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TV EQUIPMENT, SYSTEMS, FACILITIES, AND PERSONNEL--A GUIDE FOR SCHOOL ADMINISTRATORS, A STUDY PREPARED FOR THE CALIFORNIA PUBLIC SCHOOLS INSTRUCTIONAL TV COMMITTEE.

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DESCRIPTORS- *TELEVISED INSTRUCTION, EQUIPMENT EVALUATION, *FACILITIES, EDUCATIONAL TELEVISION, *INSTRUCTIONAL TELEVISION, BROADCAST TELEVISION, CLOSED CIRCUIT TELEVISION, BROADCAST RECEPTION EQUIPMENT, *ELECTRONIC EQUIPMENT, EQUIPMENT UTILIZATION, CONSTRUCTION NEEDS, PERSONNEL, ENGINEERING TECHNICIANS, TECHNOLOGICAL ADVANCEMENT, *COSTS, VIDEO TAPE RECORDINGS, INSTRUCTIONAL TELEVISION FIXED SERVICE, CENTRAL PROJECTION SYSTEM

TELEVISED INSTRUCTION IS WIDESPREAD, YET THERE EXISTS LITTLE QUALIFIED, IMPARTIAL INFORMATION EXPRESSED IN NONTECHNICAL TERMS (AS IN THIS REPORT), CONCERNING EQUIPMENT AND PERSONNEL STANDARDS, REQUIREMENT, AND COSTS, FOR SCHOOL ADMINISTRATORS TO CONSULT. EVALUATION OF THE MEDIUM'S POTENTIAL MUST BE BASED ON INFORMATION CONCERNING TELEVISION'S CHARACTERISTICS AND ON ADMINISTRATIVE CONSIDERATIONS. AN INSTRUCTIONAL TELEVISION SYSTEM CONSISTS OF ORIGINATION, TRANSMISSION, AND RECEPTION-DISTRIBUTION SUBSYSTEMS. IT HAS THESE CHARACTERISTICS--IT CAN TRANSPORT IMPULSES, MULTIPLY THE POTENTIAL AUDIENCE, JUXTAPOSE NORMALLY SEPARATED OBJECTS, MAGNIFY SMALL OBJECTS, AND TRANSPOSE IMAGES IN DIFFERENT WAYS. FURTHERMORE, TELEVISION IS IMMEDIATE AND REPRODUCIBLE. GIVEN ALL THESE TECHNICAL POSSIBILITIES, SCHOOL ADMINISTRATORS MUST SPECIFY WHAT THEY EXPECT A PROPOSED TELEVISION SYSTEM TO DO, AND UNDER WHICH CONDITIONS. EACH PIECE OF EQUIPMENT MUST BE ANALYZED IN TERMS OF ITS FUNCTIONS. FINALLY, EVERY OTHER CONCEIVABLE ALTERNATIVE FOR PERFORMING THE TASK MUST BE EXAMINED TO MAKE SURE THAT THE PROPOSED SYSTEM IS THE BEST FOR THE GIVEN EDUCATIONAL NEEDS AND BUDGET. (OH)

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TV EQUIPMENT, SYSTEMS, FACILITIES, AND PERSONNEL: A GUIDE FOR SCHOOL ADMINISTRATORS

A Study

Prepared for

The California Public Schools Instructional TV Committee.

by

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Chairman, Sub-Committee on Equipment Standards

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CHAPTER I

INTRODUCTION

The use of televised instruction in schools is wide-spread today with 11,678,512 students on all grade levels of education enrolled in televised courses of instruction.[1] The equipment, facilities, and staffs required to service the present users of televised instruction represent a substantial investment of school funds. Unfortunately, there has been little qualified, impartial information which school administrators could consult to ensure that the television equipment, facilities, and staffs which they were considering for acquisition were appropriate (in terms of intended function, quality, and cost). Too often, the vendors of facilities and equipment have been the major or only source of technical information consulted by school boards and administrators. Too often, the results have been inappropriate application of the medium, inappropriate quality of equipment selected (sometimes under-sophisticated in terms of school requirements, sometimes over-sophisticated), lack of external equipment compatibility, and in some unfortunate cases, lack of internal compatibility.

Purpose of this Document

This document is intended to serve as an instructional TV primer for school administrators and other responsible officials to help them

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[1] Lawrence E. McCune (ed. and comp.), National Compendium of Televised Education, Vol. XI (East Lansing, Michigan: Michigan State University Continuing Education Service, 1963), p. i.

make wise selections of television equipment and facilities and avoid expensive mistakes.

Overview of Contents

Presented herein are brief descriptions of the three major sub-systems which make up an instructional TV equipment system. These include TV origination, transmission, and reception-distribution sub-systems. The discussion also touches on considerations concerning school plant implications, overhead related to personnel and maintenance, and guidelines for the assessment of TV's potential in a school system.

Nature and Level of Discourse

The discussion herein is purposely written in non-technical language so that responsible educators, legislators, and interested lay people who may not have extensive backgrounds in the area of TV engineering can grasp the function of each piece of equipment described and develop a general appreciation of the quality standards (and associated cost range) which it should meet for specific purposes.

The Pace of Technological Change and its Implications for Readers

A vigorous and healthy competition among television equipment manufacturers generates a force which results in a continual improvement in TV hardware available to schools. While the descriptions of equipment in this document may be relatively accurate during their preparation, there is no assurance that the state of the art will not have changed materially by the time that the document is in the hands of readers. Therefore, when actual equipment negotiations are contemplated, the information in this section should be supplemented with engineering specifications prepared by unbiased sources. Such specifications will serve as a guide for vendors and if followed will help ensure that equipment supplied by them will meet the standards desirable for school-owned TV systems. A listing of several unbiased, qualified sources of engineering specifications may be found in Appendix A.

CHAPTER II

ORIGINATION SYSTEMS

An origination system might be defined as those items of TV equipment necessary to perceive visual and audio information, change it into an electronic signal, and present it in acceptable form to the transmission-distribution system.

An origination system can range in complexity from one simple, industrial, self-contained camera costing approximately $700 to an elaborate TV studio with multiple cameras, lights, audio, and special effects equipment costing in excess of one million dollars.

Origination systems would include any of the following, either alone or in combination: (1) TV film chain, (2) video tape machine, (3) local school TV cameras /and audio system where necessary/, and (4) incoming signals from local educational or commercial TV stations.

