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ABSTRACT

This report provides guidance in designing and implementing a performance-oriented learning center program, an approach to training which emphasizes the application of instructional technology in helping the individual or individual team to learn more effectively. Although intended for training personnel and instructional technologists in an Air Force training program, this report could be applicable to anyone interested in developing a learning center. Sections are entitled Orientation, Establishing a Learning Center, Courseware Preparation, Media Courseware Production, Hardware, Learning Environment and Carrel Design, Physical Plant, and Quality Assurance. Recommendations and working conclusions, based on the current state-of-the-art (as of spring, 1974), are presented in a simple how-to-do-it manner. Many additional resources are cited for those who desire to explore various aspects of instructional technology, as applied to learning center programs. The two appendixes provide information on learning centers for flying training activities (four pages) and on selecting equipment for school media programs (18 pages). Explanatory illustrations (44) and tables (10) are provided throughout the report. (SH)

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AIR FORCE

HUMAN RESOURCES

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HANDBOOK FOR THE DESIGN AND IMPLEMENTATION OF AIR FORCE LEARNING CENTER PROGRAMS

By

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TECHNICAL TRAINING DIVISION
Lowry Air Force Base, Colorado 80230

December 1975
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This interim report was submitted by Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, Colorado 80230, under project 1121, with Hq Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235.

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This technical report has been reviewed and is approved.

MARTY R. ROCKWAY, Technical Director
Technical Training Division

Approved for publication.

HAROLD E. FISCHER, Colonel, USAF
Commander

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This report provides guidance in designing and implementing a performance oriented learning center program for Air Force training. Sections are entitled Orientation, Establishing a Learning Center, Courseware Preparation, Media Courseware Production, Hardware, Learning Environment and Carrel Design, Physical Plant, and Quality Assurance. Recommendations and working conclusions, based on the current state-of-the-art, are presented in a simple how-to-do-it manner. Many additional resources are cited for those who desire to explore various aspects of instructional technology, as applied to learning center programs.

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SUMMARY

Problem

Investigation and evaluation of research-based approaches to economical and effective instruction often imply that a learning center may best meet Air Force technical training requirements. Thus far only minimal guidance has been provided (as summarized in ATCOG 52-2 and general requirements in AFM 50-2, AFP 50-58, and ATCR 51-22). The problem was to determine and document the current state-of-the-art in the establishment and operation of learning centers for use by Air Force personnel.

Approach

A survey both of the literature and experience of learning center design and implementation was performed. Emphasis was placed on two aspects. First, the characteristics associated with learning centers which appeared to be effective (Sullivan, Smith & Filinger, 1974) were explicated into operational recommendations. Secondly, those aspects of learning center design not readily available from other sources (such as carrel design) were emphasized while traditional facilities requirements were simply enumerated. Guidelines were determined although adequate evidence of their validity is not available. Field evaluation and resultant feedback has been incorporated into this document prior to dissemination.

Results

The present state-of-the-art in learning center design and implementation is documented in eight sections. The sections deal with the orientation and establishment of a learning center, courseware preparation and production, media equipment, design of carrels and learning environments, the physical plant, and quality assurance. Recommendations and working conclusions are provided.

Conclusions

A learning center program may be effective and economical when used in Air Force training. Many complex factors and trade-offs require careful preplanning. Some administrative changes may also be required for a more economical and efficient learning center operation. More examples and experience from actual operation is required for better guidance.

PREFACE

This report was completed under Project 1121, Technical Training Development; Task 112107, Media Design and Evaluation; Work Unit 11210704.

The authors wish to acknowledge technical support provided by the following personnel: Mr. Robert E. Coward, Chief Instructional Technology Division, Aerospace Defense Command, who prepared the Appendix A material; Dr. Ray Wyman, University of Massachusetts, who prepared the Appendix B material; and Mr. C. Gant, who prepared the cost formula data presented in Figure 5. Appreciation is expressed for the reviews and comments from representatives of SAC, TAC, MAC, ADC, ATC, AFSC, AAVS of the Air Force, the National Guard Bureau, TRADOC of the Army, and NTEC and TAEG of the Navy. Apprendix B material is used with the permission of the Association for Educational Communication and Technology (AECT).

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HANDBOOK FOR THE DESIGN AND IMPLEMENTATION OF AIR FORCE LEARNING CENTER PROGRAMS

I. ORIENTATION

This report will provide guidance in planning and implementing a performance-oriented learning center, an approach to training which emphasizes the application of instructional technology in helping the individual or individual team to learn more effectively. The learning center provides individualized modular instruction through the application of the Instructional System Development (ISD) process. The report is intended for use by training personnel and instructional technologists and represents the state-of-the-art in the spring of 1974. However, where the state-of-the-art is adequately discussed in other sources, they are cited rather than discussed. Regrettably, few examples of how to meet many of the needs in designing and implementing a learning center are available. However, strong authoritative management and dedicated personnel with control over courseware development are key factors in the development of a learning center program.

This report includes the citation and illustration of products and manufacturers by name for clarity and illustration of specific points. This practice does not constitute an endorsement of the product by either the authors or the United States Air Force.

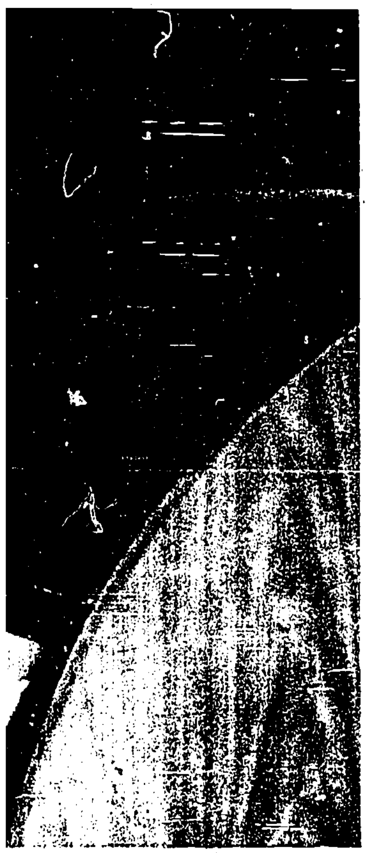
Several background studies have preceded this report. Of particular note is the technical report by Sullivan et al. (1974). The overall conclusion of this survey was that learning centers can provide a cost effective approach to instruction. More importantly, three characteristics were associated with those learning centers which appeared most effective: (1) the learning center was designed to meet a clearly existing and clearly specified need (this need typically included requirements for student performance), (2) the learning center was administered under centralized authority (this authority provided a unified control of the courseware content and production quality), and (3) the learning center courseware, designed to meet specific and often unique needs of the learning center, was developed and produced largely within the organization. Courseware (or module development) and local control of production were deemed essential. Courseware refers to the instructional materials, textual or mediated, which are presented to the student.

Note that present Air Force structure and procedures may limit the ability to fully implement these characteristics. Their implementation should improve learning center operations. Trainers should not wait, however, for an optimal working framework before initiating the best program possible.

A learning center is an individual-oriented program using a preplanned environment which applies educational technology to assist learners in achieving criterion performances. Smith and Filinger (1973) have defined a learning center more completely as:

> A learning center is a program or environment in which instructional technology (including the ISD process) is specifically directed at the instruction of individuals or small teams. While the most visible aspects of a learning center are generally the devices and carrels, the courseware aspects are of equal importance. Courseware is virtually always locally or specifically prepared. It includes a learner-centered environment, with emphasis on both self-pacing and self-selection among alternate instructional packages and alternate presentations of the package. These presentations may vary in terms of media type, difficulty level, or purpose (i.e., overview, instruction, review, etc.). Often the program is conducted in a series of learning stations or carrels in which automated presentations include visual presentation of what to do, verbal presentation (written or auditory) of how to do it, with provisions for actual task performance. Considerable emphasis is placed on instructional strategies, with frequent elicitation of specific response and confirmation of the appropriateness of the response. Learning centers may be enabled by a computer which facilitates the presentations, records and/or interprets the performance and may assist in pacing and sequence selection. It must be stressed that a learning center is a *program* and not merely a facility: it is something you *do*, not something you *buy*.

It cannot be emphasized too strongly that the primary mission of a learning center is training. The nature of the tasks to be trained must determine the specific preplanned environment which supports individual-oriented learning. The learning activity is defined and, when appropriate, the learning center is designed to apply technological support to that activity (Figures 1 and 2).



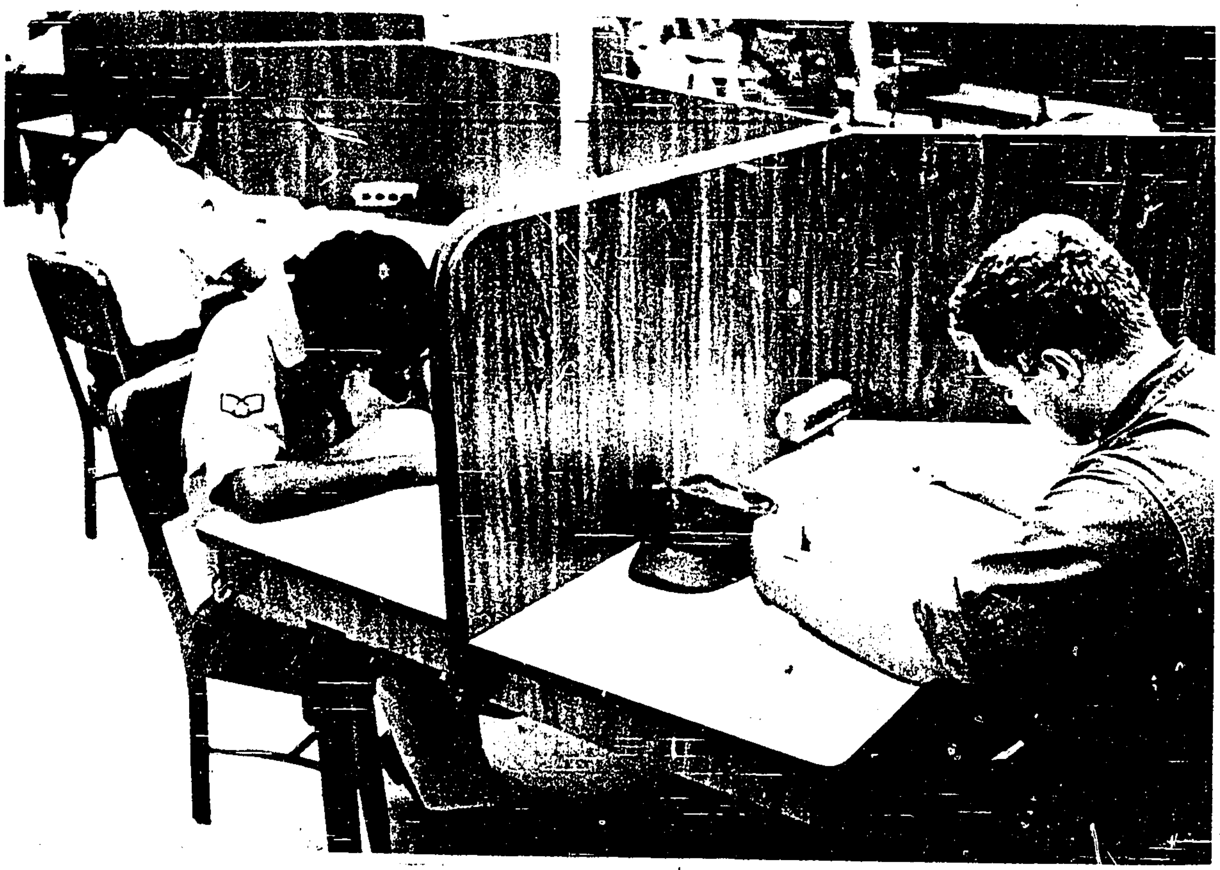


Figure 2. Learning center, Lowry AFB, CO.

The learning center program, discussed in this report is a specific result of the application of the Instructional Systems Development (ISD) process implementing a learner-centered philosophy of instruction and operated by trained subject matter specialists. While some information useful in the design of an Instructional Materials Center or a Learning Resource Center may be included, this report does not emphasize the management and administration of a library of instructional resources. The learners interface with the body of knowledge and activities enabling criterion performance is facilitated by a technical (subject-matter) specialist, usually called an instructor. While learning centers may efficiently use resources in presenting and managing instruction, the preplanned learning environment and experiences (based on the thoughful application of AFM 50-2 and AFP 50-58) is essential for the program.

Learning center technology supports the instructor. The instructor, who is responsible for training, must be given a high level of technical support to accomplish his mission. The instructor role in AFM 50-2 is defined as a classroom administrator and an individual tutor and counselor. In some Air Force learning centers, the instructor is referred to as the Course Manager to emphasize his distinctive roles in the learning center program. He is the person who facilities the interaction between the student and the knowledges, skills, and attitudes being learned. The instructor should automate those functions which can be done mechanically, such as conveying basic information. A live instructor can function at a much higher level than a tape recorder, and will emphasize those aspects of learning which require skills unique to humans, such as tutoring and counselling. Selected senior instructors (with appropriate training) should also carry the primary responsibility for the development of validated courseware. For this task he must have technical support which is rapidly responsive to his needs. The instructor in a learning center should be a flexible, competent individual. The training of this person will be discussed in a future report.

Development and production of courseware appears to be a critical, local requirement. Very little off-the-shelf courseware will be available to meet the specific learning center requirements. Frequently, many high level and unique skills must be provided to relatively low numbers of students. Some examples are: training boom operators on the KC-135, training most avionics specialties, training gunners on the B-52, training dental technicians, and training precision photo technicians.

Courseware development should be done using a team approach which is discussed in Section III. The development team must be able to develop, pretest, and revise prototype instructional sequences. Courseware should be validated using small group tryouts (AFM 50-2) *prior* to incurring significant production expense. Revision and veto power should be limited since module validation is based on student performance. Approval authority should not involve an extensive chain of command; maximum support should be provided to the instructors responsible for developing and validating an instructional module.

It is reasonable to assume that for Air Force training about 20% of the courseware must be revised and updated each year when accurate data are not available. The learning center program should have subject matter and job performance expertise and develop (and frequently also produce) courseware adapted to the needs of its students. Large initial investments in courseware development and production facilities may be necessary for a learning center operation. The learning center cannot meet courseware requirements within a reasonable and necessary time frame without control over their development and production. Current Air Force procedures are costly both in time and effort. Technology, such as instructor storyboarding, must be used to reduce the cost of courseware development and production without lowering teaching effectiveness. Costs of courseware development and production must be suitable for low student flow and rapidly changing material, as well as for high student flows with widely differing knowledges, skills, and attitudes.

As research concerning various aspects of learning center operations and functions continues to develop new knowledge, our working conclusions may change. This report gives what the present state-of-the-art indicates as the best decisions in 1974, with emphasis upon the interface between the student and the job skills to be acquired. Recommendations are based on what is now available in hardware and techniques. We would appreciate sharing in the experiences of those users who can provide insight into the problems and available solutions concerning learning center design and operation.

For this report to be maximum usefulness to the learning center manager, some deviations from our recommendations and current Air Force procedures may be necessary. However, managers should do what is possible within the given structure so that innovative improvements may be documented and justified.

II. ESTABLISHING A LEARNING CENTER: PURPOSE AND OVERALL PLAN

Learning centers are effective only when they are established for a clearly defined and clearly existing need. The learning center must be an effective way of meeting the specific training need.

If you are now beginning to design a learning center, what should you expect to accomplish? Before you start a learning center you must remain aware that traditional ways have been successful for teaching the majority of Air Force students. You must have good reasons for converting your training program to a learning center approach. The learning center must be able to yield a sufficient benefit when compared to the existing system to justify the expenditure. Questions such as the following should be asked during a predesign phase. Answers to some will provide the rationale for implementing or rejecting a learning center program. Providing answers to some of the other questions may not be within your immediate capability. However, these questions are intended to focus your attention on important aspects of learning center operation.

Will the learning center provide more rapid learning?

Will the learning center provide increased student flow?

Will the learning center provide a more flexible student flow?

Will the learning center provide more economical learning?

Will the learning center provide more current training?

Will the learning center reduce relocation of personnel?

Will the learning center center reduce the wash-back or wash-out ratio?

Will the learning center handle a broader range of entry level students?

Will the learning center enable learning not previously possible?

Will more time be given to assisting marginal students?

Will the learning center improve student morale, attitude, or motivation?

Will the learning center better allocate fixed resources?

Table 1 provides the rationale reported by a number of learning centers recently surveyed under an Air Force contract with Hughes Aircraft Corporation (Sullivan et al., 1974). You require more than a simplified rationale. You must determine and clearly state the overall goals of the learning center which you are designing. This statement should contain the mission, the rationale, the context, and the limitations of your learning center. Two available examples are shown in Figures 3 (O'Callahan, undated) and 4 (Basic Electrical and Electronics School, Naval Training Center, San Diego, undated).

During the initial design phase an overview of the various courses and modules is necessary to provide the big picture. The training requirement to be met by the various modules and courses gives on design parameter. However, limiting yourself to a single way of achieving your training goals is not always helpful. Instructional design in an iterative process and other factors can cause you to redesign various facets of your learning center approach.

Cost information is of considerable importance. A simple approach to collecting relevant information required for a cost estimate in design is shown in Figure 5. DoD Inst 7041.3 provides basic guidance for actual performance of an economic analysis of alternatives. The MODIA cost model (which requires computer support) should become available for training systems design. Preliminary discussion of MODIA is found in Carpenter (1972a, 1972b) and Petruschell and Carpenter (1972). Another cost model requiring computer support is reported in *A Technique for Choosing Cost-Effective Instructional Delivery Systems* (Braby et al., 1975). Braby (1975) recommends that economic considerations should be carefully thought out before freezing the design of a learning center.

Table 1. **Rationale for Establishing Learning Center**

Activity	Learning Center Research Program	Better Facility Utilization	Better Staff Utilization	Better Student Time Utilization	Better Cost-Effectiveness	Better Training	Use Student Centered Instr	Use Behavioral Objectives	External Pressure
Chanute AFB IL				2	1	2			
Davis-Monthan AFB AZ		2		2	2		2	1	
Keesler AFB MS									
CE Officer				2			1	2	2
CE Staff				2			1	2	
ElecPrin				1			2		
Randolph AFB TX		2		2	1	2		2	
Williams AFB AZ	2			1		2	2		
Ft Benning GA				2		1	2	2	
Ft Monmouth NJ	2	2	1	2	2		2	2	
Ft Rucker AL									
Aviation School						2	1		
Helo Maint				2		2		1	
NTC Orlando FL									
Torp Tech	1							2	2
Test EQ Tech						1			
NTC San Diego CA	2	2	2	2	2			1	
Forest Service AZ						1			
SCROC CA		2	2		2			2	1
Maritime Inst of Tech MD		2			2	2			1
American Airlines TX			2	2		2	1		
Douglas Aircraft CA		2			2			1	2
Eastman Kodak NY		2	2	2	2	1		2	
Hughes Aircraft CA		2	2			1			2
IBM KY		2	2	2	1			2	2
BYU UT	2				1	1	2	2	
Dallas Baptist TX	1	2	2	2				2	
Illinois State IL		1	2	2		2			
MT San Jacinto CA		2	2	2			2		1
Purdue IN		2	1	2					
Univ of Illinois IL	1		2		2		2		

Note. — 1. Primary reason.

2. Other reason for establishing learning center.

AIMS AND GOALS OF THE
MARITIME INSTITUTE OF TECHNOLOGY AND GRADUATE STUDIES

To develop to highest levels the executive command character, skills, disciplines, personal and social responsibility of the Licensed Deck Officer.

To educate and train the Masters, Mates, and Pilots of the American Merchant Marine to completely adapt to and master innovations in Marine design, function, structure and technology.

To provide the foremost training, study curricula and technical tools to upgrade and update navigational expertise.

To insure command of comprehensive technical capacity dedicated to fullest operational safety at sea for cargo and crew.

To define and teach a deep sense of concern and responsiblity to the ecology of the seas; for the preservation and protection of marine life and its relationship with population density and general perils threatening the human environment.

To induce Masters and Mates toward new insights and directions to advance and promote Maritime Industry profitability and productivity.

To offer institute resources for conventions of broad communication and activity assembling the knowledge, aspirations, and common goals of Maritime Industry, Labor, and Government Agencies toward achievement of our mutual national ambition.

To re-dedicate and re-assert faith and pride in the U. S. Merchant Marine; to devote ourselves to the accomplishment of the strongest, proudest and most productive Merchant Marine in American History.

In the present Space Age, the Bridge of the ship is, more than ever, the "COMMAND CONTROL MODULE." We shall teach and train the Licensed Deck Officer to prove and affirm his prime command and executive leadership post; for this ultimately is the mission of the Maritime Institute of Technology and Graduate Studies which we pridefully dedicate today.

Figure 3. Aims and goals of Maritime Institute of Technology and Graduate Studies.

SOME QUESTIONS AND ANSWERS ABOUT
THE BASIC ELECTRICITY AND ELECTRONICS INDIVIDUALIZED
INSTRUCTION SYSTEM
at Naval Training Center – San Diego CA

COURSE SPECIFICATIONS

Q. What is the name of the course?
A. Basic Electricity and Electronics.

Q. What is the mission of the course?
A. The Basic Electricity and Electronics Class "A" School is a preparatory school for advanced schools in the electrical/electronic field. Graduates of the BE/E School are ready to begin training in the operation, maintenance, and repair of the particular circuits, equipment, and machinery associated with their rating.

Q. What are the end-of-course objectives?
A. Upon completion of this course, a graduate will be able to:
1. Apply proper safety precautions to protect himself and equipment.
2. Solve fundamental electrical problems by applying basic principles.
3. Adjust and use basic test equipment (multimeter, VTVM, audio signal generator, and oscilloscope) for making measurements of voltage, current, and resistance in AC and DC circuits.
4. Explain basic current, voltage, resistance, and power relationships in AC and DC circuits.

Q. What methods/media are employed?
A. The course is a multi media, individualized program. Students are completely self-paced. The available media are: (1) three modes of printed material, (2) sound/slide lessons, (3) motion picture lessons, and (4) audio taped lessons. In addition, a subject matter expert is always available.

Q. Can the learner select instructional mode/method?
A. This kind of student management and decision making is basic to the success of the system. At least 90% of the instructional mode/method selections are made by students. Only when the learner is having Selections are made by students. Only when the learner is having difficulty does it become necesary for the learning supervisors to intervene, and even at this point, he should attempt a non-directive approach. Usually, the learning supervisor reviews what the learner has already done, then presents alternatives. A student who makes his own decision is apt to be more committed to it than to one made by someone else.

Q. Is course performance functionally oriented?
A. Absolutely! The entire course was developed, and all learning materials were written using behavioral learning objectives. The results are readily observable and measureable.

Q. Is there more than one difficulty level? How many?
A. There are three levels of printed material for each lesson and one of the levels, the narrative, is available on audio tape. Many of the lessons are supported by motion pictures and sound/slide presentations.

Figure 4. Questions and answers about individualized instructional system.

Calculations for gross instructional costs of learning center or conventional instruction.

A. RANK (STUDENT): NUMBER x PAY X TIME = COST

I	II	III	IV	V

I indicates there is one line per rank. II the number of graduates in that rank is used to multiply III, the pay of that rank. IV, the average resident time for students of the given rank is multiplied to II and III to give the cost of student pay for graduates of that rank (column V). The sum of Column V costs is total student pay cost.

$A = \Sigma a_i$ where (II) x (III) x (IV) = (V) = a_i

$\left(\frac{\Sigma\ (II \times IV)}{\Sigma\ II}\right.$ = average graduation time for all ranks)

B. RANK (INSTRUCTOR): NUMBER X PAY X TIME = COST

I	II	III	IV	V

The calculation is similar to part A (time is ordinarily equal to one year).

(II) X (III) X (IV) = b_i and $B = \Sigma b_i$

C. The cost of special equipment plus maintenance

$(E/10 + M) \times P = c_i$

Where E = equipment cost, and assumes a useful life of 10 years

M = annual maintenance cost

P = percentage of useful time equipment is used for course in question.

Total equipment cost would be $C = \Sigma c_i$

Total variable course cost per graduate can thus be estimated using the above formulae over a convenient period (a year) and summing:

Cost per graduate = (A + B + C)/ (annual) number of graduates

Figure 5. **Cost formula to compare learning center costs with conventional instructional costs.**

An entire training program should be incorporated in the learning center. A learning center program in this discussion is assumed to provide training for an entire course. A learning center peripheral to the normal training program is a luxury item and normally cannot be justified. Whatever is required to provide successful training should be integrated into the program. Use such authority, your own or your superiors, as is necessary to implement the training requirements.

Seldom is it possible to acquire off-the-shelf courseware (instructional materials) suitable for use in a learning center. Courseware designed to your specifications must be used. Technical experts in the necessary training tasks of the learning center should be available within your organization. When using a contractor he would have to be trained into those technical competencies necessary for developing accurate courseware. We recommend, whenever possible, that the learning center retain responsibility for the development of pre-tested prototype courseware. The men with technical competencies to revise courseware to reflect both current technology and regulatory requirements must be available to the learning center. The testing and validation of courseware prior to initiating a significant production effort makes possible significant cost savings. We further recommend that the maximum turnaround time (time the revision requirement is recognized until the revised courseware is available to students) for technical revisions (such as modifications of equipment) be ten working days. Excessive turnaround times will destroy the continuity of the revision process, while creating a relearning requirement (with regard to the misinformation provided during the initial learning process). While some of the recommendations cannot immediately be implemented in a given command, a better learning center program will result from their implementation.

As suggested above, local control of courseware development and production will aid in the successful operation of a learning center. This control of courseware is particularly important when the training mission is unique. Additionally, the specific tasks in a career field reflect a rapidly changing technology and courseware must be responsive to these changes. These two conditions typify most Air Force training programs. The objectives of a learning center program will be achieved through the selection or development of effective courseware.

A performance-oriented learning center will have strong visual emphasis. This visual emphasis must be provided from the beginning stages of courseware design (Figure 6). Initially the developer of courseware (an instructor trained in courseware development) determines what must be shown the student to enable him to perform. Words are then used to focus on, emphasize, or relate visual material, to explain what is not clearly evident, and to generalize or interpret what is shown. For meeting individual requirements different words could be used with the same visual materials.

The mission of a learning center includes providing effective individual oriented hands-on instruction. Authorization to set up a learning center must come from your higher headquarters. This would also imply that initial and continuing funding would either be or become available. Nevertheless, the procurement cycle typically requires several months lead time (and easily up to a year if not a TA item). Justification for funds is probably needed at least six months prior to a new fiscal year. Not only must budgeting action be accomplished but also supply action (including authorization) must be initiated about six months before acquisition. Procurement, delivery, and fabrication can be initiated only when funds are ensured. Total elapsed time may easily exceed these optimistic estimates.

A training requirement is implied by the authorization of a learning center. The training requirements for which you are responsible should be clearly and explicitly spelled out by a task analysis. Information such as Occupational Survey Data, Specialty Training Standards and the like should be available to you. If you are converting a currently operating training program to a learning center, the Plan of Instruction and various lesson plans would also be available. See AFM 50-2 and AFP 50-58 for additional guidance.

Information concerning student flow and general student ability range may be available to you. Changes in student flow impact upon staff, space, and courseware production. Changes in student ability level will impact upon courseware development.

Given the human and material resources available many things must be determined. The following checklist indicates several areas of consideration in designing a learning center:

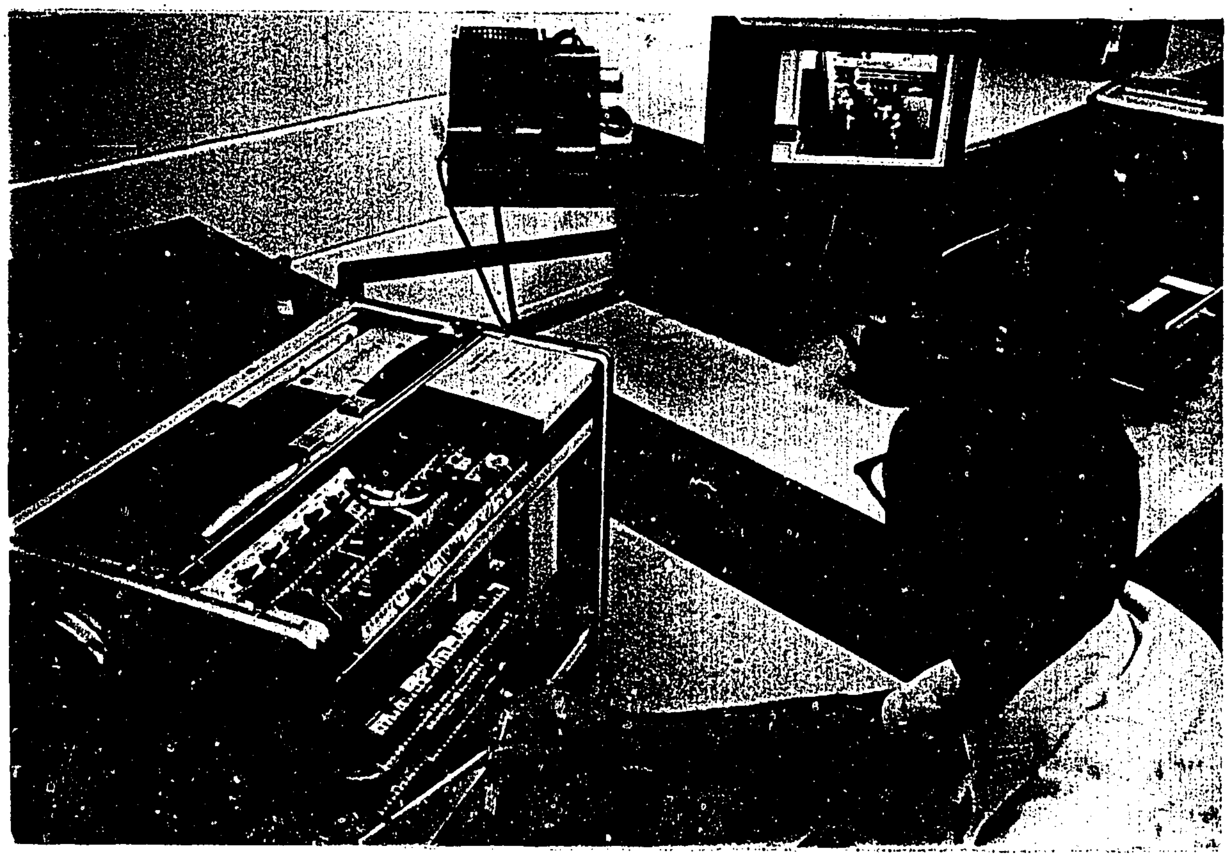


Figure 6. Visually directed training, Lowry AFB, CO.

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Have you performed an economic analysis?

What will the student do?

How will you develop the information the student needs to finish the training task?

How will you prepare for the student to use the information you have developed?

How will you present the information to the student which enables him to do the necessary task?

Where will the student learn?

Are special environmental requirements implied in the learning task?

What facilities are required to expedite learning?

What courseware production capabilities are available to you?

How do you determine whether the various operations are satisfactory?

What information is needed to ensure that learning center training functions are meeting job requirements?

What must your personnel be able to do so that they satisfactorily fulfill their various functions?

How can instructors be selected and trained in the various required functions?

How are the functions necessary to your learning center put together?

This technical report should help you make some of the above determinations, but many other sources will be required. While administration and management of the learning center is not discussed in this report, Appendix A discusses organization and operation of an Air Defense Command learning center. Even when you are purchasing the services and equipment these determinations are required. Do not overlook the development and use of appropriate management tools. Minimum requirements would include a milestone chart or an events network.

III. COURSEWARE PREPARATION

The Instructional System Development (ISD) process, as prescribed in AFM 50-2, provides the framework in which courseware will be prepared, produced, presented, and evaluated. This section will discuss and amplify processes involved in mediated courseware preparation. Printed or programmed text will not be discussed although it will be quite important. Since the duties and tasks requiring instruction and the proficiency level to be trained are normally provided to the trainer, their development will not be discussed in this report. Further, how to select and train the instructors to develop courseware and assist students remains a major problem area which is beyond the scope of this report. (However, see MACP-50-26, *Instructional Program Developer*, the AV Methods course at Sheppard AFB, TX, and the *Instructional Program Developer Training* in ATC flying training.)

For each module of instruction you must have a clear statement of what the learner should be able to do as a result of the instruction. AFM 50-2 outlines the determination of objectives in the instructional systems development process. AFP 50-58 provides additional help in determining objectives. Two documents which describe how the instructional development of real courses was accomplished are published by AFHRL as technical reports. Pieper et al. (1972) describes how each phase of the instructional development process was accomplished in two courses of self-paced job training in the Security Police career field. Fallentine et al., (1974) contains a description of how the instructional development process was accomplished in a logistics course. Other documentation and discussion of the development of objectives of academic interest can be found in Ammerman (1966); Ammerman and Melching (1966); Banathy (1968); Davies (1971); Edling (1968, pp. 177-192); Esbensen (1968); Haggard et al. (1970); Kibler et al. (1970); McKnight and Hundt (1972); Mager (1962); Mager and Beach (1967); Melching et al. (1966); Miles and Robinson (1971, pp. 39-46); Paulson and Nelson (1969); and Smith (1964).

The translation of job performance requirements into learning objectives remains an art. Three ingredients are required: (1) an expertise in the job requirements, (2) an expertise in training, blending together learning theory, instructional technology, human factors, and the ability to put together opportunities for effective performance in the learning center, and (3) a realization of the talents and resources which are available. A sample of how these ingredients are blended is found in Pieper et al. (1973). The guidance of Occupational Survey information, as recommended in AFP 50-58, will be quite useful.

An expert knowledge of job requirements does not insure adequate statements of objectives; either of job objectives or of learning objectives. Difficulty in putting the objectives into words has been reported by some personnel involved in the ISD process.

One helpful technique in clarifying statements of job objectives uses portable video technology. Actual job performances to be trained are recorded on video tape. From the video tapes, the range and variety of duties can be inferred. The sorts of conditions under which duties are performed are defined visually. For example, there are manuals that describe the duties of a security policeman. One of his duties is guard mount (Figure 7). Recording on video tape a guard mount and studying it in detail gives insight and meaning to the words guard mount. In the first place, guard mount is not an object but a series of actions. The system designer would probably add a word to specify stand guard mount rather than guard mount. In the development of the automated apprenticeship program, considerable use was made of portable video recordings to clarify such tasks. What precisely do you do during a guard mount? Among other things, you cover the special orders of the day, and you make assignments. What does the gate sentry do? To state that he "controls entry into his assigned area" does not convey much information. Viewing recordings of the gate sentry at Lackland, Brooks, Cannon, Kirtland, Lowry, Webb, and Goodfellow Air Force Bases gives a better understanding of the variety of tasks and the conditions under which they are performed. Also, assistance can be provided by others who are able to use language more adeptly.

Developing training objectives as presently practiced by many has erroneously been reduced to a somewhat futile exercise in word changing. Job performance objectives should be clearly stated (included performance, conditions, and standards) to provide a baseline which clearly shows the job performance requirement from which the learning objectives are developed (Figure 8). Training to perform this function must be provided. In many instances the job objective and training objectives will be identical. Having both job performance objectives and training objectives will allow for validation of training (possibly by correlation analysis of the two sets of objectives).

The development of learning objectives is an iterative process; an important input is the actual job which the student is being trained to perform. As technology and administrative constraints change, limitations on what is most useful in a training environment are changed. For example, the reduced cost, smaller size, and increased reliability of available digital computers now may enable their economical and effective use in simulation technology. New capabilities may be incorporated into the training environment as a result of technological advances. Learning objectives must be systematically reviewed substituting new objectives which will provide student ability to perform the actual job more proficiently on entry.

Learning objectives based upon skills and knowledges are much simpler to develop than those based upon attitudes. Frequently those behaviors not easily measurable or quantifiable are omitted. Behaviors such as "practices job safety" may be reduced to "lists ten job safety practices." Other behaviors indicated by such terms as "is proud of his career field," "patriotism," "reenlists," and "willingly cooperates" are usually ignored in the development of learning objectives. Because behaviors are difficult to describe and assess, do not exclude them from your training. Developing positive attitudes toward the area of instruction should always be incorporated into your goals. Not only do you want the student to learn, but also to like to learn. Motivating the student will assist adequate learning. Attitudes essential to job success must also be acquired. Learning objectives should represent minimum acceptable performance standards not maximum standards in your training program. Take an overview of the adequacy of your objectives, cutting off unnecessary fat but insuring the flesh of a course remains.

The clear statement of a training objective will frequently either be based upon or imply a specific instructional strategy (that is, how the knowledge or skill will be acquired). If, for example, full simulation devices or partial simulation devices will be used, this fact will be reflected in the statement of the conditions of the training performance, as would the use of actual equipment. Thus, certain specific factors in the training environment normally will be built into the statement of the training objective. (Note the earlier requirement to review training objectives.)

Figure 7. Recording guard mount on video tape.

LEARNING OBJECTIVE WORKSHEET

INSTRUCTIONAL STANDARD NUMBER: ~~CTS~~52-3AIR75100-X

TASK/KNOWLEDGE STATEMENT(S)	STATEMENT NUMBER(S)	PROFICIENCY LEVEL(S)
Select and use appropriate methods and techniques to achieve lesson objectives.	4f	3b

a. PERFORMANCE/BEHAVIOR(S)	b. CONDITION(S)	c. STANDARD(S)
Conduct a demonstration-performance lesson.	Assigned topic Class of 10 students	Lesson should be completed in 25 to 30 minutes. All students must display their ability to perform the task demonstrated.

d. CRITERION OBJECTIVE(S)

Given a topic, conduct a demonstration-performance lesson for a class of 10 students. All the students must display their ability to perform the task demonstrated.

ENABLING OBJECTIVE(S)

Locates reference material.
Researches information gathered.
Organizes information.
Plans for active student participation.
Prepares lesson plan.
Plans for the most effective instructional aids.
Develops instructional aids.

Figure 8. Sample learning objective worksheet.

