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ABSTRACT

The Federal Government creates and disseminates large accounts of technical information in various forms, i.e., handbooks, manuals, guides, texts, brochures and periodicals. Much of this information is of value to the vocational-technical secondary school teacher for updating lessons and giving information which keeps pace with occupational changes. This study was conducted to "Determine the Feasibility of Developing a Model Describing the Flow of Occupational and Economic Information into the Secondary Vocational-Technical School." The study went beyond this to produce quantitative models which describe and measure the utilization of government-published data. It was also expanded to include the comprehensive secondary school as well as the vocational-technical secondary school. (Not available in hard copy due to marginal legibility of original document). (NH)

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Systems Engineering of Education VIII:

QUANTITATIVE MODELS FOR OCCUPATIONAL TEACHER UTILIZATION OF GOVERNMENT-PUBLISHED INFORMATION

Leonard C. Silvern and Carl N. Brooks

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CONTENTS

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The following faculty and staff at the University of California-Los Angeles examined, reacted and contributed to the ideogram in section C-Analysis, 1-Flowchart Model:

Dr. Miles H. Anderson, Director, Clinical Instructor Training Program, Division of Vocational Education.

Dr. Robert W. Hayes, Director, Institute of Library Research.

Dr. Richard L. Lano, Supervisor, Trade and Technical Teacher Education, Division of Vocational Education.

Miss Mary J. Ryan, Head, Public Affairs Service, UCLA Library.

While in Los Angeles participating in the "Designing Education and Training Systems" course at ETC, Dr. Lewis D. Holloway also was interviewed. He is Assistant Professor, College of Medicine; and Teacher Educator, Health Occupations Education, University of Iowa.

We are particularly indebted to our correspondents who furnished Lesson Plans for the sample detailed in section B-Approach to Problem:

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M.D. Boatwright	Director	Swainsboro Area Vocational-Technical School, Swainsboro, Georgia
C.W. Branch	Dean	Richland Technical Education Center Columbia, South Carolina
M.R. Clark	Superintendent	Area One - Vocational Technical School District Calmar, Iowa
J.F. Collins	Director	Weymouth Vocational Technical High School, East Weymouth, Massachussetts
B.O. Compton	Dean of Instruction	Technical Education Center Sumter, South Carolina

G.W. Dudley, Jr.	Director	Horry-Marion-Georgetown Technical Education Center Conway, South Carolina
M. Estrada	Director, Vocational Education	Campbell Union High School District Campbell, California
D. Fleckles	Coordinator, Vocational Education	San Jose Unified School District San Jose, California
J.C. Ghrist and E.T. Petrie	Superintendent Intern Director	EHOVE Vocational School District Milan, Ohio
W.G. Hartline	Acting Director	Columbus Area Vocational-Technical School, Columbus, Georgia
H.F. Hays	Director	South Georgia Technical and Vocational School Americus, Georgia
J.S. Hull	Dean of Instruction	Piedmont Technical Education Greenwood, South Carolina
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M.P. Nolan	Director	Area Vocational School Florence, South Carolina
L.T. Oglesby	Director	Bradford-Union Area Vocational-Technical Center Starke, Florida
C.O. Ross	Director	Southwest Vocational Technical Institute East Camden, Arkansas
A.P. Wood	Vocational-Technical Curriculum Specialist	School District of Kansas City Kansas City, Missouri

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Leonard C. Silvern
Principal Investigator

Carl. N. Brooks
Associate Investigator

A. INTRODUCTION TO PROBLEM

1. Background Study

In December 1966, the U.S. Office of Education contracted with Education and Training Consultants Co. (ETC), Los Angeles, to "Determine the Feasibility of Developing a Model Describing the Flow of Occupational and Economic Information into the Secondary Vocational-Technical School" (1).

The study was completed and submitted to the Commissioner of Education in June 1967. The study went beyond the original proposal and *developed* a flowchart model. In addition, it was expanded to include the *comprehensive* secondary school as well as the vocational-technical secondary school. In order to improve dissemination of the systems engineering conceptualization inherent in the project, ETC published it with the title, "Systems Analysis and Synthesis Applied to Occupational Instruction in Secondary Schools," in November, 1967 (2).

a. Conceptualization of a Model

In the study, a flowchart model was synthesized having 49 separate and and distinctly identifiable feedback loops. A *rigorous* definition of "feedback" was established based upon closed-loop control systems theory rather than on the less stringent meaning implicit in non-physical systems applications.

This model is a high-fidelity analog of teacher relationships in real-life. It is a cybernetic model which relates the occupational teacher with the real-life environment *outside* the school subsystem. It is from this real-life domain that information is received and to which graduating students are sent. A simplified model appears in Figure 1. It is delineated at the first or major level of detail. The complete model will be discussed later.

Both student and teacher are subsystems within (4.0). Students leave a secondary school by graduation or as dropouts and enter employment (1.0), enter an institution of higher education (3.0) or perform military service (2.0). Non-employment is not specifically depicted but may be regarded simply as state two of the two-state subsystem (1.0).

At some point in time after leaving secondary school (4.0) they will also leave the military (2.0) and college (3.0) subsystems for employment in business, industry and government (1.0). It is virtually impossible for a particular person leaving (4.0) and entering (1.0), (2.0), or (3.0) to return to the *same* (4.0) environment. Thus, any inputs to (4.0) from outside, due to this time continuum, will affect younger students and not the original students. The model describes *functions and the interrelationships* and not individuals per se.

However, while the flow is discrete at the atomic level, it may be viewed as continuous at the molecular level. Certainly, the occupa-

tional teacher performs as a continuous function and it is this function within (4.0) which is identified in Figure 1. The conventional electrical signal analog applies exactly. (4.0) has more signal inputs than any other sub-system, 10 to be precise. While there are many *feedback* signals *in the complete model*, (4.0) has 8 major feedback inputs.

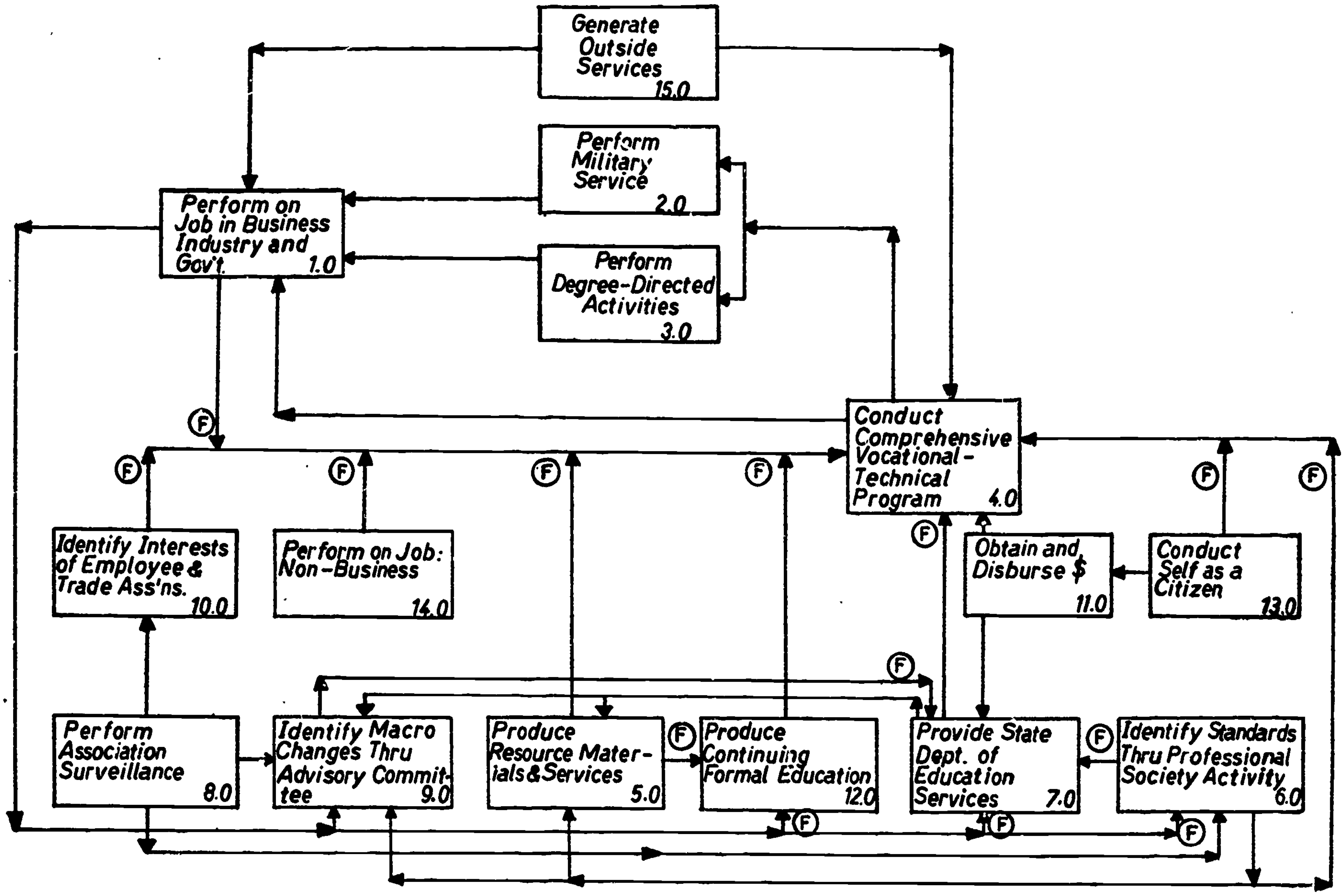


Figure 1 - Flowchart Model Developed in Initial U.S. Office of Education Study by ETC at the First Level of Detail.

Subsystem (10.0) produces feedback to (4.0) generally in the form of information obtained from employee and trade association magazines, brochures, meetings, etc. Such data is supposed to add to an instructor's knowledge bank and thereby modify his behavior. The information in (10.0) is obtained in part from various surveillance or *early warning* sensors operated by associations and societies (8.0).

The same surveillance data (8.0) also influences (9.0) and is translated into recommendations and policies by advisory bodies at various levels. At the macro level, information is transmitted to the State Department of Education (7.0). At a lower macro level, it is transmitted to the school district, and at an even lower macro level to the occupational teacher in a particular secondary school of the same school district (4.0). (9.0) obtains information from (7.0) and both information and manpower (members) from (1.0).

Professional societies (6.0) also perform a surveillance function (8.0) and use any *feedback* to control their outputs and thereby stabilize that loop. This is accomplished through meetings attended by teachers (4.0), recommendations for licensing (or non-licensing) and curriculum requirements transmitted to (7.0).

The State Department of Education (7.0) uses (6.0) and (9.0) information as *feedback* to control its output but one signal input from (11.0), namely federal and state tax dollars, has a profound influence. At the regional level where programs are operated to reach an occupational teacher (4.0) directly, *feedback* from real-life is most often embodied in the form of experienced managers and supervisors in (1.0) who instruct in (12.0) and also may have a role in contributing to the selection of occupational content for teacher training programs (7.0).

It is the tax-paying citizen (13.0) who inputs his dollars to (11.0) which go to (7.0) at the state level and to a particular school or school tax district (4.0) at the local level. (13.0) acting as a non-parent, can create and apply pressure to the management of a district in various ways (4.0). (13.0) rarely has acted as a parent in this role, but organized parent action groups outside of the PTA variety are beginning to emerge as a powerful force in certain geographical areas.

Occupational instructors look more and more to state colleges, community colleges, junior colleges, and non-public trade schools (12.0) to obtain information used as *feedback* to correct errors and control their output (4.0). These institutions face the same problem of presenting updated information, thus error-correcting *feedback* enters (12.0) in the form of experienced managers, supervisors and technical employees from (1.0).

Because of great academic freedom for the individual teacher in higher education, *feedback* enters (12.0) from (5.0) as vendors furnish in-service training which invariably focuses upon the products being produced in (5.0). To a lesser extent, internally generated research and development in occupational materials and methods may reach the continuing education function (12.0) and eventually be transmitted to (4.0).

Occupational instructors rely upon resources (5.0) and the information generated to update their content and, as *feedback* from real-life, to alter their outputs. There are minor signals to (5.0) from (6.0) which consist mainly of the provisioning of mailing lists for vendor advertising. *Major* signals to (5.0) from (6.0) consist of state-administered tests used for licensing or other purposes.

In terms of national practice, subsystem (14.0) is undoubtedly the *least* significant. It consists of job experience obtained by an occupational teacher instructing at a junior college or college and reviewing books and manuscripts for publishers. The *most* significant is (1.0) which describes job functions in business, industry and government. Students from secondary school enter (1.0) and spend 25% of their working lives there, over a time period of 45 years (20 to 65). Error-correcting *feedback* from (1.0) to (4.0) may be in a variety of forms: supervisory instruction to students engaged in cooperative, work-study programs, supervisory instruction to teachers employed either in a special program or randomly, information channeled through social or leisure-time activities from employees to teachers, information transmitted

by personnel departments to teachers, and so forth.

b. Characteristics of the Model

Five characteristics are identified with the information processed in the model, Figure 1.

(1) *frequency* (f): nature or rate of information flow; a measure of the continuousness of information using as a unit one semester of secondary school; the *frequency* of information fed back to an occupational teacher could be high, moderate, low or zero;

(2) *entropy* (H): order and organization of information and the signal path and information flowing through it in terms of order-disorder; the *entropy* of information and/or path could be high, moderate or zero;

(3) *figure of merit* (M): usefulness of information without alteration; a measure of the percentage of information usable by an occupational teacher so he may integrate it into a unit, sub-unit, lesson, teaching point, or step; the *figure of merit* of information fed back to an occupational teacher could be high, moderate or zero;

(4) *reliance* (R): changes in information content during transmission and at reception; a measure of the percentage reliability based on the absence of noise, distortion, data transmission errors (bits), etc. which change the information meaning so an occupational teacher will receive information different than originally generated at a source; the *reliance* of information fed back to an occupational teacher could be high, moderate or zero;

(5) *recency* (t): age of information at reception; a measure of the time elapsed from transmission to reception, the transmission time using as a unit one semester of secondary school; the *recency* of information fed back to an occupational teacher could be high, moderate, low or zero.

Forty-nine closed-loops are identified and *each* is described in terms of these five characteristics. From this, an evaluation statement is made concerning the value in pursuing or abandoning the loop under discussion.

c. Conclusions, Implications, and Recommendations

In gross terms, the teaching performance (P) of the occupational teacher may be expressed as:

$$P = f(f, H, M, R, t)$$

The model has these characteristics:

(1) it is a high-fidelity analog of real-life;

(2) it is a cybernetic model, showing interaction with a real-life environment;

(3) it is closed-loop with a large number of feedback signal paths, extrinsic and intrinsic to the school or school district;

(4) it is a general model of secondary schools and of occupational teachers in those schools;

(5) it has closed-loop feedback signal paths each of which is identifiable in terms of up to five characteristics;

(6) it appears possible to measure the value of each feedback loop in crude units;

(7) instructor performance (P) dealing with the inputting of updated information is a function of (f,H,M,R,t).

The most efficient method of measuring the effectiveness of occupational instruction is to examine conventionally the activities of program graduates in their jobs. However, this can prove to be impractical if the overall purpose is to improve occupational instruction rather than merely statistically examine employment outcomes. The study reveals that the interface between teacher and student was extremely critical since it is at this interface that communication occurs and information in the mind of the occupational teacher is transmitted to and received by the student. If we are interested in the method of instruction, per se, then we would wish to study the signal path itself. However, if the interest is in the content being instructed, in terms of updatedness, then we must study the information being transmitted.

The study concludes that the occupational teacher's *performance* is related to frequency, entropy, figure of merit, reliance, and recency as defined. This may be interpreted to mean that variations in these characteristics could alter teacher performance. Assuming that the method of instruction was suitable and satisfactory, students would receive far better information than at present.

Using this logic, if it is possible to quantify the flowchart model using one or more mathematical models, then an occupational teacher in a secondary school could be measured and his performance determined. However, his entire performance would not be so measured. Only that aspect of his performance which dealt with occupational content would be delineated.

This has become a major problem in education today since technology in the real-world is causing so many changes in jobs that it is becoming a major headache to the occupational teacher who wants to keep up but is unable.

Such mathematical models would provide a uniform instrument for measuring occupational teacher performance in any school district. They would allow comparative analyses to be made. They would identify courses in schools which were outdated and would tend to improve and maintain the experience of the occupational teacher. He would have a measurable whole which he could utilize to justify obtaining additional assistance from his school and school district management.