Film Chain

A TV film chain consists of a motion picture projector (with special adaptation of the film pull-down mechanism) and slide projector which are placed so that they project into a small, permanently mounted TV camera. The TV camera, in turn, sends the signal into the distribution or transmission system. A typical film chain is the size of a small steamer trunk and will cost between $3,500 and $7,500. Commercial TV stations use such a device to present the late, late movie. (Bretz and Wade tried using a conventional unadapted film projector as a film chain component for a closed-circuit system. It proved to be very satisfactory. Predictions of flutter and film bar were not substantiated. If it is possible to use a conventional projector as part of a closed-circuit TV film-chain, it will lower the cost considerably - $1,000 vs $7,500, plus camera control.) If a school TV system has a film-chain, it can be used to distribute regular materials from the A/V library. Such a system offers considerable attraction under certain circumstances (over conventional classroom film projectors) in terms of (1) economy of distribution /in broadcast situations/ and (2) convenience in use /in closed-circuit situations/.

It is usually desirable to add a slide projector to the film-chain. The slide projector is usually mounted at a right angle to the TV pick-up camera. The slide image is directed into the TV camera through a system of prisms or mirrors, called a "multiplexer" which makes this right angle projection possible. When not using the slide, the multiplexer passes the motion picture image directly through and into the TV pick-up camera. The slide projector will range in cost between $500 and $1,000. A multiplexer will cost $1,680 and up.

Video Tape Machines

A video tape machine works on much the same principle as an audio tape machine; that is, it records and plays back or simply plays back images and sound on magnetic tape. Standard size video tape machines range in cost between $40,000 (black and white) to $65,000 (color). Smaller, so-called portable video tape machines which meet FCC broadcast standards range in cost between $14,500 and $22,000. Portable machines currently on the market which meet closed-circuit standards range between $10,900 and $12,000. Both the broadcast and closed-circuit portables noted above are about the size of a medium suitcase and weigh between 68 and 98 pounds. Recently, several domestic firms have introduced to the market a very small closed-circuit machine which uses ¼" tape. These machines reportedly sell for between $750[1] and $3,900.[2]

Video tape devices offer advantages in terms of (1) economy and quality of production, (2) economy of distribution, and (3) convenience in program use. In addition to the programs which can be produced locally with video tape, there are large libraries on the regional and national levels which have hundreds of high-quality instructional TV courses on all grade levels and in a wide variety of subject areas that can be rented and played back over a district recorder-distribution-display system.[3] Use of these materials, where appropriate, can trim local production budgets materially.

Where distribution and display systems are contemplated, the addition of a video tape machine as an originating source is highly desirable. Where local production facilities are contemplated, the inclusion of a video tape facility is mandatory if true quality and efficiency are to be achieved.[4] (When used in distribution systems, a modulator must be added to the tape machine at a cost of approximately $850.)

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[1]Wesgrove Video Recorder (San Francisco: Hal Cox, Inc., 1965), pp. 1-4.

[2]VR-303 Videotape Television Recorder and Videotrainer Closed Circuit Television Tape System (Redwood City, California: Ampex Corp., 1965), pp. 1-4.

[3]The latest National Instructional TV Library Catalogue lists 324 telecourses available for rental. For further information see A Guide to Films, Kinescopes, and Videotapes Available for Televised Use 1964 (Third edition; New York: National Instructional Television Library, 1964), pp. 1-61.

[4]For a more complete discussion of the potential of TV recording systems for schools, see Warren L. Wade, TV Recording Systems: A Guide for School Administrators (Redwood City, California: Ampex Corp., 1964), pp. 1-17; for a comparative engineering evaluation of three portables extant, see William C. Lewis, Television Tape Recorders (Boulder, Colorado: University of Colorado, 1964), pp. 1-52.

IN SHORT, THE CAPACITY OF VIDEOTAPE INSTRUMENTS TO RECORD, STORE, AND PLAY BACK INFORMATION MAKES POSSIBLE THE ACHIEVEMENT OF ECONOMY IN PRODUCTION AND EFFICIENCY-EFFECTIVENESS IN UTILIZATION WHICH ADVOCATES OF TELEVISION IN EDUCATION HAVE ATTEMPTED TO ACHIEVE FOR THE PAST TEN YEARS BUT WITHOUT DEMONSTRABLE SUCCESS.

TV Camera Chains

One of the most universally recognized origination systems is the television camera. TV camera chains have become more sophisticated in capability, more simplified in packaging, more durable and less expensive over the past 5 years. Existing TV camera chains fit under two major categories. These are identified mainly by (1) type of operation (manned or unmanned) and (2) type of camera pick-up tube (image orthicon or vidicon).

Manned and Unmanned Cameras. A camera which is to be manned by an operator at the camera position is usually of the "view finder" type. It has a small TV screen at the rear of the camera for the operator to view and has controls for the local manipulation (pointing, focusing, etc.) of the instrument. This kind of camera is most commonly employed in a studio situation or in a situation where it is necessary to follow, rapidly, unpredictable and widely diverse movements.

A camera which is not to be manned at the camera location is commonly referred to as an "industrial" camera and is particularly characterized by an absence of a view finder. An industrial camera is employed for a variety of purposes including educational, industrial, medical, and military. Industrial cameras are used in those situations where observation assignments are relatively static or predictable or where it is not possible to use human operators because of limited space or hazard to personnel.

<u>Image Orthicon and Vidicon Camera Pick-up Tubes</u>. The normal image orthicon tubes used in cameras today are either of the 3" or 4½" diameter. The length of the 3" tube is approximately 12" and the length of the 4½" tube is only slightly more. The cost of the associated circuitry for the image orthicon camera varies between $8,000 for industrial models (e.g., GE TE 17-A) to $25,000 for view finder models (e.g., RCA TK 60). Vidicon tubes measure 1" x 6" (although 1½" tubes are used in some special purpose equipment). The cost of the associated circuitry for vidicon cameras varies between $700 for the economy class industrial models (e.g., Du Mont Tel-Eye) to $9,000 for view finder models (e.g., RCA TK-15, GE PE 23). In size and shape, image orthicon cameras range from 10" diameter x 18" length for industrial models to 18" x 18" x 30" for view finder models. In size, vidicon cameras range from 2" x 4" x 6" for special purpose industrial models to 18" x 18" x 30" for view finder models. The shape ranges from cylinder to rectangular box.

With special adaptation, both image orthicon and vidicon models are capable of picture resolution up to 1,000 lines. The range for vidicons is from 400 to 1200 lines. As a generalization, it can be said that <u>most</u> image orthicon cameras have better light-response characteristics than vidicons, some giving usable pictures with a light level of ½ foot-candle. However, recent significant advances in the field of vidicon tube construction and associated circuitry have placed the vidicon camera in a competitive position. One model now boasts of usable picture response in light levels of 2 ft.-lamberts.

