows a table of these classes, with the recommended film/developer combinations.

Films designed for copy and reproduction are generally slower than conventional films for general usage. This reduced sensitivity provides good resolving power, maximum subject definition and greater contrast control. However, the exposure latitude is usually very short, increasing the need of exposure accuracy. In fact, the proper exposure of the slower photomechanical films (used for line drawings), become most critical. Even the manufacturer, realizing the various illumination sources, omits any specific ASA data for these films. Only a suggested exposure is included in the data sheets.

Orthochromatic film is used frequently because it is not sensitive to red safelights. Since the film does not have a notching code indicating the emulsion side, this safelight feature allows for identification of the emulsion side. Process panchromatic film is available when panchromatic emulsions are needed. A line drawing with several different colors of ink would require a process panchromatic film.

Commercial Ortho can be classified as a general purpose film

| FILM DESCRIPTION | SUBJECT CLASSIFICATION | DEVELOPER | RATIO OF DILUTION | TIME @ $68^{o}F$ ($20^{o}C$) |
|---|---|---|---|---|
| Process Orthochromatic | B&W Line Drawings | D-19 (AFD #1) | None | 6 Min |
| Photomechanical Orthochromatic | B&W Line Drawings | Fineline* "A" & "B" | A-1:3 B-1:3 | 2-4 Min |
| Process Panchromatic | Colored Line Drawings | D-19 (AFD #1) | None | 6 Min |
| Photomechanical Panchromatic | Colored Line Drawings | Fineline* "A" & "B" | A-1:3 B-1:3 | 2-4 Min |
| Commercial Ortho 4125 | Continuous Tone B&W | DK-50 (AFD #2) | None | 8 Min |
| Med-Contrast Panchromatic | Continuous Tone--B&W or Colored | DK-50 (AFD #2) | None | 8 Min |

NOTE: Copy films are fixed, washed, and dried in the same manner as conventional black-and-white films. In all cases it is best to consult the manufacturer's directions for specific time and temperature for each processing and finishing step.

*Should be a substitute solution as AFD #1 (D-19) be used, increase exposure 25%.

Figure 2-5. Film Classification Table

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used frequently in routine copy work. The structure of this film is such that exposure controls the quality and contrast of the final negative more so than development. Landscapes, portraits, machine illustrations, and mechanical parts are typical subjects for copy purposes using Commercial Ortho. One exception would be red colored images, since Ortho films are not sensitive to red.

CAUTION: Do not use a red filter with this film. A red filter absorbs blue and green to which the film is sensitive and no image would be recorded.

Another popular copy film is Medium Contrast Panchromatic. Its characteristics of contrast, speed, grain, and resolving power all fall within the useful range. This is a panchromatic, continuous tone film having the ability to copy continuous tone black-and-white or color subjects. Also, many general purpose films can be used for copy work.

## COPY CAMERAS

There are many cameras specifically designed for copy work. These cameras vary in size of negative production, light sources and controls, but many features are very similar. Figures 2-6 and 2-7 show the two cameras used in this course. Note the similarities. Both cameras have ground glass focusing, front and rear focusing, swing lights, and a long bellows extension. Even though not shown, both cameras also have a process anastigmat and apochromatic lens.

### Copy Camera Operation

The general operating procedures for the average copy camera are very similar.

1. Loading the copy board:

   a. Check to see that the original material and the copy board are free of lint, dust, and other foreign matter.

   b. Load the original in the center of the copy board.

2. Scale and focus:

   a. Determine and position the copy board and bellows for correct scale (size) and focus. Fine focusing must be done by viewing through the ground glass.

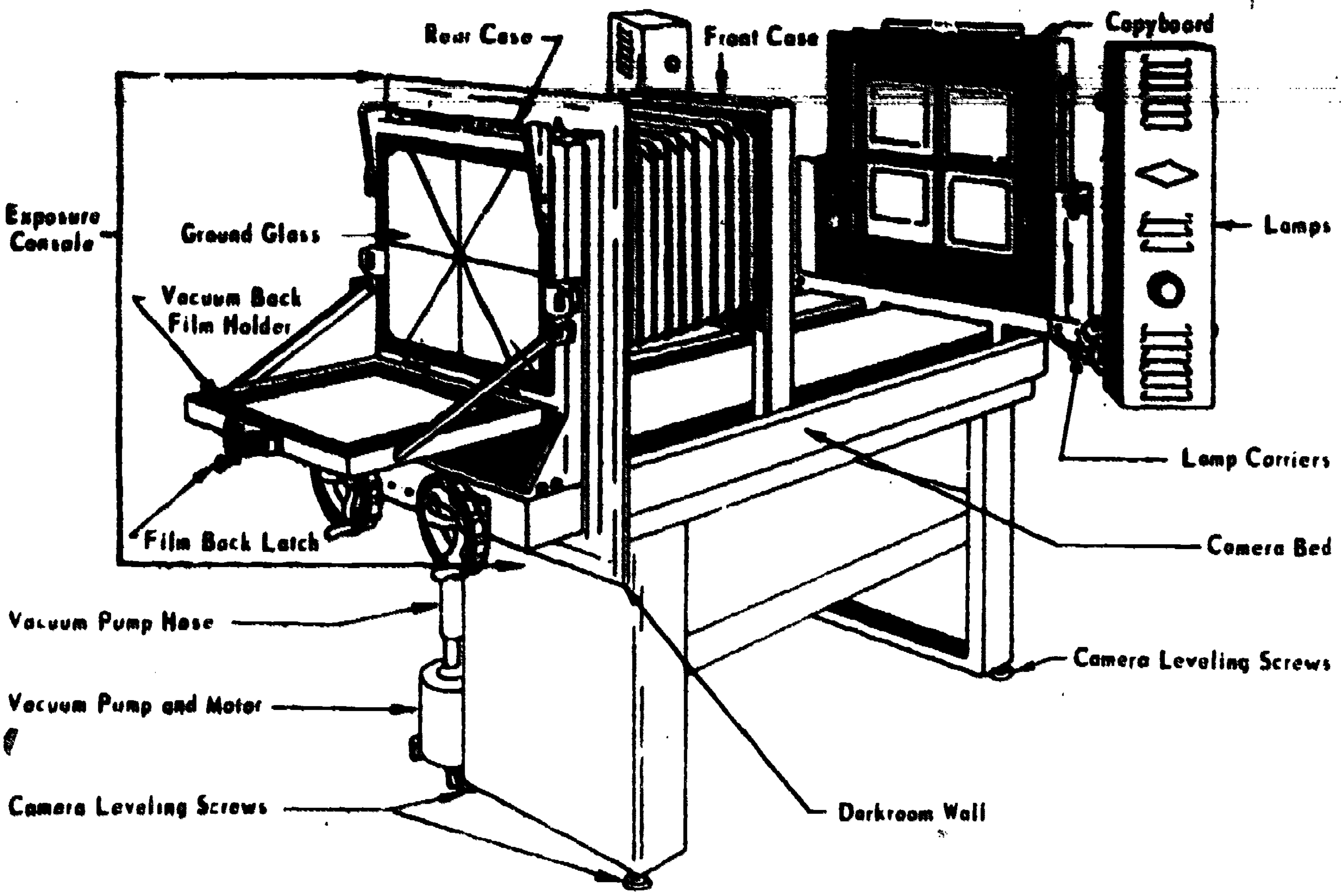


Figure 2-6. NuArc Copy Camera

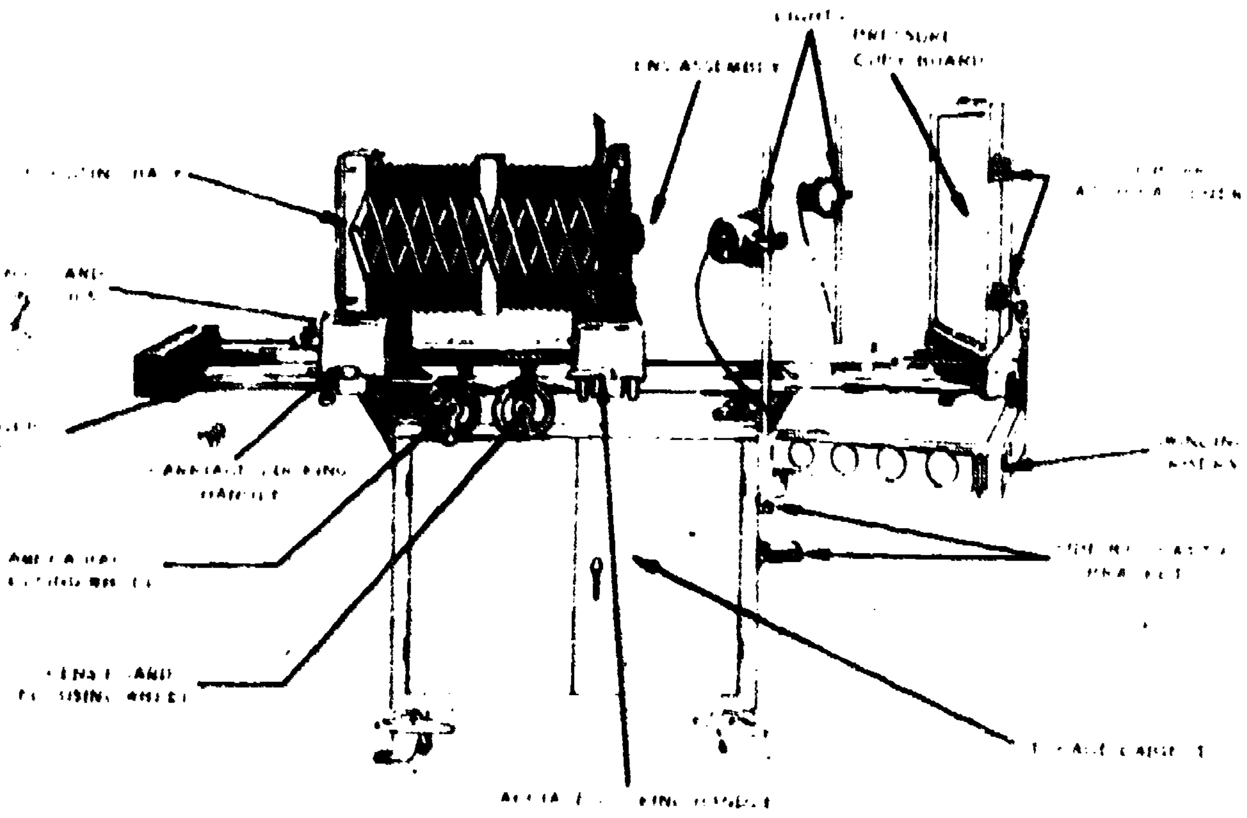

Figure 2-7. Princeton Copy Camera

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b. Position the lights for even illumination. Check for reflections through the ground glass. Reposition the lights as necessary.

3. Exposure:

a. Determine exposure and set the timer and f/stop to the correct settings. When possible, the lens should be set at its critical aperture, (the aperture that renders the sharpest image.) Normally, the critical aperture is three or four stops from wide open, (i.e., an f/4.5 lens is usually sharpest at f/11.)

4. Film loading and exposing:

a. Position the film so that the emulsion will face the subject during exposure. (The NuArc copy camera is set up so that the film loading/exposure section is in a darkroom and the copy board is in a lighted workroom.)

b. Start timer and expose. (Most copy cameras are equipped so that when the timer is started, the shutter diaphragm automatically opens.)

c. After the exposure is completed, remove the film and process.

CAUTION: When operating any copy camera, do not force any component to move. If any part does not move freely, check the camera carefully to determine the cause. If the cause cannot be determined, inform the supervisor or repair personnel.

NUARC MODEL SST-1418. The NuArc copy camera model SST-1418 is designed to be installed outside the darkroom with the exposure console end placed against a light locked opening into the darkroom wall. This arrangement enables darkroom personnel to load, expose, and process film under safelight conditions. Included as standard equipment are:

1. A counterbalanced 21 x 25 inch (53.3 x 63.5 cm) copy board.

2. A percentage calibrated diaphragm control.

3. A Wray 8 1/4 inch (210 mm) wide angle precision lens providing a reproduction range from 20% reduction to 300% enlargement.

4. Direct-reading dials for focusing and scaling.

5. A vacuum back to accommodate all film sizes up to 14 x 18 inches (35.6 x 45.7 cm).

6. An automatic reset timer.

7. A self-contained quartz iodine lighting system with four lamps.

Operation of the NuArc 1418. To position the copy board for loading purposes, swing it to [illegible]esting position on the stop plate. A locking pin keeps it in this [illegible]izontal position. The copy board has a spring latch and pressure type copy platen with a polished glass cover. The platen accommodates varying thicknesses of copy material, ranging from thin typewriter paper to pages pasted on thick boards.

Using the latch bar, raise the glass from upward past the locking position and then lower it slightly until it locks. Both hands are now free for placement of copy material. Always center the material to be copied in the copy board. The platen has been rectangularly zoned for this purpose.

Close the glass frame by lifting it slightly beyond the lock point and letting it down again, reversing the earlier procedures. Close the latch firmly. Pull out the locking pin and swing the copy board forward to its vertical position.

The quartz-iodine cycle lighting system illuminates the copy board and gives optimum efficiency and economy. Each reflector is individually adjustable for controlled copy board coverage. The quartz bulb should be mounted with the tube protrusion focusing up.

CAUTION: Always use cotton gloves, Kleenex or similar materials when handling quartz lamps -- NEVER BARE HANDS. This protects the bulbs against fingerprints which can be etched into the lamps when they are hot.

The Wray precision lens on the NuArc camera was specially designed to give optimum results with process cameras. The SHUTTER for this lens is solenoid operated from the exposure console.

On the lens board, directly above and controlling the lens opening, is the lens diaphragm chart with a manual setting arm.

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The diaphragm opening governs the amount of light that passes through the lens to the film at a given time exposure.

The top line on the lens board represents the actual f/stop setting (f/6.8 to f/3.2.) The 22, 16, and 11 lines represent settings for varying types of copy material. The 22 line is used mostly when copying continuous tone subjects. The 11 line is seldom used unless the subject matter is very hard and the large f/stop is needed. When the percentage of enlargement or reduction is calculated, the setting arm is aligned on that percentage along the chosen line (i.e., 22, 16, 11.) By doing this compensation for bellows extension or reduction is automatically calculated and the lens diaphragm (f/stop) is in the correct position for the copy.

All the controls and features of the Exposure Console are conveniently placed and clearly identified. Flip the MASTER SWITCH on the control panel to the ON position. This turns on the power for all the accessories on the camera.

The tape switch illuminates the percentage tape viewers. The left viewer is for the lens board tape, the right viewer for the copy board tape. The percentage tapes are moved by corresponding cranks below the control panel. When both tapes are set at the desired percentage, the copy material is in focus.

NOTE: Focus should always be checked on the ground glass.

To open the shutter and turn on the copy lights, move the TIMER-FOCUS switch on the left end of the panel from OFF to FOCUS position. Use the latch knob to open the camera back. Move the ground glass into position for viewing.

The vacuum film back assures a perfectly flat placement of the film so that there is no distortion of the copy image. The vacuum pump is oversized to provide a steady vacuum draw through each of the perforations on the film back. The vacuum does not cause vibrations that destroy sharpness and detail in the filmed image. The film back is zoned into the standard film sizes. Centering the film on the film back, positions the film opposite the centered subject material.

To eliminate finger and scratch marks on the emulsion, handle all film by the edges only, or wear cotton gloves whenever possible. Place the film on the film back with the emulsion side facing up. This can be checked under the proper safelight. When the film is in the proper place on the vacuum back, turn the vacuum pump on. The pump

immediately draws the film tight to the film back which is now ready to close for exposure.

The exposure timer is numbered in seconds and has two hands, colored green and red. The timer is set by turning the black dial in its center to the desired exposure time. Turning the black dial moves both the green and red hands from the previous exposure to the new setting. The red hand moves towards zero when you press the exposure button. The green button remains stationary so that another exposure at the same setting can be made immediately.

Press the white button to begin the exposure. At the end of the selected time interval, the timer clicks and the red hand on the timer returns to its position under the green hand. At the instant that the exposure is completed, the lens shutter closes and the copy lights go off.

PRINCETON COPY CAMERA. The Princeton copy camera comes in a variety of sizes and models. Regardless of size, the operation procedures are the same. The major difference among the various models is in the dimensions of the cameras.

Unlike the NuArc, the Princeton is not designed for darkroom installation. Instead, it is freestanding with film insertion through the use of cut film holders. This arrangement allows for the full operation (except loading film holders and processing) to be accomplished in normal room light. One person can easily operate the Princeton alone.

The Princeton can produce same-size reproductions, reductions, and enlargements. The exact range depends on the particular model being used. The film size used also varies with the models, with some capable of handling film up to 18 x 24 inches (45.7 x 61 cm).

Operation of the Princeton Copy Camera. Before attempting to use the Princeton, load a sufficient number of cut film holders. The film loading must be accomplished under darkroom conditions. If the film used is panchromatic, load it in total darkness. Read and understand the loading procedures before attempting to load the holders. Practice in normal light using a sheet of dummy film.

To load film holders, proceed as follows (See Figure 2-8):

1. Pull out the slide and partially reinsert it in the film holder. Make sure that the bright side of the slide faces out. Accomplish this before the lights are turned out.

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2. Turn out the room lights and open the film box.

3. Open the hinged bottom of the film holder. Hold the hinged bottom open with the left hand and the film in the right hand, with the forefinger on the notches. (The film notches should be in the lower right corner so that the emulsion will be up.)

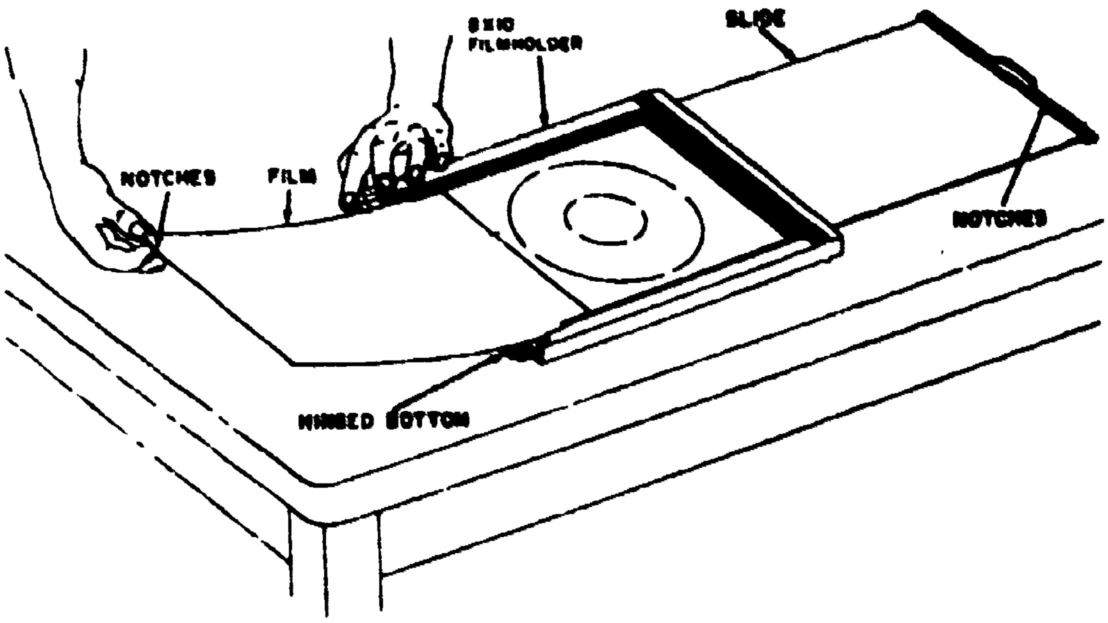


Figure 2-8. Loading Film Holders

4. Slide the film into the grooves, along the sides of the film holder, until it is fully inserted. Close the hinged bottom.

5. Insert the slide completely into the film holder and into the hinged bottom.

6. Set the locking screw (not shown) to hold the slide in position.

7. Turn the film holder over and load the opposite side.

8. Close the film box and turn on the lights.

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After loading the film holders, place the subject in the copy board and prepare to make the copy.

Remove the camera dust cover and the lens cap. Inspect the lens and camera for dust. Remove lens dust with a camel's hair brush or lens tissue and lens cleaner. Install the proper size ground glass focusing back and inspect it for dust. Remove the dust with the camel's hair brush.

To load the copy board, release the latch at the rear of it. Tip the copy board to the horizontal position. Release the side-latch fasteners and raise the glass. Insert the copy, close and fasten the copy board. Raise the copy board to the vertical position and fasten it. The glass MUST be clean for good results.

Prepare the lighting system as outlined earlier in the section on lighting.

Open the shutter and set the f/stop to its maximum aperture. This gives the brightest image for focusing. Use the following procedures to obtain the required size and proper focus:

1. Move the carriage locking handles backward to release the carriages.

2. Rotate the front hand wheel (clockwise or counterclockwise) until the image on the ground glass is approximately the desired size.

3. Rotate the rear hand wheel (clockwise or counterclockwise) until the image on the ground glass is coarse focused. Use the fine focusing knob until the image is sharply focused.

4. If the image is not the proper size after focusing, repeat steps 2 and 3.

5. Move the locking handles to secure the carriages.

6. Close the shutter and set the lens to the proper f/stop and shutter speed. (See the following section on determining exposure.)

After attaining the proper focus, insert a film holder, remove the dark slide, expose the film, and replace the dark slide. Replace the dark slide with the black side of the slide facing out, indicating the film is exposed. Turn off the copy lights, go into the darkroom and process the film.

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Determining Exposure. The exposure is determined through the use of a light meter. Turn on the lights and determine the exposure time with an incident light meter. (Remember that the lens is set at the critical aperture.) This is the basic exposure for a 1:1 reproduction. In this size of reproduction, the bellows extension equals the lens focal length. (This only applies in copying.)

Measure the length of the bellows from the center of the lens to the focal plane. Take the square of the bellows extension (BE) divided by the lens focal length (FL) to obtain the bellows extension factor (BEF.) Multiply the bellows extension factor by the original light meter exposure for the new exposure. For example: The incident light reading gives an exposure time of 1/2 second at f/16. The lens focal length is 305 mm and the bellows is measured at 610 mm. Therefore,

$$\frac{BE^2}{FL} = BEF \qquad \frac{610^2}{305} = 4$$

$$(BEF) \times (OE) = \text{new exposure} \qquad (4) \times (0.5) = 2 \text{ seconds}$$

The new exposure will be two seconds at f/16.

Keep a record of all exposures to be able to make any necessary minor adjustments to get the maximum quality.

Laboratory Safety

Both the NuArc and the Princeton copy cameras are powered by high voltage current. Never handle these cameras with wet hands. Also, water on the darkroom floor poses an electrical hazard when using the NuArc.

Besides the electrical shock hazard, water and/or spilled processing solutions on the darkroom floor can cause the operator to fall. This is particularly important since much of the darkroom work is in total darkness. Therefore, always clean up spilled solutions before proceeding.

When not using the NuArc's ground glass focusing screen, keep it secured with the chain provided. Otherwise, the screen may fall and break against the camera.

REVIEW QUESTIONS

DO NOT WRITE IN THIS SW-USE A SEPARATE SHEET OF PAPER.

1. What is a photo index?

2. What is a photographic holiday?

3. What type of paper is used to print mosaics?

4. At what angle should the lights be positioned when copying rough surface materials?

5. At what angle should the lights be positioned when copying smooth surface materials?

6. What precautions must be taken when replacing lamp tubes on the NuArc copy camera?

7. What is the critical aperture of a lens?

8. What three effects are accomplished by using a polarizing filter? Which is most important in copy work?

9. Explain one way to allow for a filter factor.

10. Given the following information, determine the proper exposure: Incident light reading: 0.2 sec. at f/16; Focal length: 400mm; Bellows extension: 660mm.

PRACTICAL EXERCISES

EXERCISE I

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Copy room facilities | 1/class |
| Darkroom facilities | 1/class |
| Copy camera | 1/2 students |
| Type V Class A film | 50 sheets/class |
| Film drying cabinet | 1/class |
| Aerial mosaics | As needed |

PROCEDURES

1. Obtain the desired scale of the copy from the instructor.
2. Determine the size of the final copy and set the camera to the correct size and focus.
3. Determine the proper exposure as outlined in this SW.
4. Expose the film following the operating procedures as outlined in this SW.
5. Process the film in accordance with the film data sheet.
6. Clean up all work areas and return to the classroom for critique by the instructor.

## EXERCISE II

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Laboratory facilities | 1/class |
| EN-22A contact printer | 1/student |
| Printer timer | 1/student |
| Continuous timer | 2/class |
| Thermometer | 2/class |
| Print washer | 1/class |
| Print dryer | 1/class |
| Negative of a mosaic | 1/student |
| Variable contrast printing paper | 5 sheets/student |

PROCEDURES

1. Make sure that electrical equipment furnished with grounding attachments are properly grounded.
2. Keep electrical equipment away from wet sink areas.
3. Do not handle any electrical equipment (printer, timer, etc.)
4. Obtain the necessary processing chemicals from chem mix. Use AFD No. 25 (D-72) diluted 1:2.

5. Check printer platen and glass for cleanliness. Both may be cleaned with a damp cloth if necessary, to remove chemical spots, etc. For safety's sake, disconnect the printer from the power outlet while doing this. (Use alcohol and cotton to clean the printer glass.) Use lint free cleaning cloths and dry the parts carefully after cleaning.

6. Position the mosaic negative emulsion side up on the printer. Tape it down by at least two corners. Use small pieces of tape and do not allow any part of the tape to extend into the picture area.

7. Cut a sheet of the printing paper into test strips, and then make test exposures and process as outlined in the previous SW.

8. Expose a sheet of printing paper for the correct number of seconds and process it carefully within the allowable time limits. Compare the density of the print with that of the test strips. With the instructor's aid, determine if an acceptable density has been achieved. If not, repeat the process until an acceptable print is produced.

9. Return all unexposed paper to its proper box. Insure that the paper boxes are tightly closed, then turn the normal room lights on.

10. At the direction of the instructor, carry the prints to the finishing room for washing and drying.

Sciences Branch
Lowry AFB, Colorado

SW G3AIR23330 001-V-3
October 1977

# PROJECTION PRINTING

## OBJECTIVE

Using manual projection printers, laboratory facilities, aerial negatives and printing materials, produce black-and-white prints which are free of exposure and processing defects.

## INTRODUCTION

Earlier in this course, basic projection printing was introduced. This section will review those principles and refine them. In this lesson, aerial negatives will be used. Far more precision is needed with aerial work than with snapshots. One square centimeter can contain vast amounts of information in reconnaissance work.

One of the main advantages of projection printing is the ability to select portions of a negative to print and eliminate unimportant portions. Also, the important area can be enlarged greatly to bring out the detail.

## INFORMATION

### PROJECTION PRINTING FUNDAMENTALS

#### Principles of Projection Printing

Projection printing is the method which uses a lens to project an image of a negative or positive, onto unexposed material. A negative (or positive) is placed in the printer between the light source and the rawstock. As light passes through the negative, the lens projects the image onto the emulsion of the rawstock. This produces the latent image on the rawstock.

The size of the projected image is controlled by the lens focal length and/or the distance from the negative to the rawstock. Selection of the lens focal length depends on the negative size being printed or the degree of magnification desired. Normally, the focal length should be equal to the negative's diagonal length. In practice, it is usually slightly shorter. In instances where only a small portion of the negative is to be printed, the lens focal length can be much shorter than the negative diagonal.

With a given negative-to-rawstock distance, the shorter the

lens focal length is, the larger the projected image size will be. With a given focal length, as the negative-to-rawstock distance increases, the image size increases. Conversely, an image is made smaller by using a lens that has a longer focal length or by decreasing the negative-to-rawstock distance.

Types of Projection Printers

The Armed Forces use two basic types of projection printers. These are the diffusion type and the condenser type. (See Figure 3-1.)

DIFFUSION SYSTEM. The diffusion type projection printer has a diffusing glass between the light source and the negative. Light strikes the diffusing glass and is scattered in all directions. Thus, the negative is illuminated evenly but softly.

An advantage of diffused illumination is that minor negative defects are not recorded clearly in the print. However, there is a softening of the image sharpness and a reduction in contrast. Therefore, diffusion projection printers are not used in aerial reconnaissance work.

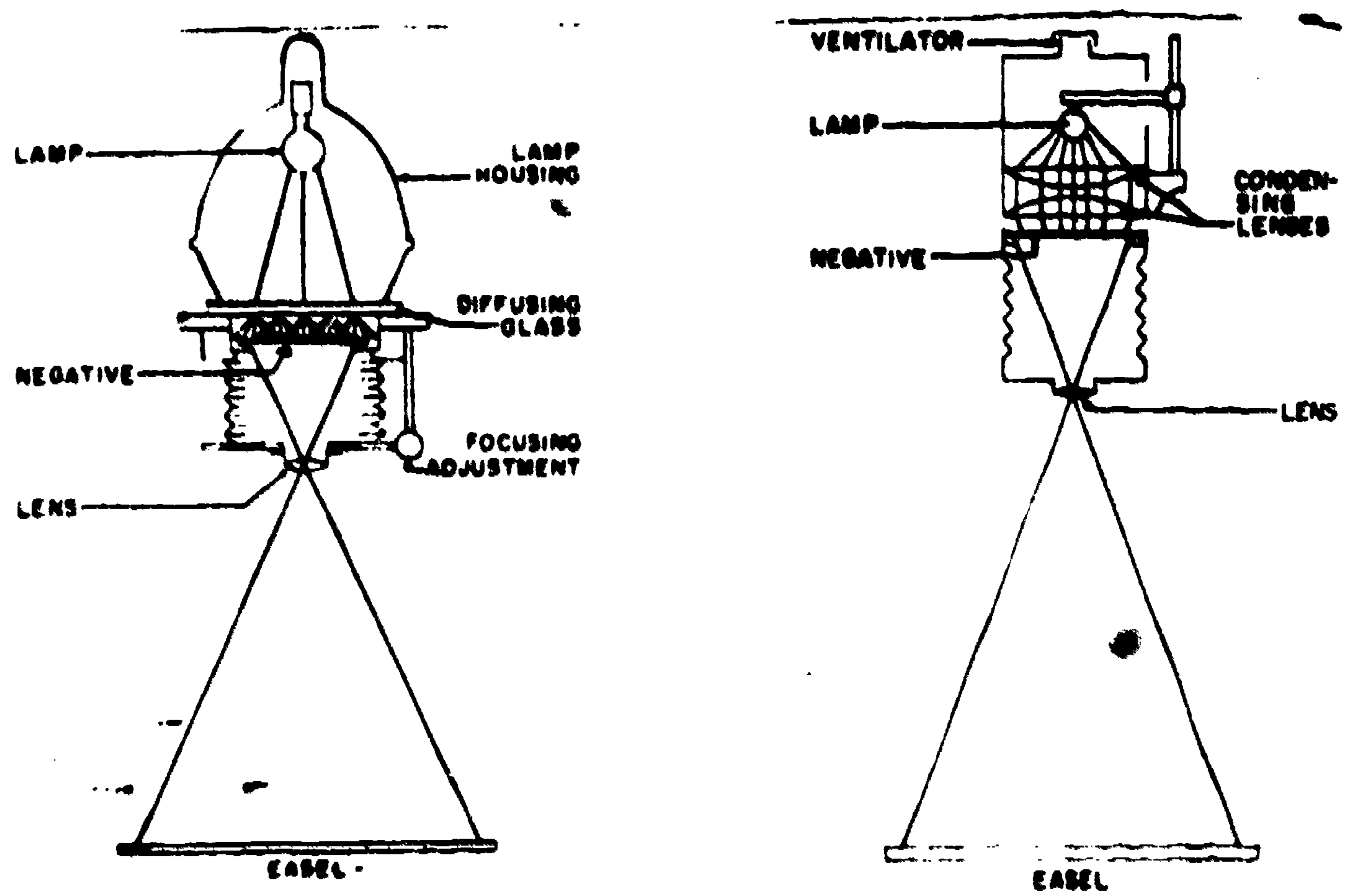


Figure 3-1. Diffusion and Condenser Projection Printers

CONDENSER SYSTEMS. In a condenser projection printer, the light is concentrated by the condenser lenses through the negative. In this manner, there is no softening of the image. Maximum detail is retained.

Condensing lenses also utilize as much of the existing light as possible. As a result, exposure times are much shorter than with a diffusion printer. In aerial reconnaissance work, even seconds count.

Projection Printer Models

The Air Force inventory contains many models of projection printers. A brief description of some of these models is in order.

BEACON PRECISION ENLARGER. The Beacon Precision Enlarger (Figure 3-2) is capable of producing enlargements from preselected areas of aerial roll film. It will enlarge negative sections with diameters of 3.7 inches to 0.32 inches (94 to 8mm) to magnifications from 3x to 40x in color and 3x to 153x in black-and-white. Enlargements are printed on rawstock up to 40 inches (102cm) on a side. The area to be enlarged is specified by coordinates within the negative frame. It will handle any standard roll film size from 70mm to 9.5 inches (24.1cm) in rolls up to 7.6 inches (19cm) in diameter.

Optics. Six standard and two optional interchangeable lens/condenser sets are furnished to provide continuous 3X-153X magnification for black-and-white enlargements with the first five lens sets being color corrected to permit color enlargements up to 40X. The precision optics are aligned rigidly on a massive frame, shock isolated from the base to enhance image sharpness.

Transport Systems. Film transport and easel drive assemblies are motorized to speed the location of selected frames in a roll of film. They also position the easel for exact focusing and magnification. A horizontal transport system moves the negative to locate a designated frame and to position the horizontal coordinate at a requested point within the frame. The vertical coordinate of the frame is positioned by a vertical transport system, which also moves the film into and out of the optical path of the enlarger.

Magnification and Focusing. A semiautomatic system for selecting magnification and focusing is also provided. An illuminated display on the easel drive indicates a magnification value at each negative-to-easel distance for the lens being used. A

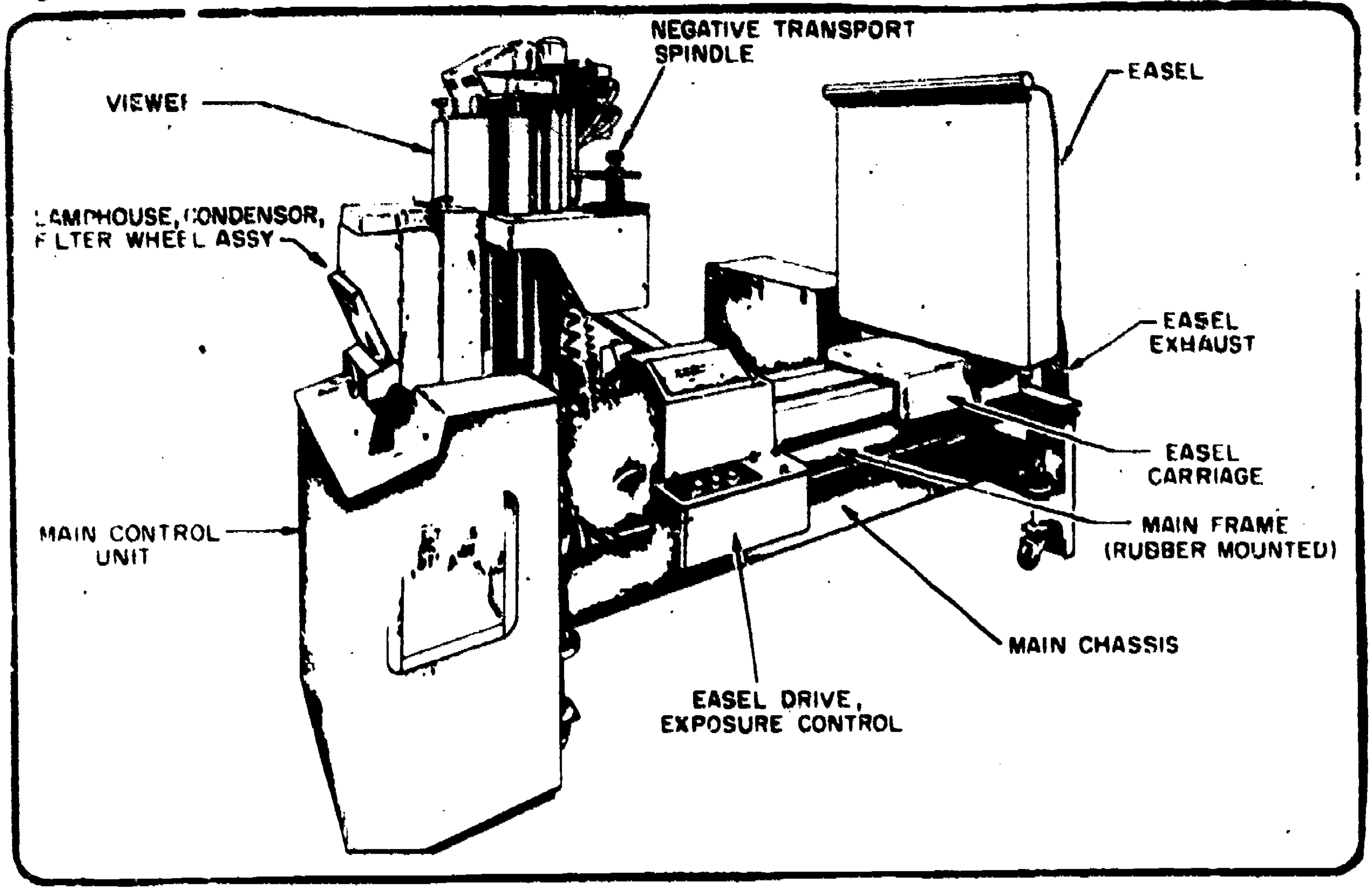


Figure 3-2. Beacon Precision Enlarger

parallel display indicates the required lens focus setting. The lens barrel moves in and out, and drives a counter that displays the numerical lens focus setting. When the lens is in focus for a specific easel position, the number on the lens is the same as that displayed beside the magnification number.

Exposure. A photometer is provided to help establish correct exposure for the print stock used. A probe, which has a 3mm diameter spot and can be held at any position on the easel, can be used to read D-min and D-max areas of the projected image. Intensity of the printing light can be varied by adjusting the voltage applied to the lamp, and exposure times of 1-second to 111-seconds, in tenths of a second, are available.

Negative Positioning. Negative film is held stationary by

clamping between glass plates. A surface coating of special fluid is injected on each side to clean the film, to eliminate Newton rings, and to reduce the effect of scratches and abrasions on the film. (Newton rings are concentric bands of colored light sometimes seen around the areas where two transparent surfaces are not quite in contact. The rings are the results of interference and occur when the separation between the surfaces is of the same order as the wavelength of light.)

Rawstock Positioning. The rawstock (paper or film) is held snugly against the vertical easel surface by a vacuum. For printing film which does not have an antihalation backing, a porous dark screen can be pulled down over the easel to prevent light scatter from the easel surface. Print stock holders are provided to hold down the edges of badly curled film or paper that might not otherwise lie flat on the easel surface.

DURST X-184M PROJECTION PRINTER. This printer consists of the projection printer head mounted on two vertical columns, a lamp house, a base equipped with casters, a movable vacuum table also mounted on the vertical columns, a power supply console and ventilator installation and a vacuum pump. (See Figure 3-3.) A counter balance is mounted at the top of the vertical columns and is connected to the printer head to reduce force required to raise and lower it.