The school and school district management would be more responsible for updating and maintaining the updatedness of course content which presently is delegated to the teacher or ignored completely. This applies largely to *existing* occupational courses and teachers.

For those districts engaged in developing *new* comprehensive schools, and for those involved in *new* vocational and technical curriculum development, it would be of inestimable value since the measurements occur at the very beginning and the models require that workable, closed-loop signal paths be created *in fact* rather than on paper.

The model may be viewed from the ***outside in***. Improvement of present methods of transmitting information into the schools from sources outside would be most welcome by these sources. For example, if a generator and transmitter of information finds that virtually none of it is ever retransmitted by occupational teachers to their students, an investigation of the breakdown in communication would be warranted. This might suggest that existing methods based on the past are ineffective and a completely new and innovative technique be synthesized.

The basis for such a decision would be the measurements made through the use of the models and the basis for the synthesis of new techniques would be localized to those areas of the non-model; i.e., where signal paths feeding back information to the occupational teacher do not exist at all.

2. Selection of Subsystem (5.0) PRODUCE RESOURCE MATERIALS & SERVICES

In essence, the initial study (OEC-4-7-061544-1601) and the one reported in this document (OEC-9-9-140152-0003[057]) view the system ideographically as an information processing network in which the occupational teacher accumulates information, sorts and retransmits it to students through classroom, shop and laboratory instruction. The students are expected to transfer this to jobs. When this sequence of events is accomplished at a high level of proficiency, the students are more acceptable and useful in the real-life world of business, industry and government. Their *employability index* is higher.

In discussing *employability*, it is assumed that *general* or academic education as commonly defined has also been acquired. The function of the occupational teacher is performed to complement the activities of the academic teacher who dispenses general education. Also, the occupational information used by a teacher for guidance purposes is considered outside of the domain in this discussion.

The 49 feedback loops were examined and those having a high probability of success in yielding to quantification were identified. The loop (5.0)→(4.0)→(1.0)→(4.0) was selected and may be traced in Figure 1. Selection was based upon the characteristics of low frequency, high entropy; figures of merit, reliance and recency which were degraded by high entropy; and specific recommendations for expansion of the loop.

Subsystem (5.0) is the function producing resource materials and services which enter the PROVIDE HUMAN INSTRUCTION (4.6) subsystem and influence the course content ultimately transmitted to the student. As seen in Figure 2, the original (5.0) subsystem contained 10 subsystems.

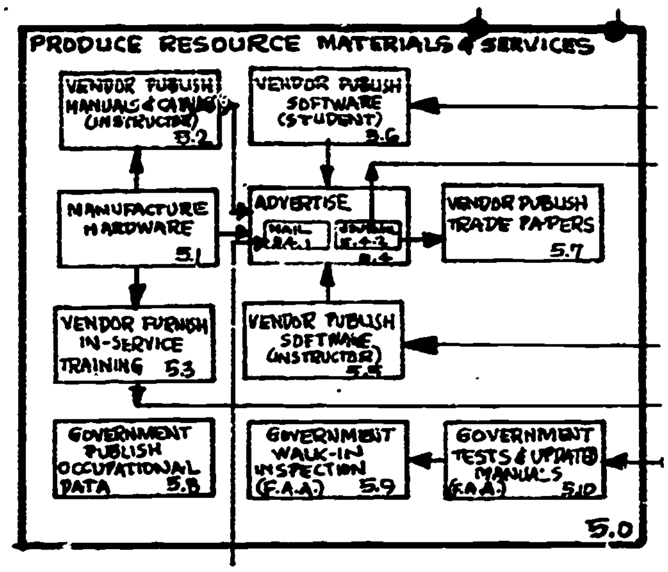


Figure 2 - The Original PRODUCE RESOURCE MATERIALS & SERVICES (5.0) Subsystem

The major generators are the government (nominally the federal government), manufacturers of hardware (physical products or materials used in product manufacture), and vendors of such hardware (manufacturers, distributors, proprietors). Because the typical occupational instructor is isolated from real-life in the sense that he is employed by a school district, one major source of information dealing with the *content* of his occupation would be (5.0).

Not *all* of the generators of resource materials and services are identified in (5.0). Only those clearly identified through interviews conducted in the initial study were depicted.

Intuitively, it appeared that (5.0) would be a good subsystem from which to develop the first mathematical model. The generator or generators could be identified *accurately*. Signal paths or non-paths in flowchart model form were *clearly* revealed. Together, these would be the basis for producing mathematical models. The products of (5.0) are tangible in the form of some kind of printed documentation, and to a lesser degree films, filmstrips, slide sets, prerecorded magnetic tapes, charts, etc. No effort was made to determine the dollar value of these expenditures. However, it is believed that $1 billion is a reasonable approximation. Since this is an extremely large sum, any study which would produce better results for the same expenditure, or the same results for considerably less money, would be worthwhile. Many firms and government agencies constitute the group of generators of materials and services because of the variety of occupational fields for which preparation is given in secondary schools. Virtually every industry and every federal agency is represented.

For these reasons, ETC selected (5.0) as the subsystem to be studied as the generator of information inputted into the school. The modeling activity *in this study* should produce not only a *solution* but more importantly a

procedure which could be followed to treat additional loops in the same model, and other complex, closed-loop models.

The application of physical science techniques such as systems analysis to a non-physical science problem in social science is quite difficult. The philosophy expressed in the initial proposal and this study, of a cybernetic model consisting of flowchart and mathematical elements, has not been utilized in education systems although several individuals have published papers based on this approach (3). Social systems, of which the education system in this study is a subset, are seen as physical systems and modeled as networks of physical entities which have word descriptors and mathematical equations associated with them (4).

3. Selection of Subsystem (5.8) GOVERNMENT PUBLISH OCCUPATIONAL DATA

The federal government generates and publishes documents each year resulting from agency activities. The yearly output of titles is measured in astronomical units. Most of this material is non-political, i.e. it is technical information of a factual nature without political implications and dealing with subject-matter applicable to thousands of different occupations.

Much government documentation is published by the Government Printing Office and sold by the Superintendent of Documents. However, many titles are distributed by other federal agencies such as the Defense Documentation Center (DDC) and the Clearinghouse for Federal Scientific and Technical Information (CFSTI). The United States Government Organization Manual devotes an appendix to ***representative publications*** of departments and agencies of the federal government consisting of fine print filling 25 pages (5). This appendix describes a very small percentage of the total annual output of these documentation generators.

The annual output of titles is mathematically a function of the number of government agencies, budgets of these agencies, permissive legislation by the Congress, diversification of agency activities, internal policy regarding publication and dissemination of significant data, and other elements. This study does not attempt to measure the quantity or effectiveness of such data but assumes that some part of it would be useful to occupational teachers in secondary schools. This assumption is based on interviews conducted in the initial study (2). In terms of that study, which produced a model having 49 loops, the one being reported represents 1/49th of the closed-loop aspect of the model. However, it represents 1/24th of those loops which should be expanded. The evaluations are summarized in 9 categories:

expand	24
redesign + expand	1
improve	10
study further	6
do not change	1
no comment	3
ignore	2
redesign or eliminate	1
eliminate	1
	49

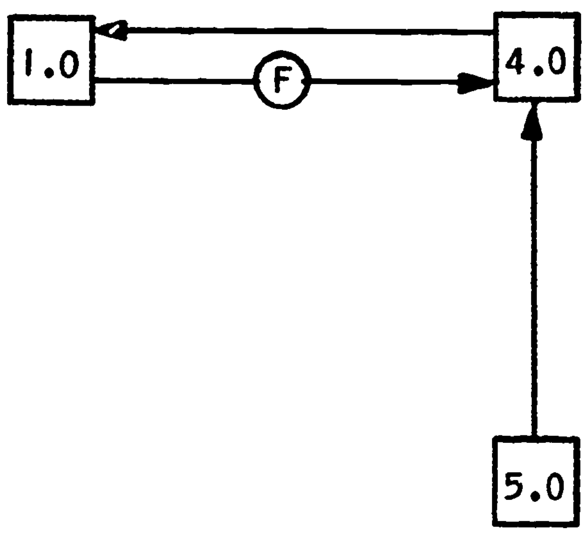
As stated in the discussion of the initial study, certain feedback signal paths are more critical than others. It is obvious that 24 closed-loops are sufficiently meritorious to be expanded, in the opinion of the investigators. It is not as obvious that the initial study was *not* designed to create or invent unique paths .... to synthesize non-existing paths.

It is difficult at this stage to state, for certain, that (5.8) is the *best* subsystem with which mathematical modeling must begin. There are no known ground rules for selecting the first loop for treatment except that it be simple and uncomplex relative to the other loops. (5.8) satisfies this criterion. Also, there should be a high probability of success in yielding to quantification. (5.8) satisfies this criterion.

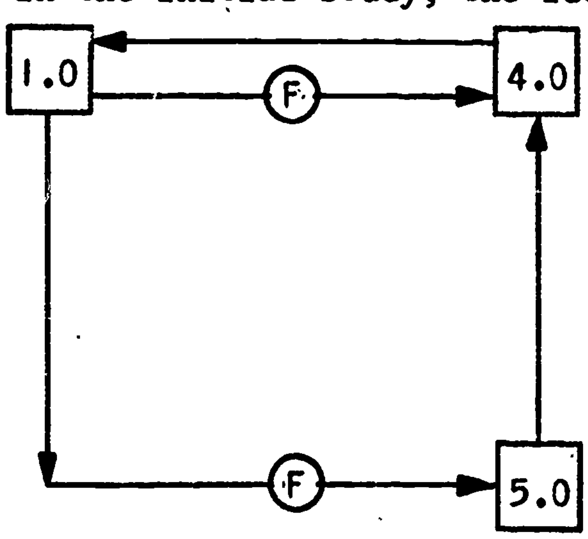
4. Objectives of this Study

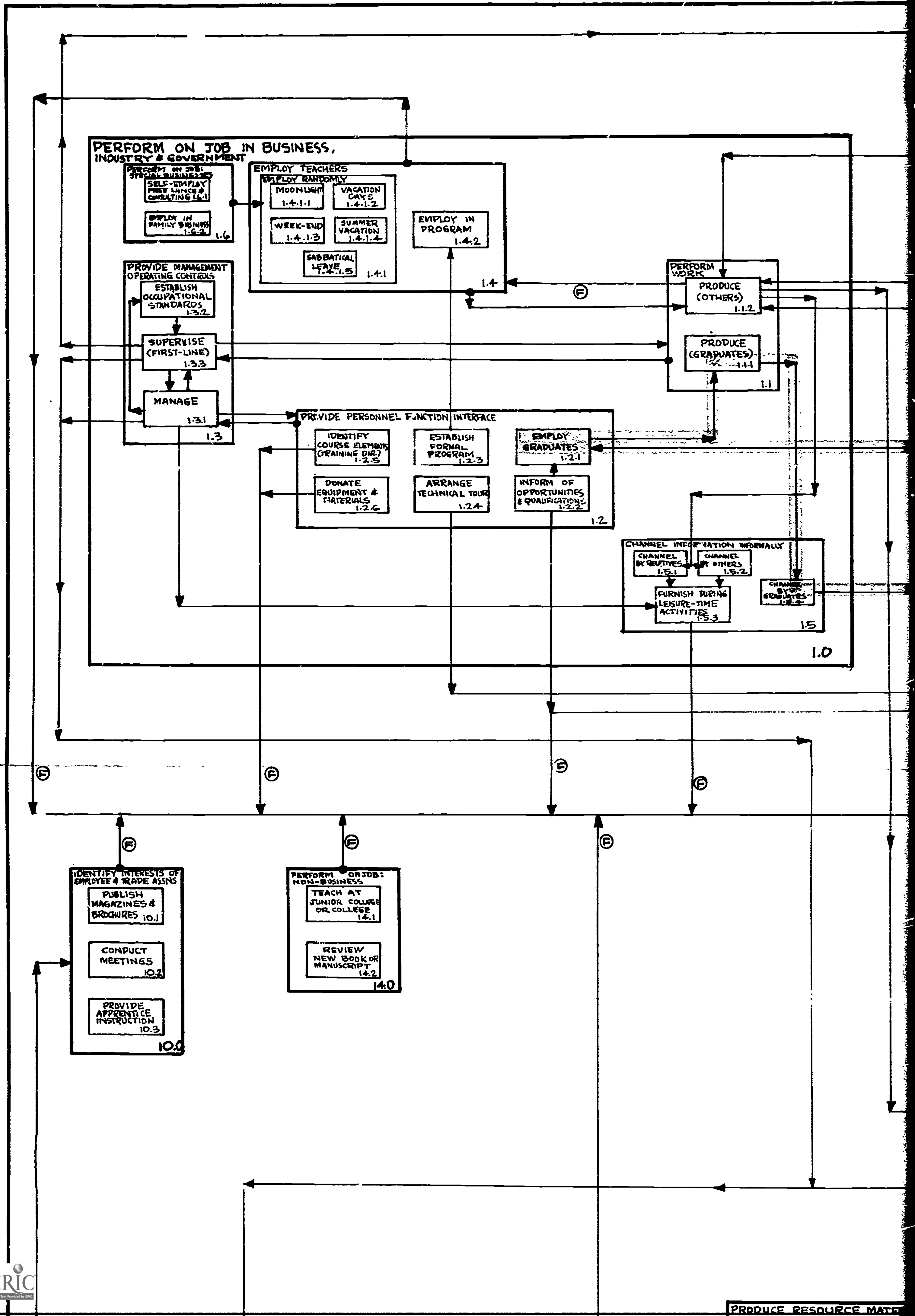
a. refine ideographically in flowchart model form, the loop described in Figure 3 *(flowchart to be folded out)* as (5.8) ⟶ (4.6.1.1) ⟶ (4.6.2) ⟶ (4.6.3) ⟶ (4.10) ⟶ (4.3.3) ⟶ (4.4) ⟶ (1.2.1) ⟶ (1.1.1) ⟶ (1.5.4) ⟶ (4.7) ⟶ (4.6.1.1).

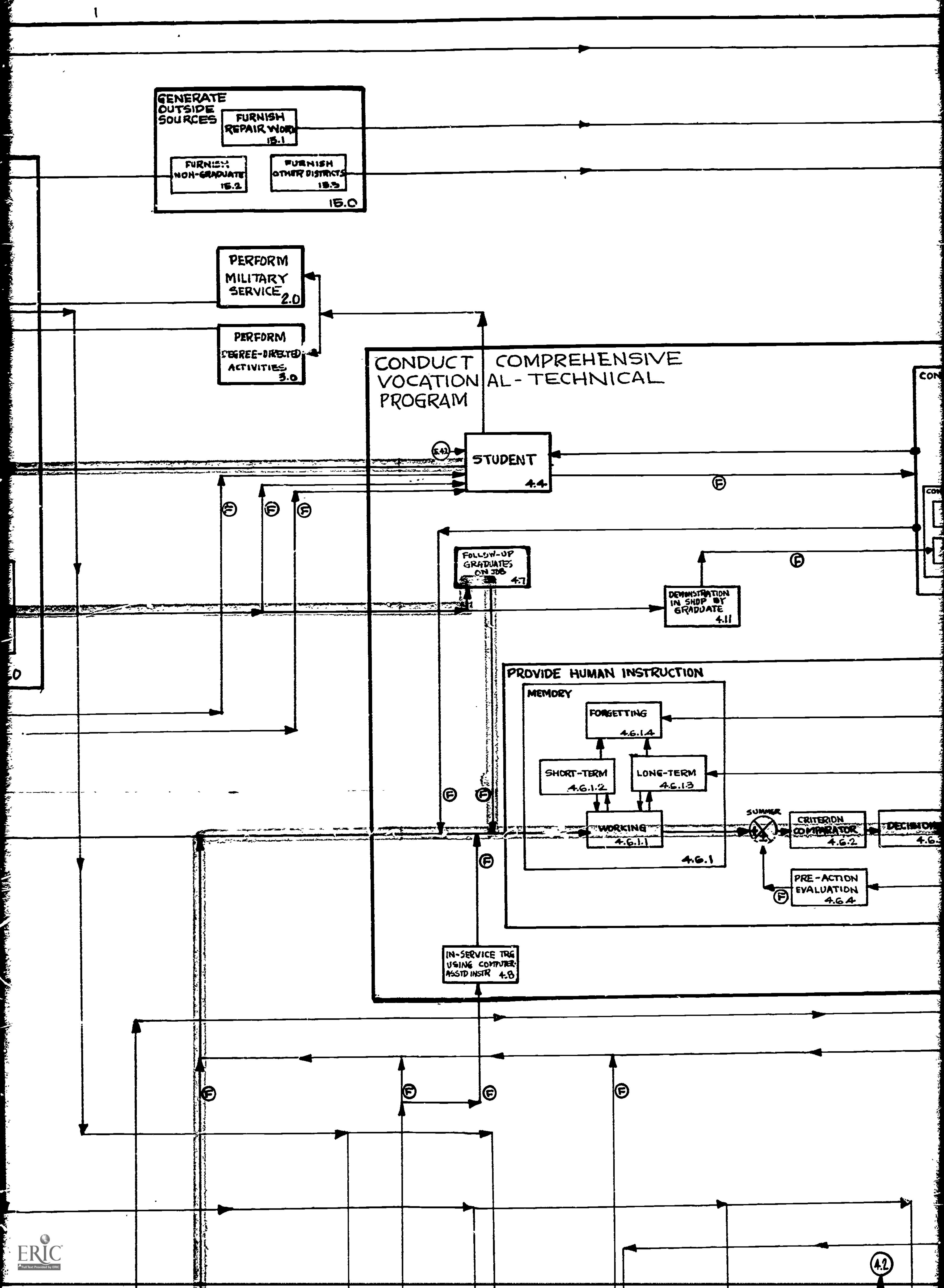
This loop has this ideogram, *derived* by analysis:



