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INDUCED STRESS, ARTIFICIAL ENVIRONMENT, SIMULATED TACTICAL OPERATIONS CENTER MODEL.

A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements of the
degree

MASTER OF MILITARY ART AND SCIENCE

by

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M.Ed., Fitchburg State College, 1972
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Fort Leavenworth, Kansas
1973

THESIS APPROVAL PAGE

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Date: 25 May 1973

The opinions and conclusions expressed herein are those of the individual student author and do not necessarily represent the views of either the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

INDUCED STRESS, ARTIFICIAL ENVIRONMENT,
SIMULATED TACTICAL OPERATIONS CENTER
MODEL

by

MAJ Don E. Gordon

June 1973

169 Pages

This study investigates the feasibility of designing, constructing, and operating a conceptual model of a tactical operations center simulator. The model is intended to simulate performance tasks identified for Army Security Agency company level officers during combat operations. The model has been operational at the United States Army Security Agency Training Center and School, Fort Devens, Massachusetts, since 1970 and continues to serve as an alternative to other more costly methods of combat simulation.

The model's subsystems include an electro-optic simulation of tactical level communications and electronic warfare techniques. High resolution aerial photography is simulated by closed circuit television suspended above a terrain board. Stress is induced by information overload, accelerated and compounded decision making, peer group pressure, and battle drills. An artificial environment is effected by performance testing and role playing in conjunction with an HO scale ($\frac{1}{4}$":1') model war game exercise. The model may be used with computer assisted performance testing.

The study describes the use of the model as an instructional device, performance testing device, and as a substitute for a brigade level command post exercise. Application of the model to civilian education and other training agencies is discussed. Technical data reporting on the method employed to simulate radio wave propagation by visible light waves are provided in detail.

ACKNOWLEDGMENTS

Special recognition is afforded to others who served as principal contributors to the design, construction, and operation of the simulation model discussed in this report:

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Captain Robert A. Morin, Jr.

Captain Gary Gurski

SFC Damian P. Wilson

SP5 James Dori

Mr. O. D. Facemire

Completion of the TOC project would not have been possible without the active participation of many other outstanding men and women assigned to the U.S. Army Security Agency Training Center and School. Special appreciation is afforded to Colonel John J. McFadden, Major Carlton Willis, Mr. "Buck" Buckley, and Mrs. Dolores Hahn.

Don E. Gordon
Major, MI
Project Director

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Chapter I

INTRODUCTION

This research project introduces a conceptual training device which is intended to simulate the managerial, electronic warfare and cryptologic influences affecting the stressful environment of a tactical operations center at brigade level. This training device, referred to as an artificial environment, induced stress, Tactical Operations Center (TOC) model, utilizes military training techniques, artificial stimuli, induced stress, electro-optics, and computer assistance to offer a substitute for the Command Post type training vehicle used at brigade level and within military service schools.

The Army is faced with the task of presenting doctrinal concepts essential to its functioning. The concepts are, by their very nature, potentially uninteresting and unappealing to the younger officer and enlisted man who may lack the experience to associate abstract concepts with personal interest. Additionally, the military student must be able to apply military doctrine to a host of situations, combat as an example, which are difficult if not impossible to simulate in the classroom. Nevertheless, cost effectiveness restricts most training to classroom oriented activities or, at best, the application of doctrinal concepts to command post exercises.

Unlike mechanical skills, weapon's marksmanship, and small unit tactics, which can be applied and tested in basic components, the more complicated aspects of military operations which include communications, transportation, and staff functioning, involving multitudes of personnel and equipment operating over extended distances, usually cannot be practiced through locally applied applicatory training.

The United States Army Security Agency Training Center and School located at Fort Devens, Massachusetts, was confronted with the problem of creating dynamic applicatory training for its officer students in areas requiring managerial skills in the fields of electronic warfare and cryptologic support to tactical organizations. The very nature of both electronic warfare and cryptologic support requires the Army Security Agency officer to be multiskilled in all fields of intelligence, communications equipment, and asset management. It is essential that he develop confidence in working with the military staff of the supported unit, that he be able to solve complicated problems quickly and accurately, and that he be able to supervise the operation of complicated equipment and supervise talented enlisted men at peak efficiency under conditions of combat operations.

A compilation of evaluative comments by officer students attending POI Course 2G-F12 (Electronic-Warfare-Cryptologic Basic Officer Course) and 2G-F11 (Electronic-

Warfare-Cryptologic Officers Specialist Course) during 1969, 1970, and 1971, indicated that the student graduates did not believe that the instructional objective was being achieved for 2G-F11 or 2G-F12 graduates.[1] POI Course 2G-F12 was comprised chiefly of newly commissioned second lieutenants recently assigned to active duty but having completed either the three month Officer Candidate School or a Basic Branch Course at the Infantry, Artillery, or Engineer Schools. POI Course 2G-F11 was comprised chiefly of officers in the grade of Captain who had several years experience (3 to 7 years) and who had completed the nine month Branch Advance Course (Military Intelligence). That is, officers who had just completed the basic officer's course did not feel confident that the instructional objectives had been achieved; additionally, officers who had graduated previously from the basic course and had subsequently been assigned to tactical units shared this opinion.[2] A survey among officers assigned as instructors to the Army Security Agency Training Center and School's Command and Staff Department reflected during interviews that they did not believe that the officer students received sufficient confidence building training prior to reporting to tactical units which were then engaged in combat

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[1]"Career Management Evaluation of Officers," Project CAMEO, Headquarters, United States Army Security Agency Training Center and School, Fort Devens, Massachusetts, 1969.

[2]End of Course Questionnaire, Command and Staff Department, United States Army Security Agency Training Center and School, Fort Devens, Massachusetts, 1969-1970.

operations in Vietnam.

Generally there was agreement among officer students and faculty alike that the curriculum offered during the POI 2G-F12 fourteen week course provided sufficient technical information to prepare the officer student to perform his duties. The training deficiency was identified as a lack of applicatory training in performing managerial decisions under stress.

Unlike the combat arms service schools, the United States Army Security Agency Training Center and School has neither school troops nor resources with which to perform military demonstrations or simulated combat. The monetary and personnel limitations simply preclude a sizeable investment in this area. The limitation of funds and personnel with which to conduct field training exercises on a regular basis remains the primary deterrent to this method of simulating combat operations. This factor is also common to other branches, the Reserve Forces, the Reserve Officer's Training Corps Program, and division and brigade size units as well.

The tactical operations center within a brigade or division size unit is the point of control for those respective organizations. It may consist simply of a large hole covered with timber and sandbagged, or it may be more elaborate. Regardless of the materials of which it is constructed or the accouterments contained within, it serves the same function in all units. It is within the tactical operations center that the unit commander, operations officer, intelligence officer, and supply officer direct and support the operations of the command. It is the de facto command organization and termination point of the command's communications regardless of the commanding officer's presence. Military personnel employed within the tactical operations center are required to accumulate a sizeable number of facts, relationships, and hypotheses while being constantly conversant about the friendly and enemy force situations and intentions. Decisions must be rapid, action-oriented, the product of sound judgement, and conceived by the comparison of facts coupled with experience. The officers assigned to the tactical operations center and their enlisted assistants frequently suffer from viscerogenic deficiencies, especially the gross lack of rest, incomplete diet, and often overwhelming psychological influences indwelled in the very nature of combat operations. An entirely new dimension, abstract reasoning, is emphasized by the recent technological innovations of the battlefield which have added an array of electronic monitoring devices that not only supplement the availability of more conventional incoming information but which add an entirely new dimension, that of electronic warfare, to the responsibilities and responsiveness of the personnel working in the tactical operations center. In addition to functioning as a control center, the tactical operations center frequently is placed under bombardment or ground attack by the enemy forces which requires that the personnel assigned to this nerve hub be able to render judgements and decisions while engaged in close combat, repelling the enemy, and often while attempting to destroy classified documents and equipment. The essence of success in this role is to remain in control of one's emotions and faculties while responding to one's training. It is conceded that the total simulation of combat is impossible; but it is thought that a close proximity of the conditions, with the exclusion of death or the fear of death, can be approached with considerable realism.

A research project initiated by the Command and Staff Department of the Army Security Agency Training Center and School investigated the need for a controlled stimuli training device built around the managerial functions performed within a tactical operations center. The project proposal stipulated that when in operation the training device would induce constant decision making and individual judgement on the part of the student during a time period similar to that experienced in combat. Most importantly, students were to be evaluated on their ability to apply the technical knowledge acquired during the previous fourteen week course under conditions of imposed stress and in relation to their ability to cooperate and perform with fellow students in a manner which stressed group effort rather than individual effort. Further, the device would be designed so as to identify the maximum potential and specific weaknesses of participating students and in many cases the weaknesses of the training program. The training device was to create a controlled battlefield environment emphasizing electronic warfare and cryptologic support while presenting all the tools available for coping with managerial situations under conditions of controlled stimuli, competition, and stress. Consideration of the projected proposal led to the development of the main problem statement.

THE PROBLEM

Is it feasible to simulate the application of managerial systems, electronic warfare, and cryptologic support to a tactical operations center at brigade level under conditions of simulated combat operations?

The circumstances which led to development of the problem statement centered upon a compilation of evaluative comments by the United States Army Security Agency Training Center and School students and their instructors who had then recently returned from combat duty in Vietnam. The comments provided the impetus for an applicatory training device designed to simulate managerial, transportation, communication, electronic warfare, and cryptologic intelligence problems encountered by company grade officers upon their assignment to military units. Both the students and instructors had reported that the then current training program was so doctrinal in nature that it precluded a sampling of the work environment. The students had reported that they had completed the course of instruction having learned the correct managerial doctrines and techniques, but without an opportunity to gain confidence through the application and mastery of the techniques. Additionally, these young men also reported they became frustrated and bored during the lectures which relegated them to a non-participating role and confined them to their desks for up to eight hours in a classroom facility described as gloomy but which can only be fully appreciated by others who have been confined to the air-stifling environment typified by security facilities. The sense of adventure anticipated in military duty remained very remote at a time when most young lieutenants very much wanted to flavor the functioning army. In considering other alternatives to long classroom hours in which the student was subjected to the lecture method of presentation and pencil-and-paper drills, it is pointed out that other methods of instruction were examined and found to be either inappropriate or beyond the resources of time or funds available to the school.

OBJECTIVE

The chief objective of this thesis is to present the conceptual design, construction, and operation of an induced stress, artificial environment, tactical operations center simulator. The simulator is predicated upon performance objectives listed below and on those constraints identified in the introductory section of this chapter: time, personnel, and funds.

PERFORMANCE OBJECTIVES

An evaluation of the problem and acceptable solutions established the following objectives required to be achieved by the TOC model.

1. Determine if the student can use basic military tool subjects:

a. military map reading

b. supply procedures

c. military radio procedures

d. military administrative procedures

e. preventive maintenance

f. estimate of the situation

g. operations order / operations plan

h. cryptologic skills

i. commander and staff sequence

j. intelligence annex

k. intelligence collection plan

l. intelligence order of battle

2. Determine if the student can effectively provide EW/cryptologic support to the supported command by:

a. evaluating the EW/cryptologic situation realistically.

b. presenting effective and realistic briefings of the EW/cryptologic situation.

c. using the Army's management information system.

d. maintaining mobility equivalent to that of the supported command.

e. using the Army structure as a critical path toward accomplishing tasks.

3. Determine if the typical student can perform effectively in consideration of the separation of the ASA

officer from his parent organization by:

a. functioning with limited guidance from the parent command.

b. using the supported command's logistical and administrative support facilities as substitutes for those of the parent command.

c. using cryptologic peculiar logistical procedures.

d. overcoming inconsistencies in the supported command's logistical and maintenance system.

4. Identify training weaknesses in the individual student, the student class, or in the training program.

a. provide recommendation for recycle training.

b. provide recommendation for change to training program.

c. reinforce attributes of present training program by identifying its strengths.

d. eliminate unqualified or incompetent students from the training program.

5. Test and evaluate each student's ability to perform rather than his ability to respond to written tests.

a. Simulate field operating conditions during the evaluation and testing period.

(1) Simulate:

(a) equipment

(b) procedures

(c) communication

(2) Test against time.

(3) Test while student is wearing protective mask.

(4) Test teamwork concept required to expeditiously solve behavioral tasks.

b. Test continuously for eighteen hours.

6. Establish a testing and training facility that meets the requirements outlined in the five objectives listed previously and:

a. Expend less than ten dollars per student and amortize the expenditure in one fiscal year.

b. Design the facility to be transportable in module components carried by four 2½ ton 6x6 trucks with M-292 expansible vans.

c. Provide students with all reference material needed to complete each task.

d. Establish a closed loop exercise so that information created at one point can be evaluated at another point, collated, used to create a military intelligence product, and then inserted back into the exercise as a structuring tool. That is, have the students provide basic structure of the exercise through their imagination, actions, and mistakes.

e. Provide an instructor ratio of one to each three to five students.

(1) Each instructor must be qualified in his area of specialization.

(2) Each instructor rewards correct procedures by the student, provides a path to correct procedures

if the student is knowledgeable but uncertain, and negative reinforcement if the student does not understand how to derive a solution. In the latter case the student is transferred to a similar but more fundamental task. Repeated failure at three or more similar tasks requires evaluation of student's competency to perform effectively in the examination.

7. Determine if application of the principles of controlled stress to improve performance, increases activity, alertness, and learning.

8. Apply principles of behavioral modification to applicatory training and testing while striving to increase student interest and participation by imaginative and enjoyable training.

9. Upon completion of the pilot military project, evaluate its application to the education of gifted and emotionally disturbed children of high school age.

a. Substitute military environment with a community environment.

b. Students play roles of community members rather than roles of military commanders and staff.

c. Students manage a model community through self-government.

d. Substitute brigade radio system with Bell Telephone Company "Tele-trainer System."

e. Substitute military reference with student created codes, ordinances, and social mores.

f. Substitute military "war game" with problems typical of the model community.

g. Substitute military equipment with model trucks and cars.

h. Substitute military behavioral tasks with those required of participating community members, e.g., mayor, police chief, school principal, store owner, truck fleet owner, et cetera.

i. Use military research and development investment to reduce cost of substitute community training facility.

j. Retain mobility of facility for use in regional or state school systems thus affording a sharing role of the capital and yearly operating costs.

PURPOSE

This investigation reports on the field experience of an artificial environment, induced stress, training device used by the United States Army Security Agency Training Center and School to train officer and enlisted students under simulated conditions of combat. The purpose of this study is to examine and report the conceptual design, construction, and operation of the device in order to determine if it is a feasible alternative to applicatory training within the limitations of time, expense, and personnel in relation to the value of the training product.

JUSTIFICATION

If the artificial environment, induced stress, training device is a viable alternative to conventional training methods conducted by the United States Army Security Agency Training Center and School, then the basic design and construction techniques may have expanded application to other military training or to civilian education requirements.

LIMITATIONS

This investigation is limited to the first hand observation of a field study of the United States Army Security Agency Training Center and School's Tactical Operations Center model located in Building P-111, Fort Devens, Massachusetts, and which is presently operated by the Tactics Division of the Command and Staff Department. The investigation is limited to observations conducted during the development of the device during the period of March, 1969, to March, 1973.

The participating population is limited to 720 male officers, 76 enlisted men, and 5 enlisted women students.

The observation does not include the measured comparison of stress or of a control group and a randomly selected group in order to derive a correlation depicting a relationship between students trained with this device and students trained with conventional methods and equipment. The evaluation is thereby subjective and non-quantitative. Qualifications of the officers participating in the evaluation include their having been trained in the conventional system, having applied this training to combat operations in Vietnam, and then having returned to the training process to instruct newly commissioned officers.

THEORETICAL FRAMEWORK

The theoretical framework is designed upon the assumption that an artificial environment, induced stress, training device which simulates the application of managerial systems, electronic warfare, and cryptologic techniques in the support of tactical operations at brigade level, under conditions of simulated combat, will be beneficial in the preparation of newly commissioned officers and enlisted men and women for assignment to Army Security Agency tactical support units.

This assumption is predicated upon a second more basic assumption that if such a device does prove to be beneficial that it also will be feasible in terms of funds and personnel. The hypothesis examines both assumptions.

HYPOTHESIS

In order to examine the problem statement as well as to achieve those performance objectives listed previously, the following hypothesis was stated:

> It is feasible to design, construct, and operate a conceptual artificial environment, induced stress, training device with which to simulate the application of managerial systems, electronic warfare, and cryptologic support to the tactical operations center at brigade level under conditions of simulated combat operations.

The hypothesis was studied by building a TOC model and gradually integrating all subsystems reported in Chapters III and IV of this report.

TERMS AND DEFINITIONS

(Additional terms, definitions, and abbreviations may be found in Appendix A.)

Artificial environment. The simulation of working conditions, social conditions, climatic conditions, and psychological and physiological influences of a working environment by artificial means.

BLUE Room. A component of the TOC model in which students playing the role of the friendly (blue) force's command and staff element perform.

Continuous Link Exercise or Problem. A training exercise begun from a common point but which continues based upon the input of student actions. It is an unstructured training exercise not dependent upon a scenario. The input of individual students or groups of students automatically creates new requirements for themselves or other students. Each student response is linked to continuing requirements. Learning or test objectives are maintained by the instructor's input of accelerated tasks or decisions.

Induced Stress. The inducement of stressful conditions through the application of information overload, peer pressure, accelerated and compounded decision making, and artificial environment. The definition includes the control of the stressful condition so as to prevent frustration and encourage the individual's ability to cope by applying socially acceptable coping techniques. An example of an acceptable coping technique is the organization of time to accomplish tasks.

Period. An increment of time during the exercise in which specific tasks and decisions must be accomplished in conjunction with the system's program. The period may vary in time. The instructor manipulates the period to control stress and achievement.

RED Room. Component of the TOC model in which students playing the role of the enemy (aggressor or red) force intelligence effort perform.

System Program. A written program of instruction by which the instructor insures that learning or testing objectives are met. The program may or may not specify a sequence for attainment of the objectives.

Tactical Operations Center (TOC). A physical groupment of those elements of an army general and special staff concerned with current tactical operations and the tactical support of those operations. (AR 310-25)

Chapter II

REVIEW OF THE LITERATURE

The review of the literature relevant to this study encompassed five general areas: dynamic training, simulation, human factors, development of the instructional model, and induced stress. Each of these contributions is reviewed individually.

As noted in Chapter I, the United States Army Security Agency Training Center and School (USASATC&S) was confronted with the task of developing dynamic and applicatory training for its newly commissioned officer students. Surveys conducted among students and faculty indicated that the then current lecture oriented instruction was unsatisfactory for the requirements of a modern Army. Students and faculty recommended an instructional method which would provide a brief doctrinal introduction immediately followed by an opportunity to apply the lesson material to contemporary problems. Students further reported that they preferred challenging tasks and the anticipation of measured stress. Euphoniously, the term "dynamic training" was developed to refer to challenging, stress oriented, adventuresome training at the United States Army Security Agency Training Center and School. Simulated training was designed to become a significant keystone in the overall, individual training program.

DYNAMIC TRAINING

In 1971, two years after the Army Security Agency began the construction of its Tactical Operations Center simulation model, the Chief of Staff of the Army (CSA) directed the Commanding General of the Continental Army Command (CONARC) to form a board of officers to develop meaningful and exciting training. The Board for Dynamic Training at Fort Benning, Georgia, resulted.[1] The CSA had indicated in his guidance to the Board that the Army had forgotten how to train without using major field maneuvers and that current training was void of technique. The CSA expressed concern that battle drills were disappearing as a proven technique.[2] Shortly after the board convened it identified several important principles of dynamic training:[3]

1. Testing should be measured by performance.

2. Training should be enriched by imaginative challenging exercises which involve the participant in planning and execution.

3. The training environment should be relatively unstructured so as to permit individual initiative.

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[1]Board for Dynamic Training, Report of the Board for Dynamic Training, Vol. II (Fort Benning, Georgia, December 1971), p. 1.

[2]Ibid., p. 2. [3]Ibid., p. 4.

The Board then defined dynamic training to include that training in which "the output for the student is job-oriented--a zestful, stimulating, rewarding learning experience."[4]

The Board conducted general surveys of personnel attitudes toward training in 1971. Results indicated that most respondents, regardless of rank, grade, or branch, felt that the current training was marginally adequate and seldom dynamic.[5]

The Board for Dynamic Training offered several recommendations for improved training. One recommendation was an encouragement of testing student "hands-on" performance and the use of simulated training devices and induced stress.[6]

The Army Security Agency Training Center and School was concurrently proceeding in the same direction as the Board for Dynamic Training. The agency's concept of correcting its training deficiencies, identified earlier in this study, resulted in the application of dynamic training techniques by construction of a training model. The training model, a simulator, was designed and constructed as a tactical operations center. The model afforded "hands-on" applicatory training and testing. An article in Hallmark magazine reported, "The purpose of [the TOC] is to give a

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[4] Ibid., p. 16.

[5] Ibid., pp. 18, 25.

[6] Ibid., pp. 105-107.

new lieutenant a chance to operate in a real life situation; to test how much he has absorbed from his training; to determine how he bears up in an extended pressure situation."[7]

The United States Army Security Agency Training Center and School is not one of the Continental Army Command's schools. Rather it is subordinate to the Army Security Agency. This dichotomy precluded the direct coordination of this project between the Board for Dynamic Training and the Army Security Agency Training Center and School.

In September 1971, the Human Resources Research Organization (HumRRO) reported that the traditional lecture centered instructional method characteristic of most army training is effective only for a narrow band of training within the Army's overall educational training spectrum. HumRRO suggested that a better training model be designed to overcome the temporal separation between the presentation of information in the lecture and an opportunity to practice what is learned. HumRRO further suggested that a training model identified as APSTRAT, an acronym indicating aptitude and strategies, be considered as a point of reference. Several instructional principles were identified with APSTRAT:[8]

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[7]United States Army Security Agency, "War Breaks Out at Fort Devens," Hallmark, (Arlington Hall Station, Virginia), May, 1971, p. 2.

[8]Human Resources Research Organization (HumRRO), The Development of a Low Cost Performance-Oriented Training Model, [by Weingarter, Hungerland, Brennan, and Allred] (Washington: Department of the Army, September, 1970), pp. 1-2. CGSC-AN: N-18107.357.

1. Performance orientation.

2. Learning in a functional context.

3. Self-pacing.

4. Insistence on mastery.

5. Rapid and detailed feedback to instructor and student.

These same principles were incorporated into the design of the United States Army Security Agency Training Center and School's MCT-4, Computer Assisted Morse Code Training System. The MCT-4 was designed in 1967 in conjunction with a Department of the Army contract to improve the training of radio operators. This system served as a functional model for the TOC simulator despite the wide variation in the application of the two systems.[9]

SIMULATION

The literature is replete with examples of successful education and training simulators. Their innovation predates this study and their valuable contribution to the field is widely accepted. It is not the intent of this review to validate the application of simulation devices with respect to modern and progressive education and training models. Similarly, military training has taken advantage of simulation devices extensively during the past twenty years.

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[9]Department of the Army Contracts: DAH07-67-0033 and DAHC07-69-C-0094; see also Training Manual 32-6940-200-15, Operation and Maintenance Manual Morse Code Training System, MCT-4, October, 1971, pp. 1-5.

Rather, the literature does not report extensively on the adoption of multistimuli, artificial environment, and induced stress to simulate managerial and tactical requirements imposed simultaneously by military operations.