When training task performance is your major activity, media would be used to show how the task is to be performed (while the student is performing it) and to tell why he is doing the selected task. Guidance in selection of other instructional strategies is contained in AFM 50-2 and AFP 50-58. Other resource materials of academic interest in instructional strategies are contained in the following documents which have been subdivided into categories.

1. *Systems approach*: Bretz (1971); Briggs (1970); Carpenter (1972a, 1972b); Davies (1971); Glaser and Glanzer (1958); Haggard et al. (1970); Petruschell and Carpenter (1972); Rhode et al. (1970); Schwarz (1960); Smith (1971); and Twelker (1969).

2. *Vocational Technical or Industrial Training*: DePhillips et al (1960); Dwyer (1972); Gropper et al. (1971a, 1971b); Mager and Beach (1967); and Odiorne (1970).

3. *School*: Ausubel and Robinson (1969); Bugelski (1971); DeCecco (1968); Divesta and Thompson (1970); Frandsen (1967); Gagne and Briggs (1974); Gerlach and Ely (1971); Johnson (1971); Postlethwait et al. (1972); Smith and Smith (1966); Teachey and Carter (1971); and Travers (1972).

4. *Attitudes*: Mager (1968); and Zimbardo and Ebbeson (1969).

5. *Theory*: Engelman (1969); Gagne (1970); Glaser (1969); Hilgard (1953); Hilgard (1964); Hilgard (1966); Hill (1971); Melton (1964); and Willis and Peterson (1961).

Costs must be considered in achieving training objectives. When cutting of costs is required in resident training, one possible way to do this is to reduce the frequency of course revision. This is a false economy, however, since teaching the wrong thing (or using erroneous materials) will not be a genuine cost saving. Job errors causing equipment damage can result from misinformation (which provides negative training). Also, misinformation in resident training would necessitate additional job training later at the work location. Delays in student progress caused by insufficient copies of training materials also significantly increase training costs. Student training time is becoming more expensive. The more rapidly a man is trained and placed on the job the more cost benefit will result for the Air Force. If costs must be reduced in resident school training transferring some training objectives to a job environment may be preferred. (Particularly those objectives which represent behaviors not immediately required by the graduate at the time of job entry.)

Major investments should always be considered, particularly if they can reduce the per student cost of training (including reduction of training time) or can train that which previously could not be taught in a training environment. It is possible that an investment of $100,000, for equipment or courseware, could save $500,000 or more in student salaries and benefits. Therefore, careful analysis is required. Cost evaluation should be calculated for overall Air Force benefit rather than the budgetary factors in a single command. Additionally amortization of costs for long term training must be considered.

Air Force career fields and training programs do not remain static, but reflect many technological advances. A systematic program to insure that training objectives reflect both current job requirements and also current applicable training technology should be designed and implemented.

Field evaluation, as described in AFM 50-2 and AFP 50-38 (Volume V), is a minimum requirement for maintaining current learning objectives. Someone must be assigned the responsibility to determine the impact of technical orders, new equipment, and administrative changes upon learning objectives. He would also initiate appropriate changes in learning objectives to reflect the other changes.

A regular re-examination of the adequacy of the learning objective with regard to job objectives should be performed. Can learning objectives be developed which will more adequately transfer to job objectives? For example, you should consider if a trainer or a simulator can be acquired which will assure cost-effective transfer of learning similar to skills previously taught on the job on actual equipment. Job performance objectives must be better approximated in modifying learning objectives. If the learning objective is frozen, then better initial job performance will not result.

One useful technique, which provides positive benefits in better training, is to base the development of learning evaluation upon job performance objectives rather than training objectives. As the evaluation more nearly approximate the actual job conditions (within the limitations of the training environment) so will the training and learning objectives. An independent evaluation effort should function to continually upgrade the quality of the learning which is being evaluated. Clearly, the evaluation program sets the limit for training performance. More adequate evaluation forces better training.

Courseware development must not be isolated from courseware production. Validation of courseware should always be based on student performance. Input from production specialists is required at the beginning of the development process. Development and production of courseware is performed as a team effort – a team composed of all the various specialties which are needed. This section will emphasize only the courseware development aspects of the team effort required. Development of print materials are beyond the scope of this report.

When media production facilities are available (such as a TV production studio) integrate them into the system design. This report, however, assumes that a production capability must be created. Therefore, production of prenarrated slides or filmstrips is emphasized.

Courseware development of non-print mediated material (as proposed in this report), apart from production, requires the combination of two specialties, the subject specialist or technical expert and the communications specialist. These functions typically have been performed by a selected senior instructor or subject matter expert and a script writer (who are supplemented by the independent decisions of the producer). Normally, the instructor will tell or teach the script writer what the student should learn. However, this process frequently suffers from communication gaps which reduce the effectiveness of the final production.

There is a very simple mediated storyboard procedure which has proven quite useful in many situtations. This procedure is used to develop a storyboard and is not recommended for production of instructional material. Train an instructor to use either a handheld or tripodmounted portable video camera along with the associated zoom lens, recorder, and monitor. This takes less than 30 minutes (and includes enough hands-on practice to enable unsupervised practice. The instructor can use the video camera informally until he reaches a level of experience where he feels comfortable operating it. The video tape can be erased and reused many times. Then the cameraman can record another instructor in a dry run of the task which is to be taught. This insures that everything necessary for the task is available and that the best camera angles are preplanned. Further, no interruptions will be caused by oversights in the preparation prior to the task. When the instructors have practiced until they can easily perform their tasks without obvious strain, someone who really doesn't know how to perform the tasks being taught (such as a new student or someone who works in a totally unrelated specialty) should be talked through what is to be learned. Now when the instructor tells the student what to do and how to do it, the cameraman records an effective and usable series of steps (Figure 9). (A naive person is important since the student who is familiar with the task will do things without being told (from habit) or else become a devil's advocate and bring out extraneous possiblities which would distract a truly naive learner.) When written words must appear on the monitor, they are written on blank paper using a felt tipped pen. Diagrams or illustrations from manuals can also be held in front of the camera when necessary. Sometimes the instructor can provide himself cues to insure that no steps are omitted. An outline can be provided on a chalk board or tear sheet visible to the instructor and not the camera. He can revise these cues to insure that a predetermined revision will not be forgotten in a retake using a new naive person. If camera angles and distances are to be changed at preselected points, this might also be indicated so the cameraman will recall what was previously decided. These should simply be rough working notes to assist memory rather than anything resembling a full scale shooting script.

To summarize, the general procedure is to have an experienced person show and tell a naive person how to perform a task while a fellow instructor records it on portable video tape. The technique (Figure 9) requires little time, money, or special talent and results in a very adequate storyboard. The procedure, while having some limitations, has unique advantages. A natural series of operations or procedural steps is cued by natural spoken words which enable their performance. With minor editing an adequate and effective dynamic mediated storyboard is generated through using this approach. The material can then be converted and produced on the media selected for learning center presentation.

When the instructor is trained to teach visually, the same general technique (Figure 10) can be used with an Instamatic, Polaroid or 35mm camera (including a tape recorder). While this latter technique requires some delay in viewing, it can provide a useful set of images. The alternative procedure demands that a slide be made each time the student is directed to do something. If the naive person must be told, the real student will probably have to be shown in the final version. This alternative technique lacks both the

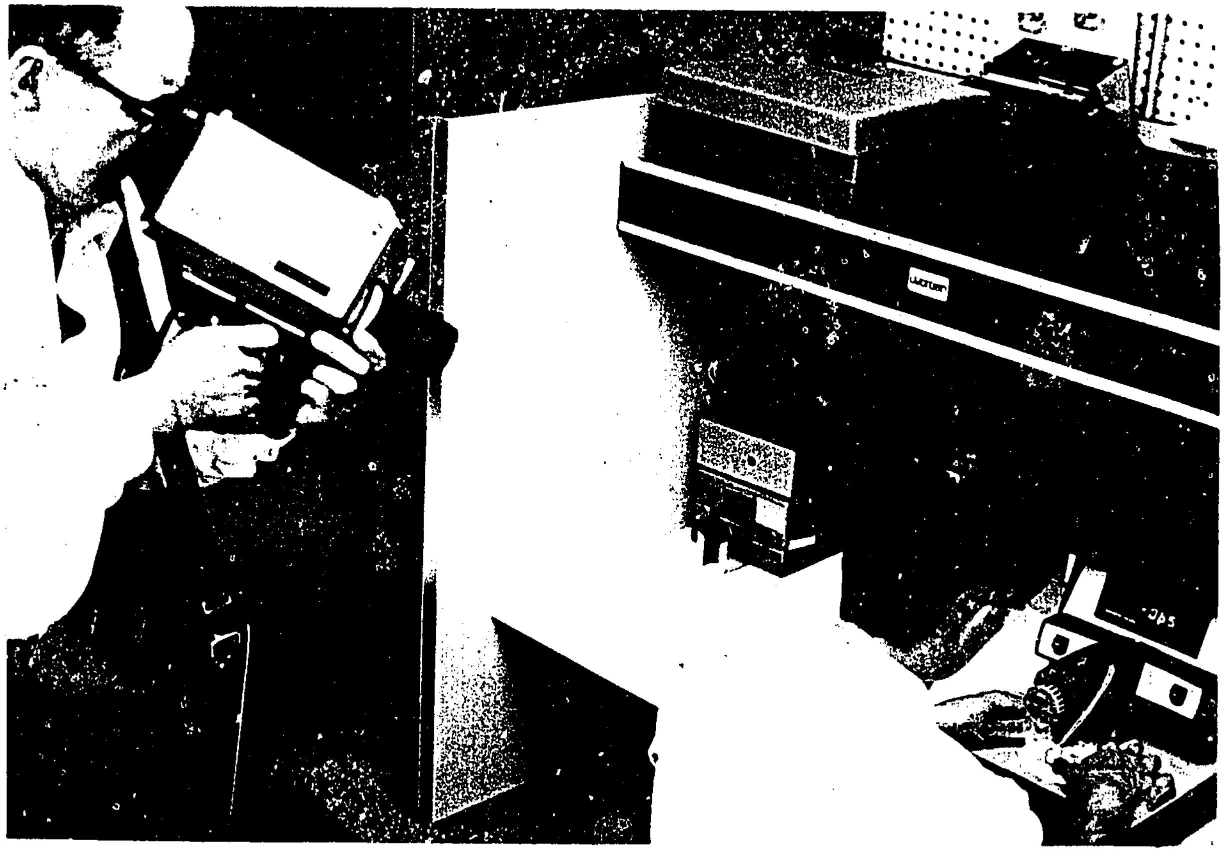

Figure 9. Preparing a storyboard on video tape.

Figure 10. Preparing a storyboard on film.

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immediate replay and the motion capability of video. (Motion may not be essential to the learning process.) The audio must also be obtained by using a second device. However, this can be a very useful procedure, particularly when the final product will be a prenarrated slide presentation.

These simple storyboarding procedures use the video recorder or photographic camera and tape recorder as a "mediated typewriter." A draft of the desired courseware is developed with minimal cost and is particularly adaptable to making rapid, simple revisions. The mediated storyboard can be viewed, discussed with other instructors, then revised. The major advantage of video tape is that it can be revised quickly and easily. Preparation of traditional storyboards by technical subject matter specialist often will suffer from stilted language and inadequate visualization.

Video tape frequently enables a more constructive criticism. Not only can the instructor who watches and hears his own presentation detect omissions or flaws in it, he can also obtain constructive criticism. Note, however, this technique records for viewing what may have been going on in classrooms for many years. Many persons are made embarrassingly aware of technical flaws in their material when it is recorded for viewing. These same errors could probably have been detected in the classroom, however, they would not be noticed without the opportunity for careful observation. When material is recorded it is put on display to other instructors for criticism. Often trivial criticism or negative comments can be overdone. Thus, a positive constructive atmosphere must be created. However, genuine disagreements concerning procedures, techniques and the like among competent instructors will occur. Clarification and resolution of disagreements between competent instructors now occurs before, rather than after, production begins. The learner then uses a superior product.

Content approval of visual materials by responsible course supervisors or appropriate administrators has not been possible prior to initiating the production process. Content approval will generally be required for acceptance of courseware for distribution. It is difficult or impossible to make changes in a final version which has been reproduced. One of the major advantages of video tape is that it can be rapidly revised. Corrections or changes are quite simple at the preproduction stage using the recommended storyboarding procedure. Often someone who has not been specifically involved in the courseware development can see important things which may have been overlooked. An early review of content with the integration of appropriate revisions by learning center supervisors provides more assurance of the courseware acceptance, which is produced for student use.

The presentation which has been prepared in this mediated storyboarding process should be pretested on students. Careful observation of individual students (or small groups of students) will initiate validation procedures while modifications can still easily be incorporated into the courseware. These initial observations usually forecast quite accurately the final acceptance and suitability of the courseware. In addition, the use of a pretested storyboard reduces trivial changes which have often amounted to a 40% revision rate in untested pilot productions. If the materials are not effective they must be revised prior to incurring any production costs.

It should be emphasized and noted carefully that the mediated storyboarding procedure does not commit the courseware to any specific production technique. There has been no need for any production cost or for a decision of which media shall be used in the final production. The video presentation should be viewed to facilitate the selection of the final media by the persons competent to make this detemination. The most appropriate media to fit the content (which is now stabilized), the student population and the given learning environment would then be selected and appropriate economical courseware producted.

Courseware is the critcal factor in the learning center. You must be able to control development and revision of courseware locally. There should be as many cameras as projectors for your personnel to use in courseware development. Courseware will frequently be the limiting factor in the effectiveness of your program. Systematic procedures to insure adequate and continued updating of courseware must be designed and implemented. Additionally, decisions of whether to revise or to redevelop will be required so as to reflect changes in job skills, training objectives, technical orders, equipment items, or regulations.

The use of standard size hard copy as part of the production process would simplify the revision process of many visual materials. This will be discussed in Section IV. Only replacement of those frames reflecting outdated information would be required; With an estimated annual requirement for revision or redevelopment of 20% of the training materials, the importance of maintaining courseware currency cannot be overrated. Additionally, a coding system which also facilitates identification of outdated portions of the courseware must be developed.

Courseware revision should be based upon criticality of information in job performance. Change of a single critical frame may necessitate courseware revision. Note that teaching erroneous information, while not giving appropriate job performance, also requires a relearning process which usually takes longer than the original learning – negative learning will occur.

IV. MEDIA COURSEWARE PRODUCTION

The media selected for courseware presentation determine the requirements for production capability. A media overlap selection technique has been developed by Smith (1971). This states:

> Ninety per cent of the time, the major media (sound/slide, filmstrip, movie or video) could be used interchangeably. Selecting a specific medium will be based more on literacy and motivational considerations, which media can be supported with courseware, and which devices can be maintained.

An instructional program (Figure 11) will usually consist of some combination of the student with other students, instructors, printed courseware, and other mediated courseware.

INSTRUCTOR
|
PRINTED COURSEWARE————STUDENT————OTHER MEDIATED COURSEWARE
|
PEER

Figure 11. Components of an instruction program.

Certain variable information, such as initial orientation and commander's call is probably best presented by lecture. However, in individualized instruction it is unrealistic to provide as many instructors as students. Emphasis on printed materials (not discussed in this report) or mediated instruction is used to free the instructor so as to provide individualized remedial tutoring and to develop or revise appropriate mediated courseware. Using a text or other mediated instruction depends upon whether the student's hands need to be free to perform a task and possibly some other considerations. In determining which media to select, assume that equivalent learning generally results from viewing prenarrated slides or filmstrip, movies or video. This has been documented in Spangenberg (1972).

Use the media which is easiest for you to support locally. That is, if you have adequate video production capabilities, use video. If you have motion picture production capabilities locally, use them. Usually (without the prior heavy initial investments suggested above) you will find prenarrated slides or filmstrips easiest to support locally. Even if there were an ideal medium, it wouldn't make sense to select it unless you are able to support it through the development of appropriate courseware. In your media selection, also pay careful attention to such support requirements as graphics, photographic processing, television film production studios, engineers, maintenance and repair requirements. The material being presented is more important than the particular device which is selected.

In summary, use the medium which is easiest to support. Use it until you have reached its limits – then add on for additional requirements. Two specific characteristics that should be carefully considered are the necessity for motion (usually over-rated) and for program hold (usually under-rated). The media selected, whether television, motion film, or prenarrated slides, usually requires that the student do the learning tasks while being shown what to do and being told why he is doing it. Show what needs to be shown to enable him to do the right actions at the right time and tell him the rest. Further discussion emphasizes the prenarrated slide approach. Use of other media (such as print or video) requires the use of different techniques than included here.

The adoption of a learning center creates a greater demand for visuals. One method of producing the visuals depends heavily on duplication of existing 35mm slides (40% of the images) with the remainder being prepared graphically. Often the graphics can be created by placing plaster of Paris or plastic letters on the graphic, photographing it, and then re-using the letters for the next graphic. As a result, if the image must be rephotographed, the entire procedure must be repeated. Other graphics can be prepared in a conventional manner. While some benefits accrue from using this technique, updating the program is difficult. Routinely updating a prenarrated slide program (for example) is usually delayed until there is a requirement for re-doing the entire package. Keeping the courseware current is a major problem for learning centers now in operation. Even after a validated package is created, revision due to changes in the subject matter material (i.e., the equipment or activity being taught changes) requires a parallel change in the courseware.

A recommended style of preparation that enables a learning center to easily update or revise content is called "captioned photos." This method requires that all images be prepared on uniform size card stock (such as 8 x 10). It emphasizes photography (as opposed to graphics). For example, in a step-by-step procedure, each step can be photographed using a 35mm camera with interchangeable lenses. These images are enlarged to color or black and white prints which are then permanently bonded to colored card stock (such as poster board). By adding a few words in a caption and an arrow or circle to highlight essential actions or parts, images may be created that combine the economy of the photograph with the clarity of the graphic. Either 8 x 10-inch or 5 x 7-inch photographic prints may be used. Usually, about 60% of the images in an instructional sequence can be prepared in this way.

Another 10% of the images can be prepared by enlarging typed copy. This would include questions and crucial definitions. It is often possible to obtain up to 15% of the images by copying illustrations from tests, forms, checklists, or technical reports.

Normally there will remain about 15% to 40% of the images that are basically graphics. Some of these can be drawn to match the size requirements of the standard size (8 x 10) card. Other images must be reduced or enlarged by using a copy camera. However, all graphics must be in the horizontal TV, movie, and/or filmstrip format and all must be matted on the standard size card. These mounted images may be used as detailed storyboard during tryout and revision. The images that must be revised can be changed individually. Images can be inserted or deleted at will.

These procedures may be clarified by referring to Figure 12. It represents a typical captioned photo mounted on 8 x 10 card stock. It should be noted that card stock on which the photo is mounted is 8 x 10 inch, the photo itself may be a 5 x 7-inch print. The captions are very effective in developing step-by-step procedures. Highlighting or calling attention to details is done by adding arrows or circles to the print. Black and white photos on colored card stock are particularly effective since color is reserved for directing attention. The black and white print is cheaper than a colored print and may take less time. (However, these differences are becoming less and less as newer color processes are developed.) If a 4 x 5 polaroid back for a view camera is available, these polaroid prints can be used.

When the visual is developed from typed copy or from a text, the appropriate portion are photographed and enlarged for mounting on standard size card stock. Graphics often have to be photographically reduced and placed on the stock since they may be of much larger sizes. For a more complete treatment see Smith et al. (1975).

In the final photography (of the mounted standard size "captioned photos"), the first image is placed under a copy camera and carefully positioned in a holder. When the standard size is 8 x 10 inches, the actual area photographed is about 6 x 9 inches to match the 2 x 3 aspect ratio of a slide or 6 3/4 x 9 inches to match the 3 x 4 aspect ratio of a filmstrip, TV, and movies. After the camera set up is completed, all subsequent images are made without requiring camera adjustment. In this way, courseware can be re-shot in minimum time. Leaving 15% additional bleed area (an area which contains no critical information and which may be cropped out as required) at the top and bottom of the area photographed for a slide allows the slide art to be used for movies, TV, or more often, to generate filmstrip (Figure 13). If only a few copies are needed, multiple copies of the filmstrip can be generated. If many copies are required it might be more economical to make a master and have duplicates made on a loop printer.

The essential feature of the captioned photo technique is that all images are uniformly placed on a standard size mat. There may be some variation between lessons or packages, but within each lesson uniformity is stressed. The actual size is arbitrary. The 8 x 10 inch is recommended since it is large enough that some graphic work can be done on it yet it is small enough that 35mm photographic negatives can be used to generate the images rather than requiring a larger film size. If the card stock is purchased in standard 30 x 40-inch sheets, it may be desirable to cut these into 7 1/2 x 10-inch pieces to save waste. But again, within a lesson, all images are on a standard size mount.

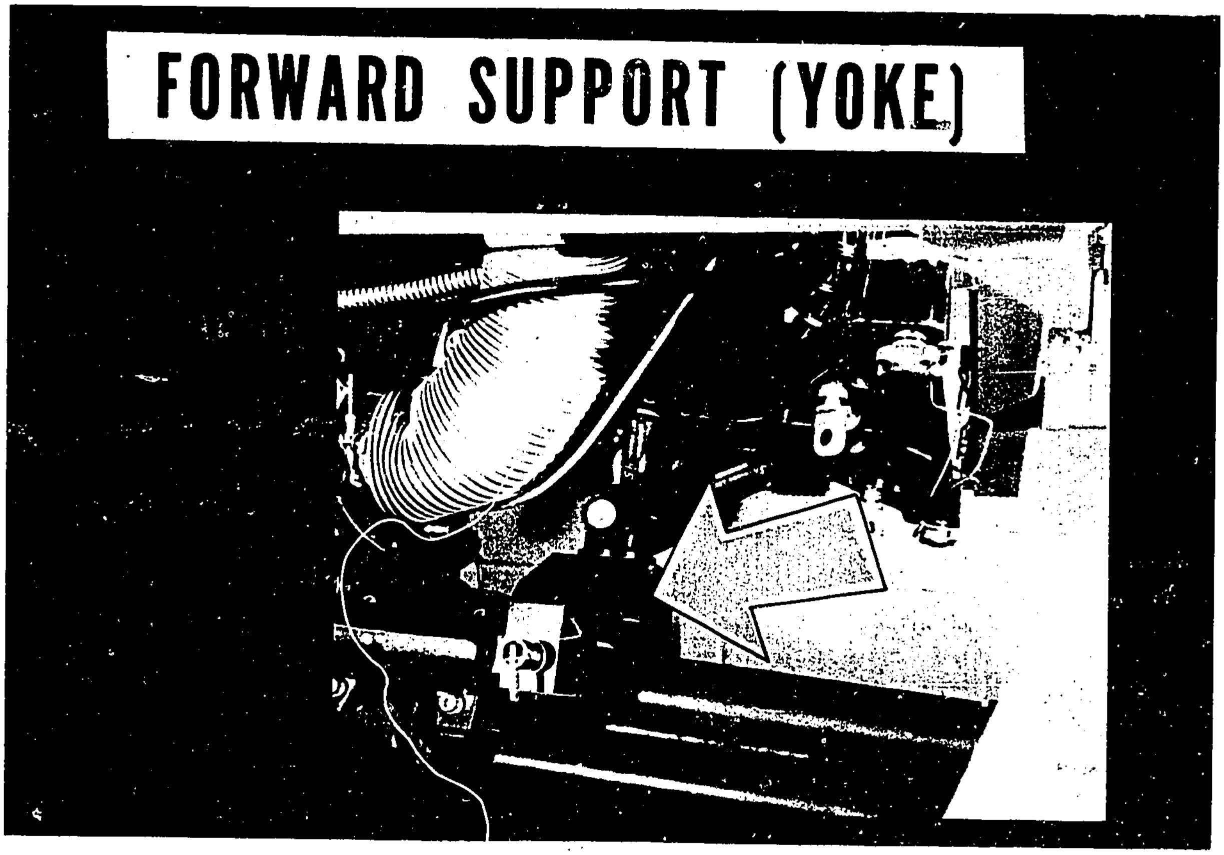


Figure 12. Captioned photo.

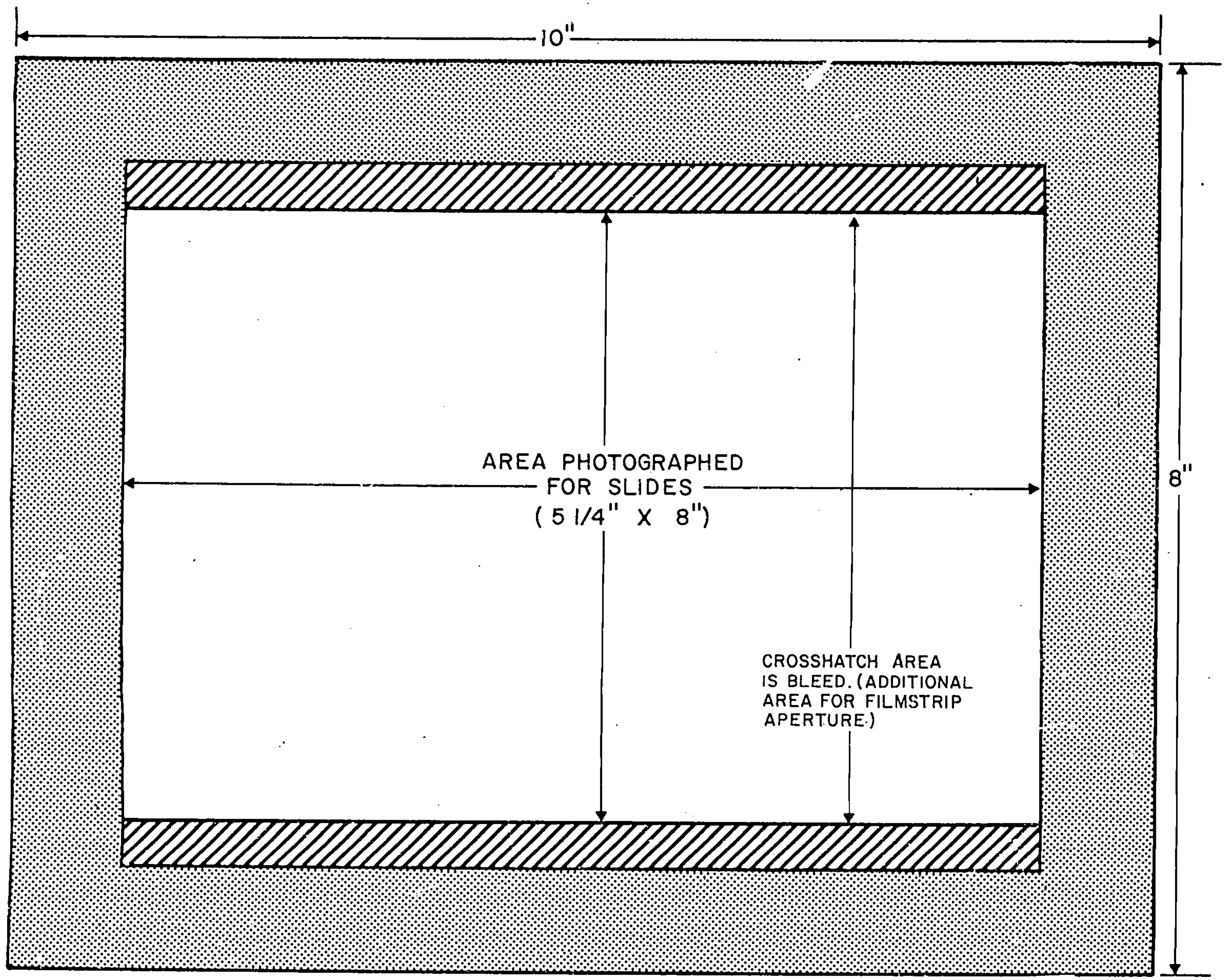


Figure 13. **Aspect ratio for 35mm slides showing bleed for 35mm filmstrip.**

The captioned photo technique encourages the use of photographic techniques in coordination with graphic production. The camera (especially the 35mm SLR with built-in exposure meter and interchangeable lenses) and the enlarger are creative tools when systematically employed. If the enlarger and camera are accepted as graphic tools, and the two fields combined rather than being separated, much time and money can be saved.

The final visuals, using the captioned photo technique, can be duplicated with ease and quality. Duplicate slides can be generated from the original card art without the increased contrast resulting from second or more generation slide duplication. Filmstrips can be updated by the change of individual mounted images and re-photographed in a matter of minutes. The difficulty of updating filmstrip has been seriously overestimated. Similarly, the difficulty of generating acceptable duplicate slide sequences from slides has been seriously underestimated. In large volume, the man-hours required to mount the slides and get them properly arranged in trays makes the production cost of slides nearly 15 times that of filmstrip.

By having every visual image in the form of standard size 8 x 10 card art, it enables the development of courseware so that it can be produced as slides, 35mm filmstrip, 16mm filmstrip, or 8 mm filmstrip with equal ease. The same images may serve as a final storyboard for movies or TV. The approach is developed first and then the most appropriate media selected. Change from one medium to another at a later date can be accomplished with minimal additional effort. The difference in shape between slides and filmstrip is compensated for by allowing about 15% extra bleed space at the top and bottom of the card. This is photographically cropped out for slides but included in movies and filmstrip.

Labor is the major cost factor in the production of visuals. Emphasis should be placed on developing the most efficient method in terms of manpower costs, with material costs contributing a nearly insignificant percentage. When the captioned photo technique is utilized, the costing is complex due to the variety of skills required. This technique relies heavily on two assumptions: (1) a 35mm camera is used for original artwork shooting, and (2) a production team that stays together until the production is completed. For costing, assume that about 60% of the images consist basically of a mounted photo. Most are captioned or highlighted and virtually all are numbered. In volume, these visuals take about 0.3 man-hours to produce. This is divided about equally between shooting, processing, and mounting. Assume that about 15% of the images are from original graphics. These require an average of 3.5 hours to draw. The captioned photo technique requires an additional 0.2 hours for conversion to standard size. Assume that another 15% are "text" images, photographed from illustrations in texts, from forms, checklists or technical orders (without major graphic revision). These are generated on the copy camera and take about 0.2 hours to shoot, process, and paste up. Most are black and white images. Finally, assume that 10% of the images can be typed, then enlarged. These would be the questions, the crucial definitions and other verbal requirements included during the development process. Summarizing this data and estimating for the production of 100 visuals:

Captioned Photos	60 x 0.3 = 18 hours
Graphics	15 x 3.5 = 53 hours
	15 x 0.2 = 3 hours
Typed	10 x 0.2 = 2 hours
Text	15 x 0.2 = 3 hours
Total Time	79 hours

For comparison, the time required using 100% graphics would exceed 350 hours. While a 60/40 mix of slides and graphics would exceed 210 hours. However, the actual time required varies with volume and equipment available.

Theoretic rationales and method media selection matrices are found in AFM 50-2 and AFP 50-58 (Volume IV). For academic interest you may read Tosti and Ball (1969). Other documents of interest are:

1. *Media by Characteristics*: Allen (1967); Boucher et al. (1971); Bretz (1972); Gerlach (1966); Van Mondfrans and Houser (1970); and Wilshusen (1969).

2. *Learning Principles by Training Objectives*: Willis and Peterson (1961).

3. *Method by Type of Information*: US Army Missile and Munitions Center and School (1970).

4. *Method by Training Objectives*: US Army Engineer School (1971).

5. *Method by Seven Criteria (Training Objective, Content, Trainee Population, Instructors, Facilities/Equipment/Materials, Time, Other)*: US Army Security Agency Training Center and School (est 1964), and US Army Signal Center and School (1967).

6. *Method by Instructional Function*: US Army Quartermaster School (undated, est 1971), and Miller (1969).

7. *Training Function by Equipment Representation*: Demaree (1961).

8. *Trainer Type by Display/Control Requirements*: Miller (1960).

9. *Media by Instructional Function*: Bretz (1971); Anderson (1974); Briggs (1970); Gagne (1970); and Spangenberg et al. (1973).

10. *Media by Training Objective*: Allen (1967); Nunnelly et al. (1966); and Parker and Downs (1961).

11. *Media by Training Objectives and Advantages (Needs)*: Parish (1966).

The most extensive selection matrix now available is the TECEP (Training Effectiveness, Cost Effectiveness Prediction) model reported in *A Technique for Choosing Cost-Effective Instructional Delivery Systems* (Braby et al., 1975). The three-step procedure matches training objectives, learning strategies, appropriate media, and costs of alternative forms of training. Computer support is required when using the costing aspects of this model.

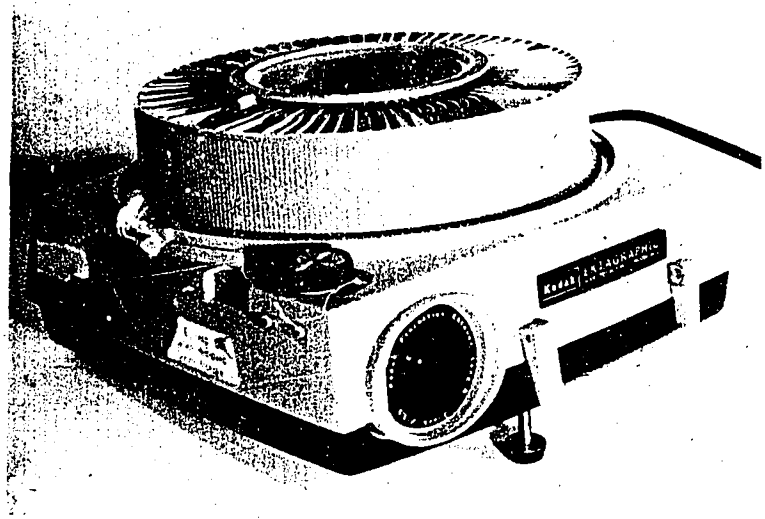
For initiating an economical learning center the following combination of presentation media (Figure 14) is suggested.

1. Slides (35mm) are recommended as the developmental and prototype medium. They will also provide backup to filmstrips. This selection is based upon availability of reliable equipment, ease of operation, and the ease of revising initial slide sets. Generally start with slides, and when the bulk of the courseware materials becomes a problem, convert to filmstrip.

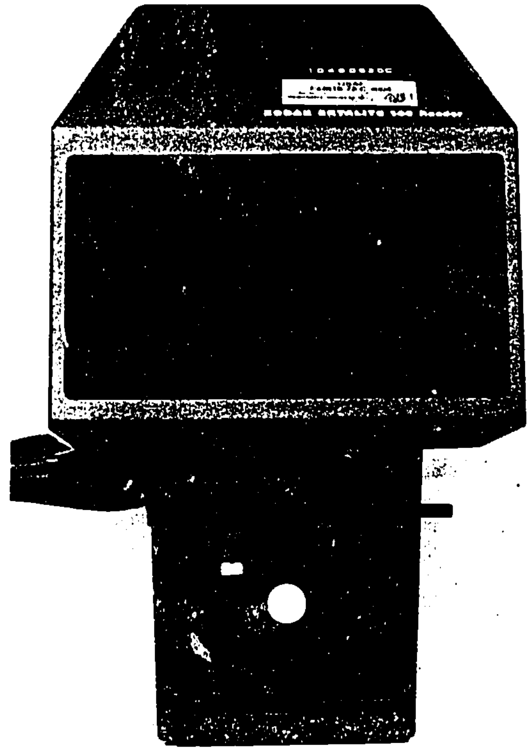
2. Filmstrip (35mm or 16mm with sound) is recommended as the primary presentation format. Low cost equipment is available, and the economic advantage in storage and distribution of courseware is significant. It has the capability of providing the images required in over 95% of the typical training tasks at a very low per item production cost. Production cost of filmstrips from card art work should be about 7% of an equivalent set of slides (mostly due to mounting and placing slides in trays).

3. Audio tape (cassette) is recommended to support the filmstrip or slides by tying the pictures together, explaining what is not clearly shown in pictures, and to generalize and interpret what is shown. The audio tape will also serve as the source of control signals for the presentation of visuals including slide advance, program stop, and program review. The selection is based on the availability of easy to operate reliable equipment, along with the ease of production, storage, duplication from 1/4" reel masters, and distribution of the cassette format.

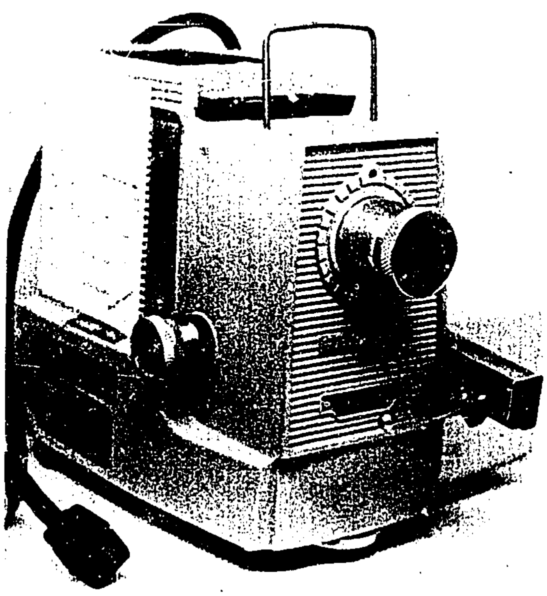
4. Super 8mm motion film (cartridge loaded/magnetic sound) is recommended as a supplemental presentation format when motion in the presentation is helpful. Motion may be helpful in depicting rate of change and when the performance speed is the same as the instructional speed. (That is, you would not use motion to teach tying shoes since the performance speed is faster than the instruction speed.) Selection is based upon the training requirement, the availability of easily operated reliable hardware and economical easily stored and distributed hardware.



35mm Slide Projector



Microfiche Reader



Filmstrip Projector

Slide Sync Player

Figure 14. Media equipment suitable for learning center.

5. Microfiche is recommended as the prime medium for textual materials when available. Ease and economy of updating the initial draft of text make this medium particularly attractive, as does the flexibility in using innovative fomats (Grausnick et al., 1971; Kottenstette et al., 1971). Selection is based upon ease of production and rapid revision of materials along with economic advantages in medium to low volume reproduction. Insure, however, that appropriate and adequate readers are available.

6. Print is recommended primarily when used as a job aid such as technical order. It should provide reliable emergency backup to the normal mediated instruction provided by the learning center. It is selected because of its availability, familiarity, and ease of use.