The projection printer head contains interchangeable type optical condensers, a filter drawer for interchangeable light filters, a negative carrier, the light source and the projection lens. The head is raised and lowered by a hand crank assembly. An electric motor drive can be substituted for the hand crank.

The light source for this printer is an xenon lamp which is controlled by the power supply console. The power supply console contains a ventilating unit which supplies cool air for the lamp housing through a duct. It also houses a precision timer for exposure time control and control of the exposure lamp cooling blowers. The exposure lamp can be operated at full or half power.

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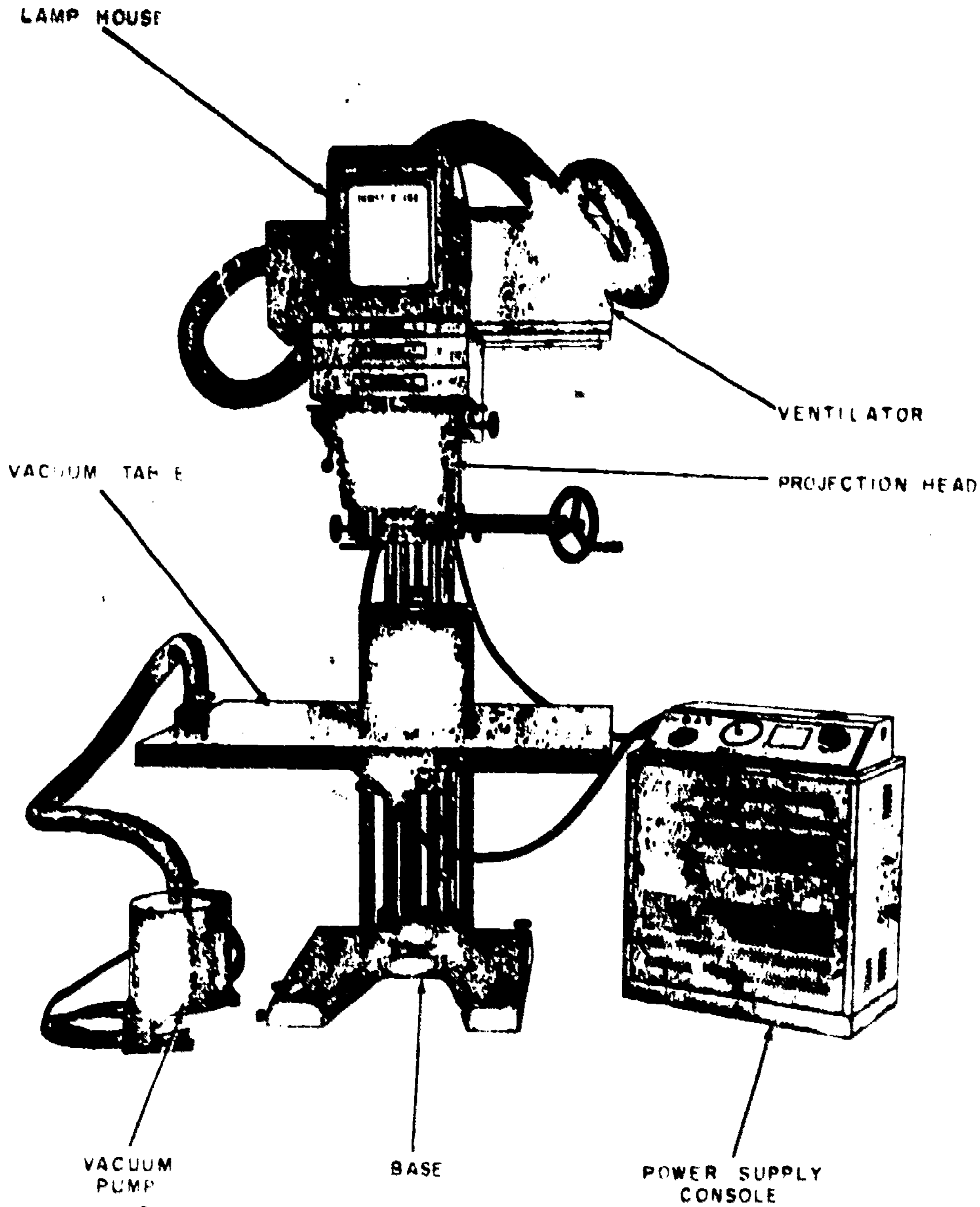


Figure 3-3. Projection Printer, Durst X-184

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| X-184M Specifications | |
|---|---|
| Negative Size limitations | 35MM to 8 x 10 inch and 9 x 9 inch (200 x 250mm and 230 x 230mm) |
| Maximum Enlargements (360MM lens) | |
| Vertical projection | 2.5 x negative length |
| Horizontal projection | 21 x negative length |
| Projection lens | 80MM f/5.6 |
| | 150MM f/5.6 |
| | 240MM f/9 |
| | 360MM f/9 |
| Vacuum table | Allows up to 30 x 40 inch (760 x 1020mm) prints |

EN-52B Projection Printer

The EN-52B projection printer is one of the more common models in the Air Force. Review figure 3-4 to recall the basic components of the printer.

Besides the features shown in Figure 3-4, the EN-52B is equipped with three lenses--an f/3.5, 50mm; an f/4.5, 105mm; and an f/4.5, 150mm. It also has a heat absorbing glass and two plano convex lenses in the condenser as well as an addition variable condenser lens. Negatives are held in place by one of six carriers of varying sizes.

The projection printer may be rotated on its base to permit the negative to be projected onto the floor. This permits enlargements larger than 11 x 14 inches (280 x 356mm). Hold the carriage and girder securely, loosen the three cap screws and secure the three rotary clamping pads. Rotate the girder 180°

1. Lens Mount Assembly, 150mm
2. Lens Mount Assembly, 105mm
3. Lens Mount Assembly, 50mm
4. Condenser lens assembly, two plano-convex lenses
5. Lamp house Assembly
6. Carriage Assembly
7. Cam, 150mm
8. Cam, 105mm
9. Cam, 50mm
10. Girder Assembly
11. Baseboard Assembly
12. Wrench
13. Cam follower wheel
14. Lifting lever - raises lamp house assembly
15. Variable contrast filter turret assembly
16. Diaphragm Control - all mounts equipped with an f/number illuminator
17. Film Stage
18. Variable Condenser Housing
19. Elapsed time Indicator - records time in use
20. Focusing Knob - contracts or expands the bellows for fine focus adjustment
21. Handwheel knob - controls the position of carriage on girder assembly; thereby controlling the size of the enlargement
22. Brake Knob - locks carriage in position on girder assembly

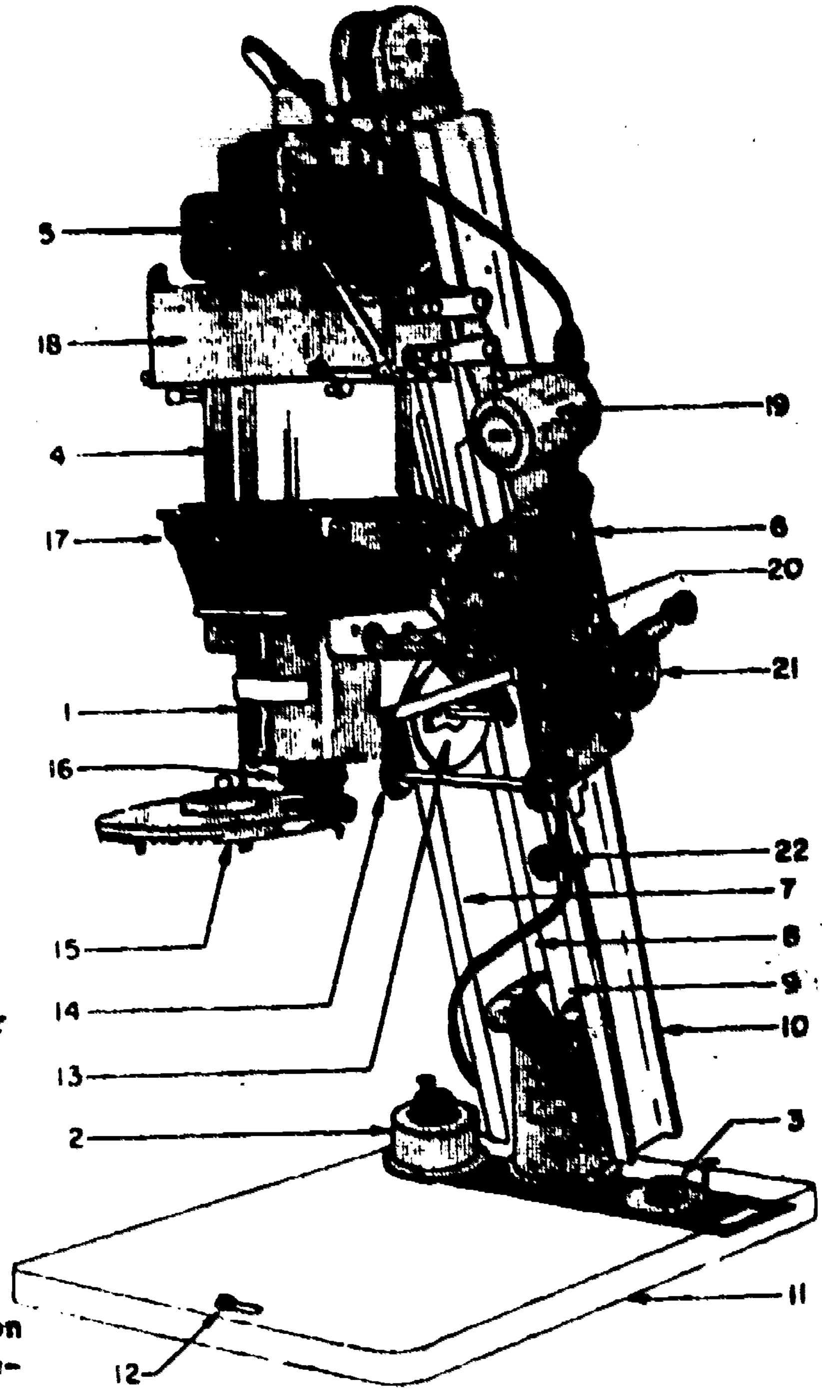


Figure 3-4. EN-52B Manual Projection Printer

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on the base and secure it in this position with the cap screws.

> CAUTION: Before rotating the girder and carriage for floor projection, secure the base board to the table with "C" clamps to prevent the printer from overturning.

Projection Printing Procedures

Regardless of the printer being used, some basic principles apply to all of them. One of these is cleanliness. Be sure that the laboratory and equipment are free of dust, dirt, and other foreign materials. Because minor dust particles on the negative or on the glass plates of the negative carrier become extremely noticeable when enlarged, cleanliness is very important.

Another basic principle is proper chemical preparation. This area has been thoroughly discussed in earlier parts of this course, so no further discussion is necessary.

Finally, there is a rule which states, "If it isn't in the negative, it can't be produced in the print." Moreover, if it is in the negative, it will also show up in the print. To produce good prints, especially enlargements, it is helpful to start with a good negative. However, in aerial photographic situations, less than ideal negatives will be received at times.

The following procedures outline the general procedures used in projection printing. Although they apply specifically to the EN-52B used in this course, they can be applied (with slight modification) to other projection printers.

1. Install the proper lens for the size of negative being used and the desired print size. Plug the printer into the timer and the timer into the appropriate electrical outlet.

2. Check the condenser lens to see that it is properly positioned in the lamp house assembly. Set the cam follower wheel on the cam so that it is matched with the proper lens.

3. Turn off the room lights and turn on the safelights.

4. After an initial manual adjustment, the lens is kept in focus for all magnifications by an autofocusing device. This device consists of a special cam cut

to match the lens characteristics and a cam follower. The cam follower changes the lens to negative distance as the printer housing is moved up or down, thus changing the lens to image distance. When lenses are changed, the cam follower must be changed to the matching cam.

5. Select the appropriate size negative carrier for the negative being printed. Insert the negative, emulsion down, on the bottom of the carrier.

6. Raise the lamp house assembly and install the negative carrier on the film stage.

   For roll film, insert the film in the left bracket assembly of the spool-type carrier. Thread and attach the film to the empty spool in the right bracket assembly. Rotate the crank of the right bracket assembly to bring the desired negative into position.

7. Set the lens aperture wide open by turning the diaphragm control counterclockwise. Turn the timer control to "focus."

8. Place a sheet of white paper in the projection printing easel. Loosen the brake knob and raise the carriage assembly to its highest position by turning the hand-wheel knob. Focus by making adjustments with the focusing knob until a sharp image is obtained.

9. Lower the carriage assembly by turning the handwheel knob until the desired size is projected on the white paper. Tighten the carriage brake knob finger tight Adjust the easel position to produce the desired cropping in the photograph.

   CAUTION: To avoid damage to the carriage gears, always loosen the brake knob before turning the hand-wheel knob.

10. Stop down the diaphragm to the desired opening. The exact amount that the lens diaphragm should be closed is difficult to determine without experience. Try to control the illumination so that the exposure requires from 5 to 10 seconds It is suggested that the lens be stopped down two to three stops from maximum aperture.

11. Turn the timer switch from "focus" to "time." Cut a

sheet of projection paper into test strips about 2-inches (5 centimeters) wide. Lower the blade after using the paper cutter.

12. If graded paper is being used, select a grade of the proper contrast. If variable contrast paper is used, position the proper filter in front of the lens. (In lieu of experience, assume that the negative has normal contrast.)

13. Remove the white paper from the easel and place a test strip in the easel with the emulsion side facing the lens. Include highlight, middle tone, and shadow areas in the test. Make a series of exposures on one test strip.

14. Process the test strip or strips. Be sure to use a 68° F (20°C) solution temperature. Develop for 90 seconds.

15. Judge the test strip for contrast and exposure. If the test does not fall within the desired range of tone and contrast, make additional tests until both are determined. Use the same processing times for each test.

16. Using the exposure and contrast determined by the test, make the desired number of prints on full sized paper. Position the paper in the easel so that the borders and composition are correct. Process the prints exactly the same as the test strips.

Projection Printing Controls

Not all negatives are perfect, by applying dodging, burning-in and contrast control, the appearance of the final print can be improved.

DODGING AND BURNING-IN. Dodging is holding back the light from specific areas for part of the exposures. Meanwhile, the major portion of the print is given normal exposure. Dodging is used to prevent certain areas of the print from becoming too dark.

Burning-in is adding additional light to specific areas after the completion of the primary exposure. During burning-in, the major portion of the print is receiving no more additional exposure. Burning-in brings out detail in print areas that tend to be too light.

Dodging and burning-in are techniques that are refined by practice. While learning these techniques, observe certain precautions. For example, an essential part of these techniques is to keep the dodging or burning-in device in constant motion during the exposure. This is necessary to blend one area into another without a noticeable dodging or burning line. If the device is held steady during the entire period of its use, a definite line will be formed between the two exposures. This is unsatisfactory.

The devices used for dodging and burning-in need not be complicated. As shown in Figure 3-5, the operator's hands may be used for dodging or burning-in. Another simple device for dodging is a piece of opaque material attached to a stiff wire. This is then held between the lens and the rawstock blocking the light on specified areas of the prints. (See Figure 3-6.)

An opaque sheet with a hole to allow passage of light makes a very useful burning-in device. (See Figure 3-7.)

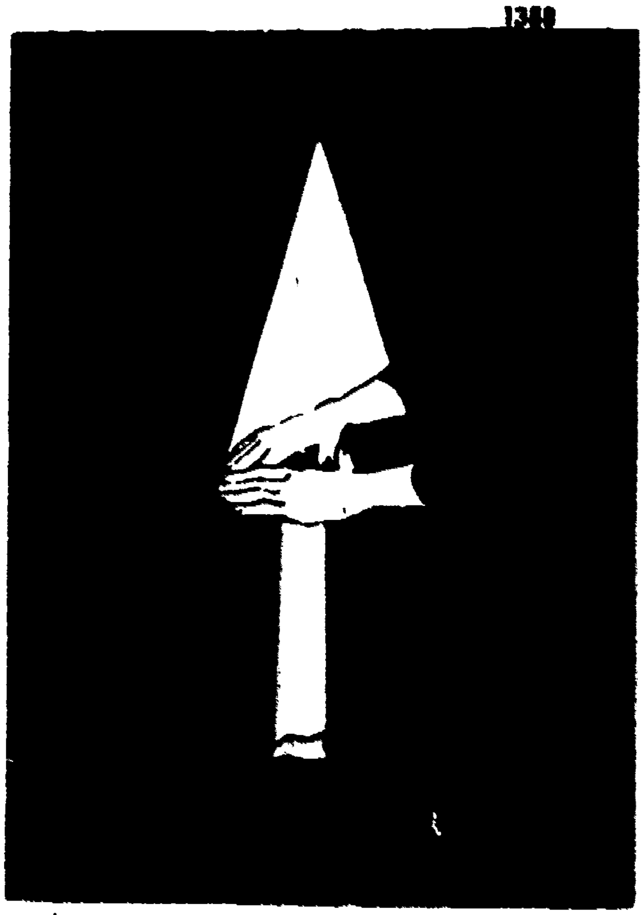

Figure 3-5. Using the Hands for Dodging or Burning-In

It is sometimes advisable to have a large burning-in device with several openings available for use as needed. With such a device and a bit of ingenuity, the operator can make minor modifications in the opening shape with the fingers or another sheet of paper.

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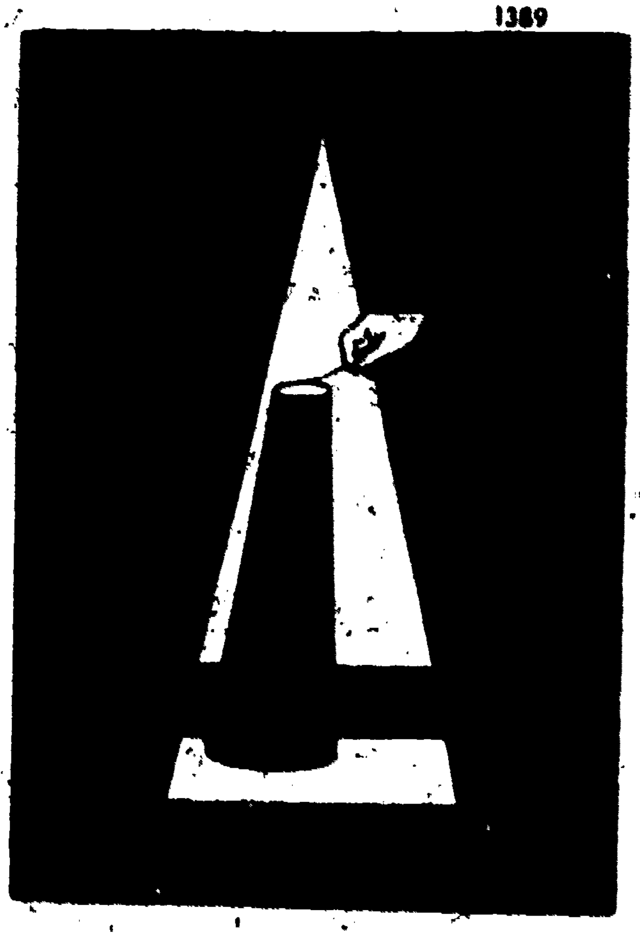

Figure 3-6. Using a Wire-Supported Dodging Device

1395

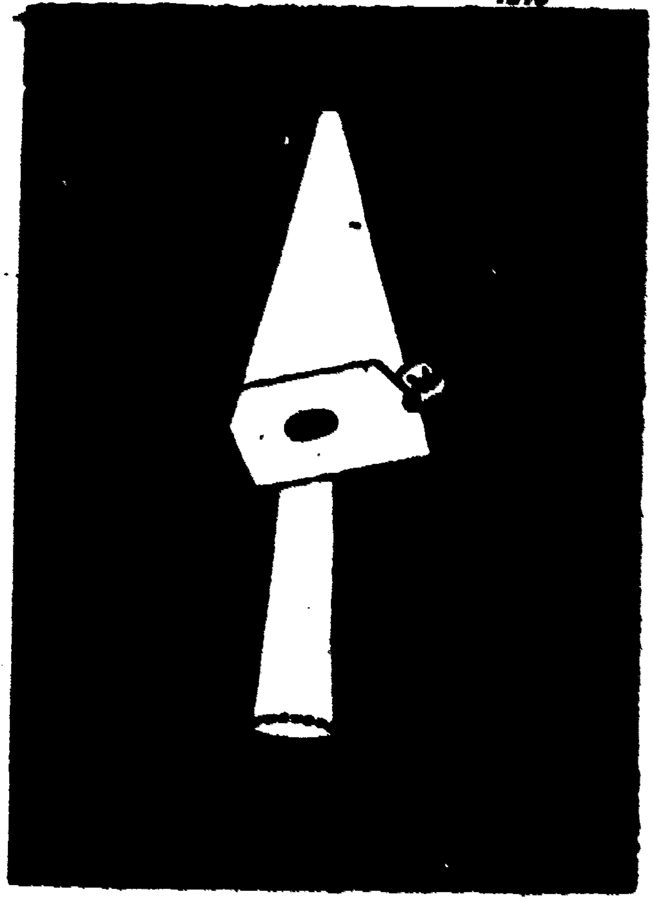

Figure 3-7. Using an Opaque Sheet for Burning-in

The closer the dodging device is held to the lens, the larger its image on the paper will be. When the device is held close to the paper, the size of the shadow closely approaches that of the device itself. Also the closer the device is to the lens, the less distinct its image will be. The closer the device is to the paper, the more sharply defined will be its shape and its edges. Normally, it is best to use any dodging device relatively close to the lens.

It tends to produce better blending of the exposure given each part of the print, less motion is required, and the device can be relatively small in size.

The relative amount of exposure given each area is an intangible factor and only experience or test exposures can produce the exact exposure times required.

CONTRAST CONTROL. Contrast is controlled in projection printing through the use of graded contrast or variable contrast papers. After making the test strips, judge the strips for contrast. If the contrast is unsatisfactory, change to another contrast. Use the same criterion as used in contact printing for determining the correct contrast grade or contrast filter.

REVIEW QUESTIONS

DO NOT WRITE IN THIS SW-USE A SEPARATE SHEET OF PAPER

1. How is the size of the projected image controlled?
2. What are the two basic types of projection printers?
3. Why is the diffusion type projection printer never used in aerial photographic laboratories?
4. Why are condensing lenses employed in projection printing equipment?
5. What are Newton rings?
6. What is the light source of the Durst X-184M projection printer?
7. What lenses are supplied with the EN-52B?
8. Explain the procedures in making a test strip for projection printing.
9. Why is it important to keep the dodging or burning-in device in constant motion during its use?
10. How is contrast controlled in projection printing?

PRACTICAL EXERCISES

EXERCISE I

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| EN-528 projection printer | 1/student |
| Printer timer | 1/student |
| Glass negative carrier | 1/student |
| Continuous timer | 3/class |
| Thermometer | 2/class |
| Print Washer | 1/class |
| Print dryer | 1/class |
| Laboratory facilities | 1/class |
| Processed aerial negatives | As needed |
| Variable contrast projection paper | 15 sheets/student |

PROCEDURES

1. Obtain the necessary chemicals for processing paper from the chemical mix section. Set up the processing trays and use AFD #25, diluted 1:2.

2. Check the projection printer as follows:

   a. Inspect the printer for cleanliness and ease of operation.

   b. Clean the lens. If necessary, brush it with a camel's hair brush.

   c. If the printer has interchangeable condensers, ensure that the set matching the lens' focal length is clean and properly installed.

   d. Check the cam follower wheel to make sure that it is on the proper track to match the focal length of the lens.

3. Adjust the printing easel to give 8 x 10 inch (200 x 250mm) prints with a border.

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4. Place the aerial negative in the carrier and insert it into the printer.

5. Follow the instructions outlined in this SW for making test strips and prints. The prints MUST have acceptable density and contrast.

6. The first print must show as much of the negative as possible.

7. After making a satisfactory print of the entire negative, consult the instructor. The instructor will choose an area of the photograph which is to be enlarged.

8. At the instructor's direction, wash and dry the prints.

9. Clean the laboratory and return to the classroom for a critique.

Sciences Branch
Lowry AFB, Colorado

SW G3ABR23330 001-V-4
October 1977

# STEP MODE PRINTING

## OBJECTIVE

Using a Mark II R5A printer, Versamat 11CM processor, negatives, and printing materials, produce prints in the contact and projection modes of operation. Prints must be free of physical and chemical defects and must have acceptable density and contrast.

## INTRODUCTION

Aerial photographic reconnaissance requires superior tone reproduction which leads to high information content and intelligence information. These factors may be present on the original negative or they may not be. If they are included in the original, can they be retained through a series of reproductive generations? If they are not present, can they be improved? Tone reproduction is not now an artistic endeavor as it once was. Nor is it a hit or miss method. It is a field where precise methodology and purposeful thought can and must be applied.

## INFORMATION

### MARK II R5A STEP MODE PRINTER

In recent years, several important developments relating to improved tone reproduction have occurred. Perhaps the most spectacular development has been the automatic dodging printers.

#### Description

The Mark II R5A printer produces contact or double-sized projection prints. It can print from aerial negatives, medical and scientific negatives, X-rays, and ordinary negatives in specified format sizes. It retains maximum detail in all areas and can be operated manually or automatically. When operated automatically, the Mark II R5A can produce up to 119 good prints before the automatic roll paper transport must be reset.

Rawstock is fed through the printer manually or automatically by the roll paper transport (RPT). The platen hood assembly holds the negative and rawstock in close contact, similar to the platen on the EN-22A manual contact printer. However, the platen hood

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on the Mark II R5A can be operated automatically by the automatic platen lifter (APL).

The RPT has an advancing speed of 5-inches (13cm) per second. It will advance the paper from 8-to 20-inches (20 to 51cm) with an accuracy of ±1/8 inch (3.2mm). It can handle rawstock up to 9.5-inches (24.1cm) wide and up to 500-feet (152 m) long. The Mark II R5A accepts single weight, double weight, and water proof paper or film in sheet or roll form.

CAUTION: Never use film with an opaque backing on the Mark II R5A. Damage to the cathode ray tube will result.

The printing light source is a cathode ray tube located near the bottom of the cabinet. This cabinet also houses a lens box assembly, two lenses, electronic circuits, and power supplies. One of the lenses is a 112mm focal length used for contact printing and the other is a 138mm focal length used for projection printing.

A photomultiplier tube (PMT) is located at the rear of the hood assembly. The PMT controls the exposure and dodging system. This PMT is expensive to replace. Never lower the hood assembly with the main power on and the room lights on. Extreme damage to the PMT will result.

All controls are located on the front of the hood assembly, on the front of the cabinet or to the right side of the cabinet. In addition, there is a safelight and a white light inside the cabinet. All indicator lights and the safelight can be dimmed during operation.

Exposure and Dodging Systems

The Mark II R5A operates on the principle of incremental exposure control. Several small areas, or increments, approximately 1/4 inch (6.4mm) wide are exposed at one time. Automatic controls keep the average density of each area the same as that of every other area.

EXPOSURE AND DODGING METHODS. As the hood is closed and exposure begins, the cathode ray tube (CRT) projects a spot of light upward through the negative onto the rawstock. This spot sweeps back and forth across the negatives and moves down the negative exposing the entire negative area. The rate of the sweep is determined by the PMT.

The PMT measures the amount of light passing through the negative and rawstock. In the denser negative areas, less light passes through. The PMT measures this and slows the rate of the sweep to give this area more exposure time. The opposite is true with thin negative areas. A great amount of light passes through the rawstock, therefore, the PMT increases the speed of the exposure sweep.

The sweep speed change is almost instantaneous. Over large areas or between areas having small density differences, the dodging effect is very uniform. However, there is some border enhancement where the scanning spot moves from a dense area to a thin one. Since the scanning spot has a finite size, it requires a certain time to move across the border between the adjacent density areas. During that time, the feedback signal from the PMT will call for a large quantity of light. The spot, having partially entered the thin area, will tend to overexpose the thin area until the feedback signal catches up to the spot position. This effect is shown in Figure 4-1.

Higher than normal density will occur at this border. In one respect this can be an advantage. This edge enhancement will cause the edges of an object to be more clearly defined. On the other hand, edge enhancement could possibly interfere with accurate measurements of objects. Moving the spot from a thin area into a dense one would result in the opposite effect. The dense border would receive less than a normal exposure, hence it would be defined by a thin edge.

EXPOSURE MODES. The printer is equipped with an exposure mode switch with three positions. TEST, MANUAL, and AUTOMATIC. In the TEST position, the CRT is fully lit to allow raster adjustment. The raster adjustment alters the light size to fit the negative size. The TEST position also allows for adjustment of the mask. (See a following section on raster and mask adjustment.) In MANUAL position, the PMT is off and there is no dodging. In the AUTOMATIC position, the PMT is on so that dodging and exposure are automatic as long as negatives of the same approximate density are being printed. If negatives are changed, or if there is a radical change in density to which the printer cannot adjust, the exposure index must be reset.

MASKING AND OVERSCAN. A mask of colored acetate is placed around the image area of the negative. The purpose of this masking is twofold: It prevents extraneous light from reaching the PMT; and it minimizes border enhancement caused by the spot

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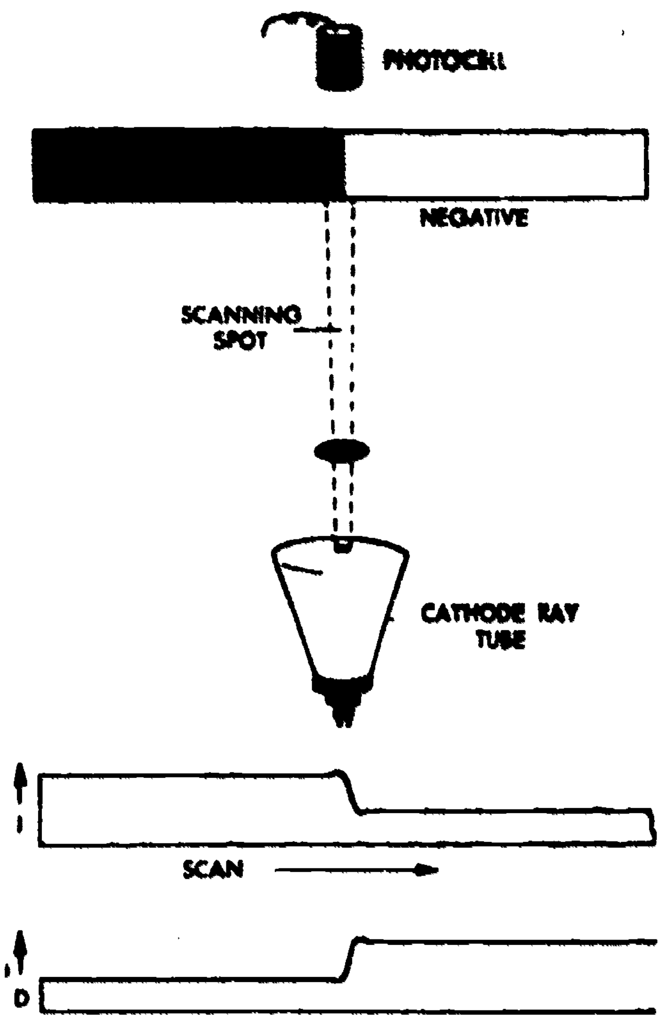



Figure 4-1. Border Enhancement

as it leaves the negative image area and enters the transparent border. If extraneous light reaches the PMT, exposure and dodging control will be reduced. Achieving either or both purposes completely is unlikely. Basically, for best results, two masks should be used as follows:

1. Use a mask, approximating the density of the negative, that extends outward from the negative image area for 1/2 to 3/4 inch (13 to 19mm). The mask must extend beyond the outer

edge of the raster overscan.

2. Use a second mask of high density, essentially opaque, extending to the edge of the printing stage. The opening for this mask must be large enough so that no part of the raster is covered.

NOTE: Generally, results are good enough with only the first mask, so that the second mask is not usually used.

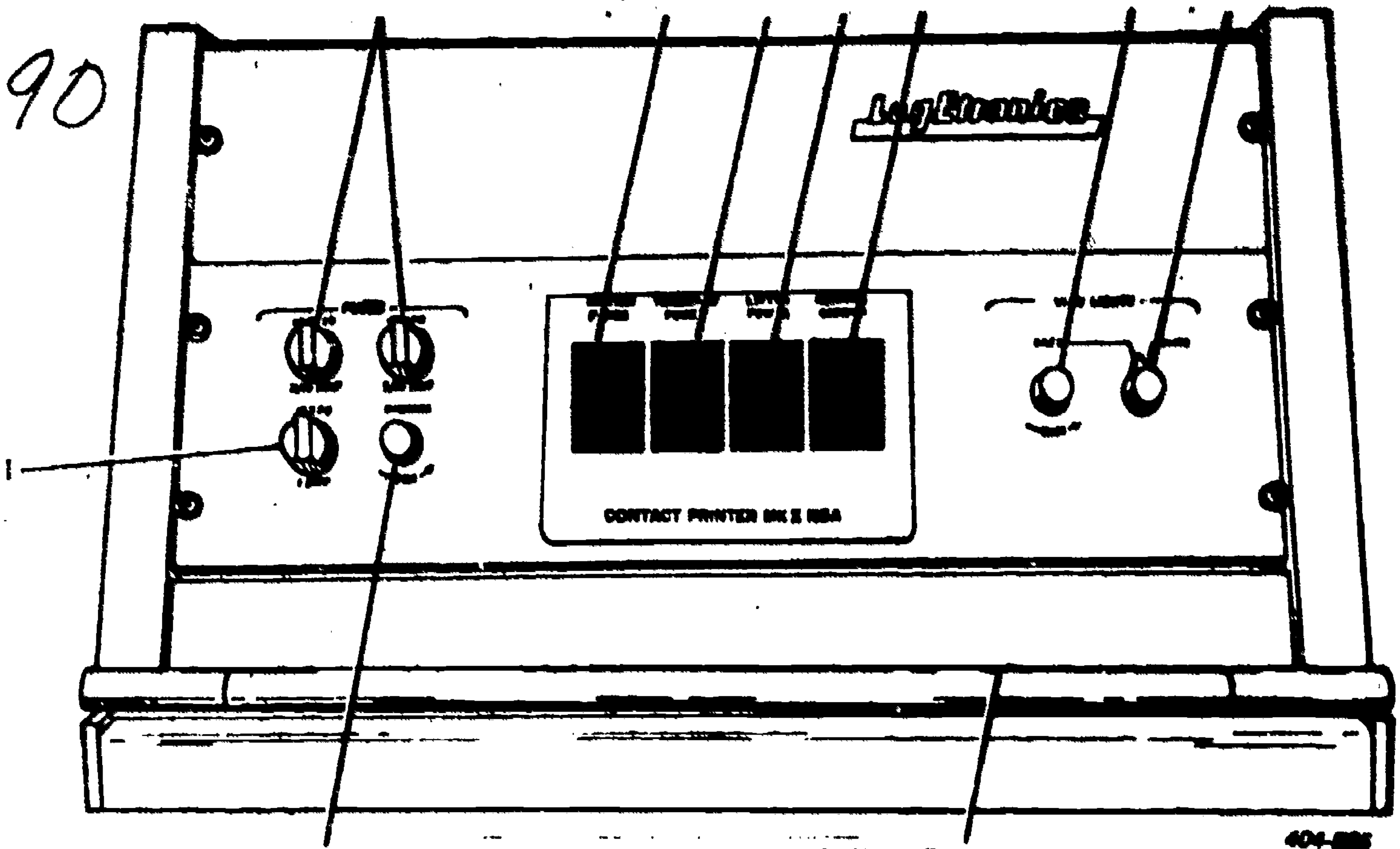
In practice, green masking material is used with a normal negative, red with a dense negative and blue with a thin negative. However, if these colors are not available, an amber mask will be acceptable for any negative.

Raster overscan is required in order to prevent a black border at the right and left edges. Some overscan is also required at the top and bottom edges because the starting and ending lines of the raster are not always complete. Generally, the overscan should be at least 1 1/2 spot diameters. This makes the overscan 3/8 to 1/2 inches (10 to 13mm).

CAUTION: No part of the raster should be masked by an opaque area. If the scanning spot is opaqued out of view of the PMT, the spot will slow down, possible burning the CRT phosphor.

Controls and Indicators

The controls and indicators are illustrated in figures 4-2, 4-3, and 4-4. Tables 4-1, 4-2, and 4-3 describe the functions. Table 4-1 describes the power control panel which is on the printer's hood. Figure 4-2 illustrates this panel. Figure 4-3 corresponds to Table 4-2 and illustrates the function control panel. Table 4-3 describes and Figure 4-4 illustrates the Roller Paper Transport (RPT), cabinet and Automatic Platen Lifter (APL) controls and indicators. Study these carefully before attempting to use the Mark II RSA.