The tactical operations center model (TOC) was designed in 1969 to simulate operational conditions affecting combat operations with emphasis on electronic warfare and unit management of USASA combat support units. It was designed as a dynamic nerve center from which to simulate accelerated decision making under stressful conditions. It is a simulation of the decision making environment.[10]

Yale addressed the importance of simulation training in an article presented to the Military Review. Yale, a retired colonel, graduate of the Command and General Staff College, is a military operations research consultant employed by the Stanford Research Institute. He is also a consultant to the German Ministry of Defense. Yale developed his thesis by noting that battle is more a matter of technique than tactics. He stressed the importance of the commander being at the proper place to influence at the opportune time in order to direct a mobile staff, effect precise fire support, and coordinate the timely use of ground and air transport systems. Yale emphasized the need of the commander to be not only conversant but to be familiar with the tools of control such as communications

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[10]Don E. Gordon, "Tactical Operations Center," Marine Corps Gazette, June, 1972, p. 50.

systems, computer systems, and intelligence systems. He notes, since unplanned eventualities cannot be anticipated, the importance of careful and forceful management is essential. The art of tactical management depends upon practice. He continues that our staff schools concentrate on staff training and inspirational leadership. We are limited in the practice of tactical management techniques in large and increasingly infrequent military exercises. This manner of practice becomes prohibitive with increased budgetary constraints. Colonel Yale makes note of the Report of the Board for Dynamic Training which emphasized the need to revitalize training in the light of challenge posed by conventional war. The Dynamic Training Board gave considerable importance to its recommendation that simulated training devices be developed for lower level unit training. Colonel Yale acknowledges the Board's recommendations and illustrates the success of the link trainer used by aviators and the success of the Combat Arms Tactical Training Simulator (CATTS) used at the United States Army Infantry School at Fort Benning, Georgia, to simulate combat leadership skills. However, Yale indicates that the command problem, which is greatest at battalion and brigade task force level, is not as dependent upon tactical simulation as management simulation. Colonel Yale recommends the duplication of a modern command post providing visual and aural sensing tasks and training objective oriented performance tasks. Finally, he concludes that failure should be interjected as a training factor. Interject failure to train the commander to cope.[11]

Colonel Yale's concepts are valuable and pertinent to a modern army. The writer corresponded with Colonel Yale after his publication of the articles cited above. In his letter, Colonel Yale continues that despite the need for simulation and despite the phenomenal success of the Miniature Armor Battlefield at Fort Knox, that it was abandoned. Colonel Yale's concepts are in agreement with the 1969 design of the TOC model in every aspect but one. Colonel Yale stresses that it is not feasible to mix tactics and management techniques in the simulation exercise. He contends that in instruction it is best to teach techniques first and then to progress to tactical simulation. One can read books on tactics, but not on techniques. The TOC model, to the contrary, integrates techniques with tactics successfully.[12]

Early in 1971, Lieutenant General William C. Gribble, Jr., testified before the Defense Subcommittee of the Committee on Appropriations, United States Senate, with respect to seven new proposals included in the Army Chief of Research and Development's "New Initiations Program." One of his proposals outlined the Integrated Battlefield

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[11]Wesley W. Yale, Colonel, USA, Retired, "The Acute Need for Simulation Command Training," Military Review, December, 1972, pp. 38-44.

[12]Wesley W. Yale, personal letter to Major Don E. Gordon, 10 December 1972.

Control System (IBCS). LTG Gribble reported the Army had made significant improvements in its capabilities for fire-power, mobility, intelligence, and combat service support. He also noted, however, that the Army's ability to integrate and control these functions has not kept pace. In the general's terms, "Our tactical operations centers...are now essentially manual." The purpose of the IBCS is to provide integration and control of all aspects of combat power, that is, management.[13]

Infantry magazine reported in 1971 that the IBCS is described as a concept developed by the Combat Development Command to integrate, control, and conserve critical resources. The major subsystems of the IBCS are STANO, TOS, TACFIRE, and CS3.[14]

Computer assisted training is an especially valuable complement to simulated training in the context of the Integrated Battlefield Control System. Salisbury notes in his study of computer terminology that computer supported training is defined as the generic term identifying those applications where the computer is used in direct support of a training function. Computer assisted instruction, on the other hand, is the "man-machine interaction in which many of the teaching functions are accomplished by use of a

[13] "OCRD: Seven New Initiative Proposals," Arrowhead, August, 1971, p. 8.

[14] "IBCS," Infantry, July-August, 1971, p. 45.

computer in direct support of a training situation." Simulation is a category of both computer supported and computer assisted instruction.[15] Hickey writing in a survey of the literature adds that computer assisted instruction provides Socratic logic to the student by which he may assert a solution in the interaction with the computer. Computer assisted instruction also permits the student to ask the computer for data.[16] In the latter application, as an example, pertinent data could be retrieved by students from Field Manual 101-10-1, Staff Officers' Field Manual Organizational, Technical and Logistical Data, in the calculation of courses of action. In this example, the instructor performs the instructional task using the computer to reinforce the presentation of concepts by providing ready access to comparative data. Bushnell and Allen writing in <u>Applications of Computer Technology to the Improvement of Learning</u> state that in the conduct of computer assisted games and simulation, the computer affords a model of real-life situations presented by a given set of circumstances and parameters stored in memory. In this application the student is able to react to a wide variety of situations

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[15]Alan B. Salisbury, Major, SC, "Computer Support of Military Education and Training: A Study of Terminology" (unpublished treatise, USACGSC, Fort Leavenworth, Kansas, April, 1970), Appendix 1. AN: 8224.405.

[16]Albert E. Hickey, <u>Computer-Assisted Instruction: A Survey of the Literature</u> (3d ed.; Newburyport, Massachusetts: Entelek, Inc., October, 1966), p. 74.

synthesized by the computer. This technique provides competition, variety, and stress which contribute to alternative simulations.[17]

Though simulation models had been used previously, the Vietnam War served as a catalyst for their total integration into the training program. The Vietnam War accentuated decision making at the small unit level. The simulation models provided an excellent vehicle for providing accelerated decision making situations in the instructional environment.

The United States Army Infantry School has developed a compartmented simulator in which officer-students are placed in a model of an assault helicopter. Flight is simulated by a terrain belt moving under the model at a rate similar to that perceived in flight. The student then coordinates a helicopter assault landing using techniques and communication procedures previously instructed. This device, referred to as the Combined Arms Tactical Training Simulator (CATTS), is an excellent performance oriented application of simulation.[18]

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[17] Don E. Bushnell and Dwight W. Allen (eds.), "The Computer in American Education," Applications of Computer Technology to the Improvement of Learning (New York: John Wiley and Sons, 1967), pp. 59-76.

[18] United States Army Infantry School, "Training Device Requirement for the Combined Arms Tactical Training Simulator (CATTS)," Aerial Employment Committee, Tactics Group, Brigade and Battalion Operations, Fort Benning, Georgia, 1971.

Channon writing in Infantry magazine proposed a simulation model to be used in developing an instinct for intelligence collection. His simulator is designed for the individual soldier. His proposed model combines a multiscale terrain model with electronic subsystems simulating the sights, sounds, and smells of the battlefield. It is surprising but encouraging that Major Channon, a military intelligence officer, considers the olfactory sense as a critical discriminator. Olfactory discrimination has been too long overlooked as a critical discriminant in the intelligence field. Channon proposes the simulation of an artificial environment battlefield. His contribution emphasizes the recognition, interpretation, and reporting of intelligence factors as an essential ingredient to the effective intelligence training of the individual soldier.[19]

HUMAN FACTORS

The Naval Training Device Center, Orlando, Florida, has been remarkably successful in matching the influence of human factors with simulated training. Their research conducted primarily through grants has been directed largely toward the simulation of factors affecting aviation training, team performance, combat and combat support skills, multidimensional tracking tasks, fidelity of training simulators, and simulated combat control centers (CCC). The navy ship

[19] James B. Channon, Major, USA, "Intelligence Instinct Can Be Developed," Infantry, May-June 1972, p. 28.

CCC functions similarly to the army TOC. Studies completed by this agency reinforce the basic concepts upon which the TOC model was designed and constructed. The research is reported in a complete bibliographic reference with accompanying abstracts provided for 765 publications of the Human Factors Laboratory conducted during the period 1945 to 1968.[20] In June 1972, two representatives of the Naval Training Devices Facility visited the TOC model at Fort Devens. Both representatives indicated that while the TOC model accomplished simulation goals adequately, an expenditure of funds approximating $500,000 would be needed to effect a level of sophistication compatible with their agency's objectives. The TOC staff disagreed, contending that sophistication was not an indication of performance.[21]

DEVELOPMENT OF THE INSTRUCTIONAL MODEL

A basic requirement for model design is the objective that it accomplish a behavioral performance goal. The instructional system used to develop the TOC model followed the guidance provided in the United States Army Security Agency Training Center and School's Procedures Manual for

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[20] Albert K. Kurtz and Mary C. Smith, Annotated Bibliography of Human Factors Laboratory Reports (1945-1968), Human Factors Laboratory, Naval Training Device Center, Orlando, Florida, February, 1969. N-17783.158.

[21] Letter. Subject: Suggestion 71-649 (TOC); To: Commanding General, U.S. Army Security Agency; Attn: CPMD; Arlington Hall Station, Virginia 22212; 12 July 1972; From: Major Don E. Gordon.

<u>the Development of Instructional Systems</u>. The system evolved from Project MINERVA which oddly enough is not a military acronym. Project MINERVA is a systematic approach to the design, development, validation, and implementation of instructional systems.[22]

Behavioral and performance objectives were then extrapolated from the <u>United States Army Security Agency Career Management Evaluation of Officers</u> (Project CAMEO) and the United States Army Human Research Unit (HumRRO) reports pertaining to the identification of army officer skills.[23]

Behavioral and performance objectives designed to provide simulation in those functional areas in which the Army Security Agency officer would be required to perform were incorporated into the TOC model program. Additionally,

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[22]Edward B. Flynn, John C. L. Legere, and William R. Tracey, <u>Procedures Manual for The Development of Instructional Systems</u>, USASATC&S, Fort Devens, Massachusetts, 1970.

[23]John C. L. Legere, "Career Management Evaluation of Officers," (Project CAMEO), Hqs., USASATC&S, Fort Devens, Massachusetts, 1969; also a letter, Subject: "Knowledges and Skills of the Combat Arms Maneuver Battalion Commander," U.S. Army Infantry Human Research Unit, U.S. Continental Army Command, Fort Benning, Georgia, September, 1971; also a letter, Subject: "Results of Research Concerning the Combat Arms Maneuver Battalion Commander," same as above; also Human Resources Research Organization (HumRRO), "Battalion Commander, Combat Arms Maneuver Battalion: Identification of Knowledge and Skills and Investigation of Thought Processing," [by Arthur J. DeLuca and Theodore R. Powers] (Washington: Department of the Army, 1971).

behavioral and performance objectives designed to simulate functional areas in which ASA supported officers perform also were incorporated into the TOC model program. In the latter application, it was felt necessary that the Army Security Agency officer understand not only his own performance objectives but that he be familiar with the performance objectives of other officers with whom he worked and cooperated. It is believed that this application is unique with respect to simulation. The premise upon which the concept is based stresses the need for extrospectiveness on the part of Army Security Agency officers. In this manner the student acquires an appreciation for the stresses and performances required of others as well.

INDUCED STRESS

Liebman notes that when an individual experiences unnecessary or excessive frustration he tends to become psychologically fixed at the point of frustration. Optimum instructional systems should, therefore, preclude the development of stress into frustration.[24] It is upon this one tenet that the inducement of stress into simulation problems is governed. The TOC model program induces stress while effectively providing alternatives to frustrations. The instructional scheme

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[24] Samuel Liebman, Stress Situations (Philadelphia: J. B. Lippincott Co., 1954), pp. 1-18.

provides one or more methods by which the student may alleviate the stressful situation. In effect the simulation model is used to instruct the student to cope with stress.

Torrence writes that in order for stress to be beneficial, the individual needs to have accurate information and sound concepts regarding mental and emotional response to stress; otherwise it may overwhelm him. He reports in the Gifted Child Quarterly that research has shown that mild stress may generally result in improved performance, increased activity, alertness, more learning, and a higher level of creativity. To the contrary, Torrence reports that extreme stress results in deterioration of mental functioning and emotional control. Anxiety is a personality variable which acts in the same manner as stress. Essentially, Torrence indicates that mild and controlled stress can stimulate learning, providing the student has been taught to cope with it.[25]

Berkun, Bialek, Kern, and Yagi, writing in Psychological Monographs, report on a HumRRO study investigating the degradation of behavior in combat. The authors note that "further exploration of the differences between effective and ineffective persons--that is, of the dynamics accounting for more or less successful coping with hostile environments--clearly requires the observation of such

[25]Paul E. Torrence, "Helping Gifted Children Through Mental Health Information and Concepts," The Gifted Child Quarterly, Spring 1967, Vol. XI, No. 1, pp. 4-5.

coping behavior." The authors recommended that a logical procedure is to study individuals experimentally in a hostile environment characterized by noise, unpredictability, fatigue, conflicting decisions, darkness, and rugged terrain. However, cognitive defense remains an obstacle to the experimental study of human response to stress. Researchers have attempted to substitute information overload as a stimulus for stress. While information overload is known to have certain psychomotor consequences, the correlation between its effect and behavior in combat is at best an untested hypothesis.

Similarly, the stress of achievement failure or frustration of aspiration in situations where the failure is not life threatening is not representative of stress in combat or catastrophe.

In order to reduce cognitive defense, the perception of the threat must be increased to the cognitive level by using cognitive stimuli as an inducement of combat stress.[26]

At this point it should be interjected that a current study of stress among Special Forces teams and helicopter air ambulance teams indicates that stress versus nonstress cannot be equated without consideration of the manner in which each individual perceives the threat.

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[26]Mitchell M. Berkun, Hilton M. Bialek, Richard P. Kern, and Kan Yagi, "Experimental Studies of Psychological Stress in Man," Psychological Monographs, United States Army Leadership Human Research Unit (HumRRO), Presidio of Monterey, California, 1962, pp. 1-4.

Writing in Men, Stress, and Vietnam, Bourne reports that hormonal data obtained in studies indicated that the 17 OHCS adrenal excretion among Special Forces and air ambulance crew member subjects indicated no direct relationship as to whether the subjects were engaged in combat missions or not. The daily levels of 17 OHCS did not deviate significantly from the overall mean of each individual and were significantly lower than that predicted by weight or with respect to a comparable military population at Fort Dix, New Jersey. Bourne reports that intimate association with the subjects led him to the conclusion that these subjects utilized extensive and effective psychological defenses to enable them to minimize the affective response to danger. They perceived their environment differently than casual observers. When forced to face tangible evidence of their danger, the men rationalized the evidence as an exception. The members of the Special Forces team relied more heavily on feelings of self-reliance to maintain their perception of invulnerability than did the air ambulance crewmen. Bourne also noted that the Special Forces team members were action oriented individuals, not prone to introspection, who routinely substituted a furor of activity to dissipate developing tension. Although the Special Forces officers had low 17 OHCS excretions, their excretions were slightly higher than those of the enlisted men. The difference is attributed to the requirement for rapid decision making and social demands created within the group.[27]

The TOC model program approached induced stress within the simulation model with the assumption that combat stress cannot be totally simulated. The TOC model uses compounded and accelerated decision making in conjunction with information overload, peer group pressure, and combat drills to approximate combat stress. Since the program exercise is a student reinforced, closed loop, scenario, the influence of peer pressure is important.

The Walter Reed Army Medical Center published the proceedings of its 1964 Symposium on the Medical Aspects of Stress Within the Military Climate. The report presented indications that concepts of stress, anxiety, and related processes may be quite misleading if taken literally as referring to unique functions or forces. Preferably, stress should be considered as an interaction of the individual and his environment with respect to particular modification of the information load, threat, and physiological damage. This report is in keeping with the 1966 findings of Bourne noted previously.[28]

SUMMARY

The literature identifies a need for multistimuli,

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[27] Peter G. Bourne, M.D., Men, Stress, and Vietnam Boston: Little Brown and Co., 1970), pp. 94, 95, 120, 121.

[28] Walter Reed Army Institute of Research, Symposium on the Medical Aspects of Stress Within the Military Climate (Washington: Walter Reed Army Medical Center, April 1964).

artificial environment, and induced stress simulation devices. Many agencies are developing independent devices but there is no evidence to indicate a coordinated effort in this pursuit.

Despite LTG Gribble's testimony that the Army had a deficiency in its ability to integrate the tactical operation center's control functions and HumRRO's consistent recommendations for advanced simulation techniques, the TOC model remains relegated to serving as a training model for a comparatively small number of army students.

In July, 1971, Headquarters, United States Army Security Agency submitted the design and construction proposals for the TOC model to the Office of the Assistant Chief of Staff for Force Development (ACSFOR) for its consideration. ACSFOR forwarded the proposals to the Command and General Staff College at Fort Leavenworth, Kansas, for evaluation. The Command and General Staff College serves as a focal point for combined arms training. Despite the "New Initiative Program" and its attendant emphasis on the Integrated Battlefield Control System, the college returned the design as unsuitable for current training needs. Evaluators at the college did not observe the TOC model in the conduct of training. In fact, they did not visit the United States Army Security Agency Training Center and School to perform an evaluation at any level. The design was simply dismissed as a matter of expediency despite its operant success for a period in excess of one year. This evaluation resulted in ACSFOR returning the design to Headquarters, USASA without action.[29] Concurrently, the literature reports on a need for the development of a TOC model. In 1971, General Norris, Office of the Chief of Staff, Department of the Army, conducted a survey of the Army educational system. After examining the TOC model he identified it as one of only a few good training systems which should be emulated and one having application outside of the confines of the Army Security Agency.[30]

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[29]Department of the Army, Headquarters, United States Army Security Agency, Arlington Hall Station, Virginia 22212, Attn: CPMD, Suggestion 71-649.

[30]Major General Frank W. Norris, "Review of the Army Officer Educational System," Vol. III, Annex A (Good Programs), Office of the Army Chief of Staff, Washington, D.C., 1972.

Chapter III

THE TACTICAL OPERATIONS CENTER MODEL

A review of the problem statement, the general situation, and the professional literature, related in Chapters I and II of this report, suggested the design of a training model. The model, referred to as the tactical operations center model or by its acronym the TOC, is described as an academic substitute that simulates the capabilities of a USASA tactical unit. Its design was directed toward simulating the behavioral job descriptions required in officer military occupational specialties 9610, 9620, 9630, and 9640. A screening of USASA tactical unit "Lesson Learned Reports" submitted during the Vietnam War and a review of the United States Army Security Agency's "Career Management Evaluation of Officers," Project CAMEO, provided a basic outline of behavioral job descriptions.[1] The military occupational specialties noted above are the basic USASA officer specialties and are discussed in greater detail in Appendix A of this report. Behavioral job descriptions for USASA enlisted men had been completed

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[1] "Career Management Evaluation of Officers," Project CAMEO, Hqs, United States Army Security Agency Training Center and School, Fort Devens, Massachusetts, Dr. C. L. John Legere, 1969.

by the command and were instrumental in designing a TOC system for use in the training of enlisted personnel.

The TOC was originally designed to fulfill the training requirement of the officer courses of instruction; however, it has proven to have as much application in the conduct of enlisted courses of instruction. An additional and unforeseen advantage has been the combat simulation provided to enlisted women who subsequently began training at the USASA Training Center and School. The training model has provided significant information pertaining to the integration of male and female personnel under stress situations.

The chief purpose of the TOC is to provide a training and testing vehicle by which to measure individuals in the performance of tasks that they may be expected to perform upon completion of their training cycle. It affords an opportunity to observe and conduct behavioral testing and to induce controlled stress within measured standards in both the training and testing environment. Significantly, the TOC offers the potential to teach students to cope with stress using socially acceptable defense mechanisms. Finally, it permits the training facility to provide analysis of both student and instructor performance.

In a simple example, assume that students are requested to complete the following task in conjunction with the exercise conducted during the evaluation period: "Student must submit an Equipment Improvement Report, DA Form 2407, indicating that the X-mode cable connecting the AN/PRC 25 radio to its associated KY-8 speech security set has a manufacturing limitation. The X-mode cable plugs are easily broken. Task must be completed in fifteen minutes. Student may use reference material." Should a significant portion of the class be unable to complete this requirement as specified, the result may indicate that even though the class had previously performed satisfactorily on the objective test for this instruction, their instruction had been inadequate for applicatory testing and performance. If this is the case, then the instruction is assumed to have been inadequate since the goal is not to condition students to perform on objective tests but to apply their instruction to requirements presented in the field.

DESIGN AND FUNCTION

Figures 3.1 and 3.2 illustrate the entrance to the TOC facility. The TOC occupies a four room complex encompassing about 3,000 square feet. The instructional portion of the facility is contained in two rooms consisting of a 12' x 25' terrain board at HO scale (¼":1'); thirty-two student cubicles; an 8' x 16' map projection of the terrain board; and an eight-net, seventeen station simulated brigade level VHF radio system. Tactical maps of the terrain board at 1:40,000 scale; a functioning communications center with a half-duplex circuit; a division tactical operations center's Electronic Warfare Element, EWE; a Signal Support Element, SSE; model military equipment at HO scale; HO scale cargo aircraft and railroad loading facilities; and a closed