The production of courseware quite obviously must be based upon the combination of presentation media selected as most appropriate for achieving the training objectives of the learning center. Our recommendations of a combination of presentation media indicates those which are potentially helpful. Since most leaming centers will have unique educational or training requirements, insure that the media combination selected will present selected courseware and can be supported quickly and easily by the production team (and its equipment and facilities). We do not recommend selecting a non-standard media format or combination which makes the audiovisual training program dependent upon sole source procurement. Leave alternative ways of gaining the same training objective. Then if a manufacturer withdraws a given device from the market the learning center operation is not jeopardized. The most extensive discussion of production equipment and facilities requirements pertinent to your needs is found in Sullivan and Smith (1974).

Given the above approach to courseware production, plan to begin production of courseware as soon as you have the capability for any given medium. Give priority to production requirements common to most modules. For many leaming centers, this could consist of 35mm slides and audio cassette tapes. Production procedures should be established and stabilized early in the development of a learning center program. Further, quality control procedures must be established and integrated into your courseware production from the start.

V. HARDWARE

Hardware selection is based upon courseware requirements. However, great flexibility remains in the selection of specific hardware items. Availability seems to be the limiting factor. In general, we recommend a combination of presentation media consisting of filmstrip, slide, audio tape cassette, Super 8 motion picture film with magnetic sound in cassette, microfiche, and print for a leaming center..Special training requirements of your leaming center require different combinations of media, as would access to and use of other kinds of production facilities (as for example, television).

The first factor in media hardware selection must be availability. What you need must be matched with what exists. Media courseware requirements may also have to be modified if what you desire is not available. After media courseware requirements are determined, available media hardware must be compared and selected on criteria which include usability, reliability and maintainability. However, there is much less hardware available which will meet Air Force needs than is generally assumed. In general, it is unwise to select a media format available from only a single manufacturer unless the courseware can be made compatible for presentation by other available media equipment.

Usability refers to the suitability and ease of use by the people you want to use the equipment in the place you want them to use it. Are human factor considerations taken into account? Is the equipment engineered so that a student is able to effectively use it in a carrel? Will the leaming environment tolerate the heat or noise from a projector? Can the organization support the equipment repairs? These questions comprise the usability factor.

Reliability refers to the ability of an item of equipment to function properly, that is, to do what it is supposed to do when it is supposed to do it and how long it works. Quantitative terms indicating reliability are failure rate, mean time between failures and success ratio; where failure is defined as the inability of the item to do its job. In addition, it is helpful to separate what proportion of the equipment failures can be overcome or remedied by the operator.

Maintainability refers to the level of difficulty or work by a qualified maintenance person to keep an item of equipment doing what it is supposed to do for a selected time period. Quantitative data are usually based upon down time or the time the equipment is not available for use, and typically includes both corrective maintenance down time and preventive or routine maintenance down time. Mean down time, maximum down time, ready rate, maintenance cost/operating hours, and manhours/overhaul are common expressions indicating maintainability. The important factor is whether your maintenance people can keep the equipment operating properly.

While the criteria of usability, reliability, and maintainability are critical for selecting between available hardware items, data based comparisons of these factors are not readily available. Your friendly media hardware salesman may not be the most reliable source of information upon which you can make equipment selections. We recommend that you collect data which reflects the usability, reliability, and maintainability of the equipment you procure. You may then be able to make future hardware selections on the basis of your data. Consultation and related technical information may be obtained from the Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, CO 80230.

In addition to the basic criteria cited above, consideration should be given other factors such as flexibility in adapting to and incorporating new technology in media hardware. TA 646 provides a baseline of useful equipment. Standardization without limiting your future capabilities should also be considered.

Extreme care should precede selecting items with a self-contained viewing module. However, when portability is required for the students home use, a wide variety of combinations are available. These include 16mm filmstrip with 1/4 inch audio tape, 35mm filmstrip with audio cassette, Super 8mm with magnetic sound, 8mm filmstrip (and motion) with audio cassette and programmer, and 35mm slide and audio cassettee. These units should be selected for compatibility with the production capability of your learning center in additon to the earlier stated factors.

We recommend the incremental acquisition of media hardware. This procedure could minimize the effects of hardware acquisition which does not meet your initial expectation. The normal life expectancy for media equipment can be estimated at five years. This means that you should set up a replacement schedule in which 20% of your equipment will be replaced each year. This schedule also will enable you to take advantage of technological advances on a trial basis. Stabilized funding should also result.

In the spring of 1974, an ISD Media Equipment Standardization seminar was conducted at Lowry Air Force Base and sponsored by Hq USAF/XOOG. A significant proposal of this seminar, in which all major commands were represented, was the establishment of an additional part to the Table of Allowances for support of the ISD process. Recommendation for media to be included in future TA listings are shown in Tables 2, 3, 4, and 5, and Figures 15, 16, and 17. Table 2 identifies the equipment for student use and provides for 15% spares allowing for maintenance requirements. Table 3 identifies the equipment required for courseware development (three per ISD team or development function). Table 4 shows equipment required for production of ISD materials. Table 5 summarizes these three tables.

Inclusion of brand name items in this listing does not constitute an indorsement of this item by the Air Force, nor does it imply in any way that competitive brands of equipment would not be quite acceptable. The listing is intended to indicate the type, quantity, and quality of devices that were considered by this group to be suitable for use in Air Force learning centers. Note that these recommendations reflect the state-of-the-art in the spring of 1974. As technological improvements are offered they should be considered, however, using the minimum performance capabilities suggested in this listing.

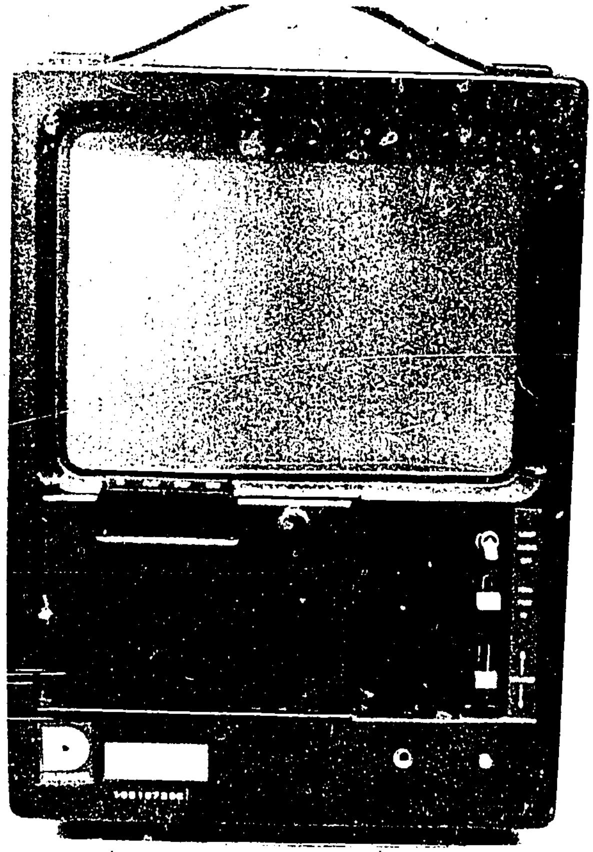
Table 2. Devices for Student Use

1.	Player, Slide Sync Telex 87991-00	5835-264-0946	ASC 636	$254.00
	Cassette tape player (has no record capability), two channel with built-in synchronization to advance a slide projector and to provide program stop.			
	or			
	Player, Slide Sync Wollensak	Model 2575	Item No. 136-21	$271.95
	Playback only deck, built-in sync and program stop.			
	Headsets to use with the carrel may be ordered with cassette player or procured locally.			
2.	Projector, 35mm slide	6730-777-3374	ASC 636	$142.28
	Kodak Carousel Ektagraphic 35mm Projector Model AF-2 with Automatic Focus. Uses slide trays. Compatible with Slide Sync Players. Order with 2.5 inch f3.5 lens to use in carrel.			
3.	Projector, 35mm Filmstrip Graflex 400-RC			$ 72.67
	Remote control filmstrip projector with film rewind. 2" f3.5 lens required for carrel use. Graflex Cat No. 3501.			
4.	Projector, 35mm Sound/Slide			$249.50
	Graflex Caramate, Model 8805, playback only with automatic slide advance. Program stop feature desirable.			
5.	Projector, 16mm Filmstrip with Sound	Audiscan TSM		$276.00
	Self contained unit including projector, sound, and rear projection screen. Film and tape held in single cartridge. Cartridges and special 1/4" tape must be ordered separately. Earphones purchased locally or with unit.			
6.	Carrel, Student	7125L000125T		$541.00
	Atkins and Merrill, 7700 East 385th Street, Tulsa, Oklahoma 74145; is the manufacturer. Part number is ART S-10055-4 carrel with 4 answer responder.			
7.	Projector, Super 8mm, Movie, Sound/Motion	6730-151-6410		$323.76
	Eastman Kodak Supermatic Model AV60Z, with zoom lens and built in screen, magnetic sound, 18 and 24 fps, no record capability. Basis of Issue: Two per classroom or group of carrels.			

Note. — All equipments must be compatible with standards described in ANSI PH 7.4.

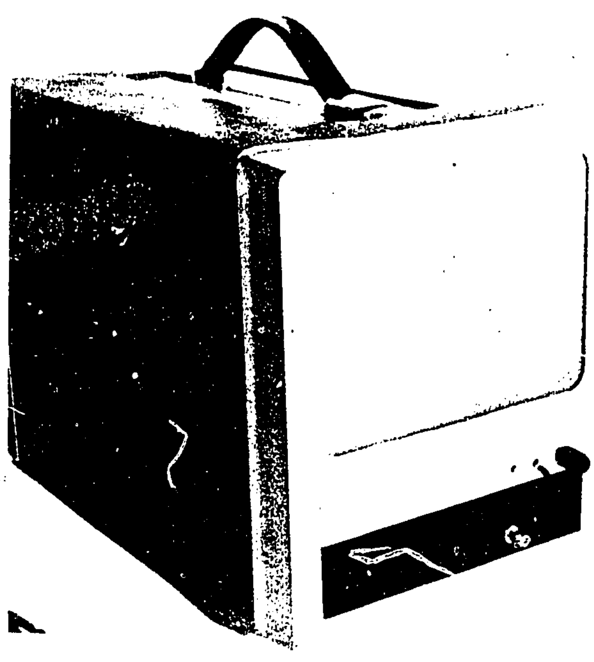
Recommendation of the ISD Media Equipment Standardization Seminar 1974.

Basis of Issue: One per 10 students or one per carrel plus 15% for maintenance cycle (all items except 7). Carrels range from one per student for content taught exclusively in carrel to one per four students for more performance oriented courses (when the performances are using actual job equipment and environments). Even fewer carrels would be required in an on-the-job environment for continuing or upgrade training.

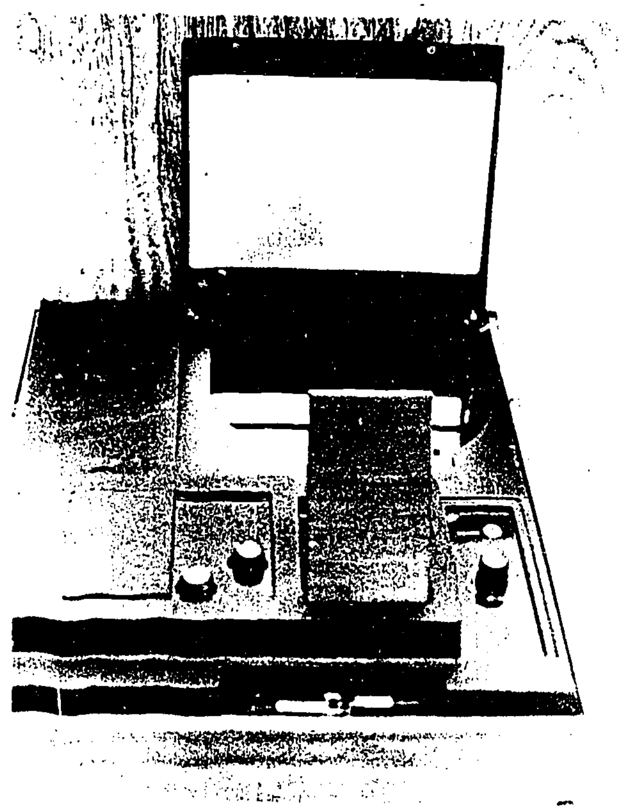


Prenarrated 35mm Filmstrip

Prenarrated 35mm Slide



Prenarrated 16mm Filmstrip



Super 8mm Motion Film Projector

Figure 15. Media devices for student use.

Table 3. Development Devices

1.	Recorder, Cassette Slide/Sync, Telex 87990-00	5835-245-9445	ASC 636	$320.00
	or			
	Wollensak	2570		$295.95
	A cassette recorder/player with built in synchronization switches to put sync pulses on 2nd channel of cassette. Will run a sound/slide program in a carrel. Can be used to make a draft program to check script and slide timing prior to master tape run. Can be used by operational wings to produce limited number of local programs.			
2.	Projector Recorder, 3M Sound-on-Slide, Model 625A6A		6730-235-6598	$413.17
	Automatic, self-contained unit capable of recording and playing back separate messages on each slide as projected. (GS-00S-08034)			
3.	Projector, 35MM Sound/Slide			$206.33
	Graflex Caramate, model 8806, playback and record with automatic slide advance and program stop.			
4.	Projector, Super 8mm, Movie with record			$358.16
	Eastman Kodak Supermatic 70 Model AV70Z, with zoom lens, magnetic sound, with built in screen. With record capability at 18 and 24 frames per second.			
	BOI: One per ISD development efforts.			
	Also item 2, 3, 6, and 7 from list A.			
	BOI: Three per ISD development effort (All items except 4)			

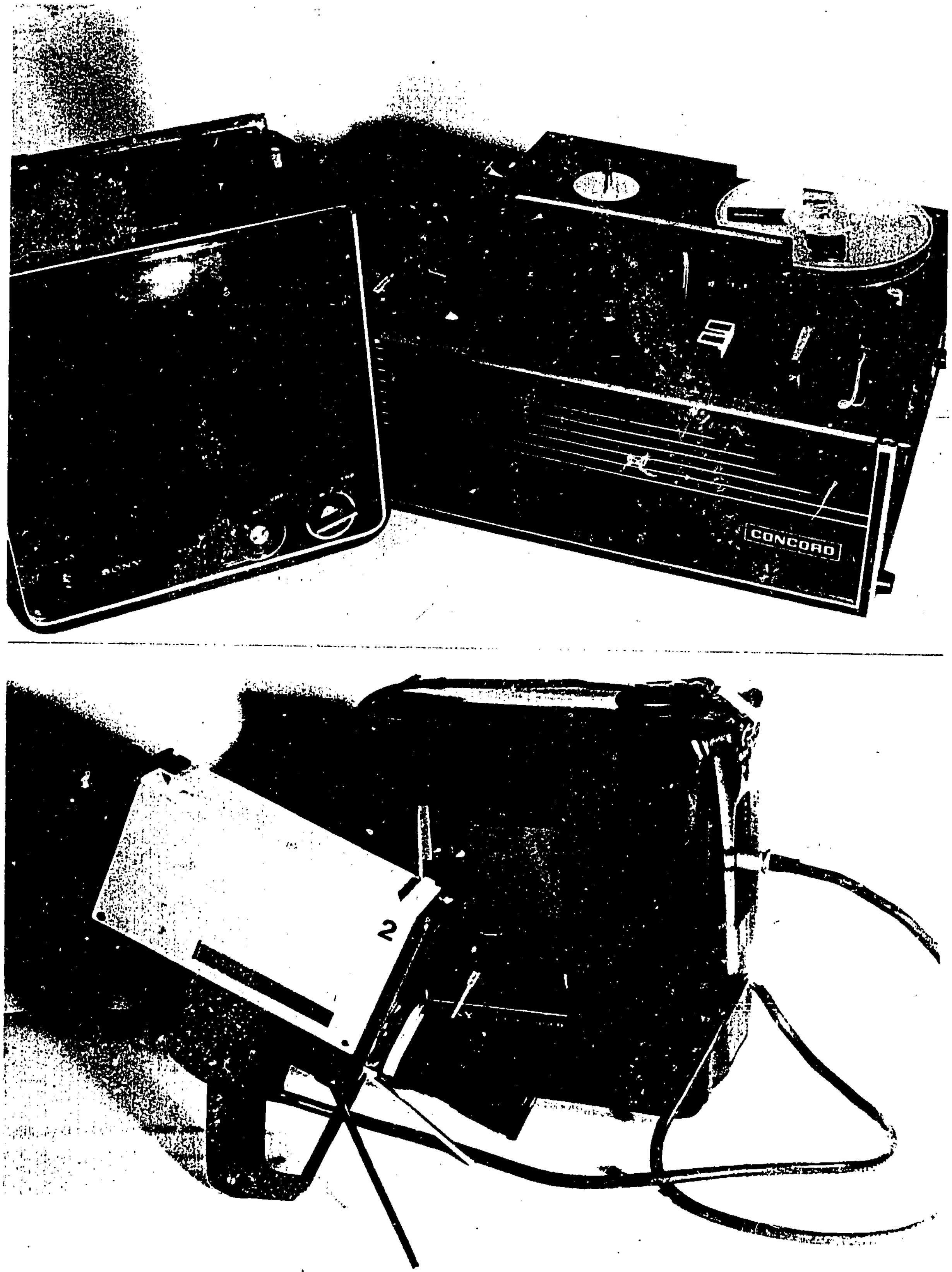


Figure 16. Videotape recording and playback equipment.

Table 4. **Production Devices**

1. Recorder Reproducer, Wollensak, Model 6250AV — 5835-235 — ASC 629N — $450.00

   2 channel, 1/4" reel-to-reel recorder used to record master tapes for sound/slide programs.

   Two required for proper operation. Must provide inputs for microphone magnetic phone, impulse generator, and auxiliary. Tape/source monitoring, sound-on-sound, and sound-with-sound features required.

   BOI: Two per ISD effort.

2. Player, high speed duplication master, Wollensak, Model 6030AV — 5835-235-6960 — ASC 699N — $399.95

   Used to duplicate cassettes at a high speed. The master tape made on the recorder is played on this unit at 4 times the record speed. The output is fed into synchronized high speed cassette copiers.

   and

   Copier, Cassette Wollensak, Model 2760AV — 5835-235-6983 — ASC 629N — $240.00

   Used to produce duplicate cassettes of a sound/slide program. Used with Wollensak Model 6030AV. Records two channels on one cassette at 4 times normal speed. Has visual indication that sync pulse is being recorded.

   BOI: One 6030AV and three 2760AV required to generate duplicate cassettes.

   Acceptable substitutes would include:

   Telex Reel-to-Cassette System, Model 300 with 3 slaves — Catalog Number 8647-082 — $2340.00

   BOI: One per ISD effort

3. Programmer, signal Elec. Model No Audio 105601-01 — 5835NC11252211 — ASC 629N — $190.00

   A signal generator, used to put the required synchronization pulses on the master tape. Provides the proper sync tones and lengths for use in the carrels. Push button operation.

   or

   Impulse Generator (Universal Signal Generator) — $119.00

   Twin oscillator system allows the generation of any two cue signals. Pulse duration automatically set at 0.500 second plus or minus 0.010.

   Montage Cat No. 450 or equivalent.

   BOI: One per ISD activity.

4. Programmer, Audiscan

   Required to place cues on 1/4" recording tape for use with Audiscan TSM units. Used in conjunction with half-track recorder and 1/4" tape with special coating for endless loop cartridges.

   BOI: One per ISD effort.

5. Camera, 35mm Professional KF48C — 6720-479-0414 — ASC 629X — $750.00

   Nikon F 35mm single lens reflex camera kit includes 35mm, 50mm, and 135mm lens plus 9 filters, lens and body caps carrying case, lens hoods, and photomic FTN finder. Camera has through the lens metering for correct exposure. A locally procured MACRO lens will expand the capability of the camera to photograph very small objects or pictures.

   BOI: One kit per ISD effort.

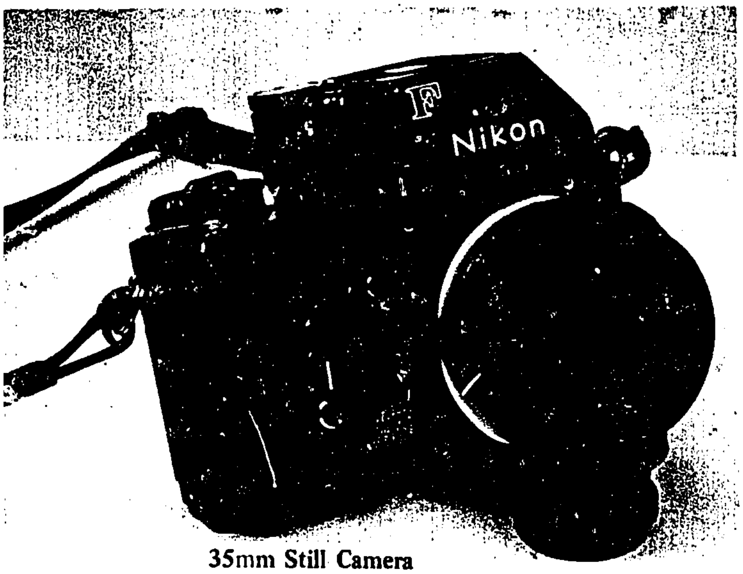
6. Flash Unit, Photographic — 6760-146-3431 — ASC — $100.00

   Electronic strobe providing complete automatic exposure control at distances from 2 to 23 feet. Includes rechargeable Ni-Cad battery and charger, which also provides AC power source. Supplementary sync cords and mounting brackets must be ordered. Variable Range Lens Kit (Cat No 4302) recommended as accessory.

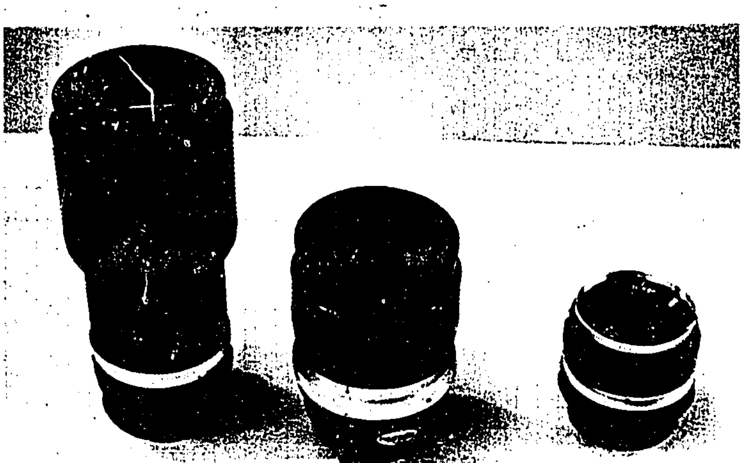
   Honeywell Auto/Strobonar 470 or equivalent.

   BOI: One per ISD effort.

7. One portable videocorder and one 3/4" U-Matic recorder/player monitor authorized per ISD effort. Particular make and model to be determined by CEMO at time of purchase.

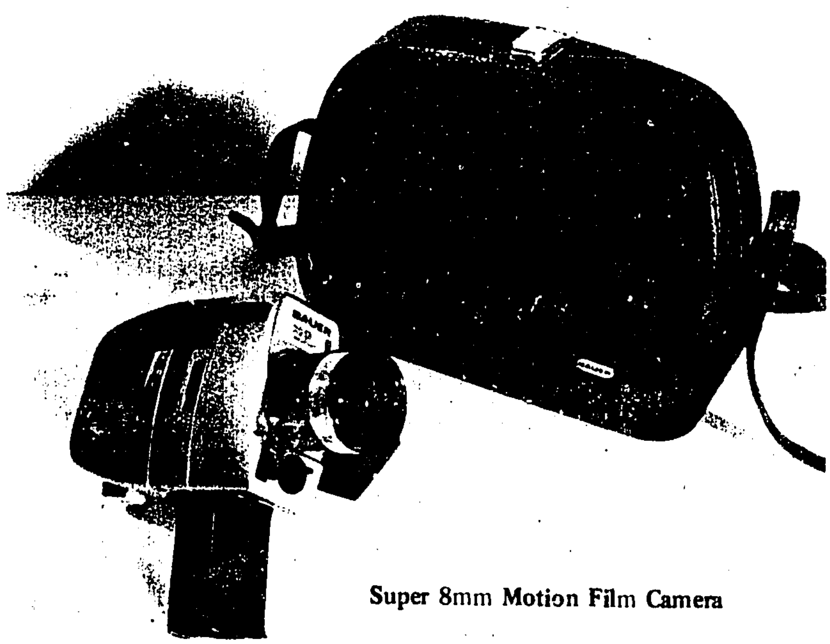


35mm Still Camera



Lenses

Flash Attachment



Super 8mm Motion Film Camera

Figure 17. Cameras and accessaries.

Table 5. Summary

A Student	B Development	C Production
1. Telex 87991 or Wollensak 2575	1. Telex 87990 or Wollensak 2570	1a. Wollensak 6250AV (reel-to-reel) 2 required
2. Slide Projector Ektagraphic AF-2	2. See column 1	1b. Wollensak 6030AV plus three 2760AV or Telex 300
3. No comparable item approved	3. Sound-on-Slide 3M AGA	1c. Programmer, Elco or Impulse Generator
4. Filmstrip Projector Graflex 400 RC	4. See column 1	2a. Camera set, 35mm, Nikon
5. Graflex Caramate 8805	5. Graflex Caramate	2b. Flash Unit
6. Carrel	6. See column 1	2c. Portable Videocorder and U-Matic recorder/player with monitor
7. Audiscan TSM	7. See column 1	
8. Movie, Super 8 Supermatic 60 (BOI: 2 per ISD effort)	8. Movie, Super 8 Supermatic 70 (BOI: 1 per ISD effort)	

Basis of Issue, unless otherwise indicated in listing:
Column 1. One per 10 students or 1 per carrel plus 15% for maintenance.
Column 2. Three per ISD effort of activity or learning center.
Column 3. One per production facility.

Note. — All devices must be compatible with ANSI standard PH 7.4.

VI. LEARNING ENVIRONMENT AND CARREL DESIGN

Learning environment and carrel design are based on predetermined types of learning activity. The learning must be designed first. Learning environment or carrel design depend on what the student needs to do while achieving the training objectives of the learning center. Functional requirements of the student's training tasks should be expressed in the carrel design. Discussion in this section will be more extensive because few other sources of the necessary information are available.

A carrel is a specialized learning area enabling the performances involved in individualized (or individual team) self-paced instruction. The carrel is designed around the performance oriented needs spelled out by the design of learning for the training program. Since the training needs vary considerably, only rarely will a single carrel design effectively meet all the learning center requirements. Too often the physical setting limits and even negatively directs the nature and kinds of activities in learning. The learning design (both actual and anticipated) must determine the limits to your learning area, not what you can buy off the shelf. Keeping as many options open in your carrel selection or design as is economically reasonable is a wise course to pursue.

We recommend a family of single purpose flexible carrels. A multi-purpose carrel usually will only be used in a single mode at any given time. Since expensive components would be tied up when using any single media device, a multi-purpose carrel would not represent the best allocation of limited resources. On the other hand, short learning sequences requiring special equipment items or media could be shared among the students in a designated carrel. In fact it is a useful strategy during learning to permit movement from one device to a different location (not too far away).

A modularized single purpose flexible carrel would consist of permanent and temporary components. Flexibility is gained by using various modularized capabilities. For example, there would be no need to leave an oscilloscope in a carrel unless the student would be using it in his learning. Likewise motion picture projection equipment may be required infrequently. The carrel and its components would provide an appropriate work area for the student. Dedicating some carrels for permanent installation of highly specialized components may be helpful. Thus, the student may use three or four different carrels during a given day. The design of a family of single purpose flexible carrels should enable tailoring the learning area to meet all of the learning design needs. Commercially available carrels may not always meet the functional requirements of the objectives of your center. Local design and fabrication may be necessary since so few different carrels are available. Costs for the fabrication may be lower at some Air Force installations. For example, local fabrication of 260 carrels at Lowry AFB saved $64.000 over commercial acquisition. The required performance-oriented learning activities determine your carrel selection or design, not the availability of an item from commercial sources. Nevertheless, don't delay initiating operation of your learning center because of specialized design problems. Design what you know you need and then add on as required to meet special purposes or training problems.

A locally designed carrel seldom becomes a high volume production item. To keep the cost reasonable, you must thoroughly examine several areas of design consideration in developing a new design or improving or modifying an existing design. Consideration of three major factors must be incorporated into carrel design. These three factors are: student activities (What will the student do?), information display and presentation (What will the student see and hear?), and carrel structure (What do we make it with an how do we put it together?).

Look first at the training objectives to find out what the student must do. The training objective should clearly describe the student's training task and the conditions under which he will act. Frequently the location for student performance-oriented learning is predetermined by the statement of the training objectives.

Without considering specially designed simulators or trainers, three basic work areas are most common. These three work areas are (1) hands-on training on large equipment (e.g., aircraft), (2) hands-on training on bench equipment (e.g., oscilloscope). and (3) pencil paper tasks (e.g., work book). If reading of printed materials is the only intended activity, the facilities provided by most libraries are adequate. Libraries typically provide the choice between lounge chairs or library tables with straight back chairs. Reading books (text or reference) as the major learning activity will not be further considered since the common facilities are well known and readily available. Recall, however, that performance training also requires the use of appropriate manuals and technical orders.

Work Areas

The work area for hands-on training on large equipment is the equipment itself. When loading a missile on an aircraft, the aircraft will be the work area. The large equipment defines the work area. Arrangements for mediated instruction will be discussed later.

The work area for hands-on training on bench equipment suggests a work bench as a minimum requirement. A work bench similar to that actually used on the job is preferred. Student motivation may be increased when the training environment resembles the job environment. The importance of his work environment is emphasized to the student when he uses a similar environment during training. Procurement may be simplified if a work bench similar to that actually used on the job is used. In general, a work bench should stand between 36 and 40 inches high. Figures 18 and 19 show the recommendations contained in Van Cott and Kinkade (1972). The arrangements for mediated instruction will be discussed later.

When the student will be seated at the bench (as would be normal for extended training time periods). a chair would be required. Figure 20 shows recommendations (Van Cott & Kinkade. 1972) for the chair to be used at a work bench.

The chair would be adjusted so as to provide best access to the work required. For example, with the top of the chair seat at 30 inches the writing surface should be at 41 inches to best perform pencil paper tasks while at the work bench. The surface of the bench equipment being worked upon should be about eleven inches higher than the chair seat.

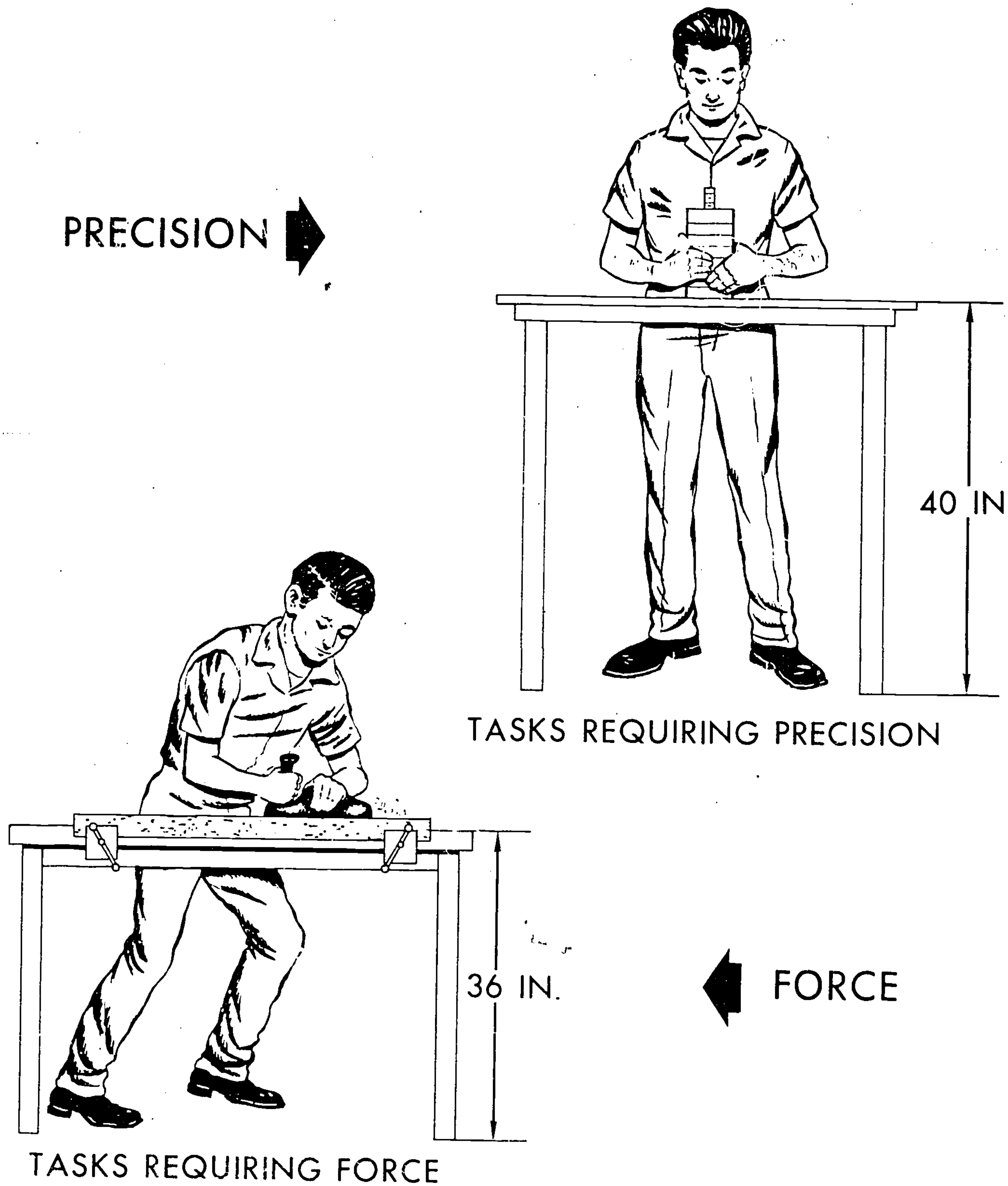


Figure 18. Recommendations for workbench height.

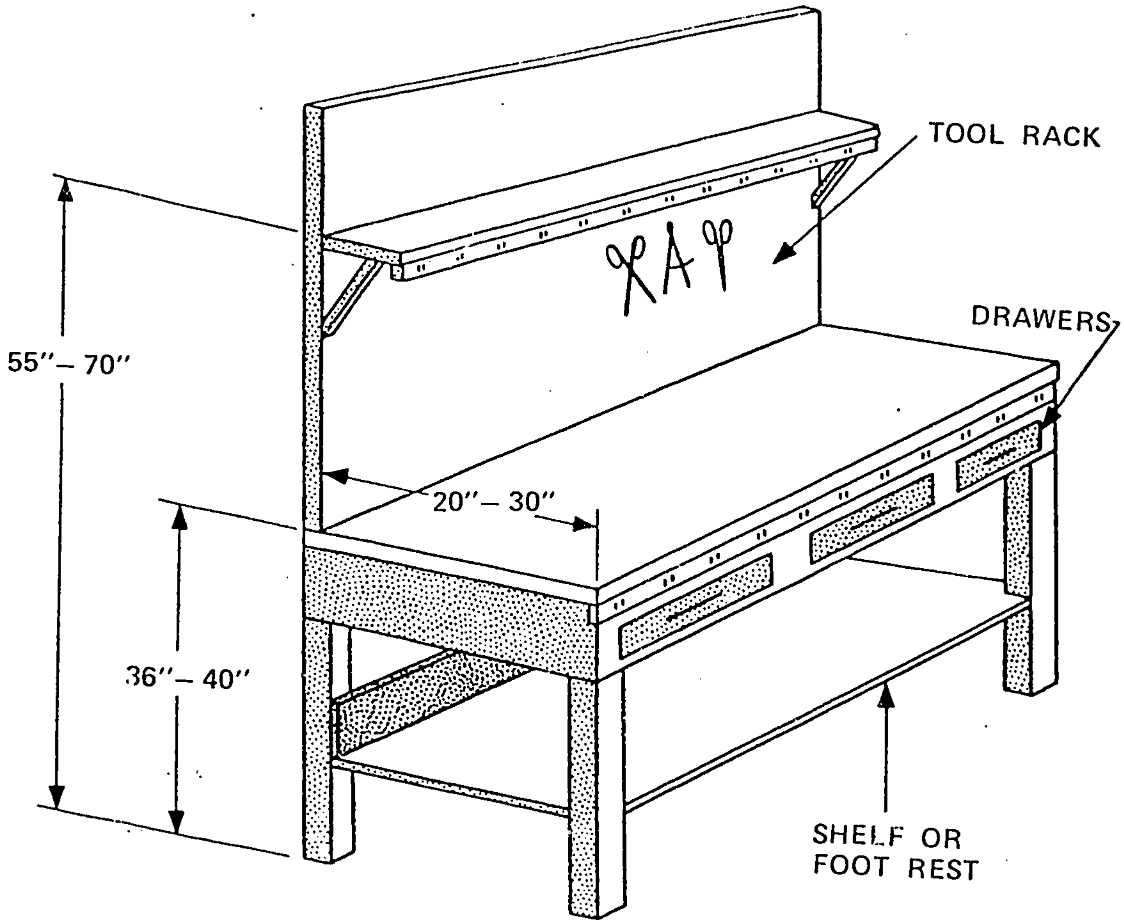


Figure 19. Recommendations for typical workbench design.