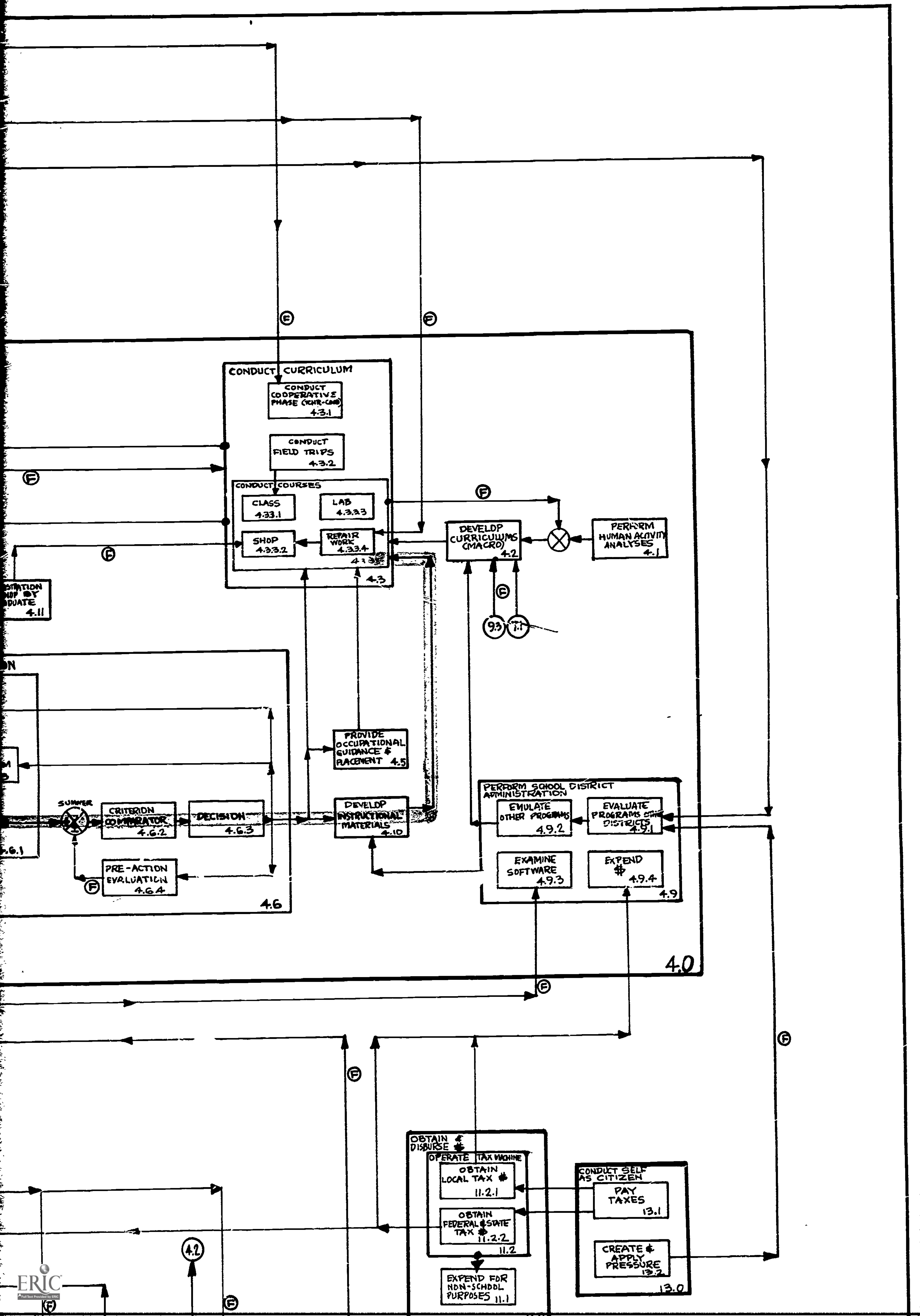
b. examine but do not refine alternative feedback signal paths which were not revealed in the initial study; the ideograms of three such alternatives are:

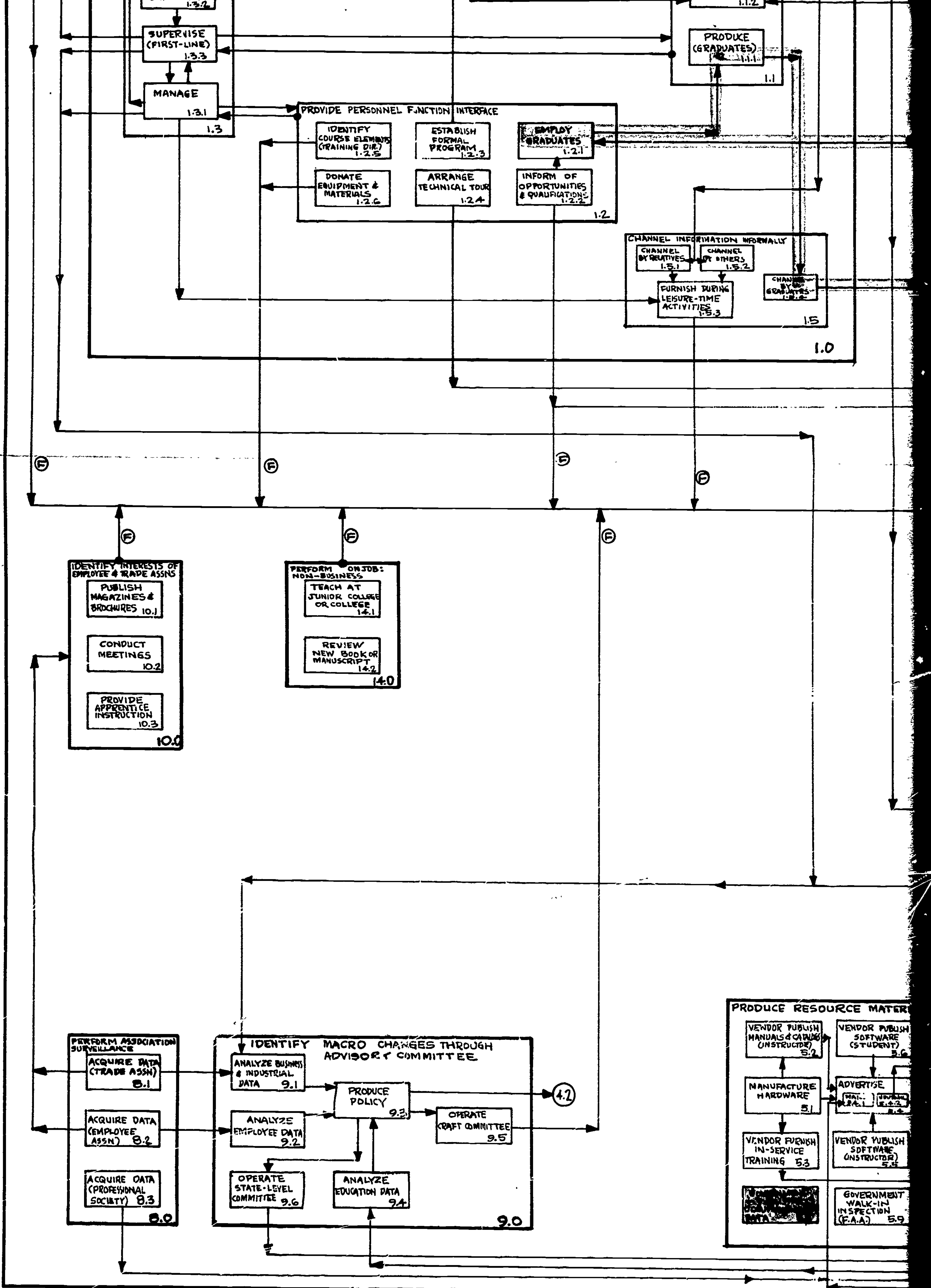



PERFORM ON JOB IN BUSINESS, INDUSTRY & GOVERNMENT
PERFORM ON JOB: SPECIAL BUSINESSES
SELF-EMPLOY FREE LANCE & CONSULTING 1.6.1
EMPLOY IN FAMILY BUSINESS 1.6.2
1.6
EMPLOY TEACHERS
EMPLOY RANDOMLY
MOONLIGHT 1.4.1.1
VACATION DAYS 1.4.1.2
WEEK-END 1.4.1.3
SUMMER VACATION 1.4.1.4
SABBATICAL LEAVE 1.4.1.5
1.4.1
EMPLOY IN PROGRAM 1.4.2
1.4
PROVIDE MANAGEMENT OPERATING CONTROLS
ESTABLISH OCCUPATIONAL STANDARDS 1.3.2
SUPERVISE (FIRST-LINE) 1.3.3
MANAGE 1.3.1
1.3
PERFORM WORK
PRODUCE (OTHERS) 1.1.2
PRODUCE (GRADUATES) 1.1.1
1.1
PROVIDE PERSONNEL FUNCTION INTERFACE
IDENTIFY COURSE ELEMENTS (TRAINING DIR.) 1.2.5
ESTABLISH FORMAL PROGRAM 1.2.3
EMPLOY GRADUATES 1.2.1
DONATE EQUIPMENT & MATERIALS 1.2.6
ARRANGE TECHNICAL TOUR 1.2.4
INFORM OF OPPORTUNITIES & QUALIFICATIONS 1.2.2
1.2
CHANNEL INFORMATION INFORMALLY
CHANNEL BY RELATIVES 1.5.1
CHANNEL BY OTHERS 1.5.2
FURNISH DURING LEISURE-TIME ACTIVITIES 1.5.3
CHANNEL BY GRADUATES 1.5.4
1.5
1.0
F
IDENTIFY INTERESTS OF EMPLOYEE & TRADE ASSNS
PUBLISH MAGAZINES & BROCHURES 10.1
CONDUCT MEETINGS 10.2
PROVIDE APPRENTICE INSTRUCTION 10.3
10.0
PERFORM ON JOB: NON-BUSINESS
TEACH AT JUNIOR COLLEGE OR COLLEGE 14.1
REVIEW NEW BOOK OR MANUSCRIPT 14.2
14.0
PRODUCE RESOURCE MATE



GENERATE OUTSIDE SOURCES
FURNISH REPAIR WORK 15.1
FURNISH NON-GRADUATE 15.2
FURNISH OTHER DISTRICTS 15.3
15.0
PERFORM MILITARY SERVICE 2.0
PERFORM DEGREE-DIRECTED ACTIVITIES 3.0
CONDUCT COMPREHENSIVE VOCATIONAL-TECHNICAL PROGRAM
STUDENT 4.4
FOLLOW-UP GRADUATES ON JOB 4.7
DEMONSTRATION IN SHOP BY GRADUATE 4.11
PROVIDE HUMAN INSTRUCTION
MEMORY
FORGETTING 4.6.1.4
SHORT-TERM 4.6.1.2
LONG-TERM 4.6.1.3
WORKING 4.6.1.1
4.6.1
SUMMER
CRITERION COMPARATOR 4.6.2
PRE-ACTION EVALUATION 4.6.4
IN-SERVICE TRG USING COMPUTER-ASSTD INSTR 4.8
4.2


CONDUCT CURRICULUM
CONDUCT COOPERATIVE PHASE (TCHR-COOR) 4.3.1
CONDUCT FIELD TRIPS 4.3.2
CONDUCT COURSES
CLASS 4.3.3.1
LAB 4.3.3.3
SHOP 4.3.3.2
REPAIR WORK 4.3.3.4
4.3.3
4.3
DEVELOP CURRICULUMS (MACRO) 4.2
PERFORM HUMAN ACTIVITY ANALYSES 4.1
9.3
7.1
4.11
SUMMER
CRITERION COMPARATOR 4.6.2
DECISION 4.6.3
PRE-ACTION EVALUATION 4.6.4
4.6.1
4.6
PROVIDE OCCUPATIONAL GUIDANCE & PLACEMENT 4.5
DEVELOP INSTRUCTIONAL MATERIALS 4.10
PERFORM SCHOOL DISTRICT ADMINISTRATION
EMULATE OTHER PROGRAMS 4.9.2
EVALUATE PROGRAMS OTHER DISTRICTS 4.9.1
EXAMINE SOFTWARE 4.9.3
EXPEND $ 4.9.4
4.9
4.0
F
OBTAIN & DISBURSE $
OPERATE TAX MACHINE
OBTAIN LOCAL TAX $ 11.2.1
OBTAIN FEDERAL & STATE TAX $ 11.2.2
11.2
EXPEND FOR NON-SCHOOL PURPOSES 11.1
CONDUCT SELF AS CITIZEN
PAY TAXES 13.1
CREATE & APPLY PRESSURE 13.2
13.0
4.2



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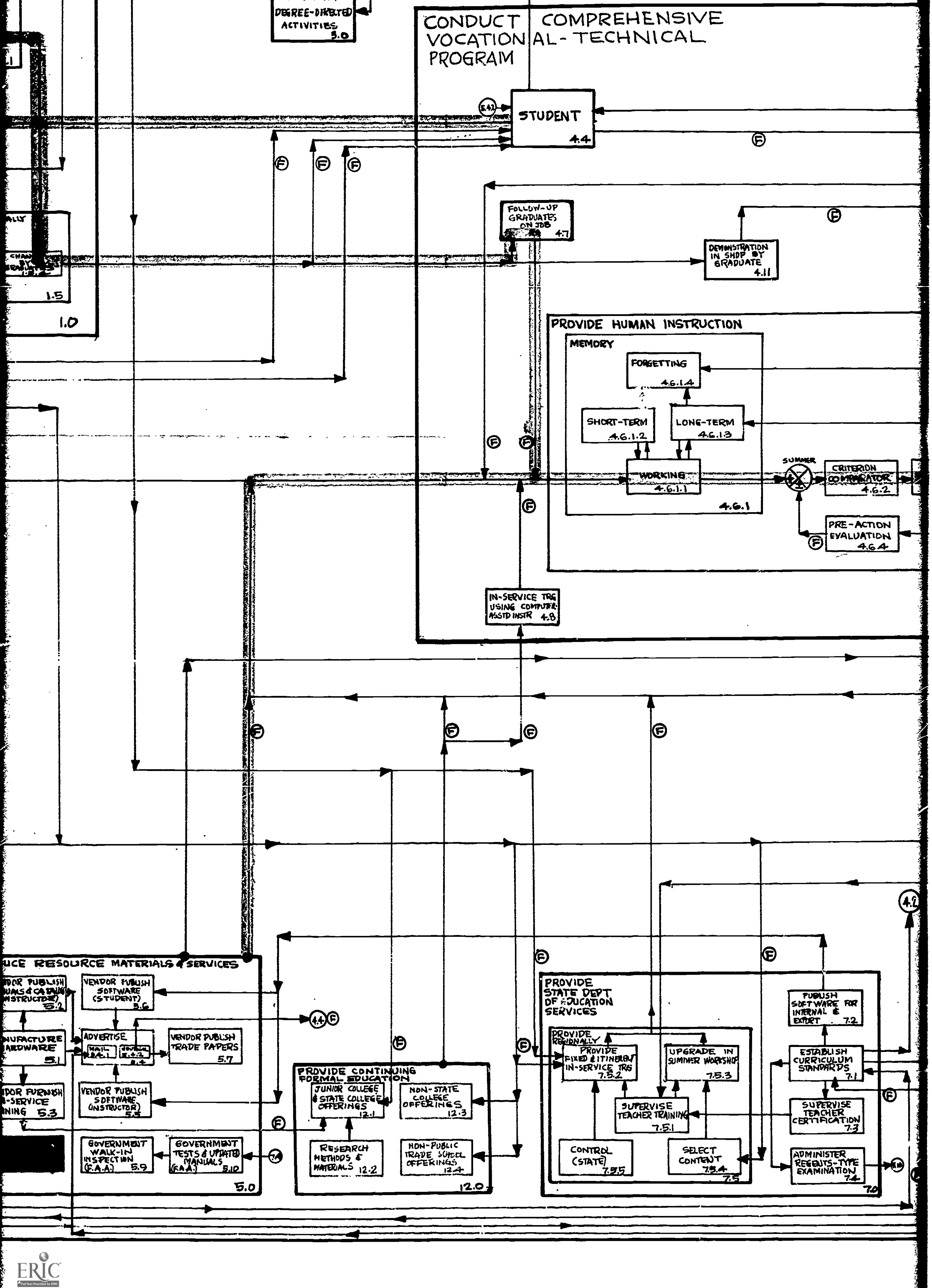