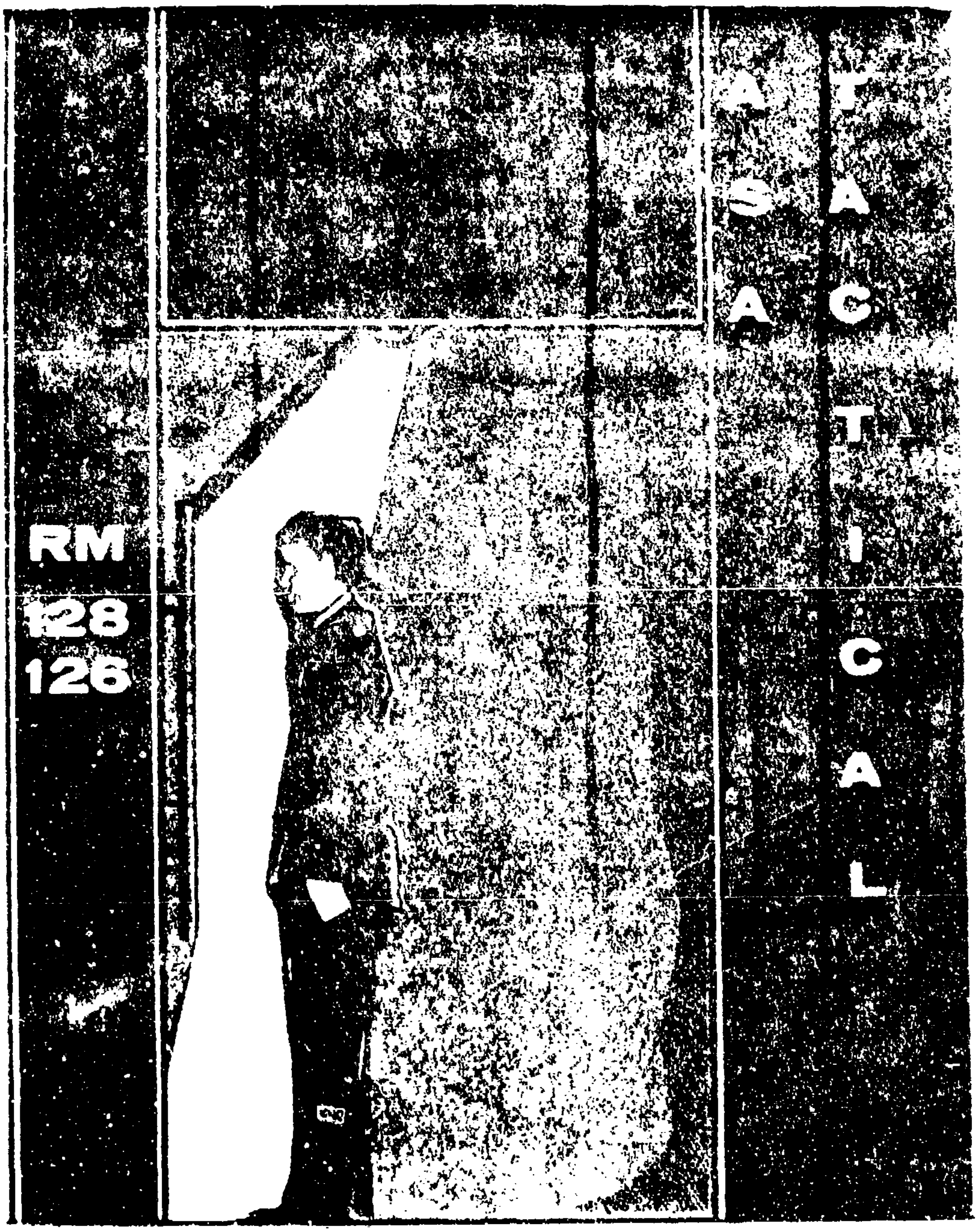

Figure 3.1

TOC Entrance

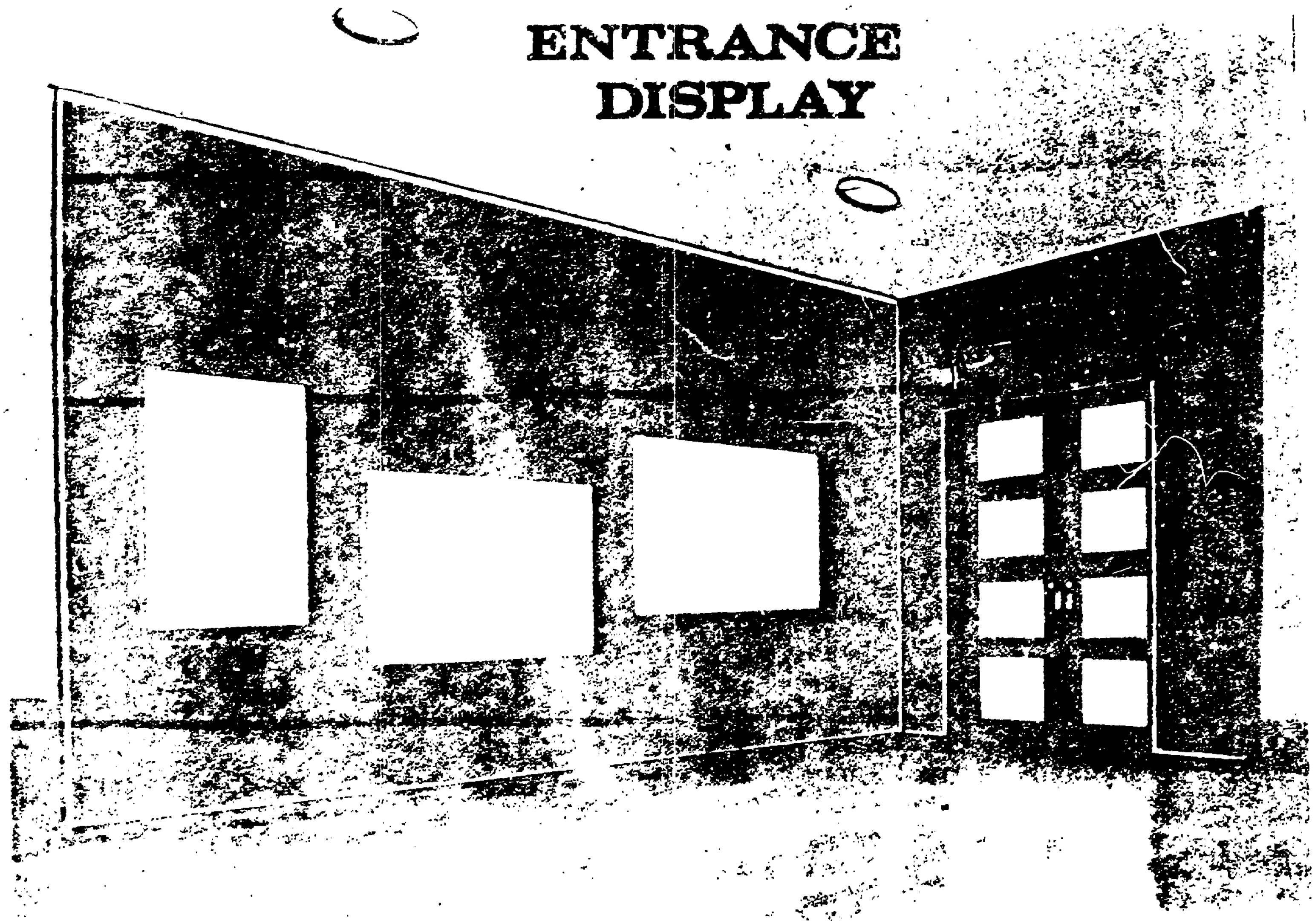

Figure 3.2

TOC Entrance Display

circuit television system are included in the training model.

The facility presently occupies two large rooms which can be isolated from one another as shown in Figures 3.3 and 3.4. The rooms are identified as the BLUE and RED rooms respectively to denote the friendly and aggressor control functions.

The BLUE room consists of the terrain board, student command cubicles, the brigade radio system, and the controller's position. The electro-optic system which will be discussed in detail in the following chapter and the closed circuit television system are oriented to the terrain board in the BLUE room.

The RED room is comprised of student cubicles, the map projection, radio intercept positions used for either communication security or low level voice intercept (LLVI), and the electro-optic system display consoles. Additionally, the RED room contains the position management section, the division tactical operations center, and the communications center. The intercept cubicles in the RED room can monitor communications originated in and between all cubicles in the BLUE room. The BLUE SSI-SOI has been designed so as to be easily attacked by cryptanalysis. The brigade radio system has been designed so that its effect upon the RED intercept positions is one of intercepting a series of simplex nets; that is, it requires two intercept positions to copy both sides of a BLUE room communication. This aspect stresses position management on the part of the RED SIGINT effort.

RED ROOM

BLUE ROOM

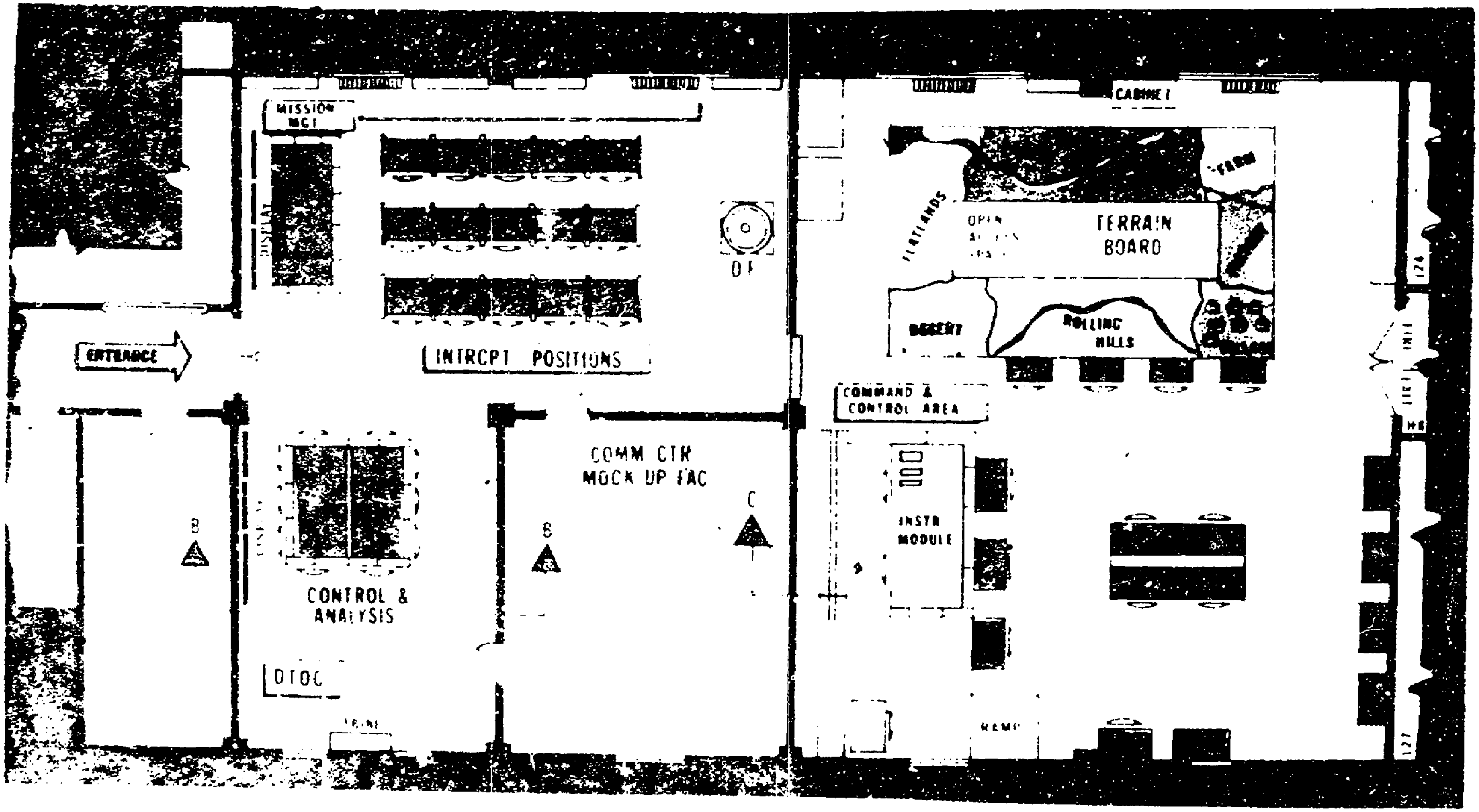

Figure 3.3

TOC Floor Plan--Overhead View

NOTE:
Key to Figure 3.3
on following page

Arrow B indicates input of control and analysis product to Communications Center for transmission to other USASA units.

Arrow C indicates half-duplex communications circuit which provides intelligence product between the RED force DTOC and the instructor-controller.

Students playing roles within the BLUE Force are identified by numbers 1 through 16:

1. S4 Officer
2. Bde Commander
3. Bde S3
4. Bde Intelligence Officer (S2)
5. USASA Division Support Company Commander
6. Fire Direction Center
7. Battalion Commander
8. Battalion Commander
9. Supply and Transportation Battalion Commander
10. Battalion Commander
11. Battalion Commander
12. Net Control Station
13. S3-Air Officer and FSCC
14. Artillery Battalion Commander
15. Engineer Battalion Commander
16. Military Intelligence Detachment Commander

Key to Figure 3.3

TOC Floor Plan--Overhead View

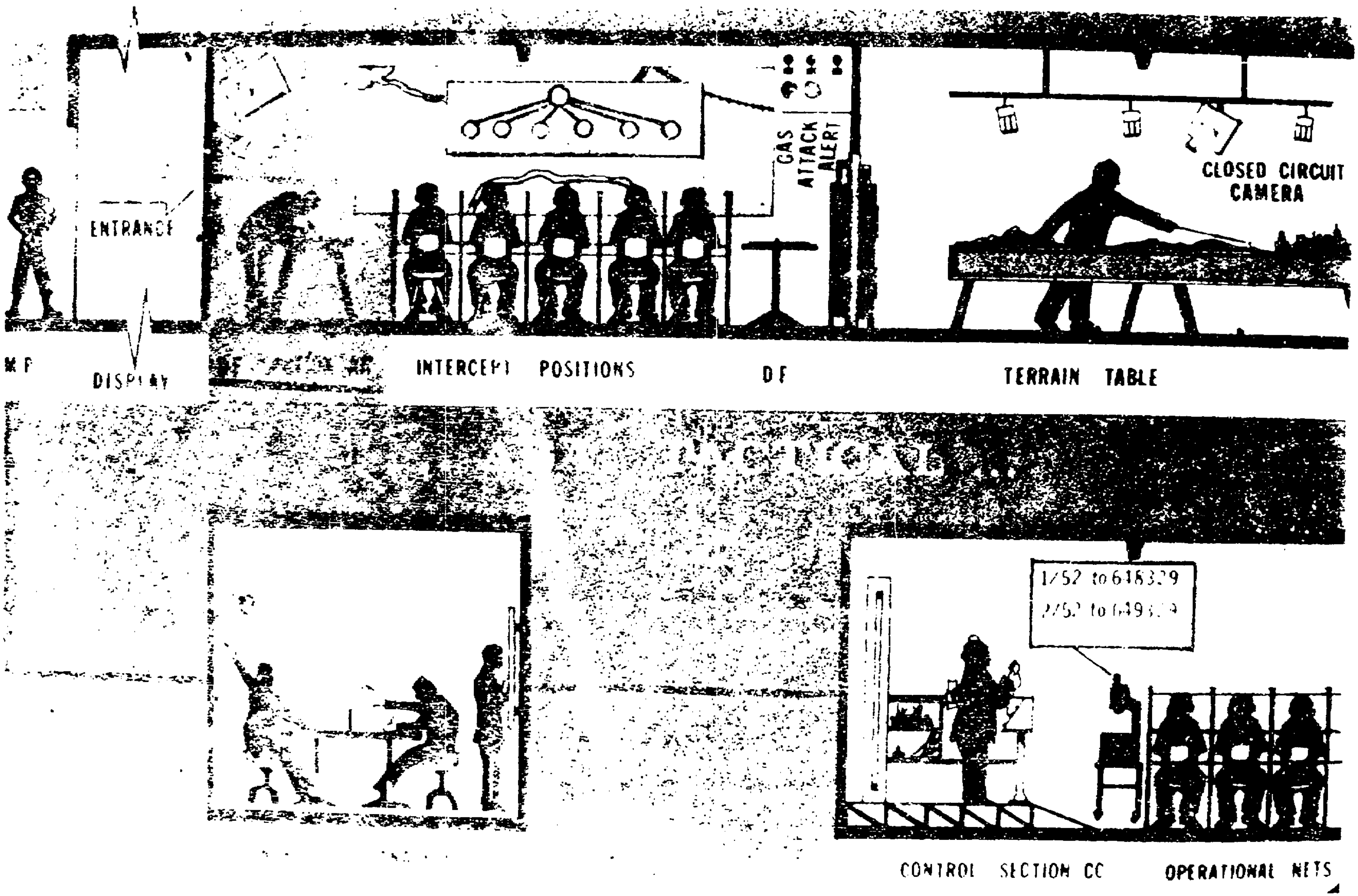

Figure 3.4

TOC Floor Plan--Side View

Figure 3.5 illustrates the student cubicles in both the RED and BLUE rooms. Each cubicle contains a work area, a tactical scale map of the terrain board, and a radio set simulated by an intercom which permits realistic communications possessing the inherent assets and limitations of FM tactical communications. The RED room student cubicle is similar to the BLUE room cubicle, but its communication set is restricted to the functions of monitoring, imitative communications deception, and jamming. RED room cubicles do not provide an intercommunications capability. Appendix B, Communications System Wiring Diagrams, presents the technical aspects of the brigade level simulated radio system.

Instruction in military tactics is not the principal objective of the TOC; rather, it serves as an important incidental accomplishment. The tactical environment serves as the mechanical catalyst by which to develop a communications and managerial problem. Emphasis is placed on the sequence of commander and staff actions.[2]

There are two opposing forces represented by HO scale model military equipment appropriately painted RED and BLUE. The models are excellent replicas of equipment standard to both United States and Soviet forces. The RED force is operated by the instructor-controller and the BLUE

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[2]Department of the Army. FM 101-5, Staff Officers' Field Manual, Staff Organization and Procedure, Chapter 5. July 1972.

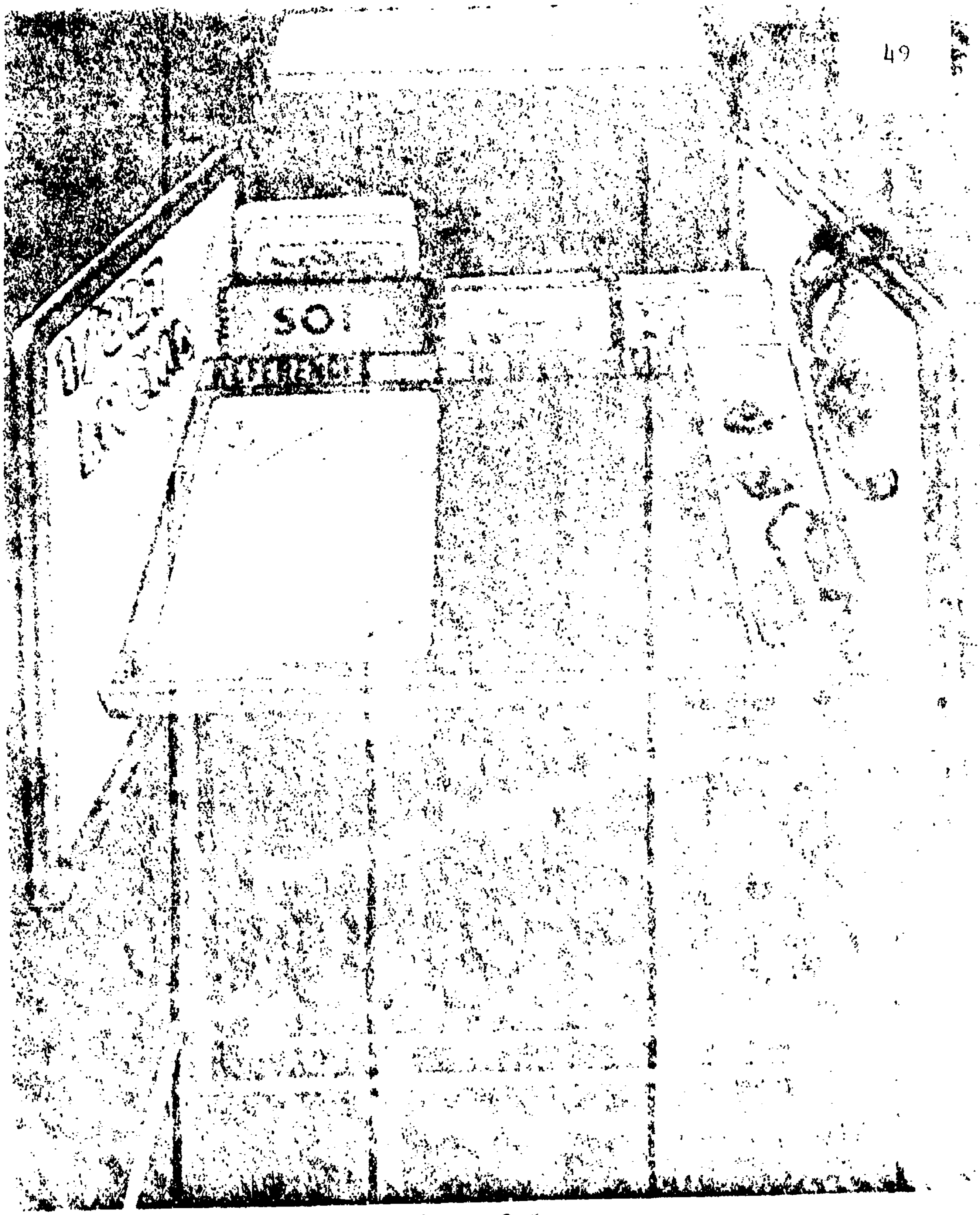

Figure 3.5

TOC Student Cubicle

force is operated by Group A of the student class--the student class having been divided previously into groups A and B. Though there is an inherent competition between the instructor and the students, this is not the chief consideration. The RED force is deliberately configured with respect to quantity and capability of its equipment so as to afford the instructor domination of the battlefield by which to structure the progress of the problem.

The TOC Operation Manual outlines the concept of the training facility and introduces an elementary system for using the device effectively. Essentially the system is an analysis of those steps and tasks which must be introduced into the training exercise in specific sequence, coordination, and convergence. However, the exercise conducted within this model is not predicated upon a scenario. The flow of the problem is determined by student participation and is a continuous link exercise. The system program permits the instructor to induce stress or to accelerate exercise requirements for individual students or the entire group.

As presently organized, the BLUE room is designed to serve as the command function of a brigade size unit, thus enabling each student to participate in the problems and responsibilities incurred by their supported commanders in the field. Role-sharing creates a definite appreciation for the problems of others and provides an insight into the true dimension of ASA support requirements. The RED room is designed to serve functionally as the operational element of an ASA divisional support company or separate detachment employing low level voice intercept (LLVI). Included in the RED room is a communications center deliberately constructed with multi-deficiencies which are the subject of a crypto-facility inspection performed by students. The aggressor TOC, located in the RED room, operates in compliance with the doctrinal concept of ASA-75.

NON-ASA FUNCTIONS

One of the major advantages of the RED room is that it is extremely versatile. It is, as an example, easily converted from an operational function of a support company into a communications security function, affording communications security training to both ASA personnel and personnel assigned to conventional field units. The entire project can be built into expansible vans affording a mobile training team capable of teaching communications security as it travels to active and reserve force units at their stations or armories. See Figure 3.6. The mobile team could easily add a new and active role to ROTC training. The visited unit commander would assign his officers to specific roles in the BLUE van and conduct a command post exercise (CPX) while his supporting ASA unit provided a COMSEC evaluation in the RED vans. Other members of the commander's staff could engage in intelligence processing and evaluation from the data provided by the COMSEC effort which also is essentially LLVI. An ideal situation could include newly assigned and junior officers performing as principal participants while more experienced officers

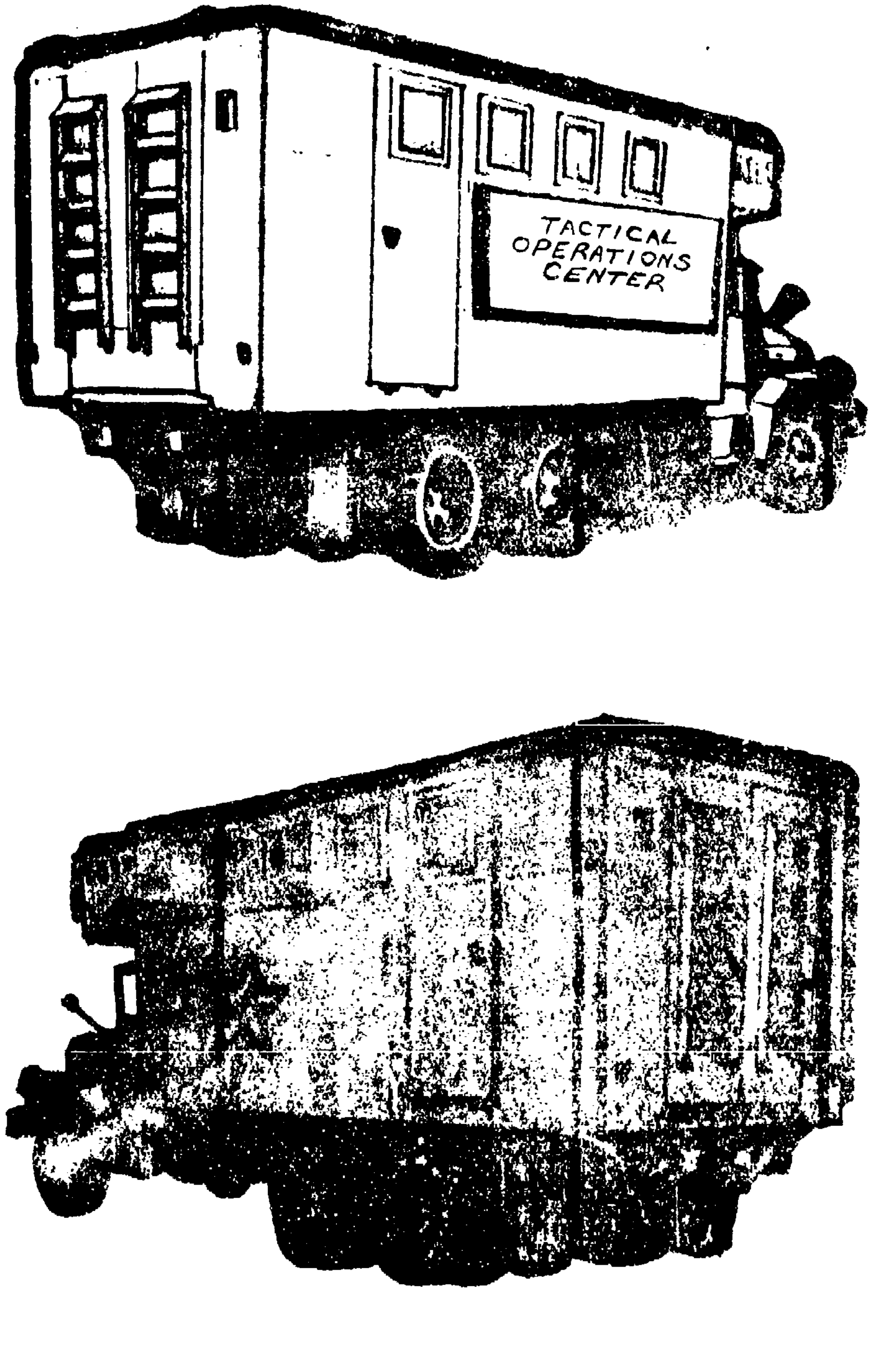

Figure 3.6

TOC Mounted in M-292 Van

served as their advisors during the exercise in order to more effectively execute the sequence of command and staff operating procedures and techniques peculiar to the unit. Rather than expend valuable time, equipment usage, maintenance, and fuel in a typical CPX, in which individual radio positions disperse over the post's training area, the mobile TOC could be used with the added advantages of immediate feedback and an opportunity for participants to grasp the situation in its entire perspective. This latter advantage overcomes the most serious shortcoming of the CPX conducted in the field.