9 Figure 4-2. Power Control Panel 8

Table 4-1. Power Control Panel Controls and Indicators

| INDEX NO. (SEE Figure 4-2) | CONTROL OR INDICATOR | FUNCTION |
|---|---|---|
| 1 | Indicator fuse holders | Lights to indicate power on and fuses good |
| 2 | MASTER POWER switch | Controls power to entire unit |
| 3 | TRANSPORT POWER switch | Controls power to RPT and APL |
| 4 | LIFTER POWER switch | Controls power to APL |
| 5 | NEGATIVE CARRIER power switch | Controls power to negative carrier and filter holder solenoids at lens box |
| 6 | SAFE VIEW LIGHTS DIM potentiometer | Reduces safe view lamp intensity |
| 7 | SAFE-WHITE VIEW LIGHTS selector switch | Select WHITE or SAFE view lamps |
| 8 | Hood Handle | Latches hood down and starts exposures |
| 9 | DIMMER potentiometer | Reduce fuse indicator lamp intensity |

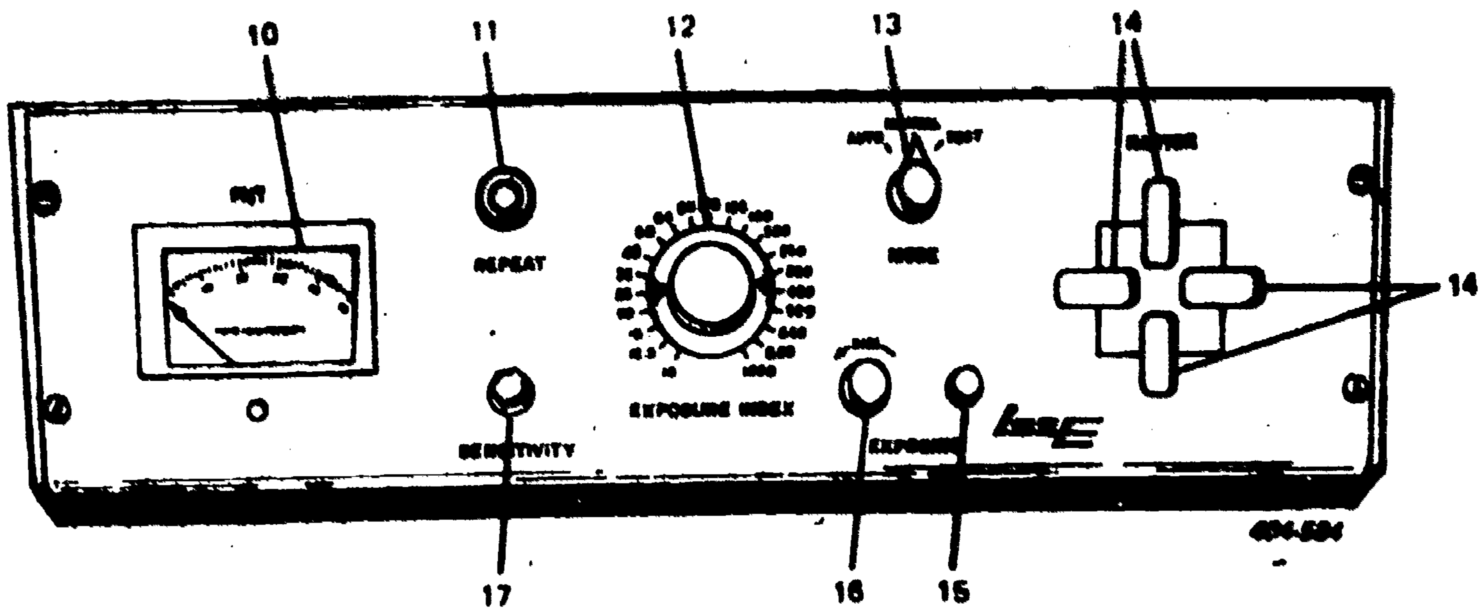



Figure 4-3. Function Control Panel

Table 4-2. Function Control Panel Controls and Indicators

| INDEX NO. (SEE Figure 4-3) | CONTROL OR INDICATOR | FUNCTION |
|---|---|---|
| 10 | PMT meter w/internal view lamp | Measures PMT current when calibrating against emulsion used |
| 11 | REPEAT switch | Allows repeat exposures without moving hood |
| 12 | EXPOSURE INDEX switch | Provides calibrated exposure adjustment from 10 to 1000 units |
| 13 | MODE switch | Provides choice of TEST, MANUAL, or AUTO operating modes |
| 14 | RASTER edge controls | Allow individual selection of raster edge position |
| 15 | EXPOSING lamp | Lights to indicate that printer is in exposure position of cycle (manual and automatic modes only) |
| 16 | EXPOSING lamp dimmer | Allows decreased level of indicator lamp brightness in meter lamp and EXPOSING lamp |
| 17 | SENSITIVITY adjustment | Adjust gain of photo-multiplier tube |

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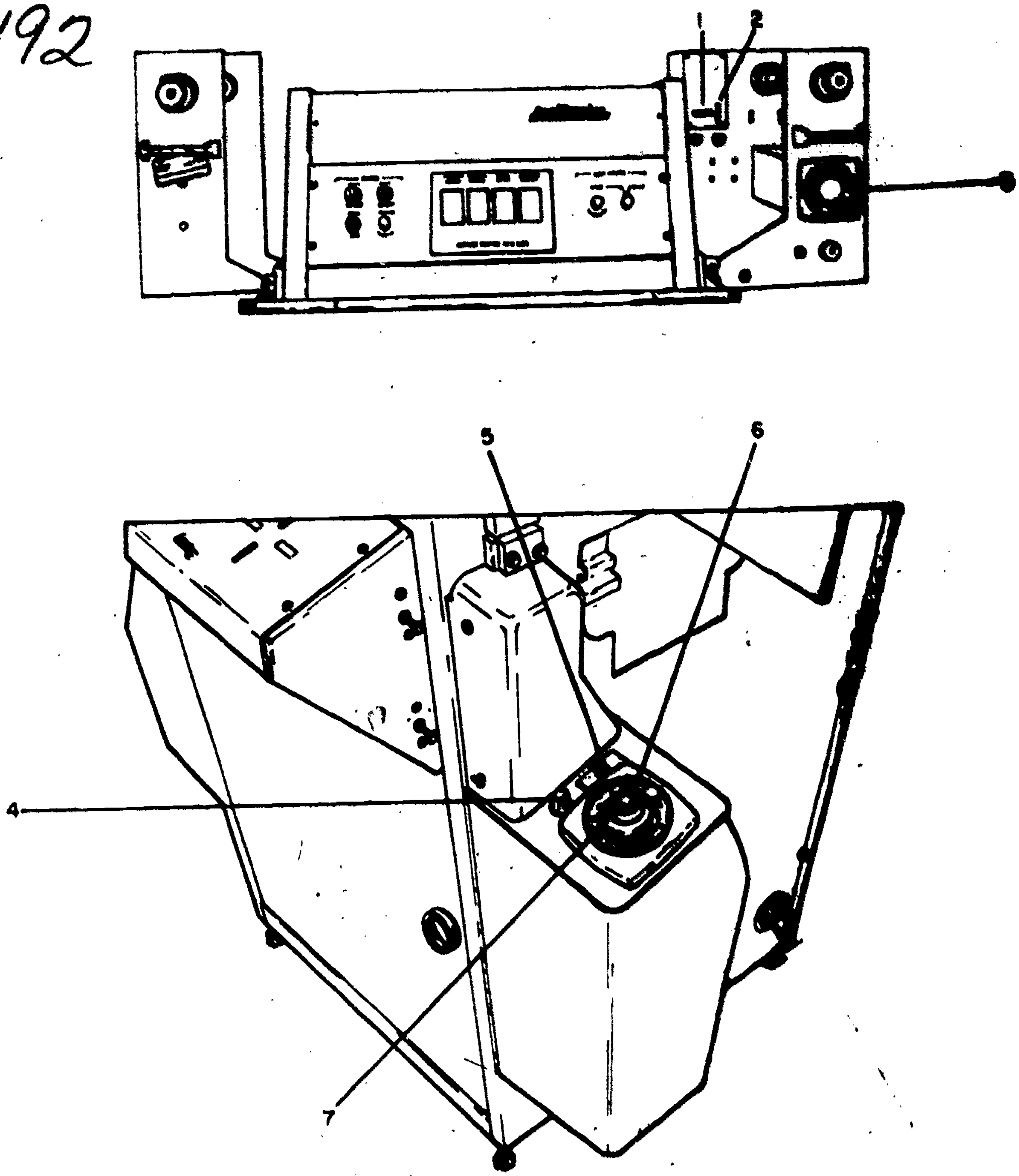


Figure 4-4. RPT and APL Controls and Indicators

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Table 4-3. Roll Paper Transport, Cabinet, Automatic Platen Lifter Controls and Indicators

| INDEX NO. (SEE Figure 4-4) | CONTROL OR INDICATOR | FUNCTION |
|---|---|---|
| 1 | RPT print counter | Number of RPT advances |
| 2 | RPT counter reset | Thumb wheel to reset counter to zero |
| 3 | RPT paper advance revolution counter | Provides adjustment of paper advance 8 to 20 ± 1/8 in. (20 to 51 cm + 3.2mm) |
| 4 | APL fuse holder | Holds APL fuse |
| 5 | APL SINGLE/MULTIPLE PRINT switch | Disables motor control circuit for single print operation |
| 6 | APL print counter | Allows number of desired prints be dialed in for automatic repeat operation |
| 7 | APL print counter reset button switch | Start switch for Auto Repeat operation |

Operation of the Mark II R5A

Follow these directions carefully when operating the Mark II R5A. This ensures the best results and the minimum of problems.

PRELIMINARY INSTRUCTIONS. Follow these general preparations when using the Mark II R5A regardless of the type of printing to be done.

1. Ensure that the power cord is connected to 105-130-volt, 60-Hertz input power receptacle and to an external power source. Never operate the printer without an electrical ground connection.

2. Check that the RPT power, the APL power and the negative power are off.

3. Check the airbag inflation by raising and lowering the hood assembly several times. The airbag holds the printing material and negative in contact during the contact mode. In the projection mode, it prevents wrinkles or air bubbles between the printing material and the printing stage. Use a spring balance to measure the airbag pressure. Attach the spring balance to the platen handle. Place a sample of negative and rawstock on the printing stage. Close and lock the hood by pulling down on the balance. If the hood locks at a weight indication of 8 to 12 pounds (3.6 to 5.4 kg.) airbag pressure is satisfactory.

4. Ensure that the printing stage is clean and free of dust and fingerprints.

   CAUTION: Never have the hood down with the power on and the normal room lights on. Damage to the PMT will result!

5. Raise the hood to the maximum up position. Set the MASTER POWER switch to ON and allow a 30-second warmup time.

CONTACT MODE. Follow this step-by-step procedure to operate the printer in the contact mode. Remember rawstock may be either in roll or sheet form.

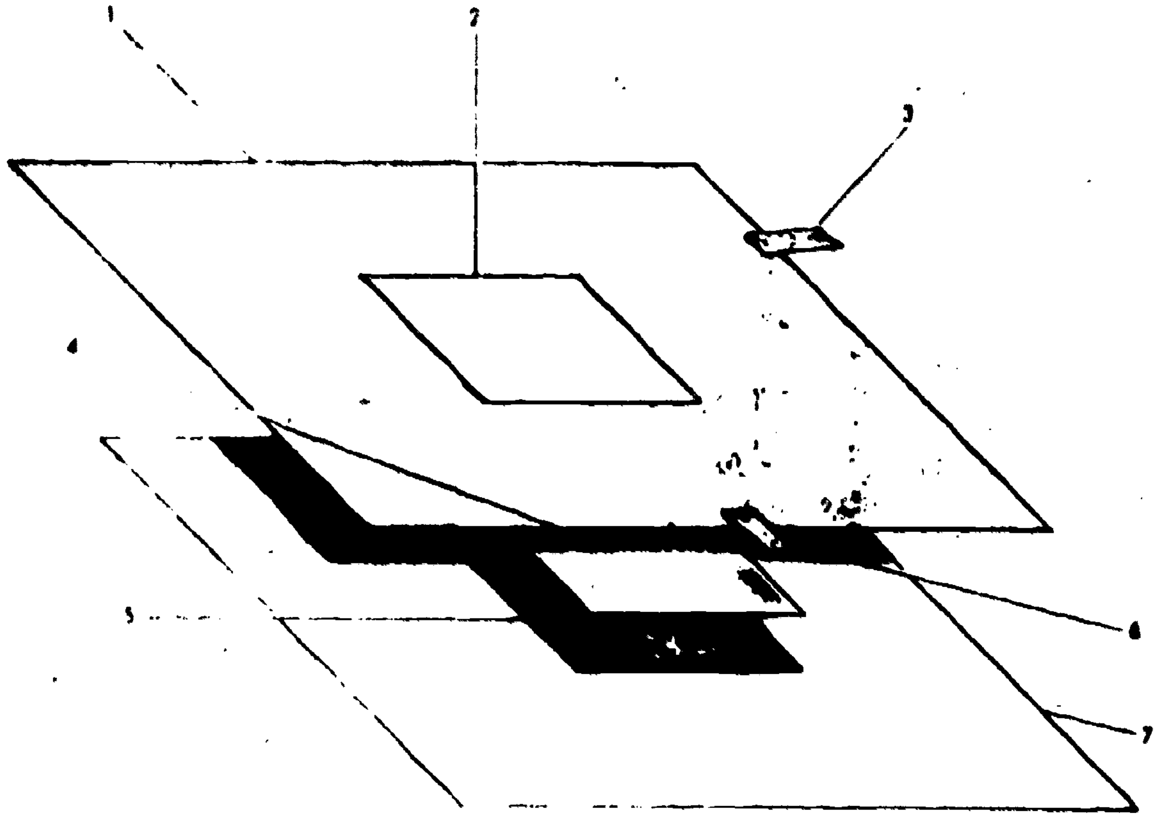
1. Be sure that the proper lens for contact printing is securely in place. The 112mm lens is used for general contact printing. Select a mask of proper density and size. (See Figure 4-5 for placement of the mask.) Turn off all lamps except safe lamps and adjust SAFE VIEW LIGHTS potentiometer for the brightness level desired.

2. Set the MODE switch to TEST. Adjust all raster edges to fall inside the mask cutout.

3. Place a sample of the unexposed rawstock over the cutout and overlapping the mask on all four sides.

4. Close and latch the hood. Read the PMT sensitivity on the meter. Set the SENSITIVITY adjustment to bring the sensitivity reading to 25 (midscale) on the meter.

5. Raise the hood and remove the rawstock sample.




(1) MASK
(2) CUT OUT SAME SIZE AS NEGATIVE AREA
(3) TAPE TO PRINTING STAGE
(4) PRINTING MATERIAL
(5) NEGATIVE
(6) TAPE TO RAISE AND LOWER MASK
(7) PRINTING STAGE

Figure 4-5. Mask Placement

6. Adjust the RASTER controls until the rasters extend approximately 1/2 inch (13mm) beyond the cutout into the mask on all four sides.

7. Set the MODE switch to AUTO.

NOTE: Step 8 applies only when the exposure index is unknown. If the exposure index is known, proceed to step 9.

8. Make a test print using the exposure index calibration sheet.

   a. Select a negative the same size as the cutout

area with average density and some detail. Tape the negative beneath the mask with the emulsion up. The image areas of the negative should coincide with mask cutout edges.

b. Obtain a piece of unexposed rawstock approximately the size of the negative. Place the calibrator (emulsion side up) behind the material. Fold the numbered flap of the calibrator over the rawstock so that the numbers overlap the rawstock emulsion. Place the rawstock (emulsion down) and calibrator on the negative with the numbered flap on the right hand side.

c. Set the EXPOSURE INDEX switch to 10. Lower the hood assembly and lock it in position. During exposure the EXPOSING indicator lamp is lit. When the indicator lamp goes out, raise the hood assembly and remove the exposed rawstock.

d. Process the exposed rawstock.

e. The numbers on the left side of the test print are exposure index settings. Use the number beside the area of best exposure as the proper setting for the rawstock tested.

If all areas of the test are too light, repeat the test with the EXPOSURE INDEX set to 100. Multiply the number beside the area of best exposure by 10 to obtain the exposure index.

f. With the EXPOSURE INDEX switch at the proper setting, place another sheet of rawstock (emulsion down) over the negative and expose it without the calibrator. Expose two more sheets--one with the EXPOSURE INDEX switch one setting higher and one with it set one setting lower than determined by the calibrator.

g. Process the three exposures and select the best exposure index. Set the EXPOSURE INDEX accordingly.

NOTE: Normal room lighting may be used for step 9.

9. Remove the test negative and place the negative to be printed on the printing stage. If the negative is in

cut form, place it (emulsion up) under the cutout area so that all image areas coincide with the cutout edges. Tape it to the printing stage. If the negative is in roll form, place the roll on the spool holder at the left of the printing stage. Insert an empty spool holder at the right. Feed the negative (emulsion up) over the rollers, under the mask and thread it into the empty spool. Position the negative so that the image areas coincide with the mask cutout.

10. Turn off all but allowable safelights. Position the rawstock (emulsion down) on top of the negative on the printing stage. If the rawstock is in roll form, thread it according to Figure 4-6.

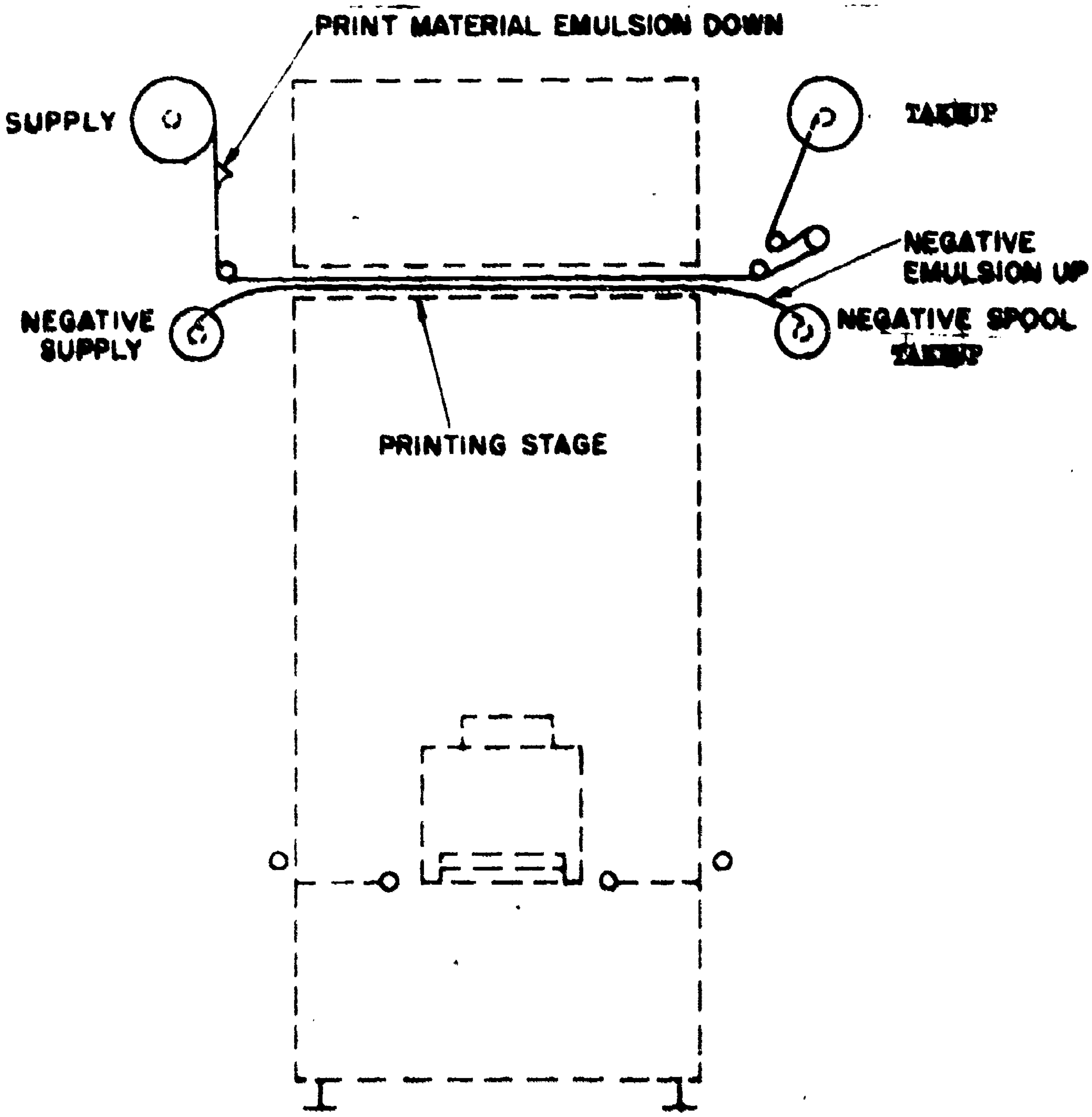



Figure 4-6. Contact Mode Threading Diagram

11. Set the MODE switch to AUTO and the EXPOSURE INDEX switch to the desired position.

12. Lower the hood assembly and lock it. Exposure begins automatically when the hood is locked.

13. Unlock the platen handle and raise the hood. Remove the exposed rawstock and process it.

PROJECTION MODE. Operating procedures for the projection mode are very similar to the contact mode. Once again, follow these steps carefully and in the order given for the best results.

1. Set the f/stop of the 138mm lens to f/4.5. Adjust the PMT sensitivity as before.

2. Set the MODE switch to TEST. Adjust the raster control until the outline of the raster edges barely extends beyond the outline of the projected negative carrier.

3. Place a mask over the printing stage. The mask should be large enough to extend beyond the printing stage. Mark the mask to coincide with the outline of the projected negative carrier.

4. Remove the mask and cut out the indicated area. Tape the mask to the printing stage.

NOTE: Do not touch the raster controls or the mask for the remainder of the operation.

NOTE: Step 5 applies only when the exposure index is not known. If the exposure index is known, proceed to step 6.

5. Determine the proper exposure index.

   a. Obtain a test negative equal in size to the mask cutout area, with leader extending on the right and left sides.

   b. Open the cabinet door, unlatch the lens box and center the test negative (emulsion up) in the negative carrier. Close and latch the lens box.

c. Set the NEGATIVE CARRIER switch to ON. Adjust the negative position by the leader until the projected image is centered in the cutout area on the printing stage.

d. Set the NEGATIVE CARRIER switch to OFF, remove the test negative, close the cabinet door and set the MODE switch to AUTO.

e. Follow the instructions given in the contact mode procedures for using the exposure index calibration sheet.

6. Place the negative to be copied on the negative carrier.

a. If the negative is in cut form, open the cabinet door and lens box, position the negative on the negative carrier (emulsion up) and close the lens box and cabinet.

b. If the negative is in strip or roll form, thread it as shown in Figure 4-7. Feed the negative (emulsion up) over the stainless steel roller to the upper right of the supply spool, down the left side of the cabinet under the black aluminum roller. Pass the negative through the slot, under the left aluminum roller, over the lower negative carrier and under the right black aluminum roller. Bring the negative up the right side through the slot, over the stainless steel roller and into the takeup negative holder. Turn the takeup spool until the roll of negative is firmly engaged. Close the lens box.

7. Set the NEGATIVE CARRIER to ON and position first negative. Set NEGATIVE CARRIER switch to OFF and close the cabinet.

NOTE: Before proceeding, turn off all but allowable safelights.

8. Place translucent material over the mask cutout on the printing stage. Check that the negative is correctly positioned for proper projection on the printing stage. Focus the lens if necessary.

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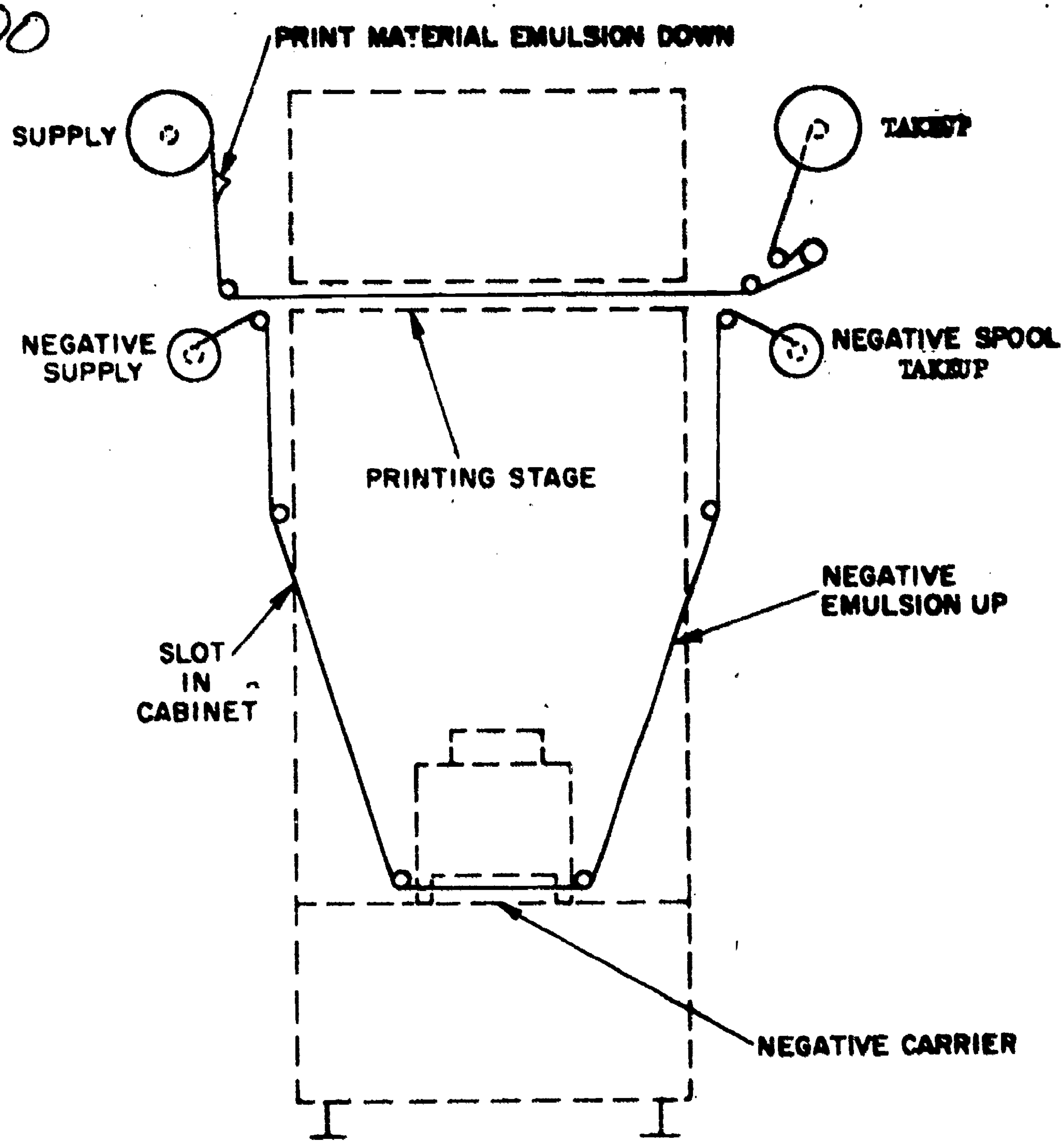


Figure 4-7. Projection Mode Threading Diagram

9. Set the MODE switch to AUTO and place rawstock (emulsion down) over the mask cutout on the printing stage. If the rawstock is in roll form, thread it according to Figure 4-7.

10. Set the EXPOSURE INDEX switch to the predetermined setting.

11. Lower the hood assembly and lock it.

12. After the exposure, unlock the platen handle and raise the hood. Remove the exposed rawstock and process it.

13. Set the NEGATIVE CARRIER switch to ON and the MODE switch to TEST.

14. Transport the roll film to the next frame and position the negative. Set the MODE switch to AUTO and the NEGATIVE CARRIER switch to OFF.

NOTE: If cut film is used with roll rawstock, place an opaque mask on the printing stage during positioning of the negative. The mask prevents the rawstock from being exposed when the lens box is opened.

RPT AND APL OPERATION. Using the Roll Paper Transport (RPT) and the Automatic Platen Lifter (APL) frees the operator from raising and lowering the hood between exposures and from manually feeding rawstock into the printer.

Before using the RPT and APL, set up the printer for its intended use (contact or projection printing). Determine the exposure index and adjust the PMT sensitivity. Then thread the rawstock (emulsion down) through the roller assembly, across the printing stage and into the takeup spool.

Check that the LIFTER POWER switch if OFF and that the APL is in single print mode. Set the RPT paper advance control to the proper number. (Ninety-six is the approximate setting for a 10-inch (25.4cm) long original. This gives a 3/4 inch (2cm) space between prints.) Check for the proper amount of paper advance by marking the rawstock, lowering the hood without locking the handle and then raising the ' cd. Measure the distance from the first position to the mark. Adjust the paper advance accordingly.

After any final adjustments, expose the emulsion, raise the hood and allow the rawstock to advance before making the next exposure. Repeat as necessary.

If a large number of prints is needed, it is best to use the Automatic Platen Lifter (APL.) Prepare the printer as before and set the RPT. Set the APL print counter to one more than the number of prints required. The final exposure is double; thus, the extra count achieves the required number of

copies. Set the APL switch to MULTIPLE PRINT.

Set the LIFTER POWER switch and the TRANSPORT POWER switch to ON. Push the white APL print button. Close and latch the hood. Operation is now automatic.

CAUTION: Do not set the print counter higher than required. When the APL operation has begun, decreasing the dialed number of prints causes excessive wear on the APL counter.

To turn the APL off, set the APL switch to SINGLE PRINT and turn off the LIFTER POWER. The APL must be turned off at the bottom of a stroke or the printer will not operate in the manual or automatic modes.

SHUTDOWN PROCEDURES. When the operation of the printer is completed, set all power switches to OFF. Set the MODE switch to MANUAL. Raise the hood and remove any unexposed rawstock from the printer. Leave the hood in the raised position. Clean the printer.

After each seven day period, make a set of dodged and undodged prints from the standard negative or step wedge supplied with the printer. The prints should be made under carefully controlled conditions and then compared with previous prints. Any deviations should be checked, using the trouble-shooting chart in Section VI of TO 10E8-2-19-11.

Safety Precautions

The Mark II R5A is a highly sophisticated piece of equipment. Treat it as such. Do not operate it without an electrical ground connection. It contains very high electrical voltage. Carelessness can cause damage to the machine and injury to the operator.

Keep hands and fingers away from the hood assembly during automatic operation. Be extremely careful when working inside the cabinet in safelight conditions. Electrical shock could result. Never operate the machine with wet hands.

REVIEW QUESTIONS

DO NOT WRITE IN THIS SW - USE A SEPARATE SHEET OF PAPER.

1. What is "incremental exposure control"?
2. What widths and lengths of rawstock does the Mark II R5A accept?
3. Which lens is used for projection printing on the Mark II R5A? Which one is used for contact printing?
4. What is the purpose of the TEST, MANUAL and AUTOMATIC positions of the exposure mode switch?
5. How is the raster adjusted for proper length and width?
6. For what two reasons is the image area of the printer masked?
7. Why is raster overscan required?
8. What is the printing light source of the Mark II R5A?
9. What is the advancing speed of the RPT?
10. What is the purpose of the PMT?

PRACTICAL EXERCISES

EXERCISE I

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Mark II R5A | 2/class |
| Aerial Negatives | As needed |
| Masking Material | As needed |
| Printing Material Roll Paper | 30 feet (9m)/student |
| Versamat 11CM | 1/class |
| Exposure Index Calibration Sheet | 1/class |

PROCEDURES

1. Prepare the printer as outlined in this SW for contact printing with roll paper.

2. Determine the exposure index using the Exposure Index Calibration Sheet as outlined in this SW.

3. Process the test in the Versamat 11CM.

4. Using the APL, RPT, and an aerial negative, make three acceptable prints.

5. Compare the results of the finished prints. Inspect for contrast, density and physical defects.

6. Upon completion of printing, shutdown the printer as outlined in this SW.

7. Shutdown the Versamat 11CM according to normal procedures and clean the lab. Return to the classroom for a critique of the results.

EXERCISE II

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Mark II R5A | 1/class |
| Roll of 5" (12.7cm) Aerial Negatives | As needed |
| Roll of printing material | 30 feet (9m)/student |
| Masking Material | As needed |
| Versamat 11CM | 1/class |
| Exposure Index Calibration Sheet | 1/class |

PROCEDURES

1. Prepare the printer as outlined in this SW for projection printing with roll paper.

2. Determine the exposure index using the Exposure Index Calibration Sheet as outlined in this SW.

3. Process the test in the Versamat 11CM.

4. Using the APL, RPT and a normal negative, make three acceptable projection prints.

5. Compare the results of the finished prints and inspect for contrast, density and physical defects.

6. Upon completion of printing, shutdown the printer as outlined in this SW.

7. Shutdown the Versamat 11CM according to normal procedures and clean the lab. Return to the classroom for a critique of the results.

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Technical Training

Continuous Photoprocessing Specialist

# CONTINUOUS COLOR PROCESSING

October 1977

3400th TECHNICAL TRAINING WING
3430th Technical Training Group
Lowry Air Force Base, Colorado

Designed For ATC Course Use

DO NOT USE ON THE JOB

Sciences Branch
Lowry AFB, Colorado

SW G3ABR23330 001-VI-1
October 1977

# COLOR THEORY

## OBJECTIVES

Provided exercises pertaining to the function of white light in forming colors, identify colors formed by additive and subtractive means.

Using provided diagrams, write the names of dyes formed in various color film emulsions when exposed to given colors.

Describe the major characteristics of motion picture sensitized materials.

## INTRODUCTION

During the past few years, there has been an ever increasing demand for color photography in the armed services. Much of this is due to the rapid improvements which have been made in color photographic products during the last decade. For example, aerial color emulsions are now capable of yielding one third more topographic information than do production type black-and-white films. As color quality and speed are continually being improved, more widespread usage is indicated for the future.

Since processing color photography used to be difficult and time consuming, it was limited to just a few labs. Now most laboratories are capable of processing color photography without excessive expense or extra space requirements. New processes and equipment have made it much easier for the photographic technician to process color photography with reasonable assurances of obtaining satisfactory results.

## INFORMATION

### LIGHT

Most of the principles and procedures used in color photography are adaptations or extensions of those used in black-and-white photography. In order to understand color photography, it is first necessary to understand what is meant by the terms "light" and "color." Color does not exist in the absence of light. It is an integral part of light, and since this is true, a logical beginning point is a short review of prior studies into the nature of light itself.

Supersedes SW 3ABR23330, October 1973

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The term "light" has often been defined as visible radiant energy. To be more specific, it is necessary to define each of these words - visible, radiant, and energy - separately and in more detail. The term visible is defined as being detectable by the human eye. Radiant describes the way in which light energy is emitted or given off by its source. Energy, literally, is the ability to do work. The work done may vary from raising the temperature of an object, to stimulating the retina of the eye, or causing a minute change in the photosensitive emulsion, which upon development, yields an image.

Electromagnetic Spectrum

Light or visible radiation occupies a very small region of the electromagnetic spectrum, embraced at one end of the extremely short cosmic rays, and at the other end by radio waves which may extend to a mile in length. By referring to Figure 1-1, the extent of the electromagnetic spectrum may be noted. The various types of radiation which constitute the electromagnetic spectrum are cosmic rays, gamma rays, X-rays, ultraviolet, visible, infrared, and radio waves.

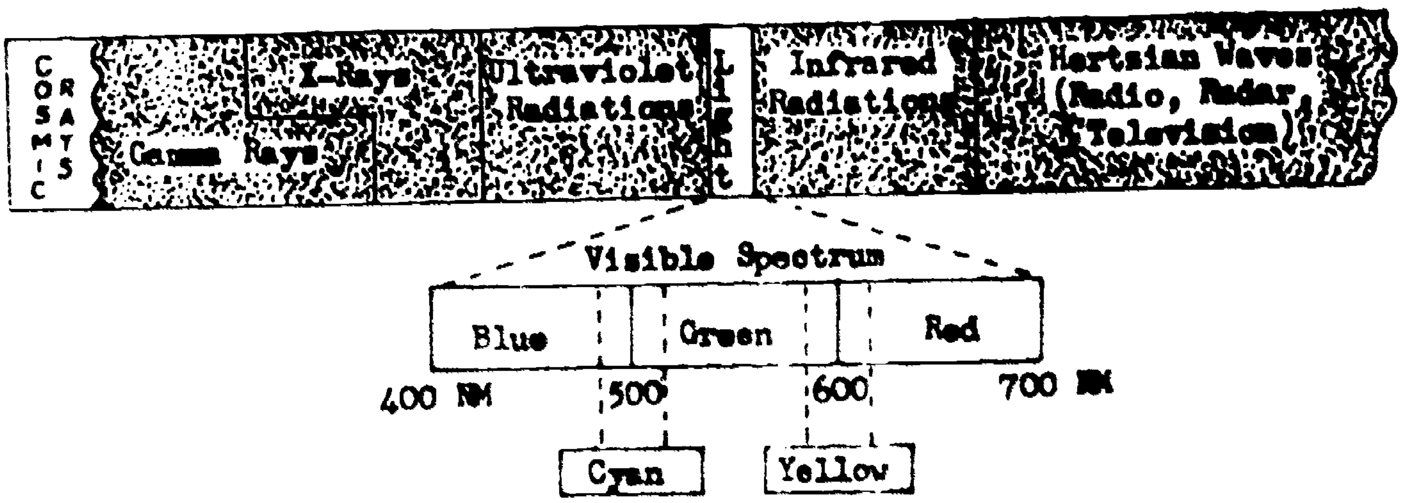


Figure 1-1. Electromagnetic Spectrum

All forms of radiant energy travel in wave motion and if seen, would resemble the waveform created by dropping a pebble into a still pond. These forms of energy travel at the same tremendous speed, about 186,000 miles per second (297,600 km/sec), but they differ in wavelengths and frequency. A wavelength is the distance from the

crest of one wave to the crest of the next wave, while frequency is the number of waves passing a given point in one second, noted in Figure 1-2. The product of the two is the velocity of travel, commonly known as the "speed of light."

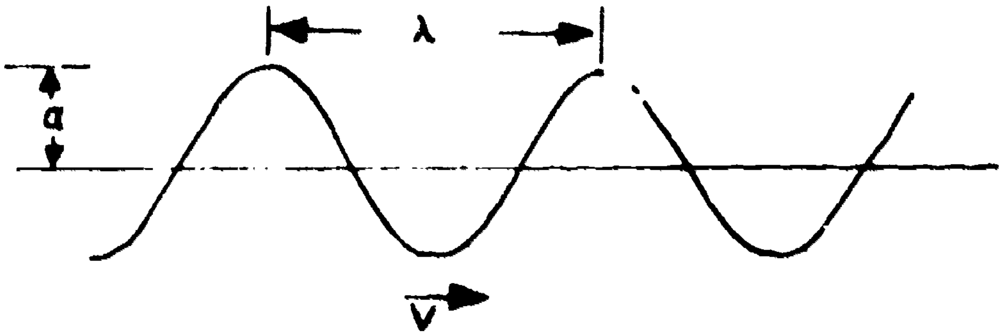


Figure 1-2. Simple form of Wave Motion

Photography is interested in the central regions of the electromagnetic spectrum, that is wavelengths from 200 to 1350 nanometers. This area includes the ultraviolet, visible, and infrared regions which occupied a very small portion as compared to the entire spectrum. Because of these short wavelengths in this area, the standard unit of measurement is in nanometers previously referred to as millimicrons. For purposes of comparison, a millimicron or nanometer is equal to one-millionth of a millimeter, whereas a millimeter is approximately the thickness of a dime.

Visible Spectrum

The visible portion of the spectrum has been explained in Figure 1-1 which includes wavelengths of from approximately 400 to 700 nanometers. These are not the exact limits since the human eye is relatively insensitive to the extremes of the light spectrum. Immediately below 400 nanometers are the ultraviolet rays and above 700 nanometers are the infrared rays. Although these two types of radiations are invisible to the human eye, they do produce a similar effect, as do light, on sensitized material and are very much utilized in photography.

When light of all wavelengths from 400 to 700 manometers

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reaches the eye in very nearly equal quantities, the visual sensation of colorless or white light is produced. If the amounts are varied, or a particular portion of the spectrum viewed, "color" is seen. Color is simply brought about by the changes in wavelengths of the energy reaching the eye. If an observer could view separately the energy of three single wavelengths, say 450, 550, and 650 nanometers, he would see "pure colors" of blue, green, and red.

At one time, the common belief was that "white" was a separate and distinct color as was blue, green, and red. It was not until after Newton demonstrated the composition of white light by the means of a glass prism, that the theory of the color spectrum was fully accepted. By using a similar prism today, one can identify the same areas of the spectrum as being, violet, blue, blue-green, yellow, orange, and red. The separation of white light into different colors (See Figure 1-3) is explained by the fact that the speed of light is reduced in glass by different amounts for different wavelengths. When a beam of white light enters the flat glass surface at an angle, the differing wavelengths are bent or "refracted" by different amounts, the shorter wavelengths being refracted to a greater degree than the longer wavelengths.