<u>Essential Differences Between Camera Chains</u>. The essential differences between camera chains include (1) operational type and (2) cost.

Operational Type. The selection of a "view finder" or "industrial" camera is or should be predicated on use requirements. In those situations where on-site operator control is required, an industrial model borders on being totally unacceptable. The reverse is not true. However, the use of a view finder camera where an industrial model would suffice holds considerable implications in terms of excess costs.

Costs. The costs of a camera system are related to the requirements of intended use and the implications which this equipment holds for design and circuits (e.g., required light-response characteristics, resolution requirements, necessity for Electronic Industries Association /EIA/ sync, compatibility with other systems, and pictorial matching with other cameras in the system). If an industrial camera can be used in the place of a view finder camera, the costs of the chain can be cut by 50% or even as much as 66-2/3%. If a vidicon model can be located which meets the other requirements for the system (and there is no reason why one cannot be located), the costs (both initial and maintenance) can be reduced further.

> The simpler external circuitry of the vidicon camera, as compared with the image-orthicon camera, made possible smaller and less expensive cameras. Another advantage of the vidicon for educational and industrial applications was the lower operating cost. Whereas the image-orthicon depreciates over a 500-hour guaranteed life, the vidicon can be used up to ten or fifteen times as long. Since its initial cost is about a quarter that of the image-orthicon, the advantage can be very great.[5]

The cost of a new image orthicon tube ranges between $ 1,200 for a 3" tube and $2,000 for a 4½" tube. A vidicon tube costs approximately $200.

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[5] Rudy Bretz, Techniques of Television Production (New York: McGraw-Hill Book Company, Inc., 1962), p. 26.

> . . . more recent improvements in sensitivity, plus the fine gray-scale rendition which has always characterized the vidicon, have led some persons to the conviction that the vidicon would soon challenge the pre-eminence of the image-orthicon as well.[6]

Specific Roles of Various Camera Chains. Neither the "view finder" nor the "industrial" TV camera chain is a "better" device. Each device is designed to meet the requirements of certain well-defined situations. The view finder camera is mandatory when it is necessary to follow, rapidly, unpredictable and widely varying movements. The industrial camera is perfectly acceptable for use when movements are narrow in scope and can be predicted with some accuracy.

Neither the image-orthicon nor the vidicon camera tube is a "better" tube. The preferability of each can be assessed best in terms of the requirements of the situation in which the camera will be used. These requirements are functions of light conditions, resolution, compatability with other system components and pictorial matching considerations. It is suggested that vidicon systems which meet each of these requirements can be located today.

Other Stations

Incoming signals from local ETV or commercial stations can be rebroadcast through a simple arrangement similar to a receiver and signal amplifier (plus TV tape recorder where time delay is desirable). With such an arrangement, then, local TV stations not owned by the school system can become an originating source. Permission to carry these signals, however, must be received from the originating station.

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[6] Ibid.

System Configuration Determinants

The qualifications which should determine the type of origination equipment that would be most appropriate for a given situation would be those listed on pages 37-38 of this chapter. To be more specific, will the proposed originations be used for (1) intra-facility or (2) inter-facility purposes? Will they be transmitted via (1) closed-circuit, (2) fixed service, or (3) broadcast TV? For the most part, intra-facility closed-circuit uses require the least sophisticated origination equipment, whereas inter-facility broadcast TV uses require the most sophisticated.

Intra-Facility Origination Systems. Simple camera origination systems are not expensive and can be most effective when used to magnify live demonstrations in motion and other small scale, three-dimensional materials. No other visual device can do this in a "live" situation. The magnifier can be handled most appropriately by the teacher or lecturer himself. (This is one of the few cases where a non-view finder camera is the most appropriate instrument even though the potential operator is on-site.) It is designed to serve viewers within the four walls of a single room. Most secondary schools and many elementary schools which include large numbers of demonstrations in the classroom can justify the purchase of a TV magnifier. Divergent examples of possible subject uses in secondary schools would include chemistry (experiments), physics (demonstrations), drafting (drawing skills), and music (wind instrument fingering). Examples of possible use in elementary schools might include skill demonstrations in art by both teacher and student or the sharing of student work samples simultaneously with all students in the class, with the teacher directing attention by pointing under the camera to various important facets.

The magnifier should be provided with a manually controlled zoom-type lens (25-100mm Pan Cinor @ $325.00, or some comparable instrument) with a 1/4mm close-up adapter. Normally, the magnifier will be mounted on a simple pipe rack in a position over the lecturer's head. From there, it can observe all objects on a desk, demonstration table, or in the lecturer's hands. This camera should also be provided with a floor tripod (on a simple dolly and wheels) as an alternate mount. The placement of the camera, overhead or on the floor, will be determined by the nature of the demonstration. The overhead mount should not exceed $50 in cost (if fabricated in a school district's own shop). The tripod mount, complete with wheels, dolly, and pan head should not exceed a range between $150 to $250 for a simple setup for a small camera.

In a limited number of cases, it may be desirable to add a second camera (this time on a floor tripod-dolly and equipped with a view finder) to the overhead magnifier. With this second camera, a switch ($25-$50 for a small mechanical switch or $1,200 and up for a switcher-fader) to permit the lecturer to change the TV view from one to the other, and a modulator ($850), it is then possible to transmit a complete teaching lesson beyond the four walls of a single classroom over the building distribution system.

The camera or cameras, used with either system should be capable of transmitting either a video or an RF signal, preferably both.[7] (RF cameras require an audio adder if fed to other rooms.) Demonstrations

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[7] "RF" is an abbreviation for "radio frequency." It is a term used to identify <u>one</u> method of transmitting picture or picture and sound through space or over a cable. The picture or picture and sound are sent through a modulator and transmitted on a regular TV wave. The use of "RF" transmissions over a cable permit the simultaneous use of that cable for more than one program. Your TV receivers at home receive an "RF" signal.

"Video" is a term used to identify another method of transmitting requiring high resolution will require video cameras; however, many communication situations do not require greater than the 300-400 lines of resolution possible with an RF camera. In any case, an RF camera should present 400 lines of resolution and a video camera should present a minimum of 600 lines. Either camera should be able to present an acceptable picture with a lens opening of f2.9 at a light level of 10 foot-candles. There should be no noticeable image lag under these conditions. It is probably not mandatory that the cameras meet EIA sync standards since either the "Overhead" or "Self-Directed TV" system would be used strictly for closed-circuit purposes within a single classroom, a single school or a single campus. However, those schools or districts contemplating studio and/or broadcast systems in the forseeable future would wish to specify EIA standards for origination equipment at the outset. (Several companies now offer cameras which can be converted from closed-circuit standard to broadcast standard EIA sync by plugging in one or two additional circuit boards. This might be a desirable camera feature for schools that plan to begin with closed-circuit service and develop, sequentially, a broadcast service.)