The purpose of the TOC should not be mistaken as a replacement for field training. To the contrary, it makes field training, when conducted, a more manageable and efficient undertaking. The TOC offers an optimum facility with which to train commanders and staff and even non-commissioned officers to perform effectively as a team. The TOC requires good communication procedures and communications management, both of which are serious weaknesses in the United States Army. The TOC requires management of resources, staff coordination, and cooperation, and will produce success only when army procedures are conducted properly. It does not reward innovated temporary solutions to minor problems at the expense of aggravating major crises in the long term.

The TOC is not merely another "map exercise" or another terrain table problem. It is not simply a game. It is a complex exercise incorporating all the advantages of the map exercise and terrain table with the action and incentive afforded by competition; but most importantly, the crucial aspect of communications and communications security is interjected as the lubricant for the entire exercise. Experience with the pilot project indicates that it places more stress upon the student and requires more functional ability than does a CPX. It prepares a command to conduct a profitable CPX or FTX, rather than expending time in a futile training exercise because of a lack of practice and understanding of key concepts.

INDUCED STRESS AND BEHAVIORAL EVALUATION

The benefits of the TOC are not relegated only to those aspects outlined above. It also includes a potentia for behavior evaluation. The exercise is run in sequential and continuous twenty minute cycles over a period of eighteen hours as outlined in the exercise program. Each cycle is termed a "period." There is no programmed cessation of the exercise for break time. The student determines when he can afford to leave to [illegible] or rest. Behavior task cards are continually introduced in the BLUE room. Each task card requires the student to complete a specific task in a given amount of time. Accomplishment of the task is keyed to clearly defined steps and reference material available in the BLUE room. The tasks are based on situations frequently arising in combat and require the student to function in all general and basic areas of military management. A task is presented to the student and he evaluates a problem described on the card. As an example, a 1¼ ton truck, 4x4, M715, FSN 2323-921-6365, needs a specific spare part (brake band for rear wheel). The student must then reference the appropriate manual (TM 9-2320-244-20) (P series) and identify the correct spare part and its part number. He must then submit a DA Form 2765-1 to the Brigade S4 and make the proper entries on his document register and the vehicle log book. By accelerating these tasks with respect to time or complexity, information overload, a form of induced stress, may be created.

The task cards are normally presented in a sequential pattern programmed to structure the conduct of the exercise. The tasks progress from elementary to extremely difficult. The variety and number of tasks remain limited only by imagination. In the pilot project, they include artillery fire missions, resupply requests, troubleshooting, air support missions, air-loading, rail-loading, implementation of modified work orders, equipment improvement recommendations (EIR's), use of equipment log books, computing fuel and ammunition expenditures, and many others. The magnitude and complexity of the task cards are adjusted to the capability of the class involved so that the technique is of value to either ROTC students or officers in the grade of captain. The exercise program may be either accelerated or decelerated by the instructor based on the stress situation appropriate for each individual and group. One instructor is assigned for every five students to provide on-the-spot correction and assistance.

The TOC provides a mixture of realism, action, competition, and application as an exciting alternative to tedious and unimaginative classroom lecture and multiple choice examinations.

One of a series of alarms requires students to use their protective mask while performing their roles during a simulated gas attack. Another alarm requires an orderly and systematic protection of classified documents and waste material prior to evacuating the aggressor TOC during an enemy ground attack. Students assigned to key leadership positions are summarily replaced at crucial periods during the exercise requiring other students to instantly step into these key positions. These battle drills provide another integration of induced stress. Red lights, creating personality abrasiveness, are used during part of the problem.

The entire training exercise is structured to a large extent by the students themselves. First they are encouraged to practice their part of the exercise as a class, to develop operating procedures and to execute proper actions upon the breakdown of communication. They enter the exercise prepared as a class to work together. The controller provides structure and direction only by virtue of his superior RED force and enforcement of the rules of the game. The students, however, control the individual aspects of the problem and are rewarded immediately for their ability and innovation. The chastisement afforded by the peer group either effectively eliminates a lackadaisical attitude or results in recommended replacement of an incompetent contemporary. Peer pressure is another method of inducing stress.

It is a continuous link problem as demonstrated by Figure 3.7. As the students operating the BLUE force commit their units, the students operating the RED intelligence function begin to develop the intelligence aspect of the problem and feed it back to the RED force operated by the controller. The BLUE communications security officer gains insight into the RED intelligence effort and successes and he attempts to brief the BLUE force on its communications weaknesses. But the BLUE communications security officer typically finds his fellow BLUE students (who have completed two weeks of communications security training in the 2G-F12 course) not willing to sacrifice mobility for security. Hence another practical learning advantage. There are countless others.

The TOC introduces the student lieutenant to the magnitude of responsibility incurred by a commissioned officer. Many of the students in the pilot project are awed by the complexity of the actual operations after participating in this program.

CLOSED CIRCUIT TELEVISION SIMULATION OF AERIAL PHOTOGRAPHY

The students in the BLUE room are dependent upon abstract recollection of the disposition of their simulated units. A tactical scale map assists the student in maintaining his relationship to his positions on the terrain

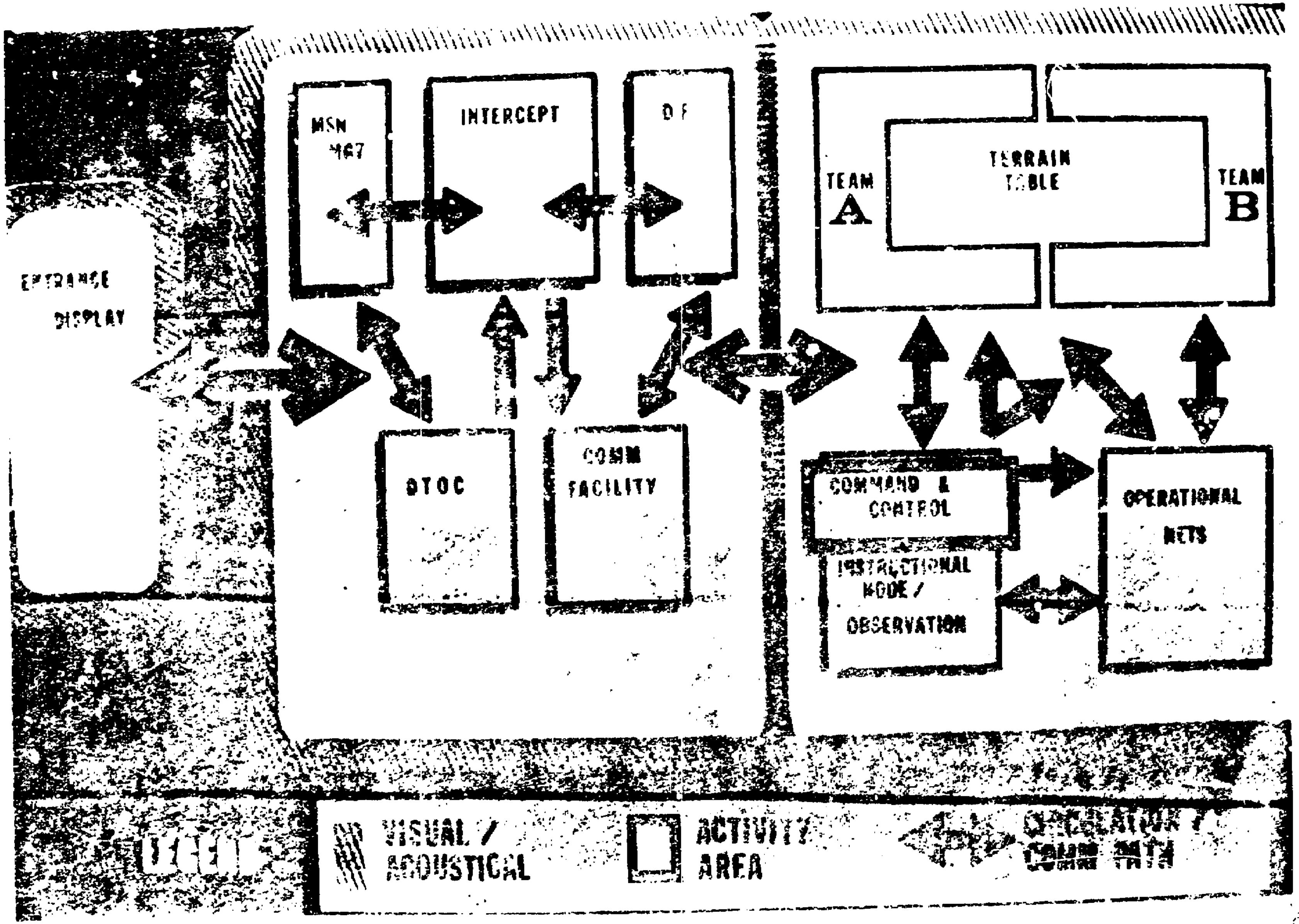

Figure 3.7

TOC Information Flow

board after the exercise begins. Students' positions are represented by HO scale model military equipment exact in detail to that equipment normally used by the major units which the students are controlling. Figure 3.8 illustrates the detail of a M-37 truck.

A closed circuit television (CCTV), free of radiation problems, is used to simulate high resolution aerial photography and infrared detection devices. The students in both the BLUE or RED rooms are allocated aerial photography and infrared reconnaissance missions. These missions are simulated by the CCTV system. The CCTV system is installed over the terrain board to simulate high resolution aerial photography. Adjustment of the CCTV's resolution and contrast provides an excellent simulation of infrared as well. The pan and tilt capability of the CCTV system permits an excellent method of instructing students in the effects gained by the different types of aerial photography normally available from MIBARS units.

The video camera is mounted in a dolly which tracks laterally and horizontally across the terrain board while permitting the camera to be aimed by panning 360 degrees at 30 degrees per second nominal speed and to be aimed tilting 45 degrees at a nominal speed of 2 degrees per second. Track, pan, tilt, and a zoom lens (16mm to 64 mm telephoto) may be controlled from a remote position at the controlling position. The video picture is displayed in black and white on several television monitors located in both the BLUE and RED rooms. The controller may also control

Figure 3.8
M37 Model Truck at HO Scale

the monitors. The controller responds to aerial reconnaissance or infrared missions submitted as requests for preplanned or immediate tactical air reconnaissance missions. The instructor may also use the CCTV to maintain control of the exercise.

The CCTV system utilizes a Sony model AVC 3200 video camera capable of performing with excellent results with only that light afforded by the classrooms overhead flourescent lights. The camera uses a Sony model VCL 16B zoom lens. The Sony model CVM 192U monitor permits multiple viewing when connected in series. A recording capability is not necessary under these circumstances. The tracking system is a TRI-PAN model TP 4. Installation of both the CCTV and tracking systems was completed by the school's facilities engineers and facilities branch of the training aids section. Technical specifications are provided in Appendix C, Closed Circuit Television (CCTV) Technical Specifications.[3] Similar simulation is now employed by the University of California, Berkeley, in a "dynamic simulation" to improve the Bay Area City Planning functions.[4]

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[3]The Sony equipment is readily available from a Sony dealer. The TRI-PAN tracking system was purchased under government contract from the Centurion Products Division, Megatronics, Inc., 7607 Page Blvd., St. Louis, Missouri 63133.

[4]"TV Tours Scale-Model Cities," Popular Mechanics, December 1972, p. 68.

SIMULATION OF STANO EQUIPMENT

STANO equipment is simulated by electronic, electro-optical, and acoustic devices which are then interjected by the controller as collateral intelligence.

TRAINING AND BEHAVIORAL OBJECTIVES

Several examples of training and behavioral objectives are presented in this section. In these examples, the objectives are typical of those selected for officers attending the Basic Cryptologic Officer's Course, 2G-F12.

Tactics

1. The student must make estimates of the situation.
2. The student must formulate operations plans and orders.
3. The student must deploy battalion size forces.
4. The student must call for artillery strikes.
5. The student must call for tactical air strikes.
6. The student must manage battalion/brigade size units.

Logistics and Maintenance Requirements

1. The student must submit equipment improvement reports.
2. The student must implement modified work orders.
3. The student must estimate and requisition all classes of supplies.
4. The student must institute preventive maintenance programs.

Map Reading

1. The student must use tactical scale maps to find and report his location.

2. The student must use tactical scale maps to explain the effect of terrain on tactical operations.

3. The student must maintain situation maps.

Radio Procedures

1. The student must use correct radio prowords.
2. The student must use the phonetic alphabet.
3. The student must practice good COMSEC.
4. The student must use military terminology.
5. The student must use communications management.
6. The student must use KAT codes.

Composition of U.S. Army Units

1. The student must be able to assess any Army unit's combat capability and employ it to the maximum advantage to influence the combat situation.

2. The student must carry out staff functions and identify and assign actions that are appropriate to various staff levels.

Personnel and Management

1. The student must manage personnel and resources.

2. The student must coordinate, control, and supervise the completion of a mission.

Intelligence

1. The student must examine and evaluate collateral

intelligence.

2. The student must maintain an intelligence workbook.

3. The student must maintain an intelligence collection plan.

4. The student must prepare an intelligence annex.

5. The student must prepare an intelligence estimate.

COMMUNICATIONS CENTER

As noted earlier in this chapter, a communications center was included in the RED room. The communications center provides a half-duplex circuit between the instructor-controller in the BLUE room and the students operating the aggressor TOC in the RED room. The communications center was deliberately designed with numerous violations of security regulations. Part of the student requirement is to identify security violations within the facility and to provide recommendations for correction of the violations.

The communications center consists of one automatic send-receive (ASR) model 35 and one model 1742 line printer. Computerization of the communications center can be effected by installing a secure telephone circuit between the center and the CDC model 1700 computer in an adjacent building, one model 103A2 Data Set, one CDC model 314 adapter, and one model 1749 controller multiplexer. A similar set of equipment is located in the BLUE room for use by the controller.

The communications center is used to transmit collateral intelligence reports from the controller-instructor in the BLUE room to the aggressor TOC. It is also used to transmit SIGINT product reports from the RED room intercept effort to other stations in a cryptologic reporting net. In actuality the SIGINT reports are dead-ended within the communications center. This system enables the instructor-controller to influence the exercise by providing additional data to the RED force or to integrate the evaluation of collateral intelligence with the evaluation of SIGINT. This should not be understood to mean that collateral and SIGINT are integrated in the training cycle or in the exercise.

MODEL COMPUTERIZATION

The training model may be readily computerized at minimum cost using existing computer equipment. Computerization of the model would enable the student to compute force development and force requirement figures on a real-time basis. Those portions of FM 101-10-1, "Staff Officers' Field Manual, Organizational, Technical, and Logistical Data," could be retained in memory for use by the students.[5] Additionally, students would be able to work simultaneously on completing programmed texts, programmed tasks, or responding to tasks programmed by the instructor. As noted in the previous section, the computer can be connected

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[5]Department of the Army. FM 101-10-1, Staff Officers' Field Manual, Organizational, Technical, and Logistical Data, July 1971.

into the communications center to provide programmed collateral intelligence or to correlate intelligence trends.

Computerization would require installation of fourteen model 33 KSR-keyboard send and receive sets (one per BLUE room student cubicle), fifteen model 103A data sets, fifteen CDC model 314 adapters (one per cubicle, two for controllers), one model 1749 controller multiplexer, one model 1732 magnetic tape controller, and two model 609 tape drives. It is at the point of computerization that information at the Army Electronic Warfare Information System can be utilized in expanding electronic warfare instruction within the various programs of instruction. By installing two model 1708 storage modules (4K), expanded storage can be provided for increased applications.

Computerization of the TOC is compatible with doctrinal concepts advanced in the United States Army Computer Systems Command's Developmental Tactical Operations System (DEVTOS II). The TOC computer system will support the Modern Army Selected Systems Test Evaluation and Review (MASSTER) and will provide student instruction permitting the integration of the TOC computerization into both the DEVTOS II and MASSTER concepts. Figure 3.9 illustrates the DEVTOS System. Figure 3.10 illustrates the TOC system.[6]

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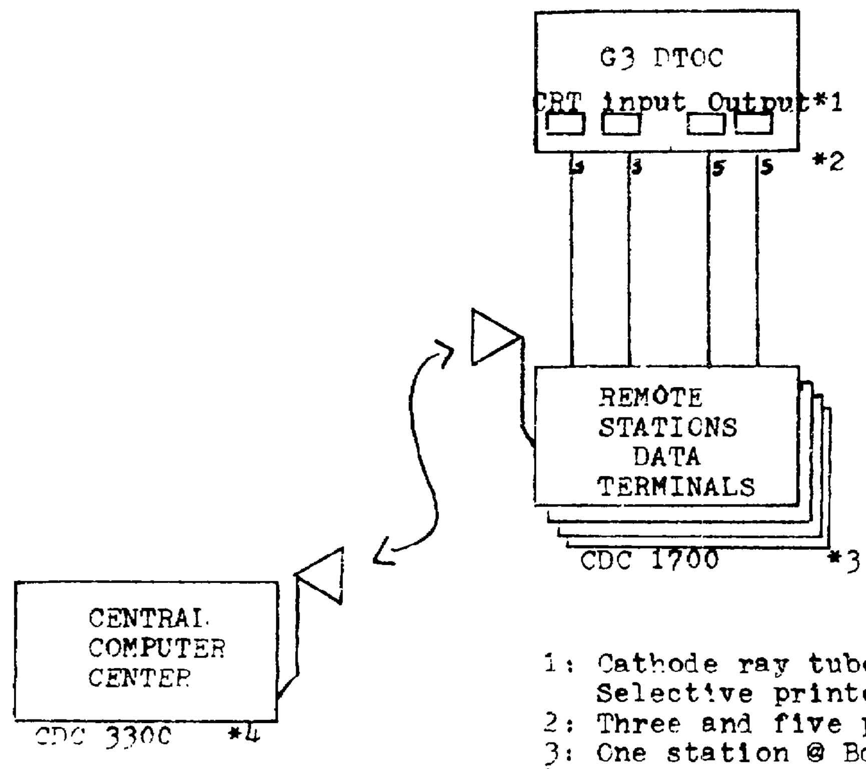
[6] TOS Development Group, United States Army Computer Systems Command. Technical Documentary Report, 1970, revised 1972.



1: Cathode ray tube inputs
   Selective printer output
2: Three and five pair cable
3: One station @ Bde, one station Div. Main
4: E.g. Division support command

Figure 3.9

DEVTCS System

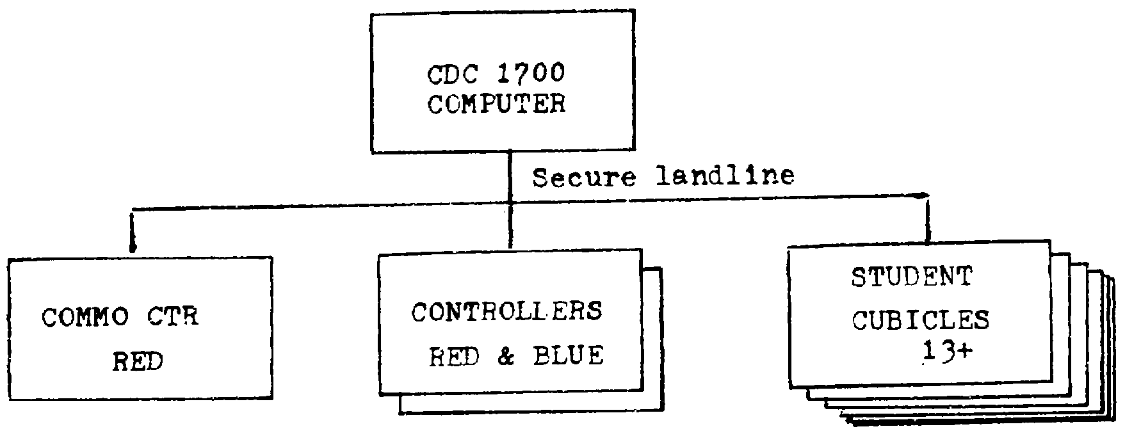


Figure 3.10

Tactical Operations Center Model
With Computer System

ELECTRO-OPTICS SYSTEM

The final subproject of the TOC model is the electro-optics system. The electro-optics system is an attempt to optically simulate an electronic battlefield. The electro-optics system presents an electronic battlefield consisting of SIGINT targets which include voice, CW, printer, and multichannel modes; non-COMINT emitters to include radars, telemetry, and beacons; COMINT and ELINT direction finding sites; airborne radio direction finding; and jamming transmissions. The electro-optic system provides a low cost alternative which does not produce a Temptest internal radiation security problem. Involvement of the National Security Agency is not required and there is no requirement to obtain Federal Communication Commission clearance. The electro-optic system is discussed in additional detail in Chapter IV of this report.

The experimental equipment discussed in Chapter IV has been designed, constructed, tested, and found to be a feasible subsystem. As of March, 1973, the TOC project involving construction of the electro-optic subsystem had begun. Most parts had arrived and completion of the subsystem is scheduled for March, 1974.

The electro-optic subsystem is presented as a continuation of the methodology in a separate chapter, Chapter IV, to distinguish the technical innovation of the subsystem from the other simulation techniques.

Chapter IV

ELECTRO-OPTIC SIMULATION

Light waves offer the potential of being the greatest communication medium within the electromagnetic spectrum. This central theory first observed by the 19th century English physicist James Clark Maxwell was inspired by Michael Faraday's earlier basic discoveries in electric power. Maxwell's eloquent equations illustrated that all forms of energy to include heat, light, sound, and electric current, among others, are wave-particle phenomena. All forms of energy may be distinguished by their wave length and may be converted from one form to another.