DEGREE-DIRECTED ACTIVITIES 5.0
CONDUCT COMPREHENSIVE VOCATIONAL-TECHNICAL PROGRAM
STUDENT 4.4
FOLLOW-UP GRADUATES ON JOB 4.7
DEMONSTRATION IN SHOP BY GRADUATE 4.11
1.5
1.0
PROVIDE HUMAN INSTRUCTION
MEMORY
FORGETTING 4.6.1.4
SHORT-TERM 4.6.1.2
LONG-TERM 4.6.1.3
WORKING 4.6.1.1
4.6.1
SUMMER
CRITERION COMPARATOR 4.6.2
PRE-ACTION EVALUATION 4.6.4
IN-SERVICE TRG USING COMPUTER-ASSTD INSTR 4.8
4.2
UCE RESOURCE MATERIALS & SERVICES
VENDOR PUBLISH SOFTWARE (STUDENT) 5.6
NUFACTURE ARDWARE 5.1
ADVERTISE 5.4
VENDOR PUBLISH TRADE PAPERS 5.7
VENDOR PUBLISH SOFTWARE (INSTRUCTOR) 5.5
GOVERNMENT WALK-IN INSPECTION (F.A.A.) 5.9
GOVERNMENT TESTS & UPDATED MANUALS (F.A.A.) 5.10
5.0
PROVIDE CONTINUING FORMAL EDUCATION
JUNIOR COLLEGE & STATE COLLEGE OFFERINGS 12.1
NON-STATE COLLEGE OFFERINGS 12.3
RESEARCH METHODS & MATERIALS 12.2
NON-PUBLIC TRADE SCHOOL OFFERINGS 12.4
12.0
PROVIDE STATE DEPT OF EDUCATION SERVICES
PROVIDE REGIONALLY
PROVIDE FIXED & ITINERANT IN-SERVICE TRG 7.5.2
UPGRADE IN SUMMER WORKSHOP 7.5.3
SUPERVISE TEACHER TRAINING 7.5.1
CONTROL (STATE) 7.5.5
SELECT CONTENT 7.5.4
7.5
PUBLISH SOFTWARE FOR INTERNAL & EXPORT 7.2
ESTABLISH CURRICULUM STANDARDS 7.1
SUPERVISE TEACHER CERTIFICATION 7.3
ADMINISTER REGENTS-TYPE EXAMINATION 7.4
7.0

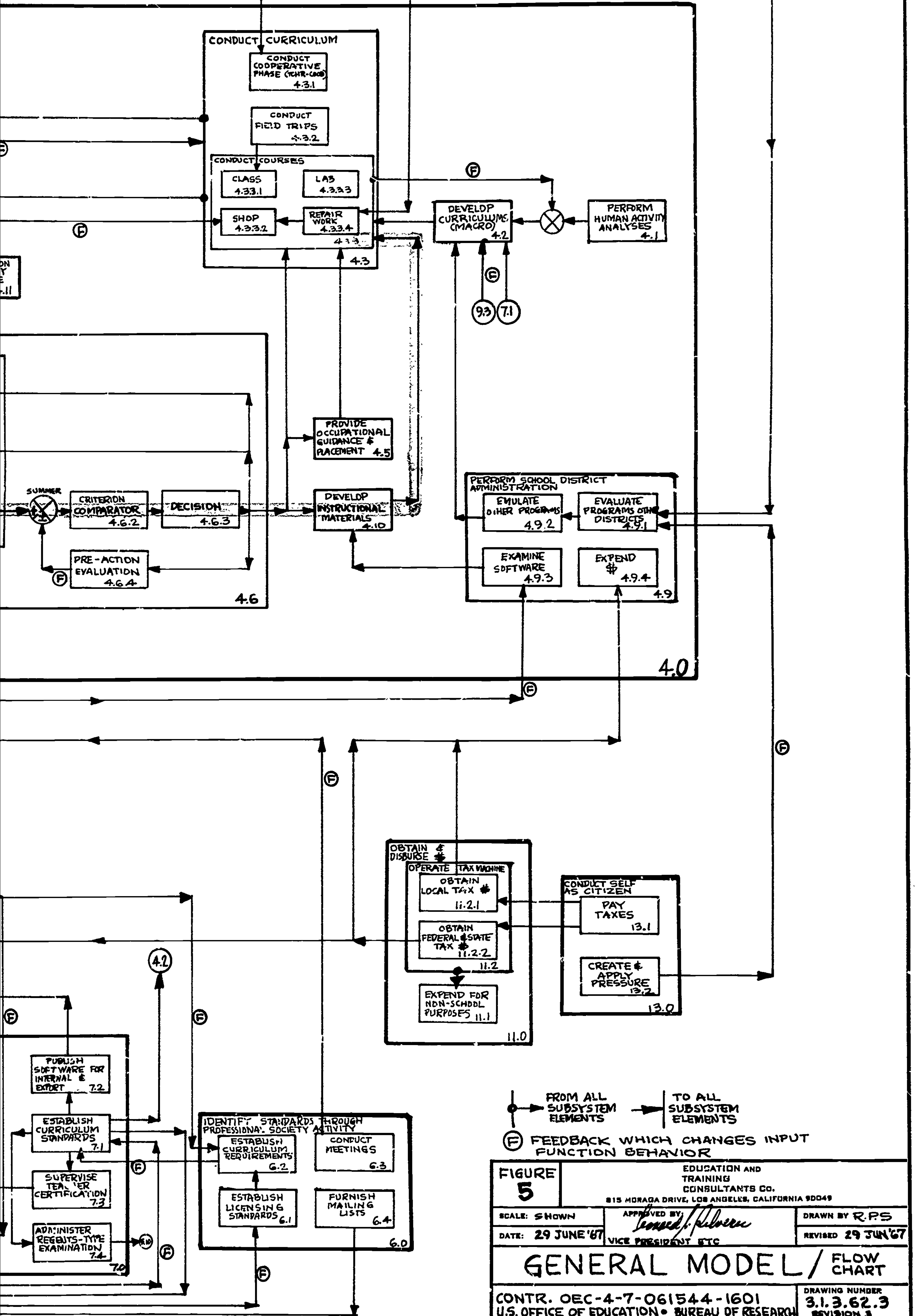
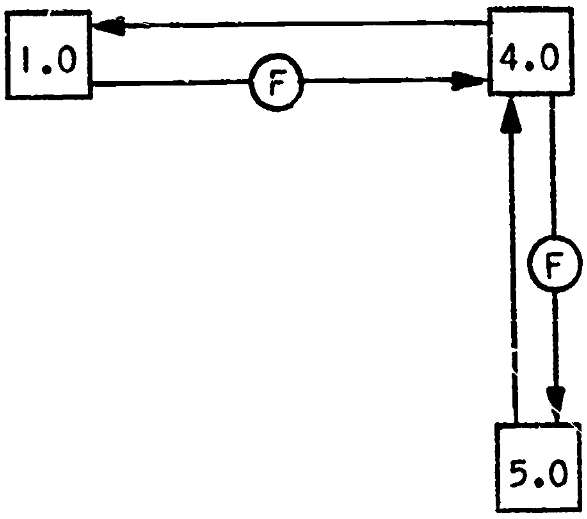
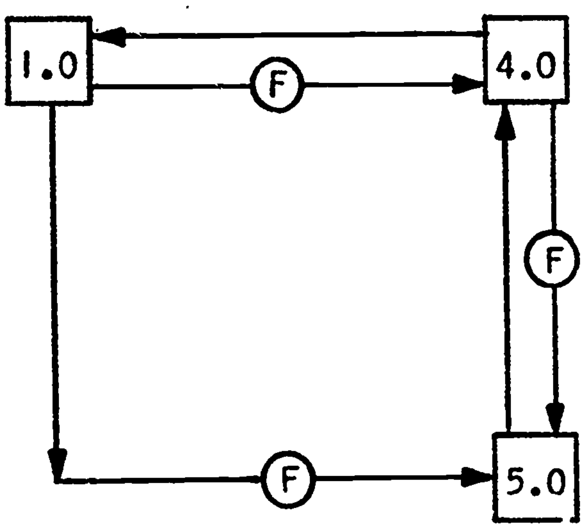

CONDUCT CURRICULUM
CONDUCT COOPERATIVE PHASE (TCHR-COOR) 4.3.1
CONDUCT FIELD TRIPS 4.3.2
CONDUCT COURSES
CLASS 4.3.3.1
LAB 4.3.3.3
SHOP 4.3.3.2
REPAIR WORK 4.3.3.4
4.3.3
4.3
DEVELOP CURRICULUMS (MACRO) 4.2
PERFORM HUMAN ACTIVITY ANALYSES 4.1
9.3
7.1
PROVIDE OCCUPATIONAL GUIDANCE & PLACEMENT 4.5
SUMMER
CRITERION COMPARATOR 4.6.2
DECISION 4.6.3
DEVELOP INSTRUCTIONAL MATERIALS 4.10
PRE-ACTION EVALUATION 4.6.4
4.6
PERFORM SCHOOL DISTRICT ADMINISTRATION
EMULATE OTHER PROGRAMS 4.9.2
EVALUATE PROGRAMS OTHER DISTRICTS 4.9.1
EXAMINE SOFTWARE 4.9.3
EXPEND $ 4.9.4
4.9
4.0
OBTAIN & DISBURSE $
OPERATE TAX MACHINE
OBTAIN LOCAL TAX $ 11.2.1
OBTAIN FEDERAL & STATE TAX $ 11.2.2
11.2
EXPEND FOR NON-SCHOOL PURPOSES 11.1
11.0
CONDUCT SELF AS CITIZEN
PAY TAXES 13.1
CREATE & APPLY PRESSURE 13.2
13.0
4.2
PUBLISH SOFTWARE FOR INTERNAL & EXPORT 7.2
ESTABLISH CURRICULUM STANDARDS 7.1
SUPERVISE TEACHER CERTIFICATION 7.3
ADMINISTER REGENTS-TYPE EXAMINATION 7.4
7.0
IDENTIFY STANDARDS THROUGH PROFESSIONAL SOCIETY ACTIVITY
ESTABLISH CURRICULUM REQUIREMENTS 6.2
CONDUCT MEETINGS 6.3
ESTABLISH LICENSING STANDARDS 6.1
FURNISH MAILING LISTS 6.4
6.0
FROM ALL SUBSYSTEM ELEMENTS
TO ALL SUBSYSTEM ELEMENTS
F FEEDBACK WHICH CHANGES INPUT FUNCTION BEHAVIOR
FIGURE 5
EDUCATION AND TRAINING CONSULTANTS Co.
815 MORAGA DRIVE, LOS ANGELES, CALIFORNIA 90049
SCALE: SHOWN
APPROVED BY:
VICE PRESIDENT ETC
DRAWN BY R.P.S
DATE: 29 JUNE '67
REVISED 29 JUN '67
GENERAL MODEL / FLOW CHART
CONTR. OEC-4-7-061544-1601
U.S. OFFICE OF EDUCATION • BUREAU OF RESEARCH
DRAWING NUMBER 3.1.3.62.3
REVISION 3

Figure 3





c. consider a number of mathematical techniques to quantify the flowchart model in a, above.

d. select the most promising technique and synthesize a set of mathematical expressions which support the position that the model will measure existing occupational teacher performance insofar as updating course content is concerned.

e. publish the results of the study so federal government agencies, as producers and disseminators of data, will learn how to adjust data configuration and current dissemination channels to allow their products to reach and be used by large numbers of occupational teachers and be retransmitted to students.

f. publish the results of the study so other generators of data, represented by functions (5.1), (5.2), (5.3), (5.4), (5.5), (5.6), (5.7) and (5.10) in Figure 3, will understand and accept systems techniques as applied to updating occupational course content in secondary schools.

g. publish the results of the study so the *techniques* of *anasynthesis*; i.e. analysis, synthesis, modeling, and simulacion; as illustrated by this project can be understood and used in general as well as occupational education (6).

B. APPROACH TO PROBLEM

1. Refinement of the Flowchart Model

It is necessary to decompose (5.8) to at least the fourth level of detail so functions and interrelating signal paths are clearly revealed. The sequence of events is:

a. conceptualize a flowchart model of (5.8) based upon the knowledge and experience of the investigators, corresponding to (2.0) of Figure 4.

b. present this subsystem model as an interview-based stimulus to a small number of highly expert individuals in a university setting who respond analytically using their experience; experts have direct contact with secondary school occupational instructors and library documentation practices, corresponding to (1.0) of Figure 4.

c. reconceptualize this subsystem using responses from experts, corresponding to (2.3) of Figure 4.

d. perform a low-fidelity simulation to test and debug the model, corresponding to (3.0) of Figure 4.

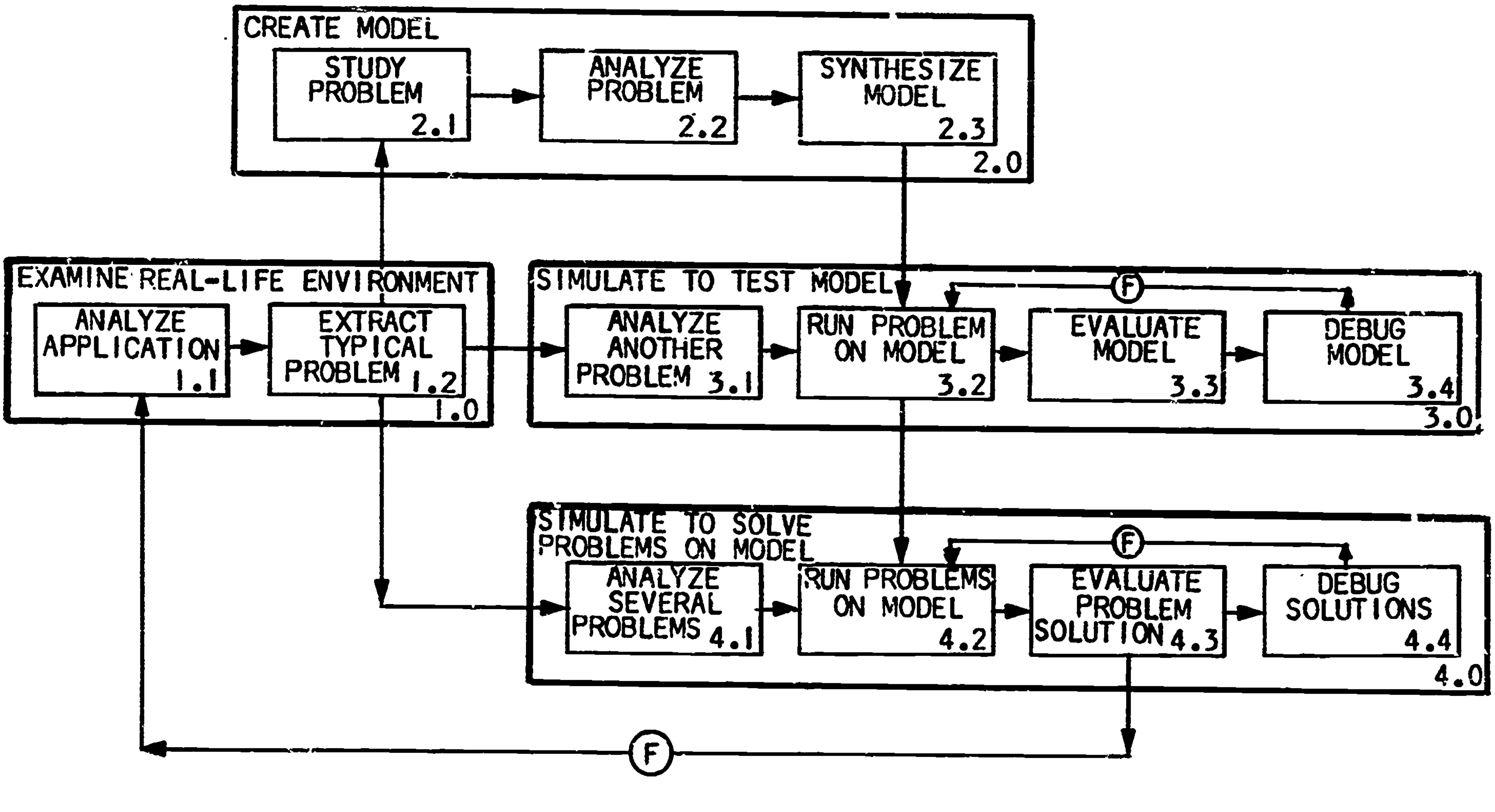


Figure 4 - Model for Producing a Model

2. Conceptualization of the Mathematical Model

a. assume that all content updating is performed in (4.10) of Figure 3, and that this occurs independently of (4.2) which refers essentially to the introduction of completely new or completely revised groups of courses constituting a curriculum.

b. consider the course content as a Markov chain of *main facts* and *teaching points*; a course consists of lessons, lessons consist of main facts, main facts consist of teaching points (7).

c. define *KEYCEPT* as:
   (1) the key word analog of the concept expressed by a main fact (a group of teaching points) in a human-instruction lesson plan.
   (2) consisting of one or more key words which are nouns, adjectives, verbs and/or adverbs.
   (3) an element of a Markov chain.

d. treat *KEYCEPT* mathematically and overlay the equations on the appropriate subsystems in Figure 3, corresponding to (2.3) of Figure 4.