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picture only over a closed-circuit line. A video signal cannot be transmitted through space under normal operating conditions. It must be transmitted from the point of origin to the point or points of reception over a coaxial or biaxial cable. It occupies the capacity of the entire cable and therefore a separate wire must be provided to carry the sound signal if sound is to be transmitted with the picture.

The essential differences between "RF" and "video" are these. RF can be transmitted through space or over a cable. Video can travel only over a cable. Both sound and picture are carried by the same cable when an RF system is used, while a video system requires that a separate cable be used to carry each. However, where high definition is essential (e.g., where small print must be read or where small scale demonstrations are to be shown on the TV screen) video is superior, since a normal video system can present 600 lines of resolution at the receiver, while an RF system is lucky to present 320 lines at the receiver. (Incidentally, your receiver at home seldom presents over 275 lines.)

In terms of cost and present developments, it is difficult to recommend or justify more sophisticated camera systems than the ones described above on a district, single school, or single campus level. Full scale TV production (of a quality suitable to maintain viewer respect) requires expensive facilities and a corps of highly trained technicians who usually command rather high salaries. It is the type of expenditure which can be justified at this time only when carried out in a broadcast situation where the costs can be absorbed by a large reception population or when carried out via closed-ciruit in a large enrollment, geographically compact district where considerable numbers of viewers watch simultaneously.

In terms of results, the same types of TV demonstrations up to a given level of complexity can be accomplished with the simple "Overhead TV" and "Self-Directed" systems described herein as with considerably more sophisticated systems, and they can be accomplished with comparable quality. A definite increment in quality over the two simple systems cannot be expected until this given level of complexity is exceeded and a studio-type operation is entered.

Two other origination systems might be considered for inclusion in an intra-building or intra-campus situation. These would include (1) film chain origination and (2) video tape origination and recording systems. The film chain makes available materials from the A/V library which are on film while the video tape machine makes available materials which are on video tape;and video tape also makes it possible to preserve for reuse the best demonstrations which are recorded via the local TV camera system. This latter capability is particularly interesting in terms of potential economy since good demonstrations which are recorded can be replayed without the repeat investment of TV crew time and TV teacher time.

The Armed Services pioneered the use of closed-circuit TV for the distribution of pre-recorded instructional materials at the Ft. Monmouth, New Jersey, Signal Corps Depot. Other military organizations developed similar installations. These systems were reported to have yielded considerable improvements in instruction and considerable economies in staff time and actual dollars.

Bretz and Wade developed what they called a "Central Projection System" at UCLA in 1959. It hooked a number of film projectors located in a central site into a campus-wide TV distribution system. This system was designed primarily as a convenient and efficient distribution system for conventional audio-visual instructional films.[8]

According to written reports, both the military installations and the UCLA installation met their objectives very well. Both used coaxial cables to carry the signal and both were concerned with providing a convenient film distribution service to a limited area (confined to a single military installation or university campus). At least they demonstrated the advantages and disadvantages of a central film projection installation. The less expensive video tape machines developed recently might be added to the central projection installation, thus increasing the dimensions of the "canned" resources to include the contents of vid tape libraries which now exist and the library of accumulated locally-produced quality demonstrations. Note, however, that the less expensive ½" tape machines have a maximum of 150 lines of horizontal resolution.

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[8] Rudy Bretz, "Central Projection: A New and More Practical System for the Utilization of Educational Films," Journal of the SMPTE, 72:4-5, March, 1963.

Inter-Facility Origination Systems. At least one institution in a county or region may wish to provide a first-class broadcast and closed-circuit origination facility. It should be of sufficient size and sophistication to permit the mounting of any kind of local programs required. Such a facility will cost between $40,000 and $150,000 to equip. Added to this would be the costs for housing and staffing. Annual operating budgets for such a facility would range between $40,000 and $200,000, depending on the size of the facility and the number and scope of the productions mounted.

In brief, a broadcast studio would have at least two high quality floor cameras with view finders @ $7,500 for vidicon cameras and $20,000 for image orthicon cameras, a film chain (@ $5,000 - $7,500), associated sound equipment (cost not projected), control booth (cost not projected), and video tape machine (@ $14,500 - $34,500). All equipment for this facility must meet EIA standards and FCC requirements.

Because of the costs associated with such a facility, it is mandatory that it be available for use to all institutions, departments, etc., participating in the TV service which have need to originate TV communications. A junior college, large high school district, or large elementary district would be logical organizations to consider the acquisition of such a facility.

Inter-Facility Origination Systems, Mobile. It is possible that one institution in a county or region may wish to provide a mobile TV camera facility. Ideally, it should be capable of reaching any relevant point in the area with its cameras to record on video tape or send back to the studio, via microwave, pictures and sound from that remote location. A mobile facility will range in cost between $20,000 and $250,000, depending on its quality and flexibility.

A mobile facility would have two high quality view finder cameras similar in cost and characteristics to those recommended for studios. However, it is essential that they be compact enough to be carried by one or two men from the vehicle to the tripod, and rugged enough to give trouble-free service in spite of constant transportation. Associated sound and control equipment will also be required as will sufficient space to house these permanently in the vehicle in locations which are easily accessible to production and maintenance personnel. It would be highly desirable to have the vehicle equipped with both video tape and microwave. The vehicle leg of the microwave link would cost approximately $7,500, and the video tape machine between $14,500 and $40,000. Although it is desirable to have both, if a choice must be made between microwave and video tape, the latter would provide the greatest service and flexibility for the unit.

The vehicle required to carry this equipment will vary in size according to the completeness of the facility. A minimal facility, consisting of a vidicon camera and a helical-scan video tape recorder, can be housed in a station wagon. A complete facility with a standard size video tape machine and a microwave link could be fitted into a small moving van or converted airport bus.

Because of the cost of staffing such a facility and the skills required to operate it with maximum efficiency, it is suggested that only one such unit would be operated within a county or region. It is even possible that one such unit could service several counties.

CHAPTER III

TRANSMISSION SYSTEMS

A transmission system includes that equipment which is necessary for accepting picture and sound information from the origination system (studio, video tape, film chain, or mobile camera unit) and converting it to electronic waves for movement from the point of origin to the point or points of reception. The main types of transmission systems available for use by education today include (1) standard broadcast, (2) fixed service, (3) microwave, and (4) cable.