The use of light waves to simulate radio wave propagation presents an application of Maxwell's basic theory. However, the use of light waves to carry radio wave originated communication is a quantum jump to an entirely new application of ultra-shortwave transmission. After experiments simulating radio wave propagation with light waves were concluded and found to be successful, additional experiments were conducted to determine if light waves were capable of transmitting radio wave originated communication. These experiments at the United States Army Security Agency Training Center and School TOC model indicated that electro-optic simulation was feasible and successful.[1]

Radio and radar transmitter and receiver characteristics can be duplicated using visible radiation. A high intensity light source can be modulated to simulate a radio transmitter. Various lens and aperture configurations can be used to demonstrate the concepts of antenna gain and the directional characteristics of high gain antennae. The radiation pattern of the light source can be observed directly by the student. The characteristics of a receiver system also can be simulated with a light sensitive detector. The modulated light source will be sensed by the detector. The resulting signal from the detector can be used to modulate an audio oscillator and also can be displayed on an oscilloscope. This will give the student both a qualitative and a quantitative representation of the signal characteristics for different antenna gains, levels of background noise, and the effects of a jamming signal. The simplicity of the transmitter and receiver will allow a graphic and easily understood demonstration of such concepts as the reciprocal nature of receiving and transmitting antennae, the direct relation of antenna gain, directivity, and similar phenomena. Color filters can be employed to simulate the radio frequency of both receiver and transmitter (e.g., a red transmitting light can be detected only by a receiver with a red filter). The

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[1]Lawerence Lessing, "Communicating on a Beam of Light," Fortune, March, 1973, p. 119.

pulse rate of the transmitter can be used to identify the transmitting station. This in effect will represent the station call sign and can be changed as the training situation develops. The extent to which the scale factor now in use on the problem board can be maintained in the optical simulation will depend on the sensitivity of the detectors used. This is the most sensitive item in attempting to determine cost and performance levels of the proposed system. A more detailed analysis will be required during the future designing stages to determine the cost/performance trade-offs. Three different performance levels are outlined: minimum, nominal, and advanced.

Minimum Performance Requirement

1. Demonstrate line of sight propagation characteristics.
2. Demonstrate direction finding principles.
3. Demonstrate antenna gain effects on directivity and range.
4. The scale factor will not be maintained.
5. All transmitter and receiver sites will be fixed.
6. All transmissions to be on one frequency.

Nominal Performance Requirement

1. Demonstrate line of sight propagation characteristics.
2. Demonstrate direction finding principles.
3. Demonstrate antenna gain effects on directivity and range.

4. Demonstrate complex working net in operation.

5. Demonstrate signal jamming effects.

6. Transmitter and receiver sites will be movable.

7. Scale factor will not be maintained.

Advanced Performance Requirement

1. Demonstrate line of sight propagation characteristics.

2. Demonstrate direction finding principles.

3. Demonstrate antenna gain effects on directivity and range.

4. Demonstrate complex working net operation.

5. Demonstrate signal jamming effects.

6. Demonstrate multi-channel data links in operation.

7. Use variable gain antennae to demonstrate communications security concepts.

8. All intercept will be remotely controlled from an intercept position.

9. All transmitter and receiver sites will be movable.

10. Additional modulation modes will be available to simulate different transmission modes, manual Morse, printer, voice, data, et cetera.

ELECTRO-OPTIC OBJECTIVE

The general objective of simulating radio and radar transmission characteristics using optical devices is to assist the student by demonstrating certain fundamental concepts of radio waves. More specifically this training aid should impress upon the student the consequences of these physical phenomena as they occur in the employment of ASA resources in the field.

APPROACH

The student will encounter optical simulation of radio and radar transmitters and receivers in problem solving and practical application situations where the results of proper understanding and the consequences of improper understanding are graphically evident. In cases where direct student participation is not feasible a controlled demonstration will be employed. This will afford the student the opportunity for total comprehension of the physical principles which can be accurately simulated in a classroom environment while allowing little chance for misunderstanding in situations where the simulation is not complete. In the controlled situation the instructor will actively demonstrate the propagation characteristic and its implications in mission management while pointing out the limitations of the simulation employed.

LIMITATIONS

Light waves and radio waves are both electromagnetic radiation governed by the same physical laws and in principle all propagation phenomena can be demonstrated either at radio or optical frequencies. However, due to the dramatic difference in the scale factor of the two cases, optical simulation in some instances is monetarily unreasonable and graphically useless. These cases would require a controlled demonstration of the principle involved and would be more accurately described as visual aids rather than optical simulators.

CAPABILITIES

The system is a relatively straightforward system which will accurately demonstrate the following propagation concepts:

1. Line of sight properties.
2. Effects of antenna gain on maximum usable range.
3. Relation of antenna gain and directionality.
4. Effects of electromagnetic interference.
5. Jamming concepts.

The above capabilities provide an accurate and essentially complete simulation of tactical operations. Significant propagation effects for strategic operations cannot be accurately simulated in a classroom situation. A limited demonstration of these principles could be accomplished in a controlled situation. Some of these properties include:

1. Refraction of radio waves.
2. Ionospheric effects.
3. Terrain effects on propagation.
4. Effects of antenna geometry on radiation patterns.

In essence it includes all of the nominal performance requirements and some of the advanced performance requirements. A more detailed description of the device's capabilities is included in Appendix D, Technical Aspects of Electro-Optic Simulation.

The total electronic environment may be simulated by six different types of receiving and transmitting devices. They include:

1. Omnidirectional transmitter.
2. Directional multiplex transmitter.
3. Directional jamming transmitter.
4. Directional radar transmitter.
5. Omnidirectional receiver.
6. Direction finding receiver.

The collection mission from the intercept site and three direction finding sites is completely controlled from a single remote position. See Figure 4.1. The same receiving equipment is utilized in two modes of operation. One mode simulates communications reception and the second, noncommunications reception. The capability of operating a four-station communications net exists on the opposite side of the board. A two-channel printer simulation is included in the net. Radar transmitters with scan characteristics are available. In addition, a direction jamming transmitter is capable of imposing varying degrees of interference when targeted against the opposing force's receiving sites.

The general capabilities of each of the individual devices are outlined below:

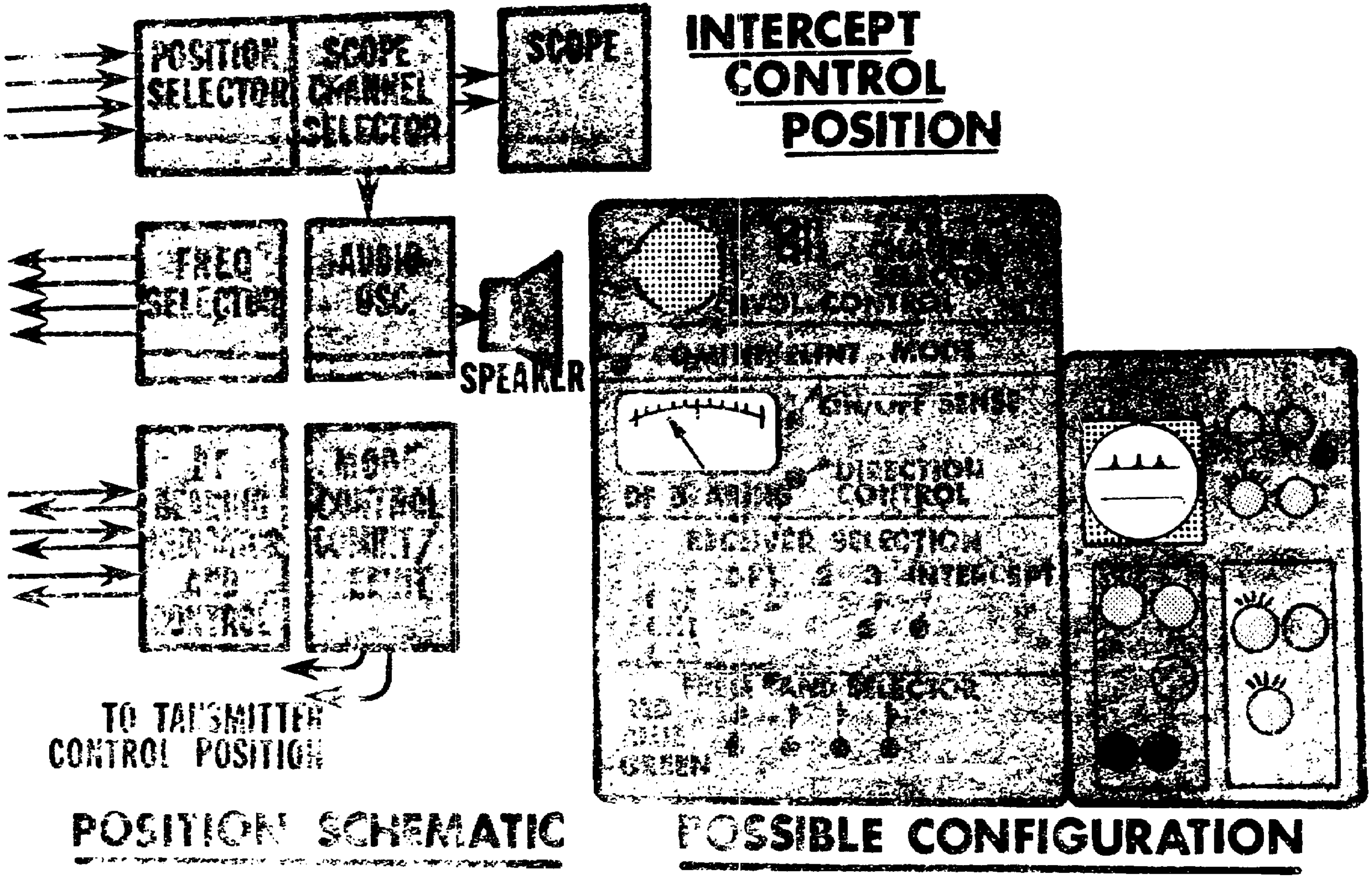

Figure 4.3

Master Remote Control Panel

1. Omnidirectional transmitter. This is the simplest of all the devices employed. It is basically a selectable rate strobe lamp capable of pulsing from one to fifteen times per second. A color filter can be employed to represent stations operating on different frequencies. The pulse rate can be representative of the station call sign. Higher gain antennae can be simulated using a reflector or lens with the same lamp source. See Figure 4.2 and Figure 4.3.

2. Directional multiplex transmitter. A two channel time division multiple transmitter with radioprinter signal format can be simulated using a high intensity lamp, two-lens collimator, and a rotating disc as shown in Figure 4.4. The first lens images the lamp near the rotating discs. Perforations in the first layer of the disc correspond to a printer code and the second layer alternates the color of the transmitted light simulating time division multiplexing. The second lens collimates the transmitted light resulting in a directional signal beam.

3. Directional jamming transmitter. The directional jammer (Figure 4.5) is a collimated white light source of variable intensity. When directed toward a receiving antenna the interference is controllable from a nuisance level to totally obliterating the normal signal.

4. Directional radar transmitter. This device employs a collimated light source with a rotating mirror to simulate a scanning radar (Figure 4.6). The basic

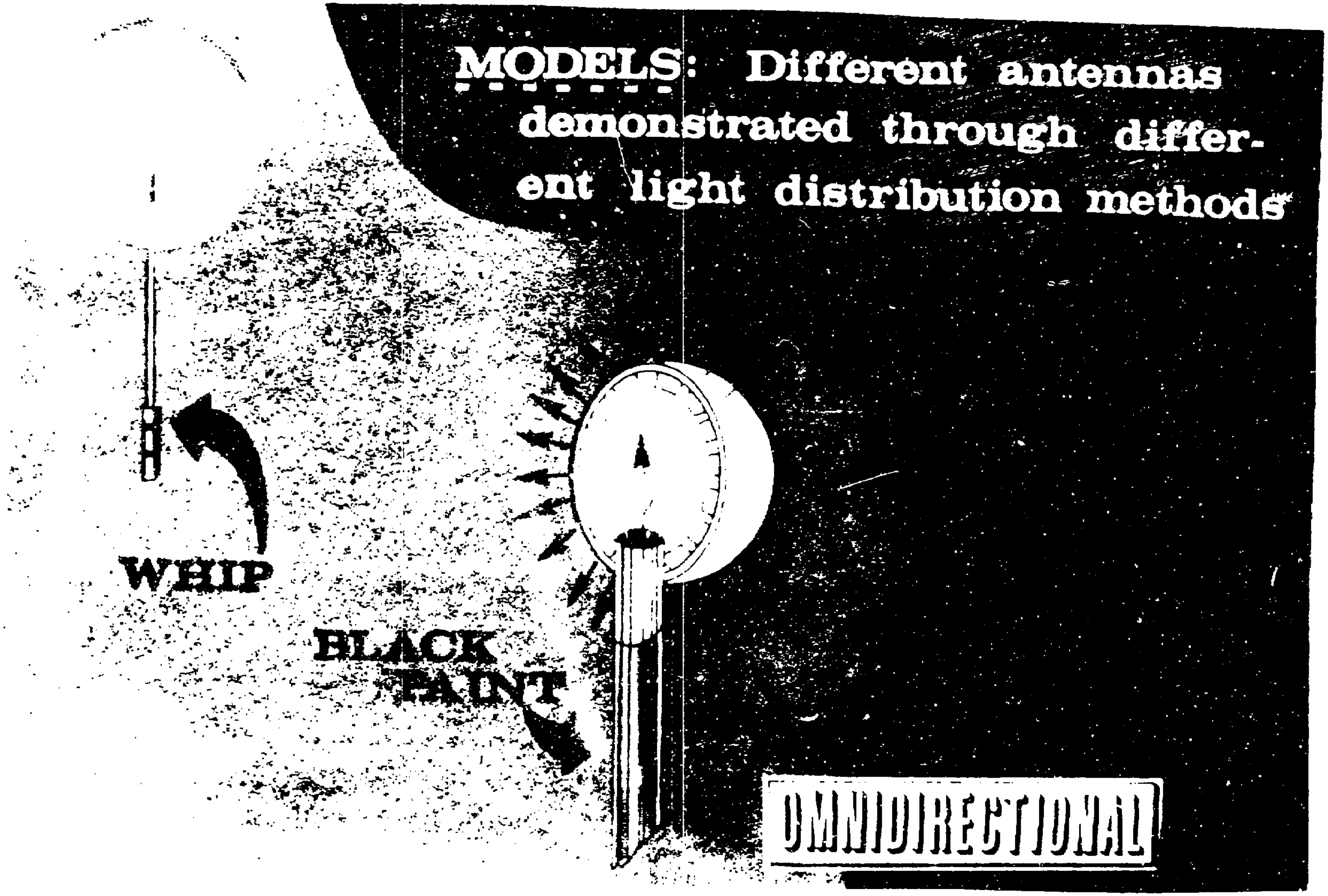

Figure 4.2

Omnidirectional Light Distribution Model
Depicted As Whip Antenna With
Close-Up of Antenna Tip

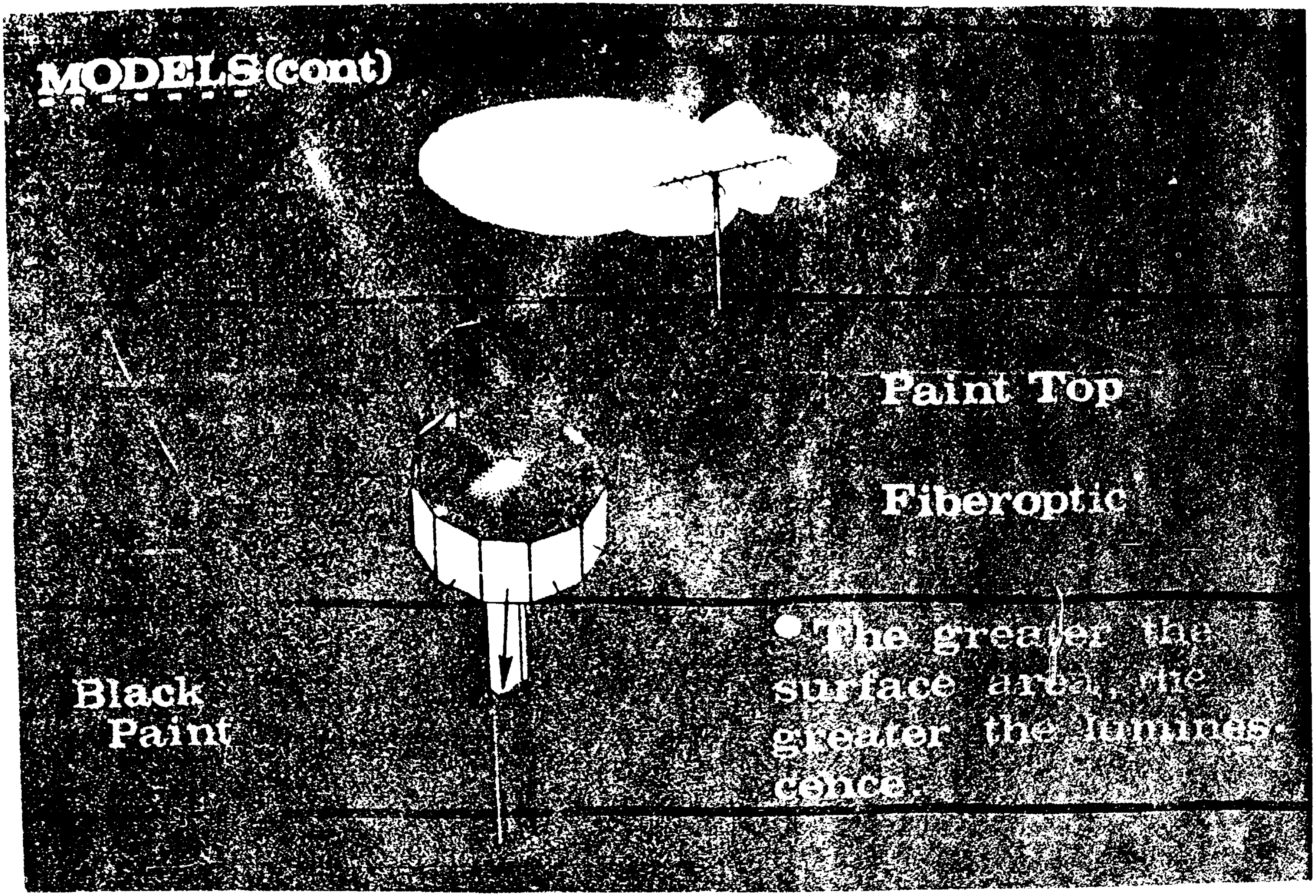

Figure 4.3

A Method of Duplicating the Radiation Lobe Peculiar to Multichannel, HF, Antennae