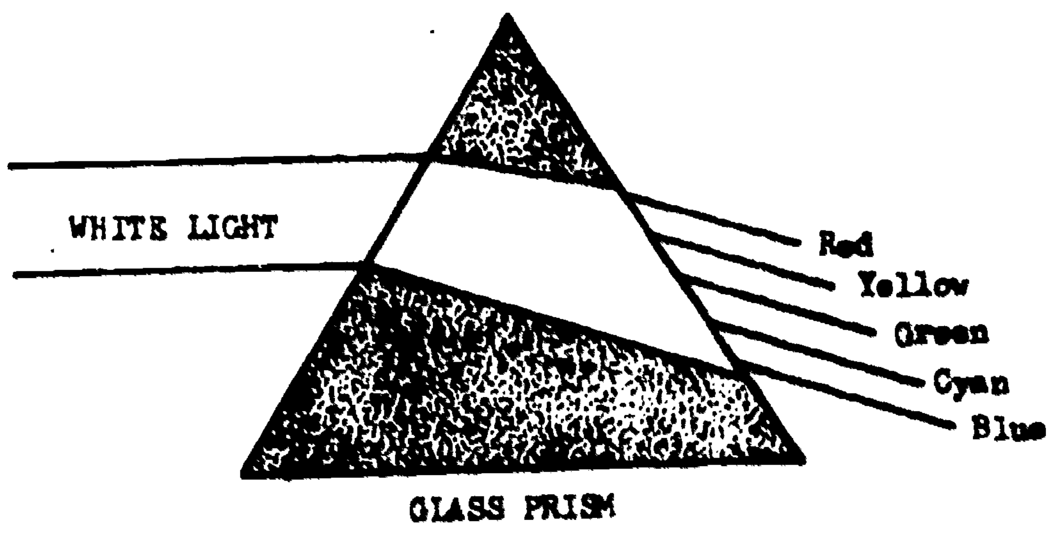


Figure 1-3. Dispersion of Light

COLOR

Trichromatic Systems

Maxwell followed Newton and . monstrated in 1861, that all colors

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can be observed by adding together certain amounts of light of the three "additive primary colors." Hence, the Maxwell method (commonly referred to as the trichromatic theory) is fundamental to all modern processes of color reproduction.

Color reproduction infers the ability to match the spectral distribution of an object sufficiently close so that a human observer (and sometimes an objective measurement system) cannot tell the difference. If it were necessary to match the duplicate with the original scene at each wavelength, the task would be extremely difficult, if not impossible. Fortunately, the task can be simplified by the use of the so-called trichromatic systems. These systems are based upon the selection of three primary colors which, when mixed in various proportions, may be used to match any color in the visible spectrum.

PRIMARY COLORS. Blue, green, and red have been designated the primary colors because of their specific characteristics. Three of the characteristics of these colors which should be considered are as follows:

1. All three colors (blue, green, and red) must be present in approximately equal proportions to produce white light.

2. Almost any color can be matched, or produced, by suitable mixtures of light beams of these three colors.

3. No one of them can be reproduced by any mixture of the other two.

FILTERS. In order to understand how the human eye sees colors, consider the action of light filters. A filter is defined as a substance which selectively absorbs or transmits certain portions of the spectrum. Theoretically, any filter transmits light of its own color and partially or completely absorbs all other colors. In practice the amount of absorption depends upon the characteristic of the filter itself.

Because a filter selectively absorbs certain light waves, it naturally appears colored. A green book appears green because it reflects green light and absorbs light of the other colors. A green filter appears green because it absorbs red and blue light and transmits green light. A filter which absorbs red and green light appears blue. Looking through such a filter, all red and green objects will appear darker while blue objects will appear lighter. A filter which absorbs only blue light appears yellow because it transmits green and red, and these colors affect the eye as yellow. See figure 1-4.

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Since the amount of energy absorbed by a filter varies with the wavelength, the characteristics of a filter may be represented by plotting this absorption (or its reciprocal, transmittance) as a function of wavelength. Figure 1-5 shows the characteristics of Wratten K-2 yellow filter plotted thus.

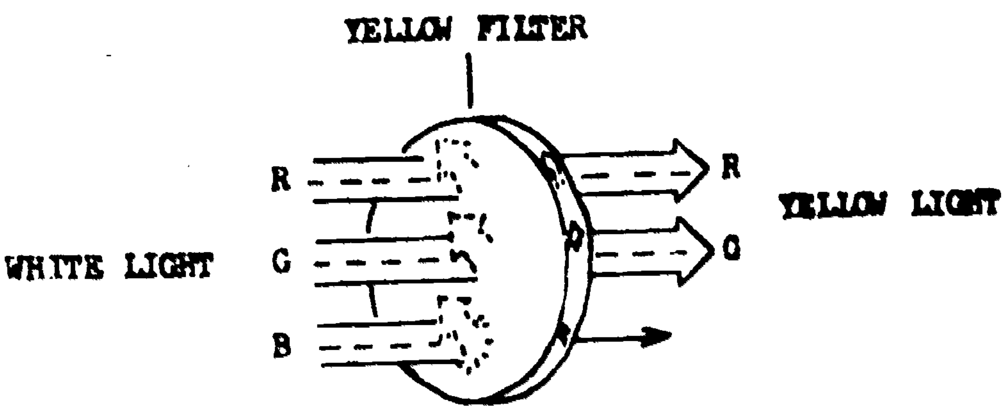


Figure 1-4. K-2 Yellow Filter

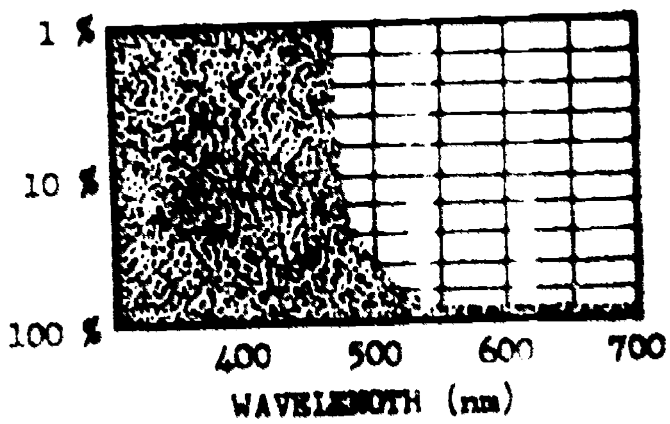


Figure 1-5. Typical Filter Absorption Curve (K-2 Filter)

Now consider the relationship of sharp cutting filters of the primary colors and one white light source. Sharp cutting filters are those which will transmit only their own color and absorb all others. If a red sharp cutting filter is placed over the light source, blue and green are absorbed, or eliminated from the white light, with only the red portion being transmitted or allowed to pass. If either a blue or green filter is placed over the light source in combination with the red filter, all of the light is eliminated since either has the capacity of absorbing red. This is true of any filter combination of the primary colors. If the filters used are not sharp cutting, any combination of two primaries will create a neutral density since a portion of all three colors is absorbed. These characteristics of the primary colors make them impractical for use in the finished color print or transparency.

Additive Color Process

All color processes in use by the Air Force at present start with the application of the additive color process or principle. They utilize the primary colors--blue, green, and red--for photographically recording the original scene. An understanding of additive color mixtures will help in understanding the structure of color materials and how to use them.

When equal parts of blue, green, and red light are projected from separate projectors and partially superimposed on a white screen, white is seen in the area of overlap of all three colors, as shown in Figure 1-6. The area of overlap between the blue and green light produces cyan (blue-green), the area of overlap of the red and blue light produces magenta, and the overlap of the red and green light produces yellow. Almost any desired color match can be produced by varying the amount of one of the two colors used for producing that color. For example, if equal proportions of red and green are present, the result is yellow; by increasing the amount of red, the result is orange. Since matching a wide range of colors with red, green, and blue light involves addition of colored light, the primary colors are often identified further as the additive primaries.

In color photography, the three colors produced by mixtures of the additive primaries in pairs are of particular importance. These colors--cyan, magenta, and yellow--are known as the subtractive primaries, or secondary colors. Since each represents white light minus one of the additive primaries, the subtractive primaries are complements of the additive primaries. For example, cyan, and red light blend together to give white light. Similarly, magenta is complementary to green, and yellow is complementary to blue.

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At this point, refer to Figure 1-7, and study the illustration of the color star. Remember which colors are the additive primaries (blue, green, and red) and notice that the subtractive primary colors between any two of the additive primaries and mixtures of these two primary colors. Also, notice the colors that are directly opposite each other in this star; these colors are complementary to each other.

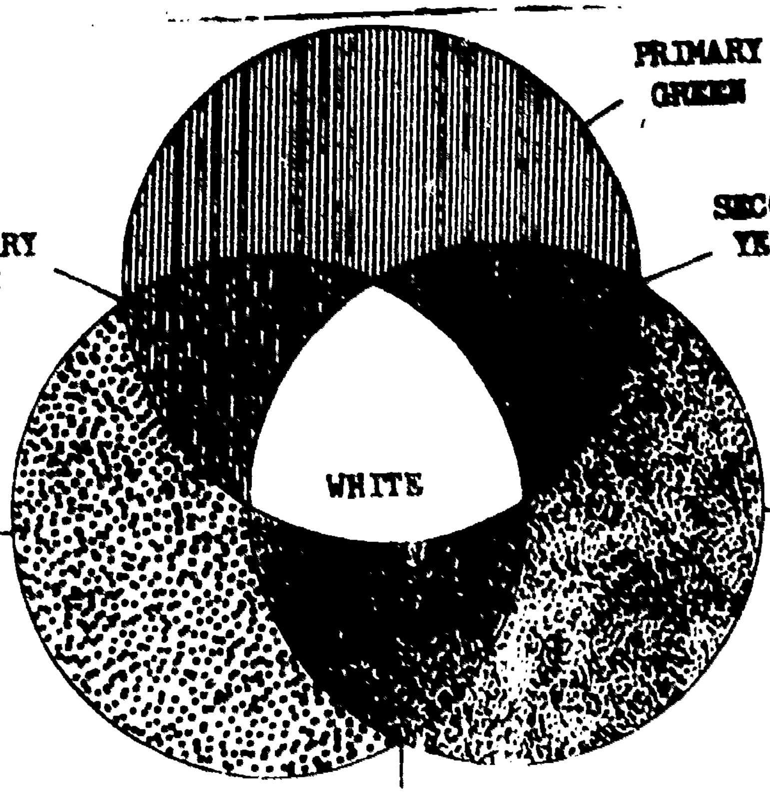


Figure 1-6. Additive Process

Although the original photographic record on color material uses the additive primary colors, these are not suitable for the final color product in general use. Three filtered light sources, such as those produced by three projectors, are required for producing colors by the additive color mixtures. For practical purposes, most color transparencies or prints must be viewable when only one white light source (made possible by the use of the subtractive color process which is just the reverse of the additive color process) is used.

Subtractive Color Process

In the additive color process where three projectors were used

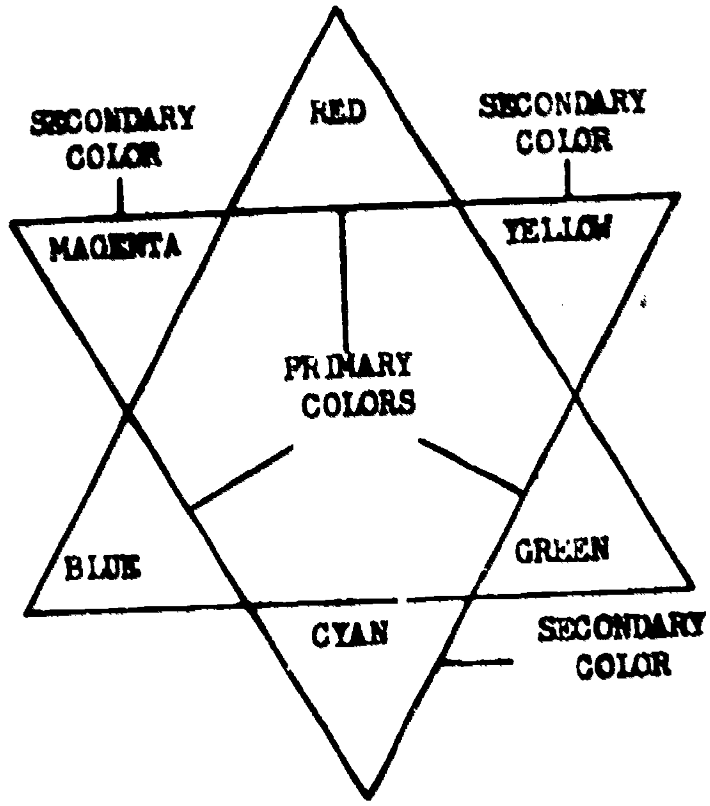


Figure 1-7. Color Star

(one lens was covered with a red filter, one with a green filter, and one with a blue filter), any desired color could be produced. Theoretically, any filter transmits light of its own color and absorbs all other colors. The amount of absorption depends upon the density of the filter. Therefore, all three filters could not be placed over a single light source. To a certain extent, the filters are mutually exclusive; that is, none of them transmits light passed by either one of the other two. Consequently, any two of the filters used in combination in front of a single light source absorb all of the light.

Since a filter of any of the additive primary colors transmits only that one primary color, the subtractive primary colors are used as filters in the structure of color materials. This makes it possible to transmit any two of the additive primary colors and subtract the third.

A cyan filter transmits blue and green light, but absorbs red light; hence, it subtracts red from white light. Similarly, a magenta filter (which transmits red and blue) does nothing more than subtract green from white light. Finally, a yellow filter (which transmits red and green) functions by subtracting blue from white light.

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Since each of the subtractive primary filters transmits approximately two-thirds of the spectrum, superimposing any two of them over a single light source produces other colors. Refer to Figure 1-8 for an illustration of the principle of the subtractive color process. Notice that the combination of any pair of the subtractive primary colors in equal densities produces one of the additive primary colors. For example, a yellow filter transmits red and green and absorbs blue, and the magenta filter transmits red and blue and subtracts green from the light source. When these two filters are used over a single light source, the one color that is transmitted by both magenta and yellow is red. Therefore, yellow plus magenta produces red.

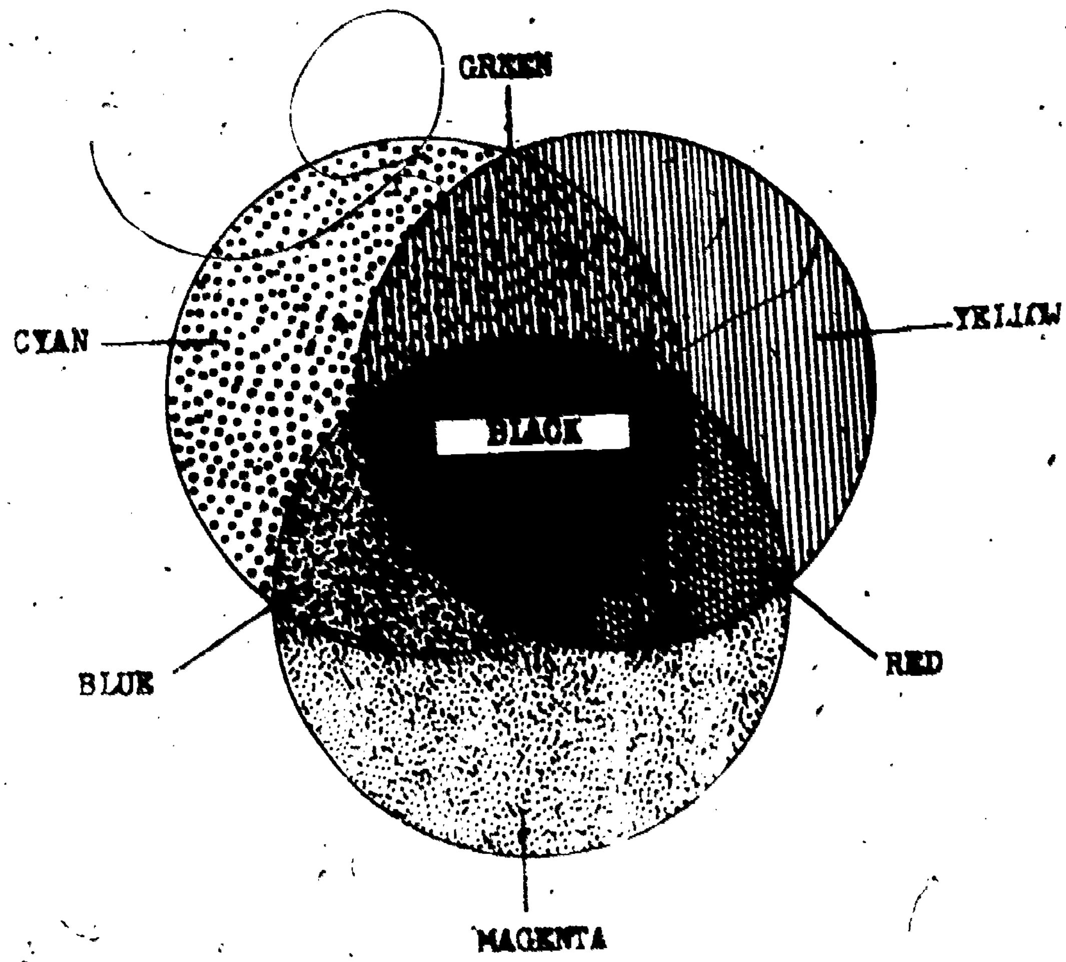


Figure 1-8. Subtractive Process

In the same manner, when yellow and cyan are used in combination, the one color that is transmitted by both filters is green, since yellow transmits red and green and cyan transmits blue and green. Cyan plus magenta produces blue, because blue is transmitted by both

filters. (See figure 1-9) where all three filters overlap in the center, all of the light is subtracted, and the result is black.

By varying the densities of subtractive filters used in combination, any desired change in the color produced can be accomplished. For example, to change the appearance of red to make it an orange, the amount of yellow may be increased or the amount of magenta decreased. All three colors may be needed in varying densities to produce some colors other than black, such as shades of gray or brown.

These same principles apply to artists' colors (water colors, paints, etc.) and dyes such as those used for dye transfer prints. However, much confusion has resulted from the common practice of designating the artists' primaries as blue, red, and yellow. If

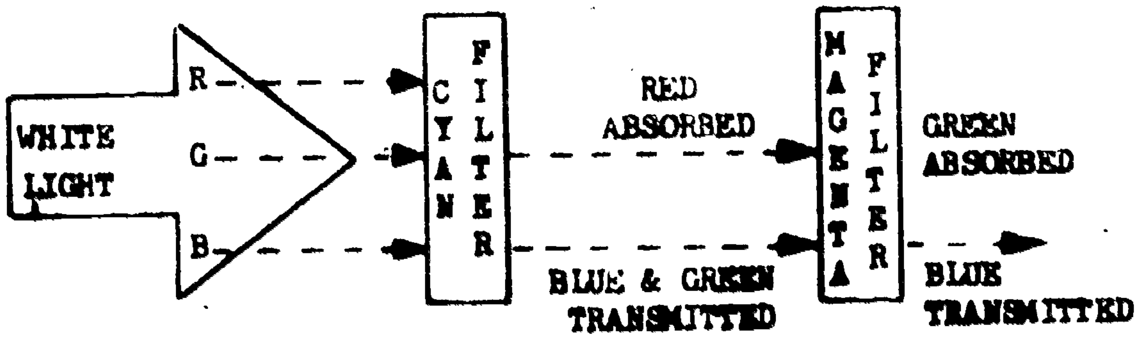


Figure 1-9. Effects of Subtractive Filters

a full range of colors is to be produced completely as possible, however, the red will really be a magenta and the blue will really be a blue-green or cyan. It is unfortunate that the quoted names have so often been used, because their use in this sense has undoubtedly acted as a bar to a more widespread understanding of the principles of color mixture.

As previously stated, all color materials - negatives, transparencies, and reflective type prints - in current use by the Air Force begin with an application of the additive process. But the subtractive process is utilized for the final product; that is, these materials all incorporate yellow, magenta, and cyan dye layers, which act as subtractive filters, to reproduce the original subject colors.

Additive and Subtractive Printer Systems

In a printer system using the additive process, three separate exposures are required to obtain the overall exposure. This is normally accomplished by either using three separate light sources (one primary filter over each source) or one light source and individually placing each filter between the light source and the print material for three separate exposures times.

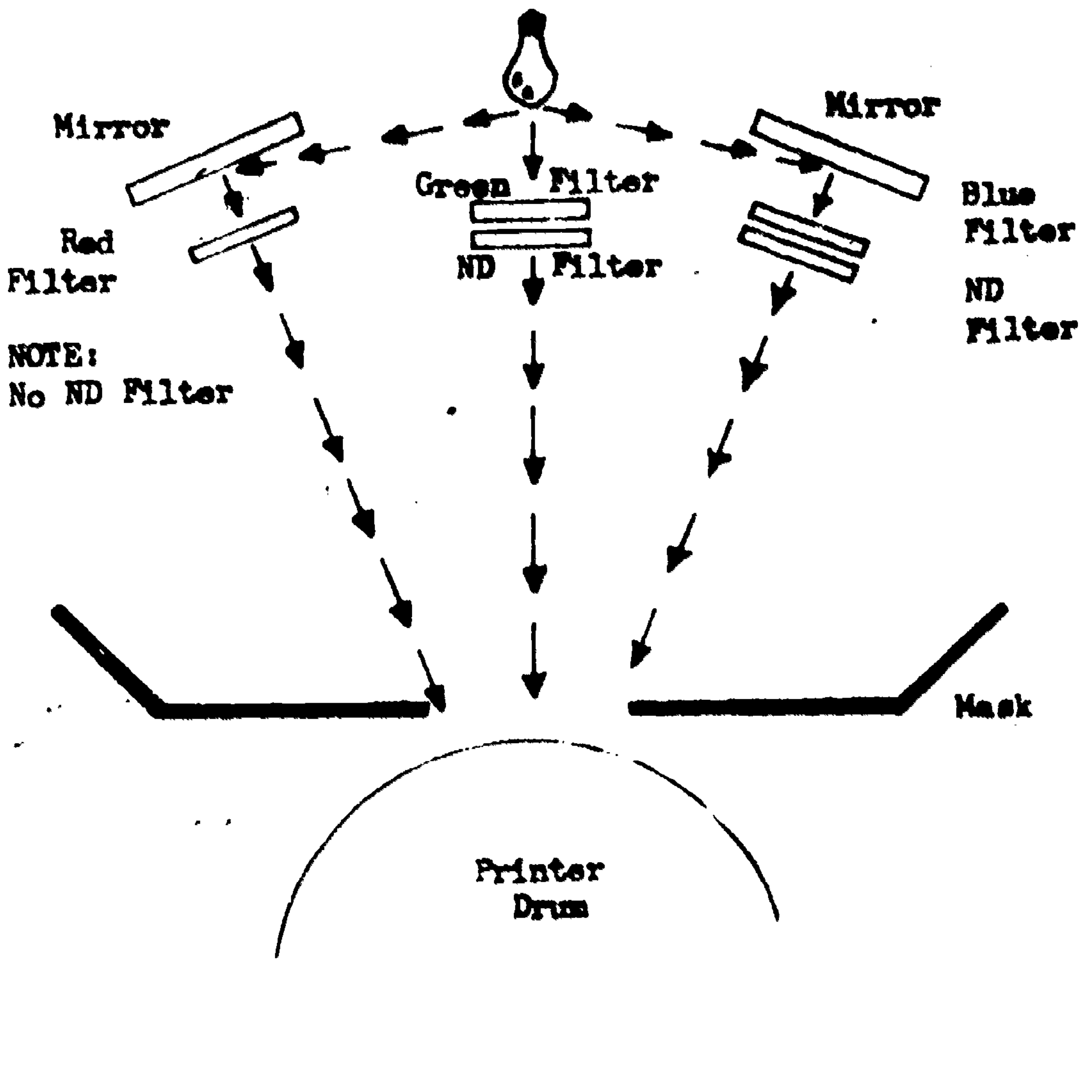


Figure 1-10. Additive Process Plus Neutral Density Filters

Figure 1-10 illustrates one of the latest designs in an additive (or tri-color) printing system, employing the use of ND filters. Because of the mirror configurations the overall exposure can be made simultaneously, making it ideal for continuous type contact printers.

Many motion picture and aerial color printers manufactured today employ this or similar principles.

The earlier concept of tricolor exposing can be related to projection printing as shown in Figure 1-11. The projection printer has one light source and in order to obtain an overall exposure of white light, three separate exposures are required, one through each primary filter.

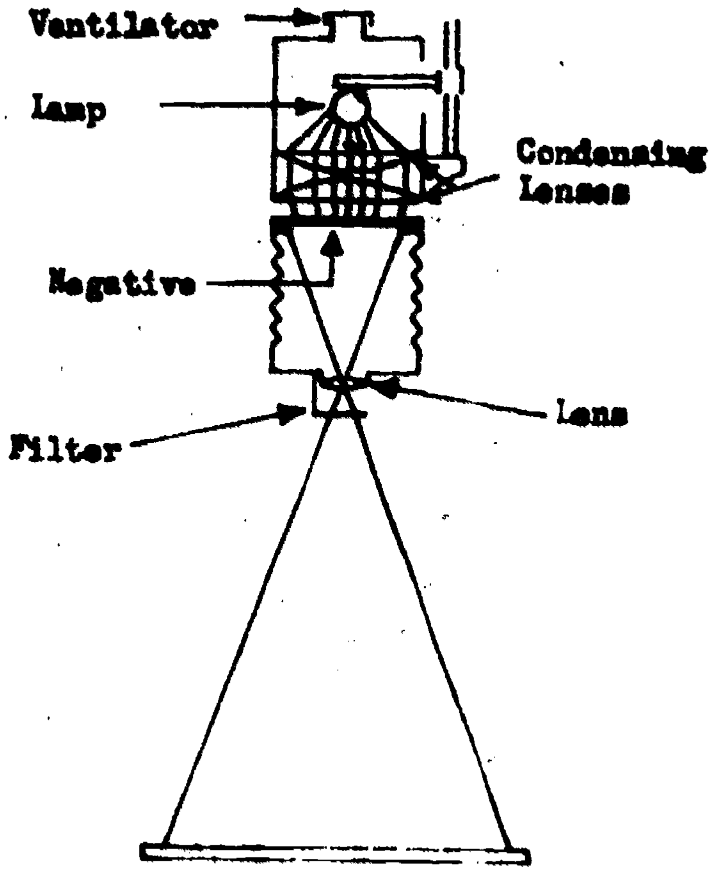


Figure 1-11. Projection Printing

The advantage of the additive system is that it does produce a higher quality product, both in definition and color saturation as compared to the subtractive system. However, the main disadvantage is the type of filters which are required for this printing system. Filters normally employed in tricolor printing are the Kodak Wratten Series No. 25 (Red), No. 98 (Blue), and No. 99 (Green). These filters are constructed of dye glass which has

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sharp-cutting characteristics and are very dense, requiring either very long exposure times or very high intensity source.

Recently, the subject of additive color reproduction has been reappraised in light of recent technical developments. The commercial development of dichroic coated mirrors created the beam-splitting means by which the optical system was able to increase the light energy arriving at the film plane. The dichroic mirrors consist of a glass with a number of evaporated metallic coatings. They are able to reflect selectively a chosen wavelength band of the spectrum while allowing the remaining wavelengths to be transmitted. They do this with an efficiency of approximately 95 percent. This compares with the figure of 30 times more required light on a system not using dichroic coated mirrors, therefore the tricolor printing process has been shortened considerably. The 6100C Motion Picture Printer used in this career field employs the dichroic mirror principle of exposure.

Printers for many years have utilized the subtractive system, employing the use of Kodak Color Compensating filters. These filters are constructed of lightly dyed gelatin on acetate having higher transmission properties than the additive primaries previously mentioned. Color Compensating (CC) filters are available in the following colors; magenta, yellow, cyan, green, blue, and red.

The subtractive system (commonly called the white light method), employed the same setup as illustrated in Figure 1-11. This system has the advantage of requiring only one exposure of shorter duration for the print material. The color of the light is controlled by placing the desired CC filters of various hues and densities in the light path of the printer. These filters subtract their respective complementary colors from the printer light, thus modifying it to specific requirements of the negative or positive being printed.

## SENSITIZED MATERIALS

Most color films, whether reversal or negative, are integral tripack films. The term "integral" is used whenever more than one emulsion is coated on a single base. An integral tripack consists of a single base with three light sensitive emulsion layers coated on one side, each layer responsive to a separate region of the spectrum. The three emulsions are not separable and must be processed together.

An integral tripack emulsion consists of (1) a suitable base, (2) an antihalation coating, which may be coated on either side

of the base, (3) three individual light-sensitive layers and (4) thin layers of gelatin used to separate the light-sensitive layers and which, in some instances, function as filters.

The complete tripack is about one-thousandth of an inch (.25mm) thick. In addition to silver halides, the emulsion layer may contain sensitizing agents and substances for the formation of dye images.

Between the emulsion layers are interlayers of gelatin. In some instances they may serve as color filters for the sensitized emulsions, but their main purpose is to minimize the effects of one layer on the other.

This combination of emulsion layers and gelatin interlayers plays an important part in image resolution. Resolving power is a function of emulsion thickness and the size of the light sensitive grains. To produce a color film with normal speed, the grain size must be fairly large. The increase in grain size results in a loss of image resolution.

Because of the tripack construction, light striking the emulsion must penetrate a considerable distance to reach the lower two layers. In traveling this distance, the light scatters and the image becomes diffused. This light scatter also results in lowered image resolution.

To provide adequate light transmission and to retain the sharpest possible image in the lower emulsion, the top emulsions are designed to be as transparent as possible. These emulsions may also contain light-absorbing dyes to help minimize light scatter.

The magenta image is most readily seen because of the eye's sensitivity to this part of the spectrum. Unfortunately, this layer is located in the middle of the tripack, which is not the best location for maximum resolution. The top layer is best suited for resolution, but it contains a yellow dye image which is least visible to the eye.

Attempts have been made to design films with the magenta layer on top, but it has been virtually impossible to remove the magenta layer's sensitivity to blue light. The classical order of yellow, magenta, and cyan from top to bottom will probably exist for many years to come.

The location of the dye image, in the emulsion, is determined by the location of the developed silver grains. The dyes are formed in the areas adjacent to the reduced silver. When the silver is removed, during processing, the dye remains as a cloud centered where

the grain was located. Because the dye images are partially transparent, rather than opaque, and are formed by chemical diffusion, their density increases gradually from the edge to the center. On the other hand, the density of a silver image changes abruptly at the edge of the grain. Therefore, color film appears less grainy than black-and-white, but the image has lower edge sharpness and image definition. The magenta dye image (green-sensitive layer) has the greatest appearance of graininess because the peak sensitivity of the human eye is in that region of the spectrum.

Since red, green and blue are recorded in the same manner in almost all color films, negative and reversal, a cross section of a typical piece of color film will help in better understanding. Refer to figure 1-12.

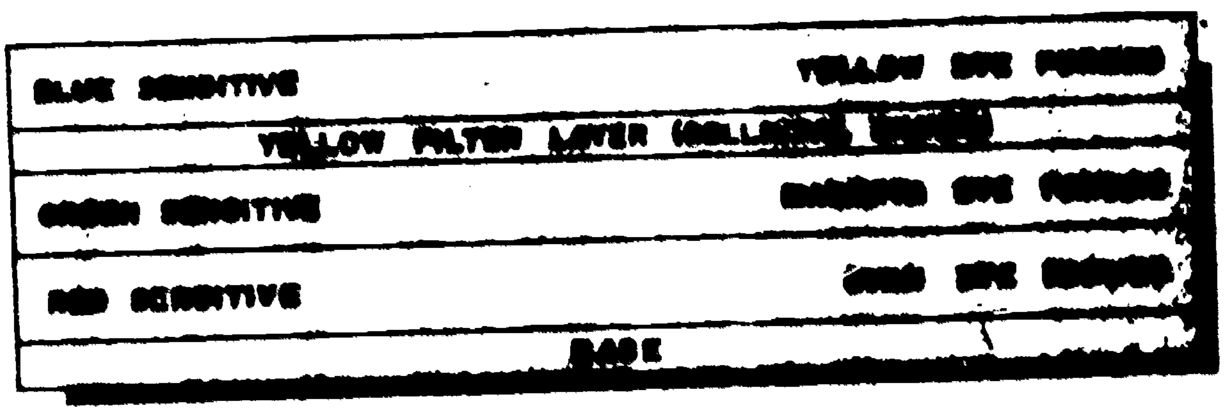

Figure 1-12. Color Film Emulsions

Starting at the top and working down, first is the blue sensitive layer of the emulsion. This is where the blue record is made. Remember the blue sensitive emulsion is sensitive to blue light only. Below the blue sensitive emulsion there is a layer of colloidal silver suspended in clear gelatin which absorbs the stray blue light which penetrates the blue sensitive emulsion - this layer is similar to a yellow filter. The colloidal silver is bleached and fixed away during the processing. The green recording layer is an orthochromatic emulsion and is sensitive to both blue and green light. Because of the colloidal silver, only red and green light is allowed to penetrate to this point. Since this emulsion layer is not sensitive to red and since all the blue light has been absorbed, the only exposure possible at this point is that produced by green light. Following the green, another

record is made in the next layer which is a panchromatic emulsion that records red. This emulsion is manufactured with a very low sensitivity to green. Therefore, since the blue cannot penetrate to this point, only a red record is made.

In effect then a sheet of negative or reversal color film is made up of three separate emulsion layers, each one sensitive to only one of the additive primary colors.

Dye Couplers

The most accepted method of producing dye images within a color negative or transparency is by a chemical reaction of substances known as couplers combining with the oxidized developer. This reaction is called coupler development and is the secondary function of the color developer. As the developer reduces the exposed silver halides to form metallic silver, the developer itself is oxidized. The by-products of this reaction combine with the coupler agents to produce the dyes. This dye-forming reaction produces dyes in proportion to the amount of silver developed; in other words, for each silver halide that is reduced by the color developer, there is a molecule of dye formed. Since the dye formed is insoluble, it will remain in the emulsion to yield a photographic image in color.

Originally, the dye coupling agents can be colored or colorless when first introduced into the emulsion and then they are changed to another color during the developing process. The type of coupling agents used will depend on the particular film. In reversal films, the end-product is primarily designed for direct viewing, in which case, the coupling agents must be colorless in nature. However, color negatives are not intended for direct viewing, but are judged for their printing characteristics. Thus it is possible by utilizing colored couplers in the negative material to overcome the effect of incorrect dye absorptions that are so prominent in color prints.

Coupling agents (colored or colorless) combine with the oxidized color developer to produce either a yellow, magenta, or cyan dye, depending upon emulsion. Normally, the color of the dye formed is complementary to the original light sensitivity of the emulsion layer. For an example, the bottom emulsion layer is sensitive to red light. After color development, it will yield a cyan dye image.

Dye couplers may be placed in either the developing solutions or in the three emulsion layers, depending on the type of film. In the Kodachrome and Ilfochrome process, the coupling agents are put into the processing solutions. These couplers must be readily soluble in the developing solutions and they must diffuse freely through the gelatin together to the site of the exposed silver halide. To confine

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the dye images to their appropriate layer, it is necessary to use three separate color developers, one for each dye. Also, it is necessary to reexpose selectively each emulsion before development. This type of process requires both elaborate equipment and extreme accuracy in its control. Due to its complexity, only a few of the larger processing laboratories operate this process.

By mixing the coupling agents into the emulsion, all dye layers can be formed simultaneously, thus eliminating the need for multiple reexposures and color developers. Films such as Agfacolor, Ansco-chrome and Ektachrome incorporate the coupler components into the emulsion layers during manufacturing. By doing so, the three different colored dye images can be produced utilizing only a single reexposure step and color developer, thus simplifying the process so that it can be performed in any darkroom, with standard darkroom equipment.

When these coupling compounds are incorporated into the emulsions, they must meet certain major requirements. They must be nondiffusing (remain in one location), be evenly distributed, and not become crystallized. To produce the cyan, magenta, and yellow dyes, the different couplers must be capable of reacting with the same color developing agents. The resultant dyes formed must have definite spectral characteristics, so that all colors are accurately reproduced in the final product. Also these couplers must be stable compounds to provide permanency (nonfading) of the color dyes. These compounds must not interfere with the initial exposure of the film and must not cause any harmful effects during storage of the film prior to exposure.

Standard Reversal Process

The standard color reversal process is illustrated in Figure 1-13. Such films as Kodak Ektachrome EF Type 7241 (daylight) and Ektachrome R Print Type 7389 are processed in this manner. A latent image of the original scene is formed by the light reflected from the subject, exposing the silver halides in one or more of the appropriate light-sensitive layers. Each emulsion layer is sensitive to a different part of the spectrum: the top layer to the blue region only, the second layer to the green region, and the bottom or third layer to the red region. Also, a colloidal silver (yellow filter) interlayer is placed below the blue-sensitive emulsion. After the camera exposure, the film is developed in a modified black-and-white developer to form a silver negative image. (See Figure 1-13A.) No dyes are formed in this "negative" since the black-and-white developer yields no coupling compounds.

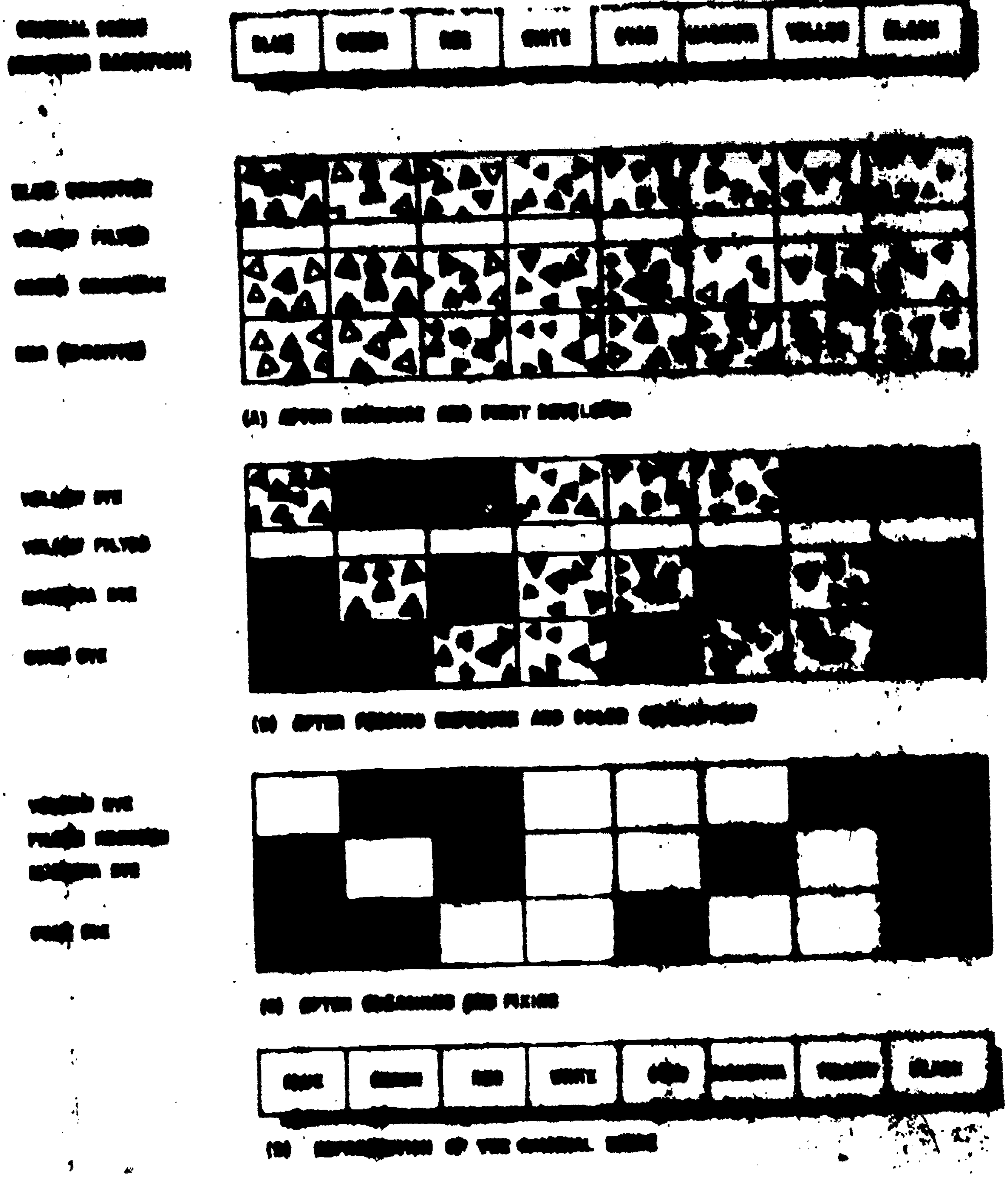

Figure 1-13. Typical Color Reversal Process

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After this step, the film undergoes fogging to expose all the remaining residual silver halides that were unaffected by the initial camera exposure and the first developer. This reexposure may simply consist of holding the film under a strong light, or by a chemical fogging agent which has been introduced in some color chemistry, such as Kodak's E-4, and EA-5 processes. This chemical called Kodak Reversal Agent RA-1 (tertiary-butylamine borane, also known as T-BAB), is added to the color developer to produce the same effect as the physical reexposure.