Broadcast System

A broadcast system accepts information from the origination system, converts it to broadcast waves and transmits it in a more or less omnidirectional pattern to receiving antennae at school sites. Equipment items in this system include a broadcast antenna, transmitter, transmitter control and associated test and monitoring equipment. It should be capable of placing a 500 micro-volt signal on any receiving antenna in the primary coverage area.

Housing for a transmitter will require a minimum of 1600 square feet and because of the heat generated, the transmitter area must be air conditioned (for the good of the equipment).

Federal Communications Commission (FCC) regulations require that an engineer with appropriate license (1st class) be in attendance at the transmitter controls whenever it is in operation.

Broadcast transmitting equipment is expensive. The transmitter, control system, test equipment, and monitoring equipment for a 1-kw device will cost approximately $60,000. A 25-kw device and associated equipment will cost approximately $236,000. The broadcast antenna, depending on size and construction, will cost between $5,000 and $25,000. The tower necessary to hold the antenna up in the air will vary in cost according to height and structural specifications (cost not projected).

The signal range will depend on the height of the antenna, terrain, power, pattern, etc. It might be as great as 50 miles or as small as 10 miles.

Instructional Television Fixed Services

There are two TV emission systems available to education which stand midway between regular (VHF and UHF) broadcast and closed-circuit cable systems and which achieve much of the same effects of transmission privacy and multiple program capability as cable. One system was approved in September, 1963, for use by education. It is called the "Instructional Television Fixed Service" or 2,500mc, multi-channel, low-power broadcast system. It differs from microwave in that its transmitter signal may be omnidirectional. The privacy of the system is maintained at the receiver location. Only those receiving sites provided with a special, highly directional dish or corner antenna, which is oriented toward the transmitter location, can receive the signal. Up to five programs can be transmitted simultaneously via this system if appropriate equipment is provided and the necessary channels are assigned by the FCC. (There are actually 31 channels available, but only five may be assigned to any one school district.) The signal range of this equipment is 15-20 miles depending upon terrain, antenna, and locations. It is limited to line of sight transmission-reception.

Required equipment at the transmitter location includes (at the present time) one transmitter instrument per channel, transmitter controls, and associated test and monitoring equipment. The transmitter antenna mast is relatively short (to help limit the distance to the horizon and thus limit the range and danger of interference with adjacent instructional fixed installations).

Required equipment at the receiver location includes a relatively tall antenna mast, a corner or dish antenna, and a special converter. Once out of the converter, the signal is fed into the building distribution system and displayed on a regular TV receiver.

FCC regulations require that the engineer who attends this equipment during operation have only a 3rd-class license (and remote operation is permissible).

At the present time, the transmission apparatus for the fixed facility system is relatively expensive, but less costly than regular UHF-VHF equipment. The transmitters cost between $10,000 and $15,000 each. The master receiving antenna and converter for each school site will cost between $500 and $1,000.

It is anticipated that future fixed facility packaging will be similar to that now standard with microwave. That is, it will be possible to purchase a single transmitter instrument into which it will be possible to plug additional channel modules as necessary (up to 4) for a cost of no more than $1,000 each. (One firm now offers a dual channel instrument. It is an encouraging step in the right direction.) The fixed facility system will be more appropriate for educational use at that time. In the interim, it will offer an economical, workable alternative to cable systems for the inter-connection of widely separated building sites. It is incumbent on educators to demand of equipment manufacturers the packaging that they feel is appropriate to school needs. Without information concerning the needs of education, the manufacturer can do little.

Microwave Systems

Another through-the-air transmission system is called "microwave." It employs highly directional transmitter and receiver "dish" antennae and is used most frequently to connect (per link) any two line-of-sight points with one or two-way picture, sound, and data information. At the pleasure of the FCC, more than one channel may be assigned to make possible simultaneous, multiple program transmission between the sites so connected. Depending on the terrain and height of antennae above terrain, this equipment can project a usable signal between 25 and 50 miles. Like the 2500mc system discussed previously, microwave transmission is limited to line-of-sight. Of course, it can be received, amplified, and sent on to the next link and from there to the next. (Most cross-country phone conversations are now carried by such a system of microwave links.)

Inter-connection via microwave costs approximately $10,000 to $15,000 per link ($5-$7,500 per site) for the first channel and $1,000 per link for additional channel modules.

FCC regulations require only that an engineer with a 2nd-class license be in attendance during operation and remote operation is acceptable.

Microwave would seem to be useful for inter-connecting one or two widely separated school sites; however, the use of microwave for inter-connecting buildings within a school district where rapid and large scale development of new school sites is anticipated would seem to be less than desirable since its ultimate cost would probably be more expensive than would the use of the instructional fixed system which may transmit an omnidirectional pattern and costs only about $1,000 (vs $5-$7,500 for microwave) at the head end of each reception site.

Cable

Cable transmission systems at the present time are of two main types, "coaxial" and "biaxial." The coaxial cable normally ranges between 1/8" and ½" in diameter. The wire itself is about 1/16" in diameter, is implanted in the center of a polyethylene insulation which in turn is surrounded by a metal (flexible) shield which is in turn surrounded by a neoprene outer cover. Biaxial cable is best described as a twin wire system, separated by spacers at regular intervals.

Considerable discussion ensues between engineers concerning the relative merits of coaxial and biaxial cable. Most engineers will agree that coaxial cable is suitable for school building requirements. Opinion concerning biaxial wire varies. On the negative side are those who suggest that the open wire biaxial system is more prone to (1) radiate signals and (2) induce spurious signals. On the positive side are those who point out that the biaxial systems are easier to install and generally have less signal loss than coaxial cables if properly installed and maintained. If any generalization can be made from this controversy, it would seem to be that coaxial cables might be most appropriate for use in metropolitan areas where there is danger of interference with other TV users because of signal radiation and interference with your reception because of the possible induction of the TV signals of others. On the other hand, biaxial cable systems might be more appropriate for use in schools in remote areas if, as is claimed, the system is characterized by less signal loss than coaxial. No decision either way should be made until an unbiased and qualified engineer has assessed the local situation.

Concerning costs, coaxial wire costs approximately 4¢ - .15¢ per foot to purchase outright. Biaxial wire costs approximately . 2¢ - 11¢ per foot. (The fittings associated with biaxial systems are somewhat less expensive than those of the coaxial systems.) Of course, common carriers and various cable companies are willing to install and maintain systems for schools. However, these companies have set difficult rental rates for their facilities thus far. Under the impact of healthy competition from alternative systems (e.g., 2,500mc ITV fixed service) the picture may change.