3. Relationship to Real-Life

It is desirable to synthesize the model by using real rather than contrived data. By definition, a course consists of lessons and the document which contains lesson *content* and *method* is the *LESSON PLAN*. Therefore, obtain a small sampling of lesson plans from occupational teachers; examine these to verify that *KEYCEPTS* do, in fact, exist and are present in the typical plan.

The *KEYCEPT* is created in (4.6) of Figure 3 and is recorded on the lesson plan form in (4.10). The lesson plan is used by the instructor in (4.3) and the *KEYCEPT* is indicative of the information that is transmitted to the student (4.4). The *KEYCEPT* as such is not transmitted.

The mathematical modeling aspect of the study will be concerned with the (5.8)$\rightarrow$(4.6)$\rightarrow$(4.10) section of the loop.

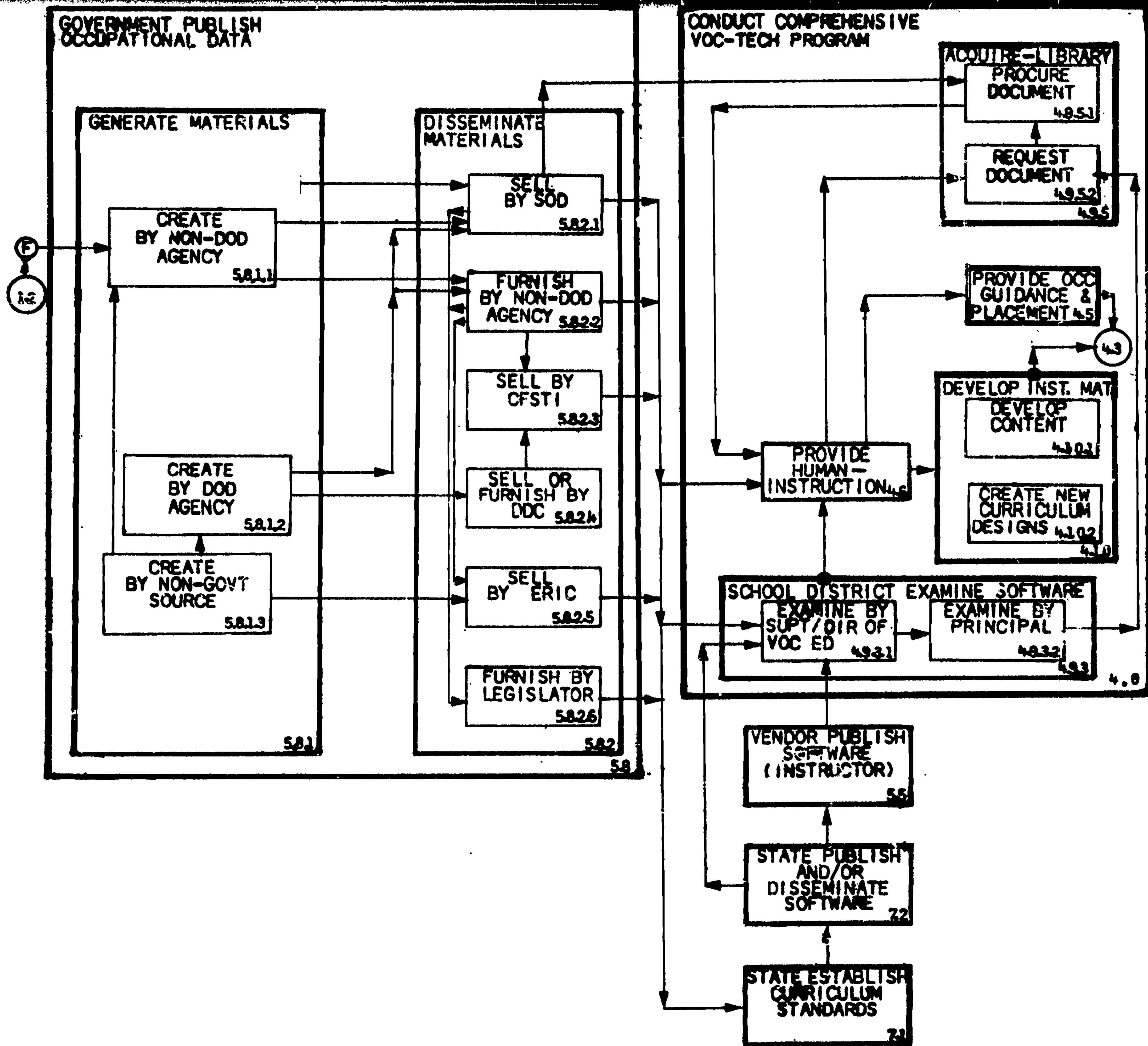
C. ANALYSIS

1. Flowchart Model

This section reflects the experience of five experts and the ETC investigators identified in ACKNOWLEDGEMENTS. Reference is made to Figure 3 which resulted from the initial study (2), and to Figure 5 which resulted from steps 1a, 1b and 1c, page 11. However, responsibility for the design of this submodel rests exclusively and solely with the principal and associate investigators.

see Page 13a

Figure 5 - Reconceptualized Configuration of (5.8) (4.0), (5.5) and (7.1)


GOVERNMENT PUBLISH OCCUPATIONAL DATA
GENERATE MATERIALS
CREATE BY NON-DOD AGENCY 5.8.1.1
CREATE BY DOD AGENCY 5.8.1.2
CREATE BY NON-GOVT SOURCE 5.8.1.3
5.8.1
DISSEMINATE MATERIALS
SELL BY SOD 5.8.2.1
FURNISH BY NON-DOD AGENCY 5.8.2.2
SELL BY CFSTI 5.8.2.3
SELL OR FURNISH BY DDC 5.8.2.4
SELL BY ERIC 5.8.2.5
FURNISH BY LEGISLATOR 5.8.2.6
5.8.2
5.8
F
1.2
CONDUCT COMPREHENSIVE VOC-TECH PROGRAM
ACQUIRE-LIBRARY
PROCURE DOCUMENT 4.9.5.1
REQUEST DOCUMENT 4.9.5.2
4.9.5
PROVIDE OCC GUIDANCE & PLACEMENT 4.5
4.3
DEVELOP INST. MAT
DEVELOP CONTENT 4.10.1
CREATE NEW CURRICULUM DESIGNS 4.10.2
4.10
PROVIDE HUMAN-INSTRUCTION 4.6
SCHOOL DISTRICT EXAMINE SOFTWARE
EXAMINE BY SUPT/DIR OF VOC ED 4.9.3.1
EXAMINE BY PRINCIPAL 4.9.3.2
4.9.3
4.0
VENDOR PUBLISH SOFTWARE (INSTRUCTOR) 5.5
STATE PUBLISH AND/OR DISSEMINATE SOFTWARE 7.2
STATE ESTABLISH CURRICULUM STANDARDS 7.1

a. Analysis of (5.8)

(5.8) is analyzed as having two functions, (5.8.1) GENERATE MATERIALS, and (5.8.2) DISSEMINATE MATERIALS. Technical materials are created in (5.8.1.1) by federal agencies other than the Department of Defense (DOD), often as *byproducts* of their routine activities. These may be purchased from the Superintendent of Documents (SOD) in (5.8.2.1), or requested from the generating agency (5.8.2.2).

DOD creates materials (5.8.1.2) not only as byproducts but as *endproducts* for training and education programs. Additionally, it contracts for the creation of materials from non-government sources (5.8.1.3) and these materials are often available to Educational Resources Information Center (ERIC) organizations (5.8.2.5). It is true to a lesser degree that (5.8.1.1) will contract for the creation of materials by non-government sources as revealed by the signal path from (5.8.1.3) to (5.8.1.1).

DOD produces (5.8.1.2) or has produced for it (5.8.1.3) materials which *must* by regulation or law be deposited in the Defense Documentation Center (DDC) as described in (5.8.2.4). Occupational teachers ordinarily do not qualify for documents held by DDC. However, certain (5.8.2.4) documents are released to the Clearinghouse for Scientific & Technical Information (CFSTI) shown in (5.8.2.3) and may be obtained as described in Figure 5. (5.8.2.3) also processes documents from (5.8.1.1) through function (5.8.2.2). In addition to receiving documents from (5.8.1.3), ERIC (5.8.2.5) also receives inputs from (5.8.2.2).

Finally, legislators (5.8.2.6) receive materials from (5.8.2.1) and (5.8.2.2) and furnish these whenever practicable.

The (5.8) function as described should account for nearly 100% of government published data which is approved for external consumption.

b. Analysis of (4.0)

(4.0) as depicted in Figure 3 is expanded to the detail in Figure 5. The occupational teacher (4.6) can receive inputs from all functions in (5.8.2) *except* (5.8.2.4). The school library may receive promotional information from (5.8.2.1) and this might reach (4.6), but the teacher is normally his own search and early-warning sensor. If he is aware of a specific document, he may request it through the school library (4.9.5.1) and the path (4.6)→(4.9.5.1)→(4.9.5.2)→(4.6) is followed.

$$\begin{array}{c} (4.9.5.2) \\ \uparrow \\ (5.8.2.1) \end{array}$$

A more circuitous route involves the acquisition by an appropriate subpart of a state education agency of documentation (7.1) from (5.8.2). This is disseminated in (7.2) and reaches the local school district office (4.9.3.1). It is also possible for (7.1) to disseminate information from (5.8) by inputting (7.2) into (5.5) where a commercially-oriented organization will convert it into instructor's materials which reach the teacher through path (5.5)→(4.9.3.1)→(4.9.3.2)→(4.6). Even if (4.9.3.2) is bypassed, the path is

extremely long with a transit time measured in years.

The school district (4.9.3.1) need not rely solely upon path (7.1) → (7.2) → (5.5) but can input directly form (5.8.2). The Superintendent of Schools and/or the District Director of Vocational Education receive the inputs (4.9.3.1) and either file them or pass them on to the Principal (4.9.3.2) or to the teacher (4.6) perhaps through a department chairman. It is possible for an interested Principal (4.9.3.2) to order materials through his school or district professional library (4.9.5.2) for his teachers. Materials which contribute to *updating* of occupational course content are not usually ordered by Principals for their own use.

The teacher (4.6) will occasionally use the documentation to assist him in performing the *occupational* guidance and placement function (4.5) which occurs in (4.3.3). However, this study is concerned mainly with updating content for skills and knowledge rather than for guidance purposes although there is a side effect reinforcing guidance.

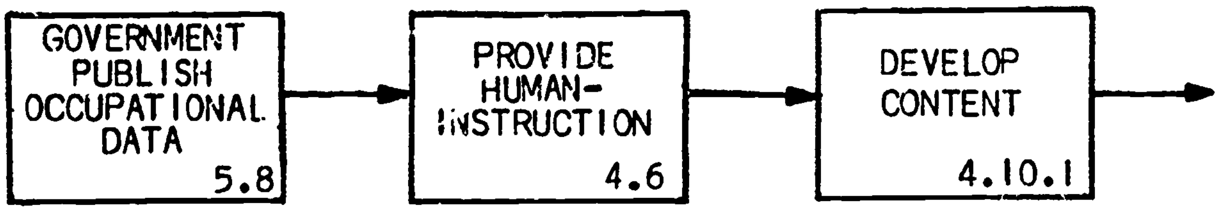
It is in fuction (4.10) that the development of instructional materials is performed by (4.6). The basic device is the *lesson plan* containing content coupled with the method of instructing the content in detail. The teacher (4.6) uses his inputs to update old *content* by modifying main facts and teaching points in (4.10.1). If he utilizes his inputs to improve the *method* of instruction, this is performed in (4.10.2). There is an interaction between (4.10.1) and (4.10.2) when content updating calls for a new method and when new methods force a review of old content. The best instruction and optimized learning occurs when content dictates the method for communicating....rather than the reverse. At the secondary school level, particularly in occupational subjects, the body of knowledge for any particular subject is both well-defined and voluminous. Therefore, content updating decisions to include, delete, or otherwise modify existing content will dictate the method.

2. Mathematical Analysis

The principal objective of the mathematical analysis is to ***measure existing occupational teacher performance insofar as updating course content is concerned*** as described in 4d, page 10. This objective requires the measurement of

a. teacher performance
b. old course content
c. updated course content

The first objective of the mathematical analysis is to describe course content in mathematical terms. Then updated course content can be compared readily with the old to determine the amount of change. This actual change can then be compared with the desired change to determine the teacher's performance. The *open-loop* part of closed-loop (5.8) → (4.6) → (4.10) → (4.3) → (4.4) → (1.2.1) → (1.1.1) → (1.5.4) → (4.7) → (4.6) to be analyzed is:



The first step is to analyze course content in function (4.10.1)

a. Mathematical Representation of Course Content

Consider a course as a sequence of main facts and associated teaching points:

1.1.1 Main Fact, $MF(t_1)$
  1.1.1.1 Teaching Point
  1.1.1.2 TP
  ⋮
  n TP
1.1.2 $MF(t_2)$
etc.

where $MF(t_i)$ designates the ith main fact occurring at time t_i. The whole course $C(t)$ is described by the equation:

$$C(t) = MF(t)$$

$$C(t) = \begin{cases} MF(t_0), & 0 \leq t \leq t_1 \\ MF(t_1), & t_1 \leq t \leq t_2 \\ \vdots & \\ MF(t_{n-1}), & t_{n-2} \leq t \leq t_n \end{cases}$$

$$C(t) = \sum_{i=0}^{n-1} MF(t_i)[U(t_i) - U(t_{i+1})] \tag{1}$$

where U is the unit step function.

Equation (1) defines a course as a sequence of main facts.
To compare two courses prepared by two occupational teachers on the same subject, the course equations could be developed in detail and would show whether or not the courses were identical. Because teachers are human and have individual differences, it is quite likely that the courses would not be the same. That is, in general:

$$C_A(t) \neq C_B(t) \tag{2}$$

where the course subscripts A and B refer to two different teachers. However, in comparing two different versions of a course, the interest is in how much are they alike or, particularly for this study, how up-to-date is the course.

Since, these are *statistical* concepts of equality, it is necessary to describe main facts in statistical terms. Each main fact appears in the lesson plan as a collection of words. The main fact dealing with any subject-matter is described by certain key words which will be used by most occupational teachers when preparing a lesson plan for the course.

Now, define $MF(t)$ by the statistics of its key words. Consider these

key word statistics on the key word or w-domain. Then, on the main fact-key word plane, there will be this joint probability density function:

$$p(w, MF(t_i)) = p(w|MF(t_i))p(MF(t_i)) \tag{3}$$

The probability will be non-zero for only certain points in the MF-w plane. These points are the key words that represent each specific main fact. This set of key words is called the *KEYCEPT* for a specific main fact as illustrated in figure 6.