Once fogged, the reexposed silver halides are reduced to metallic silver by the color developer and dyes are simultaneously formed in those areas, as illustrated in Figure 1-13B. Note that not all the silver halides have been developed by the first developer. Note also, that the dyes formed are the complementary color to the emulsion's original sensitivity. That is, the yellow dye forms in the blue-sensitive layer, magenta dye in the green-sensitive layer, and cyan dye in the red-sensitive layer. At the end of color development, the film (if viewed) would be completely opaque (nontransparent) to transmitted light since there are now three silver negative images, three silver positive images, and three positive dye images within the emulsion layers of the color film.

Figure 1-13C represents the film after the bleaching and fixing steps. Both the negative and positive silver images are removed, along with the metallic yellow filter layer, leaving only the superimposed dye images. Perfectly registered, these images form a positive color transparency which can be viewed by transmitted light or by projection on a screen.

When the processed transparency is placed over a source of white light, the various colors of the original subject are reproduced by the subtractive process. For example, red if formed by the overlapping of the magenta and yellow dyes or colorants. The magenta colorant absorbs the green portion of the white light, and the yellow colorant absorbs the blue part of the white light, thus preventing these colorants from being seen. The only part of the viewing light not absorbed by either colorant is red, which is transmitted and therefore seen. By utilizing the secondary primaries, dye or colorants (cyan, magenta and yellow) in the final product, almost any color can be produced. Black is produced by the overlapping of the heavy dye formation in all three layers permitting no light to be transmitted. Lesser amounts of these three colorants (of equal portions) would yield various shades of gray. White is produced by the unobstructed passage of light through the three emulsions, since colorless couplers are used in this type of film.

Since each emulsion layer of the tripack forms a dye image complementary in color to its sensitivity, each layer can be thought of as a primary color absorbing filter; thus each emulsion controls the transmission of its own color. In reversal film, the density of absorption of the dye image is related to the amount of residual silver left in the emulsion for color development. For example, an area of the subject that reflects a bright green would produce a very dense image in the green-sensitive layer by the first developer; therefore very little magenta dye can be formed. At the same time the other two layers receive little or not exposure and are not affected by the first developer, thus leaving almost all of the residual silver halides in each of these layers. After color development, the top emulsion would produce a dense yellow dye and the bottom or red-sensitive emulsion would yield a dense cyan dye. Therefore, with the combination of these two layers, the area would appear a deep green in the final transparency.

Intermediate tones and shades of color are produced by the various amounts of silver halides in the different emulsions. After coupling development, the colorants or dyes produced yield only a partial absorption within the given emulsion layers. For example, orange is produced by a dense or heavy deposit of yellow dye and only half the maximum amount of magenta dye with no cyan dye present. Various shades of pink are obtained by the varying amounts of magenta dye only.

At this point, it should be explained, that the above examples are based upon theoretically perfect dyes or colorants. Unfortunately, the best available dyes absorb some of the light that they should be transmitting freely. For example, a perfect cyan dye would absorb only red, and would transmit freely the blue and green lights. However, all known cyan dyes absorb a significant amount of both blue and green. Likewise, a perfect magenta dye would absorb only green light, while transmitting freely the red and blue lights. Actually, magenta dyes transmit red light freely, but absorb some of the blue light. Of the three dyes used in subtractive color photography, only the yellow most closely approaches the ideal colorant. Because of these dye imperfections, some colors such as the blues and greens will be darker and have less saturation. Some colors will actually change in hue.

Although, these unwanted dye absorptions tend to degrade the resulting colors, they have no serious effects on the original color transparency, which is to be used only for direct viewing or projection purposes. However, the real problem is encountered when a duplicate transparency or color print is reproduced from the original transparency. The dye deficiencies of the original are then multiplied by the deficiencies present in the reproduction material. It is possible to minimize many of these deficiencies by various selective masking

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procedures. Many masking procedures are available to the technician to improve the color quality of the final product in the reproduction stage.

## Color Negative Process

The physical structure of negative color film is similar to other multilayer color films. The dye couplers are placed in the emulsion layers at the time of manufacture. The negative process is illustrated in Figure 1-14. The blue sensitive (top) layer produces yellow dye, magenta is produced in the green sensitive (middle) layer, and cyan is produced in the red sensitive (bottom) emulsion layer. The dye layers perform the same function as in the case of reversal color films; each layer acts as a subtractive filter for control of one of the additive primary colors.

Unlike the color reversal materials, color negative films are developed only once, in a color developer solution. After exposure to the original scene, the film is processed in the color developer (Figure 1-14A) where both the negative silver images and a negative dye image are formed in each layer. Again, these dyes are formed only where the exposed silver halides are being reduced to a metallic silver. Therefore, the amount of complementary dye produced in each emulsion layer is proportional to the exposure that layer received. Since the desired result is dye negative images, both the negative silver images and the colloidal silver (yellow-filter) in the interlayer must be removed from the film. This is accomplished by placing the film in a bleach solution which changes the metallic silver back to a silver complex molecule. The fix, then, removes the silver halide complex, leaving the dye images intact in each layer. The dye images which remain are negative with respect to the tonal graduations of the subject. Also, they are complementary to the colors of the original subject (Figure 1-14B).

## Storage

Color emulsions are subject to change, caused by aging. These emulsions are easily damaged if exposed to heat, high humidity, or to long periods of uncontrolled storage. Multilayer films are especially critical since each layer is likely to respond differently to the aging process.

The manufacturer marks each batch of color material with an expiration date. These dates assume normal storage conditions. However, if color films are stored under conditions that retard the aging process, they may be safely used after this date expires.

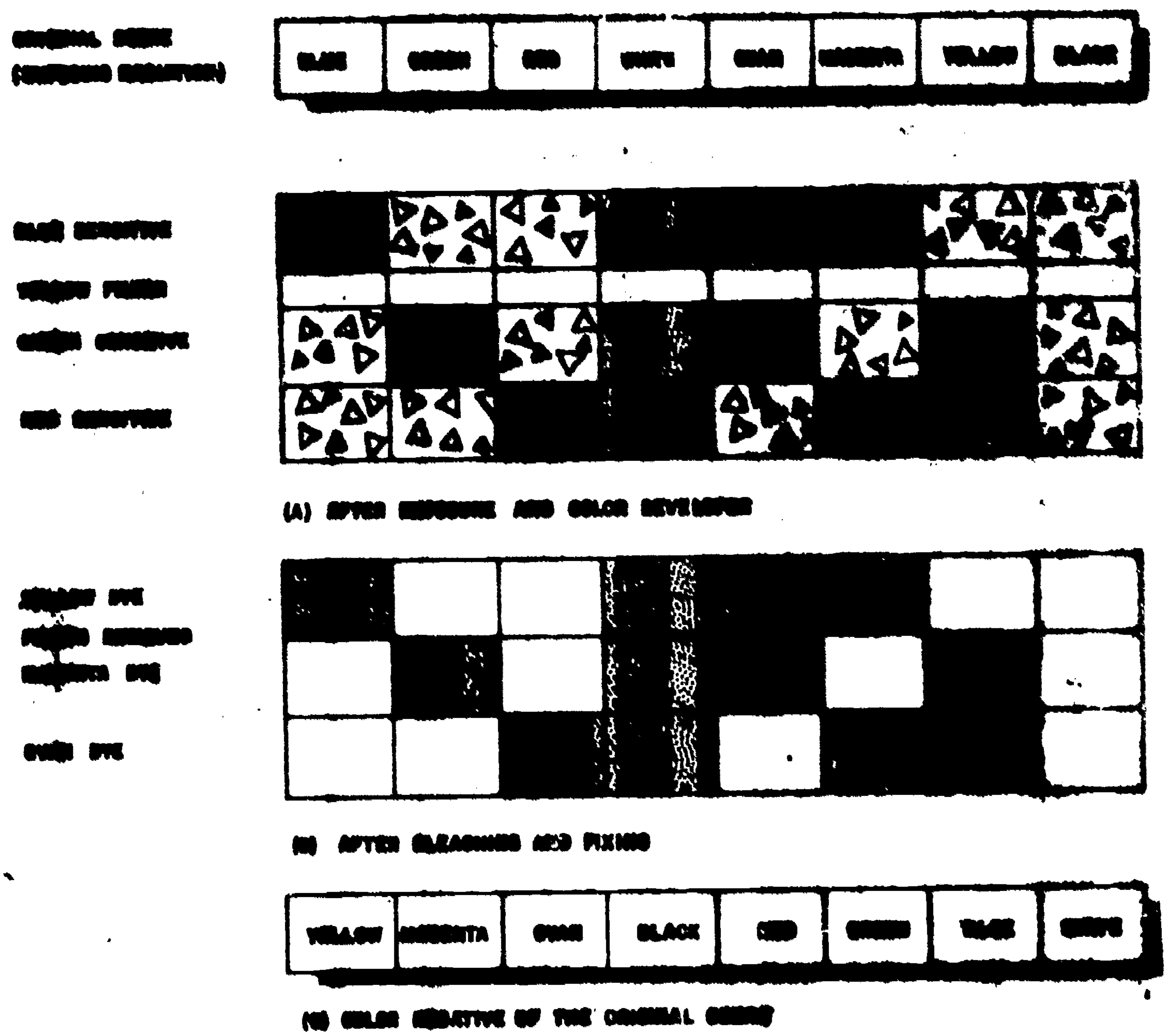

Figure 1-14. Color Negative Process

Color films that are going to be used in a relatively short period of time may be safely stored at 50°F (10°C). For long term storage (6 months or more) temperatures of 0°F (-18°C), are recommended. Emulsion changes are minimized at these temperatures. Relative humidity should be between 40 to 60 percent, preferably nearer 40 percent.

Illumination

The eye automatically adjusts for changes in the color quality of the illumination source. Color films, unfortunately, do not have this capability. They are constructed to meet lighting situations having specific spectral qualities. Therefore, a color emulsion will most accurately reproduce the colors of the subject when exposed under illumination for which it is balanced.

Spectral quality refers to the various combinations of wavelengths present in the light source. Daylight consists of approximately equal amounts of these wavelengths. Daylight color films, therefore, must receive equal amounts of these radiations in order to produce a satisfactory color balance.

Tungsten illumination is comparatively high in red and deficient in blue wavelengths. For this reason, tungsten color films have a relatively higher blue sensitivity. Due to this increased sensitivity, if exposed under daylight conditions, tungsten reversal emulsions will have a predominately bluish cast. On the other hand, daylight color films appear reddish, if exposed under tungsten illumination.

Whenever possible, the source of illumination and the color emulsion should be matched. However, situations sometimes arise that make it necessary to use color emulsions and light sources that do not match. Under certain conditions, acceptable results can be obtained provided filters are used to alter the spectral quality of the light source.

## CHARACTERISTICS OF MOTION PICTURE FILM

Requirements of Motion Picture Film

Although motion picture film follows the basic structure of film, there are some characteristics of motion picture film which need discussing.

The base of a motion picture film for use in the laboratory must possess several very important properties. One of the most important is flexibility. The film must be able to withstand being bent or flexed many times during processing, duplication, and projection.

Motion picture film requires a strong, tough base with excellent wearing qualities because it has to be transported, often at high speed, by mechanical teeth which engage perforations located along the edges of the film. In addition, the film is subjected to

stress and strain during processing, printing, and projection.

One factor, not as critical now as it has been in the past, is the degree of inflammability of motion picture film. Many years ago, motion picture film was made almost entirely from cellulose nitrate. Then it was discovered that in the presence of high heat, cellulose nitrate would sometimes burst into flames due to the decomposition of the nitric and sulfuric acids. This led to the production of improved film bases and the ultimate production of acetate base materials. Now, except in rare cases, most motion picture bases are made of flame-resistant materials.

An easy method of identifying nitrate base film is to check the edge of the film. Nitrate base film nearly always has the words "NITRATE FILM" printed at frequent intervals along the edge of the film. The danger in using this method is that there is a chance the acetate film has been printed onto nitrate base film, or vice versa. This can cause a misidentification. So, when inspecting stored film for any nitrate base film, be sure to check carefully.

Another method of identifying nitrate base film is through its peculiar odor of nitric acid. When a can of stored nitrate base film is opened, a strong odor of nitric acid fills the air.

Since about 1950, virtually all motion picture films have been coated on safety supports (most often with the words "SAFETY FILM" printed frequently along the edge). These supports are of cellulose triacetate, or acetate propionate materials. The latter is used only for multilayer reversal-type color films. These, of course, are flame resistant and have excellent dimensional stability. They provide a very satisfactory base upon which to bond the all-important, light-sensitive film material.

Motion Picture Film Configurations

Figure 1-15 illustrates four configurations of motion picture film that might be seen in the field. In the figure, the most obvious difference is size; two are 16mm films and two are 35mm films. Another difference is that two of the films are for silent pictures while the other two include a sound track. Look at the 16mm sound film a little more closely and see a third difference. The 16mm sound film has sprocket holes down one side only. This is to allow space for the sound track. The film would be too narrow to accommodate the sound track if it had sprocket holes on both sides. In the case of 35mm film, there is space for both a sound track and the sprocket holes.

Sprocket holes are the perforations down the edge of the film. These holes engage teeth in both the camera and projector which move the film along the film travel path. Note that the 35mm film has more sprocket holes than the 16mm. This is because the 35mm film must travel at a faster speed through the projector; therefore, more sprocket holes are provided to lessen the chances of tearing the film. The 16mm film will permit exposure of 40 frames per foot (just over 131 frames per meter) while the 35mm film will accommodate only 16 frames per foot (or about 52.5 frames per meter).

Spooling

Motion picture film is supplied on many types of cores and in several types of winding. Films that are said to be "wound on" are fastened to, and wound around a solid core (center) and cannot be removed except by unwinding the film. Often, film is initially wound on a collapsible spindle which is then removed and the solid core inserted. However, in the case of "inserted" winding, the film is not fastened to the core. Be careful when handling the film and do not allow it to slip loose from the core inadvertently. If the film does slip loose from the core, it will be totally uncontrollable.

Two different windings, designated as winding A and winding B, are used for motion picture film. The purpose of these windings is twofold. The first reason is identification of the position of the soundtrack. On 16mm films, the sound track is located on the edge of the film where there are no perforations. On 35mm films, the sound track is located on the inside of the perforations along one side of the film (see figure 1-15). To identify the film as A or B wind, the film must be wound onto a core, emulsion in, with the head end of the film coming off of the top of the reel, going from left to right. If all of these conditions are met, and the soundtrack is toward the operator, the film is said to be in the A wind position (see figure 1-16). If all of the conditions hold true and the soundtrack is away from the operator, the film is in the B wind position.

The other use of A and B windings is to describe the manner in which the information on the film was recorded. If the information on the film can be properly read by viewing it through the base of the film, the film is in the B wind position. If it can be read through the emulsion, it is A wind. This is important because not all motion picture films used by the Air Force contain a soundtrack. When film is processed (camera original), it is in the B wind position. When a contact print is made, (emulsion to emulsion) the position of the information is reversed, and therefore

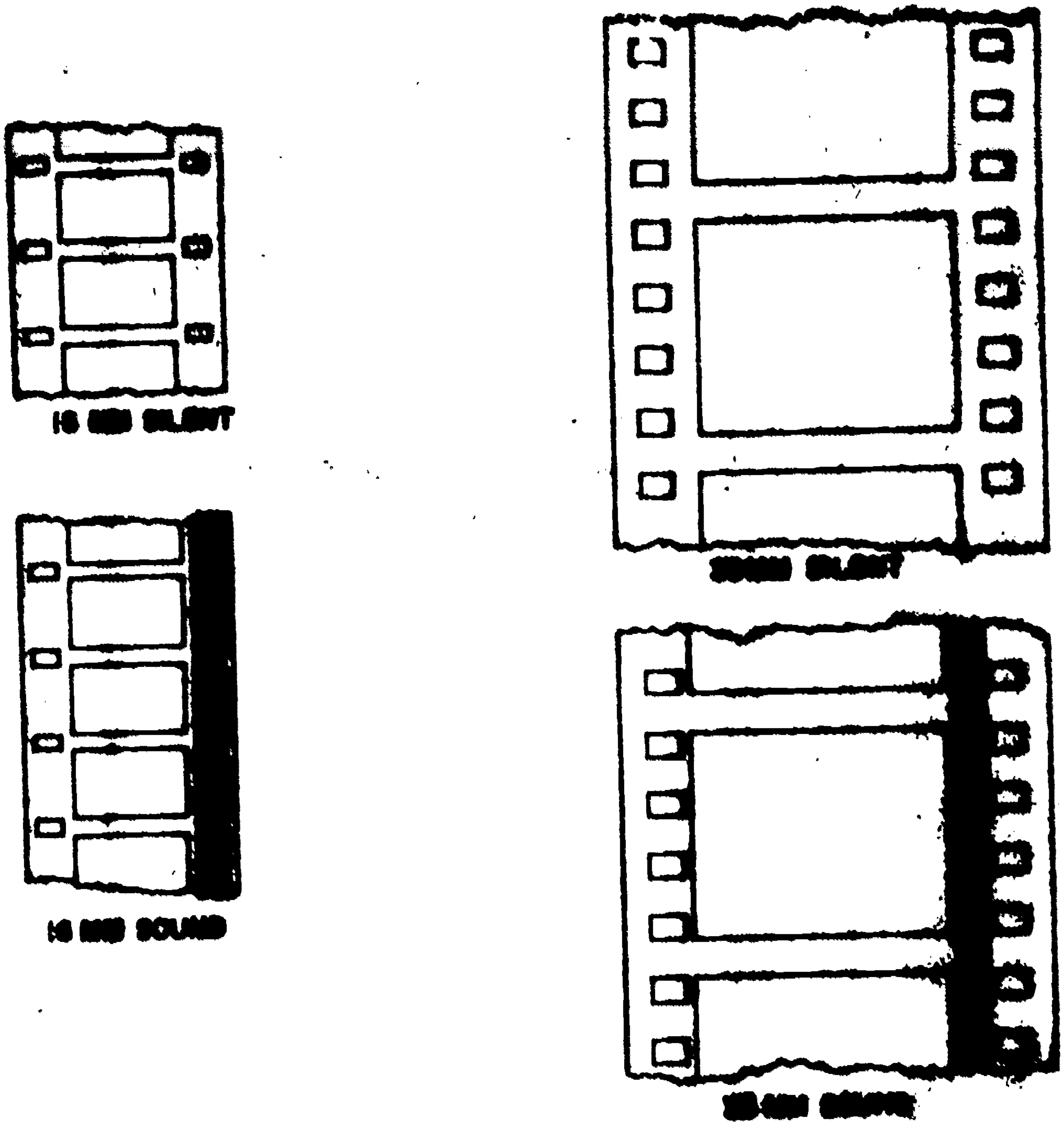

Figure 1-15. Motion Picture Films

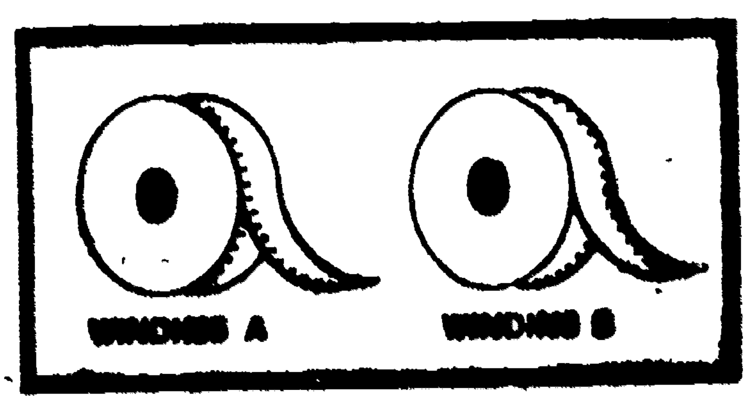


Figure 1-16. A and B Film Windings

the print is A wind. This holds true for all widths of motion picture film (16, 35, or 70mm).

Reversal Films

In the conventional negative/positive system, to obtain the positive film needed for release to the using activities, one had to make positive prints from the negatives. Although the quality of the end production warrants it, this process is time consuming and involves large quantities of material. To cut down the time element for special projects, (where speed is more important than quality), use a film which can produce a positive (same as original scene) image during processing and eliminate intermediate duplicating steps. This type of film is known as reversal film.

There are no basic structural differences between negative and reversal films; and while it is possible to reverse any black-and-white film to obtain a positive image, reversal film has an emulsion designed especially for the reversal process.

Reversal film has other advantages. One of these is that the developed reversal film images are found to be less grainy than those obtained by developing a negative and printing positives from it. Remember, the larger the grain in the film, the more sensitive it is. Consequently, the larger grains, being those which are exposed most easily, produce the negative image. They are developed and then removed by a bleach solution during the reversal developing sequence. The remaining silver halides being smaller, develop up to a finer grained positive image.

If reversal film provides a positive image without the necessity of going through the other phases of the production process, why bother with any other type of motion picture film? By using reversal film, the need for negative film could be eliminated entirely. There are two basic answers to this question. First, negative film is used when a large quantity of copies must be made for release to other agencies. The films that are used in mass production of reversal prints have inadequacies that restrict their uses. Thus, the quality of the release prints would slip if reversal films were used for master production films. The second reason is that a finished motion picture film is made up of many segments of the film spliced together to form the final release print. To get the final release print, it is necessary to produce duplicate copies of the reversal master so that the film can be cut and spliced during production. This, too, would result in a loss of quality.

Positive motion picture films are obtained by two methods. They are produced either by the reversal process, or from a

negative onto positive material. Although reversal films are limited in their use because the original is the only positive, additional positives can be made if needed. Since there are many similarities in the several systems, they will be discussed together.

Generally, when many prints are needed, the procedure is to make an intermediate positive from the original negative film and then make duplicate negatives to produce the release prints. By using duplicate negatives, as many release prints as needed can be produced without damaging the original.

When intermediate positives and duplicate negatives are made to produce release prints, what kind of film should be used? (To simplify matters, this discussion only deals with black-and-white films). The release positive film is a slow speed, fairly contrasty photographic material. Its emulsion is generally blue sensitive only and is applied to a clear base having high scratch resistance. High scratch resistance is necessary to protect the film from the frequent handling that it receives from the using organizations. The release positive material should also be extremely fine grained and have high resolving power and image sharpness. When producing release positives, these factors should govern film choice.

An advantage of using an intermediate positive and duplicate negatives to produce release films is that it is a very effective way of producing large quantities of high quality film. Also the various steps allow the correction of any undesirable densities or contrast that may be found in the original. The steps also allow control of the between-scene densities in the finished print so that light scenes intermixed with dark scenes can be avoided. But if only one or two release prints are needed for immediate use, this process is too long and costly. What should be done instead?

In this situation, turn to a reversal duplicating film. This is a slow-speed, orthochromatic (non-red-sensitive) film that is used for making duplicate positive prints for immediate release. It is also acceptable for producing black-and-white positives from color reversal originals. By using reversal duplicating film, one or two copies can be produced for immediate use and would still preserve the original copy. But remember, the quality will suffer since this does not have the control afforded by the previous procedure.

Occasionally one may be called upon to produce positive films, such as titles or silhouettes, where extreme high contrast is desired. In this case, use a high-contrast positive film. Sensitive to blue light only, and quite slow, this film gives the extreme blacks and

whites that are required.

REVIEW QUESTIONS

DO NOT WRITE IN THIS SW - USE A SEPARATE SHEET OF PAPER.

1. What is light?

2. What portions of the electromagnetic spectrum are photographically significant?

3. What is the approximate electromagnetic range of the visible spectrum?

4. What type of radiation is directly above the visible spectrum?

5. What are the additive primary colors?

6. How are additive primary colors used to produce white light?

7. Which primary colors are used during the original photographic record?

8. What are the subtractive primary colors?

9. How are subtractive primary colors produced?

10. What are complementary colors?

11. How are complementary colors located on the color star?

12. How much of the visible spectrum is absorbed by an additive primary filter?

13. How much of the visible spectrum will an additive filter transmit?

14. Subtractive primary filters transmit and absorb how much of the visible spectrum?

15. What is the effect of super-imposing two subtractive filters over a single light source?

16. What is the effect of additive filters over a single light source?

17. If a cyan filter and a yellow filter are superimposed in a beam of white light, what would be the resultant color of the beam?

18. What is the chief advantage of the additive printing system?

19. What is the advantage of the subtractive printing system?

20. What is the purpose of the yellow filter layer in color film?

21. At what point in the color process is the yellow filter removed?

22. Why are the color images not visible at the end of the color development step?

23. What color dye is formed in the middle layer in the color reversal process?

24. What is the function of the first developer in the color reversal process?

25. What is the purpose of the second exposure in the color reversal process?

26. Since there is no red dye in color reversal film, how does an object appear red when projected or viewed?

27. How should color films be stored?

28. Describe some of the requirements of a motion picture film base?

29. How can nitrate base film be distinguished from safety base film?

30. What are some of the advantages of using a reversal film instead of a normal negative film? What are some disadvantages?

PRACTICAL EXERCISES

EXERCISE I

PROCEDURES

DO NOT MARK OR WRITE IN THIS SW. Use a separate sheet of paper

for the illustrations. Complete parts a through e as directed by the instructor. Turn in the answers for evaluation when completed.

a. List the additive primary colors and their corresponding subtractive primaries as complements.

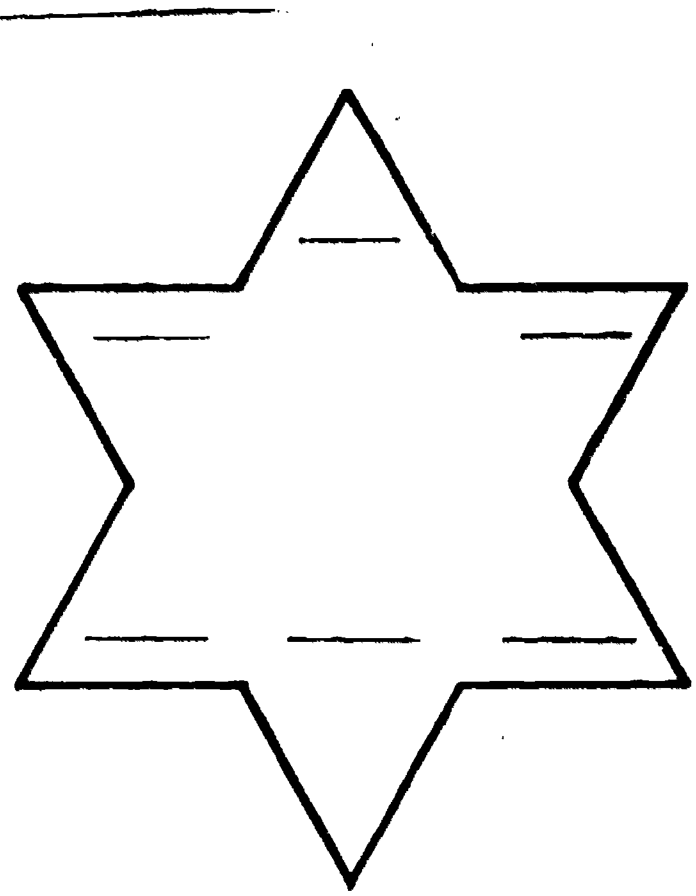

Figure 1-17. Color Star

b. Fill in the names of the colors formed by the three projected beams.

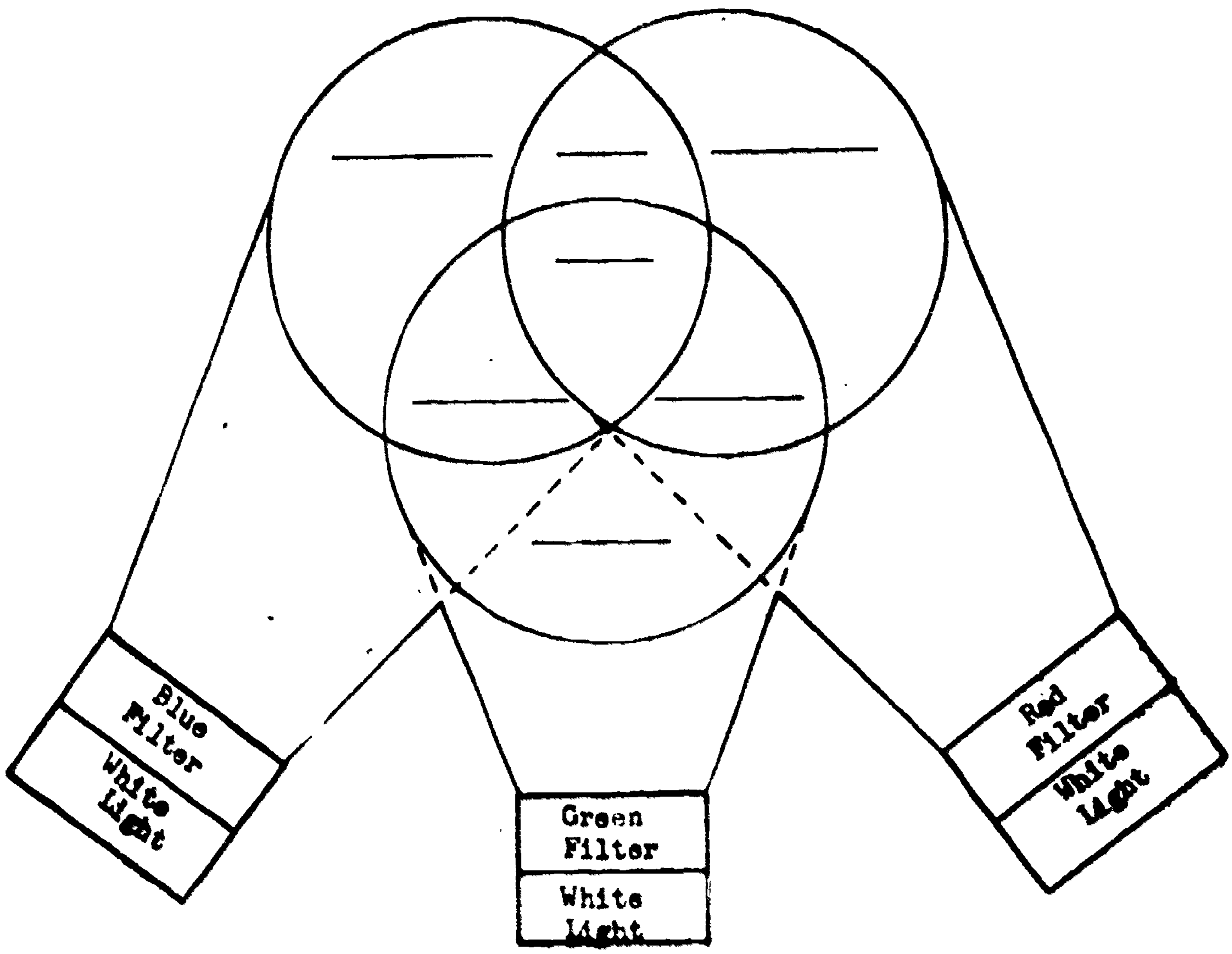


Figure 1-18. Additive System

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c. Fill in the names of the colors formed by overlapping the three subtractive primaries filters over a single light source.

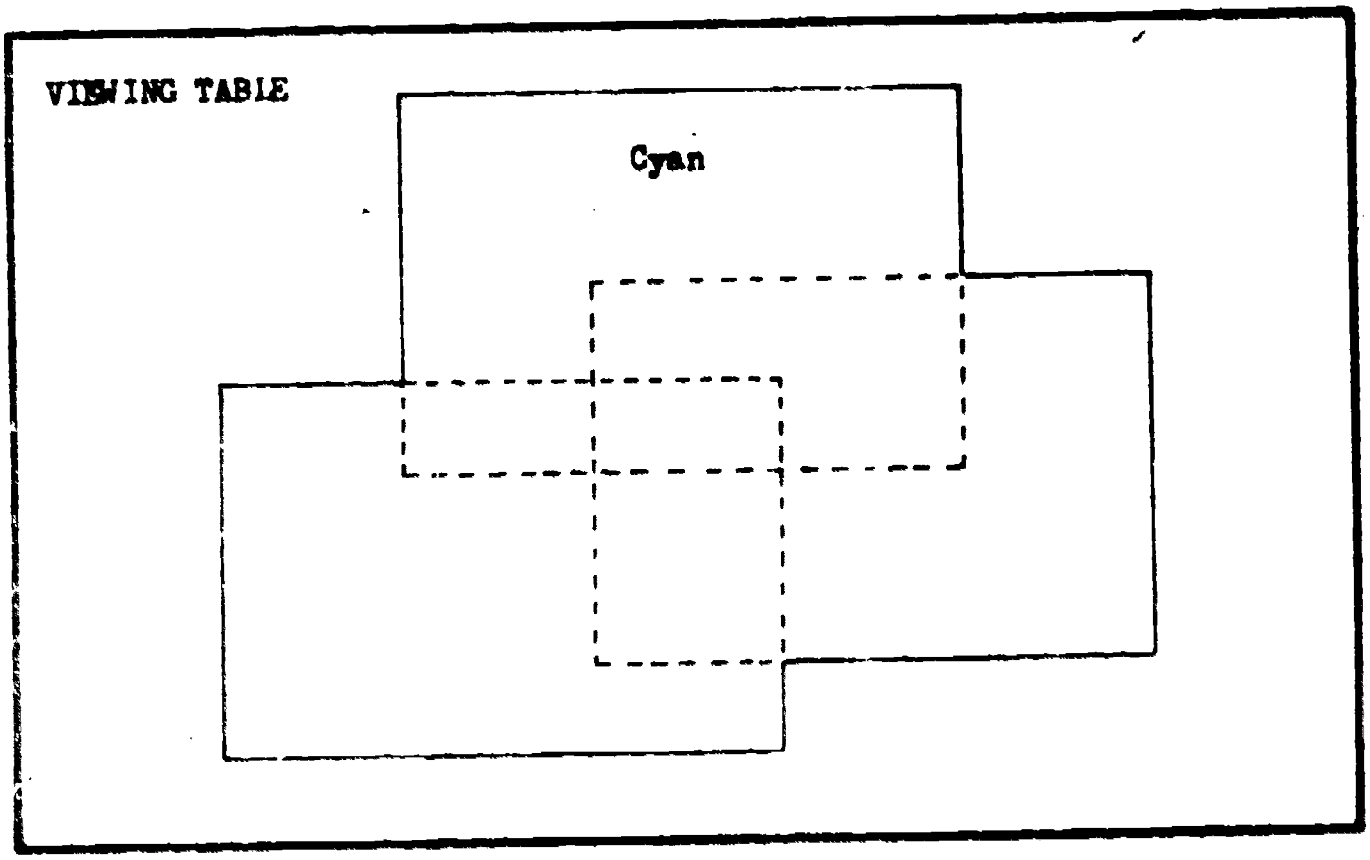


Figure 1-19. Subtractive System

d. Label in order the refractivity of the various colors of white light.

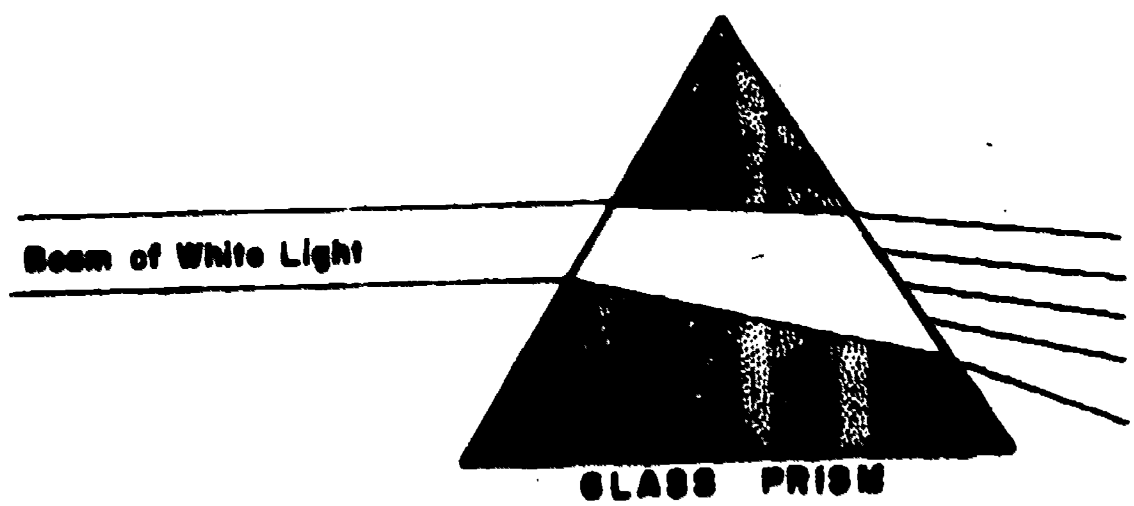


Figure 1-20. Dispersed Light

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e. To indicate the effects of filters on white light, use the appropriate symbols R, G, and B to indicate colors transmitted and an 0 to indicate colors absorbed.