Cable systems do not use the public's air waves and therefore the FCC has little direct interest in their operation (unless there is interference with neighbors from spurious radiation or microwave interconnection is required). There are no licensure requirements for engineering operators of such systems. It will, however, require the services of a qualified engineer to maintain the operational standards of the system at a level necessary for reliable school service.

Cable systems may be used to carry TV signals throughout a school building. T hey may also be used to interconnect several buildings. It is recommended that buildings on a single campus be so connected; however, the interconnection by cable of buildings of a school district which are widely separated is not recommended at this time. Alternative systems such as the 2,500mc fixed service (or in certain limited cases, the microwave) would seem to offer the same multiple program channel capability as cable but might provide this service at a lower cost over the long haul. However, transmission system selection must be done on a case-by-case basis. All interested vendors should have opportunity to submit competitive bids.

These bids should then be evaluated by an impartial, qualified engineer and cost accountant to determine which is the most appropriate for the school system in question.

Retransmission System

In conjunction with broadcast or quasi-broadcast systems it is sometimes necessary to extend the signal coverage of the basic transmitter instrument or to "fill in" shadow areas that do not receive the basic signal because of terrain interference. Devices for retransmitting TV signals at the instant of their emission include "translators" and "boosters." These devices may be licensed to users (such as a school district) by the FCC (and with the concurrence of the transmitter operator if the operators of the signal extender and the basic transmitter are not one and the same). These retransmission instruments may not be used as basic transmitters, only as the extenders of signals from another basic transmitter. (There is one exception to this rule. The University of Utah has been granted permission by the FCC, on an experimental basis, to use a translator as a basic transmitter. It is not anticipated, in the light of the development of the 2500mc service, that this will become standard practice on the part of the FCC.)

A "translator" is a device for retransmitting the signals of a television broadcast station by means of direct frequency conversion and amplification of the incoming signals without significantly altering any characteristic of the incoming signal, other than its frequency and amplitude, for the purpose of providing television reception to areas which cannot receive the original station signal due to topography or distance. A 100-watt translator will cost approximately $8,600 - $13,000, plus antenna and other associated gear. Installation, site acquisition, and site development will probably bring the cost up to between $12-$15,000.

A "booster" is a device for retransmitting the signals of a television broadcast station by amplifying and reradiating such signals which have been received directly through space, without significantly altering any characteristic of the incoming signal other than its amplitude. Its purpose is to extend TV reception to areas which cannot receive the original signal because of topography or distance. Boosters cost between $3,000 and $5,000, plus installation, site acquisition, and site development.

Depending on power, frequency, terrain, height of antenna above average terrain, and signal pattern, the range of translators and boosters can be as great as 20 miles or as little as one mile. The use of directional transmission antennae can extend the range further yet.

Translators and boosters can be housed on telephone-type poles or in concrete block vaults. They can be remotely operated, and FCC regulations do not require the physical presence of a licensed engineer at the instrument site as long as it is under the supervision of the engineer at the main transmitter site and receives the appropriate regular maintenance and monitoring.

CHAPTER IV

RECEPTION-DISTRIBUTION SYSTEMS

A receiving system is usually composed of an antenna, distribution and display system when used in an institutional situation requiring reception in multiple locations within that institution.

The systems described herein will permit the reception of broadcast programs at schools, and the distribution and display of those programs for students in classrooms. It will also permit the distribution and display of live or recorded, locally-produced programs or information. IN SHORT, IT IS AT ONCE A BROADCAST RECEPTION SYSTEM AND A CLOSED-CIRCUIT TV SYSTEM.

Antenna System

This refers to the device which is normally erected on the exterior (roof) of a building to catch the "RF" signals emitted by a TV station's transmitter a number of miles away. For the purposes of this discussion, this system will include, also, a UHF-VHF and a 2500mc converter where necessary. The antenna height and general construction will depend on the distance between the transmitter and the receiving antenna location and certain line-of-sight considerations. In general, the further from the transmitter, the higher the antenna required. All antenna arrays should be equipped to receive VHF (channels 2-13), UHF (channels 14-83) signals and where necessary 2500mc signals. (Obviously, if the only station in an area were a VHF station, the only antenna array necessary on the mast would be a VHF antenna array.)

One UHF converter per station (and 2500mc converter per 4 channels where necessary) should be added to the antenna system. The UHF converter should be able to discriminate between adjacent channels from 14 through 83 for UHF. It should cost between $90 and $250 for UHF and $500-$1,000 for 2500mc systems.

The purpose of any converter is to convert a UHF or 2500mc frequency signal to permit its reception and display by VHF receivers. (All-channel receivers, i.e., 2-83, cost approximately $30 more than VHF-only receivers and their ability to discriminate between adjacent channels is not good at this time.) For this reason, and the fact that there is considerable signal loss when UHF is distributed directly, better reception quality is provided by having a single unit per transmitting station convert the UHF (and one per 4 channels 2500mc) signals to VHF than to have it tuned and converted at the individual set. THIS MAY CHANGE RAPIDLY AND RADICALLY NOW THAT THE ALL-CHANNEL LAW IS IN EFFECT. CONCERTED EFFORT ON THE PART OF EQUIPMENT MANUFACTURERS MAY BE EXPECTED TO IMPROVE THE QUALITY OF UHF SETS AND SIGNAL DISTRIBUTION TECHNIQUES SOON.

Only one antenna mast will be required per building or per campus in the normal situation. Only one converter per UHF channel (one per 4 2500mc channels) will be required per building or per campus where a master distribution system is utilized.

Distribution System

This term refers to the system of coaxial or biaxial wires which takes the signal from the reception antenna (or origination device) and transports it to viewing locations within rooms of a building. A distribution system can also interconnect several buildings. And it is recommended that buildings on a single campus be so connected; however, the interconnection of buildings of a school district widely separated is not recommended at this time for any but thoroughly need-documented uses.

The suggestion here is not that school districts should not interconnect all buildings with TV service, but rather that districts should contemplate this step only after a thorough study of the problem. The 2500mc system for low-power transmission of multiple programs through the air is available now. Though the equipment is available, it is rather expensive in educational budget terms and not packaged in the most appropriate form for schools. When the packaging of the equipment is further refined (per the suggestions on page 20 of this document), it will make low-power, multiple channel broadcast service by districts to most school sites possible and feasible. This system requires no wires between buildings. And, it is not impossible that the cable companies and other common carriers will offer more attractive rates in the face of the competition offered by the 2500mc system. However, the time for districts to interconnect widely separated school sites is not yet here <u>unless</u> there is solid justification and strong indication that use of the system will be heavy enough to warrant the expenditure for the equipment and its operation.