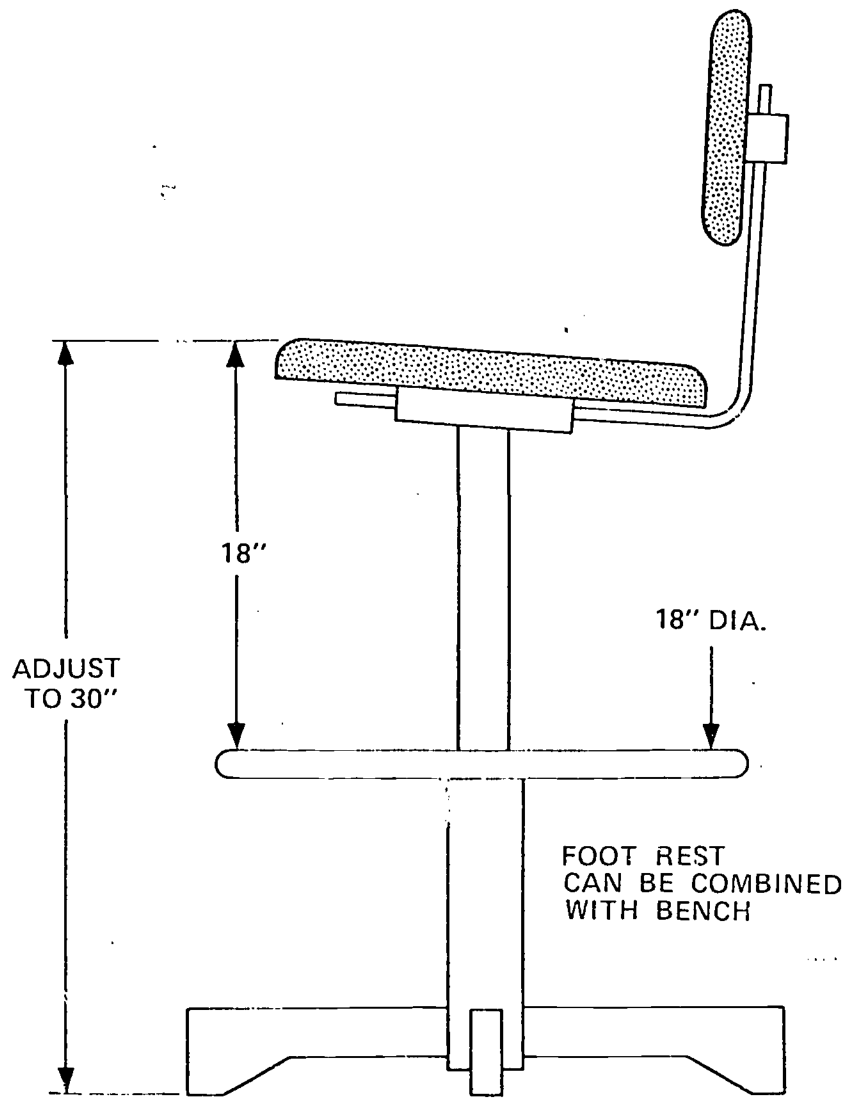


Figure 20. Recommendations for chair at sit-stand bench.

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In designing a learning environment, some components of the activity in the work area design may be overlooked. For example, don't forget the need for easy access to and reading of technical orders and manuals while working at the bench. A shelf should clear any bench or projection equipment. To position the top shelf (if more than one) measure the largest book. The top of the carrel should be at least 65% the height of book above the shelf. Many work areas have not made adequate provision for doing the pencil paper portions of the task requirements, such as noting meter readings. All components of the activity should be integrated into the design of the work area by the designer.

When the major student activity is doing pencil paper tasks the suggested work area dimensions (Van Cott & Kinkade, 1972) are indicated in Figure 21. An adjustable chair would be helpful if the student is to remain at the work station for extended periods of time. Note the key dimension from the chair seat to the work surface. If the student is using a typewriter or computer keyboard the table should be lowered so that working level of the typewriter or computer keyboard is about 11 inches above the chair. For further information Van Cott & Kinkade (1972).

Information Presentation

Pictorial and verbal information is generally necessary for students while learning to perform tasks during training. While actually doing the task, the student is shown what to do and told how and why he is doing it. Projected images provide the most important source of visual information in carrel instruction. While technical orders and manuals can be the major source of information during job performance, during performance oriented training the printed page (hard copy or microfiche) is a secondary source of visual infomation. Typically, the student is shown what to do and told why he is doing it that way. Students often would listen to the spoken information using headsets which should reduce the level of noise distraction of the student.

Visual. For individualized hands-on training use a rear projection system for providing visual material. Both instructional and optical advantages are provided by rear projection systems (as compared to front projection). Some of these advantages are spelled out in Trow and Smith (1965b). A typical rear projection system is shown in Figure 22.

Light is necessary to perform most training tasks. The student needs light when he is working or reading. The needed amount of light varies with what the student is doing. When projected visuals are used to direct training a front projection system suffers from the ambient light level in most work areas. With an increase of light at the screen of five times normal room light it is possible to show gross line drawings; while the light at the screen should be increased 100 times for viewing color and fine detail visuals. A high initial ambient (room) light level dramatically increased light requirements. When viewing on front projection screens the room must either be darkened, or the light output of the projection lamp increased. In a front projection system, a projector designed for large group presentations in a shadowed carrel may be used. You then increase the power requirements of your individualized learning system and the excess heat generated by the additional power usage must be dissipated. However, adequate cooling of the equipment must also be provided in rear projection systems. We do not recommend the use of front projection screens in learning carrels since this system may create cooling, design, and maintenance problems. When the student needs light to work as he views a projected image, it is wiser to select a rear screen projection system.

Some general illumination levels recommended for different kinds of work conditions (potentially associated with training) are found in Table 6 (Van Cott & Kinkade, 1972). Some specific values from the IES Lighting Handbook (Kaufman, 1972) are also indicated.

If the student is filling out a form, a certain minimum light level is required in the carrel. If the student is performing a continuity check with the PSM 6 multi-meter, a different minimum light level is required. The amount of light in a carrel depends on what the student is doing at the carrel. Design of the viewing system is modified by the amount of light in the carrel (and will be discussed later). The training task should be supported by the viewing system not vice versa. Design the brightness of the screen so that it

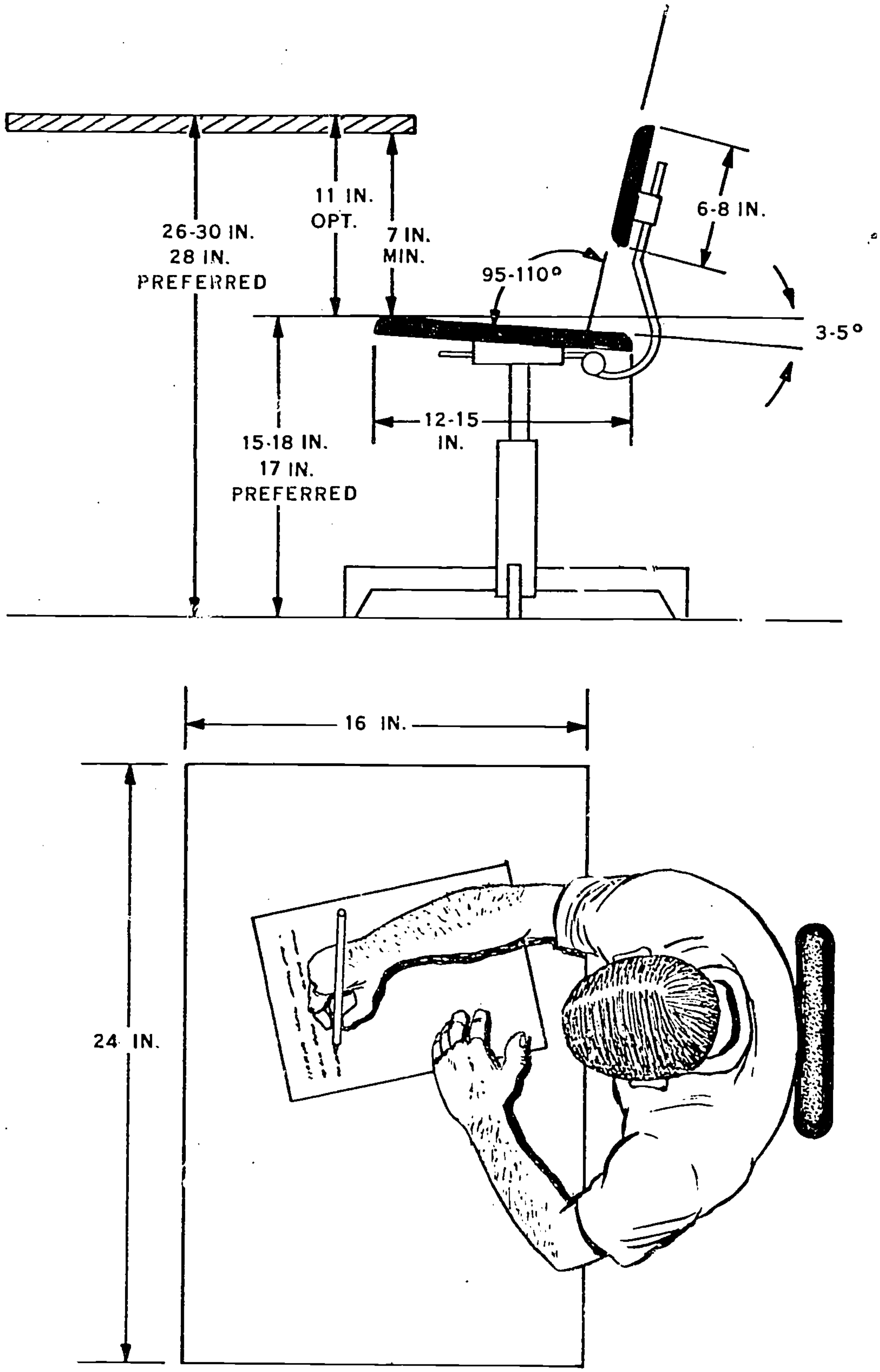
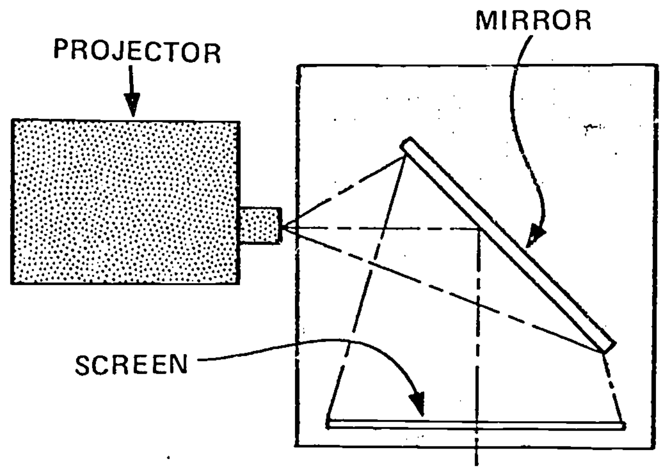
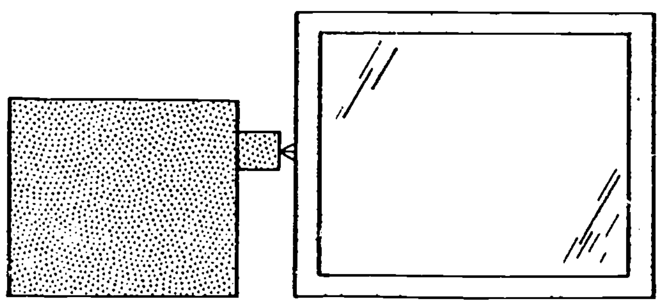


Figure 21. Recommendations for pencil paper work area.



TOP VIEW SHOWING LINES
OF PROJECTED LIGHT



FRONT VIEW

Figure 22. Typical rear screen projection system (consisting of a projector and viewing unit with mirror and screen).

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Table 6. General Illumination Levels for Different Task Conditions and Types of Tasks

Task condition	Type of task or area	Illuminance level (Ft. -c)
Small detail, fair contrast, speed not essential	Machining, detail drafting, watch repairing, inspecting medium materials, etc	50-100
Study carrel	Pencil paper/reading	70
Lab performance	Chemistry laboratory	50
Discussion	Conference area	30
Microform study	Viewing microform	30
Normal detail, prolonged periods	Reading, parts assembly; general office and laboratory work	20-50

will be approximately 10% above the brightness of the work area. (For design purposes, project an 18% grey scale to determine the base value and measure the screen and the work surface light with a foot candle meter.)

There is an optimal viewing location. This prime location may be dedicated to a viewing screen or to apparatus required in the training task (such as an oscilloscope). Typically the training apparatus would take the preferred viewing location. The best location for the center of a visual display is straight in front of the student, about 15° below eye level. The best place for an entire display would be within an area bounded by a horizontal angle 15° on each side of straight in front of the student and a vertical angle from eye level 0° to 30° below eye level. When a rear projection viewing screen is placed in the optimal location, the top of a 12½" x 12½" viewing screen 24 inches from the eye would be at eye level (Figure 23).

The student, when viewing as he works for extended periods of time, should normally be seated. Some recommended (Van Cott & Kinkade, 1972) carrel dimensions are shown in Figure 24 for a student seated in an office chair.

The training task is the most important factor in the carrel design. Given the use of a rear projection system (such as is shown in Figure 22) to show the student what to do, then the screen size, screen location, screen material, other projection unit components and design, and hardware (including lens, lamp and distance) must be determined. The size and type of the screen is determined by both the type of information to be presented and the places from which the screen must be viewed as the student does his assigned training tasks.

A screen one foot square is not unrealistic if the planned student activities permit him to be from 2 to 10 feet in front of the screen. Note also that acuity increases of the human eyes in lighted areas permit the use of smaller rear projection screens in lighted rooms than in darkened rooms (The ratio is almost two to one). When the visual displays are properly designed, greater viewing distances on smaller screens are also possible. The designer of carrels must incorporate certain assumptions concerning the courseware design as used in these carrels.

The size of print and fineness of detail used in the design of projected materials is often the critical factor in viewing distances. Print as used in visuals directing a student's training task performance provides cues or data involved in the task performance. Only those printed words which must be recalled by the student for satisfactory task performance should be presented visually, and they should be in a telegraphic style. For example, when the student must torque a bolt to 15 pounds, only the words *15 pounds* would appear on the screen. The student should be able to glance read the print associated with doing his task and not be distracted by the reading. One or two lines of print is all that normally should be provided. This print should be so large that if the screen were filled with print, only five to seven lines could be presented.

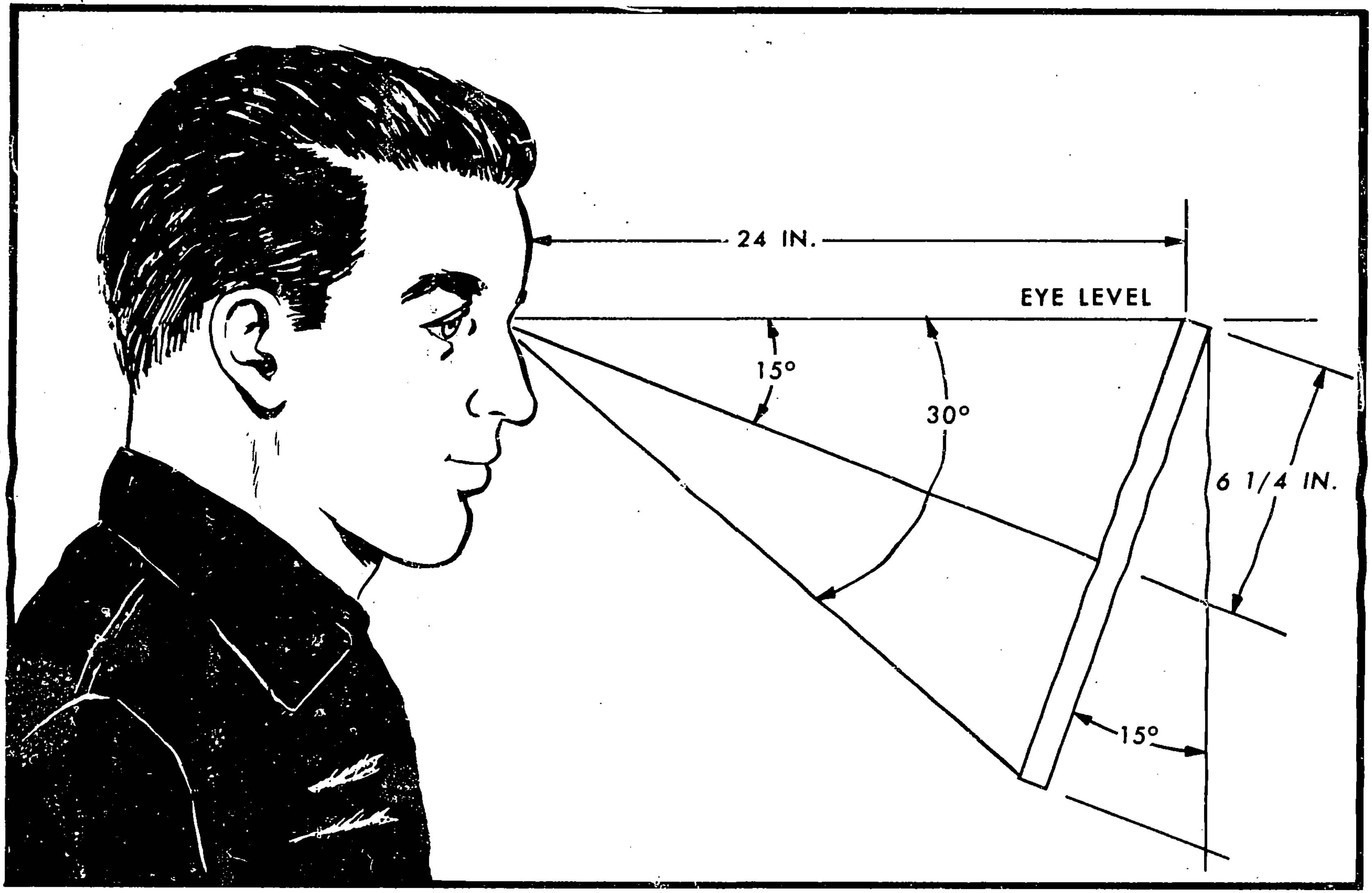

Figure 23. **Optimal location for visual display.**

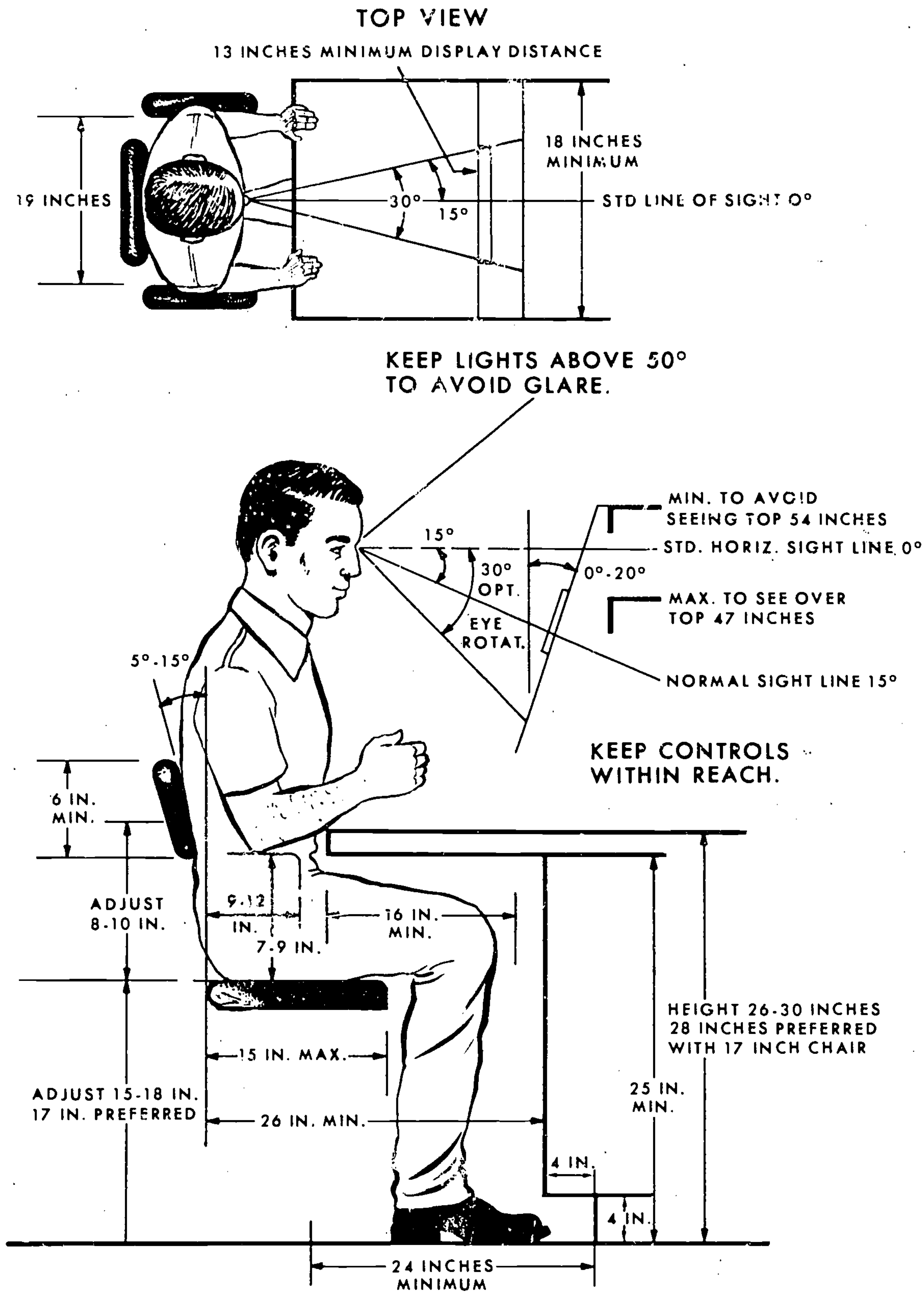

Figure 24. Suggested work area dimensions, seated.

Print projected from microform represents a different print format. Microform is discussed in previously published technical reports (Grausnick & Kottenstette, 1971; Grausnick et al., 1971; Kottenstette et al., 1971). Print size in this format may approach the minimum of 15 minutes of arc of visual angle.

A normal optimal viewing area defined in terms of screen widths (actually the width of the image prjected through the screen) is shown fo. a standard rear projection screen in Figure 25 (Trow & Smith, 1965a).

The side limits of the viewing area will be defined by the material of which the screen is made. Viewing area is typically reported in terms of viewing angle—that is, the angle of the student viewing location from the center of the projected image on the screen. For a rear projection system the critical design factor in screen selection is the maximum bend angle—the maximum angle through which the light must be diffused by the screen to reach the viewer. Figure 26 (Trow & Smith, 1965b) shows the relationship between viewing angle and bend angle through a rear projection screen. Practical values which reflect available kinds of projector systems are shown in Table 7 (Trow & Smith, 1965b) as an example to show the kind of information necessary for design.

Table 7. Bend Angles for Typical Projection Systems at 20° Off Axis

	16mm movie		35mm filmstrip		35mm slide	
F.L.	α	β max.	α	β max.	α	β max.
0.625	16.9°	48.9°	---	---	---	---
1.0	10.8	42.8	---	---	---	---
1.5	7.2	39.2	16.8°	48.8°	---	---
2.0	---	---	12.7	44.7	18.6°	50.6°
3.0	---	---	8.6	40.6	12.6	44.6
4.0	---	---	---	---	9.5	41.5

Note. — F.L. is focal length in inches; Typical projection system incorporates Polacoat LS 60 G 1/8" glass screen.

Twenty-one commercially available screens were evaluated using a goniophotometer by Smith and Caudill (1970). The optimal viewing angle lies in the area within which the brightness of the light falls off less than 50% of the peak of the normal axis reading. The maximum usable angle lies in the area within which the light falls off less than 25% of the peak of the normal axis reading. Going beyond this 25% angle would usually make adequate viewing impossible. Distortion makes viewing beyond the 60 degree viewing angle unfeasible on any kind of flat display. Figure 27 shows the relationship of the angles giving 50% and 25% of peak normal axis brightness. The viewing angle giving 50% and 25% of peak normal axis brightness are shown in Table 8 (Smith & Caudill, 1970) for the 21 screens.

The selection of the rear projection screen for a learning environment or carrel must take into account the viewing areas possible and relate these areas to where the student will be working. If the student can sit directly in front of a screen placed in an optimal location, a highly directional screen may be used. Since such a screen concentrates the light into a narrow viewing area, a relatively small light output is required. This condition is usually favorable in terms of operational economics, reliability, heat generated, and maintainability. Use the narrowest viewing area enabling adequate student performance and viewing.

When the learning activity requires that the student move from place to place to do various tasks or complete an activity, the screen placement can not always be optimal. Further, the task requirements may not permit locating the rear projection screen in the best location. In such a case a wide angle screen would be used to provide the necessary viewing area. This condition is less favorable in terms of operational economics, reliability, heat generated, and maintainability. For example to achieve the same normal axis

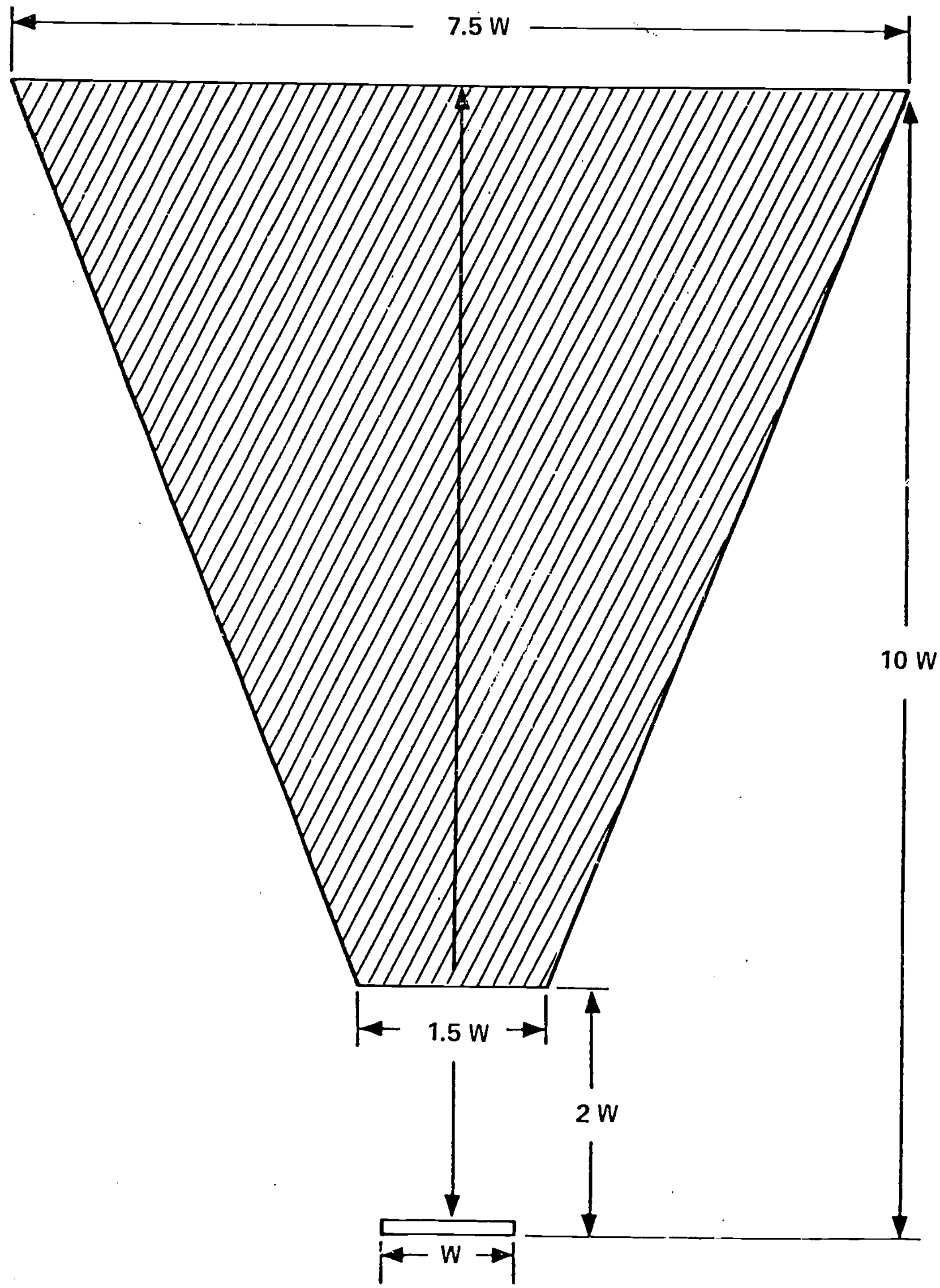

Figure 25. Optimal viewing area for standard (Polacoat LS 60 1/8 inch glass) rear projection screen. Maximum viewing distance based on symbol size 15 minutes of arc.

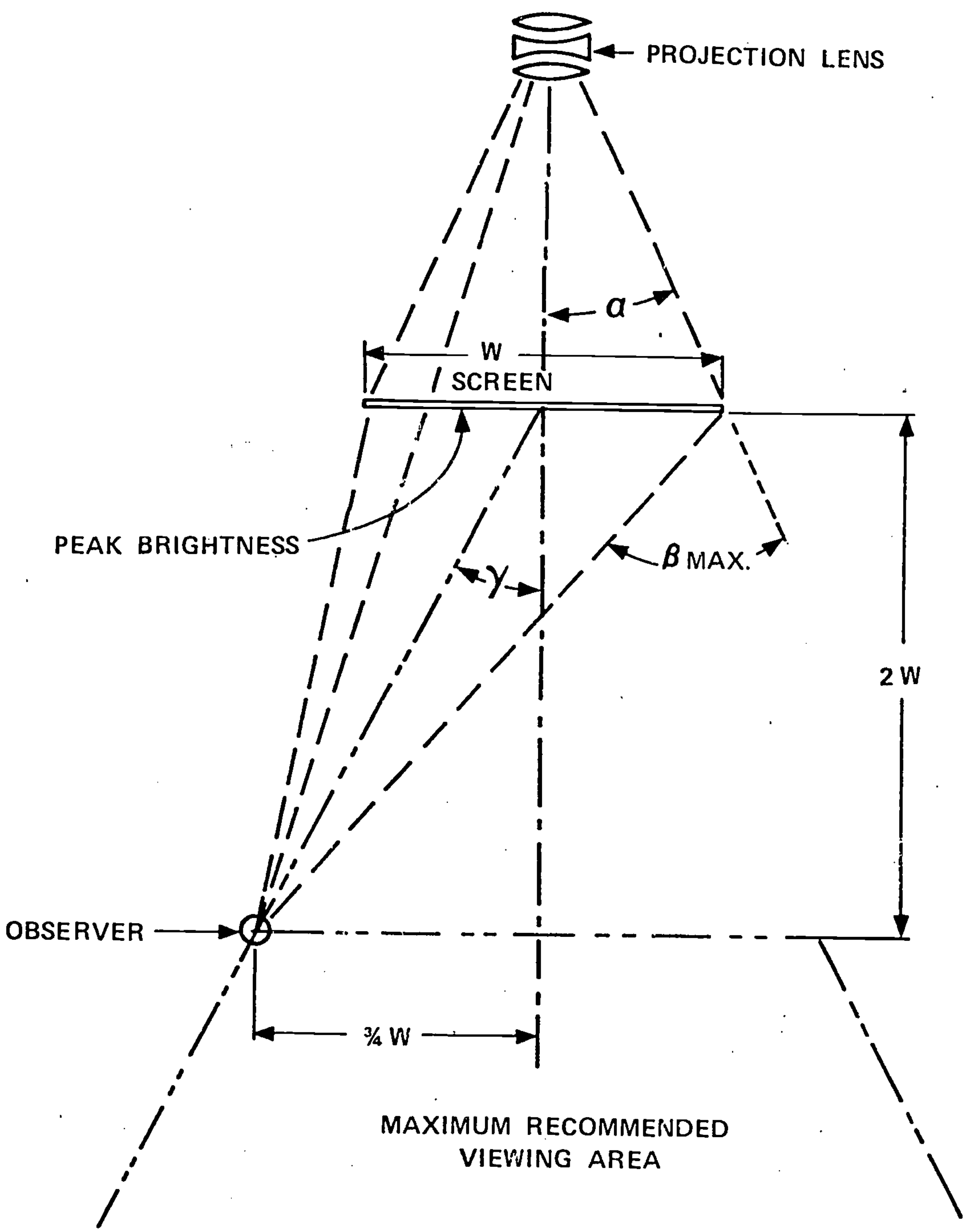

Figure 26: **Relationship between viewing angle γ and bend angle β in a rear projection screen.**

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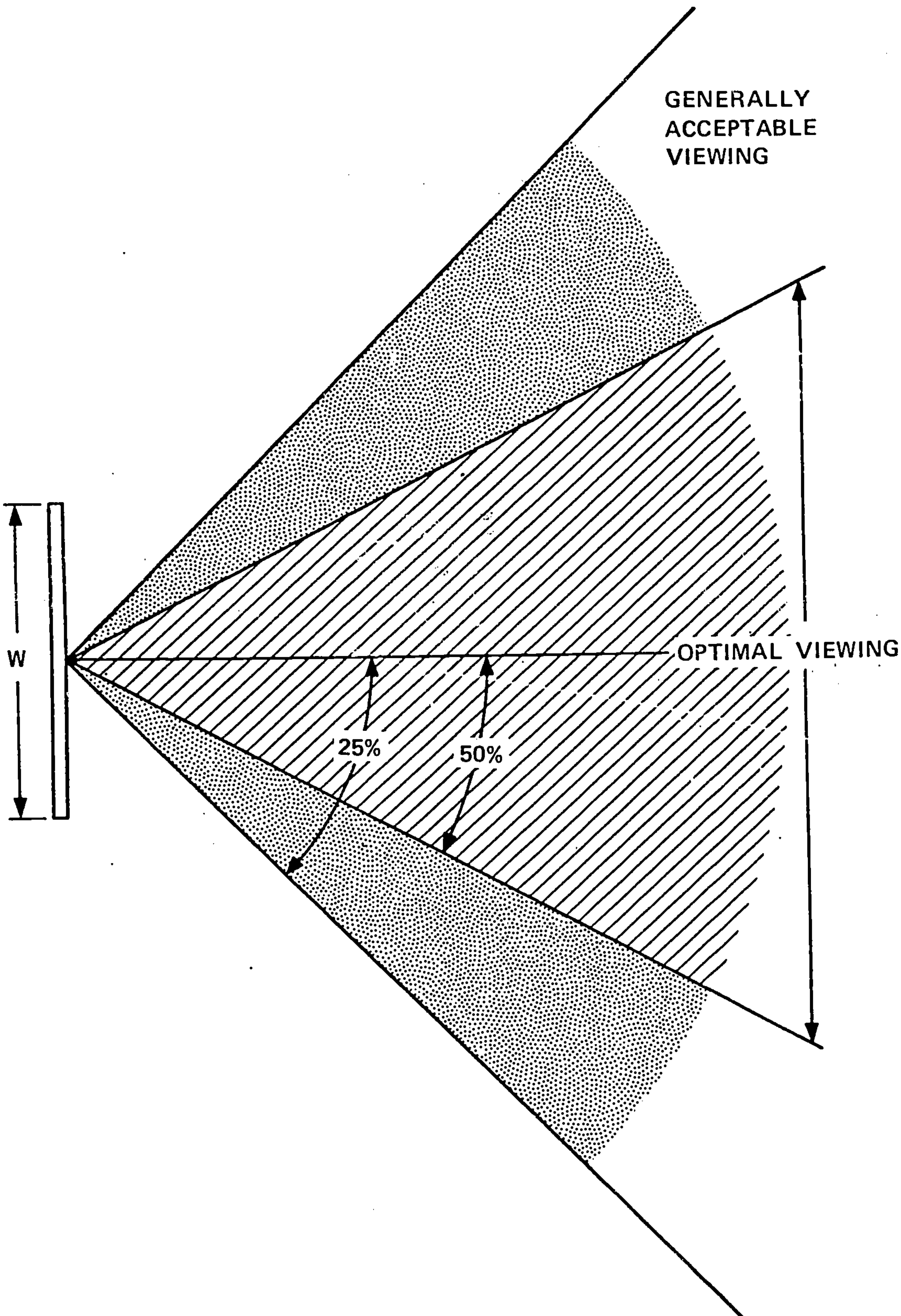


Figure 27. Areas providing 50% and 25% of peak normal axis white light to the viewer.