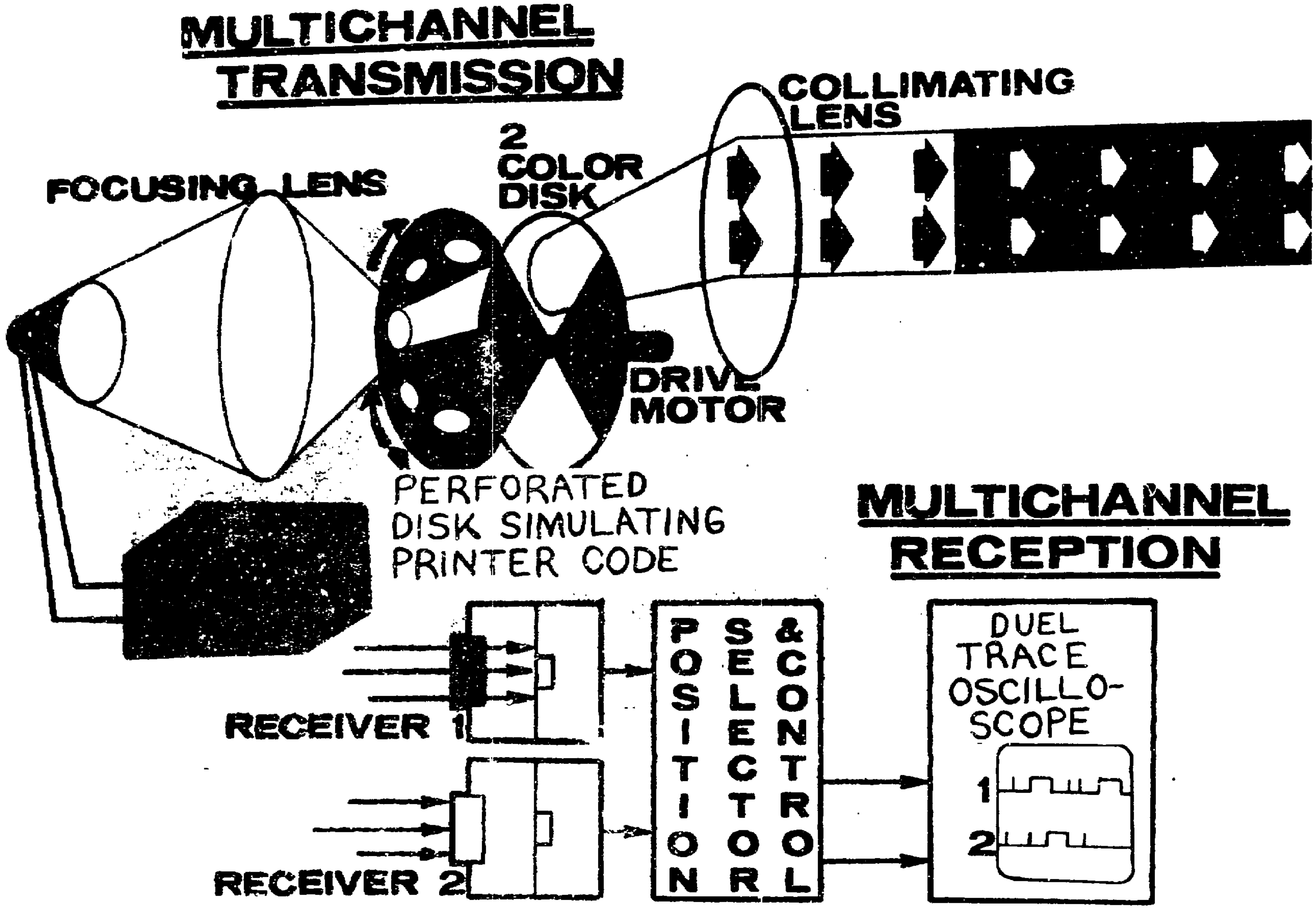

Figure 4.4

A Multichannel Transmitter Model Using Rotating Optical Multiplexing Disks

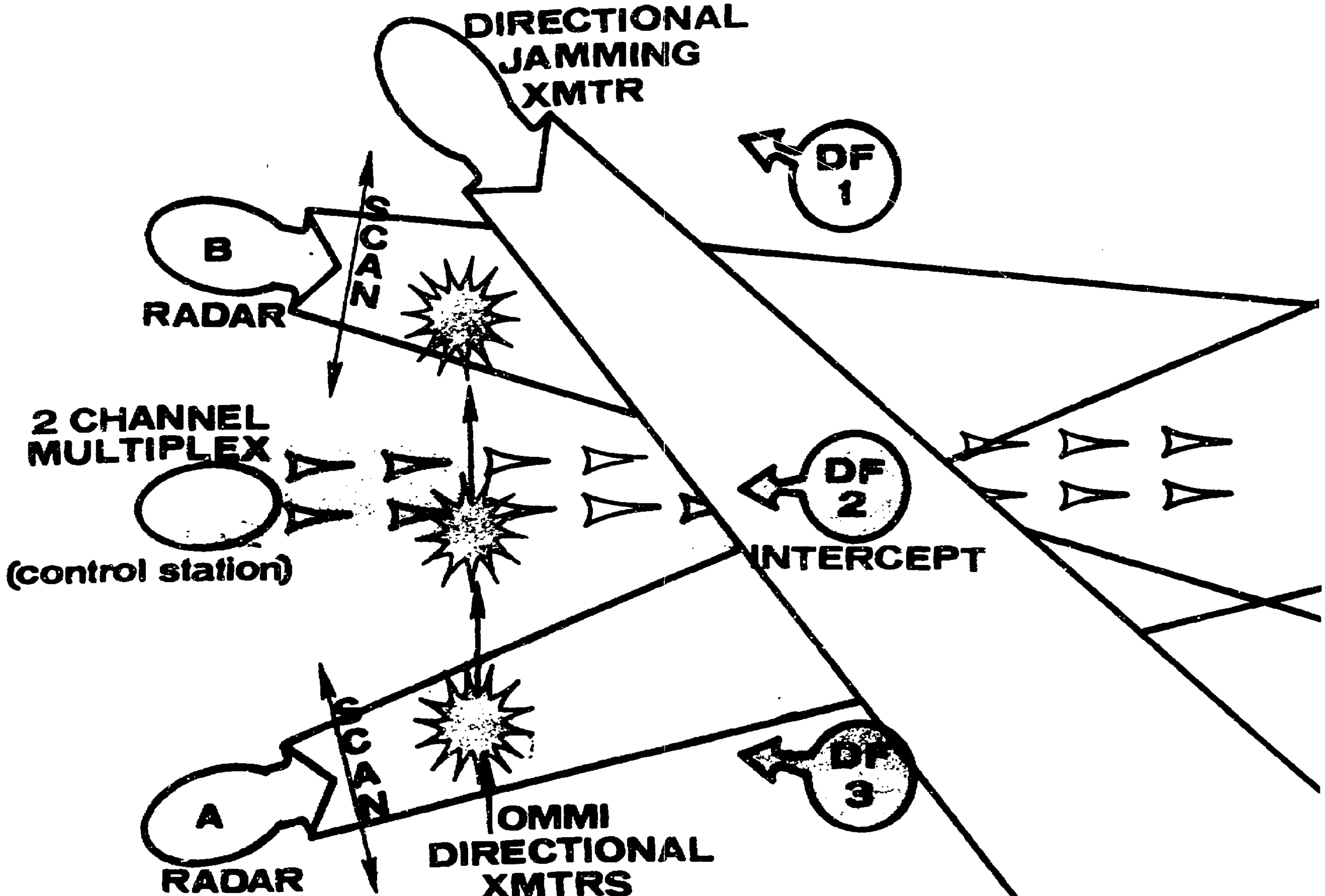

Figure 4.5

Use of a White Light, Optical, Directional, Jamming Transmitter

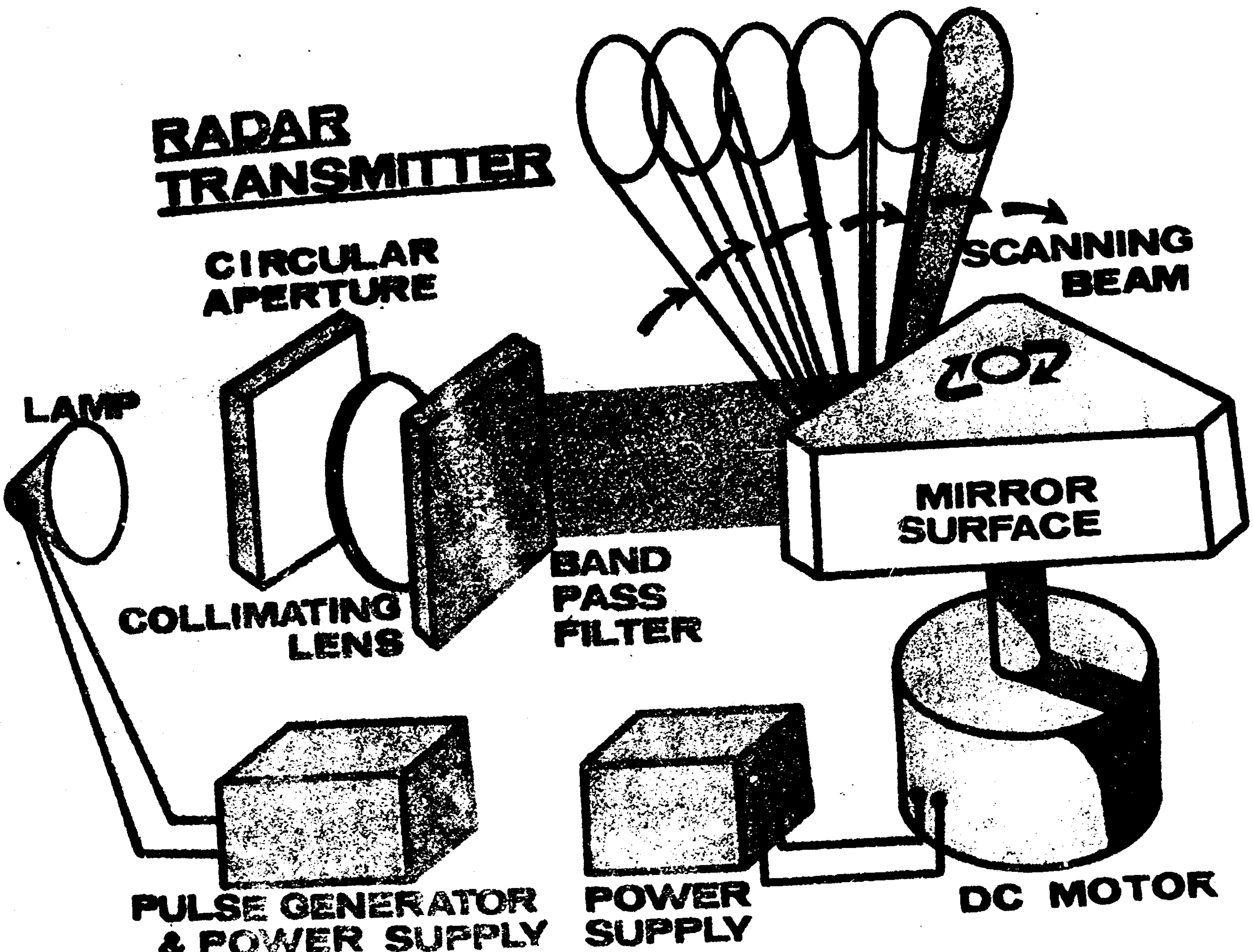

Figure 4.6

A Method of Simulating A Scanning Radar
With A Collimating Lens

capabilities include selectable pulse rate, selectable frequencies (color filters), selectable beam width, and adjustable scan rate.

5. Omnidirectional receiver. This receiver is capable of detecting all transmitted signals not obscured by terrain features. A high gain antenna field is simulated with an array of lenses connected optically to a single photodetector by fiber optic bundles (Figure 4.7). The receiving frequency (color) is selected by placing different band pass filters in front of the detector. See Figure 4.8.

6. Direction finding receiver. The direction finding receiving equipment employs a single lens to focus the incoming radiation through a band pass filter onto the photo detector. This configuration, shown in Figure 4.9, results in an effective beam half-width of ½ degree. The entire device is attached to a swivel base whose orientation is remotely controlled by activating a direct current reversible motor. The orientation is indicated at the control position by a meter connected to a potentiometer pick-up on the motor shaft. Once the site is properly aligned and calibrated, this allows line bearings to be read directly from the meter.

TYPICAL UTILIZATION OF OPTICAL SIMULATOR

The optical simulator is capable of approaching a total simulation of the ASA tactical support mission and many facets of strategic operations. It is possible to

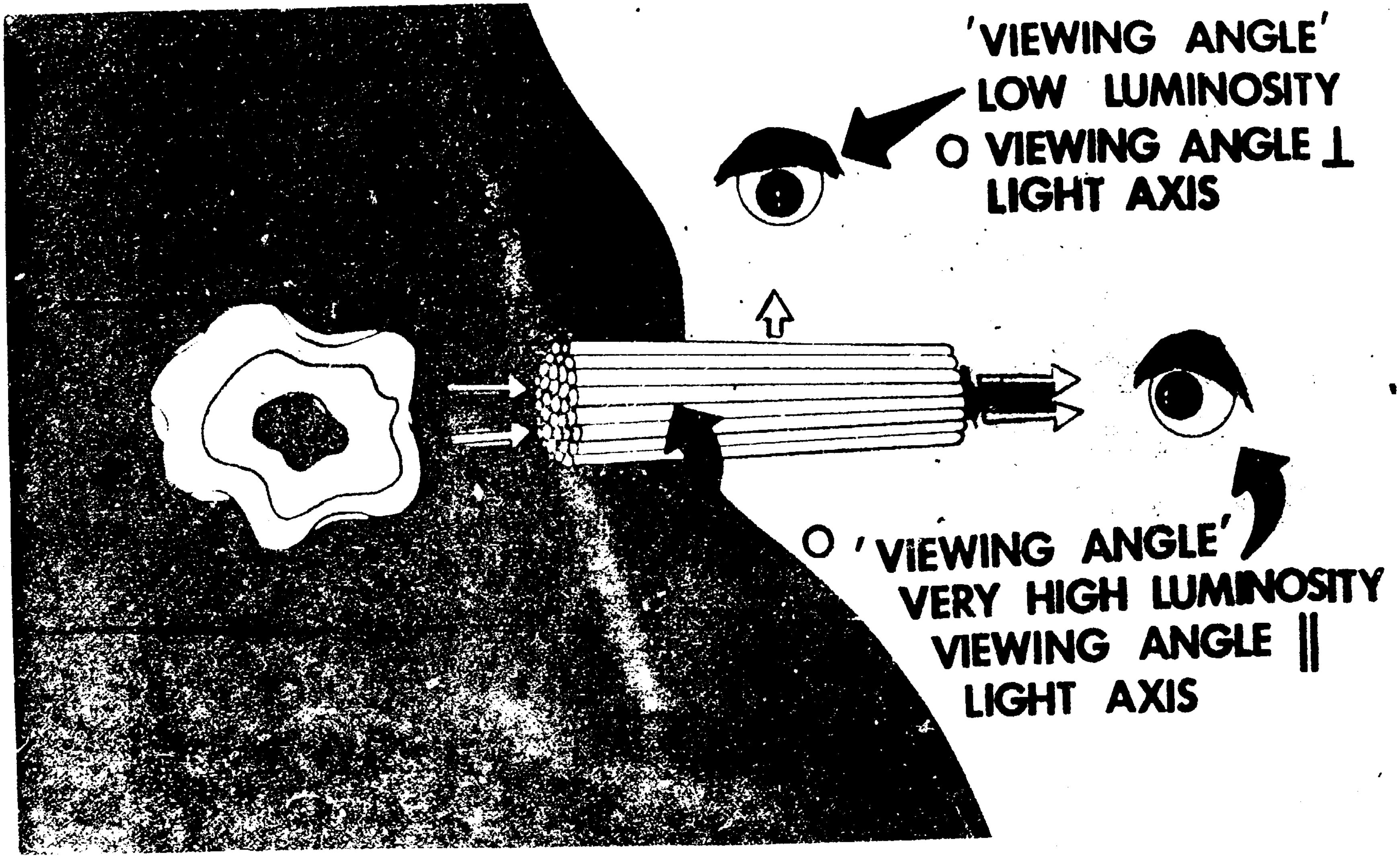

Figure 4.7

A Method of Simulating A High Gain Antenna Field
With Corning Fiberoptics

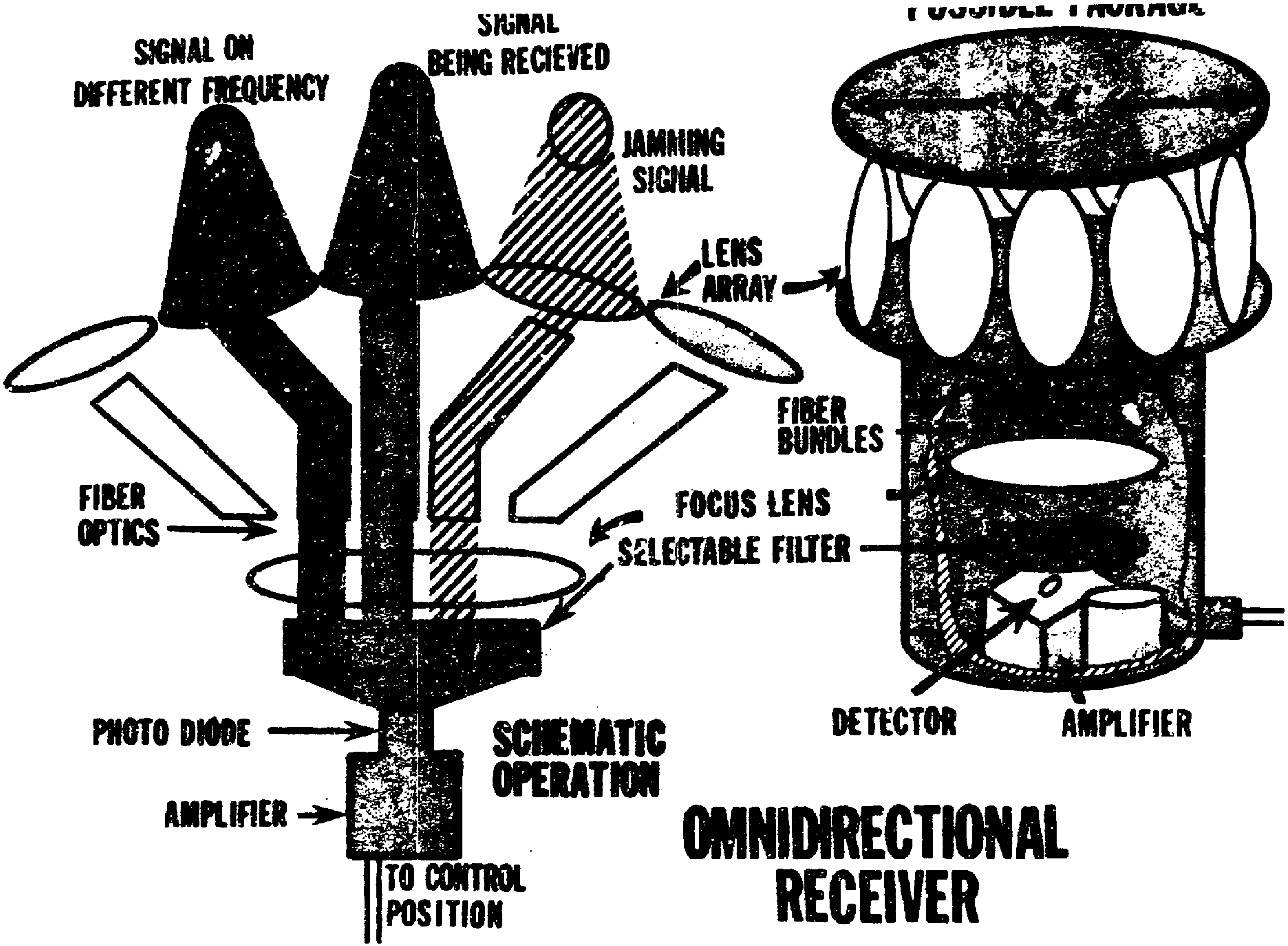

Figure 4.8

A Method of Simulating An Omnidirectional Receiver

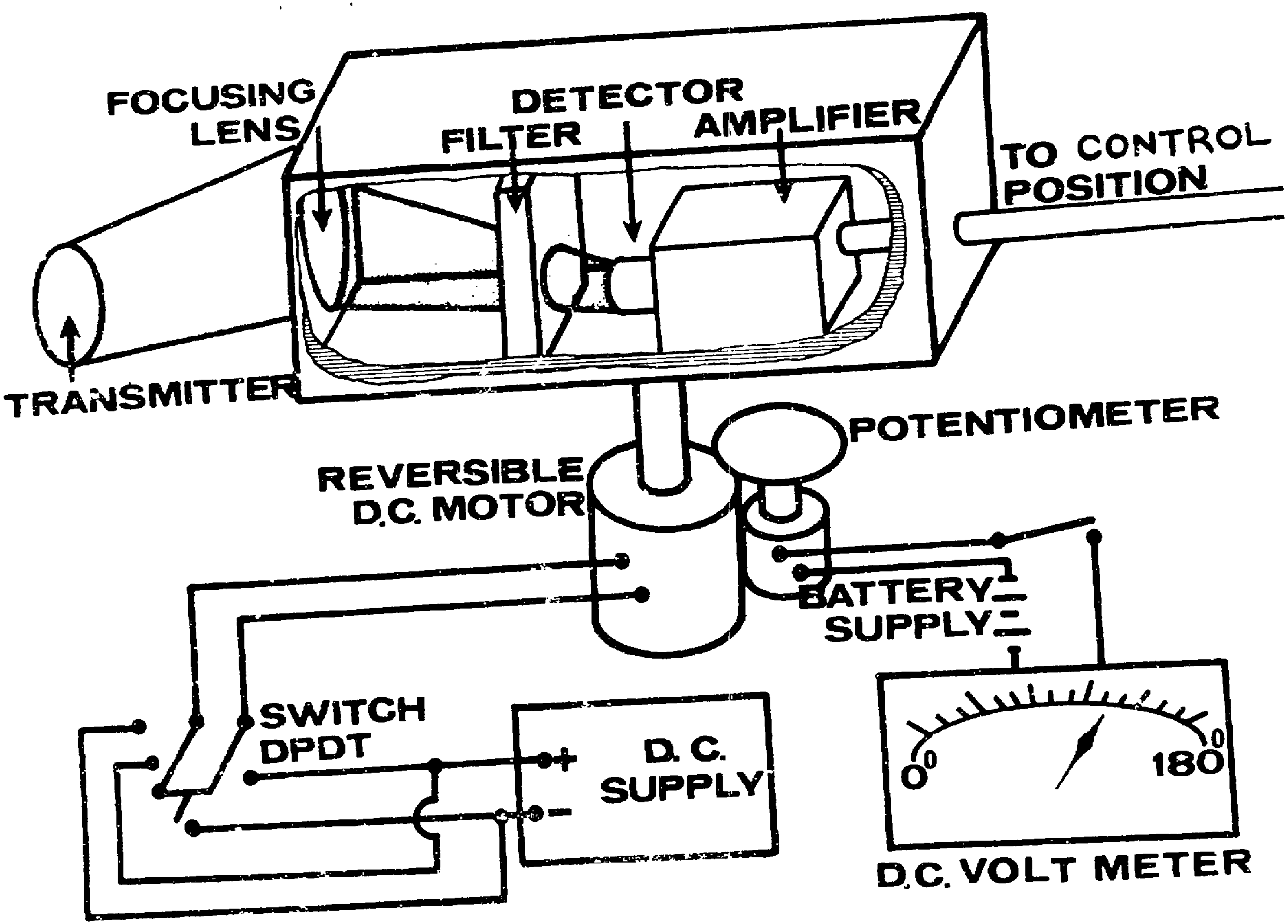

Figure 4.9

A Method of Simulating a Direction Finding Receiver
To Indicate Direction and Signal Strength

utilize this equipment in various ways. Some typical ways in which the simulator can be used are briefly discussed below. The actual use of this equipment is primarily limited by the imagination of the instructor and his knowledge of ASA operations in the field. This is true because this simulator is actually an electronic battlefield operating at optical frequencies instead of radio frequencies so that the simulation is accurate and essentially complete.

As an example, radio and radar transmitting and receiving characteristics can be effectively taught and demonstrated using the proposed equipment. The principles of theorem and many other principles can be graphically represented.

As another example, direction finding plotting and evaluation, which historically has been a difficult block of instruction due to the abstract nature of the material, can be effectively converted into a practical exercise where the student can actually perform a direction finding mission and perform the necessary plotting and evaluation of the results. This should greatly enhance student interest and understanding. See Figures 4.10 and 4.11.

In a third example, the mission simulation when incorporated into the TOC operations problem can encompass the totality of ASA missions in the field. Essentially, any desired facet of the ASA operations can be included such as mission management, tasking, signal intelligence collection procedures, special identification techniques,

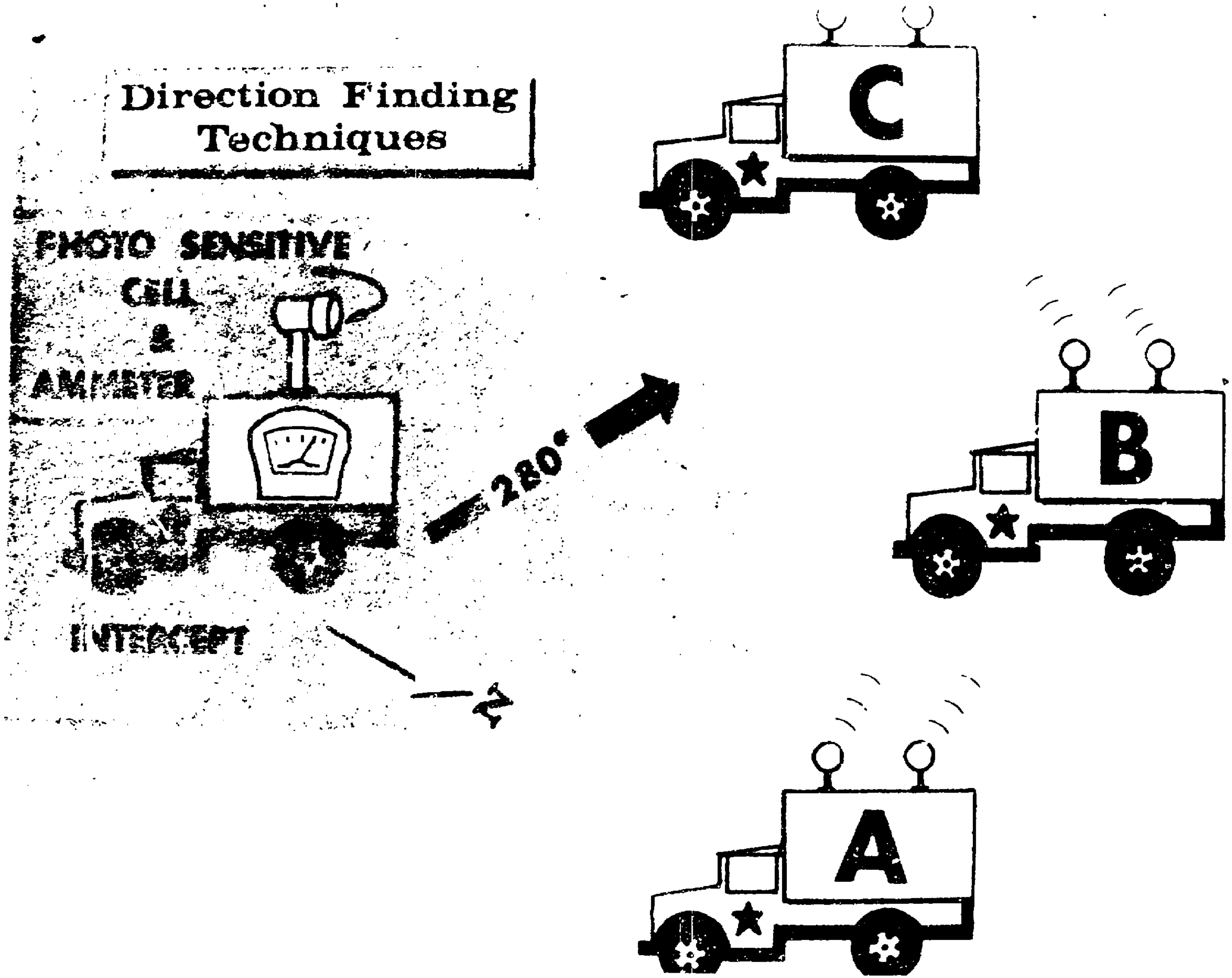

Figure 4.10

[illegible] the Electro-Optic Direction Finding Technique
[illegible] Scale Model Equipment

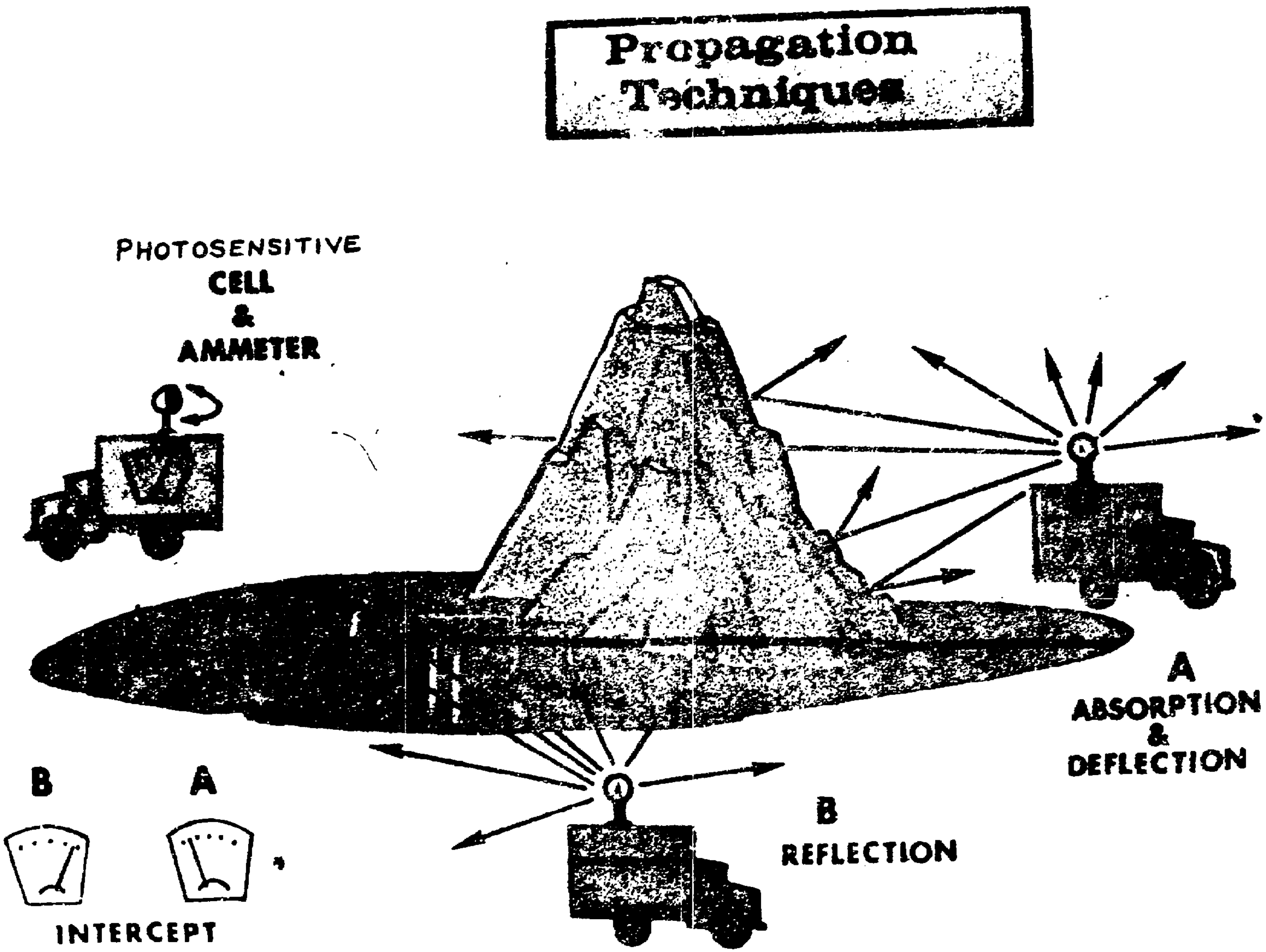

Figure [illegible].11

Use of Electro-optics to Simulate
Radio-Wave Propagation

site selection, analysis, reporting, electronic warfare concepts, and signal security techniques.