What is appropriate for school districts and educational institutions to contemplate at this time in terms of TV? It would seem important that they enter the TV field by planning and installing good quality, solid, reliable systems for receiving, distributing within buildings and displaying broadcast TV programs from VHF-UHF and any other proposed local instructional TV service such as intra-building film/video tape origination. There is little doubt that school districts will need to interconnect school sites in the future when the associated technology is priced and packaged appropriately. However, if individual buildings are provided with the type of reception, distribution, and display systems suggested herein as a first step, the problem of interconnecting buildings as a second step in the future will be simple and, by then, more feasible.

Building distribution systems should be capable of (1) carrying both video and RF signals without major modification after installation; (2) carrying up to twelve /12/ different RF programs simultaneously; (3) carrying the signal to the most distant viewing location in the system without appreciable loss of signal; (4) being expanded or extended without loss of service to existing installations and without extensive modification of existing systems.

In those school locations where the "off-the-air" signals are weak, it will be necessary to boost the signals before they enter the distribution system. This can be accomplished with a distribution amplifier. This is a small (8" x 10" x 8") piece of electronic gear. It should be capable of boosting RF signals and should cost between $125 and $250. Distribution amplifiers may also be necessary in those situations where the lengths of the cable runs are extremely long.

Each room selected as a viewing location should be equipped with a junction box at a convenient wall location. This junction box should have fittings to permit the following:[1] (1) the plugging in to the distribution systems of at least two receivers; (2) the reception of either RF or video and audio signals; (3) the plugging in of live television cameras for the live origination of programs in the room and their transmission throughout the system; (4) the inclusion of an

[1]Not all of these features need be included in the system at the outset of operations or in most K-6 installations; however, the capacity to permit sequential additions without major modification must be present in the initial installations.

intercommunication circuit; (5) room for expansion, and (6) self-termination and automatic balancing. After the main trunk of the distribution system is installed, it should cost approximately $50 to wire each viewing room, including tapping into the main cable, purchasing associated materials and installing the junction box. Incidentally, all video connectors should be of the rugged UHF type.

Display System

This refers to the equipment necessary to accept the signal from the distribution system at the junction box, and present it to viewers in the form of pictures and sound (e.g., a TV receiver-monitor of 19", 23", or 27" or a TV projector which would display the image on a standard motion picture screen of 2 to 10 feet in width).

First, with few exceptions, TV projectors are not recommended for use in schools at this time. They are too expensive and the resolution is insufficient for most instructional purposes. Public agencies such as police, fire, or civil defense, however, might find this large scale display device useful in spite of its cost and operational limitations.

Second, TV receivers-monitors should meet the following minimum specifications. They should: (1) have a diagonal screen width of no less than 19"; (2) be capable of receiving VHF channels only;[2] (3) be equipped (jeeped) to display both RF and video picture information where necessary;[3] (4) have a sound system capable of servicing an

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[2]See paragraph 2, page 27 of this report for an explanation of the reason that VHF rather than all-channel receivers are suggested at this time.

[3]Regular TV receivers cannot display straight video information unless they are specially adapted. This adaptation is called "jeeping." It may cost as low as $1.75 for materials to jeep some sets and as much as $35 to jeep others. This is a serious point to consider in the selection of receivers.

average classroom with clarity and without distortion /front mounted speakers are a must here/; (5) be equipped with a glare shade over the receiving tube or some device to achieve the same effect; (6) be equipped with a power transformer circuit; (7) have A.G.C (automatic gain control); (8) present a minimum of 300 lines of resolution RF and 600 lines of resolution video; (9) be mounted on a wheel-equipped portable stand which places the center of the picture tube approximately 60" above the floor for secondary classrooms (56" for elementary) and permits adjustment of the receiver downward to help eliminate overhead light glare;[4] and (10) be completely shock-proof. Purchased in moderately large lots (10 or more), these sets should average $175 each in cost. The range will be between $135 and $250, depending upon intended video applications.

[4]Permanent wall or ceiling mounts would be acceptable, too, if there are sufficient funds to provide each viewing location with a resident TV receiver. It is anticipated, however, that most schools will have too few receivers (at least at the outset) to mount them permanently and will, of necessity, be forced to mount the receivers so that they may be moved from viewing area to viewing area upon demand.

CHAPTER V

SCHOOL PLANT IMPLICATIONS

The inclusion of television in a school program holds considerable implications for school plant construction. However, it would be a mistake to approach the problem of school construction solely from the point of view of television. Education is the product of an instructional system, not television alone. The components of this system include (1) a learning-communication theory, (2) the classroom instructor, (3) the media of mass dissemination /including films, film-strips, radio, and television/, (4) the media of individual instruction /including textbooks, and auto-instructional materials and devices/, and (5) the learner.

The ultimate objective should be to arrive at the most efficacious combination of the above components and employ this combination in the schools to effect improvement in instruction and learning. Unfortunately, there is little research-documented guidance for the solution of the questions raised here as related to school plant design.

About the only generalizations that can be made at this time concerning school plant provisions for the newer media are as follow:

1. The trend seems to be toward the centralization of instructional resources (library materials, films, video tapes, audio tapes, etc.).
2. The trend seems to be toward distribution systems which facilitate the access to learning resources by teachers, classrooms and individual students at remote locations.

3. These two trends would seem to dictate the provision of multipurpose, high capacity distribution systems within school buildings and school campuses. If distribution systems are to be provided, it is desirable to build into new school plants conduit of adequate size leading from the central learning resource area to all instructional spaces in a school plant.

Most of the ideas concerning school plant modification for the inclusion of newer media have come from practitioners in the field and the expert judgment of experienced architects. Though these are undoubtedly valuable guidelines, they do not provide the school administrator who is faced with the responsibility for making decisions on plant construction or modification with the same confident base for judgment that data from controlled experimental comparisons would. One notable exception to this rule has been the research and development supported by the Educational Facilities Laboratories. Particularly helpful in this area is a series of Case Studies of Educational Facilities, supported and published by EFL.[1]

It is difficult if not impossible to make projections concerning the remainder of the school plant as it relates to the instructional system. School philosophy concerning the grouping of learners and faculty will be the determinant of classroom size and composition. Little else can be said.

[1] Case Studies of Educational Facilities (New York: Educational Facilities Laboratories, 1958-1964).