Table 8. Optimal and Acceptable Viewing Angles with Normal Axis Readings for 21 Rear Projection Screens

Rear Projection Screen	Angle of optimal Peak normal axis viewing (50% of luminance)	Max. angle of acceptable viewing (25% of peak normal axis luminance)	Normal axis reading (% of standard)
Polacoat LS40G 1/8" Glass	24.3	36.5	58.7
Polacoat LS40G 1/4" Glass	20.0	29.8	95.3
Polacoat LS60G 1/8" Glass*	21.3	31.3	100.0
Polacoat LS60G 1/4" Glass	21.8	32.5	97.3
Polacoat LS60G 3/8" Glass	19.3	29.3	115.3
Polacoat LS75G 1/8" Glass	15.5	23.0	213.1
Polacoat LS75BG 1/8" Blue Tint Glass	16.8	24.8	157.6
Polacoat LS75GG 1/8" Green Tint Glass	15.3	22.5	175.3
Polacoat OC50G 1/8" Glass, 2 way	53.3	over 60°	24.0
Polacoat TR50G 1/8" Glass	34.5	52.3	55.3
Polacoat TR70G 1/8" Glass	21.1	32.4	132.7
Polacoat TR80G 1/8" Glass	16.3	24.3	222.0
Polacoat LS60PL 1/4" Plexiglass	23.0	33.8	88.7
Polacoat LS60PL 3/8" Plexiglass	18.8	28.0	133.2
TransLux Techscreen VG 50	17.5	22.1	108.0
TransLux Techscreen VG 70	15.4	23.5	258.8
TransLux Stewart Process	15.8	25.0	133.2
TransLux Stewart Black	12.0	17.8	133.2
TransLux S50-R	34.3	53.5	45.3
TransLux TV-Blue	21.2	34.0	72.0
TransLux Hi-Trans	14.8	21.8	226.4

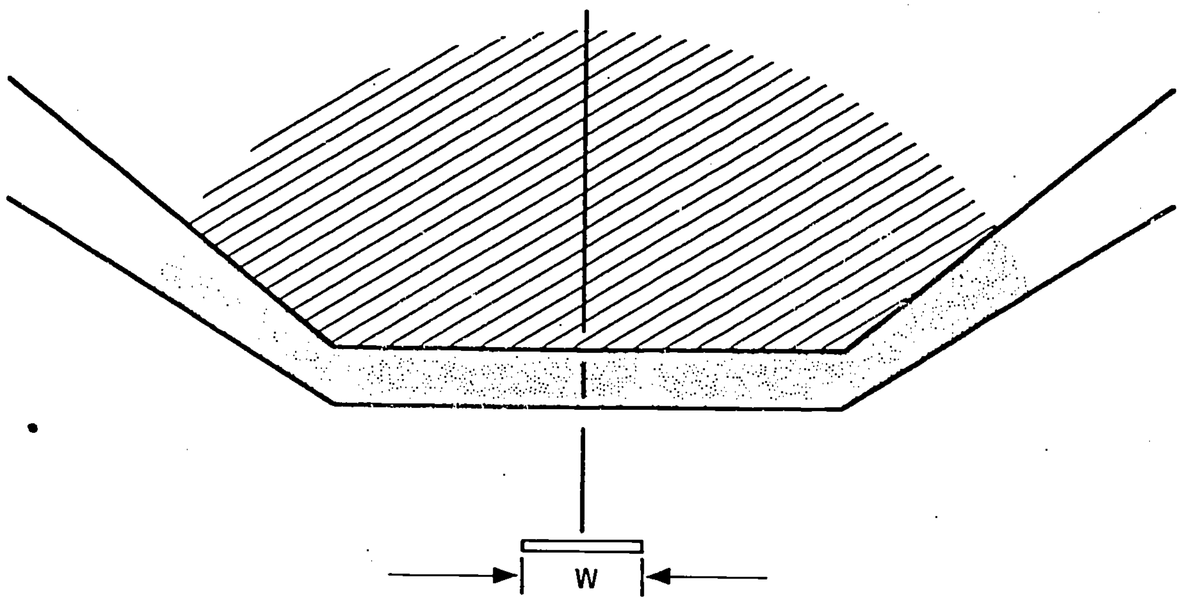
*Used as standard.

brightness on the wide angle screen pictured in Figure 28 nearly 10 times the light at the screen is required than would be required for the highly directional screen pictured right below it. For additional information concerning screen material selection see Smith Caudill (1970).

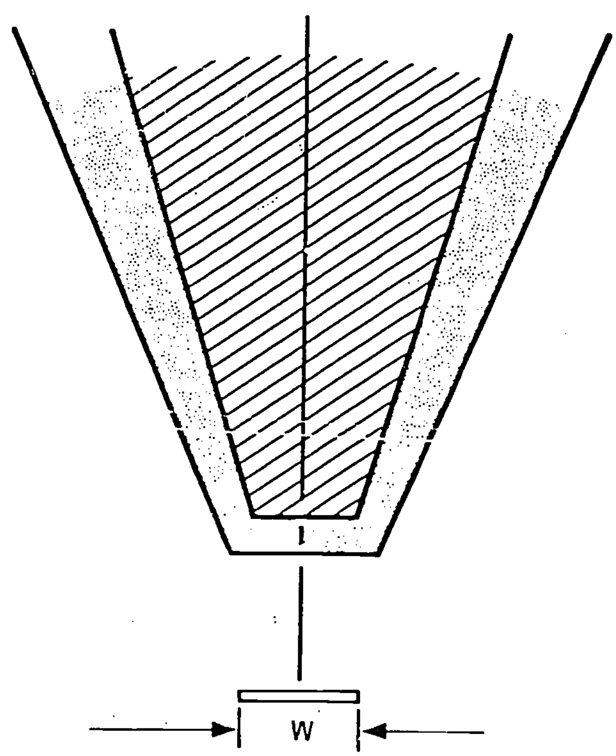
Pigmented screens are generally available in green, blue or neutral (black). Green and blue pigments are primarily intended to control scintillation, that is the sparkle seen under very bright lighting conditions. Neutral pigmented screens have a dark pigment added to the screen material which absorbs a percentage of the surrounding light rather than reflecting it. However, the efficiency in passing light through the screen is reduced (more light is required). The net result of this darkening is a picture with deeper blacks (giving better contrast). However, the use of the darkest screens should be limited to applications where room light behind the screen cannot be controlled by the enclosure since the light output must be increased for a low reflectance screen. The projector output (brightness) must be increased for a pigmented screen. Additional information concerning pigmented screens is found in Trow and Smith (1965b), and from the manufacturers of screens. It is generally advisable to use normal screens rather than pigmented screens.

The level of lighting where the student works is a limiting factor in viewing unit design as previously discussed. To provide good contrast and image color values, the rear screen projection compartment should be darkened, reducing brightness requirements from the projection system. Rear stray light should be controlled not only by outer compartment design, but also by mirror location and angular placement.

An important difference between front and rear projection is that the image is reversed right for left (when no mirrors are used). Correcting this by reversing the slides or filmstrips is generally inconvenient. (Some plastic slide mounts should not be reversed.) Reversing most movie film is impossible (special prints



OC50G 1/8 inch glass (wide angle) screen



TR80G 1/8 inch glass (highly directional) screen

Figure 28. Comparison of viewing areas.

must be purchased). Thus, it is best to accomplish this correction by designing the projection system with an odd number of mirrors.

The optical axis of a projection system should be in the center of the screen and perpendicular to the screen. Projection angles which are not perpendicular to the screen will cause "keystoning" as illustrated in Figure 29. If the screen is vertical and the optical axis is horizontally displaced to one side, the image will not be rectangular. The image at the side of the screen nearest the projector will be narrower than at the far side of the screen. Vertical displacement of the optical axis from the perpendicular axis provides a simiiar effect. The difference in length of the top and bottom (or left and right) of the projected image should not exceed 10 percent.

A horizontal optical axis often is most convenient in the design of the viewing unit component. Based on the conventional placement of controls on standard projection equipment, the logical arrangement would be to use a one-mirror system with the projector to the left of the screen box (Figure 22). Several viewing units will be discussed later.

Recommendations for viewing are shown in Table 9. Some of these recommendations are based upon the Uniform Practices of the Photographic Society of America for judging projected images and selected American National Standards Institute documents. They represent a helpful compromise between the ideal and what is feasible, available, and reasonably economical.

When using different sizes of film (as for example 16mm and 35mm), it is desirable to have the picture fill the fixed screen size, or nearly so. It is also desirable to maintain approximately the same projection distance to the screen with different projection equipment. These two requirements can only be met by matching the focal length of the projection lens to the film frame size. A set of projection lenses should be selected from standard focal lengths since any custom made lens would be quite expensive. The set of lenses matched with projectors should project about the same picture size at a common projection distance. The wider the field coverage required of a projection lens (the shorter the lens), the more difficult and expensive it becomes to project the full image without darkened corners. Thus, there is a practical low limit on focal length. Table 10 (Trow & Smith, 1965a) lists two sets of lenses, designated A and B, which are presently available and would be suitable for compact configurations. Also shown are a few moving picture projection lenses which might be used. For purposes of this comparison, we have selected an 8-inch square screen as standard. Set A, using the shortest standard focal lengths available and practicable, gives a film to screen distance of about 16 inches, which would provide a very compact design. Set B, using the next higher increment of focal lengths, results in a distance of around 22 inches. These dimensions would be used in the design of viewing units which would fit into your carrels.

The desirable light output of a projector is strongly dependent upon three factors relating to intended use: room lighting, viewing area, and picture content. When application requirements permit, substantial reduction in costs may be made by including such features as a low wattage convection-cooled lamp, an uncoated diffusing screen, and a lens system of lower quality. However, the selection of projection and viewing system components must provide adequate performance and reliability. In addition, the selected system should not be burdened by excessive costs caused by including characteristics above and beyond those that will be actually used.

One common difficulty in projection is insufficient light output. Move the projector closer to the screen for producing brighter (although smaller) images. Halving the distance will increase image brightness four times. However, this solution is satisfactory only when the material being projected is so designed that the print (or other information) is clearly legible at the smaller image size. While the need for greater light output is usually recognized, the need for reducing light output can be as great and may be neglected. Over bright images may cause a dazzling effect. Further, over brightness makes the flicker more apparent in motion pictures. The problem of too much brightness is encountered most often with line drawings or print projected from a high contrast film. Normal screen brightness should be slightly above the brightness of the work area (note our earlier recommendation that screen brightness should be 10% above light level of work area), but never as much as three times as bright as the work area. Substitution of lower wattage projection lamps in the projection system is one way of reducing light output. Raising the general room lighting will often serve the same purpose as reducing projection light since it is the brightness ratio which is critical. These practices can be useful in reducing the dazzle effect of excessive brightness in showing negative or "reverse" text slides.

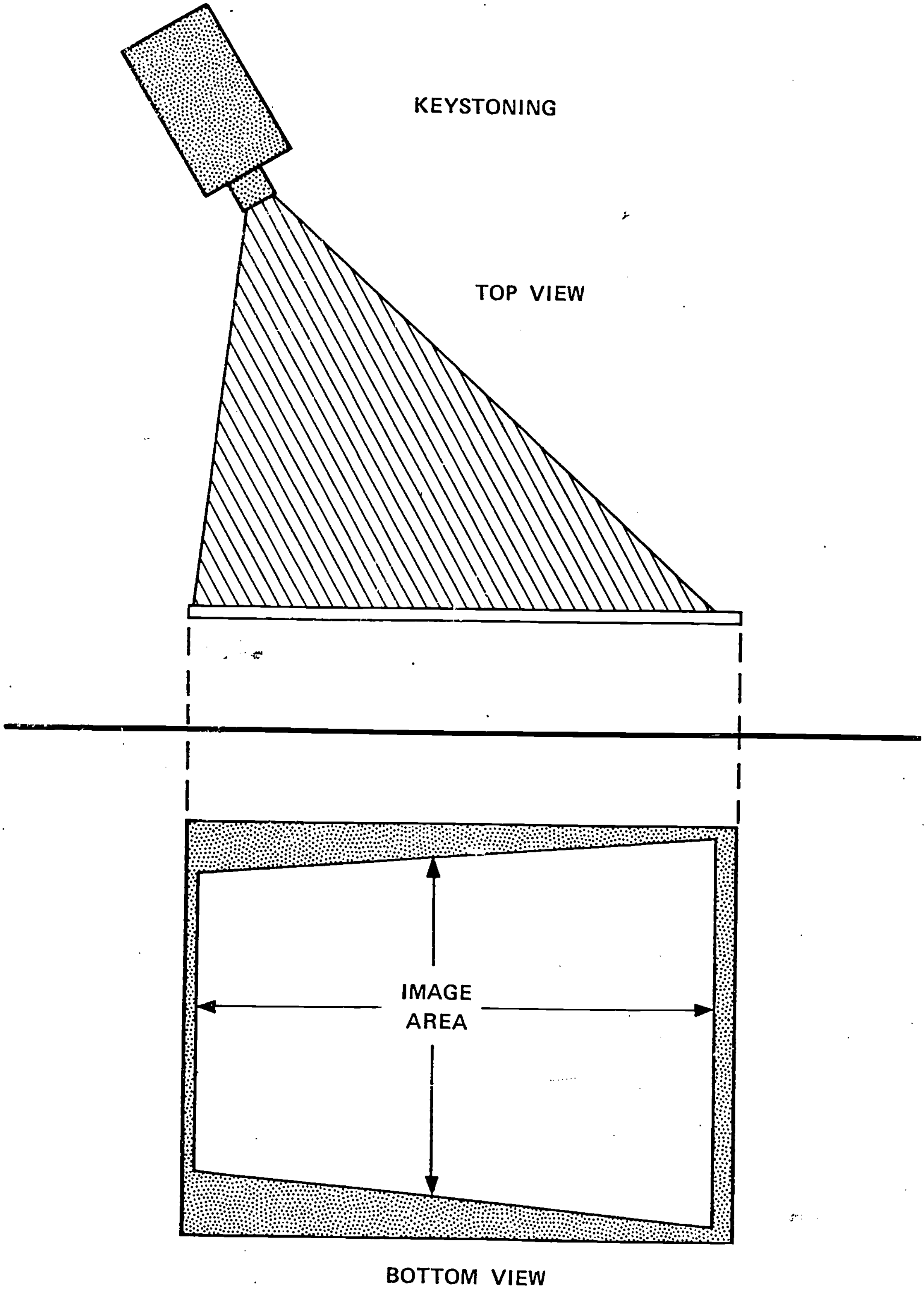


Figure 29. Keystone effect when projector is horizontally displaced.

Table 9. **General Recommendations for Viewing Rear Screen Projection**

FACTORS	OPTIMUM	PREFERRED LIMITS	ACCEPTABLE LIMITS
Ratio of viewing distance / image width	3 to 4	2 to 10	1.5 to 14
Viewing Angle (horizontal standard screen, in degrees)	0 to 10	20	30
Viewing Angle (vertical, in degrees)	15 below eye level	0 to 30 below eye level	+ 15 above eye level to 45 below eye level
Image luminance (ft-lamberts, no film in projector)		In darkened room	In darkened room
Slides (full color)	10% above ambient	25 ± 10	5 to 50
8mm (full color)	10% above ambient	12 ± 3	5 to 50
16mm (full color)	10% above ambient	16 ± 4	5 to 50
See contrast ratio			
Luminance variation (ratio of maximum to minimum luminance, 10% screen width from edge)	0	1.5	2.0
Luminance variation as a function of seat position (ratio of maximum to minimum luminance)	0	2	4
Stray light (ratio of capped projector to uncapped, no film in projector, full color)	0	.01	.01
Contrast ratio (highlight to dark screen or clear film to maximum density, full color rendition and fine detail)	Varies	100 (min)	Vary
Contrast ratio (highlight to dark screen or clear film to maximum density, color diagrams, continuous tone black and white, no fine detail)	Varies	25 (acceptable)	Vary
Contrast ratio (highlight to dark screen or clear film to maximum density, no fine detail line drawings, text, max.	Varies	20 to 30	5 (Minimum) 40 (Maximum in darkened room)

Table 10. **Projection Lenses Suitable for Compact Designs**

Set	Format	Frame Width	Focal Length	Film-to-screen Distance	Picture Width	Picture Height
A.	35mm slide	1,344	2.0	16.25	8.0	5.4
	35mm strip	.906	1.5	15.6	7.5	5.63
B.	35mm slide	1.344	3.0	22.6	7.2	4.85
	35mm strip	.906	2.0	21.95	8.0	6.0
	16mm movie	.380	.625	14.4	8.0	6.0
			.750	17.3	8.0	6.0
			1.0	23.0	8.0	6.0
	8mm movie	.172	0.5	24.2	8.0	6.0
			15mm	28.4	8.0	6.0

Audio. Audio presentations would be used with a visual presentation or with training equipment and simulators. The training task defines the appropriate work space. Audio will have been selected as an effective way of providing the necessary information. For individually paced instruction, either headsets or acoustical isolation combined with audio speakers would be used in designing the work area.

For training students on large equipment or in several related successive areas we suggest the consideration of what is here called a mobile audio carrel. The mobile audio carrel would be where the student carries a small cassette audio playback unit, or uses headsets attached to an umbilical cord, or uses headsets designed to receive a short range broadcasted message. Note that visual orientation should be provided prior to working on the equipment.

Figure 30 shows an application using headsets designed to receive a short range broadcasted message. This training technique, using quadraphonic sound, is intended for team training. Each of four team members receives individualized instructions through a headset directing his activities in coordination with the rest of the team. Simpler audio systems can be used for tasks requiring only one person. Cordless headphones may be helpful when a trailing cord would be a safety hazard.

Headset selection is most frequently a compromise between comfort and equipment performance. Generally in training, medium size earphones on a headband can be used for periods up to six hours. Van Cott and Kinkade (1972) indicate that the optimal signal system for training would have a dynamic range of 40-45dB. They further indicate that essentially no listening errors occur (using male speakers) when the speech peaks (for the range of 200Hz – 6100 Hz) are at least 30dB over the noise (background) level. An important problem which may affect headset selection could come from multiple users. If different people use the headsets, sanitation procedures are required. Cotton coverlets have not been found satisfactory by users. We recommend normal sanitary practices such as regular swabbing of headsets with a mild antiseptic solution. The advice of medically trained specialists would also be helpful.

In carrel design, audio distraction requires a much greater level of control than does visual distraction. For visual distraction, the student must shift his attention away from the display. Audio typically will distract the student far more than visual since the sound comes to the student whether he is attending to it or not. It is important to consider and include sound isolation or reduction techniques in your carrel design or selection.

When listening for extended periods of time, listening stations or booths may be helpful. Group interaction and discussion will be incorporated into many learning centers. Special rooms may be required, or special portable group interaction carrels may become necessary. This would essentially be a small mobile room which provides a good sound barrier from the rest of the environment.

Carrels

Several carrels have been designed by or for the Air Force Human Resources Laboratory. A number of other carrels are available. However, the largest number of commercially available carrels merely provide an expensive alternative to a library table. Various carrels will be described, not as the solution to your carrel design problem but to demonstrate some possibilities for your own design consideration.

Carrel A (Figure 31) is essentially a 5-foot long library table with 4-foot high partitions providing visual control. Several different types of information display and presentation systems could be accommodated.

Carrel B is a variation of the design of Carrel A (Figure 31) which eliminates some of the panels which would be redundant if four carrels of the Carrel A configuration were placed together. Visual control is provided. Several different types of mediated presentation systems could be accommodated.

Carrel C incorporates minor modifications into the carrel originally designed as the ATC standard UPT carrel (Figure 32). The carrel includes a 3/4" plywood cubical, a formica covered work surface, six power outlets, and an adustable viewing module (discussed later). The overall dimensions are 48" wide x 41" deep x 50" high (work surface 36" deep). The leg adjustment permits the work surface to be set from 26" to 29" from the floor. Several other different types of mediated presentation systems could be accommodated.

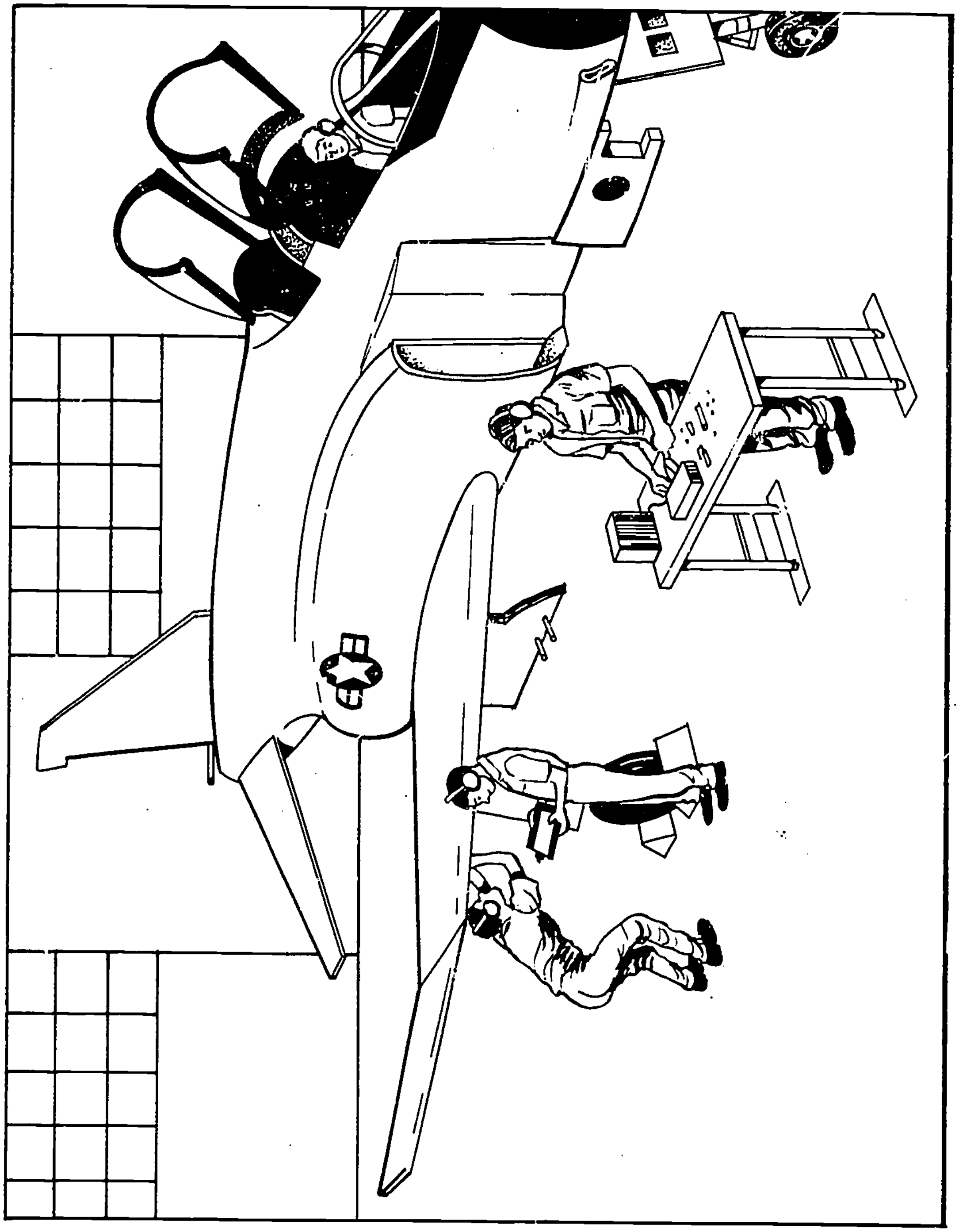


Figure 30. **Broadcast audio team training.**

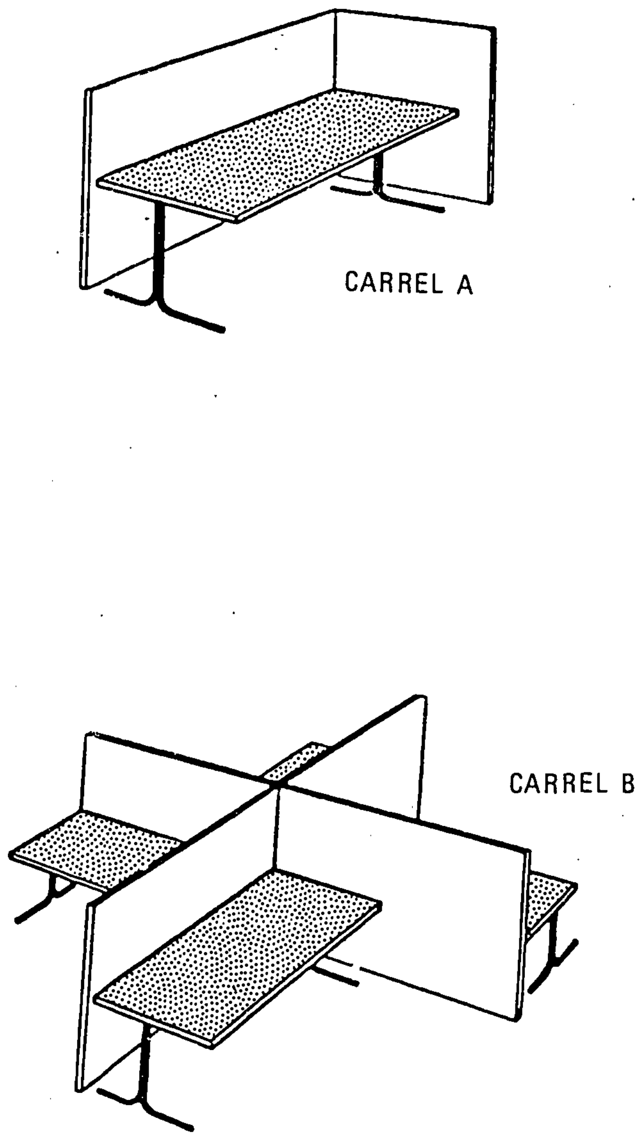


Figure 31. Study carrels based on standard tables.

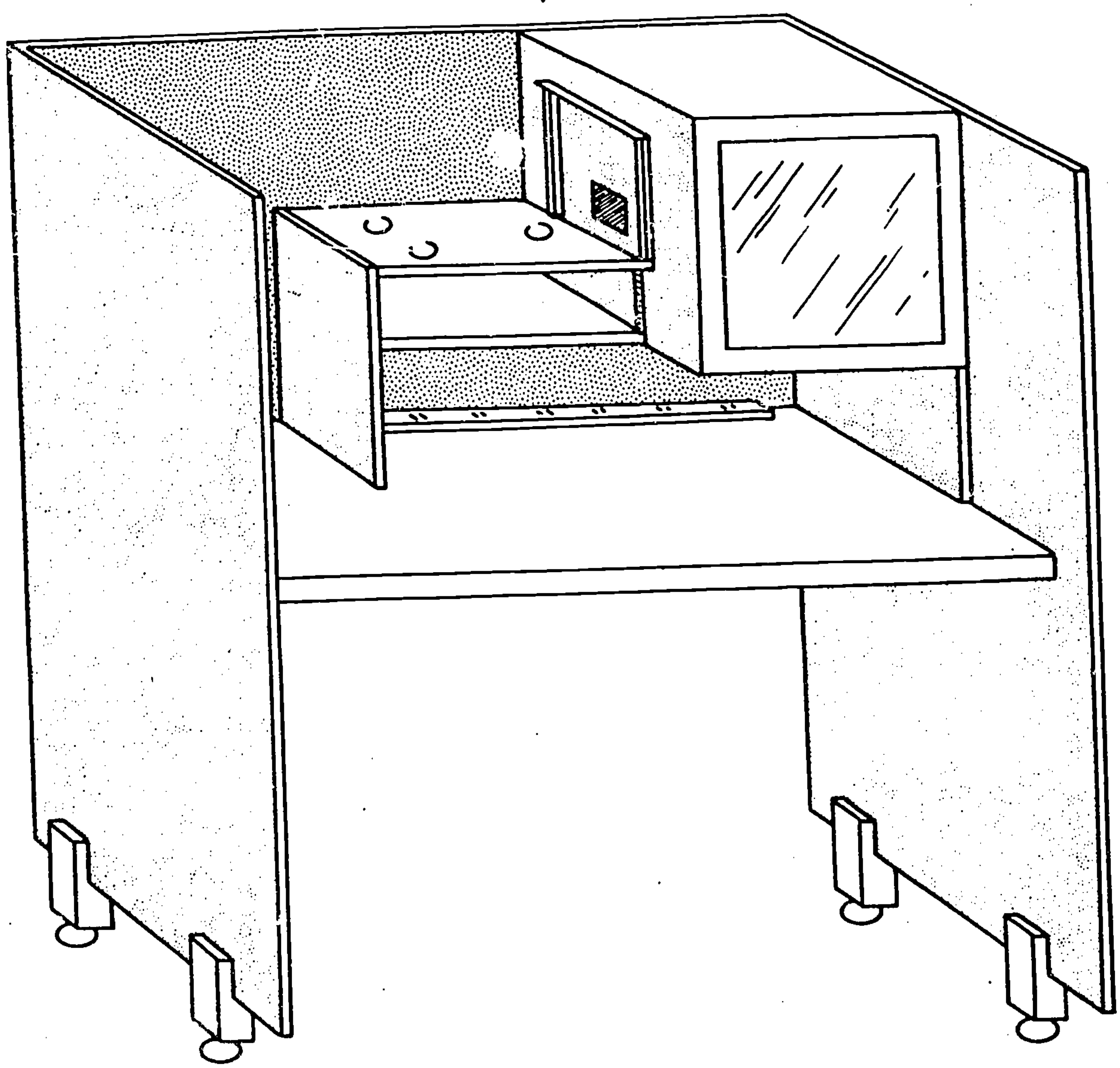


Figure 32. Carrel C with adjustable viewing module installed.

Carrel D provides a later modification of carrel C, which also enables shelf storage of technical reports. The work surface of the carrel is 3/4" plywood (formica covered) mounted on a frame made of 1½" square aluminum tubing (Figure 33). Overall dimensions are 48" wide x 42" x 56" high (work surface 34" deep). Legs are replaced to change the work surface height; the present height is 29 inches. Visual isolation is provided by ½" flakeboard covered with vinyl. A shelf and drawer are incorporated. A customized viewing module (discussed later) may be included. Several other different types of mediated and presentation systems could accommodated.

Carrel E was designed to promote interaction between students (Figure 34). The contour enables two persons to observe presentations and also to converse comfortably. The blunt front edge is designed to accept bench equipment such as an oscilloscope. The overall dimensions are 48" wide, 26-45" deep, and 56" high. The work surface is covered with formica and the shelves hold a library of up to 100 hours of mediated training. The inner vertical surfaces are lined with Velox hook and loop material so that small items can be attached. Several types of mediated presentation systems could be accommodated.

Carrel F represents a commercially available variation of the normal structural concept in instructional carrels (by the Worden Company) (Figure 35). The overall dimensions are 36" wide, 36" deep (work surface 30" deep), and 56" high. The work surface is covered with a plastic laminate as are the particle board sides and back. The projector unit is mounted on a platform which allows for vertical adjustment which compensates for lens location and alignment. The projection unit is adjustable to compensate for differences in projector lens focal length.

Carrel G represents another commercially available carrel (Howe Furniture Corporation) (Figure 35). The overall dimensions are 36 13/15" wide, 30" deep (work surface 23" deep), and 46" high. An 8" shelf slightly over a foot above the work surface can be used for books or a rear view projection module (discussed later as a viewing module). The 1" square steel tube legs make the work surface 29" high. The work surface is covered with a plastic laminate and is strengthened at the edge with a 4" deep steel apron. Front surface projection is possible using a 7½" x 10" plastic screen. A projector tab permits the projector to be placed far enough back so as to be able to focus the shortest available lenses. Three power outlets are controlled by a master switch (with a pilot light). Visual isolation is provided by 3/4" particle board screens covered with plastic laminate.

Two portable table-top or bench-top viewing modules have been developed at Lowry Air Force Base (Figure 36). One is adaptable to a range of projection devices, the other is customized to specific devices.

The adjustable viewing module (previously mentioned with carrel C) has overall dimensions of 29" wide x 22" deep x 23.5" high. It incorporates a 12 x 12 front surface mirror and a 13 x 13 rear projection screen. The mirror is set at a 45° angle from the screen and the center is 10.5" behind it. A projector shelf adjustable from 9½" to 14¼" high is 13" wide and 15" deep. Performance is improved in high light level rooms by reducing the effective size of the projection opening by inserting masks customized for the selected projector. The shelf provides opening to accept the legs of a variety of projectors, automatically centering the image with little or no distortion.

A customized viewing module was designed for use in carrel D although it could be placed on a table top or bench top. It is customized to fit selected projection equipment. The overall dimensions of the viewing module are 25" wide 13" deep and 16 3/4" high. It incorporates a 9" x 9½" front surface mirror and 9½" x 11" rear projection screen. When the viewing module is set parallel to the edge of the table, the angle of the projector is -11½°, the mirror is at 56° and the screen is at 22½°. Note that the entire viewing unit can be reoriented to improve the viewing angle at the student position. The projector placement is predetermined so that the image is centered on the screen without distortion. An audio-cassette playback unit for programming the projector and providing audio rests on a shelf under the projector.

Different viewing modules are available from commercial vendors. Figure 37 shows two representative kinds of viewing modules. For example, Howe Furniture Corporation produces a family of "rear view projection modules" which fit on a carrel shelf, table top, or bench top and each are designed to accommodate those projectors suitable for carrel use. A hood designed to reduce glare is also included. The size of units of this type would range from 25 to 50 inches wide, 8 to 16 inches deep, and 7 to 10 inches high.

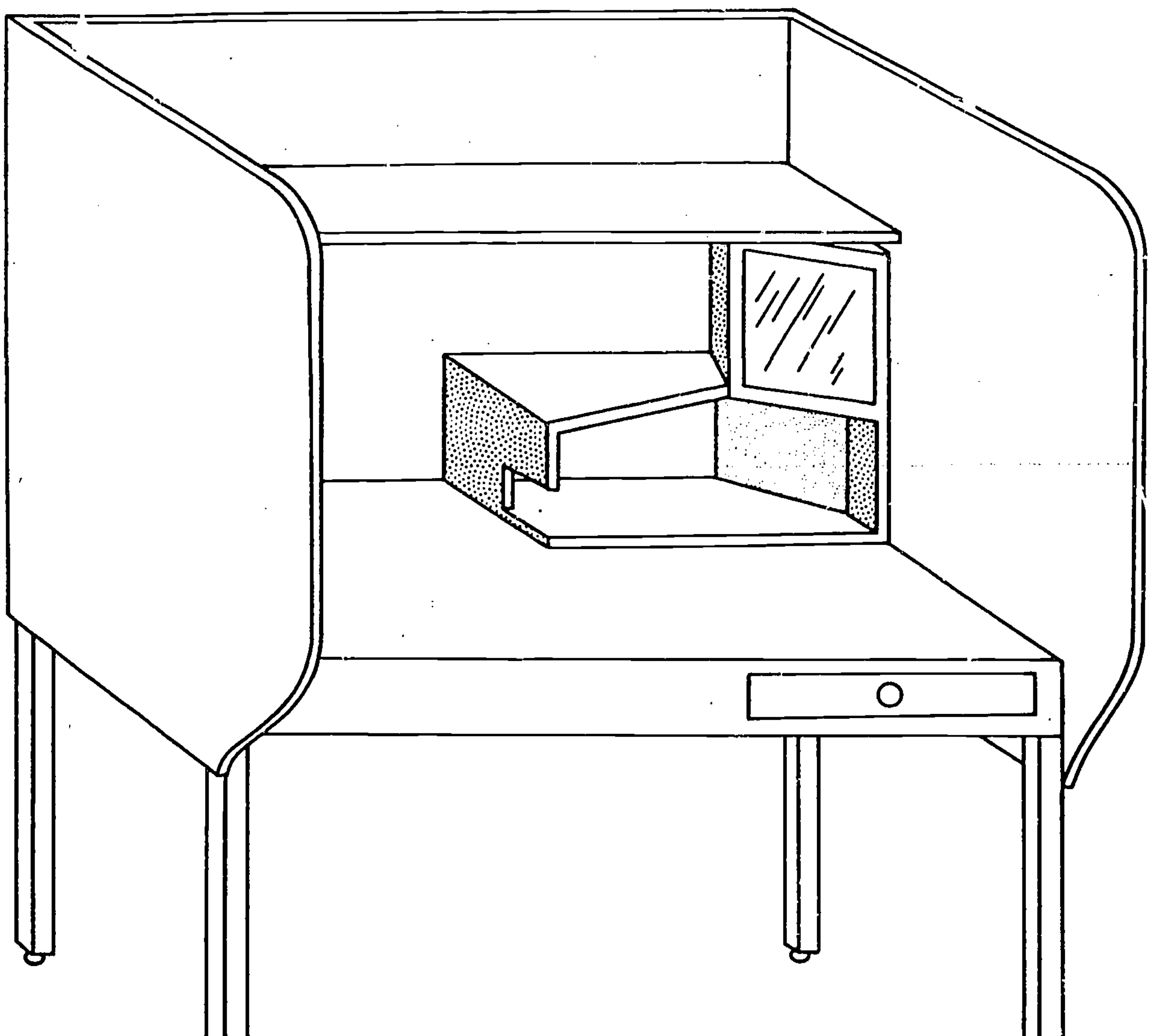


Figure 33. Carrel D with customized viewing module installed.