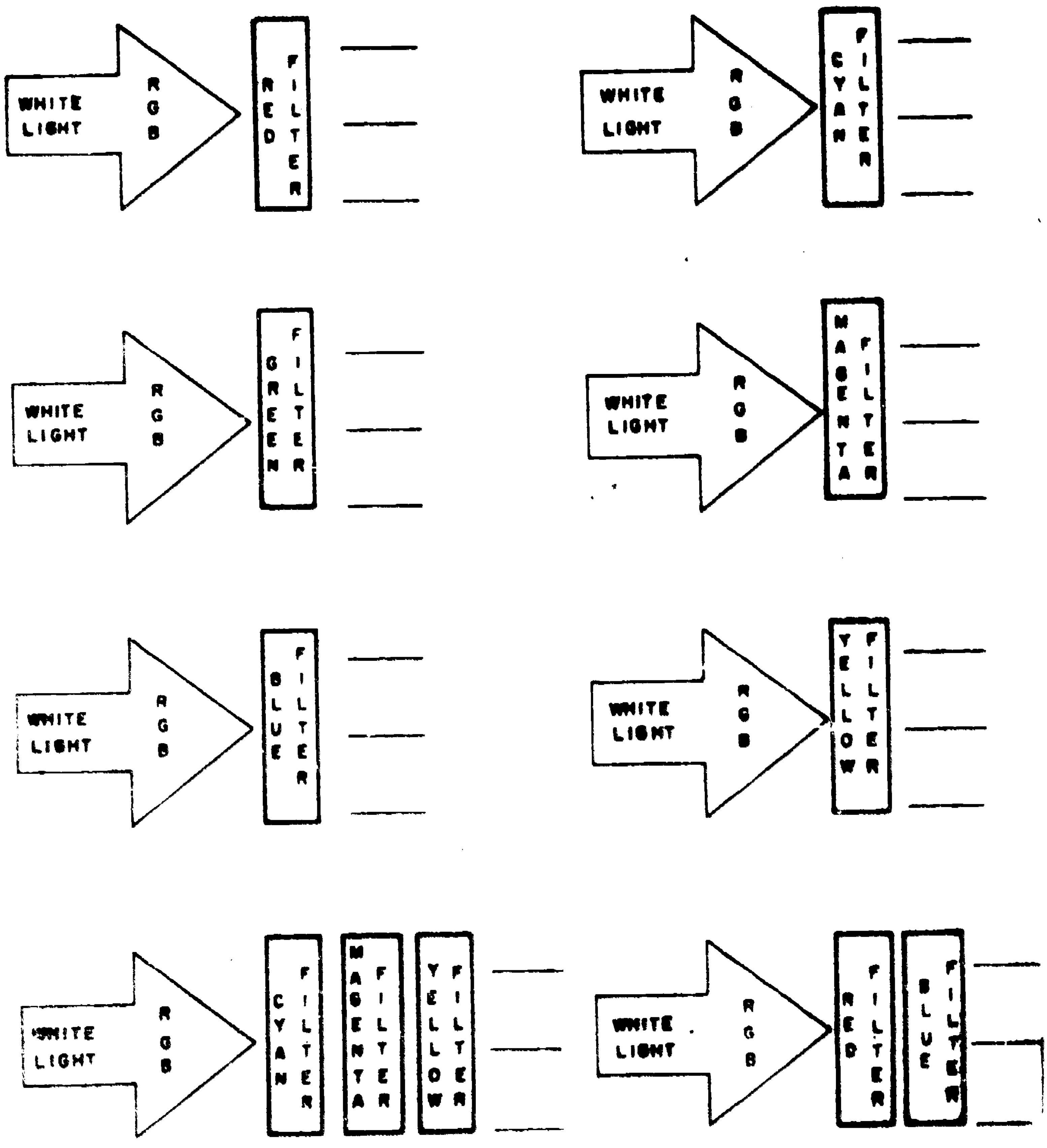


Figure 1-21. Filter Effects

EXERCISE 11

**PROCEDURES**

Use a separate sheet of paper and complete procedures a and b.

a. The following illustrations represent cross-sections of negative color film. The top illustration represents colors of an original scene. Mark an (X) in each block of each illustration that is affected during exposure to the additive and subtractive primaries and then processed. No errors are permitted.

ORIGINAL SCENE

| WHITE | RED | GREEN | BLUE | CYAN | MAGENTA | YELLOW | BLACK |
|---|---|---|---|---|---|---|---|

COLOR DEVELOPER

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

BLEACH

| | | | | | | | |
|---|---|---|---|---|---|---|---|
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| | | | | | | | |
| | | | | | | | |

FINAL DYE IMAGE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Figure 1-22. Negative Process

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b. The following illustration represent cross-sections of color reversal film. The top illustration represents colors of an original scene. Mark an (X) in each block of each illustration that is affected during exposure to the additive and subtractive primaries and then processed. No errors are permitted.

ORIGINAL SCENE

| WHITE | RED | CYAN | MAGENTA | BLUE | GREEN | YELLOW | BLACK |
|---|---|---|---|---|---|---|---|

FIRST DEVELOPER

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

SECOND EXPOSURE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

COLOR DEVELOPER

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

FINAL DYE IMAGE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Figure 1-23. Reversal Process

EXERCISE III

**PROCEDURES**

Referring to the attached figure, answer all of the following questions.

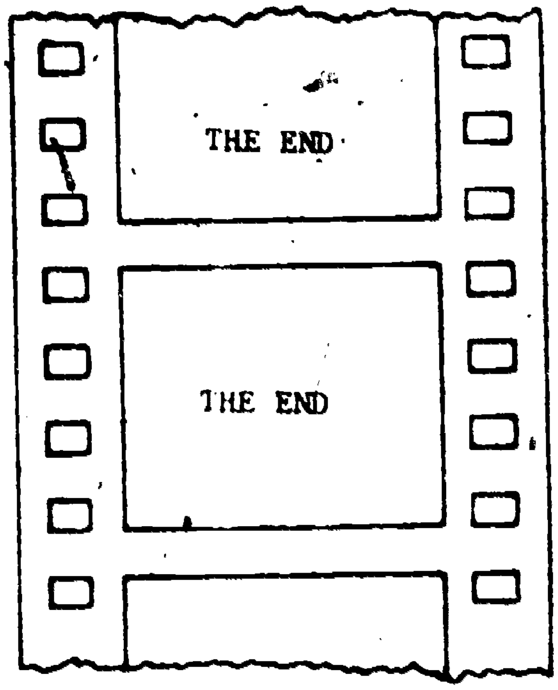


Figure 1-24. Motion Picture Film

This figure illustrates a contact print from a "B wind" original.

a. Which side of the film is toward you?

b. Is this print "A wind" or "B wind?"

c. If a soundtrack was included on this film, where would it be?

d. Is this film 16mm or 35mm?

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EXERCISE IV

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| 16mm motion picture camera | 1/student |
| Exposure meter | 1/class |
| 16mm dummy film | As needed |
| 16mm color reversal film | 200 ft/student |

PROCEDURES

1. Practice loading the dummy film into the motion picture camera as directed by the instructor.

2. Using the dummy film, practice filming different scenes.

3. Load the unexposed film into the camera.

4. Using camera exposure settings determined by the instructor, expose several different scenes.

Sciences Branch
Lowry AFB, Colorado

SW 3ABR23130 001-VI-2
October 1977

# COLOR CHEMISTRY

## OBJECTIVES

List the major processing steps that are required for processing different types of color film.

List the components of the ME-4 process in order and briefly explain the purpose of each component.

Using packaged ME-4 color chemicals, chemical mixing facilities and equipment, mix ME-4 color chemicals following the manufacturer's instructions.

## INTRODUCTION

The final step in the production of an image is that of processing. There are numerous photographic processes, some produce a negative image, while others produce a positive image.

Some of the processes that will be discussed are EA-5 used for processing of aerial color films, E-4 used to hand process color reversal films, ME-4 used to machine process motion picture reversal films and finally E-6, one of the newest color reversal film processes.

Since most of these processes are similar, this SW will concentrate on the ME-4 process.

## INFORMATION

### COLOR PROCESSING

To better understand the steps needed to process color films, a review of the black-and-white process is required. In the black-and-white process a developer (reducer) changes the exposed silver halides into black metallic silver. The fixer (hypo) converts the remaining silver halides into water soluable silver complexes. All that remains on the film after processing is a black-and-white negative silver image.

### Color Negative/Positive Processing

When a color negative is viewed, although colors are present throughout the entire negative, it is not completely opaque. That is, one can still see through any portion of the negative. This means that metallic silver no longer remains in the emulsion after

processing. Since only a color dye image remains, a slight modification of the process is required. The developer must be one that will form dye images as well as a negative silver image. Subsequently, the silver must be removed. The first part is easy because a special color developer is used. The second part is more difficult.

It is already known that the fix removes the silver halides and has no effect on the metallic silver. Therefore, if the metallic silver can be changed back into silver halides before fixing the film, the silver can be removed altogether. This is done by introducing a bleach step into the process. The purpose of the bleach is to change all of the metallic silver into silver halides once again. This allows the fix to remove all silver particles leaving only a negative dye image. The major steps of the negative/positive process are:

1. Color Developer

2. Bleach

3. Fix

The overall orange cast seen on a color negative is purposely built into the film to correct for unwanted dye transmission and absorption qualities. Process ECN-2 or the newer process C-41 are typically used for processing color negative films.

Reversal Processing

The purpose of the reversal process is to provide a positive image directly from the exposure (without the use of an intermediate negative). A color transparency (a slide) is the most common example of the reversal process.

Something extra must be introduced to develop the film to a positive image rather than a negative one. This is accomplished by using a modified black-and-white developer to develop a negative image. This leaves only a negative silver image and unexposed silver halides. The film is then reexposed chemically in a color developer and positive silver and positive dye images are formed. The bleach and fix steps act exactly the same here as they do in the negative/positive processing. That is, the bleach changes the metallic silver to silver halides and the fix removes them. The primary steps in a basic reversal process are:

1. First developer

2. Color developer

3. Bleach

4. Fix

There is no overall orange mask on a color transparency because a transparency is designed primarily for direct viewing. Various reversal processes are as follows:

PROCESS E-4. The E-4 process is used for processing still photography reversal films. The chemistry may be used in continuous processors or in manual daylight processing tanks. This process consists of thirteen steps and the average processing temperature is 85°F (29.4°C). Processing time is 56 minutes.

PROCESS E-6. The most recent development in still reversal processing is the E-6 process. Designed to replace the E-4 process, this process consists of ten steps and operates at 100°F (37.8°C). The higher process temperature reduces processing times by approximately 50 percent. In addition to the reduced number of chemicals used, some ecological changes have been made also. The bleach has been improved to prevent corrosion of metal tanks and environmental pollution.

PROCESS EA-5. The EA-5 process is similar to the E-4 process except that it is designed for processing aerial reversal films in continuous processors. The EA-5 process essentially contains the same chemistry as E-4, but processing temperatures are 115°F (46°C) as opposed to 85°F (29.4°C). This allows for faster processing times but it also poses more control problems resulting in stricter tolerances.

PROCESS ME-4. Process ME-4 is the currently recommended process for Ektachrome ER, EF, MS, and color print reversal motion picture films. Basically, this process contains the same chemistry as the E-4 and EA-5 processes. Processing temperatures may range from 95° to 110°F (35° to 43°C). The process is critical and one slightly off-standard condition or the presence of contamination may adversely affect quality.

## ME-4 CHEMICAL COMPONENTS

The ME-4 chemical components, functions, and processing steps are explained in the following paragraphs.

### Prehardener

The prehardener is the first ME-4 processing step. The two

major components of this solution are formaldehyde and succinaldehyde. These two aldehyde groups act to harden the emulsion of the film. They work in an additive fashion. That is, the two chemicals together act more effectively than the sum total of each alone. These aldehydes react by cross-linking with each other to harden the emulsion, and to reduce emulsion swelling, making the film more resistant to physical damage. The prehardener also supplies antifoggants to prepare the film for first development.

Prehardening time controls the amount of hardening and the thickness of the gelatin emulsion. Increasing or decreasing the treatment time changes sensitometric speed (30 seconds = 1/6 stop). Because secondary effects may result from over or under hardening, do not use prehardener time adjustments for process control. Increased temperature or increased prehardening time causes an increased rate of hardening. Thus, for optimum results the temperature must be kept within ± 1°F (±0.5°C) of the recommended processing temperature. Recirculation must also be controlled to prevent foam from forming on the solution. Air bubbles in the solution can cause uneven hardening and produce spots on the film.

Neutralizer

The neutralizer forms harmless complexes with any aldehydes carried over from the prehardener. In this way they cannot react with the first developer. There are normally no control problems with the neutralizer. Its reaction is rapid and goes to completion with no further effects.

First Developer

In the first developer, the exposed areas of the film are developed to give a black-and-white negative silver image in each layer. In general, the first developer is a very stable. easily controlled solution. When any constituents are off-standards, there is usually a well defined correlation with sensitometric results. Treatment time in the first developer controls sensitometric speed. As a rule of thumb, one minute is equivalent to about one camera stop in speed. This is useful for forced processing of films. The major components are similar to those contained in other black-and-white developers. These components consist of a solvent, reducer, accelerator, restrainer, and a preservative.

The reducer is a combination of hydroquinone and phenidone (a metol-like chemical). The other components are the same as those used in the developer that was discussed in Block I.

First Stop Bath

The stc bath is a buffered acetic acid solution which stops development and replaces the chrome alum hardener. It simply stops the action of the first developer. By proper replenishment, the pH of the bath can be maintained within control limits. High pH caused by excessive carryover of first developer, or by inadequate replenishment, causes high photographic speed.

First Wash

Each step in the photographic process produces by-products which must be removed from the emulsion. Water wash baths accomplish this most effectively. The wash serves to remove by-products of the development step and to keep the acidic first stop from contaminating the alkaline color developer which follows.

Color Developer

In the color developer solution, the remaining silver halides are sensitized and developed to a positive silver-plus-dye image. Reexposure is accomplished through the use of an RA-1 fogging agent. The dye is complementary in color to the layer sensitivity. For example, the image in the blue-sensitive layer consists of developed silver plus yellow dye. The image in the green-sensitive layer consists of developed silver plus magenta dye, and the image in the red-sensitive layer consists of developed silver plus cyan dye. RA-1 is one of the two major components in the color developer. The other is a color developing agent CD-3.

As in all development systems, the principal chemical control in the color developer is pH. Control pH carefully; high pH produces excess yellow dye and the final image will appear yellowish. Low pH produces insufficient yellow dye and the visual appearance will be bluish. Maintain the pH of the replenisher higher than that of the tank to make up for the pH lowering effect of the development reaction and the pH lowering effect of the carbon dioxide absorbed from the air. Store the replenisher under floating covers. To maintain the correct tank pH, it may be necessary to adjust the pH of the replenisher slightly to compensate for differences in machines and storage conditions.

Second Stop Bath

The second stop bath stops the action of the color developer carried over by the film and reduces emulsion swelling. This solution removes oxidized color developer agent (CD-3) from the film, and its pH should be held to standard by proper replenishment.

An exhausted (high pH) second stop bath causes pink stain in highlights because CD-3, carried into the bleach, further oxidizes to form a red compound.

Second Wash

This wash serves to remove by-products (such as any minute traces of CD-3) from the color development step and prohibits the carry-over from the second stop bath from decreasing the pH of the bleach solution which follows. A decrease in pH of the bleach will cause a stain called Prussian blue. Also, a low flow rate of water may permit some CD-3 to enter the bleach, thus causing a magenta stain to form.

Bleach

During the bleach process, all metallic silver is converted to silver salts and then removed by the fixing bath. The bleach also converts the silver in the yellow filter layer and the antihalation layer to silver salts. Inadequate bleaching, due to low-bromide or low-ferricyanide concentration, appears as a cloudy streakiness with dark red and magenta areas. The bleach is usually trouble-free as long as proper replenishment is maintained.

Fixing Bath

As the film enters the fixing bath, it contains the dye images and a large amount of silver salts. The purpose of the fixer is to remove most of the silver salts and convert the remaining salts into water soluble compounds, leaving the dye images intact. Inadequate fixing will leave traces of silver salts in the film which, on continued exposure to light, will photolyze to metallic silver, causing the final image to darken as it ages.

Final Wash

This particular wash serves to remove residual fixer, by-products of fixation, and any remaining small amount of water soluble silver compounds from the film. An inadequate final wash will give poor dye stability in the final imagery.

Stabilizer

The stabilizer solution hardens the emulsion and stabilizes the dye images. The stabilizer is an integral part of the process and is required for good dye stability. Since it is the last wet step in the process, it is important to keep the solution clean

and to replenish it adequately. A good practice is to dump and refill on weekends, or whenever there is evidence of dirt particles on, or in, the solution.

### Drying

The final processing step is to dry the film before it rolls up on the film takeup core. Drying is performed to remove excess moisture from the emulsion.

In Table 1, the normal temperatures, pH of each solution and some of the major components are included as a quick reference to process ME-4.

## PREPARATION OF COLOR PROCESS SOLUTIONS

The mixing and preparation of processing solutions is a major factor in determining the final quality of the photographic product. This is particularly true in processing color materials since more solutions are used than in normal black-and-white processing. Minor errors here can cause major discrepancies in the resultant color images. However, this is only one reason that the technician involved in the preparation of processing solutions must carefully observe all precautions and procedures relative to his task. The second reason for extreme care lies in the fact that many of the chemicals used in color processing present a potential hazard to the safety of those who handle them. The technician who allows himself to become careless in this area, then, is not only jeopardizing the quality of the final product but his own personal safety as well.

In consideration of product quality, the techniques used to mix photo solutions are in many cases just as important as the chemical ingredients used. Temperature, agitation, aeration, chemical order, and rate of addition can all affect the characteristics of the final mix. Once mixing is completed, measurements such as specific gravity and solution pH can be made to indicate possibility of improper preparation. In most cases, if no such indication appears in these tests, the mix can be assumed good.

In the area of chemical mixing, there are certain requirements common to all processes, particularly in the physical aspects of the laboratory. First, mixing should be accomplished in an area convenient to, but distinctly separate from, the processing area. Mixing areas should be well-lighted and MUST be well ventilated. Above all, the area MUST BE CLEAN. Chemical

TABLE #1. PROCESSING AND RELATED DATA FOR PROCESS ME-4

| PROCESSING STEP | pH | Temperature (°F) (°C) | Major Components | PURPOSE |
|---|---|---|---|---|
| 1. Prehardener | 4.85 | 95 ± 1 (35 ± .5) | HA-1 Formaldehyde | Hardens the emulsion to prepare for high temperature. |
| 2. Neutralizer | 5.10 | 95 ± 5 (35 ± 2.8) | NA-1 | Renders residual aldehydes inert. |
| 3. First Developer | 9.90 | 98 ± 1/2(36.7±.28) | Hydroquinone Phenidone | Converts exposed halides to metallic silver. |
| 4. First Stop Bath | 3.50 | 95 ± 5 (35 ± 2.8) | Acetic Acid Sodium Hydroxide | Lowers pH to stop development |
| 5. Wash | 7.0 | 100 ± 2 (37.8±1.1) | | Removes stop to prevent contamination of color developer |
| 6. Color Developer | 11.65 | 110±1 (43.3±.5) | RA-1 (TBAB) Benzyl Alcohol CD-3 | Reexposes film; Develops to a silver-plus-dye image |
| 7. Second Stop Bath | 3.50 | 95±5 (35±2.8) | Acetic Acid Sodium Hydroxide | Same as first stop |
| 8. Wash | 7.0 | 100±2 (37.8±1.1) | | Removes stop to prevent contamination of bleach. |
| 9. Bleach | 7.80 | 95±5 (35±2.8) | Potassium Ferricyanide | Converts metallic silver to silver halides. |
| 10. Fixer | 8.20 | 95±5 (35±2.8) | Sodium Thiosulfate Sodium Sulfite | Converts silver halides to water soluable complexes. |
| 11. Wash | 7.0 | 100±2 (37.8±1.1) | | Dissolves remaining silver salts. |
| 12. Stabilizer | 7.0 | 95+5 (35+2.8) -20 -11 | Formaldehyde | Stabilizes dye images. Promotes even drying. |

contamination can be disastrous when dealing with color processes. To aid in the prevention of contamination, rinse all mix tanks thoroughly with fresh hot water at least three times between mixes. If contaminated solutions are discovered, clean the mix tank, the replenisher storage tanks, the replenisher lines and filters, the processor tanks and recirculation systems and filters thoroughly before mixing fresh chemistry.

Handling Color Chemicals

Figure 2-1 illustrates some of the caution markings placed on chemical containers by a manufacturer. Be sure to abide by the warnings. They are not to be treated lightly. Some color processing chemicals may only produce an inflammation of the skin after prolonged exposure, but others can be quite dangerous if they are mishandled.

The best insurance against problems caused by chemicals is a laboratory and personal program of contact prevention. Many problems stem from the fact that fairly large quantities of hazardous liquids, solvents, and solids will be handled. Even in small quantities, some of these are hazardous. Some general precautions will follow. Each lab will have many additional handling precautions and procedures. One of the outstanding preventive measures is cleanliness.

HANDLING LIQUIDS AND SOLVENTS. Some of the major precautions in liquids and solvents handling are listed below. Remember, these are generalized statements and may not include specific measures established for every lab.

1. Keep working areas clean and free from spilled solutions.

2. Wear rubber gloves, protective clothing, and tight-fitting goggles--especially when handling large quantities of liquids or any hazardous liquids.

3. Always add acid or alkali to water, never water to acid or alkali.

4. Flush and dry the outside of acid bottles before opening them.

5. Take care in opening containers. Never leave them open.

6. Do not carry concentrated acids, alkalies, or irritants in open containers.

**PART**
**B**

**CAUTION:** May cause skin irritation. Avoid contact with skin. Avoid breathing dust. In case of contact, flush with plenty of water.

KP 57681

# PART
# E

**Contains Formaldehyde**

**WARNING!** Causes irritation of skin, eyes, nose, and throat. Avoid prolonged or repeated contact. Avoid prolonged breathing of vapor. Use with adequate ventilation. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes; for eyes, get medical attention.

## POISON

**ANTIDOTE:** Give a tablespoon of salt in a glass of warm water and repeat until vomit fluid is clear. Give milk or whites of eggs beaten with water. **CALL A PHYSICIAN.**

P 1101

**PART**
**C**

**Contains sodium bisulfate**

**CAUTION:** May cause skin irritation. Avoid contact with skin and eyes. In case of contact with eyes get medical attention.

KP 57878

**PART B**

**Contains sodium hydroxide**

**DANGER!** Causes severe burns to skin and eyes. Do not get in eyes, on skin, on clothing. Do not take internally. When handling, wear goggles or face shield.

**POISON**

**ANTIDOTE** External: In case of contact, immediately flush skin with plenty of water; for eyes, flush with plenty of water for at least 15 minutes and get medical attention. Internal: Do not use emetics. Give water with large amounts of diluted vinegar, lemon or orange juice. Follow with milk or whites of eggs beaten with water. **CALL A PHYSICIAN**

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Figure 2-1. Caution Markings

7. Store large hazardous liquid containers on or near the floor.

8. Store flammable solvents in approved containers and away from ignition sources. Store them at electrical ground potential by employing a grounding wire. Observe "no smoking" regulations.

9. Do not breathe (or contact vapor) from solvents such as formaldehyde, ethylene chloride, chloroform, and benzyl alcohol. Provide forced air ventilation as required--for example, over the tanks of processing machines or other areas where these vapors exist.

10. Never pipette small quantities of any hazardous liquids by mouth. Use a rubber bulb or aspirator pump.

11. Know the location of emergency body and eye showers and how and when to use them.

HANDLING SOLIDS. The principles of handling solids safely are basically the same as those of handling liquids and solvents safely. That is, avoid skin contact and inhalation. Keep chemicals off the skin, out of the eyes, out of the lungs, and out of the stomach. This is largely accomplished by means of personal protective measures, mechanical handling, proper storage and transport, use of ventilation hoods, and clothing/area cleanliness.

All bulk weighing and container-to-container transfer should be performed under a vented weighing hood so that chemical dust is removed before it can fall on clothing or be inhaled. Keep the area clean, wear gloves and goggles, and change clothing frequently. Clothing cuffs catch chemical dust and are the most frequent cause of difficulty.

IN CASE OF CHEMICAL CONTACT. Even if one is not directly involved with mixing up large quantities of color processing chemicals, there is still a good chance of contact with them. For example, when physically checking film tension by touching the film during processing, one may get some color developer, bleach, or stabilizer on the hands.

In case of any chemical coming in contact with the skin, the most effective treatment is immediately to flush the area with large amounts of running water for at least ten minutes. In addition, the affected area should be thoroughly washed with a neutral soap such as pHisoHex (available from Medical Supply) or Neutrogena. For any skin or eye burns, medical attention should be obtained as soon as possible. It is further recommended that persons who work around color chemicals regularly contact the Public Health Branch of the Flight Surgeon's

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Office so that their medical records may be flagged "Occupational Health Hazard." This will insure prompt medical treatment in case of a medical problem arising.

Seldom will normal contact with any of the process components result in any drastic or immediately disabling injury. In the majority of instances, no effects will be noted if sensible precautions are taken. Many chemicals, however, have cumulative effects. That is, it may build up in the system day after day and its effects appear gradually and unnoticed until it becomes serious. This is particularly true of many toxic chemicals which are absorbed into the bloodstream through the skin resulting in the same effects as if they were ingested or inhaled. By far the most common affliction among photographic workers is a skin inflammation or sensitivity brought about by chemicals.

DERMATITIS AND ITS AVOIDANCE. Color developers are especially active skin sensitizers and will cause dermatitis (skin inflammation) for practically all those who handle them carelessly. The formaldehyde in a stabilizing bath and the potassium ferricyanide in a bleach bath are also chemicals that cause dermatitis.

It is not known how much chemical contact is required to produce skin sensitivity. The amount will vary with different people. Therefore, avoid all contact as much as possible. When contact is made with the above solutions, wash as soon as possible. The following statements show the major factors leading to skin inflammation:

o Frequency and extent of skin contact are the most important causes.

o Concentrated forms of the chemical (or simultaneous contact with a number of chemicals) may hasten the effects.

o Duration of the contact will have a pronounced effect. The sooner the chemical is removed, the less the chance of developing dermatitis.

o A past history of dermatitis or chemical allergy should make one especially cautious of exposure.

o Previous injuries to the skin can accelerate the appearance of dermatitis.

Once again, the best cure for dermatitis is an effective prevention program. Learn to recognize the symptoms, if they appear. It is especially important to watch the hands and wrists. If any itching, burning, redness, or swelling occurs around the fingernails or between the fingers, see a doctor as soon as possible. Do not continue working and do not attempt treatment.

ME-4 Chemical Handling Precautions

PREHARDENER. The hardener agent HA-1 (Part A in the prehardener package) and succinaldehyde stock solutions are hazardous chemicals. HA-1, which is used to form succinaldehyde, is toxic. Succinaldehyde solutions are irritating to the skin and eyes. They are also allergenic. It is imperative to prevent contact by these chemicals with the skin and eyes and to avoid prolonged breathing of their vapors. In the event of contact with skin or eyes, immediately wash the solution away with large amounts of water.

When handling HA-1, use either an exhaust hood or some respiratory protection, such as an organic vapor mask. Always use protective clothing, rubber gloves, and safety goggles in the chemical mix room. The mix and processing rooms in which the chemicals are handled must always be well ventilated. To protect the mix and machine operators from succinaldehyde vapors, remember to keep the prehardener mix tank and the prehardener processing tank covered with exhaust hoods at all times.

NEUTRALIZER. The neutralizer solution contains hydroxylamine sulfate, a chemical known to cause skin irritation and sensitivity under conditions of repeated contact. Contact with the solution and solid chemicals should be avoided.

FIRST DEVELOPER. The first developer solution contains developing agents hydroquinone and phenidone which may cause skin reactions in some sensitive individuals.

STOP BATH. This solution contains acetic acid. Avoid contact with skin, eyes, and clothing.

COLOR DEVELOPER. The color developer solutions contain developing agent CD-3 which may cause skin irritations and chronic sensitivity upon repeated contact. One part of the mix contains tert-butylamine borane, a reversal agent commonly referred to as Kodak's RA-1 or T-BAB, which is a very toxic chemical. All contact with this chemical should be avoided. RA-1, solid or in solution, should not be allowed to come into contact with the skin, because it is readily absorbed through the skin. In case of contact, wash the area immediately with large quantities of water. Avoid breathing the dust created during the chemical mixing process. RA-1, either solid or in solution, slowly releases hydrogen gas. Therefore, always store RA-1 in polyethylene bottles, never in closed-glass containers. (Polyethylene is porous to hydrogen, and storing this agent in polethylene bottles prevents any pressure buildup.) Always store RA-1 and it's solutions in a cool, dry area away from any possible contact with acidic chemicals. Other constituents of the solution, notably benzyl alcohol and ethylenediamine sulfate, can cause eye damage on contact. Irritation of the respiratory

tract will be brought on by repeated exposure to fumes from this solution.

BLEACH. The bleach contains potassium ferricyanide which may cause dermatitis. Follow normal safety procedures in handling.

FIXER. The normal care due any solution of the ME-4 process should be exercised. Do not permit the solution to contact the eyes or skin, and flush well with water should contact occur.

STABILIZER. The stabilizer contains formaldehyde. Maximum care must be taken when mixing or handling this solution. Formaldehyde fumes will irritate respiratory tracts, and the solution may damage eyes or irritate skin if it comes in contact with either.

Mixing ME-4 Solutions

The chemical constituents of the ME-4 Process are provided in packaged units. All 10 solutions provided for the process are used as mixed. In all but two, the working solutions and replenisher solutions are identical. The two exceptions are the first developer and color developer solutions which are used when initially charging the processor from an inactive state. All solutions are provided in 26.5 gallon (100L) sizes except for the prehardener which comes in a 50L size.

GENERAL MIXING PROCEDURES. The following procedures should be followed when mixing chemistry in general.

1. Start with water at the right temperature and in the right quantity. The manufacturer has carefully determined the amount of water necessary to dissolve the ingredients; water too cold will not dissolve all chemicals while water too hot may destroy some characteristics of many of the constituents.

2. Add chemicals in the order specified. Some ingredients are included to increase solubility of other more photographically important chemicals. Added out of sequence, the latter may not dissolve completely.

3. Allow the recommended time between additions. This can be particularly important. In some cases, chemicals in the solution are formed by reaction during the mixing process. Chemicals added later in the mix stop the reaction after the proper amount of desired product has been formed. Allowing insufficient or overabundant time can cause too little or too much of such an ingredient to be formed.

4. It is just as important not to overmix a solution as it is not to undermix it. Time the mixing carefully as the manufacturer

directs.

5. A number of ingredients are highly subject to aerial oxidation. Usually this reaction is not too serious as long as the chemicals are in a dry state, but once they have ionized in solution, the reaction can take place easily. During mixing, avoid opening the recirculation valve fully as this can cause a vortex resulting in large amounts of air being trapped in the solution. Recirculation systems with faulty seals should be repaired so that the plumbing does not introduce air bubbles into the solution. Mix tanks using motor stirrers should have the mixing propellers far enough below the surface to avoid splashing and removed from the center enough to minimize oxidation.

ME-4 MIXING INSTRUCTIONS. When mixing ME-4 chemistry, follow the manufacturer's mixing instructions packaged in each kit. However, since mixing instructions are subject to change whenever changes in formulation or packaging occur, do not post specific instructions in the chemical mix room. Regardless of how familiar one becomes with the chemicals involved in the ME-4 process, it is essential always to refer to the mixing instructions supplied with the kit being used. When mixing the processing solutions, mix the entire unit. Because of the manner in which the chemicals are blended, a partial mix cannot be prepared.

## Certification of Mixed Solutions

The procedures used in certifying processing solutions are primarily designed to detect mixing errors, omissions, incomplete mixing, measurement errors, etc. These tests may or may not identify inaccuracies in some of the less critical chemicals. The best protection against such defects is to follow the formula directions conscientiously and use equipment that will provide the required degree of precision. The adoption and routine use of standard operating procedures and check lists are considered essential to quality assurance.

Certification tests consisting of specific gravity and pH, are performed after a solution has been brought to final volume at a specified temperature. The solution is then remixed and samples taken for certification tests. It is important that certification procedures be conducted at the same point in time with each batch in order that results will be consistant.

## QUESTIONS

DO NOT WRITE IN THIS SW - USE A SEPARATE SHEET OF PAPER.

1. What major step is included in color reversal processing that is not in the color negative process?

2. What are the basic solution steps of process ME-4, excluding the washing steps?

3. What is the primary difference between the ME-4 process and the EA-5 process?

4. What film is processed in EA-5 chemistry?

5. What are two improvements of the E-6 process over the E-4 process?

6. Which solutions of the ME-4 process can easily cause a density change?

7. Which four processing solutions have acidic pH's?

8. What principal chemical control is used in the color developer?

9. Which exhausted ME-4 solution causes a pink stain to form in the film's highlights?

10. What is the principal function of the color developer?

11. Why is it necessary to be very careful in controlling the pH of the bleach?

12. All contact should be avoided with which chemical in the color developer?

13. Why should the color developer's reversal agent, RA-1, be stored in a special type bottle?

14. What is the best insurance against problems caused by handling chemicals in a laboratory?

15. How can chemical contact be avoided?

16. What is the most effective treatment for skin contact with chemicals?

17. What protection can be taken from toxic vapors when mixing prehardener?

18. Why is ME-4 stabilizer hazardous to human health?

19. The ME-4 working solutions and replenisher solutions are all identical except for which two?

20. Why should mixing instructions for the ME-4 process never be posted in the chemical mix area?

PRACTICAL EXERCISES

EXERCISE I

PROCEDURES

List on a separate sheet of paper, the major processing steps that are required to process the following types of film:

1. Color negative

2. Color reversal

EXERCISE II

PROCEDURES

1. Listed below are some ME-4 processing components. On a separate sheet of paper list the components in proper sequence.

| | | |
|---|---|---|
| a. Bleach | e. First wash | i. Color developer |
| b. Final wash | f. Prehardener | j. Second wash |
| c. Stabilizer | g. Second stop | k. First stop |
| d. First developer | h. Neutralizer | l. Fixer |

2. The purposes of various ME-4 components are listed below. Explain the purpose of each component by matching with the processing steps in Procedure 1. Use a separate sheet of paper.

a. Keeps the first stop from contaminating the color developer.

b. Removes oxidized color developer from the film.

c. Reduces emulsion swelling to prevent physical damage.

d. Prohibits second stop from being carried over into the bleach.

e. Is required for good dye stability.

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f. Produces a black-and-white negative image.

g. Removes the yellow filter layer.

h. Halts the action of the first developer.

i. Forms harmless complexes with any aldehydes carried over from the prehardener.

j. Produces a positive silver-plus-dye image.

k. Removes residual fixer from the film.

l. Removes silver salts from the film.

## EXERCISE III

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Prepackaged ME-4 chemistry | As needed |
| Hydromixer | 2/class |
| Safety apparel | As needed |
| pH meter | 1/class |
| Hydrometer set | 1/class |

PROCEDURES

1. Ensure mixer cleanliness.

2. Wear safety apparel.

3. Following the manufacturer's instructions, mix chemistry as deemed necessary by the instructor. Observe all safety precautions.

4. Certify mixed solutions and transfer them to the appropriate storage tanks.

5. Clean the mixers and the chemical mix room.

Sciences Branch
Lowry AFB, Colorado

SW G 3ABR23330 001-VI-3
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# PROCESSOR OPERATION

## OBJECTIVES

Identify the functions of motion picture processors.

Identify and locate the major components, systems, and controls of the Colormaster Mark II processor.

Using a Colormaster Mark II processor and an operating checklist, startup, certify, and shutdown the processor IAW the checklist.

Make up previously exposed motion picture film and process on the Colormaster processor. Film must be free of processing defects.

## INTRODUCTION

When viewing a motion picture on the screen, one sees thousands of separate positive images being projected in rapid succession. Imagine how it would look if it were not processed to have equal quality throughout its entire length. The success of motion picture production depends on the accurate, consistent processing of the film shot by the cameraman. This is why it is important to learn as much as possible about the systems and techniques of motion picture processing. The following lesson is designed to present a firm knowledge of motion picture processing.

## INFORMATION

### MOTION PICTURE PROCESSORS

#### Black-and-White Processors

For the most part, the processing machines that process black-and-white motion picture films are similar to those used for black-and-white aerial films. The major difference is the manner in which the film is transported through the machine. In the aerial machines that have been used throughout this course, a bullet was attached to the film, fed into the processor, and retrieved at the other end of the machine. In the motion picture processors, however, it is not quite so simple. These machines use a loop method of transport. That is, the film travels in loops through the solutions, and these

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loops are always threaded with either film or a leader stock (very thick, nonreactive film material.) To process film, the exposed rawstock is spliced to the end of this leader and pulled through the machine. As the end of the film is about to enter the first tank, more leader is attached to keep all of the loops on the racks properly threaded.

The number and arrangement of tanks in the processing machine depends upon the specific model of processor and the purpose for which it is designed. For example, in a machine intended for original negative processing, the tanks are usually arranged to provide a developing solution, stop bath solutions, fixing bath solution, washing section, and a drying chamber. On the other hand, a machine designed specifically for processing black-and-white reversal film consists of tanks for development, stop bath, bleach, clearing bath, second developer, stop bath, fixing bath, wash, and a drying chamber. In addition to this, many styles of processing machines are designed so that their tanks can be rearranged, by changing solutions, to permit the machine to be used for processing both negative and positive material. Some machines use a series of bypass rollers to carry the film over a tank when the solution in that tank is not part of the specific process. This makes it unnecessary to dump one set of solutions and recharge with another set whenever changing from processing one type of material to another. But regardless of the tank arrangement of the processor, its function is to transport the film through the solutions so that the photographic developing process can take place.

In any processing system, one must consider the processing time, the temperature, and the rate of agitation of the processing solutions. In addition to these variables, one must control the recirculation of the solutions, replenishment, filtration, carry-over of solutions from one tank to another, and also film drying.

MACHINE SPEED. The time that the solutions are allowed to act on the film is determined by the speed at which the machine moves the sensitized material and by the length of film contained in the developing tank. In most machines, the travel speed of the film is given by an indicator which shows the length of film passing through the machine per minute. Thus, the length per minute of travel and the specific film length in a given section of the machine determine the development time, fixation time, washing time, and drying time. If the speed control knob is set to 10-feet per minute (fpm), a certain point on the material being processed will take 3 minutes to go from where it enters the

developing tank to where it leaves the developing tank if the tank contains 30 feet of film. Thus there is a correlation between the rate of travel, the tank capacity, and the developing time. The problem can be stated another way. If the tank contains 30 feet of film, the developing time at 10 fpm is 3 minutes.

$$\text{Developing Time} = \frac{\text{Length of film in dev. tank}}{\text{Machine Speed}}$$

TEMPERATURE. One of the most critical elements in the control of the photographic process is temperature. The speed of chemical reaction increases as the temperature of a solution is raised and decreases as the temperature is lowered. In machine processing, the temperature may vary, depending on the machine and the kind of processing being done. High-speed processing machines operate at quite high temperatures. In any event, temperature control is critical and must be maintained to close tolerances to produce correctly developed results.

AGITATION. If film is placed in the solution and is allowed to remain without any movement, only the solution that has soaked into the emulsion is doing any work. As development progresses, this solution soon becomes exhausted and ceases to work, and insufficient and uneven development results. If either the film or the solution is agitated (moved), fresh solution is brought into use, and development continues as planned. This movement of the film or solution is called agitation.

Automatic processing machines must agitate the film and/or the solution in some way during processing. In some cases the simple action of moving the material through the solution provides the only agitation. But this is somewhat unsatisfactory, since agitation tends to increase as the velocity of the material through the solution is increased. For critical work, the mere motion of the film through the solution does not provide either sufficient or proper agitation. More efficient methods have been adopted. Of the many devices used for providing accurate and controlled agitation in motion picture processing, the following are most often used:

- Gaseous burst agitation--provides intermittent bursts of some photographically inert gas (such as nitrogen) which is released from the bottom of the tanks and rises up through the processing solution.