The technical aspects of electro-optic simulation are presented in Appendix D.

Chapter V

CONCLUSIONS AND SUMMARY

This chapter presents a summary of the research project, discussions and opinions, conclusions, and recommendations for additional research and application.

SUMMARY

The purpose of this investigation, as recalled from Chapter I, was to examine the hypothesis and its nine supporting performance objectives. The hypothesis:

> It is feasible to design, construct, and operate a conceptual artificial environment, induced stress, training device with which to simulate the application of managerial systems, electronic warfare, and cryptologic support to the tactical operations center at brigade level under conditions of simulated combat operations.

Nine performance objectives treated in the investigation were designed to determine if the TOC model could be used:

1. To test by performance the student's ability to apply military tool subjects. Map reading is an example.

2. To test by performance the student's ability to provide EW/cryptologic support in accordance with a mission.

3. To test by performance the student's ability to function when separated from senior officers and his headquarters.

4. To identify training weaknesses with respect to the student, his class, and the training program.

5. To test by performance the student's ability in all aspects of his instruction where such testing is practical.

6. To conduct performance testing at a reasonable cost (ten to fifteen dollars per student).

7. To apply the principles of controlled stress to performance testing.

8. To accurately simulate abstract radio wave propagation with visible light sources.

9. To examine the application of these techniques to civilian education.

The review of the literature focused on five general areas: dynamic training, simulation, human factors, development of the instructional model, and induced stress. The literature supported a professional requirement for a TOC model. Additionally, the literature supported that the TOC model was compatible with simulation requirements established by other military agencies.

The method of procedure followed in the investigation of the hypothesis is provided in Chapters III and IV. It includes the demonstrated integration of wargaming, artificial environment, role playing, induced stress, and the simulation of high resolution aerial photography, radio wave propagation and electronic warfare to develop a tactical operations center simulator model. The model is designed to provide performance testing of officer and enlisted students at the United States Army Security Agency Training Center and School, Fort Devens, Massachusetts.

Performance objectives were developed by evaluating Human Research Resource Office (HumRRO) and Army Security Agency studies reported in the literature.

The hypothesis was tested by constructing a TOC model, a simulator, and utilizing it in the instruction and testing of a participating population of 720 male officers, 76 male enlisted men, and 5 enlisted women students during the period of June, 1969, to March, 1970.

The model was constructed in a four room instructional complex totalling 3,000 square feet. The instructional portion of the facility is contained in two classrooms of 1200 square feet each. The rooms include a 12' x 25' terrain board at HO scale; thirty-two student cubicles; a control center; an 8' x 16' map projection of the terrain board; and an eight net, seventeen station, simulated brigade VHF radio system. Tactical maps of the terrain board, a functioning communications center, an electronic warfare element, a signal support element, model military equipment, model aircraft and railroad loading facilities, and a closed circuit television system are included in the training model. An electro-optics subsystem is used to simulate omnidirectional and directional transmitters and receivers, radars, jammers, and direction finding receivers. Planning includes the installation of an airborne radio direction finding subsystem mounted to an overhead track and employing other electro-optic techniques.

The TOC model induces stress by interjecting compounded and accelerated decision making in conjunction with information overload, peer group pressure, and combat drills. The TOC model approximates combat stress but does not duplicate it. Evaluation of controlled stress is, however, neither attempted in this study nor believed to be justified using the conceptual model. Quantitative measurement of this effect should be conducted in conjunction with a longitudinal study after the conceptual model has been accepted as an operating device.

Performance objectives are achieved by interjecting student tasks on a variably scheduled program designed to control stress. Each student task requires the student to identify the problem, the consequences of the problem, the proper reference material with which to research the problem, and the alternative solutions to the problem. The student then applies one of several correct solutions to the problem. The closed loop scenario provides immediate feedback to the student on the performance of each task. Instructors may provide remedial reinforcement at once. After a series of failures, the instructor may reprogram the student to less challenging tasks intended to provide reinforcement at a less demanding level of performance. The goal of reprogramming the student is to achieve satisfactory completion of performance objectives. Reprogramming is predicated upon a contention that students may be negatively affected by a bad start. Bad starts may be a result of the influence of unpredictable variables on a given personality. The manipulation of stress and task achievement provides the instructor with additional methods of measuring student achievement and reinforcing good starts or providing several opportunities for good starts.

DISCUSSION AND OPINION

In 1969, the TOC model was integrated with the then current conventional training methods, primarily lecture oriented instructions and paper-and-pencil map exercises. In 1970 the TOC model was gradually used to supersede the more conventional instruction in tactical subjects. By 1972 the TOC model had substituted all lecture oriented tactical subjects in the Tactics Department. Performance evaluation indicated that students instructed with the TOC model required about half the time to achieve the same instructional objectives as provided in lecture and paper-and-pencil map exercise methods of instruction. Student comments on end-of-course evaluation reports indicated a large degree of satisfaction with the simulator method of instruction.

The most significant limitation in the operation of the TOC model is the lack of qualified instructors available to integrate the combined disciplines of all instructional divisions with the application of controlled stress and behavior tasks and the operation of the electro-optics and aerial photography subsystems. Officer and enlisted instructors with this capability are not readily available. Ideally, instructors assigned to the TOC model should have benefit of several months familiarization training with the model. The instructor should ideally have instructed in the other divisions within the Command and Staff Department and should have previously been assigned to a tactical USASA unit.

Personnel working with this model concur that its potential is limited only by imagination and the availability of diversified instructors.

CONCLUSIONS

The hypothesis is substantiated. It has been demonstrated that an artificial environment, induced stress, training device which simulates the application of managerial systems, electronic warfare, and cryptologic support to tactical operations at brigade level under conditions of combat can be conceptually designed, constructed, and operated. The TOC model at the United States Army Security Agency Training Center and School, Fort Devens, Massachusetts, fulfills this requirement.

The nine performance objectives previously identified in the study were achieved. The TOC model demonstrated that:

1. It can test by performance the student's ability to apply military tool subjects by the application of instructor initiated behavioral tasks relating to military subjects.

2. It can test the student's ability to provide

EW/cryptologic support in accordance with a mission provided by an instructor.

3. It can test by performance the student's ability to function when separated from senior officers and his headquarters through the application of an artificial environment.

4. It can identify training weaknesses with respect to the student, the class, and the training program by performance testing.

5. It can test by performance the student's ability in all aspects of instruction in tactical subjects and at least seventy-five percent of all other subjects taught by the Department of Command and Staff.

6. It can provide performance testing at a reasonable cost. The TOC model cost less than $7,000 and 200 hours of military labor to build over a period of three years. The cost is less than ten dollars per student per year to operate exclusive of personnel costs.

7. It can apply the principles of controlled stress with performance behavior testing by inducing information overload, accelerated and compounded decision making, peer group pressure, and combat drills.

8. It can accurately simulate radio wave propagation with visible light sources and optics devices and it can simulate high resolution aerial photography using a closed circuit television system.

9. It can be applied to civilian education especially in the construction of an artificial environ-

ment, controlled stress, social-community model using the research and design of the TOC model.[1]

RECOMMENDATIONS FOR FURTHER RESEARCH

It is recommended that normative studies be conducted to report on the comparison of control and experimental groups using this simulator with special emphasis on the measurement of the effects of stress on performance.

It is recommended that continued application of electro-optic communications be studied with respect to its potential for placing more wave lengths at higher frequencies through communication channels. The bandwidth or spread of usable frequencies is enormous.

It is recommended that additional research be directed to the effects of all types of measurable stress on individual students. As an example, measurements of the tolerance to communication jamming, exposure to red lighting, the wearing of protective masks, the amount, frequency, and complexity of tasks, and the rate of decision making by students all serve as important influences on military personnel.

It is recommended that the TOC model be considered for further research considering the model's application for brigade level command post exercises, ROTC training,

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[1]Don E. Gordon, Major, USA, "Controlled Stimuli Socio-Community Training Device for Creative and Retarded Children" (unpublished paper, United States Army Security Agency Training Center and School, Fort Devens, Massachusetts, 1972).

and reserve force and National Guard training at local armories.

It is recommended that further consideration be afforded the mounting of the TOC model in mobile vans for transporting to remote training sites of which a National Guard Armory serves as an example.

It is recommended that the basic design concepts be considered for their application to civilian education. The substitution of the social community game developed by Professor Gameser of the University of Michigan, SIMSOC, would provide an excellent substitute for the war game in the TOC model while continuing to make use of the TOC model's subsystems.

It is recommended that the newly formed Training and Doctrine Command (TRADOC) consider the application of the TOC model to all aspects of training under its supervision.

It is recommended that the Command and General Staff College, serving as the Combined Arms Center, or any other agency tasked to evaluate the TOC model, visit the model when it is operating before rendering an evaluation of its performance and application.[2]

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[2] As a result of Department of the Army reorganization, the United States Continental Army Command (CONARC) previously responsible for the supervision of service school training within the United States was replaced in early 1973 with the Training and Doctrine Command (TRADOC). The USASATC&S is not under the jurisdiction of CONARC and it is not under the jurisdiction of TRADOC. The USASATC&S is directly subordinate to the Army Security Agency.

APPENDIXES

APPENDIX A

TERMS, DEFINITIONS, AND ABBREVIATIONS

APPENDIX A

TERMS, DEFINITIONS, AND ABBREVIATIONS

Aggressor. The fictitious enemy created to add realism to training exercises. May also be referred to as the Red force. (AR 310-25)

Antenna gain: optimum. Antenna efficiency measured as small energy loss and high efficiency as a radiator or receptor. (FM 24-18)

ASA or USASA. United States Army Security Agency.

CCTV. Closed circuit television, a cable television circuit.

CDC. Control Data Corporation.

CDC 1700. Control Data Corporation model 1700 computer.

Collateral intelligence. Any intelligence input except that collected from communications and noncommunications radiation emitters (radio, radar, telemetry, beacon).

Collimating lens. A lens which directs light rays in a straight, parallel line.

Combat Service Support System (CS3). A system to facilitate supply and personnel tasks by computerizing the logistical and administrative considerations down to the battalion level commander.

COMCM. Communications Countermeasures.

COMINT. Communications Intelligence.

Command Post Exercise, CPX. An exercise in which the commander and his staff conduct a maneuver utilizing only communication facilities to simulate the actual movement of personnel and equipment.

Communications and Electronics Intelligence Staff Officer. An USASA officer assigned Military Occupational Specialty 9620. See Army Regulation 611-102.

Communications and Electronics Security Staff Officer. An USASA officer assigned Military Occupational Specialty 9630. See Army Regulation 611-102.

Complex. A communications operation or net in which both sides of a conversation may be heard.

COMSEC. Communications Security.

Corning's Fiberoptic. A registered tradename of the Corning Glass Company, New York.

CPX. Command Post Exercise.

CS3. Combat Service Support System.

CW. Continuous Wave. See Morse Code.

Data. Transmission of computer or facsimile information by radio.

DF. Direction Finding.

Directional Antenna. An antenna from which signals are transmitted or received between approximately 0 to 100 degrees.

DTOC. Division's Tactical Operations Center.

Duplex Circuit. A circuit which makes it possible to simultaneously transmit and receive messages. (AR 310-25)

EIR. Equipment Improvement Recommendation, DA Form 2404.

Electromagnetic Environment. See Electromagnetic Spectrum.

Electromagnetic Spectrum. The frequencies present in a given electromagnetic radiation. A particular spectrum could include a single frequency or a wide range of frequencies. (AR 310-25)

Electronic Countermeasures Staff Officer. An USASA officer assigned Military Occupational Specialty 9610. See Army Regulation 611-102.

Electronic Warfare. The interception of enemy communication and noncommunication signals (radio, radar, telemetry, beacon, data); the jamming and manipulation of signals; and the protection of our own signals from similar interference by the enemy.

Electronic Warfare and Cryptologic Staff Officer. An USASA officer assigned Military Occupational Specialty 9640. See Army Regulation 611-102.

Electronic Warfare Element, EWE. An element within the G3 section of the TOC. The USASA unit in support provides personnel to operate the EWE. The EWE provides electronic assistance to the G3.

Electro-Optic. In the context of this study it is the interfacing of electronic devices with optical devices to portray the abstract phenomena of electronic propagation with visible light sources. That is, a light beam will transmit a radio signal.

Equipment Improvement Recommendation. DA Form 2404.

EW/Cryptologic. Electronic Warfare and Cryptologic functions.

EW. Electronic Warfare.

EWE. Electronic Warfare Element.

Field Training Exercise, FTX. An exercise in which the command, its personnel and equipment deploy to a maneuver area to conduct a training exercise.

FTX. Field Training Exercise.

Half-Duplex Circuit. A circuit which can only transmit or receive. It cannot transmit and receive simultaneously.

HF. High Frequency. 3-30 MHz.

HO Scale. Ratio 1 foot : ¼ inch.

Ionospheric Effects. Electrical phenomena created on radio waves by the constantly changing layers of heavily ionized molecules in the ionosphere (30 to 250 miles).

KAT Codes. Secure codes for use with voice mode radio transmissions at the tactical unit level.

LLVI. Low Level Voice Intercept.

Low Level Voice Intercept, LLVI. The monitoring of enemy voice communications emitters serving regimental and subordinate units.

M-292 Expansible Van. An Army procured expansible van mounted to a 2½ ton truck chassis. When stationary, the van may be expanded to provide an area 16'x11'x8'.

Morse Code. The method of transmitting communications over radio by interupting the amplitude modulation with dots and dashes. The system first demonstrated by Samuel F. B. Morse, hence its origin. Morse Code is also referred to as Continuous Wave (CW) or Manual Morse.

MOS 9610. Electronic Countermeasures Staff Officer.

MOS 9620. Communications and Electronics Intelligence Staff Officer.

MOS 9630. Communications and Electronics Security Staff Officer.

MOS 9640. Electronic Warfare/Cryptologic Staff Officer.

Multichannel. The transmission of more than one channel of communication on one frequency. As an example, two channels of printer, and two channels of voice may be simultaneously transmitted over one radio frequency after multiplexing the four channels into one channel.

17-OHCS. An adrenal secretion, 17-hydroxycorticosteroid.

Omnidirectional Antenna. An antenna from which signals are transmitted or received at 360 degrees.

Position Management Section. The control center for radio intercept positions within a USASA unit.

Potentiometer. An electronic circuit element consisting fundamentally of a resistance element equipped with a movable contact tap. It is a continuously adjustable voltage divider.

Printer. See Radio Printer.

Radio Printer (RP). Transmission by radio of manual or automatic teletype communications. Usually in conjunction with on-line cryptological devices.

Radio Set, AN/PRC-25. A small, portable, field radio. It is FM, VHF, with frequency range of 30 to 76 MHz.

Signal Operating Instructions (SOI). A series of orders issued for technical control and coordination of the signal communication activities of the command. (AR 310-25)

Simplex. A communications operation or net in which only one of two communicators is heard. This may be caused by the net using two blind frequencies. The second operator may be too far away to be heard. The second communicator may answer the first on a different schedule. It may be a blind transmission broadcast.

Simulation. The process of conducting experiments on a model of a system in lieu of direct experimentation with the system itself or the direct analytical solution of some problem associated with the system.

SOI. Signal Operating Instructions.

SOP. Standing Operating Procedure.

Special Identification Techniques (SIT). Includes the use of high speed photography of radio oscilloscope patterns and voice spectographs. Referred to as radio fingerprinting and voiceprinting respectively.

Speech Security Set, KY 8. A communications device which provides security to voice transmissions when connected to the radio set, AN/PRC-25 by inverting the voice sounds.

SSI. Standing Signal Instructions.

Standing Signal Instructions (SSI). The technical instructions required to coordinate and control the communications electronics of the command. (AR 310-25)

STANO. Surveillance, Target Acquisition, and Night Observation.

Surveillance, Target Acquisition, and Night Observation (STANO). Integrates reconnaissance and surveillance through the use of sensors, radars, detectors, night vision devices, and individual observation.

TACFIRE. The computerization of artillery fire support to increase accuracy, improve target information, reduce reaction time and provide greater efficiency in allocating fire support.

Tactical Operations System (TOS). A computerized information and retrieval system for automating the functions of operations, intelligence, and fire support coordination.

Tactical Scale Map. A topographic, five color, contour map in a scale between 1:25,000 and 1:50,000.

Tele-Trainer System. An educational telephone system provided by the Bell System. The system includes telephones and a switchboard which provides dial, busy, and wrong number tones.

TOC. Tactical Operations Center.

United States Army Security Agency (USASA or ASA). The cryptologic component of the Army Military Intelligence Branch.

USASA or ASA. United States Army Security Agency.

USASATC&S. United States Army Security Agency Training Center and School, located at Fort Devens, Massachusetts.

<u>VHF</u>. Very High Frequency. 30-300 MHz.

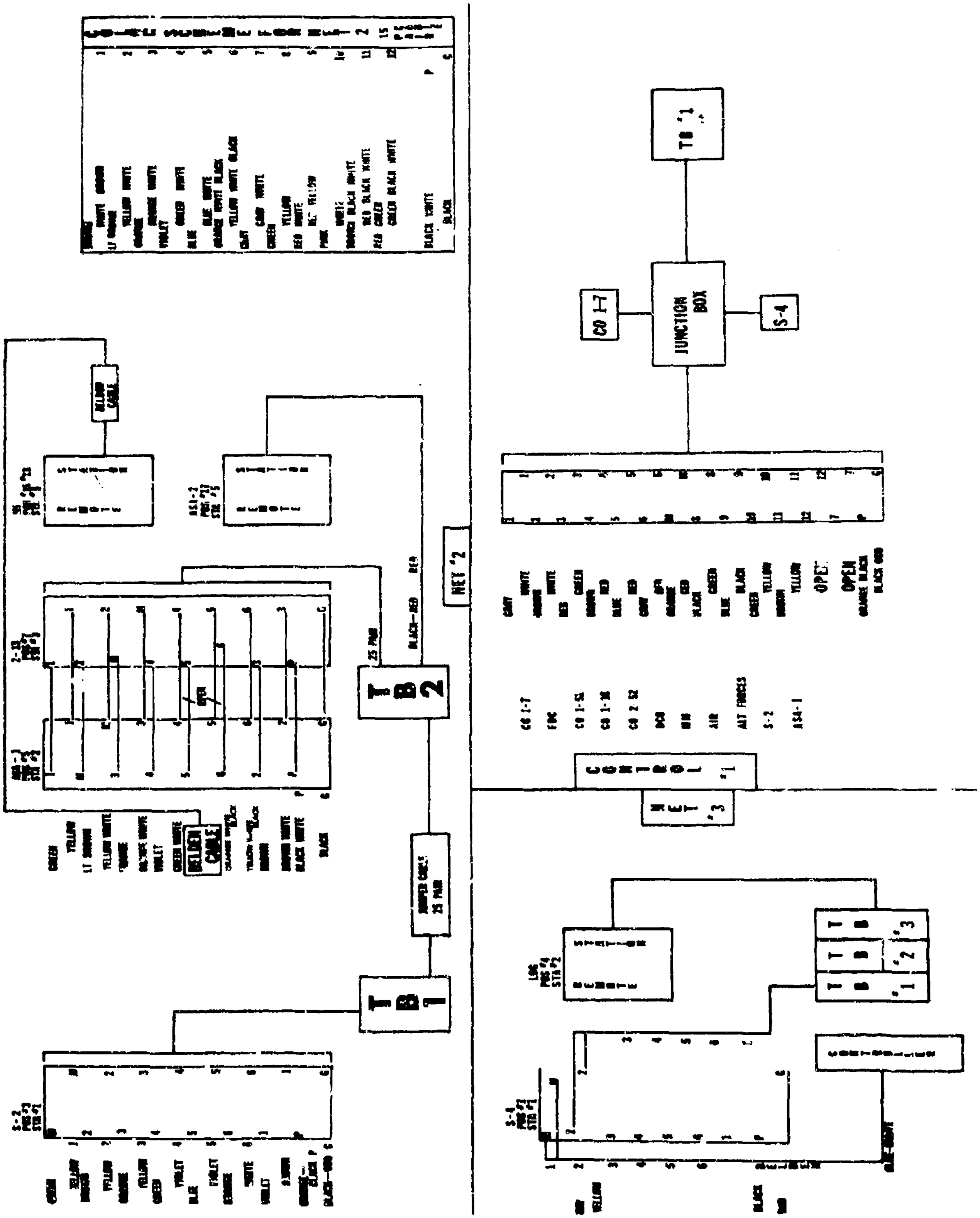
<u>Voice</u>. Transmission by radio of voice communications. Usually associated with tactical level radio nets and systems.