CHAPTER VI

PERSONNEL AND MAINTENANCE

There is a tendency on the part of school people to downgrade or disregard the continuing costs associated with the operation of a school TV system. Actually, the non-recurring capital cost for the equipment is small in comparison with the continuing operation and maintenance costs.

Operation Costs

The main operational cost of a continuing nature is personnel. TV systems do not operate themselves. The system which requires the smallest investment in personnel is the simple antenna-distribution-reception system. Depending on the dimensions of the system, it might be possible to contract with private vendors for equipment servicing. However, a large district with a sizable system would probably want to have at least one full-time repair technician ($6,000-$7,000). When simple origination systems such as the overhead TV camera or a tape-film chain central are added, a full-time operation and repair technician is probably mandatory. When full-scale production facilities are added, it requires not only the inclusion of a skilled operating engineer with at least one assistant for repair, it requires the inclusion of production personnel such as producer-directors ($7,000-$10,000), audio operators ($5,500-$7,000), switchers ($4,500), cameramen ($4,500-$6,500), floor managers ($4,500-$6,500), lighting technicians ($6,000), etc. When broadcast transmission facilities are added, the requirements are expanded to include transmitter engineers ($8,500-$10,000), and a chief engineer ($10,000-$12,000) with a first class FCC license when the system is standard UHF or VHF. These are continuing costs year after year.

<u>Maintenance</u>

Maintenance costs vary widely with the initial quality of the equipment, type of use (stationary or mobile), size of system, and age of system. If any generalization at all can be made concerning these costs, it would seem to be the rule of thumb that is advanced by several major equipment manufacturers. They suggest that maintenance of equipment can be expected to cost approximately 10% per year of the original cost of the equipment. Maintenance during the first few years of operation will probably run considerably less than 10% and considerably more than 10% during the final years of equipment life. Incidentally, this 10% maintenance figure is predicated on the assumption of a 10 year average equipment life and the exercise of reasonable care in its use.

CHAPTER VII

GUIDELINES FOR SCHOOL ADMINISTRATORS

The discussion thus far has tended to place the cart before the horse. It has examined a lot of hardware and a little of the instructional system. It has assumed (1) that TV can do something for education and (2) that there is a need for TV in schools. Given a particular situation, these could be false assumptions.

The decision to acquire a TV system for a school should begin with an assessment of the medium's potential and an analysis of the school's instructional system needs which the medium might serve. Assessing the potential of TV in any given school situation is a task which can be accomplished only by those individuals who are familiar with the characteristics of the school community and the characteristics of the TV medium and are responsible for decisions affecting patterns of school system development. Gene C. Fusco stated the problem thus in an article for School Life:

> As yesterday's dream becomes today's reality, the school administrator must carefully evaluate the potential of the new media in terms of his school program.[1]

A document of this nature and scope cannot suggest precise answers for every school situation. However, it can facilitate assessment of the medium's potential and identification of school needs by those responsible by providing (1) information concerning TV's characteristics and (2) administrative questions to ask.

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[1]Gene C. Fusco, "Technology in the Classroom - Challenges to the School Administrator," School Life, March-May, 1960, p. 4. (Reprint by H.E.W.)

Characteristics of TV

Television has at least seven characteristics. An understanding of these can aid in the selection and assignment of appropriate tasks for the medium.

1. TV can transport images and sound over vast distances.

2. TV can multiply the number of viewers who can see and hear information and it can multiply the number of reception points at which it can be seen and heard simultaneously.

3. TV is immediate. Information can be transported from the point of origin to a multiplicity of viewing locations at the instant of its origination.

4. TV is reproducible. Televised information can be recorded, retrieved, and reproduced at any point in time and as often as required. Although film and/or kinescope can be used, the video tape process makes the entire record, store, retrieve, playback cycle an instantaneous one.

5. TV magnifies small scale three-dimensional objects to the full size of the TV screen, if necessary.

6. TV can transpose images in a number of different ways. Negative images can be made positive, contrast can be heightened or de-emphasized, invisible images can be made visible through the use of infra-red camera pick-up tubes, and images can be inverted to make people or objects appear to stand on their heads.

7. TV can juxtapose normally separated objects to demonstrate their relationship, or it can juxtapose sight and sound to accomplish the same purpose.

Questions to Ask

Once the characteristics of the medium are understood, it is desirable to ask questions which can help determine the appropriateness of the medium in terms of specific tasks. These questions would include at least the following:

1. What do you expect the TV system to do? (Be specific in terms of single tasks.)
2. Under what conditions do you expect it to perform this task?
3. Analyze each piece of equipment intended for purchase in terms of (a) what it must do, (b) when, and (c) how.
4. Finally, examine every other conceivable alternative for performing the task to be sure that some less expensive system might not do it as well or better.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

This document has attempted to establish lay-term specifications concerning quality standards, compatibility requirements, and costs for a range of instructional TV system configurations. The information is presented as an assist to responsible school officials in planning instructional TV facilities for schools located in diverse communities and faced with widely varying grades, K-college. No single system will be universally applicable to all school situations. It is the responsibility of school officials to assess the requirements for television of a given instructional system. This assessment is best based on (1) an understanding of the capabilities of the TV medium, (2) a knowledge of the range of system configurations possible, and (3) a knowledge of the existing state of the local instructional system. The extent to which this document imparts the requisite understanding and knowledge and facilitates this assessment will be the measure of its success.

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A P P E N D I X

APPENDIX A

SOURCES OF IMPARTIAL QUALIFIED TV ENGINEERING CONSULTATION

The following is a representative list only. It does not include every impartial, qualified TV engineering consultant in the State of California. A number of business firms in the State of California provide engineering consultation as their primary service. Many are listed in the Television Factbook (see the Bibliography, p. 40 for full information on this publication.)

Mr. William D. Britton
Chief Engineer, KVCR-TV
1701 So. Mt. Vernon Ave., San Bernardino, California

Mr. Gorman Brown
Chief Engineer, KVIE
Box 6, Sacramento, California

Mr. Hal Kuerschner
Head, Planning and Development
Academic Communications Facility
University of California-Los Angeles
405 Hilgard Ave., Los Angeles 24, California

Mr. Robert A. Mason
Director, Communications Department
Santa Clara County
2700 Carol Drive, San Jose, California

Mr. Glen Pensinger
Technical Director, Instructional TV Center
San Jose State College
301 So. 5th Street, San Jose, California

Dr. Jacob Wiens
Director, College of the Air
San Mateo College
1700 West Hillsdale Blvd., San Mateo, California

Mr. Paul Williams
Chief Engineer, KQED
525 Fourth Street, San Francisco, California