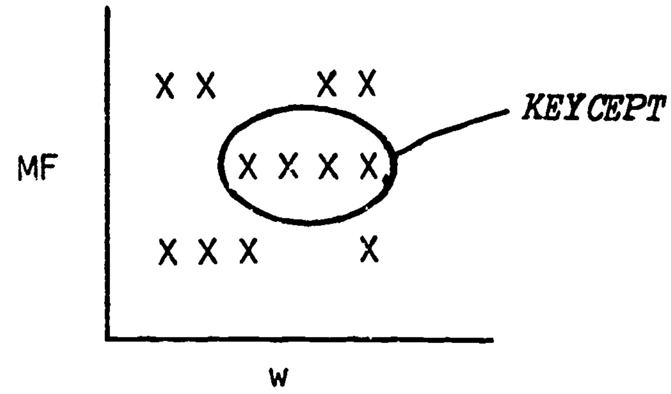


Figure 6 - *KEYCEPT* for a Specific Main Fact Defined on MF-w Plane

The *KEYCEPT* is fixed, thus the conditional probability of key words given a main fact is time-independent:

$$p(w|MF(t)) = p(w|MF) \tag{4}$$

Then, equation (3) may be stated:

$$p(w, MF(t)) = p(w|MF)p(MF(t)) \tag{5}$$

where the only time-dependence is in the last density function. This density function defines the way in which main facts are ordered to synthesize the course. The time-dependence therein is, in fact, the Markov chain statistics for the main fact sequence. In a logically structured course, such as automotive mechanics, the chain would be expected to be of high order while in a less logically structured course the order should be lower.

The chain statistics have meaning also with respect to the organization of a single teacher's course. The more ***tightly organized*** the course is, the longer will be the chain n. This long chain length reduces the course information content so it is teachable. Therefore, for well-taught courses, i.e. those instructed by good teachers, the chain statistics may be as time-independent as the *KEYCEPT* statistics.

b. Updated Documentation Representation

Figure 1 describes the flow of updated documentation (5.0) to the occupational teacher (4.0). A more explicit flowchart, Figure 3, identifies the flow as (5.8)→(4.6.1.1)→(4.6.2)→(4.6.3)→(4.10).

In order to determine the performance of occupational teachers (4.6) who incorporate updated documentation into their old course content, (4.10), the documentation and content must be commeasurate. In other words, the updated documentation must be represented so course content statistics may be compared with it. One simple way to accomplish this is to select one *KEYCEPT* for the documentation, then use this as the mean value of the desired updated course content. A slightly more complex representation would be, in addition, to specify acceptable variance limits for the updated documentation.

c. Evaluation of Teacher Performance

The evaluation method established by the representation under discussion is clearly a *statistical* process. *One* occupational teacher's performance can be evaluated when he is updating content during several different updating events, or the performance of the teacher *population* can be evaluated in a specified updating situation. However, meaningful evaluation cannot be conducted of the performance of one teacher in a single updating event. Indeed, the most important and immediate issue is to insure that most course content is up-to-date. This continues to be a *statistical* problem.

The performance of the system during one updating event can be examined by measuring the variance of performance from the specified mean *KEYCEPT*. First, count the different *KEYCEPTS*. Then, arrange this data in histogram form, ordering the *KEYCEPTS* by the number of times they occur, and placing them alternately on opposite sides of the mean. Next, calculate the variance in numbers of *KEYCEPTS*. The *figure of merit*, M, for the system is

$$M = E[(K_i-\overline{K})^2] \tag{6}$$

where E is the expected value of quantity $(K_i-\overline{K})^2$; K_i is ith *KEYCEPT* and $\overline{K}$ is the specified mean *KEYCEPT*.

d. Evaluation of Updated Content

The effectiveness of the updated content can be similarly evaluated. The specified mean *KEYCEPT* must reflect the true intentions ,I, of the generator (5.8) of the original updating material. How well this objective is met may be evaluated by

$$I = |\overline{K} - \sum_i K_i p(K_i)| \tag{7}$$

If *all* of the original updating material is used, $I = |\overline{K}-\overline{K}| = 0$ and all of the intentions are implemented.

3. Application to Sample

Two factors must be examined at a practical operating level: 1) obtaining actual lesson plans, and 2) generating *KEYCEPTS*. This constitutes, in fact, a low-fidelity simulation of the models developed, and corresponds to 1d on page 11, and subsystem 3.0 in Figure 4.

Sample lesson plans were obtained on a random basis, corresponding to (1.2) of Figure 4. Because the study did not include a full-scale simulation, updating materials specifically related to these plans were not sought. Hence, M *(Figure of Merit)*, and I *(True Intention of the Generator)* cannot be experimentally evaluated as depicted in (3.3) of Figure 4.

a. Acquisition of Sample

Using an ETC mailing list of more than 2,000 individuals who are officials, executives or employees of education or training organizations, the following criteria for selection were utilized:

(1) individual was in a vocational, vocational-technical, or technical public secondary school or school district,

(2) school or school district was in the U.S., including territories and possessions,

(3) individual was consulting in, managing, supervising, or instructing automotive mechanics and/or electrical courses.

A letter, Appendix I-1, and a general statement of the study, Appendix I-2, were sent to 86 individuals who satisfied the selection criteria.

b. Data on Obtaining Lesson Plans

Summary of data follows:

Letters (Appendices I-1, I-2)	86
Responses, total	26
Responses, with lesson plans or course outlines, or both	21
Responses, acknowledgement without lesson plans or course outlines	5

Lesson plans in vocational-technical secondary education tend to be more formalized than in general or academic education. A history of the development of the lesson plan movement, beginning with Herbart in 1806, has revealed this gradual evolution (8). Despite the fact that Charles R. Allen popularized Herbartian philosophies, and contributed to the implementation of the Smith-Hughes Act which resulted in uniformity and near-standardization, lesson plans are still individualized and vary widely in format. This position is supported by examination of the lesson plans submitted.

For the purposes of this study, lesson plans of 6 responding organizations were used.

The instructor writes his lesson plan in a kind of shorthand which communicates *to him* but not necessarily to someone else who looks at it.

For example, he may write:

Radiator core
- Types
- Construction
- Purpose
- Servicing
- Testing

The 'types,' details of 'construction,' etc., are actually *mnemonics* or symbolic of teaching points but are not, in fact, teaching points. Here is an example of a clear Main Fact (MF) and Teaching Point (TP) sequence:

Uses of Cooling Systems
- remove excessive heat
- maintain desirable heat
- complement lubricating system
- provide heat for passenger comfort

The investigators considered mnemonics in examining submitted lesson plans.

c. Generation of *KEYCEPTS*

(1) procedure
A procedure was designed following these steps
- (a) identify each MF
- (b) identify w for all MF
- (c) generate $p(w|MF)$ in the form of a histogram
- (d) scan and iterate w set for MF until reduction produces w's with <u>highest</u> $p(w|MF)$

The main objective was to establish the procedure (subsystem of model) and test it by simulation. A secondary objective was to determine the criterion for the number (n) of w's per *KEYCEPT*.

(2) simulation #1 (Automotive Spark Plugs)
Appendix H-3 represents a typical classroom-type lesson plan as submitted to ETC. The investigators identified all MF and TP by marking with hand-lettered MF and TP. This corresponds to 1d on page 11 and to sequence (1.2)→(3.1)→(3.2) in Figure 4.

The sections, "Instructional Materials" and "Test," were not identified as containing MF and/or TP.

(a) identify each MF

MF - objectives
MF - introduction
MF - construction
MF - features
MF - service procedures

(b) identify $\bar{w}$ for all MF

<u>MF - objectives</u>
- spark
- plug
- feature

<u>MF - introduction</u>
- spark
- plug

<u>MF - construction</u>
- electrodes
- insulator
- seals
- shell

<u>MF - features</u>
- thread
- reach
- heat range
- gap

<u>MF - service [procedures-deleted]</u>

removing cleaning gapping installing	change to	remove clean gap install

(c) generate p(w|MF) by counting number of times a w (key word) appears and plotting this as a histogram

<u>MF - objectives</u>

spark	2
plug	2
feature	2

<u>MF - introduction</u>

spark	3
plug	2

<u>MF - construction</u>

electrodes	1
insulator	1
seals	1
shell	1

<u>MF - features</u>

thread	1
reach	1
heat range	1
gap	1

MF - service	
remove	1
clean	1
gap	1
install	1

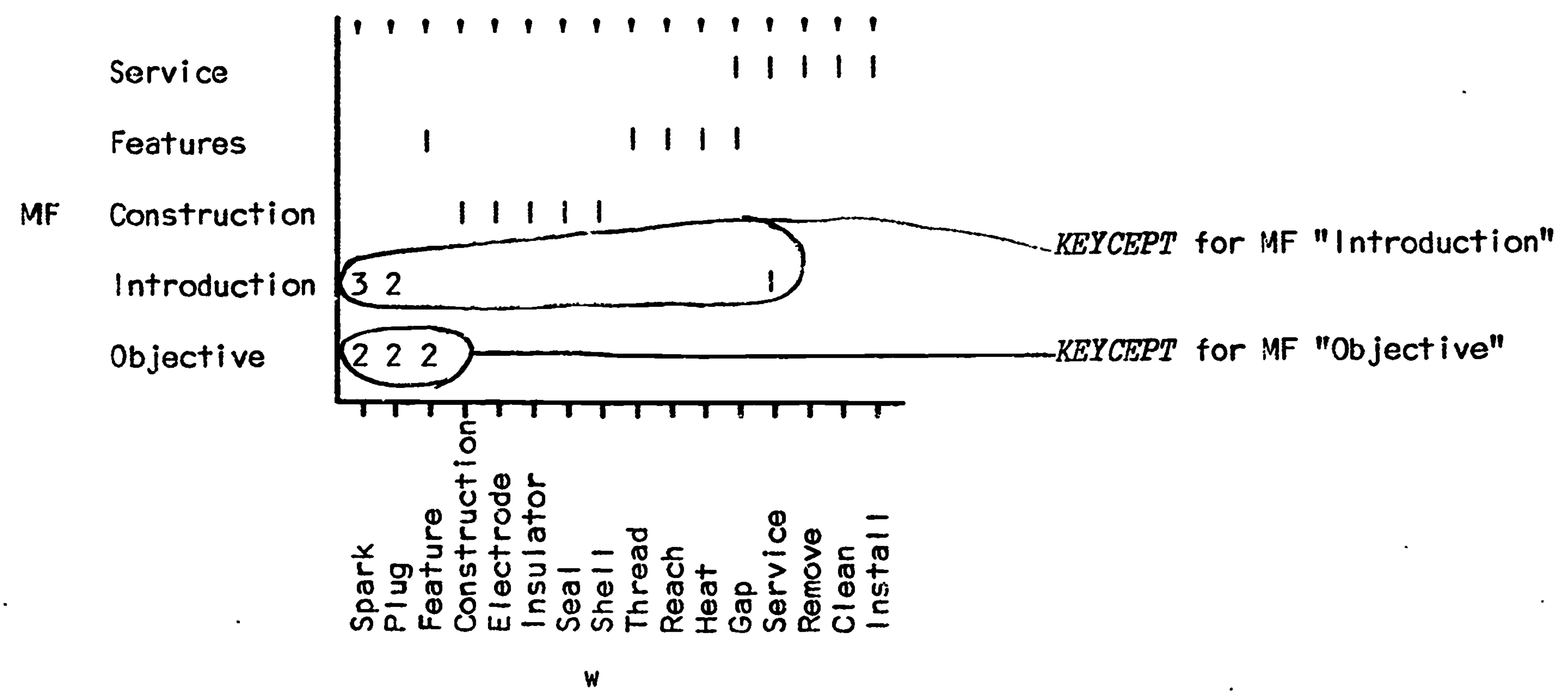


Figure 7 - *KEYCEPTS* for Specific MFs Defined on MF-w Plane; Simulation #1.

(d) scan and iterate w set for MF until reduction produces w's with highest p(w|MF).

The histogram in Figure 7 reveals the *KEYCEPTS* for all MF. This may be compared with the *theoretical* histogram in Figure 8.

On a tentative basis, the criterion for W/K (number of words per *KEYCEPT*) is: a specific W must appear at least twice in some MF.

(3) simulation #2 (Cooling System)
Appendix H-4 represents a typical classroom-type lesson plan as submitted to ETC. As before, MF and TP were identified by hand-lettering. This simulation corresponds to 1d on page 11 and to sequence (1.2)→(3.1)→(3.2) in Figure 4. All sections contained MF and/or TP.

(a) identify each $\overline{MF}$

MF - Introduction
MF - Types
MF - Uses
MF - Components/Liquid
MF - Components/Air
MF - Temperature
MF - Heat Sources
MF - Heat Dissipation
MF - Enemies
MF - Pumps
MF - Thermostat
MF - Core
MF - Fan
MF - Restrictions
MF - Pressure Systems
MF - Pressure Caps
MF - Antifreeze
MF - Servicing
MF - Air Cooled
MF - Summary

(b) identify w for all MF

[same procedure as in simulation #1]

(c) generate $p(w|MF)$ by counting number of times w appears and plotting this as a histogram, Figure 8.

In the process of developing Figure 8, it was discovered that *engine* and *lubricate* were of high-frequency and had been inadvertantly omitted in the first pass through (b) above. ETC believes this does not call for creating and adding an additional step to the procedure designed on page 20.

(d) scan and iterate w set for MF until reduction produces w's with highest $p(w|MF)$

The histogram in Figure 8 reveals that five w's, marked ×, have only one representation in any one MF. If the w-domain for defining *KEYCEPT* is restricted to w's which occur more than once in *some* MF, then those marked × are to be discarded. This does not create any ambiguity in relating an MF with its *KEYCEPT*.

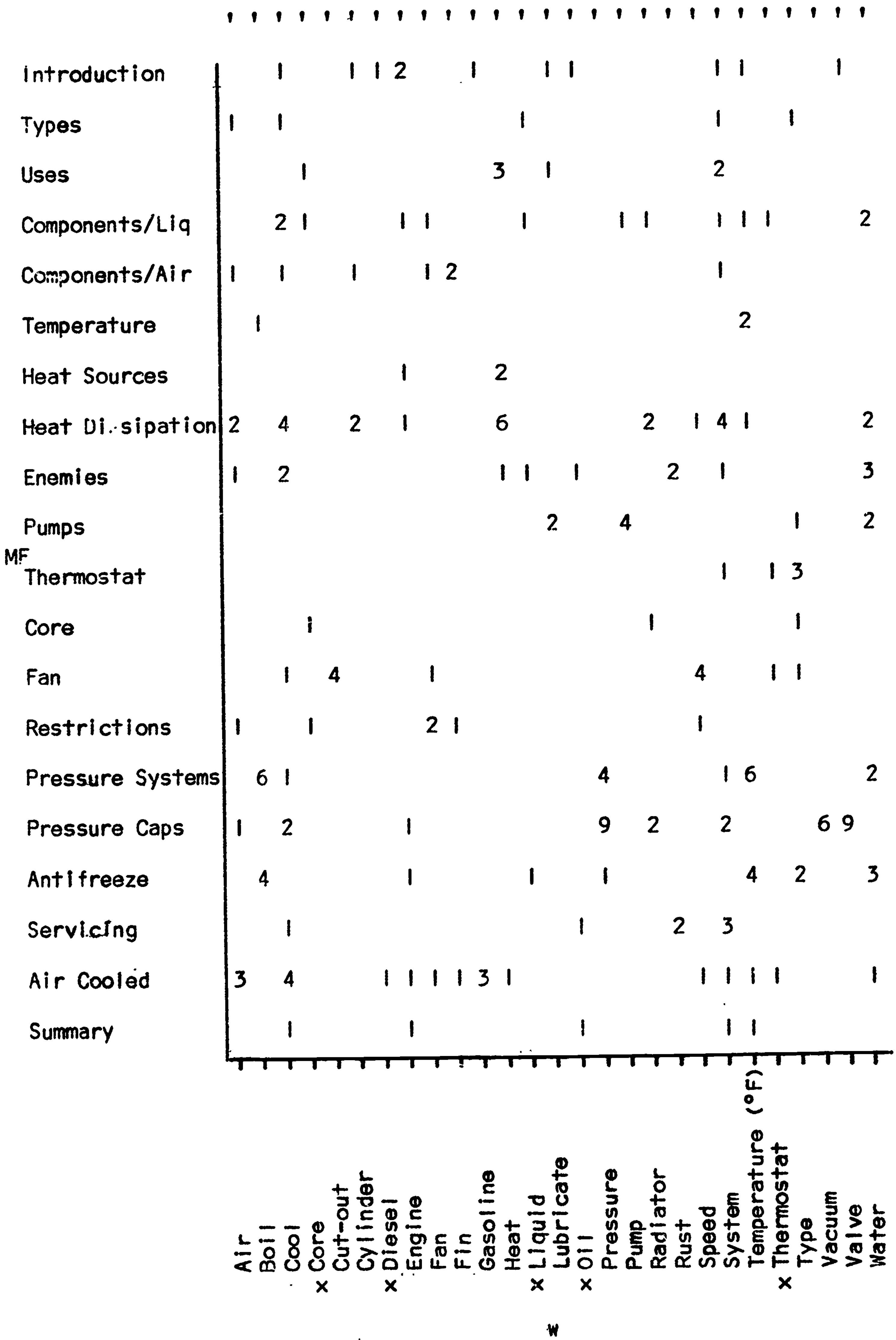


Figure 8 - *KEYCEPTS* for Specific MFs
Defined on MF-w Plane; Simulation #2

D. Summary of Analysis

1. Origin and Flow of Government-Published Information

The study has examined the origin and flow of government-published information initially identified in Figure 2 and reconceptualized in Figure 5.