- Tank turbulation or solution recirculation--provides rapid movement of large volumes of solution through the tank.

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o Jet or spray heads--often used inside of a tank to direct a stream of developer onto the surface of the emulsion. This system does not ordinarily retain a deep well of solution in the tank; instead, a series of spray heads directs the developing solution onto the film which is moving through the tank.

In many instances various combinations of the preceding agitation systems are used. For example, one commonly used processor employs both recirculation and submerged jets.

RECIRCULATION. Motion picture processing machines utilize large amounts of solutions. One of the purposes of a recirculation system is to provide filtration of the chemical solutions. This is done by installing filters into the recirculation line to remove dirt, solidified chemicals and emulsions bits that have stripped off of the film.

Recirculation aids in agitation by providing a constant flow of solution (usually in the developers) through turbulation bars on the bottom of the processing tanks. The motion of this solution up through the entire tank provides adequate agitation in most cases.

REPLENISHMENT. Motion picture processors employ replenishment systems similar to aerial processors. Replenisher formulas and the rate at which replenishers are added to a solution depend on the type of machine being used; the type and size of film being processed; the chemical formula of the original solution; and, to some extent, the temperature.

FILTRATION. Any motion picture processor employing replenishment and recirculation systems should also include some type of solution filtration device. Dirt particles can enter the system during film entry, solution recirculation, and replenishment. These particles must be continually and completely removed. In addition to dirt particles, chemical residue or even bits of processed material may enter the system and deposit themselves on the surface of the film being processed unless they are filtered out.

SOLUTION CARRYOVER. Usually, chemical carryover is minimized by the use of mechanical squeegees. Air squeegees are generally used at the end of each wash operation to prevent carryover of contaminated water to a subsequent wash and to remove surplus water before the film enters the drying cabinet. On some machines, air squeegees may be used between two tanks containing different processing solutions if the air impingement (i.e., the

high-pressure air striking the surface of the film caused by squeegee operation will not affect the efficiency of the solutions through oxidation.

In most systems, the air squeegee is simply a narrow slit through which a large volume of air passes under pressure. By forcing air against the surface of the film in this manner, most of the liquid being carried on the surface is blown back into the tank from which it came. All squeegees must operate properly if an accurate replenishment rate is to be maintained.

Any time that high-velocity air is being directed against a piece of film, as it is with air squeegees, make sure that the compressed air being supplied to the squeegee does not contain any dust, moisture, or oil. Therefore, the air supply must be filtered. A filter that can remove oil is especially desirable if the air compressor is oil-lubricated. (If there is a choice, use air compressors that do not require oil for lubrication.) Air filters provided with the machine should be cleaned or changed often enough to insure that completely clean, dry air is being delivered to the air squeegee.

DRYING. After the material is developed, fixed, and washed, it continues on through the machine into the drying cabinet, where the moisture is removed. It emerges from the cabinet in a dry condition and is spooled onto a reel.

Both the temperature and the relative humidity of the air supplied to the drying cabinet must be carefully controlled and adjusted for the speed at which the machine is operating. Newer motion picture processors usually have an impingement-type dryer using high air velocities directed against the surface of the film. Air impingement systems require precise control of temperature and humidity. Under ideal drying conditions, the drying cycle should yield film having a moisture content in equilibrium with air at about 50 percent relative humidity. The film is in equilibrium when it has no tendency to give up or to take on moisture from the air.

Differences Between Black-and-White and Color Processors

For the most part, black-and-white and color motion picture processing machines serve the same purpose. They take previously exposed film and by pulling it across a series of prethreaded rollers, deliver a perfectly developed final product. Either type of machine can be designed to process negative or reversal type materials. The major difference is the number of tanks,

temperatures and acceptable tolerances, and the overall extra complexity of the color machines. Due to the corrosive nature of some color chemistry, special steel alloys are required to contain these solutions. Because of this chemistry, more expensive, nonreactive staples are required when splicing the rolls of film together. The next section will discuss more in depth what specific differences exist when dealing with color processing machines that use ME-4 Color chemistry.

ME-4 Processing Design Considerations

Process ME-4 is very precise. The machines designed for it must meet very high and rigid standards.

The machine used for Process ME-4 should have a sufficient number of tank sections and racks for all of the solution and washing steps required. Also, the specified treatment times for each stage of the process should be posted. The processing times shown should be for normal operation for optimum quality. At the sacrifice of some picture quality, forced processing may be used to increase the effective film speed. This involves increasing the time and/or temperature of the first developer to obtain the speed increase desired. To provide for prolonged development, extra tanks are needed for the first developer.

The tanks and racks for all solutions except the bleach should be made of stainless steel. The bleach tanks and racks should be constructed of Hastelloy (a combination of titanium and Hastelloy) or of red brass to prevent corrosion and deterioration of the metal. It is feasible, of course, to use other materials for general construction if suitable linings are made from inert materials. Fiberglass, hard rubber, and polyvinyl chloride linings are widely used for color processing machines.

Black iron is suitable material for piping the first developer and color developer, and copper may be used for wash water lines; however, use stainless steel AISI Type 316 for the prehardener, neutralizer, and fixing bath lines. Lines for the bleach solution should be made of Hastelloy, red brass, or polyvinyl chloride; all of these resist corrosion from the ferricyanide solution.

An exhaust hood is needed over the prehardener tank to carry away aldehyde vapors. The hood should have an exhaust fan with sufficient capacity to remove these vapors effectively. A fan similar to one used in a home kitchen exhaust unit should be adequate.

The processing machine requires auxiliary equipment, such as

heat exchangers, temperature control devices, solution filters, flowmeters, recirculation pumps, valves, etc. To prevent solution carryover which might cause excessive chemical dilution or contamination, suitable squeegees are installed at specified locations on the machine. An oil-free air supply to operate squeegees and dryers is almost mandatory.

In the wash steps following the first stop bath, second stop bath, and fixing bath, the countercurrent flow method usually produces the most efficient washing. While a conventional drying cabinet can be used, an impingement dryer is the best choice where space is at a premium.

To increase the effective emulsion speed, (1) extend the first developer time, (2) raise the temperature, or (3) use a combination of both. To increase the effective film speed one camera stop, increase the development time approximately 1 minute or increase the temperature about 5.5°F (3°C). For a two-stop speed increase, increase the development time by about 2 minutes or alternatively increase the time by 1 minute and increase the temperature by 5.5°F (3°C).

To compensate for overexposure, reduce the effective film speed by shortening the development time or reduce the temperature, or both. All corrections should be based on the results of preliminary sensitometric tests obtained from a development time-and-temperature series.

## COLORMASTER MARK II PROCESSOR

The Colormaster Mark II Processor (darkroom loading) is the processor utilized in this course.

### General Description

The Colormaster Mark II Processor is a standard processor designed for rapid continuous processing of 16mm reversal color film. Normal operating speed is 57.5 feet per minute (17.4mpm). This processing speed meets the film manufacturer's tolerances for immersion times in all solutions, but can be adjusted over a wide range from approximately 10fpm to 100fpm (3 to 30.5mpm) to meet special requirements. Where individual tanks permit more than the required immersion times, the elevators can be operated in a partially raised position to reduce the immersed footage (and therefore the processing time) to the required value.

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The temperature control system for the Colormaster Mark II Processor has electrical immersion heaters under electronic control to maintain each solution within the required value. The tanks are built essentially of stainless steel. Metals that come in contact with the bleach solution are Hastelloy or titanium.

## Detailed Description

The processor consists of four major sections--load section, wet section, dryer section and takeup section. Refer to Tables 1 and 2 and Figures 3-1 and 3-2 while reading the following descriptions.

WET SECTION. The wet section consists of 12 tanks selected to meet the requirements and mounted on a common base frame. (See Figures 3-1 and 3-2.) The first five tanks are located in the darkroom, due to the reaction of light on the film. The remaining steps are conducted under normal room light.

FILM DRYER. The film dryer is an impingement type, in which heated and filtered air is directed against the emulsion surface of the film from perforated plenums. (See Figure 3-2.)

Table 1. Colormaster Mark II Configurations

| Figure 3-1 References | Section | Functions |
|---|---|---|
| 1 | LOAD SECTION | Darkroom areas where film is loaded on processor |
| 2 | START and STOP switch | Emergency START and STOP switch for darkroom operator |
| 3 | FEED FLANGES, two | Location of leader and/or unprocessed film prior to machine entry |
| 4 | LOAD ACCUMULATOR | A dry tank that supplies film to processor during running splice |
| 5 | MICRO SWITCH BRAKE | Activates FILM BRAKE holding film during running splice |
| 6 | PREHARDENER EXHAUST HOOD | Removes fumes from the prehardener tank |
| 7 | WET SECTION darkroom area | Consists of 5 tanks, Prehardener, neutralizer, first developer, first stop and first wash |

Table 2

| Figure 3-2 References | Section | Function |
|---|---|---|
| 1 | WET SECTION, light area | Seven wet tanks, color developer second stop bath, second wash, bleach, fix, final wash, and stabilizer |
| 2 | REPLENISHMENT FLOWRATE METERS | Regulates the flow of the replenishment solution to the chemical solution tanks |
| 3 | DRYER BOX | Dries film |
| 4 | ACCUMULATOR RACK | Receives film during takeup section change over. |
| 5 | TAKEUP SECTION | Winds processed film onto flanges |
| 6 | FLANGE TAKEUP switch | Operates upper or lower TAKEUP FLANGE |
| 7 | FILM BRAKE | Holds film during takeup section change over |
| 8 | FILM TRANSPORT | TRANSPORTS the film through the machine |

FILM TRANSPORT SYSTEM. The main drive motor is a variable speed direct current type with solid-state electronic speed control and a reduction gear. The main chain drive turns the top shafts of the processor through friction clutches, which can be adjusted to maintain proper tension on the film. Three (or two) film rollers on the top shaft are keyed to the shaft at the end that draws the film from the preceding tank. The other rollers on the top shaft and all the rollers on the lower shaft are idler rollers with ball bearings. The front film roller on the top shaft of the accumulator tank is the metering roller, which establishes the speed of the film movement.

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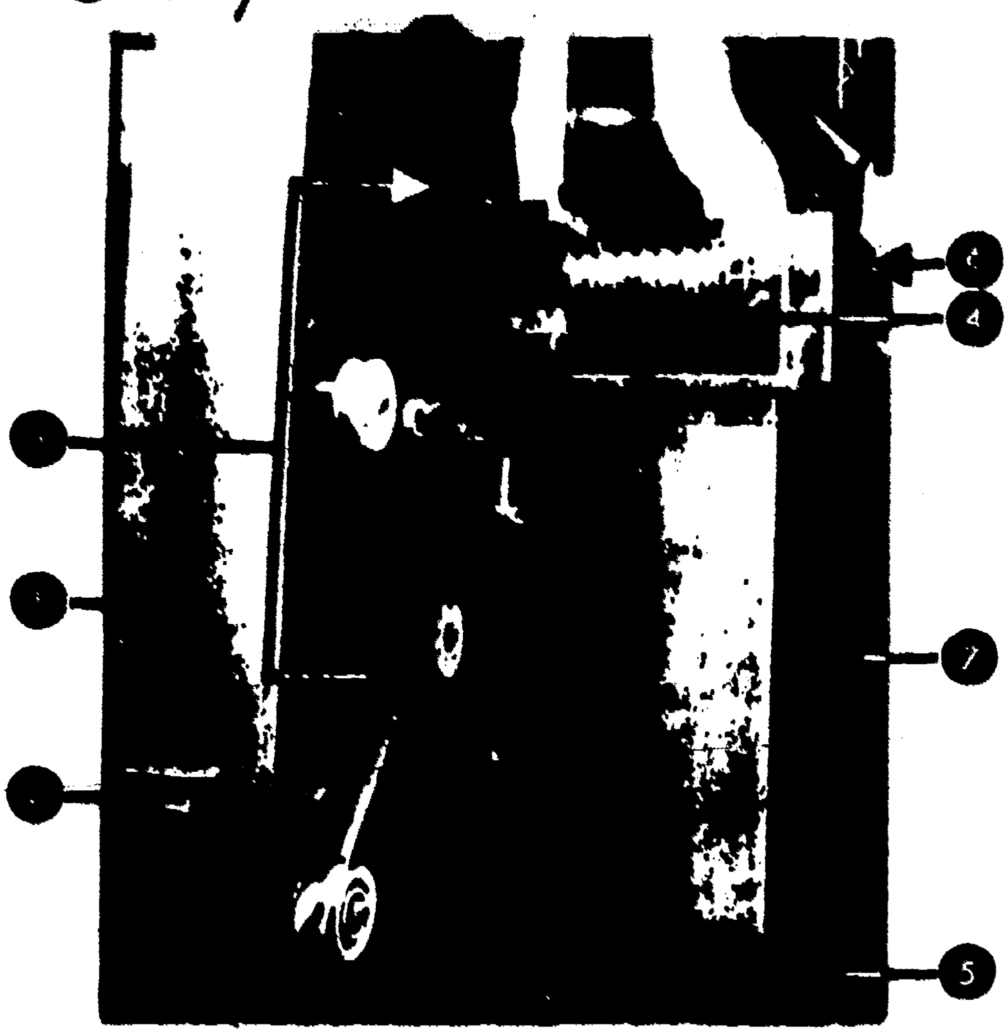


Figure 3-1. Colormaster Darkroom Sections

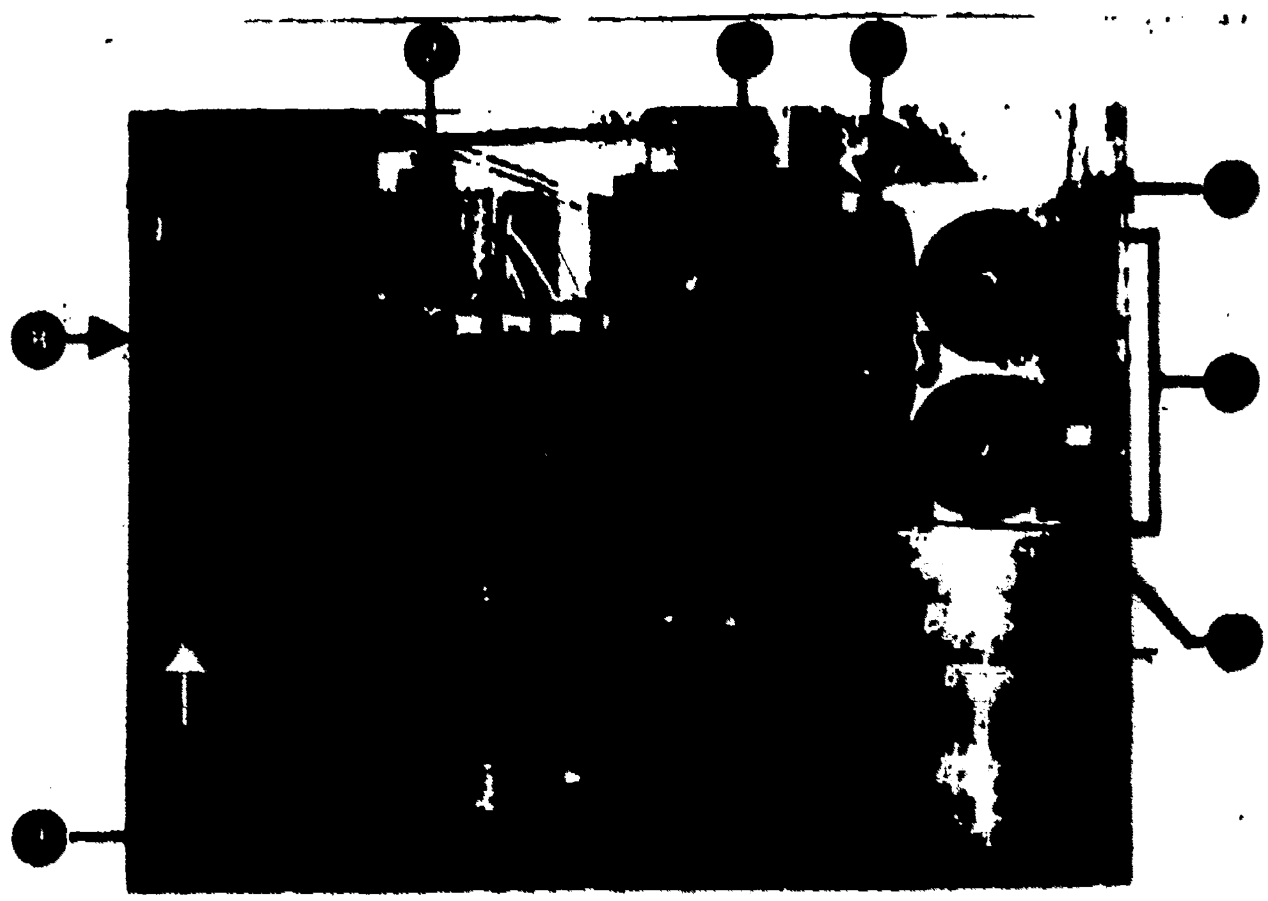

Figure 3-2. Colormaster Lightroom Sections

Table 3

| Figure 3-3 References | Control/Indicator | Function |
|---|---|---|
| 1 | TEMPERATURE CONTROL unit switches and recirculation pump indicators | These switches are used for turning the TEMPERATURE CONTROL unit on. (NOTE: The prehardener, first developer, and color developer switches also operate the recirculation pumps.) |
| 2 | HEAT SWITCHES and indicator lights for the first developer and color developer | These HEATER SWITCHES automatically come on when the temperature control switches are turned on. HIGH is used for decreasing the warmup time when the machine has been shutdown. LO is for normal processing after the chemicals have come to temperature |
| 3 | AUXILIARY | One switch turns on the air compressor. The other switch operates the replenishment pumps. |
| 4 | DRYER CONTROLS switches and thermostat knob | Blower switch, heater switch, and light switch, plus a thermostat knob used to control temperature to the dry box |
| 5 | TEMPERATURE SET/READ OUT DIAL, button and indicator STATION INDICATOR and solution | Multi-Point Indicator, makes available a TEMPERATURE READOUT immediately, also used to set the solution at the proper temperature |
| 6 | TRANSPORT/Start and Stop buttons/with indicator light | A START and STOP button to start or stop film transport |
| 7 | SPEED INDICATOR and SPEED CONTROL knob | INDICATOR shows FPM and SPEED CONTROL knob is used for increasing or decreasing FPM. |
| 8 | FOOTAGE indicator | FOOTAGE indicator counts footage of film processed |

All the other upper shafts are driven at a slightly higher speed causing the drive clutches to maintain tension on the film by the friction of the clutch. The lower shafts are mounted on elevators which can be raised with lifter rods for film threading or operated in a partically raised position to reduce immersed film footage.

TEMPERATURE CONTROL. Temperature control is accomplished for all chemical solutions except the stabilizer by using electrical immersion heaters. The heaters and coils are mounted in the solution tanks. An electronic sensing and control system actuates the heater circuits (and the refrigerant valves, if provided) as required to maintain the solutions within the temperature tolerances of the process. The temperature sensing probes are located in the recirculation lines for solutions having pumps, and in the tanks for the remaining solutions.

Wash water is temperature controlled with a thermostatic mixing valve that blends hot and cold water in the required proportions to produce the preset temperature.

FILTERING AND AGITATION. Recirculation pumps are provided for the prehardener, the first developer, and color developer. The remaining processing solutions are agitated with air bursts. A part of the solution being recirculated by the pump is passed through a replaceable cartridge filter to remove suspended matter. In the first developer and color developer tanks, the solutions are returned through turbulation bars to ensure a high rate of agitation near the emulsion surface.

OPERATING CONTROLS AND INDICATORS. All operating controls are grouped on the takeup section in thermostatically controlled sequence. Refer to Table 3 and figure 3-3.

## OPERATING INSTRUCTIONS

This section contains the operating instructions including the preliminary adjustments and control settings for the COLORMASTER MARK II processor.

### Preoperational Procedures

After the processor has been installed, connected to utilities, and checked out, the following preliminary procedures should be performed. Repeat after each relocation, major maintenance, or extended period of shutdown.

The processor is normally left threaded with film leader. If the leader has been removed, load a flange with leader and rethread the processor.

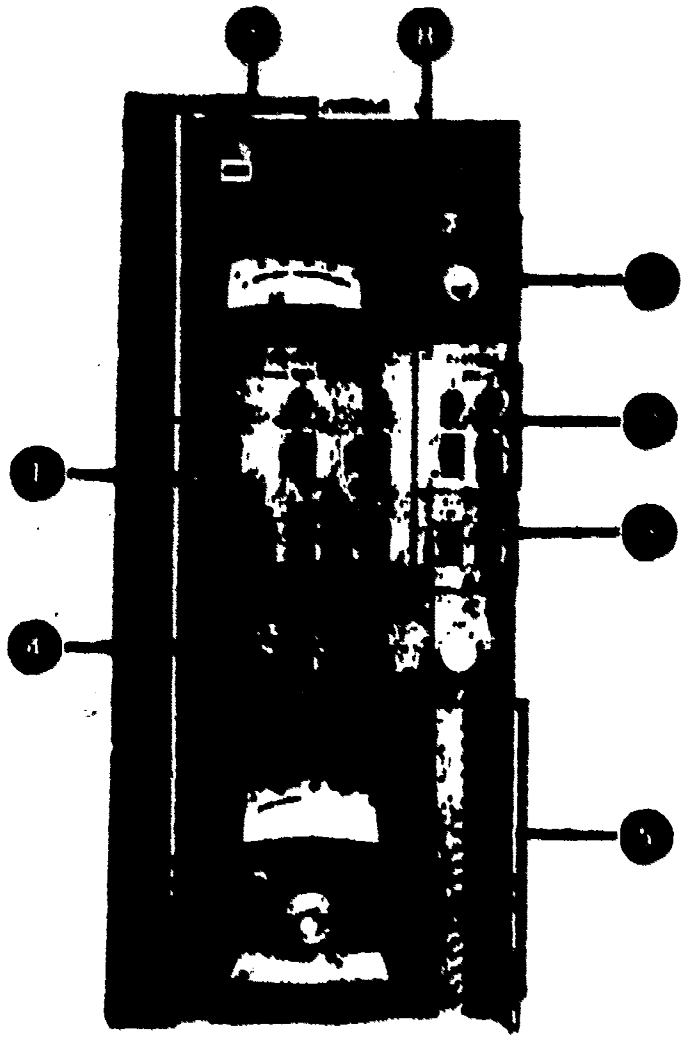

Figure 3-3. Colormaster Control Panel

NOTE: The processor should be threaded with leader at all times when not processing so that film to be processed need only be stapled to leader and processing can begin immediately. Leader should be stapled to the end of the film in the processor so that the processor is always ready to accept new film.

FILM LOADING PROCEDURES. The following procedures apply to the loading of light-sensitive materials under darkroom conditions. The procedures for loading machine leader are the same, except for the darkroom requirements.

In the darkroom, the film is placed on the left rewind: emulsion down, attached to a core on the right rewind, emulsion down, and wound across left to right. Then the core of film is placed on a processor flange.

THREADING THE PROCESSOR. The machine may be threaded with the tanks either full or empty (water or chemical solution). Only clean leader without bulky splices that might cause binding or damage to the rollers should be used. The threading procedures are as follows:

1. Install a roll of machine leader on the load flange.

2. Raise all tank elevators with lifter rods to the top position and secure with spring clips.

3. Start at load flange and thread leader through micro-brake switch.

4. Thread leader over accumulator rack guide roller, over top shaft roller of accumulator tank, and under first elevator roller. Hold elevator near top until all rollers are threaded.

5. Allow elevator to descend while holding leading end of leader.

6. Proceed threading top shafts and elevators and release lifter rods, allowing elevators to descend and accumulate a full bank of film.

7. Start and stop drive as required.

8. While threading leader, ensure leader is placed between all squeegees.

9. Proceed in same manner until all elevators are threaded. (A number of starts and stops will be necessary until experience in threading is acquired.)

INSTALLATION OF FILM OR LEADER AND SPLICING. To install a roll of film or leader and to splice it to the leader already in the processor, follow the steps listed below.

1. Place the roll of film in position on the loading flange. Slip the leading end of film onto film track and under film hold down and bring to the protruding pin. Do the same with the trailing end of the machine leader in the machine.

2. Pull mylar tape across; press tape to film; cut the tape and pull the tape and film from splicer. Seal tape on all edges and put one staple on splice overlap area.

3. Load film in the micro-switch of film brake, pull the film to release the brake and let accumulator rack lower slowly until rack is at the bottom of tank.

FILLING THE WASH TANKS. If the wash water has been drained, the procedures for filling the tanks is as follows:

NOTE: All drains and red capped valves should be closed.

1. Open and adjust water source valves so that the temperature-stabilized water level in the wash tanks remains constant at the level of the overflow opening in the overflow pipe.

2. When the tanks are filled to overflow level, adjust the shutoff valve for desired flow rate.

FILLING CHEMICAL SOLUTION TANK. If it is necessary to fill the chemical solution tanks, proceed as follows:

NOTE: All tank drains should be closed (red valves closed.)

The chemical solution tanks may be filled by pouring source pumping or gravity feeding the mixed or tempered solutions into their respective processing and replenisher tanks. The solution levels in the processing tanks will be kept up to overflow level. Replenishment chemicals should be as close to the required processing temperature as possible.

STABILIZING CHEMICAL SOLUTION TEMPERATURES. The processing solutions should be maintained at the temperatures recommended by the film manufacturer. Before processing film, the solution temperature should be checked at the thermometer on the control panel.

Startup

1. Before operating the processor, follow the checklist and check the following:

a. Processor is threaded correctly.

b. Solution tanks are filled to proper levels.

2. Turn on TEMPERATURE CONTROL for all solutions and ensure their operation.

3. Place the SOLUTION HEATERS for first developer and color developer on the HIGH position. When the developers reach their

operating temperature, place the SOLUTION HEATER switches in the LO position.

4. Turn on the wash water and adjust for desired overflow rate and temperature.

CAUTION: Excessive water pressure will cause wash water to splash over the tank partition walls. When the processor is running with leader, adjust water valves to prevent any splashing.

5. Activate the AIR COMPRESSOR MOTOR and ensure that the air squeegees are operating.

6. Ensure that drying compartment polishing drums are clean and then turn on the DRYER switch.

7. Ensure that the dryer blower, heater, and temperature controls are operating properly. If the dryer does not reach the proper temperature, adjust the DRYER TEMP control knob.

8. Ensure that the solution replenishment equipment is on and operating properly.

9. Attach a roll of machine leader to the processor.

10. In the TAKEUP SECTION, ensure that the machine leader is attached to a takeup flange and that the flange is activated.

Operation

1. Depress DRIVE START switch.

2. Observe processing speed on SPEED INDICATOR and adjust to 57.5 fpm (17.4mpm).

3. During subsequent processing, monitor the following:

a. Film transport speed.

NOTE: The film transport speed should be changed and monitored only while the machine drive is in operation.

b. Film loop tension (elevator position).

c. Solution temperatures.

d. Replenishment and recirculation flow rates.

e. Wash and rinse tanks overflow rates.

f. Squeegee air pressure and flow rates.

g. Dryer temperature.

h. Takeup tension.

## Certification Procedures

It should be recognized that among the various facilities in the Air Force that some differences exist as regards to machine design, machine speed, agitation rates, recirculation and replenishment systems, extent of carryover from one solution to the next, wash water rates, water pHs, etc. Therefore, no single set of recommendations can be given which will be applicable for all of these facilities. In each instance, therefore, a period of testing is required in order to arrive at the specific conditions necessary to obtain satisfactory results.

The ultimate goal is to produce color products whose quality level will satisfy the customer. This means that there should be no color shift in the finished product. Also there should be an adequate contrast and saturation; there should be detail in both important highlights and shadows; and the extreme highlights should be clean and bright. For these (and other) reasons it is customary to include a pictorial scene along with the sensitometric strip when establishing standards.

During the initial testing stage, one must obtain all pertinent data relative to the mechanical and chemical conditions of the process so that when the desired photographic quality has been obtained, the process can then be specified as completely as possible in these terms. Both sensitometric and picture tests should also be made, thus enabling one to include the film as well as the chemistry of the process in the complete specification. At later stages, when the process has been stabilized, it should be possible to hold the process in the proper control with the use of sensitometric tests and chemical checks such as pH and specific gravity.

Changes in time, temperature, agitation, composition of the processing solutions, etc. do not affect each layer of the film in exactly the same manner. It is never safe, therefore, to assume that an off-standard condition can be compensated for by a change

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in some other condition, and that some modifications in the process will yield satisfactory results for all emulsion batches of the same film. There are also more steps in processing a multilayer color film than for a black-and-white film, and each step must be carried out to a greater degree of precision and attention to detail than what is normally required in black-and-white processing.

Once the conditions have been established which are known to produce satisfactory results, there is left very little opportunity for modification of the process. Adequate control equipment and procedures are an absolute requisite if consistently high quality results are to be expected.

The control of the color process requires first a knowledge of the characteristics of the product and process, and the specific conditions which are required to obtain the desired results. Also, there must be a means for continuous evaluation of the process to see that the status of the process remains unchanged and to insure that the characteristics in the finished product are being maintained. If changes do occur, then a means for diagnosing the difficulty and locating the cause must be available. Finally, the proper corrective action must be taken to restore the process to its original condition.

A process control system has three essential parts: mechanical, chemical, and sensitometric. All three are important, but photographic control will receive the greatest emphasis here because it provides the best index to the quality of the total system.

MECHANICAL CONTROL. Solution times, replenisher flow rates, solution temperatures, and recirculation rates should be checked periodically and proper adjustments should be made, if necessary. The actual readings and any adjustment should be recorded on the process control chart to aid in the interpretation of any process fluctuations. This control chart will be described in the section on sensitometric control.

The machine speed must be checked daily to insure that the film spends the proper time in each solution. This check should be made with a tachometer on one of the drive rollers, or as an alternative, make a mark on a piece of leader and measure the time in each solution with a stop watch.

Replenisher rates must be regulated to keep the activity of the various solutions at the correct level. The settings on the flowmeters for replenishers should be checked every hour as a minimum. Because of the carryover from one solution to another,

the replenisher should be turned on at any time there is material passing through a given solution. There should be one setting for leader, and a different (higher) setting for film. The flowmeter should be turned on when the last material leaves the tank. A sure way of losing process control is to take the "lazy man's" way out and turn all replenisher flowmeters on at one time and turn them all off simultaneously.

The setting on the flowmeter should be checked once a month by measuring the flow by means of a graduated cylinder and a stop watch. Disconnect the replenisher line at a convenient place between the flowmeter and the machine. With the replenisher running and the flowmeter set at the recommended value, collect the solution in the graduated cylinder. Measure the volume of solution collected in 30 or 60 seconds. Compare this volume with the recommended volume. If the correct volume does not agree within 5% of this recommended volume, run a second check. If agreement is not obtained, clean the flowmeter and then recheck the rate. If the correct volume is not delivered in the specified time, then recalibrate the flowmeter by measuring the flow at four different settings above the desired flow. Plot the volumes obtained against the corresponding meter settings. Connect the points with the best fit smooth curve. Use this curve to determine the proper flowmeter setting to give the desired volume flow.

Check the solution temperatures at least every half hour. The thermometers built into the machine are adequate to determine if any major drift has occurred. In addition, the temperature of the prehardener, first developer, and color developer should be checked with a high caliber thermometer before each batch of film is run.

Check the filtration system for proper operation. Processing solutions and wash waters usually contain some incoluble material. If this material is not removed, it will stick to the film, rollers, etc. Change the prehardener filter every 15 days and the rest of the filters monthly.

The processor should be mechanically certified prior to processing production film. This certification will consist of a scratch test and functional checks.

CHEMICAL CONTROL. Chemical control for the color process depends upon proper mixing procedures and the use of prepackaged chemicals. The pH and sp. gr. of all the chemicals, except the stabilizer, should be checked daily.

Because solution volumes in the processor are small, elaborate chemical analysis to evaluate each solution would be too time consuming and costly. It is more practical to replace any solution suspected of contamination or deterioration. However, if proper attention is given to mixing and using replenishers, and to avoiding dirt or chemical contamination, the working solutions can last almost indefinitely. As a practical matter, the working solutions are changed whenever a major cleanup of the processor is performed. Even then, the color developer and bleach could be transferred to a holding tank to be reused after cleaning because of their high water pollution properties.

SENSITOMETRIC CONTROL. The photographic quality of the processed film is the final test as to whether or not a photographic system is operating satisfactorily. Therefore, the best means of quality control is to process photographic control strips in advance of and with the original film. A rapid and accurate means of evaluating the process photographically is provided by the use of these sensitometric strips.

In using sensitometry for process control, there are certain assumptions which must be made. It will be well to discuss those briefly before proceeding with the details on the evaluating of the sensitometric strips.

It must first be assumed that all sensitometric strips have identical exposure. Since most labs use the preexposed control strips provided by Eastman Kodak, this assumption is reasonably valid.

It is further assumed that the film is uniform throughout the length of a roll. This is a valid assumption as long as only a single cut number of one emulsion number of raw stock is used for making strips. When the supply of the particular cut and emulsion number of film used for strips has been depleted and a new one must be used, it will be necessary to revise the photographic standards to allow for possible differences between the batches.

The assumption that the film is stable with time is somewhat dangerous. Under ordinary conditions of temperature and humidity, film is not precisely constant, and as it ages, many of its characteristics change. In addition, after it has been exposed, the latent image changes with time. Fortunately, such changes can be greatly minimized by storing the film in taped cans at temperatures of 0°F. (-18°C), or lower, prior to processing.

Preexposed control strips are supplied in 100-foot (30.5m) rolls, 16mm wide, by Eastman Kodak. There is a complete control strip every 9 1/2 inches (24.1cm), and each strip has an 11-step gray scale and three color patches (cyan, yellow, and magenta.) Each roll contains approximately 120 control strips. Notches between strips indicate where to cut them apart. To use, pull out 18 inches (45.8cm) and cut to insure having a complete sensitometric strip. Each package of control strips also includes a reference strip for each of the two process cycles recommended for each of the films in the data sheet section.

The procedure for using these control strips is given below:

1. Store at 0° F. (-18°C) or below.

2. Before processing, bring strips to room temperature before opening the can. Allow a minimum of one hour for this purpose.

3. Handle the control strips in complete darkness when the strips are outside of the light protective container.

4. Remove only a sufficient number of strips for a day's use from the roll and place them in a separate container. Return bulk roll to the freezer.

5. Run a control strip along with the scratch test, and one along with a run of film. If the run is to exceed an hour, run a strip at one-hour intervals.

Some processing laboratories utilize a checklist to insure that all variables are controlled. Figure 3-4 illustrates a typical checklist. Mechanical, chemical, and sensitometric conditions must be ideal before any film is processed on the machine. At some large laboratories the checklist must be completed by both a processor and a member of the quality assurance (quality control) section. This provides a double check and results in increased productivity.

CONTROL CHART REFERENCE READINGS. Since it is assumed that most organizations will be using the preprinted Kodak Control Strips, the discussion in this section will be limited to their use. The reference Control Strip that is included in the roll of Process Control strips is read at steps 1, 4, 7, and 11 through the red, green, and blue filters in the densitometer. This operation is repeated at least twice a day for several days. Then, the average value for each set of densities is obtained. If there are more than one box of control strips of the same code number,

MACHINE CERTIFICATION

| 1 PER ORIGINAL RUN | 1 PER DAY ON PRINT |
|---|---|

| MACH # | DATE | TIME |
|---|---|---|
| ORIG. WO # | | |

| CHECK LIST BEFORE RUNNING | Q.C. | PROC. |
|---|---|---|
| SOLUTION TEMP | | |
| REPLENISHMENT RATES | | |
| LEVEL OF TANKS | | |
| WATER ON (RATES) | | |
| WATER TEMP | | |
| THREAD UP (SKIPS & TWISTS) | | |
| REPLENISHER SUPPLY | | |
| CONTROL STRIP OK | | |
| SCRATCH TEST OK | | |
| DRYER OK | | |
| SOLUTION pH | | |
| BUFFER OK | | |
| AIR ON - SHORT STOP | | |
| CHECK LIST WHILE RUNNING | | |
| MACHINE SPEED (ORIG FPM) | | |
| SOLUTION & WATER TEMPS | | |
| REPLENISHER RATES | | |
| DRYER TEMP | | |
| CONTROL STRIP FREQUENCY | | |

REMARKS

| QC CERTIFIER | PROCESSING CERTIFIER |
|---|---|
| | |

Figure 3-4. Machine Certification Checklist

remove the reference strip from each box and read their density values as if they had been taken from one reference strip only.

Theoretically, all correctly processed control strips should be identical to the reference strip and should plot on the reference (0) lines. Recall from an earlier block that there exists certain inherent variability in any process which cannot be eliminated. It should be noted, though, that the nearer the control strips plot to each reference line, and the smaller the color balance spread, the better the quality of the process.

When a control strip plots outside the tolerance limits for either density or color balance, or when a series of control strips plot near a tolerance limit even though the control strips are within the limit, immediately investigation should be made to determine the cause.

1. Examine the control strip for physical defects, such as fingerprints, scratches, fog, etc.

2. Compare the factory code number of the Kodak control strip with that of the reference strip used to determine the reference readings.

3. Reread the control strip to eliminate measuring error as a possible cause of the out-of-control plot.

4. Process, read, and plot another process control strip.

a. If this strip plots within tolerance limits, the previous control strip may have been handled incorrectly before or during processing. Also additive conditions may have been the cause of the out-of-control plot. When this is the case, it is very possible that the process is drifting toward an out-of-control condition. Therefore, it is advisable to process additional strips in order to confirm whether or not the process is approaching an out-of-control condition.

b. If the out-of-control condition is confirmed by the plot of additional control strip(s), quality assurance will determine corrective action to be taken.

Shutdown

Procedures are as follows:

1. Splice on sufficient leader to thread the entire processor.

2. When the leader reaches the takeup section, and the tail of the leader is about to enter the first tank, stop the machine drive.

3. For extended shutdown, turn off turbulation/recirculation pumps, temperature controls and main power. For temporary shutdown, keep temperature controls and pumps operating.

CAUTION: Film splice staples will deteriorate in the fixer and bleach solutions during extended shutdown.

4. Shut off wash water and air compressor.

5. If shutdown is for a long period, drain water from wash tanks and rinse tanks.

6. Shut off the dryer heat and allow dryer blower to run four minutes to cool the dryer and the heater elements, and then shut off.

7. Clean all areas of the processor thoroughly, inside and out. Clean the processing work area.

8. For weekly shutdown, drain the wash and stabilizer tanks.

Before processing after a lengthy shutdown, check and clean processor thoroughly, especially film rollers and all other points which come in contact with film.

CAUTION: To prevent damage to the pumps and solution heaters, DO NOT OPERATE unless the processor tanks contain solution.

Preventive Maintenance

A good preventive maintenance program will not eliminate all processing problems, but it will keep them to a minimum. The goal of preventive maintenance is to eliminate problems before film is processed on the machine.

DAILY MAINTENANCE. Each of the following types of maintenance is to be performed daily as a minimum.

1. Each rack must be checked both by the operator and at regularly scheduled intervals (usually monthly) by qualified maintenance personnel. Each roller must turn either by turning

the drive shaft or by spinning them with the fingers. Also, any chemical buildup must be removed.