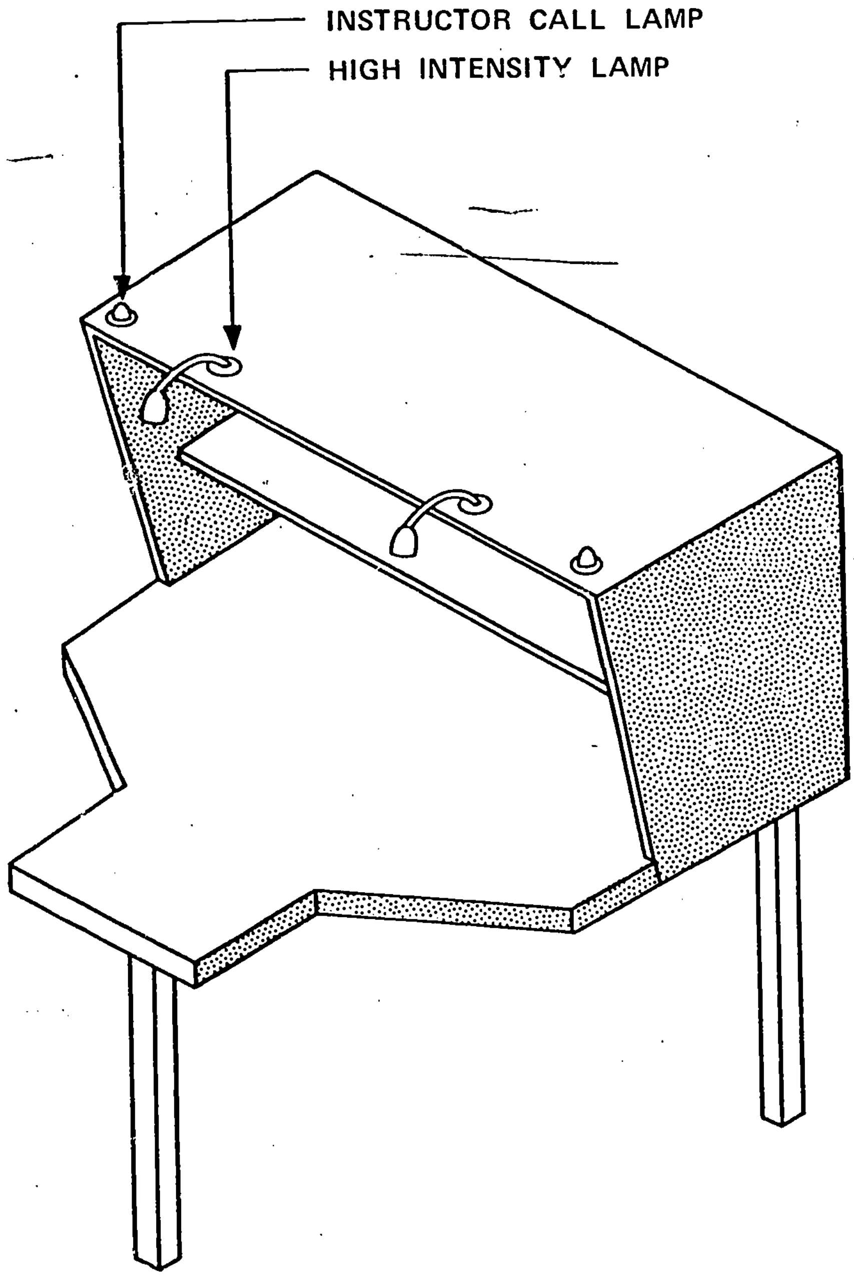
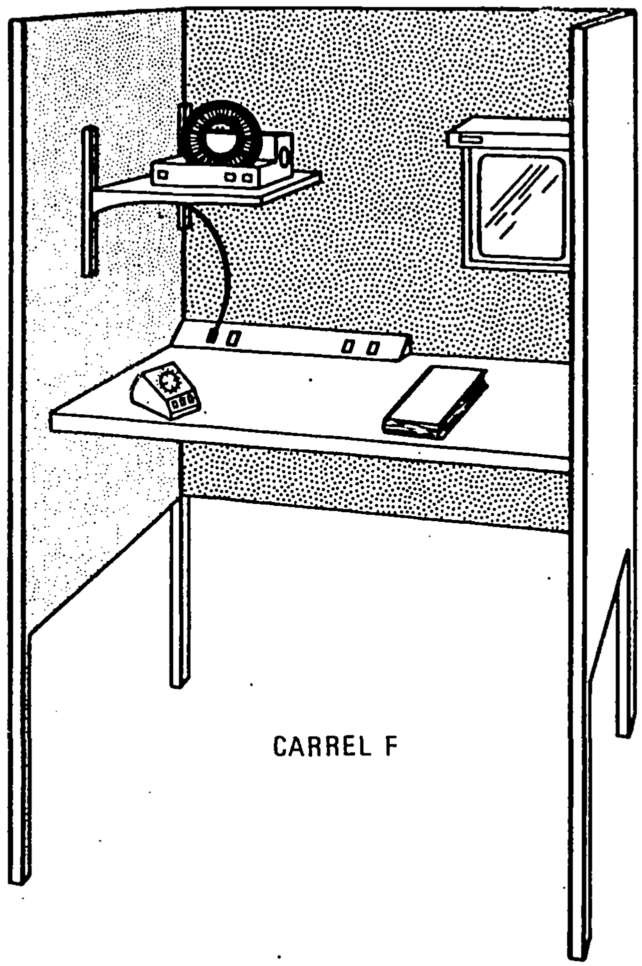


Figure 34. Interactive carrel, Carrel E.



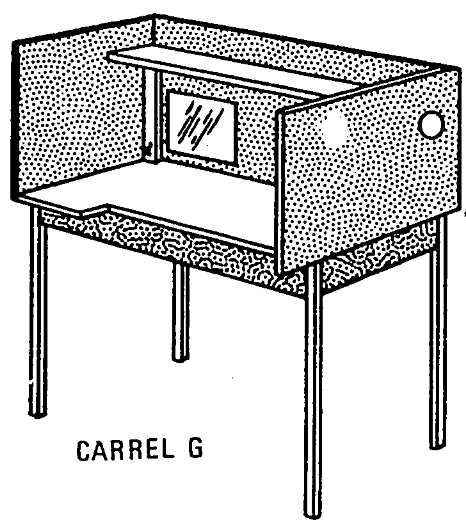


Figure 35. Two commercially available study carrels.

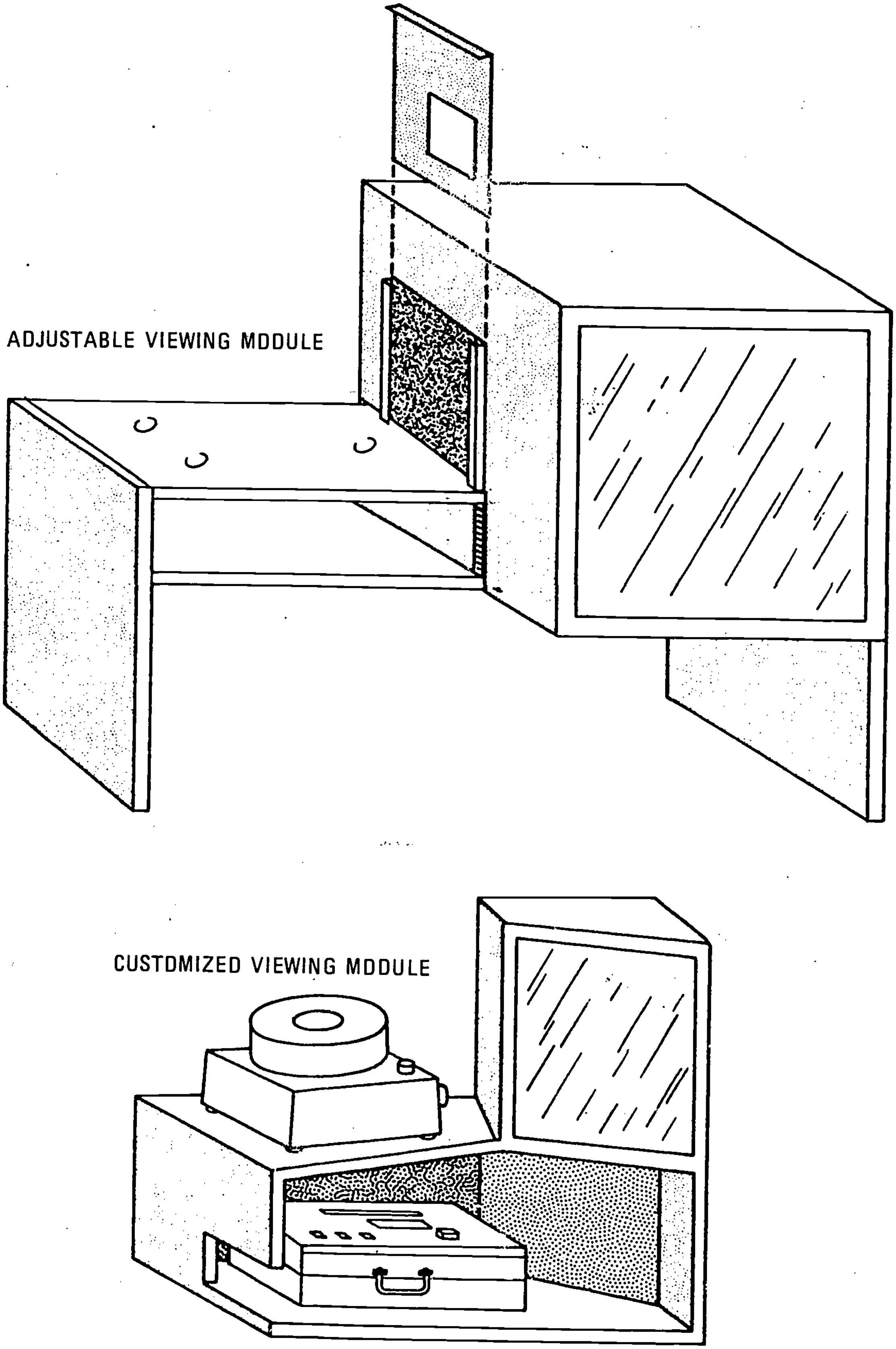


Figure 30. **Two Lowry AFB-built viewing modules.**

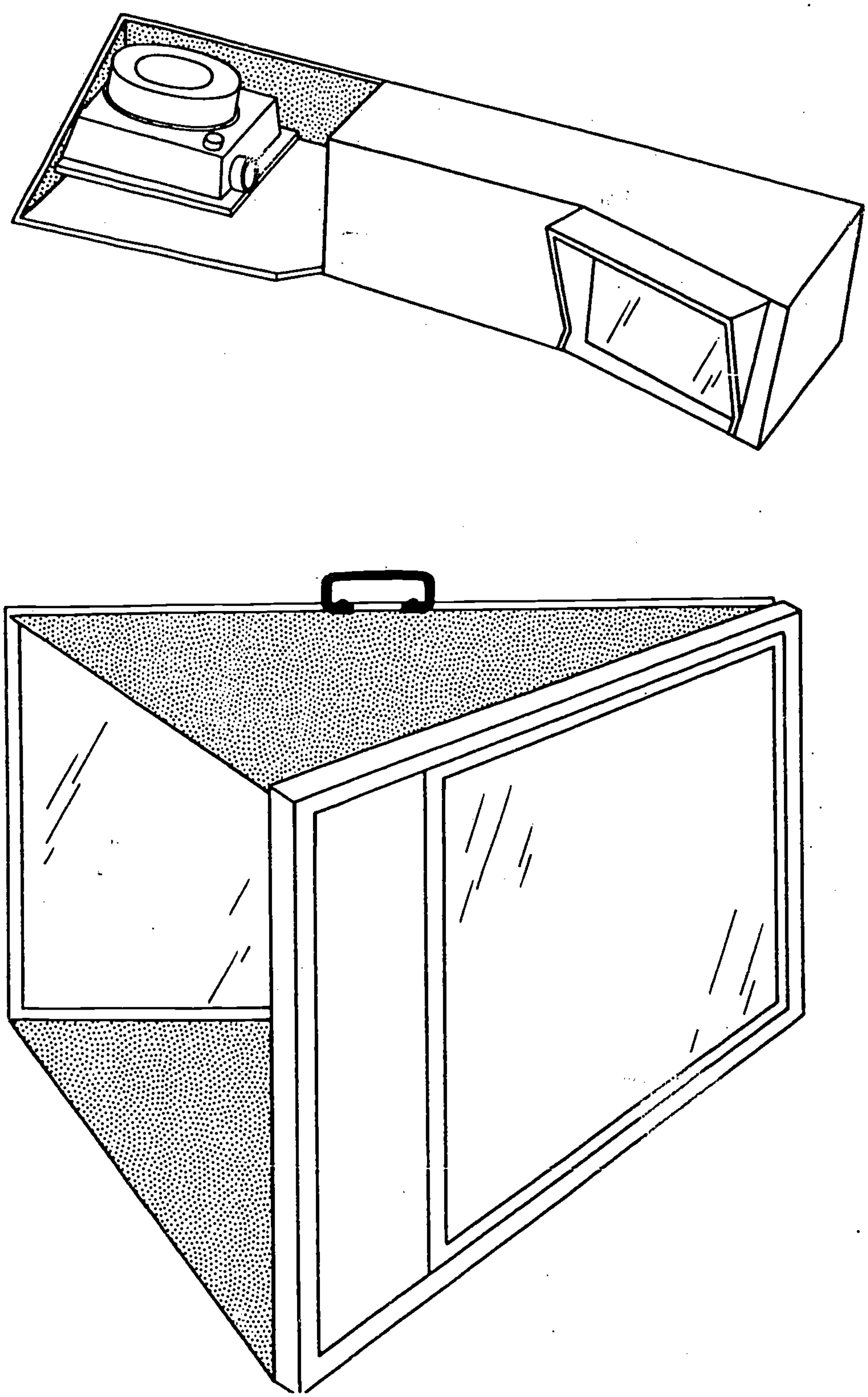


Figure 37. Two commercially available viewing modules.

Another type unit for rear projection screen viewing, shown in Figure 37, is available from numerous manufacturers. This unit which uses a wide range of screen sizes folds into a compact easily portable unit. Used on a table top or bench top it can accept a wide variety of projectors. High light levels may interfere with its use if permitted to strike the mirror. There is no included provision to reduce back lighting levels although a light shield can readily be improvised.

The viewing modules discussed above can be used on table tops, bench tops, or in most of the carrels previously discussed.

Carrel H (Worden) is commercially available (Figure 38) and is suited for use in courseware development and evaluation. Overall dimensions are 60" wide and 36" deep (work surface 30") and 56" high. A 10" x 34" viewing screen can simultaneously show three projected images through the integrated viewing unit. Easily accessible control switches are on the front of the shelf on which the projectors are placed. A projection shelf which hides the projectors when seated, deflects heat and noise away from viewing position.

Carrel J was developed at Lowry Air Force Base (Figure 38) for use during the initial tryout of instructional sequences. It provides the author with and opportunity to observe student progress unobtrusively. Overall dimensions are 36" wide and 56" high. Each of the two 30" high work surfaces are 19" deep and the total distance between the front edges is 60 inches. In use, the instructor or monitor would take notes and listen through earphones as he observes the student. Images from the projector(s) hit a beam splitter and a mirror system projects identical images on both 9½" x 20" screens. Each of the two rear projection screens is tall enough to accept two images one above the other. Book storage area is provided on the right while projection equipment and recorders are housed in the left cabinet.

Carrel K shows the performance-oriented learning area (Figure 39) for basic electronics designed at Fort Monmouth as part of the COBET (Common Basic Electronics Training) program. This carrel is one of a cluster of 12 arranged in a circle around a six foot in diameter instructor position. Each carrel is separated by a 66" high wall. Two kinds of work area are integrated into each carrel. A customized work bench about 5½ feet wide and 18 inches deep is used to work on electronic components. The bench top is 38½ inches high. Normally a multimeter (not shown) and a cartridge loaded 16mm sound filmstrip presentation device are on the bench top. Specially constructed storage areas are provided for a power supply, audio amplifier, and a test tone generator under the bench. Drawers are used to store manuals, hand tools, and connecting cables. Two sets of power outlets are also provided. A 30" high table for performing programmed instruction exercises is also provided in the students work area. It is about four feet wide and 18" deep. The top of the lower work surface is also used to store about forty hours of mediated instruction, an audio notebook, and a kit containing a variety of small electronic parts. A small blackboard (about 1½ feet square) is on the partition. The chair is adjustable and is similar to the one pictured earlier in Figure 20.

Carrel L developed at Lowry Air Force Base (Figure 40), is intended for use in performance oriented training with modularization of training task configurations. Normal dimensions 44" wide, 43" deep and 66½" high. The work surface is 30" high. An 18" square inset six inches from the front edge can be used to insert a wide variety of preplanned configurations (such as wired circuits) for hands-on training. The carrel can be expanded up to 36 additional inches (with structural integrity) to accommodate larger items of equipment. Two integrated viewing units will accept a wide variety of projectors. The rear projection screens are 8" x 8" and 6" x 8 inches. One unique feature is the filmstrip projector which projects images onto the work surface for identification or confirmation in a wide variety of tasks.

Carrel M called MAVIS (Modularized Audio Visual Instructional System, developed under Air Force contract by Hughes Aircraft Corp) (Figure 41), is designed for providing mediated instruction where access to stationary carrels is not possible due to the nature of the training environment. The viewing unit is 14" wide, 18" high and 32" deep and will accept any two projector configurations or combination of 35mm projector, filmstrip projector of 8mm motion picture projector. Each projector is modularized by mounting it on a tray which is easily inserted into the carrel. The 6½" high screens extend the full width of the carrel. A modularized audio cassette (audio and program synchronizing) unit replaces the top drawer on the Techtronic base. The mobile base has variable vertical positioning, lock wheel clamps, and some additional electrical and audio monitoring outlets. A foot-operated advance pedal and remote control activator make this carrel useful during hands-on training where the students is not able to operate normal media controls. Earphones are available and would be useful in a noisy area.

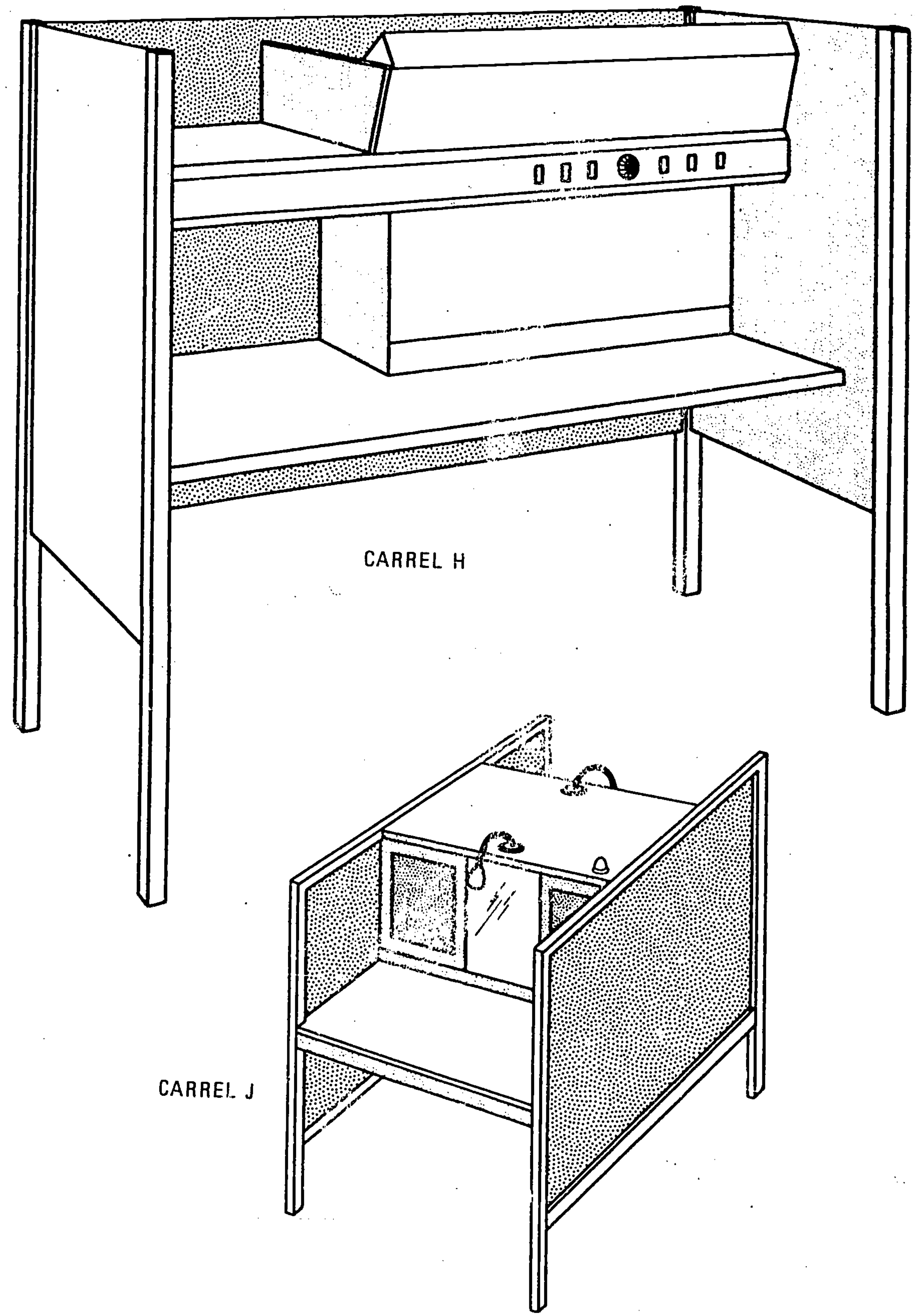


Figure 38. Two environments suitable for programming mediated instruction.

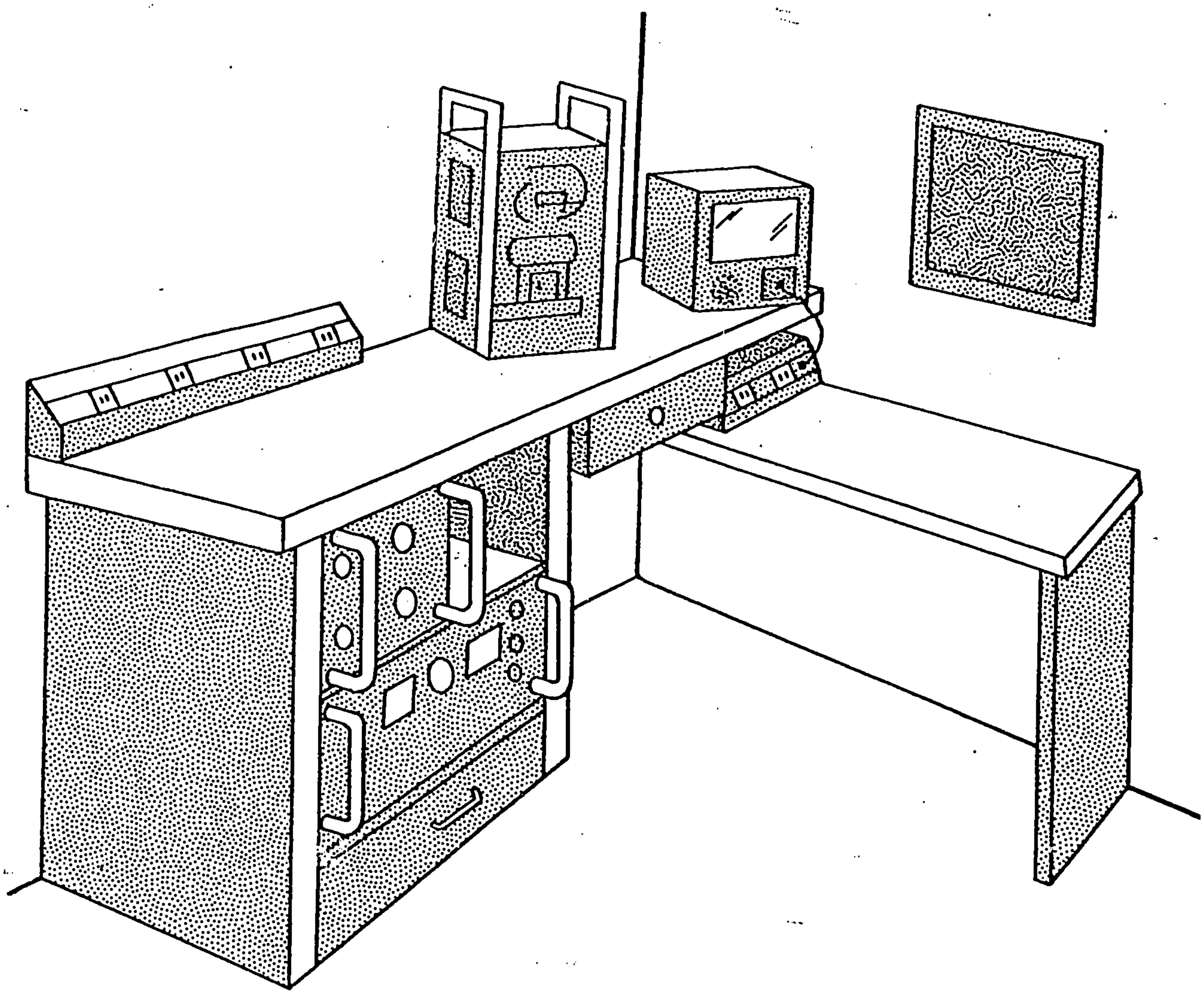


Figure 39. COBET (Carrel K) work area (shown without dividers).

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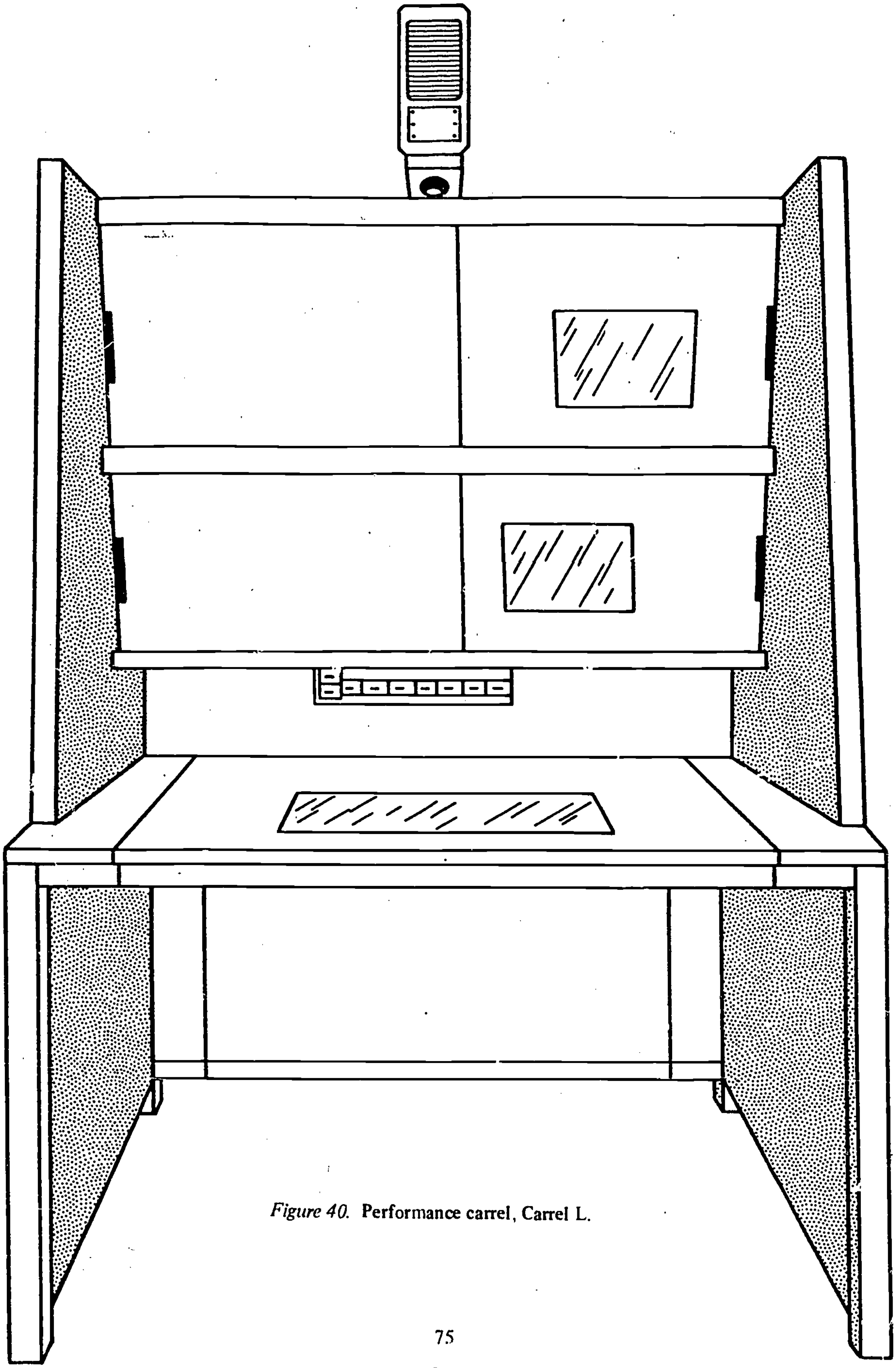

Figure 40. Performance carrel, Carrel L.

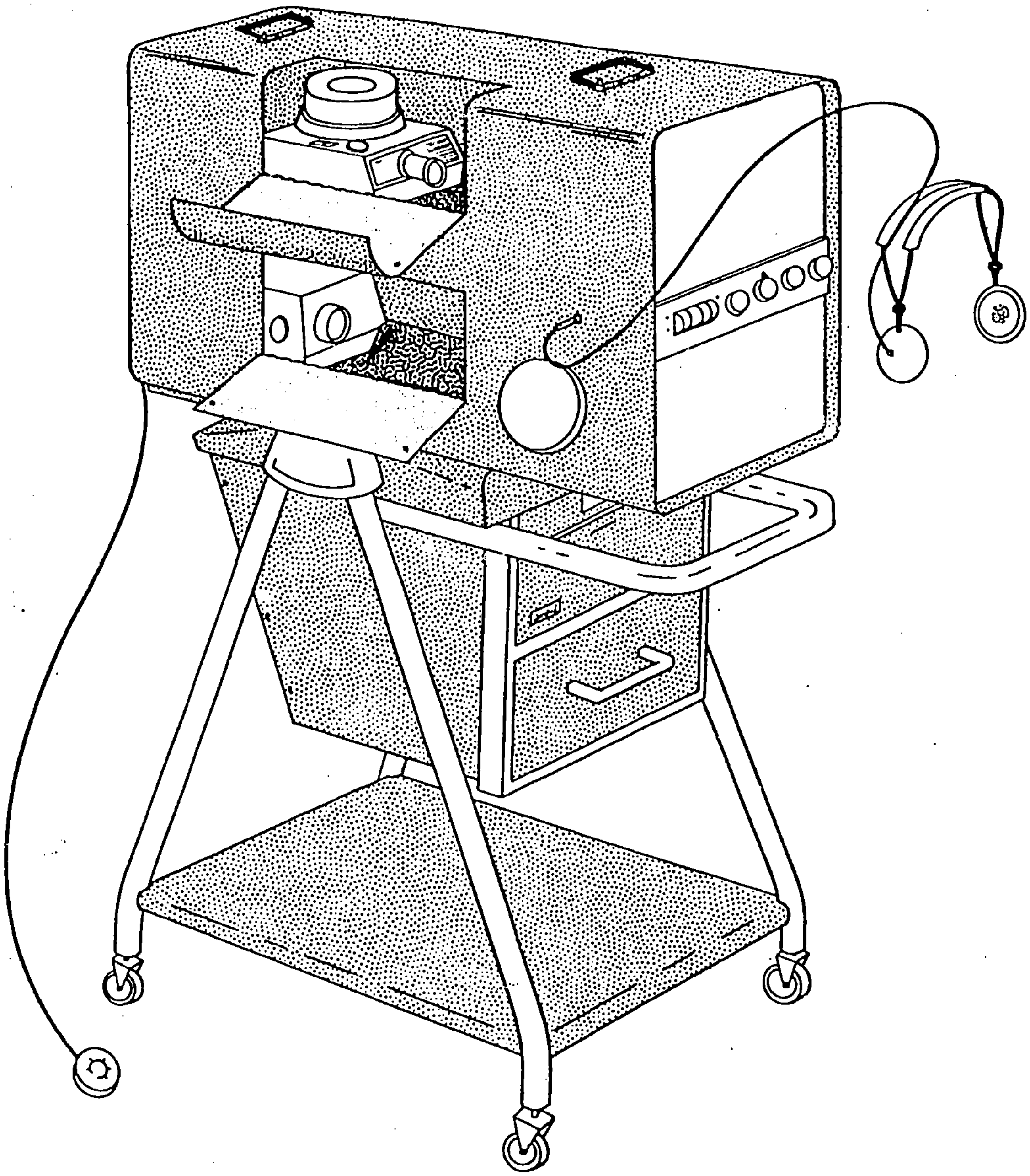

Figure 41. MAVIS, Carrel M.

Carrel N is a portable carrel (Figure 42) developed at Lowry Air Force Base for use in team or group training. The carrel is 37½" wide, 29 3/4" deep and 78" high. The three mirror viewing unit with 26" x 35" rear projection screen will accept nearly any projector (slide, filmstrip or motion). Materials used are 1/2" plywood with plastic cover and sheet metal. This carrel can be rolled to large equipment for hands-on team training or provide orientation prior to learning various procedures.

The carrels previously described are intended to solve a wide variety of special educational or training problems. Many of the principles and features integrated into the design can be helpful. Some other construction features are included for consideration.

A sturdy design able to withstand some abuse should be used. The working surface should also be resistant to scratching. Fasteners which do not lend themselves to easy removal by students would be helpful. A design which permits minimal air circulation would not let the divider be below eight inches above the floor.

Safety requirements suggest the use of at least fire retardent materials. Materials which produce noxious fumes should not be incorporated. Mediating and training equipment should not allow the student to injure himself or herself on sharp projections or electrical shocks.

The specific training tasks of your learning center must be the detennining factor in carrel design. Other psychological factors, such as those suggested in Sommer (1969), should also be considered. However, there is no available evidence to provide adequate guidelines for integrating these important considerations into your design. You note, however, that nearly every carrel shown incorporates a larger work area than is indicated necessary in Figures 21 and 24.

VII. PHYSICAL PLANT

While the learning center is a *program*, the program is accomplished someplace. Recall how the physical setting may limit the nature and kinds of activities possible in your learning environment. It has been stressed repeatedly that the learning activities must determine design requirements. This is especially true in the design of carrels and of the physical environment housing the learning center. What the student does to achieve the necessary level of learning ultimately determines the design or modification of the physical plant. The first principle is that training should be brought as close to the job as possible, both psychologically and physically. Place the learning center near or at the primary work area. Keep all aspects of your training program as closely related to the job as you are able.

Factors considered in this section will be space, thermal and air control, lighting, noise, and power. These considerations emphasize those aspects of the physical plant which are most affected by its use of a learning center.

Space

The minimum standard space for mediated instruction in carrels is about 16 square feet for each student position. (The classroom standard for lectures is 12.5 square feet per student position.) In addition, your facilities should provide for flexibility in the use of interior space usually including some kind of zoning. Whatever you build make sure that it incorporates such flexibility that your successors can alter the interior space according to their needs or attach new space in future building. Provisions should be included for such student activities as individual receptive learning, performance learning, and group interactive learning. Special areas for viewing classified programs may be necessary. Space requirements for meeting administrative requirements, service requirements, storage and security requirements, custodial requirements, courseware development and production requirements, and storage requirements should also be included.

Thermal and Air Control

Temperature and ventilation control should be incorporated into the physical plant facilities. The normal comfort range runs from about 68° to 76°F with normal levels of humidity (30% – 60%). A

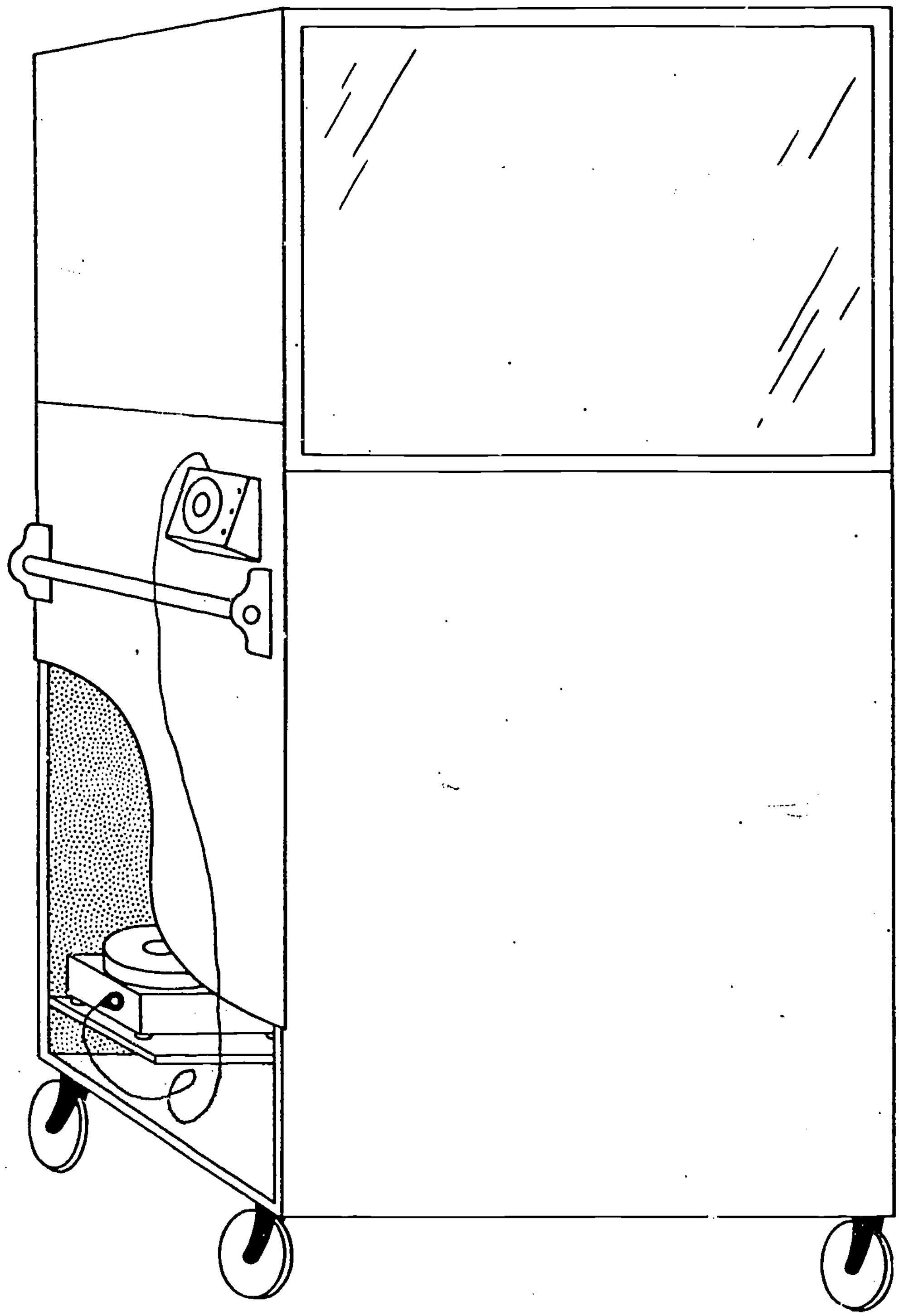

Figure 42. Portable (Carrel N) viewing unit for groups.

maximum of 80° may be possible with sedentary tasks and a 65°F minimum for very active tasks. High humidity would reduce the comfort range by about 5°. Note that temperatures above 90°F will impair mental performance. When using equipment, the heat generated may become an important factor. In general, the heat from a projector will be slightly more than the wattage of the lamp. For example, the heat output of the Carousel 850 with a 500 watt lamp ranges from 502-563 watts. This heat is roughly the same amount of heat created by five or six people. Usually estimate a tape recorder thermal output from 15-120 watts. The actual wattage will appear on the manufacturer's identification plate which is fixed to the item of equipment. It is probable that airconditioning will become necessary when a great deal of equipment is operating in a learning center. When comfort of a room is judged, the temperature is the most heavily weighted factor in the decision.

Lighting

Lighting of the work area was discussed earlier. The student working areas should be laid out so that room lighting is not distracting. The room lights should be located more than 50° above eye level, so they can not be seen readily by the student. The overall room lighting should not be a great deal darker than the working area. The brightness of the work area should not be over three times the overall room brightness. Lighting is a significant factor in judging the pleasantness and comfort of a room.