The flow of information is (5.8)→(4.6)→(4.10.1) as shown on page 16 and is the open-loop part of the complete close-loop (5.8)→(4.6)→(4.10)→(4.3)→(4.4)→(1.2.1)→(1.1.1)→(1.5.4)→(4.7)→(4.6)

2. Quantification

The study has produced a mathematical representation consisting of *models* on pages 16-18. This corresponds to subsystem 2.0 in Figure 4. Simulation was performed twice to be certain the *models* were of high- fidelity. Only two samples were used, thus the *simulation* was itself of low-fidelity. This corresponds to subsystem 3.0 in Figure 4.

E. Discussion of Results

1. Validity of Model

The histograms in Figures 7 and 8, based solely upon real-life human-instructor lesson plan content, compare well with the concept expressed in Figure 6.

In the simulation effort, the lesson plan for "Automotive Spark Plugs" was only at the 2nd level of detail and was highly mnemonic, i.e. the instructor relied mainly upon his own memory, or used other documentation, in his lesson. It was in his shorthand which communicated to him. This is supported by the "test" part which uses such terms as: fuel-air mixture; high-speed conditions; voltage requirements; fluffy, black, dry deposits; fouling; polarity; blistered, burned, badly eroded electrodes; etc. For this reason, simulation #1 in Figure 7 revealed only low w-counts for $p(w|MF)$.

However, the lesson plan for "The Cooling System" reached the 4th level of detail and was quite specific and complete in detailing various elements at all levels. This is shown in simulation #2, Figure 8. The $p(w|MF)$ in this lesson is represented by higher w-counts, accompanied by a low mnemonic level.

2. Synthesis of Updating Subsystems

What appears to be missing from the network is a return path from the real-life situation (1.0) to the educational institution (4.0) and/or to generator (5.0). This return path would close the loop, thereby producing one of the ideograms on page 9.

However, feedback signal paths from (1.0) to (4.0) alone do not produce changes in, or control, the output of (5.0). If the design objective is to *update* instructional content, through the use of technical government-published information, then (5.0) must output to (4.0) and (4.0) must have a return feedback path to (5.0). Of course, it is possible for this return to pass through (1.0) and then return to (5.0).

After examining the real-life lesson plans and the mathematical modelling and simulation, it has become clear that a feedback return *through* (4.0) would take too long and that an additional path from (4.0) to (5.0) would be of great value.

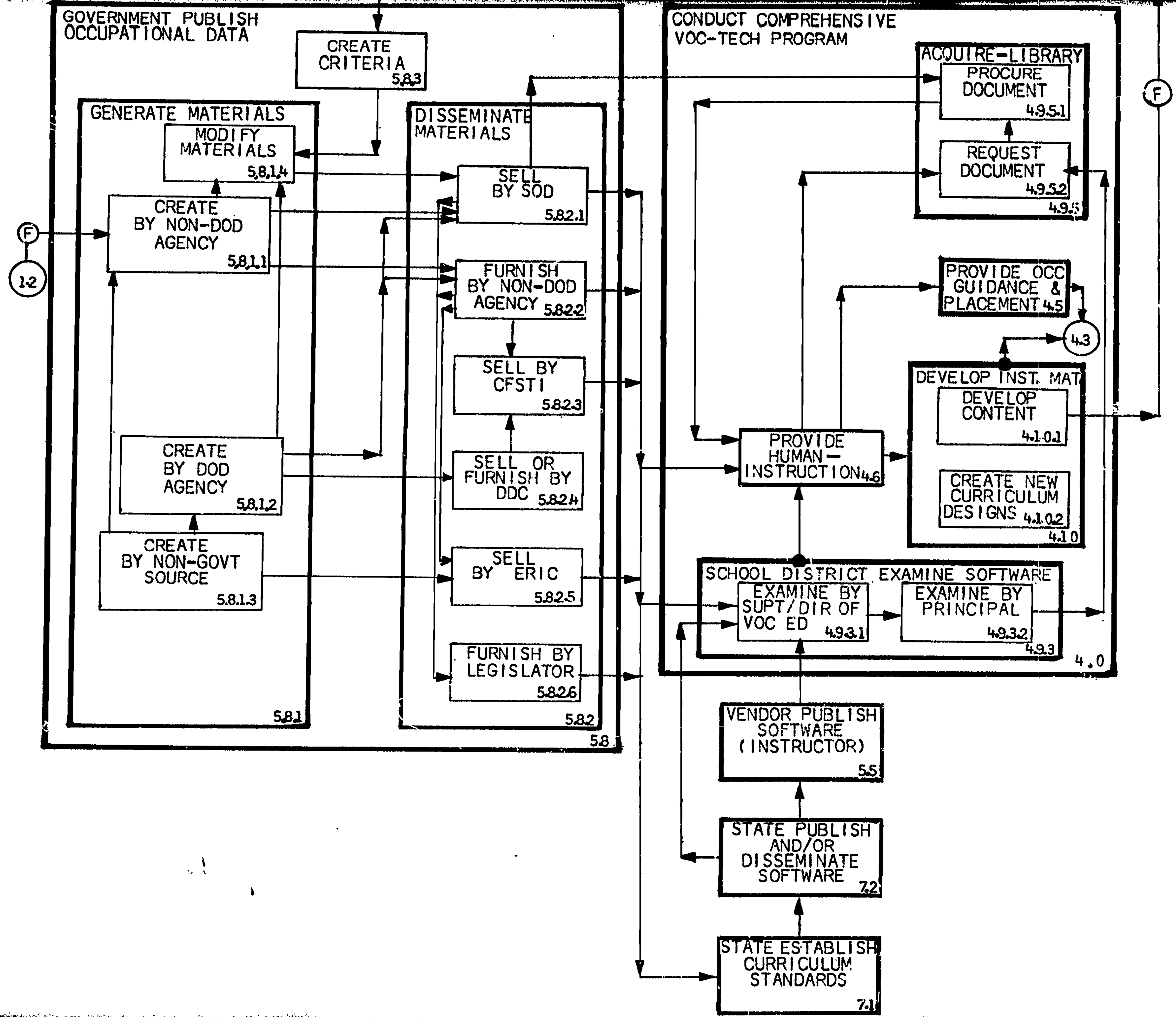
This path is seen in Figure 9 as (4.6)→(4.1.0.1)→(5.8.3)→(5.8.1.4)→(5.8.2.1)—(4.6). A close alternative is (4.6)→(4.9.5.2)→(4.9.5.1)→(5.8.2.1)→(4.9.5.1)→(4.6)→(4.1.0.1)→(5.8.3)→(5.8.1.4)→(5.8.2.1)→(4.9.5.1)→(4.6). They differ mainly in the specific manner of procurement from the Superintendent of Documents.

see Page 27a

Figure 9 - Reconceptualized Configuration
With Updating Subsystem Synthesis

When an agency creates data (5.8.1.1) it is sent to the Superintendent of Documents where it is disseminated to many individuals only some of whom may be occupational teachers (4.6). Let us create a function (5.8.1.4) which analyzes this data in the occupational frame of reference and then translates the most essential elements into a special format. This format has not been formularized but it has as its attributes:

a. high *figure of merit* (low or zero M)
b. high *frequency* (f) capability
c. low or zero variance from *intention of the generator* (I)


GOVERNMENT PUBLISH OCCUPATIONAL DATA
CREATE CRITERIA 5.8.3
GENERATE MATERIALS
MODIFY MATERIALS 5.8.1.4
CREATE BY NON-DOD AGENCY 5.8.1.1
CREATE BY DOD AGENCY 5.8.1.2
CREATE BY NON-GOVT SOURCE 5.8.1.3
5.8.1
DISSEMINATE MATERIALS
SELL BY SOD 5.8.2.1
FURNISH BY NON-DOD AGENCY 5.8.2.2
SELL BY CFSTI 5.8.2.3
SELL OR FURNISH BY DDC 5.8.2.4
SELL BY ERIC 5.8.2.5
FURNISH BY LEGISLATOR 5.8.2.6
5.8.2
5.8
F
1.2
CONDUCT COMPREHENSIVE VOC-TECH PROGRAM
ACQUIRE-LIBRARY
PROCURE DOCUMENT 4.9.5.1
REQUEST DOCUMENT 4.9.5.2
4.9.5
PROVIDE OCC GUIDANCE & PLACEMENT 4.5
4.3
DEVELOP INST. MAT
DEVELOP CONTENT 4.1.0.1
CREATE NEW CURRICULUM DESIGNS 4.1.0.2
4.1.0
PROVIDE HUMAN-INSTRUCTION 4.6
SCHOOL DISTRICT EXAMINE SOFTWARE
EXAMINE BY SUPT/DIR OF VOC ED 4.9.3.1
EXAMINE BY PRINCIPAL 4.9.3.2
4.9.3
4.0
F
VENDOR PUBLISH SOFTWARE (INSTRUCTOR) 5.5
STATE PUBLISH AND/OR DISSEMINATE SOFTWARE 7.2
STATE ESTABLISH CURRICULUM STANDARDS 7.1

In other words, the occupational teacher continuously receives updating data in a format requiring virtually no alteration and which is integrated into his lesson plan and taught as it was intended to be comprehended by the author or translator.

The flow is (5.8.1.1)→(5.8.1.4)→(5.8.2.1)→(4.6)→(4.1.0.1)→(4.3) but feedback outputs (4.1.0.1) to (5.8.3) and returns to (5.8.1.4). The (4.1.0.1) function is sampled and enters into the comarator function (5.8.3) where it is mapped onto criteria. Communication malfunctions are detected and analyzed in (5.8.3) and these enter (5.8.1.4) and control the output to (5.8.2.1).

Without the feedback path (4.1.0.1)→(5.8.3)→(5.8.1.4), the output of (4.1.0.1) is under control of long time delay signals from various subsystems described elsewhere and depicted in Figure 3 (2). In terms of this study, and ignoring any other feedback signals, part of the model interrelating (5.8) and (4.10) is *open-loop*. The ideograms on page 9 are representative of this relationship.

With the feedback path (4.1.0.1)→(5.8.3)→(5.8.1.4), the output of (4.1.0.1) is under control of both short time and long time delay signals as described in Figure 9. The model in Figure 9 closely represents the lower ideogram on page 9. Again, in terms of this study and ignoring any other feedback signals, part of the model interrelating (5.8) and (4.10) is *closed-loop*.

The design of functions (5.8.3) and 5.8.1.4) in the process of synthesizing the updating subsystems and relationships is of great importance. In essence, the feedback can only be used to control the output of (5.8.1.4) if the products reach the occupational teacher and are used to update his lessons (4.1.0.1). There are many who prefer a *diminishing* of federal government relationships with operating level personnel such as secondary school teachers particularly when the input from Washington, D.C., is curriculum content. At first glance, the path (4.1.0.1)→(5.8.3)→(5.8.1.4) merely assists the government bureau in modifying (5.8.1.1) output so it can be better assimilated by (4.6). However, the path *is closed-loop* and this means the occupational teacher *must* use the government material in his lesson plans if the output of (4.1.0.1) is to be sampled and returned to (5.8.1.4) via ((5.8.3). In this sense, the design may appear to impose federal control of lesson plan content in public secondary schools at the local operating level....a clear violation of states rights and home rule.

However, the *crucial issue* is not one of federal control but of *system equilibrium.* The real-life environment which provides employment can survive and grow only if manpower competence keeps pace with technological growth. The open-loop design of nearly all educational configurations, which by definition is insensitive to the real-life environment, is *unstable* and in a state of disequilibrium. Managers from business, industry, and government organizations have long criticized secondary schools. Now, these managers are joined by students and parents who feel that high school graduates are not properly prepared for the real world of work. And, as might be expected, there are many teachers and school administrators who agree.

When systems are simple, the number of functions and their interrelationships is small. When systems grow in size and begin to relate to other growing systems, the new whole being formed is of greater complexity than the arithmetic sum of the individual complexities. Complexity is just a function of set size and the number of interrelationships. Simple systems tend to be open-loop. Complex systems which are not closed-loop tend to become unstable. All systems have *resonant* or *critical* frequencies at which inherent natural vibrations are maximum. This is characterized by the release of energy in the form of oscillations. A system is in *equilibrium* when no spontaneous oscillations occur in it. Systems in equilibrium are said to be stable. Therefore, a system which is designed in a closed-loop configuration can have an operating tolerance zone within which it will remain in equilibrium.

If a rotating propeller in a physical system is not properly feathered and speed-governed, it can build up oscillations and disintegrate. The same would be true in a social system of which the educational system is a subset. Open-loop or poorly designed closed-loop education systems can disintegrate if they grow in complexity beyond their operating tolerances.

In this study, disequilibrium caused by open-loop design has been reduced through the synthesis of a feedback signal path together with several new functions.

Very few government organizations have any permanently organized feedback signal path from the users of their information disseminated by SOD (5.8.2.1) The U.S. Department of Labor recently issued questionnaires for a Manpower Report Use Survey, which included *school or vocational training unit* in the question dealing with "kind of organization in which you work" (9). It also listed among the "uses,"

teaching - student text book
teaching - student reading reference
teaching - preparation of lectures

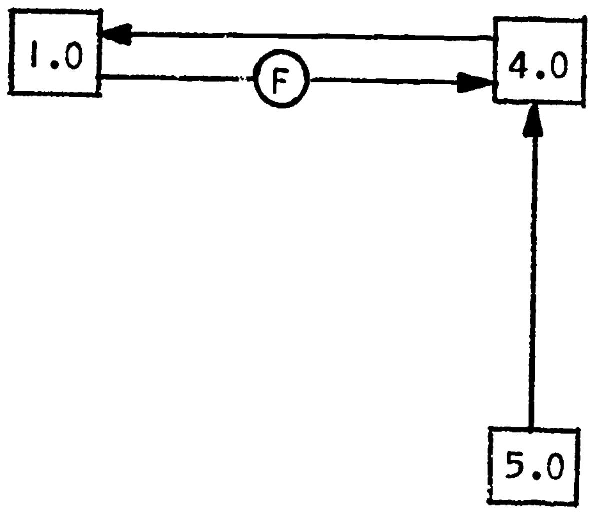
Thus, some awareness exists in the Department of Labor that teachers do utilize government-published information but this is a relatively crude measurement not considered to be typical of the (5.8.3) and (5.8.1.4) functions in Figure 9. In (5.8.1.4) the content of a technical document is translated into a format of immediate usefulness to an occupational teacher. Feedback through (5.8.3) modifies either the format or the content or both.

F. Conclusions, Implications and Recommendations

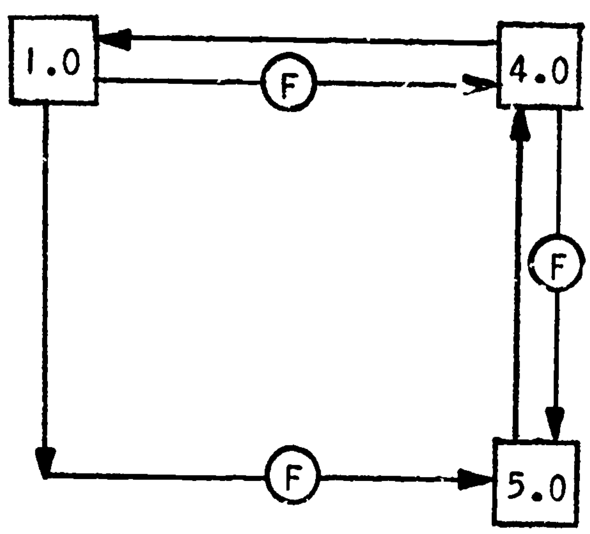
Flowchart and mathematical models have been synthesized and tested using low-fidelity simulation, corresponding to (1.0), (2.0) and (3.0) of Figure 4. These models are valid for the purposes of this study.