2. The squeegees must be cleaned and changed when necessary.

3. The sock that acts as a backup roller in the dry box must be checked and changed regularly.

4. The final phase of preventative maintenance is that of corrosion control. Since the chemistry that is used in process ME-4 is strong, even stainless steel is not immune to corrosion. To prevent the steel from deteriorating, the entire machine must be cleaned after each use. The chemistry that has splashed out of the tanks should not remain on the machine any longer than necessary. This is especially true of the bleach. The bleach will corrode stainless steel but only the bleach tank is constructed of hastelloy or titanium, not the surrounding surfaces.

5. Besides wiping the machine with water and mild detergent, a rust inhibitor can be applied to prevent future splashed chemicals from immediately contacting the steel surface.

WEEKLY AND MONTHLY MAINTENANCE. For a more detailed listing of preventative maintenance, to include weekly and monthly checks, see T.O. 10E5-2-17-1.

## PROCESSING MOTION PICTURE FILM

### Film Makeup

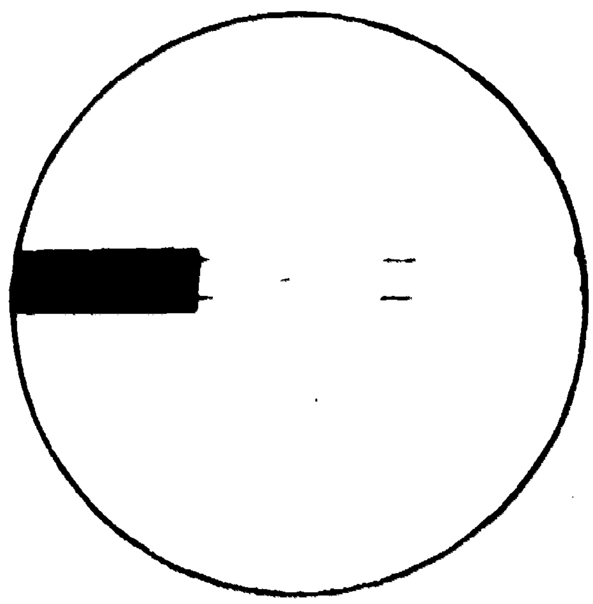
Upon receipt of film in the processing section, work orders and film can labels should contain all information regarding material size, type, speed rating, and any special handling instructions. You should check the work orders received against the film containers. Information contained on the work orders and film can labels will be compared for accuracy and consistency.

The film containers will be sorted into groups according to process required. At this time, you will begin makeup. Carefully sort through the cans, checking each one for film type, speed rating, processing time, or any special process instructions. If there is any doubt about any of the information listed, resolve the problem before any further makeup. Depending on the emulsion of an organization, you may have to further sort out the material to be processed according to security classification.

Generally, separate rooms are equipped for makeup according to the film sizes handled by a laboratory. This is a darkroom equipped

with the necessary tools such as a table, rewinds, splicer, etc. All like film materials are placed on one reel in this room by splicing separate lengths together. It should be noted that when making any type of splice, the edges of both films must be in alignment. Otherwise the film can ride up and over rollers or jump off sprockets, resulting in considerable damage or loss of product.

When splicing the film together, overlap the ends of the films about 1 1/2 inches (3.8cm) and secure them with a splice consisting of five staples. Figure 3-5 illustrates the 5-staple splice, known as the 2-1-2 splice. In making the splice, place the trailing end of the film on the windup spool over the leading end of the film on the camera spool. As the film comes off of the spool and goes into the processor, the leading edge of the splice will then be on top, allowing it to pass over the outside of the rollers during processing. This lessens the chances of splice damage or breakage.



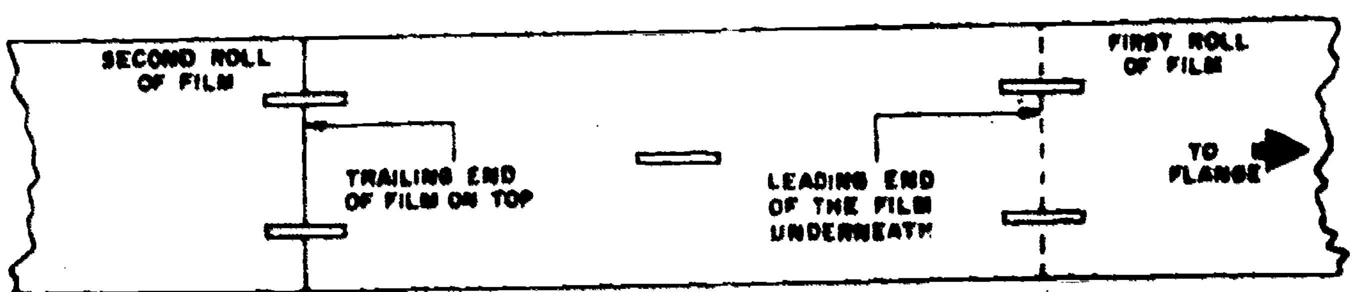



Figure 3-5. The 5-Staple (2-1-2) Film Splice

NOTE: Staples should hold leading edge of splice down firmly so that it cannot curl back. Use stainless steel staples for splicing leader. (Other staples may deteriorate rapidly.)

The handiest stapler to use in the splicing operation is the plier-type stapler. This is shaped like a pair of pliers with the stapling end in the nose portion. To make the splice, position the split nose of the stapler over the film where the staple is to be placed. Then squeeze the handles of the stapler firmly together as far as they will go. After putting the staple in place, check to make sure that it is not bent or broken. Any sharp ends can catch against a roller and tear the film.

During the makeup process, it is desirable to identify each roll of film placed on a single reel. Such identification is usually punched at one end of the roll. This can be done with a hand punch or with a special film perforator, using a locally devised coding system.

During the makeup process, the ends of the film that are to be joined will be squared off before splicing. The splice of film snipped off should be fastened to the outside of the empty original film can with tape. This sample is inspected after the lights are turned on to insure that the film type is as specified on the film can label.

To avoid breaks and failures during processing, the film must be inspected for nicks, torn perforations, creases, or other damage. This inspection can be made by running the film between the thumb and fingers, lightly holding it by the edges, and winding it slowly enough to detect any damage. The first 3 or 4 feet (0.9 - 1.2m) are inspected by holding the extreme end of the film in the right hand and running the left hand along the film edges. This provides enough inspected film to start on the takeup core of the rewind.

If a roll of film is found to contain damaged footage, it is generally returned to its original container, later repaired, and processed separately. If the damage is slight, the damaged area may be backed (not on the emulsion side) with leader to prevent processing trouble and further damage to the rest of the film. If the damage is severe, other methods must be devised, depending on the kind of damage.

After makeup is complete, the film is wrapped in black paper placed in a film can and the can is then sealed with tape before the lights are turned on. The samples of film taped to the outside of the individual cans are checked to insure that they are of the indicated emulsion. At this time, complete the makeup slip, showing all pertinent information regarding the film contained in the film can. The film is now ready for processing. In some cases, it may be necessary to transfer it to a magazine before processing. On some processing machines, it is possible to use the reel as a machine supply if the loading end of the machine is in a darkroom status.

Load Section Change Over

If the processor is prethreaded with leader, it is necessary to splice the rawstock to the leader. Just before the end of the rawstock enters the processor, more leader must be attached to the film in order that the machine may always be threaded.

These change overs are made in total darkness and most are made during processor operation. The initial change over may be made before the main drive is started. All other change overs require running splices--splices made while the film is being processed. During a running splice, the load accumulator rack supplies film to the processor. When the accumulator becomes empty, many machines will automatically stop.

When the film or leader flange feeding into the processor is nearly empty, an alarm will sound. When the low-film alarm sounds, stand by to change to the next roll of film or leader as follows:

1. When all film or leader has been drawn from the flange (as indicated by the MICRO-BRAKE switch activation) place trailing end of the machine leader onto the film splicer (darkroom condition).

2. Place the leading end of the film mounted on flange onto the trailing end of the film already in the processor and make the splice.

3. After the splice is made and checked for accuracy, thread the film through the micro-switch of the film brake and release the brake. Allow the film to feed into the machine lowering the accumulator rack.

Takeup Section Change Over

When the takeup flange is full, make a change over as follows:

CAUTION: Always cut film at a splice for takeup change over to avoid cutting a scene.

1. Have an empty takeup flange ready.

2. When the takeup flange is nearly full, check the film inside the dryer for the location of the next splice.

3. If possible, allow the splice and about 5 feet (1.5m) of film to pass, put on the film hand brake, and then cut the film at the splice.

4. Shut off the flange takeup switch.

5. Attach the film to the empty flange, wrapping it around the core four or five times. Release the film hand brake and turn on the flange takeup switch. NOTE: If the takeup section accumulator rack is allowed to ascend rapidly, it may cause a break in the film.

6. Remove the roll of film and place an empty core on the flange.

Systems Monitoring

In order to keep the color process within control limits (necessary to obtain repeatable results), a series of checks are required throughout the process. The replenishment system needs very close monitoring to maintain solution levels and solution strength. When film is entering a solution, the film rate of replenishment is required. When the leader is entering the solution, a lower rate (leader rate) is required since the only compensation necessary is that due to solution carryover.

Recirculation must be monitored because a lack of recirculation will cause uneven hardening, uneven development, and therefore the process will begin to move out of control. An excessive amount of recirculation will cause oxidation and deterioration of the developers, and air bubbles in the prehardener will cause uneven hardening. A third item that requires the close eye of the operator is the sensitometric properties of the entire system. This is performed by running a sensitometric strip after each hour of film processing.

Processor Malfunctions

When first turning on the color processor for a production run, quickly monitor all machine functions. Depending upon machine speed, there is a short time to do this before the film enters the first solution tank. The safe time is while the loading (accumulator) tank is being filled. If anything is wrong, the machine can be shutdown without causing any damage to the film since processing has not yet started.

Processing machines are reliable devices, and seldom will there be an operational failure with them. Remember, however, this reliability is dependent upon regular maintenance. Each machine has its own maintenance record. While this will be performed by maintenance personnel, it is advisable to inspect the records before placing a machine into service. Do not process

film until the appropriate maintenance has been performed.

An outstanding cause of machine failure is often a power outage. Even this should not pose an insurmountable problem. An operational unit processing important film will more than likely have a standby gasoline-powered electrical generator. Be familiar with the system used in the event of such an emergency.

Other than the above, the most common emergencies will be caused by film jamming in the processor or by a break in the film. Film breaks are held to a minimum by proper makeup inspection and the making of good solid splices. However, breaks can still occur.

Film breaks most often occur due to excessive tension building up on the film or torn perforations. When this occurs, stop the film drive. Locate the broken film area and keep the film loss to a minimum. Splice the film ends together and allow the film that is already in the machine to pass all the way through to the takeup area. Then check the racks to determine the cause of the failure.

A machine will normally give a warning that a break is about to occur. On most large machines with stationary bottom racks, as the film tightens the tops of the racks begin to jump out of the tanks. The only solution is to stop processing and correct the problem.

On the smaller machines, such as the Colormaster Mark II, excessive tension may cause the lower racks to rise. This in turn causes the elevator rods to rise. To eliminate this condition temporarily, loosen the clutch on the following rack. If excessive slack builds up in a tank, tighten the clutch on the following rack.

Film breaks will occur. Only experience will keep film loss to a minimum. Careful preinspection will eliminate most torn perforations. This will eliminate most breaks.

Post Inspection

After processing motion picture film, the film must be inspected for exposure, processing and physical defects. These include (but are not limited to): scratches, over and under exposure, blurred images, stains, reticulation, and improper color balance.

One of the most common methods of post inspection is to visually inspect the film on an inspection table with a diffused light source.

This allows the operator to stop at any point and take a closer look at any defects. This method is really the only acceptable way of inspecting film prior to printing. . .

Because the film processed for this course will not be printed, a faster, simpler method of post inspection is employed. Simply project the film onto a movie screen. Since the film is color reversal, the projected image should closely resemble the original subject in density and color balance. There should be no streaks on the image (caused by scratches) and there should not be any apparent color stains. Before the film can be projected, all of the small rolls of film must be spliced into larger rolls.

SPLICING. Before any film can be spliced, there are certain preparations which must be made in order to make a satisfactory weld. From your previous training you may recall that motion picture film is madeup of several layers of material, and these are:

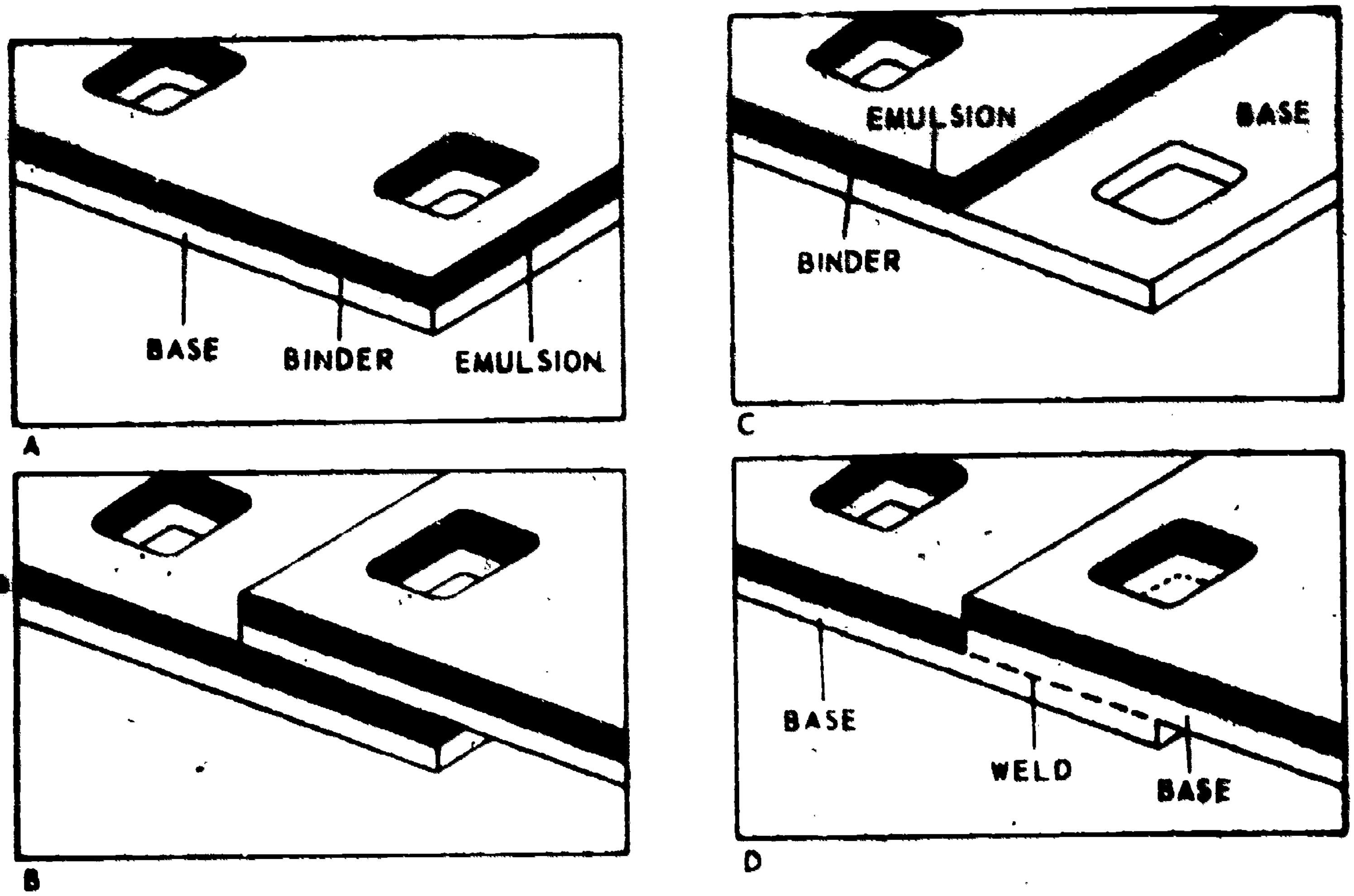
1. A flexible film base which provides a durable but strong support.

2. The emulsion layer, consisting mainly of gelatin in which are suspended the silver halides or dye that forms the photographic image, a layer called the binder which is microscopic in thickness but which binds the emulsion and base tightly together.

The structure of a section of motion picture film is illustrated in Figure 3-6(A). From this, we should begin to see why it is necessary for our preparation to include the removal of the emulsion and binder layers in order to make a satisfactory weld. It is difficult, if not impossible, to cement the base side of one film to the emulsion side of another film (B). Even though the emulsion and binder layers are extremely thin, they must still be removed (C), in order for the cement to dissolve the two overlapping areas and make a strong weld as illustrated in (D).

When splicing manual cleaning with a clean cloth dampened with alcohol or the "cement wipe" technique may be necessary. This technique is very effective in removing the thin protective coating applied to some film bases and leader material. Apply only enough film cement to the film base to cover the overlap area normally covered by the splice, and wipe off the cement immediately with a soft, clean cloth or your gloves. Do not use abrasives of any kind on the base of a film because of the danger of spreading grit throughout the roll and scratching the film.

Film is always placed in a splicing machine with the dull or emulsion side facing up. This orientation will allow you to scrape off the emulsion and binding layers readily and reach the film base. If the scraper of the splicing machine is properly aligned and its depth of cut is correct, then only one pass over the film is needed. After both ends of the film have been prepared, apply film cement to the overlap area and bring both ends in contact. If the splicer you use has means to bring pressure on the splice, wipe off any excess cement that may be squeezed out of the weld and wait until a good weld is formed. This is important because if the excess cement is allowed to remain and the film is rewound, the cement will adhere to the base of the




A. Layers of the Film
B. Unsatisfactory Splice or Weld
C. Film Ends Properly Prepared for Splicing
D. A Proper Splice or Weld

Figure 3-6. Structure of Motion Picture Film

film immediately above the splice, which then becomes distorted or "cockled." Films stored under poor humidity conditions, old films that have a pronounced curl, or those that have been wound onto reels which have a very small diameter hub are very difficult to splice because they have an excessive curl. Films such as these may be held under pressure in the splicer for thirty seconds or more to allow the splice to develop more strength. After making the splice, it is advisable to rub the splice area with a soft cloth wrapped around your finger for added assurance of a better weld.

Once any splice is made, do not put any unnecessary strain on

the film after removing it from the splicing machine. Do not test the splice by pulling the film or snapping. The film cement should be. allowed to dry and "set" properly; this usually takes about 20 to 30 seconds in the machine. After this interval, the film can be removed from the splicer and wound onto its reel at normal tension. The strength of the splice increases over a period of hours so that if the film is to be subjected to tensions, such as those incurred on film-cleaning machines, projectors, or printing machines, you should make the necessary splices at least 2 to 4 hours before its use. After the splice is made, you should examine it for quality. This takes only a second, since a visual inspection is all that is needed. Examine the spliced film by looking through its base side. A good splice will appear transparent, whereas a poor splice will appear to have hazy areas, and bubbles can be seen throughout the overlap area.

CAUSES OF POOR SPLICES. As we stated earlier, splicing operations are not complicated, and as your proficiency in the use of a splicer increases, most--if not all--of the splices you make will be satisfactory welds. On the other hand, you should know why some splices fail to hold so that you can avoid the cause for failure in future splicing operations.

Incomplete Removal of the Emulsion or Binder Layers. When any emulsion or binder remains on the base in the overlap area, the film cement will not stick, and thus a good weld cannot be made. As bad as incomplete emulsion and binder removal is, too much or too deep a cut is also the cause for poor welds. The splicer that we will discuss later requires only a single pass over the film to prepare the overlap area for cementing. Therefore, excessive scraping of the film base under the binder layer tends to weaken the remaining base layer and may cause the film to break.

Time Delays. There must not be too great a delay in bringing the two prepared film edges in contact with each other after the film cement has been applied. Film cement contains a solvent which dissolves the film base layers in order to make a satisfactory splice. However, the solvent also evaporates rapidly when exposed to air, so that the cement becomes thick and gummy. In this condition, you will not be able to make a satisfactory weld. Use only enough cement to thinly but evenly cover the two prepared film edges and immediately bring the edges together, preferably under pressure.

Amount of Cement. You must apply just enough cement to do the job; too much may cause the film to buckle after a short time. If allowed to dry, the thickened splice may cause trouble later when

the film passes through a projector film gate. It is important that you wipe off excess film cement immediately. Too little an application of film cement may not cover all areas of the prepared film edges, so that the welding action occurs only in those spots where enough cement was placed.

This splice is detected by the bubbles when examined through the back side of the film. A splice such as this will not last long and, if not redone, its edges will remain loose so that when tension is applied, it will readily tear. When you have a splice that failed even though you apparently used the proper amount of cement, then look for the cause as either improper preparation of the film base or using a cement not suited to the film base.

FILM CEMENT HANDLING PRECAUTIONS. Film cement contains a solvent which is highly volatile and can burn with almost an explosive force. Although the 16mm and 35mm films are made with a safety base which has a low burn rate and presents no fire hazard, the solvent in film cement is a fire hazard so that the proper safety precautions must be observed. This is why you should never smoke while performing splicing operations. You should also avoid getting film cement on other motion picture equipment, since the solvent will ruin the protective enamel on such items. Fumes from film cement should be vented away from your eyes to avoid irritation.

DESIGN 198 SPLICER. There are various kinds of splicers in use. Some are manually operated, requiring the use of both hands. Others are motorized to move along lengths of film quickly between splices and are controlled by foot pedals. These are found in very large organizations. A manual splicer most often used in the average processing laboratory is a commercial product and is illustrated in figure 3-7. Known as the Design 198 splicer, it is designed specifically for professional and semiprofessional work on 16mm and 35mm films. This splicer is compact and easily portable, and it is capable of handling heavy-duty work with comparable ease.

The 198 splicer operates on 110/120-volt alternating current. To one side of figure 3-7, a power cord is permanently attached to the unit. All electrical components are hidden within its base. The unit is designed to allow instant change from splicing 16mm films to splicing 35mm films. This conversion is made possible by the retracting 16mm perforation pins when the splicer is set for 35mm operation, as shown in Figure 3-7.

A permanent scraping device, controlled by a slider bar handle, is made of carbide steel. The depth of its scraping action is

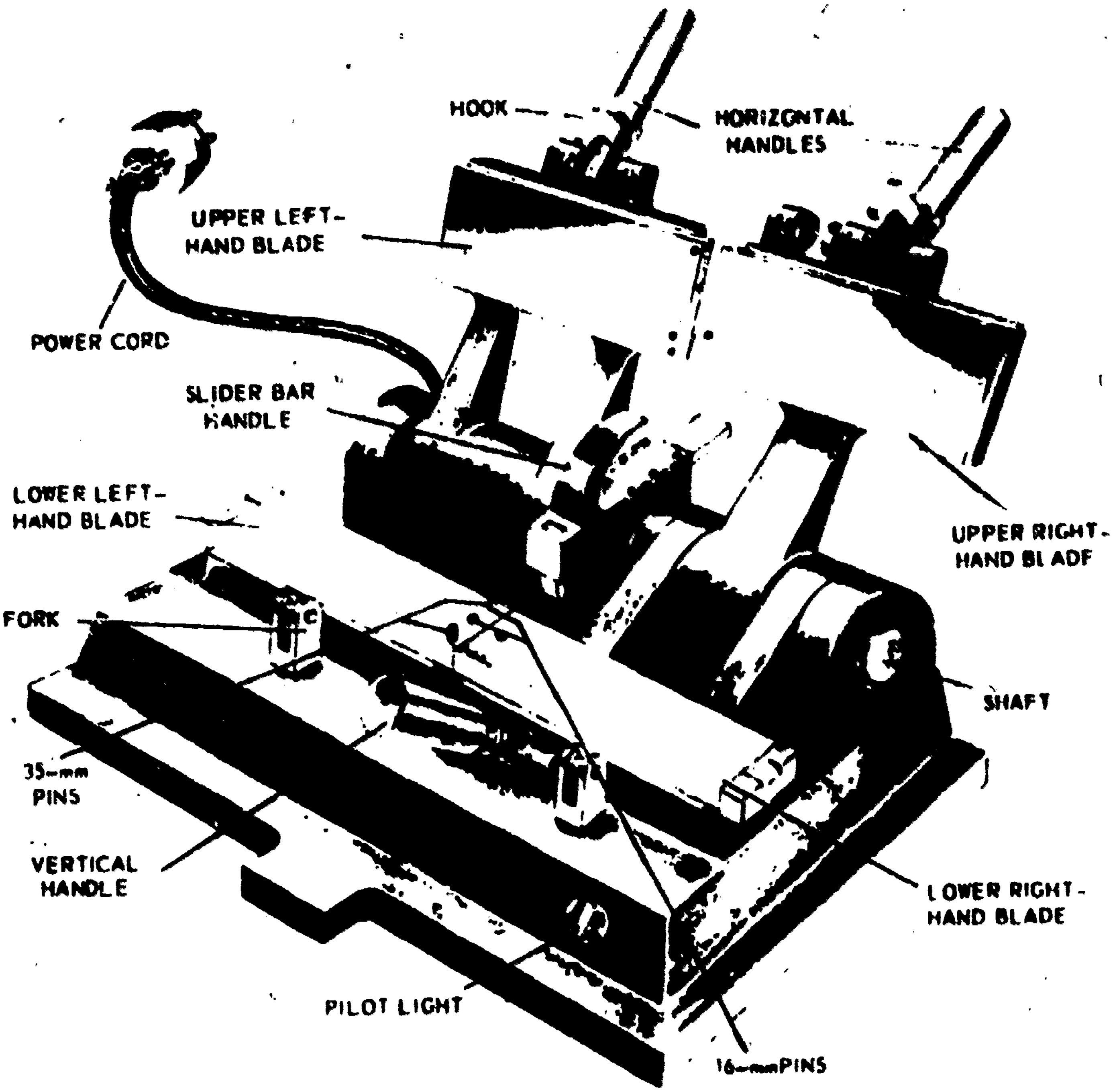



Figure 3-7. Design 198 Splicing Machine

gauged and set at the factory. An adjustment that may be required as a result of clipped or broken scraper blades should be made by a qualified repair technician. The reason for this is that the depth of cut must be measured with a gauge. Also, the parallelism of scraper movement must be determined with the aid of a micrometer.

The thermostatic electrical heating element maintains the proper temperature for welding the splice in a minimum amount of time. Unlike the scraper adjustment, field adjustments of the heater thermostat

can easily be made by the operator of the splicer.

OPERATING PRINCIPLES. With the Design 198 splicer, the prepared ends of film are joined together under pressure and heated. The proper amount of regulated heat is applied to dry the splice more rapidly.

In order to make the splice less apparent on the projection screen, the overlap area between scenes has been relocated on the Design 198 splicer. The relocation of the overlap area eliminates the annoying "combination" frame that appears on the film as a result of a splice placed midway between frames. Width of the splice made by the Design 198 machine is 0.07 inch. This width allows a full frame of Scene A to be shown before blending into Scene B. (Note in figure 3-8.) The slightly increased density of the weld makes the splice more difficult to detect when it is projected on a screen.

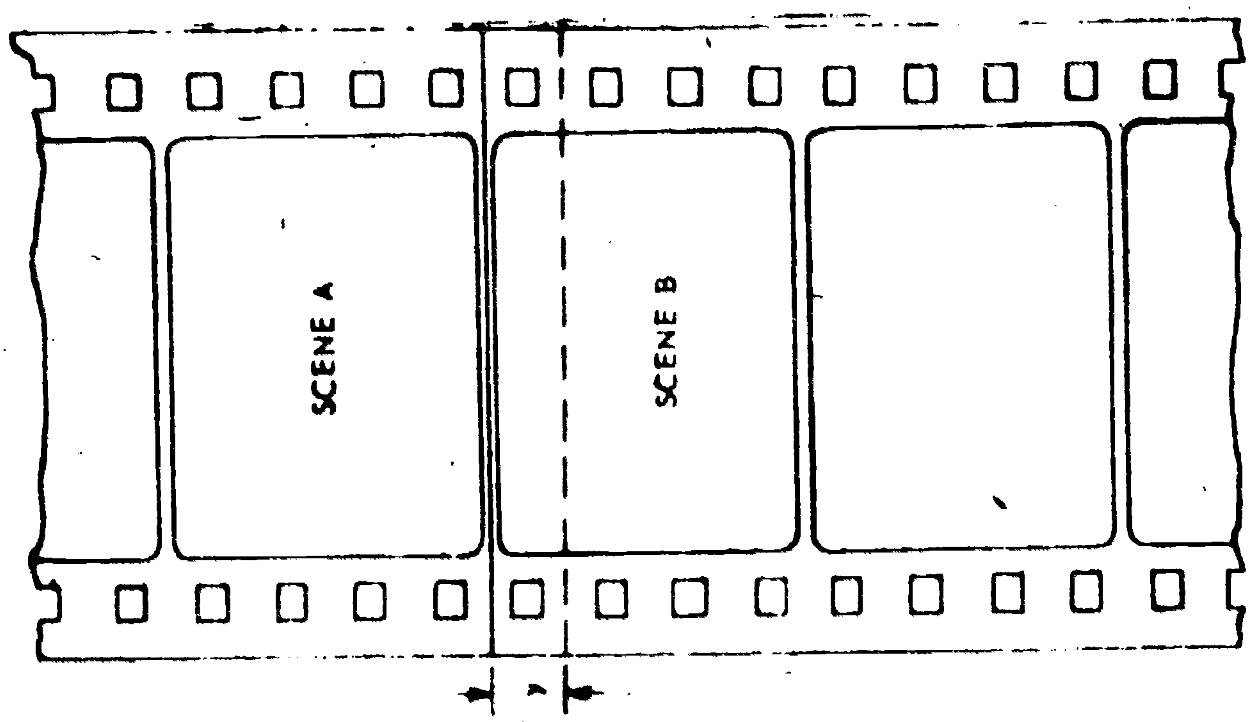



Figure 3-8. Combination Frame Splice

PREPARATION FOR USE. To prepare the splicer for use, wipe the upper and lower blades with a cloth dampened in acetone and then wipe them dry with a clean cloth. Next check the aligning action of the scraper unit and, if necessary, lubricate. A small amount of oil on the 16mm slide pins will keep the film cement from adhering to them. If these pins do not operate freely, loosen them with a few drops of acetone before oiling.

Connect the splicer power cord to a 110- to 120-volt alternating current power source. The temperature will rise to a workable point within 15 or 20 minutes and to correct maximum temperature within approximately 30 minutes. If the unit appears to get too hot, thermostat adjustment may be necessary.

OPERATING PROCEDURES. Operating procedures for 16mm is slightly different from 35mm film. The 16mm perforation pins will be raised when splicing 16mm film and retracted when splicing 35mm film. After the perforation pins are correctly positioned, proceed as follows:

1. Raise both upper blades to their top position as shown in Figure 3-7. The right lower blade must be left in its down position.

2. Place one end of the broken film (emulsion side up) across the right lower blade.

3. Register the film perforations over the locating pins in the left lower blade.

4. Lower the right upper blade and lock it in place with the vertical lever.

5. Raise both blades (with the film locked between them) to the top position.

6. Place the other end of the broken film (emulsion side up) across the left lower blade.

7. Register the film perforations over the locating pins.

8. Lower the left upper blade and lock it in position.

9. Draw out the scraper unit.

10. Press down to engage the scraper blade with the film and push the scraper unit back. (See Figure 3-9.) The scraper unit is under spring tension and must be held firmly against the film in the entire backstroke in order to remove the emulsion properly. Using both hands during the scraping operation is helpful, though not absolutely necessary. Correct pressure for the scrape can be determined only through individual use. Do not attempt to scrape the film while dragging the scraper unit outward. Torn film will result.

11. Apply film cement sparingly to the scraped area with the applicator brush.

12. Bring down the two right blades and lock them in place. In lowering, these blades will cut both ends of the film and seal them in place with pressure.

13. Release all locks.

14. Raise the tip blades and remove the spliced film from the splicer.

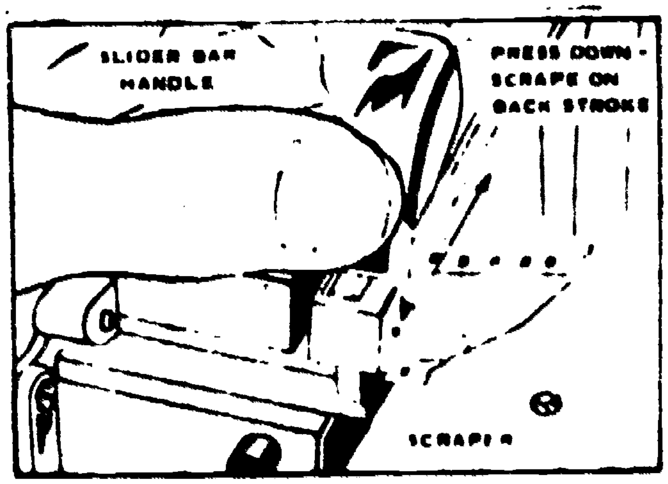



Figure 3-9. Preparing Film End by Scraping

After splicing operations are completed for the day, disconnect the cord from the power source and allow the splicer to cool completely. Then, wipe the upper and lower blades as well as the scraper blade, to ensure cleanliness. Use a cloth that has been dampened with acetone to remove all traces of emulsion.

REVIEW QUESTIONS

DO NOT WRITE IN THIS SW - USE A SEPARATE SHEET OF PAPER.

1. What method of film transport is used by motion picture processing machines?

2. Name and explain three methods of solution agitation.

3. Why is the motion picture processing machine prethreaded?

4. List the steps in threading the Colormaster Mark II processor.

5. What difference, if any, is there between color and black-and-white processors?

6. Why are metal parts in the bleach tank made of material other than stainless steel?

7. During certification, what process controls are required?

8. Why is a length of rawstock and a sensitometric control film being run?

9. Why does pH have to be checked daily?

10. What precaution is taken to avoid solution carry over which might cause excessive chemical dilution or contamination in a processing machine?

11. How can effective film speed be increased in process ME-4?

12. Why is a replenishment system needed?

13. Name the chemical solutions that are provided with recirculation pumps on the Colormaster Mark II.

14. Explain film loading procedures.

15. Explain the Colormaster's film transport system.

16. How long should the dryer be allowed to cool before the blower is turned off?

17. Describe the film dryer used in the Colormaster Mark II.

18. What is the beginning step of film makeup?

19. How and when are washed tanks drained?

20. How can film loss be kept at a minimum during a power outage?

21. How does an operator know when film tension too high on the Colormaster Mark II?

22. What is corrosion control?

23. Name and explain two methods of post inspection.

24. How often are processor racks checked? [illegible] them?

25. Name three causes of poor post inspection [illegible]

26. What three things are required to splice film?

EXERCISE I

**PROCEDURES**

1. Using a separate sheet of paper, match the [illegible] terms with the statement that best describes their function.

a. machine speed
b. filtration
c. agitation
d. drying
e. replenishment
f. squeegee
g. temperature
h. recirculation

(1). Brings fresh solution in contact with the [illegible] emulsion.

(2). The rates are determined by the size and [illegible] film being processed.

(3). Determined by the speed at which the machine [illegible] the sensitized material and the length of film contained in the developing tank.

(4). Prevents dirt particles or chemical residue from depositing on the surface of the film being processed.

(5). The last step accomplished in processing.

(6). One of the most critical elements in the control of the photographic process.

(7). Provides agitation and filtration.

(8). Must operate properly if an accurate replenishment rate is to be maintained.

2. Answer the following questions on a separate sheet of paper.

a. How does the method of transport in motion [illegible] processors differ from the aerial machines previously used in the course?

b. What determines the numbers and arrangement of tanks in processing machines?

c. What are the major differences between black-and-white processors and color processors?

d. Why are the bleach tanks and racks constructed of Hastelloy?

e. What can be done to increase the effective emulsion speed?

f. How do you compensate for overexposure?

PRACTICAL EXERCISES

EXERCISE II

PROCEDURES

Using a separate sheet of paper, match the Colormaster components in column "A" with the functions performed in column "B."

| A | B |
|---|---|
| a. Micro-switch brake | 1. Drains the tanks |
| b. Load accumulator | 2. Warns that a change over is needed |
| c. Auxiliary switch | 3. Warns that a film break may occur |
| d. Red-capped valves | 4. Provides time for change over |
| e. Flow rate meters | 5. Holds film in place during change over |
| f. Black-topped rods | 6. Establishes recirculation rates |
| | 7. Operates air compressor |
| | 8. Establishes replenishment rates |

EXERCISE III

EQUIPMENT

| | Basis of Issue |
|---|---|
| Colormaster processor | 1/class |
| Processing support equipment | As needed |

PROCEDURES

1. Perform Colormaster preoperational procedures as outlined in the text.

2. Startup the Colormaster according to procedures in the text. The instructor will provide you with necessary information pertaining to solution temperatures, speed, and the height of elevator rods.

3. If the processor needs chemistry, mix chemistry and fill the appropriate tanks.

EXERCISE IV

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Colormaster processor | 1/class |
| Processing support equipment | As needed |
| Tachometer | 1/class |
| Preexposed ME-4 control strips | As needed |
| pH meter | 1/class |
| Densitometer | 1/class |

PROCEDURES

1. Certify the chemical solutions. Your instructor will provide the standards.

2. Remove sufficient preexposed sensitometric strips from the freezer to certify the processor.

3. Mechanically certify the processor in accordance with procedures outlined in the text.

4. Process scratch test film and sensitometric strips.

5. If the scratch test film contains physical defects, locate and correct the cause (with your instructor's guidance) and repeat the scratch test.

6. Readout the sensitometric strip using a suitable densitometer and plot the densities onto a control chart. If plotted

densities are not within control chart standards, your instructor will determine corrective action to be taken. Make necessary corrections and process another sensitometric strip.

7. When the processor is considered certified, you may process the film you exposed in this block.

## EXERCISE V

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Colormaster processor | 1/class |
| Processing support equipment | As needed |

PROCEDURES

1. Using previously exposed film, each student will load one roll of film in succession onto one core. (Darkroom condition).

2. Place the loaded core onto the flange on the load section. (Darkroom condition).

3. Process the film and monitor the processor in accordance with procedures outlined in the text.

4. While this film is being processed, load another core with the remaining exposed film.

5. At the proper time, perform a change over and process the second roll of film.

6. At the proper time, attach a roll of leader to the film and rethread the processor.

## EXERCISE VI

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Colormaster processor | 1/class |

| | |
|---|---|
| Processing support equipment | As needed |
| Cleaning materials | As needed |

PROCEDURES

1. Shutdown the processor in accordance with the procedures outlined in the text.

2. When finished, clean the processor, the laboratory, and return everything to its proper place.

3. For more detailed cleaning and preventive maintenance procedures, consult T.O. 10E5-2-17-1.

EXERCISE VII

EQUIPMENT AND SUPPLIES

| | Basis of Issue |
|---|---|
| Design 198 splicer | 1/student |
| Film cement | As needed |
| Head and tail leader | As needed |
| Cotton gloves | 1 pr/student |
| 16mm movie projector | 1/class |

PROCEDURES

1. Each student will splice his two rolls of processed 16mm film together.

2. Splice head and tail leader to this roll of film.

3. Splice all of the class film into two large rolls.

4. Project the film.

5. List all the physical and processing defects present in the film.