Noise

Acoustical control is one of the critical factors in learning center design. Noise must be controlled to permit listening at normal conversational levels. The room should be sufficiently free of noise distractions to allow students to concentrate on their training tasks and programs. In general, the highest levels of background noise should not exceed 40dB (that is the highest levels of continuing noise generated by media equipment, students at work, and other environmental noise). It would be even better if the background noise level did not exceed 30dB. (Note the earlier discussion in carrel design on noise level.) The noise control problem can be seen in better perspective when you realize that one model of a projection device tested on a table top has a noise output of between 66-69dB at a distance of two feet. This noise level is representative of most other projectors.

The use of carpet and noise control ceilings are minimum requirements in the learning environment design. Carpet acts both as a superior floor covering (which costs less to maintain than other surfaces under most use conditions) and as a helpful acoustical reduction material. It is authorized in TA 636. Increases in surface softness and material bulk contribute to more satisfactory noise control. Location of the learning center may be critical if located near noisy outside operations as near the flightline or engine test area.

Power

Electrical distribution and supply must be given design consideration. Most media equipment requires electrical power. Typical media equipment for three student's working areas would use one 15 AMP circuit. Location and routing of these circuits must provide unobtrusive and safe routing of power to the media devices. In addition, other power requirements may be involved in the training task.

Aesthetics

Students react to their learning environment in favorable or unfavorable ways. The four major areas of students reaction to working or learning areas are pleasantness, comfort, friendliness, and harmoniousness. Lighting, heating, and furniture account for a large part of people's pleasantness and comfort rating. In addition, decor and layout would contribute to pleasantness, friendliness, and harmoniousness. Everything does not have to be ceramic, plastic, metallic or stone in your learning center. In fact, hard surfaces contribute to noise level problems. The student will spend a large amount of time in the learning center and those design features which make it a better place to learn should be incorporated

VIII. QUALITY ASSURANCE

The quality assurance program of a learning center should be designed to establish and implement programs and standards that assure instructional devices and mediated courseware that are both acceptable and appropriate. The acceptability of instructional packages or modules is determined by the extent to which they satisfy the training objectives as outlined in the ISD process spelled out in AFR 50-2 and amplified in AFP 50-58. The physical performance and characteristics of the instructional devices and instructional courseware provide the limits to this chapter. While logically this would include lectures and texts as well as multi-media presentations, in practice it presents only the media devices and associated courseware.

This chapter is restricted to such tasks as selecting media devices, performing acceptance testing on both the devices and courseware, developing and producing the courseware, maintaining devices, and updating the courseware. The term "courseware" refers to the movies, audio tapes, filmstrips, and other audio or visual material. It is the "instructional software." However, the term software leads to confusion between instructional programs and computer programs. "Courseware" will refer to instructional material and "software" refers to computer programming routines. For an additional discussion of quality assurance see Smith (1974); and Smith (1975).

The quality assurance program at a learning center might well be composed of four quite separate activities: (1) inspection test on receipt of equipment, (2) assurance of acceptability of visuals, (3) assurance of acceptability of audio, and (4) maintenance of devices. Initial selection of media devices, subsequent replacement as required, and the development and updating of courseware visual and audio packages are all closely related and must be carefully coordinated with the quality assurance program. However, they are normally a separate consideration and often the responsibility of different personnel, as are programs that verify the adequacy of the content of the courseware programs. Thus, organizational and policy changes may be necessary for better and more functional operation.

Inspection Test on Receipt of New Devices

This procedure can easily be accomplished in a routine manner and often results in considerable cost savings to the purchaser. Providing the results to the vendor may also facilitate his program. The inspection need not be lengthy or complex. Basically, having a simple test program in which the various functions of the device are used is usually adequate. The essential element is that it be accomplished by an assigned person who is familiar with the devices. If one person unpacks 50 tape recorders and plays a short tape he can easily verify that the device was, in fact, received in an undamaged condition. If damaged, encouraging the vendor to rectify the defects helps everyone in the long run. If an inspection test is not routinely performed, then the first person to use the device may be someone not familiar with exactly how it should operate. Having nothing to compare it with, he really has no way of knowing whether it requires attention before being put into use.

The pre-acceptance inspection does require some planning and the preparation of test material. The planning should result in some method of recording you findings. The preparation of the test material can be as simple as taking a presentation with which you are familiar or making a specific short presentation that exercises all of the essential features of the device. For example, on portable tape recorders, a visual check for gross physical damage, followed by a series of "slide advance" and "program stop" impulses, a check of running speed, rewind time, torque, and response range can be completed in three to four minutes. While this is not exhaustive, it is efficient and effective. Similarly, projectors can be checked for resolution, even illumination, slide advance and reverse operations, and noise level. Response units should be checked through each possible choice.

To illustrate the need for such inspections, a recent inspection of 23 tape recorders resulted in the foloowing findings:

Intermittent impulse failure – no record light
No audible sound
Earphone jack faulty
Cover will not open
Will not take fast forward
Excessive torque
Stops when *Synch* is pulled out

In all, nine of the 23 required corrective repair before they could be used. These were standard off-the-shelf items in the medium price range.

Quality Assurance – Visuals

Assurance should be made that quality control, safety, security, vehicular rules, and human relations rules are not violated on the slides. While it is difficult or impossible to quantify such important aspects of visual images as composition, interest, or impact there are a number of parameters that can be quantified. Even a cursory glance should indicate that many of the slides presently being used in USAF presentations probably have little or no instructional value due to low visual quality. Using too many generations of duplication or other qualitative technical defects has caused this.

If at all possible, quantitative measures should be obtained of at least resolution, contrast, density, and color balance. While reliable laboratory equipment is desirable here, much can be done with a light meter, a resolution chart, and grey scale. Call in expert assistance if it is not clear exactly what is desirable.

One specific comment appears to be appropriate here. In the production of slides, considerable control is possible on the overall exposure and, thus, the brightness of the projected image. However, this is also influenced by the projection equipment including both the projector and screen. If a high wattage projector is used to project an image on a high gain screen for viewing in a dark room, then a very dense visual is desirable. Under other conditions, this same slide might be unacceptable. As a general rule, the desired exposure can only be determined in terms of specific use. If a 18% gray card is included in the slide, then the general rule is that when this is projected it should be about 10% brighter than the work area immediately in front of the screen. While this requires some adjustment in production standards depending on the situation in which it is to be used, there is considerable consistency. For example, typical classrooms have fairly standard lighting, probably something in the order of 50 foot candles at desk level. Such rooms as those involving electronic trouble shooting might require more lighting, while other performance areas might have less as discussed earlier. Care should be taken to match the projected image to the area in which it is to be used. Production personnel must know the area of intended use.

Quality Assurance – Audio

Quality assurance is considerably more difficult in the audio area than it is in the visual area. However, it is possible. One suggested technique is to put 30 seconds of a standard 1K Hz tone and 30 seconds of white noise after each master recording. This is then duped onto all subsequent copies and provides information comparable to the resolution chart and grey scale used in visual analysis. For example, inspection of the pure tone on an oscilloscope will give a good indication of tape speed and gross indications of wow and flutter. It also provides the signal for signal to noise assessment. Analysis of the white noise can provide a good indication of response range. A fairly flat response-from 100 through 6K Hz is desired.

Of particular importance is the inspection of the control track. Many of the reports that the playback equipment in the carrel is inconsistent can be traced to control impulses that have been deformed or degraded during duplication. This "detection" of the error enables your to direct your corrective action at the right piece of equipment. It does not help to complain that the projector misses its changes if the culprit is really the tape duplicating device. The impulses are quite critical and must be held within rather close tolerances.

Maintenance of Devices

No learning center can continue to operate efficiently without adequate maintenance for its devices. While it is the courseware that provides the information, it is provided only when the devices function properly. As an analogy, when you take a trip it is the route that is of primary importance. But if your car does not run properly, you probably will not get there. The courseware contains the information, but defective devices prevent it from being provided. Both adequate preventative and remedial maintenance are required. Careful record keeping of all maintenance performed is of considerable value in planning future programs.

In this connection, it should be noted that the first purchase of any device should include many items in addition to the device itself. Surprisingly often, one forgets to order tapes and slide trays. As a result, the device arrives and there is no way of determining whether or not it is acceptable. The delay in ordering the "consumables" not only wastes time but it also allows the warranty period to expire before the device is put into operation. It is equally important at the time of planning the initial order, to include maintenance manuals and such routine replacement items as projection lamps. Without the manual and the parts, even the simplest malfunction can put a device out of operation. Good manuals are surprisingly difficult to obtain. Spare parts are also a problem. At times they may not be available, at other times the firm may insist on a large minimum order. We recommend that generally a 15% level of consumables be maintained for spares.

In summary, quality assurance is essential to the operation of an effective learning center. Development of an adequate quality assurance program is essential to the effective management and control of a learning center. Quality assurance should provide quantification, detection, correction, and prevention of substandard equipment and courseware in a learning center.

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APPENDIX A: LEARNING CENTERS FOR FLYING TRAINING ACTIVITIES

A Learning Center (LC) that is properly planned can enhance the training program by:

a. Motivating the student using appropriate principles of learning.

b. Improving the learning environment (in a quiet study room rather than a cockpit at 30,000 feet) (thus reducing anxiety).

c. Individualizing and self pacing of instruction decreasing the requirement for the instructor to repeat the same information.

d. Providing a review opportunity when needed and as a refresher when the task cannot be adequately performed in flight.

Multi-media devices used within a study carrel provide supporting equipment for students receiving informative/orientation briefings, specific lesson training, response oriented lessons, review of training and enrichment training lessons. A study carrel generally provides room for resource materials, paper and pencil work and tape/slide or video cassette equipment. Ideally the carrel includes a student response capability, an instructor call button, student headwet and operate switches/bottons for the media.

Layout. A critical function of learning center (LC) design is the layout in conjunction with other training facilities and positioning of the study carrels.

a. The LC should best be located in a centralized facility providing classrooms, instructors' offices, documents room, trainers and autiovisual support within a common area. This allows the student to obtain assistance, resources and instruction with minimum disruption or travel.

b. In cases where several activites can use the LC a centralized system can prevent duplication of equipment and storage facilities. Utilization of the LC then becomes a matter of scheduling.

Considering these two factors, planning for a LC should be based on requirements of the total training system. The LC may well deserve consideration for a new facility development--designed to the needs of the training system. Conversely, an existing facility may be readily adaptable. The point here is that both factors should be studied before committing to say an existing facility and then finding that problems such as inadequate parking space, electrical power, air conditioning, or excessive aircraft noise result in a poor learning environment.

In many cases, security requirements and control of access to the study areas may be necessary. Storage and distribution of training materials must be considered. (This will be discussed later.)

Programs. Basic to operating a LC is the determination of the scope of courseware and approaches to learning that will be used. Courseware using tape/slide, tape/filmstrip, sound-on-slide and video cassette concepts can generally be classified into four groups:

a. Basic Programs: Provide training in those tasks that are collectively organized into small (short), adaptive training exercises. Each lesson prepares the student for the next lesson. The basic programs may be:

1. Informational in nature providing orientation about a problem or concept or just preparing the student for what is to come (overview). Informational programs should be short since the student is passive and may lose interest.

2. Interactive lessons whereby the student receives audiovisual instructions and then must respond to a question or perform some task. The number of questions/tasks may vary based on the expected learning outcome. A recommended practice is that tape/slide type programs consume 20 minutes presentation time with an average of 6-10 responses per lesson. This keeps the student active and maintains his interest. Students may be required to complete some physical or mental task (select a switch, decide on power setting, choose a classified document) to a criterion level or be required to select answers from a multiple choice, forced choice, true/false or logic-decision methods. Regardless, he should received immediate knowledge or results upon making the response. This motivating stimulus leads to future correct

responses. The mechanism of the interactive system may allow programming to the next instruction or branch to another approach or lesson.

3. "How to" lessons providing step-by-step movement from some basic concept to a more difficult level. Such lessons are extremely useful when logic-tree reasoning is necessary to carry the student to the expected learning outcome. A "how to" lesson may teach emergency procedures at an early stage and move the student to an interactive lesson where he must demonstrate proficiency. "How to" lessons should be designed as short term, repetitive, adaptive programs. Such lessons are usually provided in cockpit procedures trainers (CPT), mobile study carrels (an integrated unit which may be moved to the job location) or portable projector/player units.

b. Enrichment programs: Provide additional training to students who want to specialize in a particular subject or because of personal initiative want to see the problem from another perspective. Such programs, in flying training, can best be described as "nice to know" material. Several examples are appropriate:

1. Detailed mechanical workings of aircraft systems components. Usually, only the maintenance technician receives such training. An ambitious and mechanically-minded pilot may feel he could be more confident if he knew more about the detailed operating method for the particular system. If such training can be achieved and not disrupt his required training; enrichment training can be very motivating to him. It may also be used as a reward for some early achievement of required goals.

2. Special explanatory programs. Such programs by recognized experts may be catalogued as enrichment programs. Such lessons may be reserved for the highly motivated students.

3. Varied approach programs. These are lessons similar to the normal lesson plan but presented from another point of view. Such lessons can enrichen the understanding by a student who did not follow the usual presentation.

(*Caution*: Criterion referenced tests should not include material from the enrichment programs.)

c. Remedial programs: Usually abbreviated from the original lesson but cover the key points of the task to be learned. Such lessons should act as a debriefing after the student has demonstrated poor performance in a demonstration (flying) exercise. The lesson should point out frequently missed points of the expected learning outcome but leave to the instructor the responsibility to critique the student's performance.

d. Rapid review: Programs designed to update students who were proficient but require refamiliarization with the subject. Such programs may use the broad-brush or speech compression concepts to quickly carry the student back through the material.

(*Note*. Regardless of the type program used, a requirement to demonstrate performance should be scheduled in conjunction with the training or if not possible then as soon as possible. Criterion referenced tests or checks should be given to measure the level of learning and immediate knowledge of results provided to the student.)

(*Caution*. It is important that instructors know and accept the content of courseware used by the students. If the instructor does not support the individualized training materials, the students will readily detect his viewpoint—destroying effectiveness of the courseware. The instructor staff should be major participants in courseware development.)

Administration. Use of the LC by students is a mark of its effectiveness. A prime consideration should be services to be given to the student. The learning experience should be made beneficial to his growth and professionally enjoyable. The LC should be oriented to achieving expected learning outcomes not the peripheral activities such as operating multi-media equipment. Classified lessons should be appropriately marked and adequate provisions made to secure the LC for use of classifed material so that student does not have to concern himself with classified document control. As a minimum the following requirements should be met:

a. LC procedures should require minimum student involvement in entering and leaving the facility. Students should be scheduled for LC lessons just as they are flying or simulator lessons. A sign in and out system should serve the purpose of verifying the scheduled appearance and notifying the IP of the student's actions. If the lesson requires and IP to participate with the student the IP should also appear on schedule. Two approaches may be taken to set up the lesson, the first is the most desirable:

1. When the student is scheduled for a lesson, his name and lesson number (IP, if needed) should be placed on the schedule by the training section. The LC personnel then assign the student to an appropriate study carrel. Prior to student's arrival the necessary program should be placed in the study carrel, the equipment operationally checked and the program set for student use. Any supporting material (work books, exams, publications) must be picked up by the student at sign-in. The student then signs-in, picks up supporting material (signs for classified mateials) and receives his study carrel assignment. At the carrel he only needs to don his headset and turn on the power switch. For assistance he presses the instructor call button. Upon completion of his lesson the student must turn off the power switch, return the supporting material and any classified waste and sign out. The LC personnel then rewind the audio tape (video cassette or filmstrip) upon loading the next lesson.

2. An alternate method is to provide the lesson to the student at sign-in and he checks the equipment and sets up the lesson. (This is less desirable since the student is handling AV equipment.) After the lesson he must rewind the tape, remove the cassette and tray and return all materials to the LC checkout counter.

(*Note.* Caution should be observed if any LC audio or video equipment is equipped with a record capability. Cassettes should be modified to prevent erasure or recording over established programs.)

It is important that a qualified IP is available to students in the LC. As a contingency, when an IP is not available a question/answer system should be designed so a student can direct a question about a program and receive a prompt answer. This may be done via a question/answer memo the student leaves at the checkout counter. LC personnel can then pass the question to SMEs or the IP for immediate response to the student.

(*Note.* A secondary use of the facility is to allow the Learning Center to be used as a library center for after-hours study. This may involve a logistics problem. An alternative is to provide appropriate media equipment for the student to checkout along with programs he wants to study.)

Security. Several security problems will confront the LC both with equipment and dissemination of classified information:

a. Normal procedures in handling classified information should satisfactorily serve the security problem; however, the following should also be considered:

1. For controlled access the LC door should be equipped with an electrical lock release or combination access door.

2. Study carrels should be positioned so classified information is readily [illegible] to those with a need to know. Glass-paneled doors and windows should be blocked from view of the carrel screen.

3. Audio distribution should be controlled so classified presentations can not be heard beyond the study carrel.

4. The best method is to depict classified information on the slide eliminating the requirement to classify the accompanying tape. Where classified tapes are required the tapes should be destroyed after they have served their purpose rather than be used for subsequent unclassified recordings. (Ref: DOD 5200.1-R, Information Security Program Information, para 4-302.)

b. Control should also be exercised over issue and use of media devices. Much of the equipment and supplies have applications to personal/home media systems. To reduce pilferage, certain precautions should be made. These should include:

1. Security of all exits, windows (steel bars) and vents.

2. Controlled access (limits traffic that may disturb students and protects equipment).

3. An inventory system that requires frequent daily checks of exposed equipment and supplies (headsets, responders, lamps, research publications, etc.) and periodic inventory of major equipment.

4. An ongoing education program of learning center personnel.

Equipment Maintenance. Success of a LC depends on the ability of the Center to provide current programs and continuing successful service to each student. Condition of the equipment depends on frequent preventative maintenance, spares support and replacement of unserviceable equipment. Historically the BAV Library has required that media equipment be returned to the Library for inventory and servicing. ISD equipment now authorized for Learning/Training Centers is not controlled by the BAVL so frequently is not included in the workload. Two methods exist for preventative maintenance:

a. Where AV technicians are authorized within the LC, preventative maintenance and repair should be performed by LC personnel. This requires authorization of spares, tools and work space. Work beyond LC capability should be referred to BAVL or contract services.

b. When no capability exists within the LC, local agreements should be negotiated with BAVL to periodically visit the LC to perform preventative maintenance. Equipment requiring repairs should be repaired by BAVL or, if necessary, to contract services.

(*Note.* Spare equipment should be rotated through frequently used positions to utilize it and keep it in operating condition.)

Most importantly, equipment should be kept in a state of readiness to meet training needs of the system. Responsiveness to student needs with operational equipment will foster success of any LC.

APPENDIX B: SELECTING EQUIPMENT FOR SCHOOL MEDIA PROGRAMS

CHOOSING A FILMSTRIP/SLIDE PROJECTOR FOR EDUCATIONAL AND LIBRARY USE

Introduction. "Don't confuse me with the details, just tell me which projector to buy," is the apparent request of many potential purchasers of miniature still picture projectors. This narrative and checklist are not for them. They are instead intended for the person who has a reasonably clear idea of his needs for projection in a known setting with known users. They should help him to understand and match the characteristics of available machines to a particular need or needs.

There is no one best machine for filmstrip and/or slide projector anymore than there is one best motor vehicle. There is a great variety of motor vehicles to match a great variety of needs and preferences. There is a similar variety of small transparency projectors and variety of needs and preferences. No machine is best for all purposes and every machine is probably best for some purpose.

Modern education is characterized by great diversity. There is no longer a standard educational setting or strategy. Teaching and learning occur in large groups, small groups and in individual spaces often called carrels. Professional educators, librarians, aides and students make regular use of equipment such as projectors. The trend is toward greater diversity of educational settings, strategies and staffing.

Modern projectors for filmstrips and two by two (5cm x 5cm) slides are also characterized by great diversity. The common and almost standard machine of a few years ago has been replaced by a variety of machines designed for rather specific purposes. The trend is toward greater diversity.

The purpose of this guide is to help an educator, librarian or his technical assistant to identify his particular needs for a projector and then to study the characteristics of available machines and to make a single selection or a group of acceptable makes and models for competitive bidding purposes.

Each of the following characteristics in some cases is easily determined by inspection and operation. Other characteristics can be determined from labels, hang-tags, descriptive sheets, advertisements and the NAVA Equipment Directory.[1] Other characteristics can be discovered only from technical data sheets on special request, or a knowledgeable salesman or technician. Still other important characteristics are not now commonly available to the consumer because he has never demanded them. Manufacturers are now listening to consumers, and consumers must provide understandable, responsible and realistic requests for product characteristics, and reasons for those characteristics. Many standards for measuring and reporting projector characteristics already exist, largely through the American National Standards Institute. Greater use needs to be made of them in advertisements and specification sheets. Additional standards need to be developed and put to use.

The following narrative parallels the checklist provided. Any number of available machines might be compared. Information for every box in the matrix may not be obtainable at this time.

I. *Identification.* The projector should be adequately identified with manufacturer, manufacturer's address, model designation, serial number, year of manufacture and list price. The characteristic least commonly available is the year of manufacture, which is just as important in comparing projectors as automobiles.

II. *Format(s) Projected.* The projector must be able to project the transparent materials expected to be used.

Filmstrips are now almost universally single frame with images measuring .668 x .885 inches. If double frame filmstrips with images similar to those on two by two slides are to be projected, then a larger aperture and a ninety degree rotation of the carrier must be provided. If filmstrips are to be stored and projected in cartridges, then cartridge compatibility must be checked. If very long strips are to be used, the longest one should be tried for fitting the input and takeup facilities. If an automatic filmstrip advance system is to be used, the machine must repond to the pulses on a disc or tape.

[1] National Audiovisual Association, 3150 Spring Street, Fairfax, Virginia 22030.

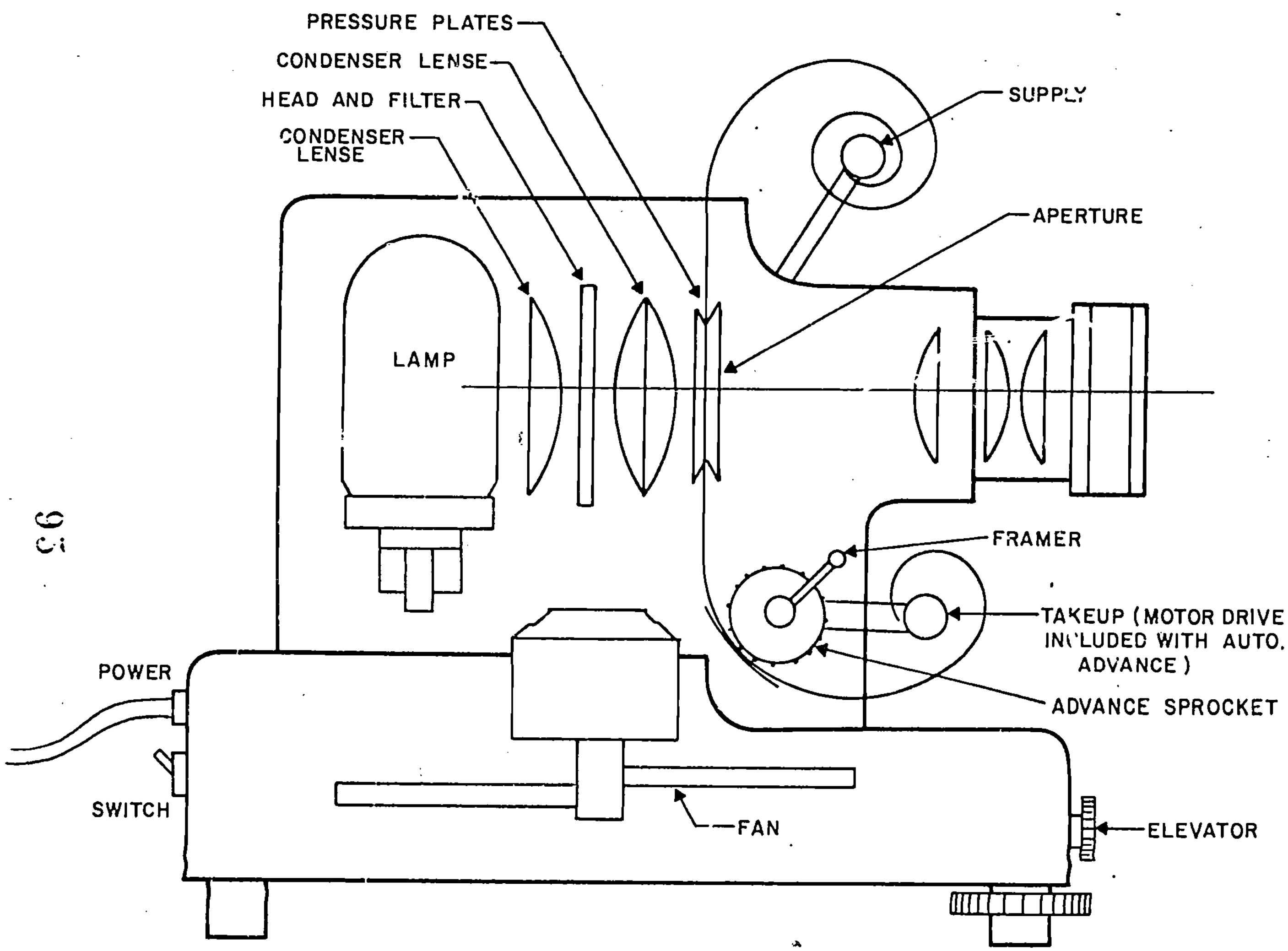

Figure B1. **Typical filmstrip projector.**

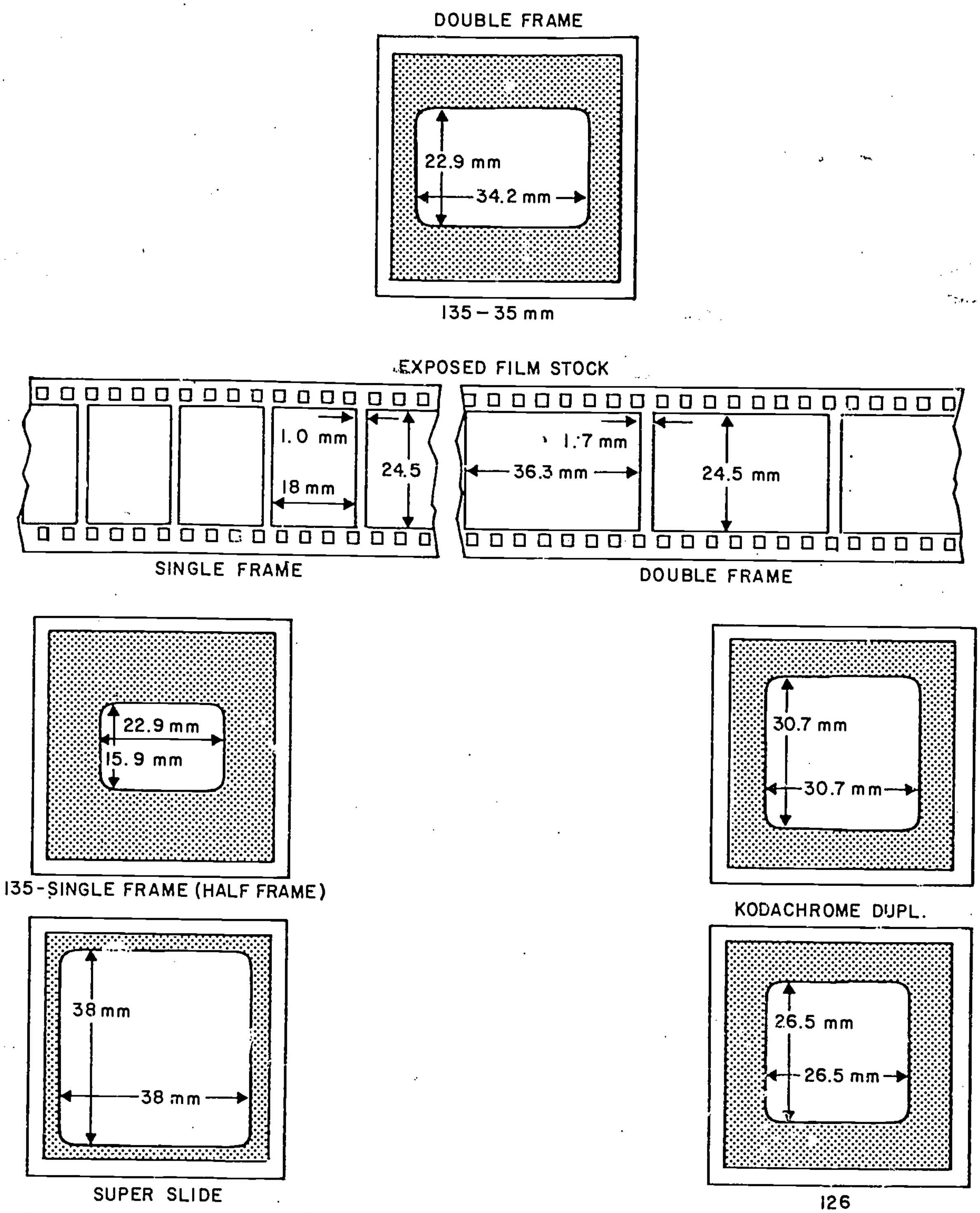

Figure B2. Slide formats.

Two by two slides (5cm x 5cm) all have the same overall dimensions but they have different thicknesses and different image sizes. Most simple manual projectors with push-pull carriers will project both thin cardboard mounts and various bound and glass covered slides. Most automatic and semi-automatic slide changers must be checked for handling thick slides, if they are ever to be used. If units of slides are to be used, the holder or tray should accept the maximum number typically encountered. All projectors will accept images in the half frame (filmstrip size), full frame (horizontal and vertical), square (Instamatic) and super slide formats, but there may be some cropping of the corners of the larger sizes. This is a particular problem with the uncommon super slides. If some form of automatic or synchronized advancing system is to be used, the projector must, of course, be compatible with the programming device.

III. *Recommended Setting(s).* The projector should be suitable for the setting or settings in which it will be used. The demands of an individual in a carrel, a small group in a windowless seminar room, a typical classroom and a teaching auditorium are quite different. The machine may be operated by a competent technical assistant, and academic teacher or a student from five to twenty years old. Students may or may not be supervised, and they may have various levels of competence and responsibility.

IV. *Safety.* The machine must be as safe as possible under usual and unusual conditions of use that can be anticipated. However, no machine making use of power line electricity, incandescent lamps and glass optics can be absolutely safe. The UL or Underwiters Laboratory seal on the machine (not just on the cord) indicates that models of this machine (but not this particular machine) have been carefully and completely checked for safety. The CSA or Canadian Standards Association seal has similar meaning and reliability.

A three wire power cord and three contact plug is often specified in order to automatically ground the frame of the machine when it is plugged into modern three hole duplex outlets. Some machines have fuses or circuit breakers to interrupt the power if a lamp or other component should short circuit inside the case. The circuit breaker may be reset or the fuse replaced.

A thermal fuse or breaker may be included to interrupt the power if the machine overheats for any reason such as a blocked fan or stalled blower. Any part of the machine except the grill adjacent to the lamp should not be dangerous or even unpleasant to touch due to temperature after at least ten minutes of operation. A maximum of 180°F might be specified. Knobs, adjustments, handles and other parts used for operating or handling the machine should not exceed 120°F. There should be reasonably certain assurance that no operator will be hurt by sharp edges or corners that might conceivably be handled under any circumstances. It should not be possible to insert a finger into the fan or any dangerous opening.

The feet, cord, case or any part of the machine should not damage or discolor any clothing, surface or material that might be contacted for expected periods of time.

The machine should be stable on a flat surface in operating position.

V. *Operating Conditions.* The machine should operate satisfactorily under all expected conditions.

The voltage range for operation should be stamped on the machine. This is normally 105-125 volts. If low voltage (brownout or dimout) conditions are expected, it is important to have a fan or blower that will start. Lamps are not harmed by low voltage but light output decreases rapidly. Voltages above 120 will seriously shorten lamp life unless special high voltage lamps are specified. The wattage of the machine indicates the load on the building's electrical circuit and its fuse or circuit breaker. Typical classroom machines use about 500 watts, individual study machines use about 150 watts and auditorium machines about 750 watts. The trend is toward more efficient light sources that deliver adequate light with lower power. A particular problem develops when several machines are used simultaneously in individual study or auditorium situtations. A twenty ampere circuit (common in schools and libraries) will supply only 2400 watts to all of the devices connected to it. Direct current is practically obsolete, but still used in the center of some old cities and at some old institutions that generate their own power. Lamps will work equally well on AC or DC, but other parts of the apparatus not only will not work, but be destroyed unless DC operation is specified, and probably at extra cost.

Hobby equipment is designed for home or infrequent use by owners with personal investment and concern. School, library or audiovisual equipment is designed for more rigorous and constant use by a variety of operators. Professional equipment is designed for special applications by specially trained people. The audiovisual duty rating is normally specified for school and library applications.

The projection aperture temperature should not harm the filmstrip or slide. Film manufacturers normally specify a maximum of 212°F. A temperature considerably lower than this would desirable even after thirty minutes continuous use. Elaborate methods for measuring aperture termperature have been standardized, but slides including thermometers with projected scales are also available and easily used.

Projectors may emit extraneous light, noise and radio-television interference that are objectionable. All of these can be roughly checked by looking, listening and operation near radio and television receivers in the setting where they will normally be used. Standards for measuring and reporting these characteristics are needed.

If machines are to be operated under extreme environmental conditions such as heat, cold, moisture and altitude, then special checking under these conditions should be included.

VI. *Physical Characteristics*. Portable machines need to have low weight, small size, a rugged case, storage space and a comfortable and strong handle. The case may be included in the price, or as an accessory. Units without cases installed in carrels, booths, cabinets, etc. need to fit allotted spaces and produce desirable images under the often severe restrictions imposed. The power cord should usually be attached, long enough to reach the outlet without an extension cord, and provided with a storage place or device. A space for storage of a spare lamp is desirable. The ASA code for the lamp (and altemates) should be stamped on or in the lamphouse. Controls should be well labeled and illuminated if operation in the dark is expected. All necessary instructions should be included on the machine and more details should be available in a booklet or on a hang-tag. A permanent and convenient serial number will help inventory control and discourage thievery. A means for anchoring or locking the machine to a table or stand may also be desirable. An accessory AC outlet permits the addition of another piece of AC operated equipment or a light.

VII. *Projection Characteristics*. The primary purpose of these machines is to put an optimum image on a screen in a specified setting, so projection characteristics are of paramount importance.

The projection lamp has an ASA or ANSI code which provides a key to all of its characteristics and makes ordering spares from any source easy and foolproof. The rated hours for the lamp designates a minimum average life for a group of these lamps operated at the voltage stamped on the lamp. This may range from 25 to 75 hours. The list price divided by the rated life gives the cost per hour for operating the projector lamp. This may range from ten to fifty cents per hour.

The focal length of the lens determines the magnification of the projection system. The ratio of any linear dimension on the slide to its projected dimension on the screen is equal to the ratio of the focal length of the lens to the projected distance. This is often stated in a formula:

$$\frac{\text{slide dimension}}{\text{screen dimension}} = \frac{\text{focal length}}{\text{projection distance}}$$

A man on a transparency 0.5″ high would appear 10″ high on a screen when projected by a projector with a 5″ focal length lens at a distance of 100″ or 8-1/3′. A variety of focal lengths may be available. A zoom lens has a range of focal lengths or magnification possibilities by rotating a ring. A zoom lens permits some adjustment of screen image size without moving the projector and it permits exact filling of the screen with a sequence of different size slide apertures such as ordinary 2 x 2 and super slides. The greater the zoom range, the greater the adjustment possible.

Long focal length lenses are needed for projection over long distances such as in auditoriums from a projection booth, or for limited magnification of large slides. Short focal length lenses are needed for short projection distances such as in carrels or for rear screen projection systems. Typical focal lengths range from four to six inches for filmstrip and 2 x 2 slide projectors for group viewing.

Lenses must be moved in and out in relation to the slide or filmstrip in order to obtain sharp focus on the screen. When focused on a distance screen, the middle of the lens will be at exactly its focal length from the slide. At closer distances, the lens must be moved away from the slide and toward the screen. Since this movement is always limited, there is a minimum projector to screen distance and corresponding image size which may be very important for individual study in a carrel. There is also a danger on some projectors that the lens may fall out of its holder when focused at close range. There are several lens barrel diameters in use and interchange of lenses among projectors is possible only with identical diameters. Standardization of this parameter would obviate the need for so many special purpose lenses.

The total amount of light on the screen is measured and reported as lumens. Projector lamp watts only indicate the electrical power consumed. Lumens indicate how much of the electrical power is converted into visible light at the screen. Lumens are computed from the average foot candles on the screen multiplied by the area of the screen image. The usual method of measuring lumens is to place a typical slide in the projector and focus it on a wall to some convenient size about 3 x 4 or 4 x 4 feet. Then a slide with the same size mask, but no film, is substituted. The projected image is then divided into nine or twelve equal areas, and the light is measured at the center of each area with a foot candle meter such as General Electric Type 213A (about $20). The average foot candles are determined and multiplied by the total area in square feet. Typical machines for individual study provide about 50 lumens, for classroom use about 300 lumens, and for auditoriums a thousand or more lumens. Comparisons among projectors but not actual lumens can be determined by substituting an ordinary photographic exposure meter. A new machine in optimum condition should obviously not be compared with one that has dirty optics and a blackened lamp. Screen lumens vary greatly with the size of the slide mask which blocks some of the light. The following table summarizes the aperture dimensions, areas and relative lumens projected. Since lumens are often reported for the largest aperture, this is indicated as 100.

Transparency	Aperture	Area	Relative Lumens
Single Frame	.668" x .885"	.59 sq. in.	26
35mm Slide	.902" x 1.35"	1.22 sq. in.	54
Instamatic	1.04" x 1.04"	1.08 sq. in.	48
Super Slide	1.5" x 1.5"	2.25 sq. in.	100

Projectors made only for single frame filmstrips have condenser systems to concentrate most of the light in the smaller area and they, or course, would not be suitable for projecting larger aperture slides even if they could be inserted.