It has been demonstrated that quantitative techniques can be developed and applied to an educational system such as a comprehensive vocational-technical secondary school.

The flowchart model described in Figure 3 dealing with (1.0), (4.0) and (5.0) was created in the initial study. It has this ideogram, derived by analysis:



It is concluded in this study that the following ideogram obtained through synthesis would be superior:



The study focused upon (4.0), (5.0) interrelationships. Figure 5 describes functions to the fourth level of detail but that particular section of the model is open-loop. To obtain system equilibrium, it was necessary to synthesize the feedback signal path shown in Figure 9....a closed-loop in which part of the output of (4.10.1) is sampled and fed back through (5.8.3) to control

the output of (5.8.1.4).

Mathematical techniques were used to identify *KEYCEPTS* created in (4.10.1), and to examine the performance of the system.

There are several different directions which may be pursued as a result of this study.

1. at the microlevel, a pilot development project might be established to follow (5.8.1.1)→(5.8.1.4)→(5.8.2.1)→(4.6)→(4.10.1)→(5.8.3)→(5.8.1.4). This would be within a single government agency. The major effort would be to examine data generated (5.8.1.1), (5.8.1.2) or (5.8.1.3) and translate it in a suitable format. The design effort would be to establish the closed-loop path with low entropy.

2. at the macrolevel, continued examination of the model initially developed under contract OEC-4-7-061544-1601 using the techniques formulated in this study.

More significant, however, are the implications for educators and training specialists dealing with systems:

1. open-loop systems in education predominate

2. government-furnished information currently flows in an open-loop to occupational teachers in secondary schools

3. government-furnished information is usually not in a form easily used by occupational teachers

4. lesson plans produced by occupational teachers vary widely in level of detail

5. lesson plans can be analyzed into main facts and teaching points

6. *KEYCEPTS* can be identified in lesson plans using specialized techniques; while manual methods were utilized in this study, optical character recognition and computing techniques can easily produce the quantitative results

7. updating content created form government-published information can be analyzed into *KEYCEPTS*

8. if government-furnished information is placed into a closed-loop system, updating *KEYCEPTS* will enter an occupational teacher's lesson plan, obsolete *KEYCEPTS* will be displaced by updating *KEYCEPTS*, and that part of teacher performance which deals with the updatedness of subject-matter content can be measured.

9. the *KEYCEPT* conceptualization has been applied to occupational subject-matter which is, by examination, highly factual; there is every reason to believe that it can also be applied to certain academic or general education subject-matter

10. the modeling technique in this study has been developed for subsystem (5.8); there is every reason to believe that it can also be applied to other parts of the PRODUCE RESOURCE MATERIALS & SERVICES, such as:

    hardware manufacturing (5.1)
    books for teachers and students (5.5)(5.6)
    manuals and catalogs for teachers (5.2)
    trade papers for teachers (5.7)

and also to other subsystems in Figure 3.

Appendix H-3 Lesson Plan, "Automotive Spark Plugs," Columbus Area Vocational-Technical School, Columbus, Georgia

AUTOMOTIVE SPARK PLUGS

Lesson Plan Code ____

MF OBJECTIVES:

TP 1. To list the features of a spark plug and the significance of each feature

TP 2. Given a sectional view of a spark plug, to identify the components.

INSTRUCTIONAL MATERIALS:

1. Overhead projector, screen, and transparencies
2. Live engine
3. Spark plug cleaner
4. Blow gun
5. Feeler gage, wire type
6. Spark plug socket
7. Ratchet
8. Gap tool
9. Solvent, non-flammable
10. Vise

MF INTRODUCTION:

TP TP TP

The purpose of a spark plug is to create a spark within the combustion chamber. The spark plug is a durable and reliable part of the ignition system; however the voltage and compression conditions under which it works call for periodic service.

PRESENTATION:

MF 1. Construction TP a. Electrodes TP b. Insulator TP c. Seals TP d. Shell	Transparency
MF 2. Features TP a. Thread	Transparency

EDUCATION AND
TRAINING
CONSULTANTS Co

815 MORAGA DRIVE
LOS ANGELES, CALIFORNIA, U S A
90049
PHONE: 213/472-2444
213/879-2444

DEDICATED TO SYSTEMATIC IMPROVEMENT OF HUMAN PERFORMANCE . . . SERVING BUSINESS, INDUSTRY AND GOVERNMENT SINCE 1952

IN REPLY REFER TO: 3.1.3.77

Appendix H-1 Letter Inviting Submission of Lesson Plans

We are presently engaged in a study to develop models dealing with occupational teaching as described in the attachment. I am writing because of your familiarity with Dr. Leonard C. Silvern's previous work in this field.

May we invite your cooperation for our research? I wish to obtain a copy of one lesson plan now used in automotive mechanics and a copy of one used in electrical courses. Photocopies of actual plans including those handwritten are desired.

Lesson plan copies and questions arising from this request should be sent to my attention. An acknowledgement will appear in the final report. We appreciate your cooperation in this important effort for the U.S. Office of Education.

Cordially,

EDUCATION and
TRAINING
CONSULTANTS Co.

Christine Cullen
Research Assistant
Educational Systems Division

Appendix H-2 General Statement of the Study

EDUCATION AND
TRAINING
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NEWS RELEASE

1 February 1969

LOS ANGELES -- The U.S. Office of Education has awarded ETC a contract to develop mathematical models for occupations, it was announced by Dr. Leonard C. Silvern, president.

The study is to produce quantitative models which describe and measure the utilization of government-published occupational data by vocational and technical teachers in high schools. The Federal government creates and disseminates vast amounts of technical information in the form of handbooks, manuals, guides, texts, brochures and periodicals. Some of these are of value to classroom, laboratory and shop teachers to update their lessons and offer information which keeps pace with changes in the occupations.

Dr. Silvern and Carl N. Brooks are conducting the research assisted by Christine Cullen of ETC's Educational Systems Division. They view the occupational teacher as an information processor, and agencies of the Federal government as generators and distributors of information. The student is a receptor and applies what he has learned to the real-life environment when he is employed after graduation.

The study is a continuation of a previous project, "Systems Engineering of Education III: Systems Analysis and Synthesis Applied to Occupational Instruction in Secondary Schools." A final report will be published by ETC in the Spring of 1969, titled: "Systems Engineering of Education VIII: Quantitative Models for Occupational Teacher Utilization of Government-Published Information."

Educational Systems Division
3.1.3.77

TP- F. Water Jacket- passages & distributing tubes

TP- G. Coolant

TP H. Temperatures gauge

1. Dash unit
2. Engine unit

MF IV. Components of an air cooled system

TP- A. Fan or blower

TP- B. Baffles or ducts

TP- C. Cylinder fins or head fins

MF V. General Temperature Requirements

A. About 200°F slightly below boiling

MF VI. Heat Sources.

TP- A. - Engine Friction

TP- B. Combustion heat

MF VII. Heat Dissipation

TP- A. 1/3 of heat energy from fuel is converted to power

TP- B. 1/3 goes out of exhaust- unused- wasted

TP- C. 1/3 handled by cooling system

TP Heat removed by a normal cooling system of an average automobile or truck at normal speed would keep a six room house warm at "0" weather. TP The system requires several thousand gallons of water circulating in the cooling system to absorb heat and carry it to the radiator for disposal. TP Heat generated by the burning mixture in the engine must be transferred from the iron or aluminum cylinder to the water jacket. TP Some heat is dissipated to air surrounding the cylinder block and TP other heat is carried by the coolant to the radiator and then dissipated to the air. TP

MF VIII. Enemies of cooling systems (Liquid)

TP A. Rust- combination of water, oxygen, and air

TP B. Lime- from water supply or may be formed when water is repeatedly heated and cooled.

TP C. Oil or grease- often binds lime and rust to iron, causing hot spots along with stoppage or corrosion in passages and distributing tubes.

TP b. Reach
TP c. Heat range
TP d. Gap

MF 3. Service procedures
TP a. Removing
TP b. Cleaning
TP c. Gapping
TP d. Installing

Demonstration

APPLICATION:

Job sheet no. ________

TEST

Complete the following statements by filling in the appropr..e word or words in the space provided.

1. The spark plug ignites the fuel-air mixture at or near the top of the __________ stroke.
2. The insulating material on almost all spark plugs is ______________.
3. A spark plug with a __________ heat range is manufactured for use in an engine that normally runs under high-speed, heavy-load conditions.
4. A 0.020 inch increase in plug gap may increase voltage requirements as much as _________.
5. Spark plugs need service more often under _________ driving conditions.
6. Fluffy, black, dry deposits on a spark plug are evidence of __________ fouling.
7. Spark plug gaps should always be checked with a __________ feeler gage.
8. The center electrode of a spark plug should have __________ polarity.
9. A blistered or burned insulator and badly eroded electrodes indicate ____________ plugs.

Appendix H-4 Lesson Plan, "The Cooling System," Technical Education Center, Sumpter, South Carolina

LESSON PLAN NUMBER

FOR: Date

COURSE: Automotive Mechanics

TEXT: Automotive Mechanics- Heitner

REFERENCES: Auto Mechanics Fundamentals- Stockel
Auto Engines & Electrical Systems- Motor

AIDS: Overhead Projector
Transparencies
M. T. S. C. Film & Record
Used or New System Components

SUBJECT: THE COOLING SYSTEM

MF INTRODUCTION:

The purpose of the cooling system, a gasoline or disel engine, is to prevent temperatures of cylinders, pistons, valves and other engine parts from rising high enough to destroy them or to destroy the oil which lubricates them. TP TP

MF I. Types of cooling systems.

TP A. Liquid- Direct
TP B. Air- Indirect

MF II. Uses of cooling systems.

TP—A. Remove excessive heat
TP—B. Maintain desirable heat
TP—C. Complement lubricating system
TP—D. Provide heat for passengers comfort

MF III. Components of a liquid cooling system.

TP A. Radiator Core
TP B. Hoses & or pipes
TP C. Water pumps
TP D. Fan blades & pulley
TP E. Thermostat

TP- F. Water Jacket- passages & distributing tubes
TP- G. Coolant
TP- H. Temperatures gauge
1. Dash unit
2. Engine unit

MF IV. Components of an air cooled system

TP- A. Fan or blower
TP- B. Baffles or ducts
TP- C. Cylinder fins or head fins

MF V. General Temperature Requirements

A. About 200°F slightly below boiling

MF VI. Heat Sources.

TP- A. Engine Friction
TP- B. Combustion heat

MF VII. Heat Dissipation

TP- A. 1/3 of heat energy from fuel is converted to power
TP- B. 1/3 goes out of exhaust- unused- wasted
TP- C. 1/3 handled by cooling system

TP Heat removed by a normal cooling system of an average automobile or truck at normal speed would keep a six room house warm at "0" weather. TP The system requires several thousand gallons of water circulating in the cooling system to absorb heat and carry it to the radiator for disposal. TP Heat generated by the burning mixture in the engine must be transferred from the iron or aluminum cylinder to the water jacket. TP Some heat is dissipated to air surrounding the cylinder block and TP other heat is carried by the coolant to the radiator and then dissipated to the air. TP

MF VIII. Enemies of cooling systems (Liquid)

TP A. Rust- combination of water, oxygen, and air
TP B. Lime- from water supply or may be formed when water is repeatedly heated and cooled.
TP C. Oil or grease- often binds lime and rust to iron, causing hot spots along with stoppage or corrosion in passages and distributing tubes.

MF IX. Water pumps (Centrifugal)

TP A. Components- of average pumps
1. Housing
2. Impeller
3. Shaft
4. Bearings
5. Seals

TP note: Older type pumps provided a means of lubricating moving parts, but current ones are lubricated for the life of the pump. TP

TP- Impeller vanes may be straight, but in most cases they are curved to accelerate centrifugal flow of water.

MF X. Thermostat

TP A. General types
1. Bellows- type
2. Pellet- type

TP- B. Purpose in the system
TP C. Location
TP D. Operation
TP E. Calibration
TP F. Testing

*(instructor has TP in mind--these are mnemonics but not the TP themselves)

MF XI. Radiator Core

TP A. Types
TP B. Construction
TP C. Purpose
TP D. Servicing
TP E. Testing

*

MF XII. Cooling Fan

TP A. How driven*
TP B. Construction
1. Pitch
2. Angling
TP C. Types
TP 1. Conventional
TP 2. Electric control- for high speed cut-out
TP 3. Hydraulic control- for high speed cut-out
TP 4. Friction devices- for high speed cut-out
TP 5. Thermostatic- for high speed cut-out

MF XIII. Restrictions to air circulating thru core.

TP A. Loose fan belt
TP B. Low fan speed
TP C. [illegible]- bent fins
TP D. Leaves, insects etc.
TP E. Ordinary paint

MF XIV. Pressure Systems.

TP A. Purpose
Provides a wider margin between a desirable operating temperature and the boiling point ofcoolant being used.

TP B. Principles involved
TP 1. Water boils at 212°F at Sea level
TP 2. It boils at 194°F at 10,000 ft.
TP 3. We can raise the boiling point by putting it under pressure.
TP 4. Each pound of pressure added will increase the boiling point by about 3°F
TP 5. By adding 7 lbs. of pressure, water will boil at 200°F at 10,000 feet or at 233°F at sea level.

MF XV Antifreeze Solutions

~~XV.~~ An alcohol antifreeze solution TP for protection to 20°F below "0" boils at about 180°F or below the efficient operating temperature of the engine- add 7 P. S. I. pressure, boiling point then up to about 200°F- TP

MF XVI. Pressure Caps

TP A. Contains blow-off ~~or vacuum valve~~ TP
1. Blow-off valve consist of a valve held against a valve seat by a calibrated spring. TP The spring holds the valve closed so that pressure will be produced in the system. TP If the pressure increases above the pressure determined by the calibration of the pressure spring, the valve raises from its seat relieving the pressure. TP

TP Vacuum valve
2. The Vacuum valve is designed to prevent the formation of a vacuum in the cooling system. TP When the engine is shut off and begins to cool, if a vacuum forms, atmospheric pressure from the outside causes the small vacuum valve to open admitting air into the radiator. TP Without a vacuum valve, the pressure within the radiator might drop so low that the atmospheric pressure would collapse it.

MF XVII. Antifreeze Solutions

TP A. Types
TP 1. Alcohol- (alcohol base)
TP Non-permanent type evaporates below the boiling point of water- TP require constant attention if desired protection is Maintained.
TP 2. Ethylene glycol- TP permanent type.
TP Remains liquid at the boiling point of water- TP little or no loss due to evaporation.

note: TP Water expands 9% in volume when it freezes, TP therefore ---

XVIII. Servicing the cooling system.

MF

TP A. System must be clean
TP B. System must be clean- protected by rust inhibitor
TP C. Hose in good condition and all connections tight
TP D. Drive belt properly adjusted TP
TP E. Protected to a desired point above or below freezing.
TP F. Must be flushed throughly if it becomes contaminated with rust, oil scale etc.

MF XIX. Air Cooled System

TP A. Examples
1. Corvair gasoline
2. V. W.- gasoline
3. Deitz- Diesel
4. 2 cycle gasoline

good illustration of need for up-dating since engine manufacture has been discontinued

TP B. Requirements
TP 1. Requires constant circulation of air (copious)
TP 2. Abundant volume
TP 3. Area to be cooled surrounded by sheet metal
TP 4. Cooling fins to assist- (air directed to them)
TP 5. Driver fan by belt to crank shaft
TP 6. Controled by thermostat
TP 7. Mechanically linked to blower ring or damper
TP 8. Adequate cooling depends on engine speed
TP a. over heating occurs if lugged or idled too long
TP 9. Nosier because of lack of water jackets and additional clearence in operating parts
TP 10. Operates at higher temperature (normal)

MF SUMMARY:

All engines are designed to operate in a deffinate temperature range which will insure currect clearences between parts, promote vaporization of fuel, keep the oil at its best viscosity and prevent the condensation of harmful vapors. In order for the cooling system to do these jobs well preventive maintenance and seasonal attention is a must.

END
9-21-70