The center of the screen is usually considerably brighter than the corners. This can be measured with the foot candle or exposure meter at the same time that lumens are measured. Usual practice is to place the meter in from the corners made by the horizontal and vertical edges of the projected aperture to a distance equal to one twentieth of the horizontal width of the image and to compare this with the center reading. The ratio will be less favorable as larger apertures are employed and many projectors provide little light in the corners of the extra large super slides. It should be noted that a corner to center ratio of 50% is barely noticeable to ordinary viewers and this is an acceptable ratio.

The f# of the lens indicates the ratio of its focal length to its diameter and enables one to compare the light gathering ability of various lenses. Like the wattage of the lamp and the condensing lenses, it is only a part of the system that results in lumens on the screen. If two f# lenses are available, the lower f# lens will ordinarily put more lumens on the screen with no increase in the lamp cost, heat produced or current consumed. This, however, assumes a total optical system designed for the lower f# lens. Typical values range from f2.8 to f3.5 with the lower value gathering about 50% more light.

Resolution refers to the ability of the optical system to reproduce fine detail. Test slides with a series of coarse to very fine lines in the center and corners are available for measuring and reporting this characteristic. (*Modern Photography* magazine sells an inexpensive lens testing kit.) Comparisons among projectors can be made with a slide of something detailed and repetitive such as a brick wall made with a high quality camera. The resolution in the center is normally much better than in the corners. Resolution is reported in lines per millimeter that can be distinguished under carefully controlled conditions. Other kinds of distortion are not normally a problem with modern high quality lenses.

Optical systems produce images that vary in the amounts of various colors of light. This makes the spectral characteristic of the system. Incandescent lamps produce a "warm" light that is richer in reds and yellows than in blues and greens. A heat filter or tinted lenses may favor the cooler colors and tend to project a more balanced range of colors. The color temperature in degrees Kelvin is a usual measure of warmness or coolness of the light. Candles produce about 1500°K, projection lamps about 3200°K and auditorium arc projectors about 5000°K, which appears as blue-white.

Alternate lamps and lenses may be available for varying the amount of light and magnification These options may be very important for special applications such as individual study and auditorium pr ion.

The optical or projection axis can ordinarily be raised so that the projected image will be hig an the projector. Most projectors have a very limited range in degrees so that books and other props a en needed. Very few machines have any means for depressing the axis so that balcony to stage projection can be done in an auditorium. Projection lamp filaments may be distorted by operation very far from their intended orientation so that unusual projection systems should be checked with the manufacturer. (Operating projectors should not be pointed at the ceiling nor should improperly oriented slides be corrected by inverting the projector.) Projectors that depend on gravity for feeding slides may not operate properly at unusal angles.

Some two by two projectors but not filmstrip projectors permit preview of the next image while one is already projected on the screen. This feature permits the operator to comment on the next picture before projection. It also allows the operator to detect out-of-order or improperly oriented slides. Professional projectionists use a standard thumb mark on slides to assure proper orientation. Slide and filmstrip images must always be inserted upside down and backwards in order to project properly.

Remote operation of a projector allows the operator to face the group and to point out details on the screen. The system may provide for advance, advance and reverse, focus and lamp On/Off. Not all of these options are as yet generally available. The remote cord needs to be long enough to reach from the projector to the screen, or an extension remote cord must be needed.

Some projectors provide a shutter that blocks the light as slides or filmstrip images are changed to avoid the moving of old and new images on the screen. It may also prevent the dazzling screen at the end of a presentation. Complex dual projection system permit the fading or dissolving of one image into another for a more professional presentation.

Automatic focus is available on some slide machines to adjust the lens to compensate for cardboard mounted slides with film in slightly different positions. The major advantage is automatic compensation for the change in the film that occurs as it heats and expends in the intense light beam and "pops" or suddenly changes position. Glass pressure plates in filmstrip projectors, glass mounted slides and slide preheat systems are designed to obviate or reduce the need for refocus during projection. Automatic focus systems are, of course, complex, and they add to cost and maintenance.

VIII. *General Observations*. A slide or filmstrip projector should be easy to set up, thread the filmstrip or insert the slides, adjust for pleasing presentation of materials and operate for a reasonable length of time. Filmstrips have four sprocket holes for each picture or frame so a framer or framing device is needed to adjust for exactly one whole picture each advance cycle. The mechanism should not damage the slides or strips as it handles them in a normal or in any logical but not intended way that a novice might insert them. The advance and reverse mechanism should operate easily and reliably. Once in operation, the sequence of pictures should appear at the same place on the screen without noticeable changes in focus or position. It should be possible to remove damaged materials that may "jam" in the mechanism. The projector should be stable on the stand, not easily upset, and it should not harm the surface on which it is placed. It should be easy to take up and rewind the strip or remove the pack the slides, dissemble the machine and put it away for future use. It should be easy to clean all parts of the optical system except the interior of sealed lenses. Cleaning the aperture area of a filmstrip projector may be a particular problem. It should be easy to replace a bumed out lamp. It should be possible to remove slides even if the power has been disconnected.

IX. *Accessories*. Items that are supplied with one machine may be accessories for another. This is a particular problem with purchase of machines on lowest bid. The manufacturer's list of accessories should be checked to be sure that the needed features will actually be included. Specifications for bidding must include many details.

X. *Guarantee*. All slide and filmstrip projectors are guaranteed by the manufacturer, but the guarantee may be of little value unless the purchaser has a local dealer-serviceman who will honor the manufacturer's guarantee. This is a particular problem when items are purchased from distant suppliers on lowest bid. The manufacturer should supply a list of approved dealer/service stations that will honor guarantees. The guarantee should, of course, spell out what is guaranteed for what length of time.

XI. *Overall Rating*. Any projector is "acceptable/not acceptable," "good – better – best," "recommended – not recommended" or a "best buy" only in terms of the specific settings and strategies for its use. This narrative and matrix are designed to help knowledgeable educators select appropriate machines for their unique needs.

Checklist for Filmstrip/Slide Projectors

Characteristics

I. **Identification**
- A. Manufactuer
- B. Manufacturer's Address
- C. Model
- D. Serial #
- E. Year of Manufacture
- F. List Price

II. **Format(s) Projected**
- A. Single Frame Filmstrip
- B. Double Frame Filmstrip
- C. Filmstrip Cartridge
- D. Max. Strip Length
- E. Auto. Advance System
- F. Two x Two Slides (Thin)
- G. Slide Holder Type
- H. Max. Slide Capacity
- I. Two x Two Slides (Thick)
- J. Slide Holder Type
- K. Max. Slide Capacity
- L. Auto. Advance System

III. **Recommended Setting(s)**
- A. Individual Study
- B. Small Group
- C. Classroom
- D. Auditorium
- E. Operator Competence

IV. **Safety**
- A. UL Approval (or CSA)
- B. Three Wire Cord
- C. Fuse or Circuit Breaker
- D. Thermal Breaker
- E. Max. Temperature (except Grill)
- F. Sharp Edges or Comers
- G. Fan Access
- H. Stability

V. **Operating Conditions**
- A. AC Voltage Range
- B. AC Watts Required
- C. DC Operation
- D. Duty Rating
- E. Aperture Temperature
- F. Extraneous Light
- G. Extraneous Noise
- H. Environmental Restrictions

VI. **Physical Characteristics**
- A. Weight in Case
- B. Case Dimensions
- C. Adequate Case
- D. Case Included or Accessory
- E. Adequate Handle
- F. Installation Suitability
- G. Atached Power Cord
- H. Cord Length
- I. Cord Storage
- J. Spare Lamp Storage
- K. Lamp Code Label

Characteristics

VI. **Physical Characteristics** (Continued)
- N. Labeled Controls
- M. Illuminated Controls
- N. Operating Instructions on Machine
- O. Instruction Booklet or Hang-Tag
- P. Permanent Serial #
- Q. Convenient Serial #
- R. Security Provision
- S. Accessory AC Outlet

VII. **Projection Characteristics**
- A. Projection Lamp ASA Code
  - 1. Rated Life Hours
  - 2. List Price
- B. Lens Focal Length or Zoom Range
  - 1. Min. Focus Distance
  - 2. Lens Barrel Diameter
- C. Screen Lumens
  - 1. Single Frame Filmstrip
  - 2. 2 x 2 Super Slide
- D. Corner/Center Light Ratio
  - 1. Single Frame Filmstrip
  - 2. 2 x 2 Slide (Specify Aperture)
- E. Center Resolution
- F. Comer Resolution
  - 1. Single Frame Filmstrip
  - 2. 2 x 2 Slide (Specify Aperture)
- G. Spectral Characteristic or Color Temp.
- H. Alternate Lamp(s)
  - 1. Rated Life Hours
  - 2. List Price
  - 3. Screen Lumens (Specify Aperture)
- I. Alternate Lens(es) Focal Length
  - 1. Lens f#
  - 2. List Price
- J. Optical Axis Max. Elevation
- K. Optical Axis Max. Depression
- L. Preview Prior to Projection
- M. Remote Control
  - 1. Advance
  - 2. Reverse
  - 3. Focus
  - 4. On/Off
  - 5. Cord Length
- N. Light Blocked during Change Cycle
- O. Automatic Focus

VIII. **General Observations**
- A. Ease of Setting up & Adjustment
- B. Ease of Threading or Slide Insertation
- C. Ease of Framing Filmstrip
- D. Safeguards for Filmstrip or Slides
- E. Ease & Reliability of Advance Mechanism
- F. Position or Focus Change during Projection
- G. Removal of Jammed Materials
- H. Machine Stability
- I. Provision for Taking Up Filmstrip
- J. Provision for Rewinding Filmstrip
- K. Ease of Cleaning Filmstrip Aperture
- L. Ease of Replacing Lamp
- M. Slide Removal without Power

Checklist (*Continued*)

Characteristics	Characteristics
IX. Accessories	Accessories (Continued)
A. Case	L. Service Manual
B. Dust Cover	M. Special Service Tools
C. Lens(es)	N. List of Mfg. approved Service Centers
D. Remote Extension Cord	X. Guarante
E. Slide Carrier	A. Time
F. Filmstrip Takeup/Rewind	B. Exceptions
G. Slide Tray	C. Place(s) where Guarantee is Honored
H. Tachistoscope	XI. Overall Rating
I. Reading Pacer	
J. Miscroscope Slide Adaptor	
K. Opaque Adaptor	

CHOOSING A TAPE RECORDER FOR EDUCATIONAL AND LIBRARY USE

Introduction. Tape recorders are available in great variety for use in a variety of settings and for many purposes. There is no trend toward standardization on one machine configuration and format any more than there is standardization of use. The purpose of this narrative and checklist is to help an educator, librarian or technical assistant to identify his particular needs for a tape recorder and then to study the characteristics of available machines and to make a single selection or a group of acceptable makes and models for competitive bidding purposes.

Each of the machine characteristics should be considered in terms of specific needs. Tape recorders are needed for individual reproduction of intelligible speech under a tree and for large group study of specially recorded symphonies as nearly like the concert hall as possible. Some characteristics are easily determined by inspection and operation. Other characteristics can be determined from labels, hangs-tags, descriptive sheets, advertisements and the NAVA Equipment Directory.[2] Other characteristics can be discovered only from technical data sheets on special request or from a knowledgeable salesman or technician. Still other important characteristics are not now commonly available to the consumer because he has never demanded them. Many standards for measuring and reporting tape recorder characteristics have been developed by such technical organizations as the American National Standards Institute. Greater use needs to be made of available standards in advertisements and specification sheets. Additional standards involving manufacturers and consumers need to be developed and used.

The following narrative parallels the checklist provided. Any number of available machines might be compared. Information for every box in the matrix may not be available at this time.

I. *Identification.* The machine should be adequately identified with manufacturer, manufacturer's address, model designation, serial number, year of manufacture and list or net price. Many machines are made outside of the United States, and such informtion should be clear for any reason desired. Probably all machines have some components of foreign manufacture. The year of manufacture may be difficult to ascertain at this time because consumers have never demanded it.

II. *Tape Reel/Cartridge/Cassette Format(s).* All tape recorders and playback machines make use of a thin and flexible ribbon of plastic tape (paper was once used) with a very thin layer of magnetic oxide firmly bonded to one side. During the recording process, the tape is pulled from the supply reel or spool, erased by passing over an erase head, recorded by passing at constant speed over a recording head that magnetizes the oxide coating with a representation of the desired sound wave and then wound up on a takeup reel. For playback, the tape is rewound and again pulled through the mechanism with the erase head deactivated and the recording head acting as a pickup head to detect variations in magnetism and translate them into electrical signals which are amplified and reproduced as sound. The tape and reels may be enclosed in a cartridge or cassette for easy handling or it may be on open reels which require threading or lacing. Until recently, all tape used in schools and libraries was one quarter inch wide. The popular new cassettes make use of one eighth inch of the tape.

One quarter inch tape on open reels has been most common for twenty years. Common reel diameters are 3¼ inches, 5 inches and 7 inches. Most educational machines will accept the 7 inch reels, but some will accept only smaller sizes. Professional machines will often accept 10 inch reels. Some professional machines also make use of tape wider than 1/4 inch, but they are used only for special purposes.

Tape must be recorded and played back at almost exactly the same speeds. The higher the speed, the more room for a given sound signal and the higher the fidelity, other things being equal. Early recordings had to be made at thirty or fifteen inches per second to obtain high fidelity. Most educational recordings are now made at seven and one-half or three and three-quarters inches per second, and some are made at a one and seven-eighths speed if fidelity is not critical. The slower speeds obviously provide more playing time for the same length of tape and greater economy. The selected machine must be able to play any library of previously recorded tapes and be compatible with other machines that may be used to play its tapes. Improvements in record/playback heads and electronics have resulted in remarkable improvements in fidelity even at slow speeds.

[2] National Audiovisual Association, 3150 Spring Street, Fairfax, Virginia 22030.

Early audio tapes had the magnetic pattern occupying most of the width of the tape. With improvements in head design and electronics, it became possible to double the recording time by using only half of the tape width and turning the tape over for a second run through the machine. Most educational tapes are now in this half track or dual track configuration. If two recordings in opposite directions share the same tape, editing is generally impossible and some confusion may result. Some commercial tape have the same program recorded on each track so that rewinding is not necessary. When stereo recording and playback was desired, primarily for home entertainment, a quarter track format was developed to provide separate right and left sound tracks in each direction. Some educational machines use this format to obtain four separate recordings to gain greater tape economy at the expense of some confusion. Any quarter inch tape can be played on any machine that has the same speed provided that only one track has been used. If more than one track has been recorded, then a compatible machine must be used for playback.

The playing time for any tape is determined by its length, the speed and the number of tracks used. A twelve hundred food length of common one and one-half mil tape (.0015") will pass through a machine at three and three-quarters inches per second in sixty-four minutes. Half and quarter tracks would double or multiply the time accordingly, unless stereo made use of two tracks simultaneously. In order to wind more footage on a given reel, tapes are made in thin (.001") and very thin (.0005") thicknesses called double and triple play tapes. The thinner tapes must be made of a very strong plastic called mylar or polyester at increased cost. Some machines have difficulty in handling the thinnest tapes.

Most educational machines and battery operated portables are monophonic only. Most home entertainment machines are true stereo with completely separate channels for the left and right signals. Quarter inch stereo tapes can be played on a monophonic machine only if recorded in one direction on a completely erased tape. A mono tape can be played in mono on a stereo machine through one channel and speaker only. The trend is definitely toward stereo sound in education as in entertainment.

Quarter inch tape has also been put in several types of endless loops (end attached to beginning) for continuous play or to avoid threading and rewinding problems. Unfortunately, there has been little standardization of the systems and specific cartridges must be used only on specific machines designed for them. These cartridges have been used far more in industry and for exhibits and displays than in education. Endless loop tapes must be specially lubricated since the tape is subjected to continous winding and withdrawal on a single reel. Rapid rewind or fast forward speeds are generally impossible. Another problem is that a tape is often left so that it starts in the middle of a program. Repairs may be difficult. This format is being replaced by the Norelco compact cassette format.

The Norelco compact cassettee was developed to avoid the threading problems of reel to reel tapes and other problems of endless loop cartridges, and also to obtain a much smaller and hopefully standard package. The format has become very popular in a brief period of time. The tape is one-eighth inch wide, made of various materials and thicknesses for various playing times, permanently attached to enclosed supply and takeup reels, and always transported at one and seven-eighths inches per second. Mono tapes are half track and stereo tapes make use of two adjacent quarter tracks so that mono and stereo tapes are completely compatible. The cassettes are turned over to use the second half of the tape. Fast forward and rewind are usual features. The thinnest and most flexible tapes (90 and 120 minutes total time) may cause problems with machines due to wrapping around the capstan or pinch roller. Most portable and educational machines record and reproduce only monophonic signals although the trend is toward true stereo reproduction, especially for music.

III. *Recommended Setting(s)*. Consumers are increasingly asking manufacturers for information about the intent of their equipment. Such information is often lacking and users are apt to think that a machine is equally recommended for personal and portable use as it is for auditorium use. Desirable equipment characteristics for individual study are quite different from characteristics for music appreciation in a large room. Even for individual study, equipment is made for very portable battery operation, fitting into a recess in a carrel and for high fidelity headphone reproduction. As students of various ages and even with various handicaps assume responsibility for operating machines, the difficulty of operating and harming the machine become important considerations. Manufacturers do not yet report on the operator competence required.

IV. *Safety*. The best method of assuring the overall safety of audiovisual equipment that operates on 120 VAC is the presence of the Underwriters Laboratory seal on the equipment itself. The UL label wrapped around the power cord only indicates that the power cord has their approval. UL approval involves a very rigorous testing of the original machine and subsequent inspection of production line samples. In addition to the UL approval, or as a substitute for it, several things should be checked. A three wire power cord and plug are very important. The proper use of this system connects the chassis of the machine to the plumbing in the school and results in maximum safety. A fuse or circuit breaker in AC operated machines is designed to interrupt the flow of current in the unlikely event that a serious electrical failure should occur. Fuses can be replaced and breakers can be reset. Unfortunately, such deliberate weak links in the circuit may fail without good reason and there is no agreement that such protection is really necessary in addition to the regular fuses or breakers in the line. Institutional tape recorders on 120 VAC are often used for long periods of time and sometimes inadvertently left on overnight or over a weekend. The motor or transformer should not get dangerously hot even under such conditions. This can be roughly checked by touching the components just after the machine has been turned off after several hours of operation. Since almost any part of a portable machine may be used as a hand-hold for moving, there should be no sharp edges, holes or corners. It should be impossible to get a pencil or a finger into the moving mechanism such as the fan.

V. *Operating Conditions.* Most audiovisual equipment is designed for operation on 120 volts. However, electrical voltage may vary over a wide range due to various demands for power and the limited capabilities of the utilities for supplying it. Equipment should operate without problems or degraded performance on voltage as low as 105 and as high as 125 volts. An external transformer would normally be needed to adjust for more extreme voltages. The AC watts required by tape recorders is normally so low that no special provisions need to be made unless a very large number of them are to be used simultaneously on one circuit. Many new tape recorders will operate on batteries and, if so, the type and number of them is important. Battery operation also involves a constantly recurring expense that may vary widely among machines. Rechargeable batteries may be available, but it is not ordinarily wise to try to recharge ordinary zinc or alkaline batteries. Alkaline batteries have several times the life of zinc batteries. The environment for machine operation varies widely around the country. If extremes of heat, cold, altitude moisture or dryness are anticipated, then special checking may be needed. Recorders are made for infrequent and uncritical hobby use, for home high fidelity use, educational and institutional (audiovisual) use and for professional use. The intermediate audiovisual duty rating would normally be specified.

VI. *Physical Characteristics.* The weight of the machine in pounds (or in metric kilograms) is important if portability is needed. Battery portables should be weighed with batteries in place. Dimensions with and/or without a case may be important for portability or for fitting into a carrel or other restricted space. An adequate handle is comfortable for an extended walk and strong enough for lifting several times the weight of the machine. Portable machines must also have a strong case, durable covering, corner guards and secure latches. Many equipment manufacturers seem to turn over the whole matter of case characteristics to a supplier with minimum requirements. From the characteristics noted above and a consideration of hazard to the working mechanism, an overall rating of portability can be derived. If the mechanism must be installed, then the same characteristics can be used to determine installation suitability.

The power cord on AC machines should obviously be attached so that it will not be lost, long enough (usually about six feet) to reach the outlet without an extension, and provided with a storage compartment if portability is desired. Many battery operated machines have an auxiliary power cord to save on battery cost when AC power is handy. These cords are usually not attached, and inserting the cord in the machine often effects the changeover from battery operation. Some machines have the transformer molded into the AC plug which may be considered inconvenient.

Controls should be labeled so that it is easy to determine proper operation. Some standard symbols would be very helpful. Since tape recorders are so important to the blind and since they may also be used in the dark, some form of raised symbols would be helpful.

Operating instructions are essential on the machine for minimum operation and additional instructions and characteristics need to be available on a hang-tag or in a booklet. Instructions, particularly those composed in foreign lands, may not be very clear.

A permanent and convenient serial number is necessary for inventory control and to discourage thievery or make identification possible in questionable cases.

Tape recorders are one of the most stolen pieces of equipment. Some method of anchoring, locking or chaining the chassis of the equipment may be needed.

A pilot light serves to indicate that power is attached and the machine in operation. It also serves to warn an operator or custodian that a machine has been inadvertently left on.

If headphones or an earphone is needed with a portable machine, a storage space is needed. For fixed machines, a secure storage compartment may be needed to avoid loss.

VII. *Sound Record/Reproduction Characteristics*. The tape is moved through the recording and reproducing mechanism by one or more motors. Most audiovisual machines have one motor and professional models or models having automatic reverse may have two or three. In order to attain practically constant motion for sound fidelity, the tape is pressed by a rubber tired pinch roller against the capstan which may be the rotating shaft of the motor or a flywheel driven by the motor. Some inexpensive machines have the tape pulled only by the takeup reel rather than a capstan and uneven speed and poor sound result. A digital counter driven by one of the reels provides an arbitrary indication of tape used. It does not count feet or minutes. Some standard for what it does count would make tape indexing far easier. The counter can be easily reset to zero at any time.

Professional machines usually use separate heads (electromagnetic transducers) for erasing, recording and playback. Most audiovisual models have a separate erase head and a combined record/reproduce head. The erase head has a broad gap and a powerful high frequency alternating current to completely erase all signals from the tape and leave it ready for a new program. Some inexpensive machines have only a permanent magnet to erase the tape. The record/reproducer head has an extremely narrow magnetic gap to record or detect alternating magnetic domains that must be very close together. To transfer or detect the magnetism, the oxide coating on the tape must be firmly held against the head. This is usually done by felt pressure pads which are lifted during fast forward or rewind modes. To further reduce wear on the heads by the abrasive action of the oxide coating, some machines have tape lifters that operate when either fast mode is used. The tape lifters have the further advantage of preventing the peculiar sound (monkey chatter) of the fast moving tape.

A pause control is often included to stop the tape instantly during recording to avoid an unwanted sound such as a cough and during playback to permit comments or a question. It also permits typists to transcribe from tapes. There should be no unplesant sound from gradual stopping or starting, and the motor should not labor unduly.

A few machines provide for repeating a brief passage by operating a switch. This would be particularly helpful if the machine were to be used for transcribing or studying a foreign language.

An automatic shutoff turns off and brakes the mechanism if the tape breaks, fails to wind or when it reaches the end. Since cassette tapes have permanently attached ends, another type of shut off mechanism is needed to keep from stalling the motor.

A fast forward button or lever permits one to advance the tape rapidly to a desired place as indicated by the digital counter.

Rewind time is important if tapes must be rewound while people are waiting. Rewind time is dependent on the length of tape to be rewound. A ratio of thirty to one would rewind a thirty minute recording in one minute.

When the speed lever is set at 1-7/8, 3-3/4 or 7-1/2 inches per second, the mechanism should advance the tape at almost exactly those speeds to that tape recorded on one machine will play back on another in almost exactly the same time and so that musical pitch will not be altered. If all tapes are to be recorded and played back on the same machine, speed accuracy is of little importance.

Rotating equipment tends to produce slow changes in speed which produce what is called "wow" and rapid changes in speed which produce what is called "flutter." Both are very undesirable when reproducing music which contains sustained notes of any kind. A good tape recorder will produce less than 0.1% of wow plus flutter.

A remote on/off control on the microphone is often provided on machines designed for dictation or any recording where remote operation is desired. This control may be a duplicate of the pause control function. A similar control for foot operation may be available.

Many record/playback characteristics need to be checked for specific applications. A microphone changes sound into electricity. It may be a crystal or ceramic (high impedance) type but dynamic or condenser (low impedance) types are generally considered better. The microphone has a plug which fits a jack on the machine. Standard phone jacks are most common and microphones with similar jacks and impedance can be interchanges. Stereo recording requires two microphones and jacks.

An auxiliary input permits recording from another recorder used as a playback, record player, radio tuner, etc. by means of a shielded jumper wire with plugs on each end rather than by using the microphone in front of the loudspeaker. Much better results are obtained with this system. The jack is usually the standard phone jack to simplify interconnection. Adaptor plugs and jacks are available if needed. A separate volume control for this input permits mixing the auxiliary sound with the sound picked up by the microphone. Two of everything are, of course, needed for stereo.

Either tubes or transistors can provide high quality amplification, but the trend is almost entirely toward transistors (solid state) in order to gain compactness, low current drain, instant start, etc. The number of either provides a rough idea of the complexity and completeness of the circuitry.

Since magnetic materials do not respond in a linear way to magnetizing forces, a high frequency AC bias signal is usually applied to the recording head in combination with the audio signal to obtain good fidelity and low background noise. A permanent magnet or DC bias system is generally not recommended. The same supersonic frequency used for bias is also used for the erase head.

The magnetic coating on the tape can be magnetized only to a certain extent, and thereafter increasing signals result in no additional magnetic pattern on the tape. Reproduction of signals that exceed magnetic capabilities would be badly distorted. Most recorders have a meter, flashing light or indicator tube to indicate that maximum recording level for good fidelity has been reached. In ordinary use, the volume control is adjusted to keep the indicator operating as explained in the instructions.

To avoid constant adjustment of the volume control during voice recording, automatic volume on level controls are often available. They tend to provide extra amplification for weak sounds and less amplification for loud sounds so that all will be optimally recorded. Classical music has deliberate soft and loud passages which would be ruined by automatic level control, so a defeat or on/off switch is usually provided.

Amplifier power output to operate loudspeakers and headphones is measured in watts. Unfortunately many systems for reporting this parameter are in use. Most engineers prefer the pure sine wave (RMS) power output in watts with the specified total harmonic distortion (THD) in percent. Most headphones require only a small fraction of a watt and classrooms can ordinarily be covered with one watt into a good loudspeaker. A small auditorium would need about ten watts into a good loudspeaker. The percent distortion is barely noticeable. High fidelity systems should have less than one percent THD.

Amplifier frequency response indicates the highest and lowest frequencies that can be amplified within a certain volume range expressed in decibels (dB). The human ear can ordinarily hear sounds ranging in frequency from about twenty to fifteen thousand cycles per second or hertz (Hz). Loudness is usually reported in decibels and doubling or halving the power results in plus or minus three decibels (±3dB). Good performance would be expected from an amplifier that provided 60–12,000 Hz ± 3dB.

Low tones are called bass and some tone controls are designed to boost them or cut them by a number of decibels such as ± 15dB.

High notes or tones are called treble and some tone controls are designed to boost them or cut them by a number of decibels such as ±15dB.

Single tone controls generally provide only very limited reduction of high frequencies. No tone controls should be in operation during the recording mode.

Amplifiers not only produce desired signals but they produce undesired signals called noise. The higher the ratio of signal to noise (S/N), the better the amplifier.

The total recording plus playback system is ordinarily far less faithful than the playback amplifier alone. The frequency response, total harmonic distortion and signal to noise ratio of the whole system should be studied for comparison with the amplifier alone and with other available machines.

Most recorders have one or more built in loudspeakers which are the weakest part of the total system. An output jack is often provided for the easy connection of an external loudspeaker or headphones.

Maximum volume and fidelity result from matching impedances so an eight ohm speaker (most common) should be plugged into an eight ohm amplifier jack. Other common impedances (resistance to flow of alternating current electricity) are three and sixteen ohms. No damage will be done by mismatching these impedances. The plug on the loudspeaker or headphones must match the jack or an adaptor must be used. Standard phone jacks are most common.

Recorders are often used to feed a group of headphones through jack boxes. Only a certain number of a certain type of headphones can be adequately driven, so special checking may be needed for this application.

Transistor amplifiers can be damaged by even a momentary short circuit of the wires going to an external loudspeaker or headphones, and the possibility of this happening is not remote. Some amplifiers have automatic short circuit protection which would be very desirable if external connections are expected.

The external speaker jack can be used for feeding another recorder or amplifier, but an auxiliary output usually produces better results. Its jack must fit the plug on the connector cord. A miniature RCA type often used in high fidelity systems is most common.

A loudspeaker converts electrical energy into sound. More than one may be included for better reproduction of low notes (woofer) and high notes (tweeter). Larger diameter cones and heavier magnets usually make more efficient speakers. Two speakers several feet apart are needed for true stereo reproduction. The loudspeakers included with most recorders are not very good and their characteristics are seldom reported for comparison. Standards for measuring and reporting the actual frequency response, sound level and distortion under certain test conditions are badly needed. Such testing cannot be done in any ordinary room due to the peculiar behavior of reproduced sounds in such rooms. An echo free (anechoic) room or quiet outdoor space must be used.

Headphones or earphones permit private listening without disturbing others. Insertion of the headphone jack normally silences the loudspeaker. Headphones may be included or available as accessories. Jack boxes permit the use of several headphones. The cord length (usually about six feet) should permit free movement, but not get in the way. Stereo headphones have separate wiring to each ear for true stereo reproduction from a stereo recorder. Frequency response, maximum sound level and distortion figures are needed for accurate comparisons among available headphones. A sound level of about 120dB from headphones is considered the maximum that is safe.

VIII. *General Observations.* There are many things about a tape recorder that are difficult to quantify and report objectively. They are nevertheless very important.

The machine should be easy to set up and put into use by the person or persons normally responsible for its use. The adjustments for optimum recording and playback should be convenient and foolproof. Every needed control and facility should be clearly labeled and detailed instructions should be available when needed.

The oxide coating on the tape tends to rub off on the stationary heads during recording and playback. With good design, no buildup of oxide in the head gap area should be evident after several hours of use. After many hours of use it should be easy to get at the heads and clean them with Q-tips or similar cotton swabs dipped in recorder cleaning fluid available from any AV or high fidelity dealer.

The tape should not spill out of the machine under any expected circumstances such as pushing any button or removing the power.

The machine's operable and moveable parts should be rugged enough to stand expected use. The machine should be stable on a table so that there will be little danger of upsetting it. It should be able to stand most any treatment that an uninformed but eager user might give it.

Thin tapes (.0005") for extra long playing times present special problems for tape mechanisms. If their use is anticipated, even though engineers do not recommend them, then special checking should be done. Such tape should not be stretched even at the end of the reel when greatest pull occurs. Evidence of stretching can be both visual and by uneven sound during playback. Thin tapes also tend to wrap around the capstan or pinch roller if there is a sudden change of direction speed.

The major purpose of a recorder is to deliver faithful and pleasing sound to the listeners. All of the details considered are only means toward this end. The best test is probably to operate a number of machines as they are expected to be operated and to assemble a group of critical people to listen. It might be wise to have a light curtain in front of the machines so that only sound is considered at this time. Many recorders produce some amount of unwanted sound in combination with the wanted sound. This could be checked at the same time and considered along with other characteristics.

IV. *Accessories.* Various accessories may be available for a tape recorder. Some items that are standard equipment for one machine may be accessories for another. Much improved or better located sound may be obtained from an accessory speaker. Two would be necessary for stereo. Headphones for intelligible to high fidelity sound are available and for mono or true stereo. Headphone and jack boxes permit the storage and use of several sets. Microphones with various degrees of fidelity and with various pickup pattern would improve sound pickup. An extension cord would permit locating the microphone at a greater distance from the machine. A carrying case is needed for some machines and one might permit the storage of accessories for another. A foot control frees both hands while the machine is started and stopped. A patch cord with plugs on each end permits recording from another recorder, a record player or a radio tuner without using the microphone. A special kit for cleaning the heads may be available. Record/playback heads on some machines may accumulate magnetism and need to be demagnetized with a small AC magnet on a cord. A service manual and special service tools will help a local serviceman to make major repairs and adjustments if they should be necessary.

X. *Guarantee.* All tape recorders are guaranteed but educators do not ordinarily understand what the guarantee means. A standard guarantee or several standard guarantee need to be developed. They should indicate how long what parts of the machine are guaranteed against what failures or problems. They should also indicate what the user needs to do and with whom in order to have the guarantee honored. Guarantees by local dealers with factory trained personnel and complete tools and parts inventory are obviously more desirable.

XI. *Overall Rating for Intended Purpose(s).* A consideration of the intended purpose(s), operator(s) and setting(s) along with a consideration of the characteristics of available machines should permit and educator, librarian or technical assistant to choose the most appropriate make and model or to assemble a list of acceptable machines for competitive bidding procedures.

Checklist for Tape Recorders

Characteristics

I. **Identification**
   - A. Manufacturer
   - B. Manufacturer's Address
   - C. Model
   - D. Serial #
   - E. Year of Manufacture
   - F. List Price

II. **Tape Reel/Cartridge/Cassette Format(s)**
   - A. 1/4" Open Reel
     1. Maximum Reel Diameter
     2. Speed(s) ips
     3. No. Tracks
     4. Max. Time on One Mil Tape
     5. Mono/Stereo
   - B. 1/4" Loop Cartridge
     1. Cartridge Type
     2. Maximum Time
     3. Mono/Stereo
   - C. 1/8" Norelco Cassette (1-7/8 ips)
     1. Stereo Record
     2. True Stereo Play

III. **Recommended Setting(s)**
   - A. Individual Study
     1. Carrel or Table
     2. Battery Portable
   - B. Small Group
   - C. Classroom
   - D. Auditorium
   - E. Operator Competence

IV. **Safety**
   - A. UL Approval (or CSA)
   - B. Three Wire Cord
   - C. Fuse or Circuit Breaker
   - D. Max. Temperature
   - E. Sharp Edges or Corners
   - F. Fan Access

V. **Operating Conditions**
   - A. AC Voltage Range
   - B. AC Watts Required
   - C. Batteries Required
   - D. Battery Life
   - E. Environmental Restrictions
   - F. Duty Rating

VI. **Physical Characteristics**
   - A. Weight
   - B. Dimensions
     1. Without Case
     2. With Case
   - C. Adequate Handle
   - D. Adequate Case
     1. Material
     2. Covering
     3. Corner Guards
     4. Latches
   - E. Portability
   - F. Installation Suitability
   - G. Power Cord
     1. Attached
     2. Length
     3. Storage
     4. Transformer on Cord
   - H. Labeled Controls

Characteristics

Physical Characteristics (Continued)
   - I. Operating Instructions
     1. On Machine
     2. Hang-Tag
     3. Booklet
   - J. Serial Number
     1. Permanent
     2. Convenient
   - K. Security Provision
   - L. Pilot Light
   - M. Headphone Storage

VII. **Sound Record/Reproduction Characteristics**
   - A. Tape Transport Mechanism
     1. Number of Motors
     2. Capstan Drive
     3. Digital Counter
     4. Number of Heads
     5. Tape Lifters
     6. Pause Control
     7. Passage Repeat
     8. Automatic Shutoff
     9. Fast Forward
     10. Rewind Time Ratio
     11. Speed Accuracy %
     12. Wow plus Flutter %
     13. On/Off Control on Microphone
   - B. Record/Playback Characteristics
     1. Microphone(s) Included (Type)
     2. Microphone Impedance(s)
     3. Microphone Input(s)
     4. Jack Type
     5. Aux. Input(s)
     6. Jack Type(s)
     7. Separate Volume Control(s)
     8. Tubes/Transistors
     9. AC Bias/Record
     10. Record Level Indicator
     11. Auto Level Control
     12. Amplifier RMS Watts @ THD
     13. Playback Frequency Response ±dB
     14. Bass Tone Control ±dB
     15. Treble Tone Control ±dB
     16. Playback Signal/Noise
     17. Record/Playback Frequency Response ±dB
     18. Record/Playback THD
     19. Record/Playback Signal/Noise
     20. Ext. Speaker/Headphone Output
     21. Output Impedance
     22. Output Jack Type
     23. Max. Number Headphones
     24. Amplifier Short Protection
     25. Aux. Output
     26. Aux. Output Jack Type
   - C. Loudspeaker(s)
     1. Number Included
     2. True Stereo Reproduction
     3. Frequency Response ±db
     4. Max. Sound Level @ THD
   - D. Headphones
     1. Number Included
     2. Cord Length
     3. True Stereo Reproduction
     4. Frequency Response ±dB
     5. Max. Sound Level @ THD

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Checklist (Continued)

Characteristics

VIII. General Observations
- A. Ease of Setting up for Use
- B. Adjustment Convenience
- C. Labels and Instructions
- D. Oxide Buildup
- E. Head Cleaning Ease
- F. Tape Spill Control
- G. Ruggedness
- H. Stability
- I. Abuse Proof
- J. Tape Stretch
- K. Fidelity of Reproduced Sound
- L. Absence of Unwanted Sound

IX. Accessories
- A. Loudspeaker(s)
- B. Headphones
- C. Headphone Storage
- D. Jack Box
- E. Microphone(s)

Characteristics

Accessories (Continued)
- F. Microphone Stand
- G. Microphone Ext. Cord
- H. Carrying Case
- I. Foot Control
- J. Patch Cord
- K. Head Cleaning Kit
- L. Head Demagnetizer
- M. Service Manual
- N. Special Service Tools
- O. Other Accessories

X. Guarantee
- A. Time
- B. Exceptions
- C. Place(s) where Guarantee is Honored

XI. Overall Rating for Intended Purpose(s)

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