<u>XMTR</u>. Transmitter.

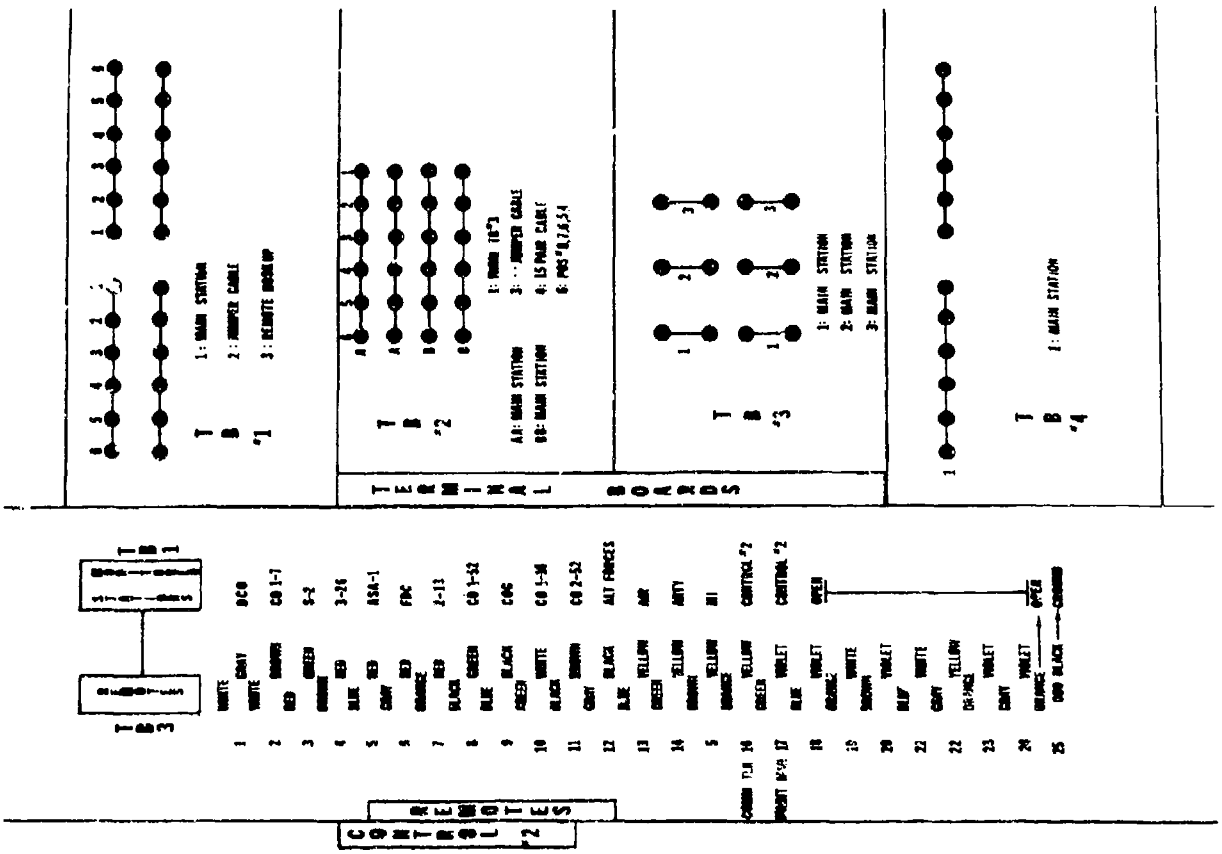
APPENDIX B

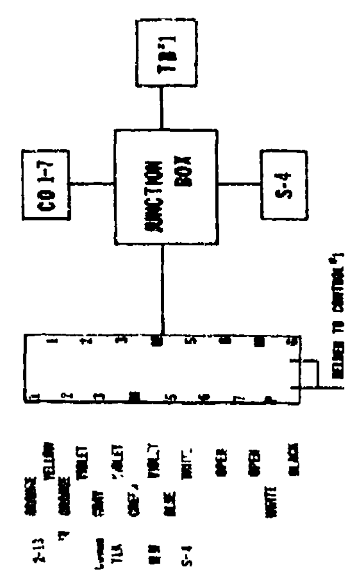
COMMUNICATIONS SYSTEM WIRING DIAGRAMS

COMMUNICATIONS SYSTEM WIRING DIAGRAMS

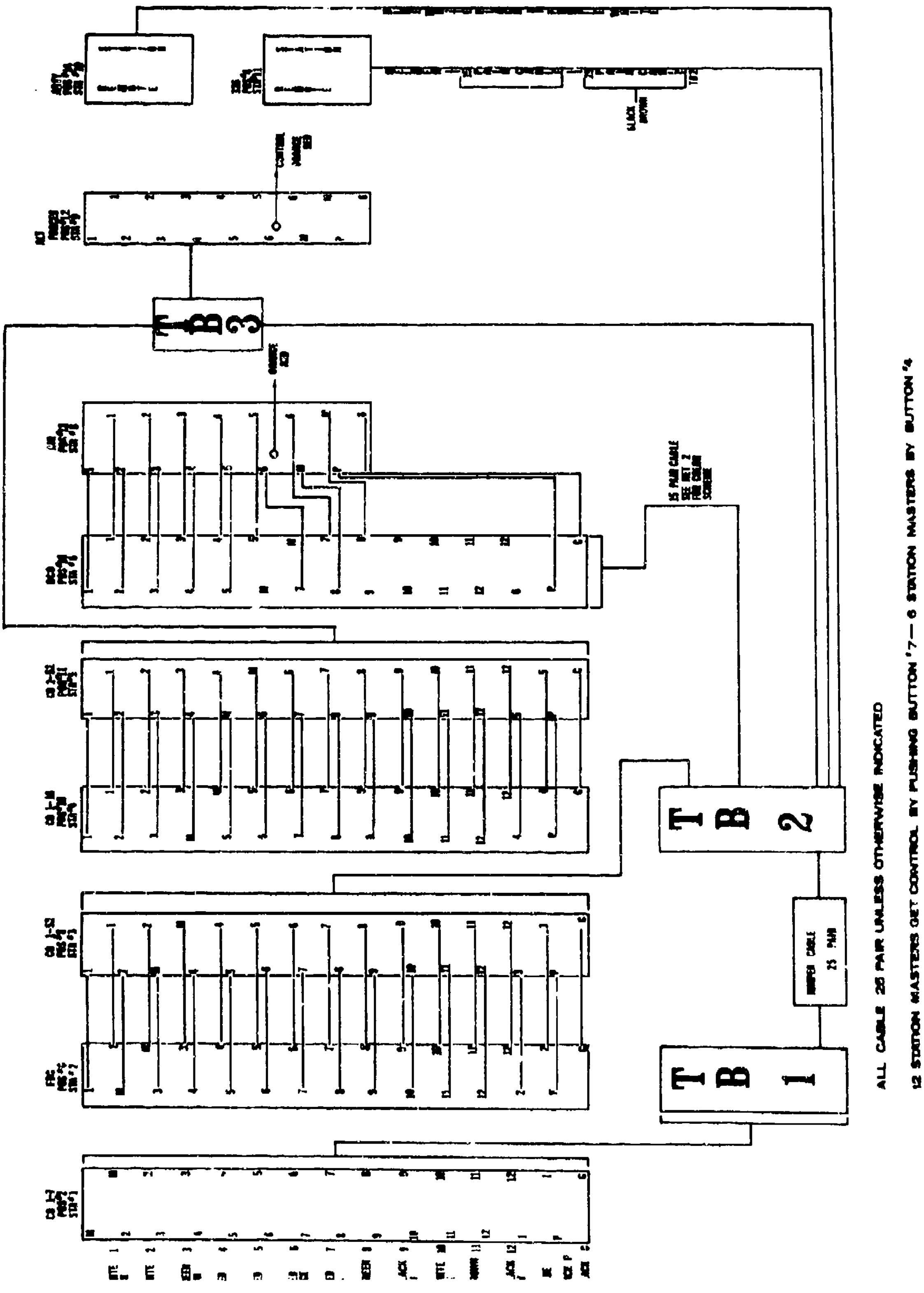


COMMUNICATIONS SYSTEM WIRING DIAGRAMS





COMMUNICATIONS SYSTEM WIRING DIAGRAMS



APPENDIX C

CLOSED CIRCUIT TELEVISION (CCTV) TECHNICAL SPECIFICATIONS

CLOSED CIRCUIT TELEVISION (CCTV) TECHNICAL SPECIFICATIONS

System	American TV standards	
Channel coverage	VHF 2-13	
	UHF 14-83	
Antenna connectors	for 300-ohm or 75-ohm external VHF and UHF antennas	
Picture tube	19" picture measured diagonally	
	114-degree deflection angle	
Bulbs	11	
Semiconductors	7 transistors, 5 diodes	
Speaker	5" x 3"	
Audio output	1 W (undistorted)	
Power requirements	117V, 60Hz, 165W	
Monitor Specifications		
Video inputs	1. OV(p-p) SYNC NEGATIVE	75 ohms(unbalanced)
Video output	1. OV(p-p) SYNC NEGATIVE	75 ohms(unbalanced)
Audio inputs	0 dB, 50 k ohms(unbalanced)	CANON Connector
	0 dB, 50 k ohms(unbalanced)	8-pin connector
Audio output	0 dB, 10 k ohms(unbalanced)	CANON Connector
	-20 dB, 10 k ohms(unbalanced)	8-pin connector
Dimensions	22-13/16" x 13-5/8" x 13-5/16" (w/ h/ d)	
Weight	50 lb 13 oz	
Supplied accessory	8-pin monitor cord	

Vidicon tube:	2/3-inch, separate-mesh vidicon
Semiconductors:	29 transistors, 22 diodes
Scanning system:	525 lines per frames, 30 frame per sec
Sync system:	Internal sync – vertical line lock (60 Hz) sync with random interlace External sync – EIA standard, 2 : 1 interlace or sine wave sync (from CV-Series Videocorder).
Horizontal resolution:	More than 400 lines at center
Horizontal frequency:	15.75 kHz
Vertical frequency:	60 Hz
Signal-to-noise ratio:	42 dB
Video bandwidth:	6 MHz
Video output:	1 Vp-p composite video signal, sync negative, 75-ohms, unbalanced
Output connector:	VTR Connector (6-pin male connector) VIDEO/RF Output (UHF connector) Viewfinder Connector (9-pin male connector)
Automatic sensitivity control range:	30-10,000 footcandles (with lens opening f/1.8)
Power requirements:	117 V, 60 Hz
Power consumption:	10 VA (without the Viewfinder)
Ambient temperature:	32°F 104°F
Dimensions:	4 3/4(h) × 4 3/16(w) × 13 1/4"(l)
Weight:	6 lb 8 oz
Supplied accessories: (AVC-3200DX includes following accessories)	SONY Electronic Viewfinder, Model AVF-3200, Zoom lens, Camera cable CCF-5 (15 ft), Microphone, Microphone stand, Microphone lavalliere, Microphone extension cord (15 ft), Elevator tripod, Carrying case, Polishing cloth.
Hz (hertz):	Cycles per second

Design and specifications subject to change without notice.

APPENDIX D

TECHNICAL ASPECTS OF ELECTRO-OPTIC SIMULATION

APPENDIX D

TECHNICAL ASPECTS OF ELECTRO-OPTIC SIMULATION

As noted in Chapter IV, the electromagnetic spectrum and radio wave propagation are abstract phenomenon which are difficult to perceive by many students. The basic approach used in this model is the simulation of basic abstract electromagnetic and radio principles using visible radiation. That is, visible light is used to illustrate invisible radio waves. In most instances, incandescent light sources are the principle means of visible radiation in this model. A detailed description of projected simulation performance levels and a suggested configuration is outlined in this appendix.

It is clear that the discovery of a simple modulation technique has opened the door to vastly extended performance levels. The limited experimentation to date indicates that in a reasonable time a total simulation system can be designed and installed. The capability to accurately and graphically achieve simulation of both short range and global scale electromagnetic environments is practical and comparatively low cost. This total simulation capability is far beyond the scope of other current programs with regard to both technology and cost requirements. The current model provides an essential level in the development of a total simulation capability. The demonstrated ability to modulate a low voltage incandescent lamp over a bandwidth sufficient for a high quality voice transmission leads to a dramatic reevaluation of simulator performance achievable with simple and reliable hardware. Total simulation of tactical communications characterized by very high frequency and short range communications is possible. The only limitation is that presented by the comparatively few number of independent channels available. The number of channels is directly dependent upon three color filtered light frequencies of red, blue, and green. In addition, a number of long range propagation effects can be introduced in this controlled situation.

The model provides an ability for the student to remotely control and operate transmission, receiving, interception, direction finding, and reconnaissance efforts, in addition to controlling simulated combat unit efforts and dispositions on a terrain board. The instructor is able to control pre-programmed and spontaneous communications emitted by aggressor transmitters, radars and electronic communication countermeasures in a war game.

INSTRUCTOR CONTROLLED SIMULATION DEVICES

1. Omnidirectional transmitters with the capability of handling continuous wave (CW), voice, radioprinter (RP), data, or any other desired signal format is available. The actual number of transmitting antennae can be quite high

(20 to 50), with the basic limiting factor being the number which can be operated simultaneously (3 to 5). Only three transmitting frequencies are available. The signal strength and quality of the transmission can be controlled by the instructor. The antenna transmitting pattern can be modified to simulate any transmitting antenna.

2. Directional transmitters, both single channel and two channel capability, are available. Both time and frequency division multiplexing can be simulated with any desired signal format (e.g., one voice channel and one printer channel). A total of one to four units may be constructed utilizing the same three frequencies as the omnidirectional transmitters.

3. Radar transmitters with adjustable pulse repetition frequency (PRF), beam shape, and scan patterns are available. Three radar frequencies are available. A total of two to five units may be constructed.

4. Jamming transmitters targeted against both communications and non-communications receivers are available with broad band and discrete frequency coverage. Adjustable beam widths and signal strength may be incorporated. Various modulation formats including white noise can be simulated. A total of one to two units will be constructed.

5. Airborne radio direction finding will be simulated using the previously mentioned techniques in an omnidirectional receiver mounted to a track directed vehicle circling the terrain board.

6. Other transmitters such as navigational aids, variable time (VT) fuses, or unintentional radiation sources may be simulated as desired. This capability is unlikely to be required until the basic operating procedures and problem control have been tested and firmly established.

7. A master control console would initiate and terminate all transmissions. The controller will introduce both pre-recorded and live signals to the various transmitters. Three to five simultaneous communications transmissions will be possible along with all radar and jamming transmitters in operation at the same time. The controller is able to select the signal strength and quality of individual transmitters as well as control the over noise level in the communications environment to simulate both natural and man-made sources of interference.

STUDENT CONTROLLED SIMULATION DEVICES

1. Omnidirectional receivers--3 units--with the following capabilities:

a. Tune over available communications frequencies.

b. Receive all transmission modes--e.g., voice, printer, etc.

c. Determine relative signal strength.

2. Radio direction finding--3 units--with the following capabilities:

a. Tune over available communications

frequencies.

b. Receive all transmission modes.

c. Direction finding signal to within ½ degree.

d. Determine relative signal strength.

3. Airborne radio direction finding (ARDF)--one unit with the following capabilities:

a. Tune over available communications frequencies.

b. Receive all transmission modes.

c. Direction finding signal to within 1 degree.

d. Determine relative signal strength.

e. Move along pre-selected flight path.

f. Determine location along flight path.

4. Electronic intelligence/multichannel--two or more units. These units could be selected for use either as electronic intelligence or multichannel receivers. Their capabilities would be:

a. Tune over frequencies in selected band.

b. Receive all transmissions within selected band.

c. Direction finding signal to within ½ degree.

d. Identify basic signal parameters.

e. Determine relative signal strength.

5. Analysis position--electronic intelligence or multichannel signals. Each position would have the following capabilities:

a. Record signals.

b. Display signals.

c. Measure signal parameters.

6. Radar reconnaissance--one or two units with the following capabilities:

a. Locate targets to within one degree.

b. Determine signal strength.

c. Simulate moving target indicator (MTI) mode of operation.

7. Control and coordination position would be capable of monitoring and recording signals at any intercept position.

SIMULATION HARDWARE

The following information presents the results of technical investigations of the electro-optic simulation project. This data is not complete nor of sufficient detail to base final hardware designs. However, the major technical problem areas have been covered. The general status of these technical areas is as follows:

1. Receiver technology: High sensitivity, low cost optical receivers have been demonstrated. The electronic amplification used to date has been the limiting factor. With proper design and impedance matching, a receiver of exceptional capabilities can be realized.

2. Transmitters: Modulation bandwidths of greater than 10KHz have been demonstrated with very simple electronics. A small effort in filter and coupling design

is required to compensate for the non-linearities in frequency response for the transmitter lamp filament.

3. Frequency and polarization selection: Providing frequency (color) diversity is the most significant engineering problem at this time. Low cost polarizers, quarter wave plates and color filters are available for visible radiation. The problem is that the near infrared wavelengths within the response range of the photodetectors are unaffected by the filters. This results in significant cross-talk in the frequency spectrum.

4. A simple continuous wave radar simulator has been demonstrated which provides accurate target azimuth and signal strength information. Use of retroreflective tape (Scotchlite) on selected targets can result in the simulation of a moving target indicator radar mode.[1]

5. Direction finding: Direction finding accuracies better than one degree have been demonstrated with simple hardware.

6. Jamming: A jamming transmitter is the most simple of all to fabricate. Both directional and omnidirectional versions have been demonstrated by modulating incandescent light through the incandescent radar transmission.

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[1]Scotchlite is a registered brand name of Minnesota Mining and Manufacturing Co., St. Paul, Minnesota.

7. Mechanical design: Standard engineering practice results in very effective small size devices. Although the mechanical design, fabrication and electrical installation create no technical problems, they do involve a massive and tedious effort in order to achieve reliable and effective operation. To date, simulated rotating radars and receivers have been fabricated at HO scale, ¼":1'. The simulator equipment places additional demands on students using this equipment. For this reason, battery powered classroom demonstration equipment is constructed to provide a transition from the lecture form of instruction to the applicatory instruction emphasized in the tactical operations center model.

PROJECTED DESIGNS

After a suitable testing period of those devices discussed previously and introduced as design packages, consideration should be afforded to development of devices able to demonstrate more sophisticated communication techniques. Advanced design is conceivable for the simulation of satellite tracking and collection, radio fingerprinting, voice fingerprinting, intercept, analysis, sporadic E sounding, wideband, laser and maser threats, and passive infrared reconnaissance techniques.

DETAILED TECHNICAL NOTES ON RECEIVER TECHNOLOGY

The photodiode used is a PIN-3D. Although a photo-transistor provides inherent electrical gain and sufficient sensitivity at a lower cost, the PIN-3D (approximately $10) is chosen because its large area allows its use without a lens as an omnidirectional receiver. A photo-transistor could be used for other receivers; however, the large area of the PIN-3D is also useful in reducing mechanical alignment tolerances when a lens is used for direction finding type applications. See Figure D.1 on the following page.

The single transistor on the photodiode provides current gain to drive a low cost commercial amplifier. An impedance matching transformer should be used on the output end of the audio amplifier to match the impedance of a head set. If a speaker output is desired, the amplification stage available in the Fannon intercom sets now in use at student cubicles could be utilized with appropriate impedance matching.

Classroom demonstration units and direction finding receivers without intercept search capability use a very inexpensive photo conductor and single transistor to indicate the presence and strength of a signal within the field of view of the receiver. The cost is low enough to provide every student a device for instructional purposes. See Figure D.2.

The use of a PIN-3D and standard electronics is recommended for all receivers since the cost is reasonable and the performance is exceptional. The uniform design will dramatically reduce errors in maintenance and repair.

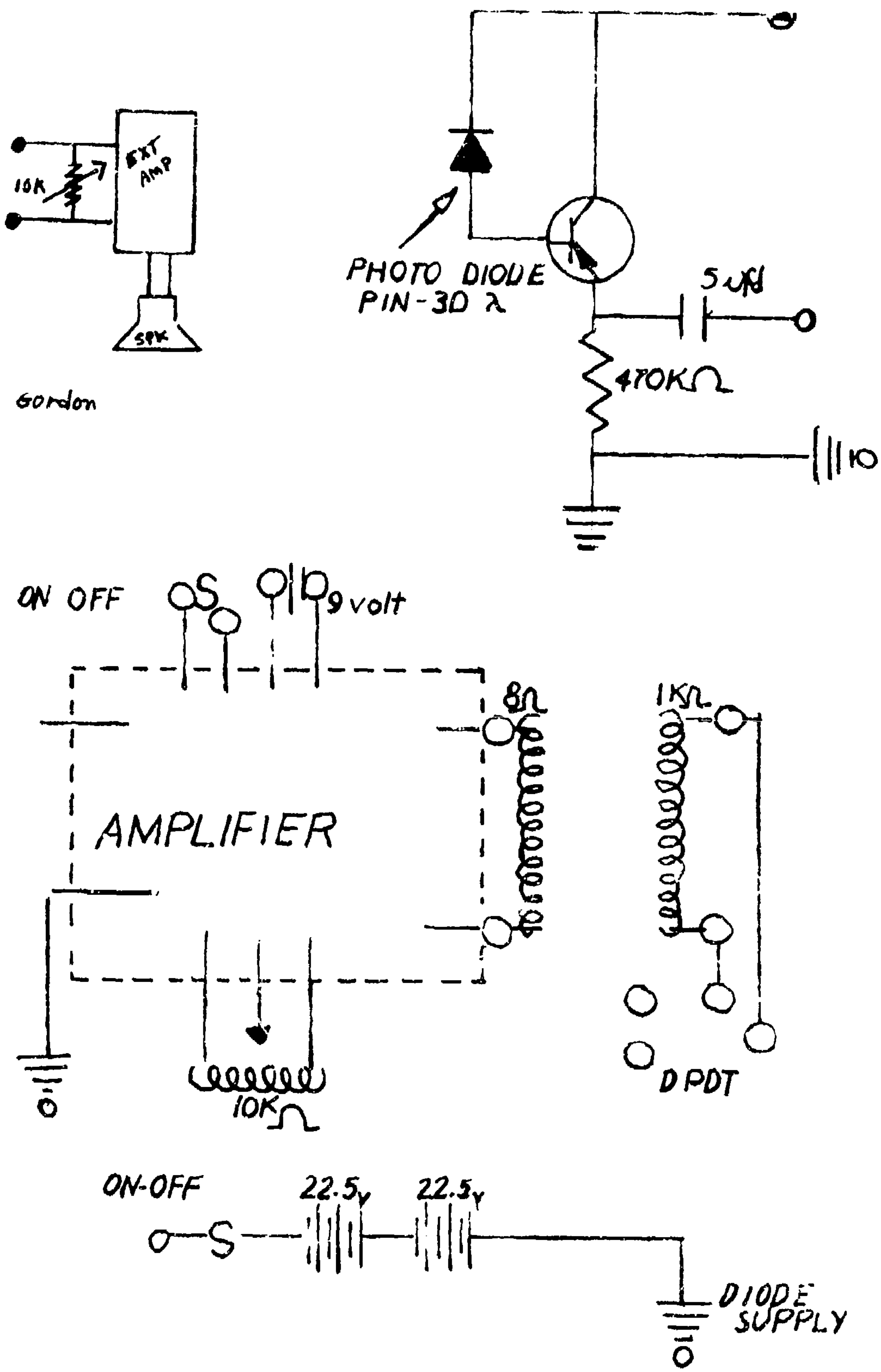


Figure D.1

Schematic of Receiver

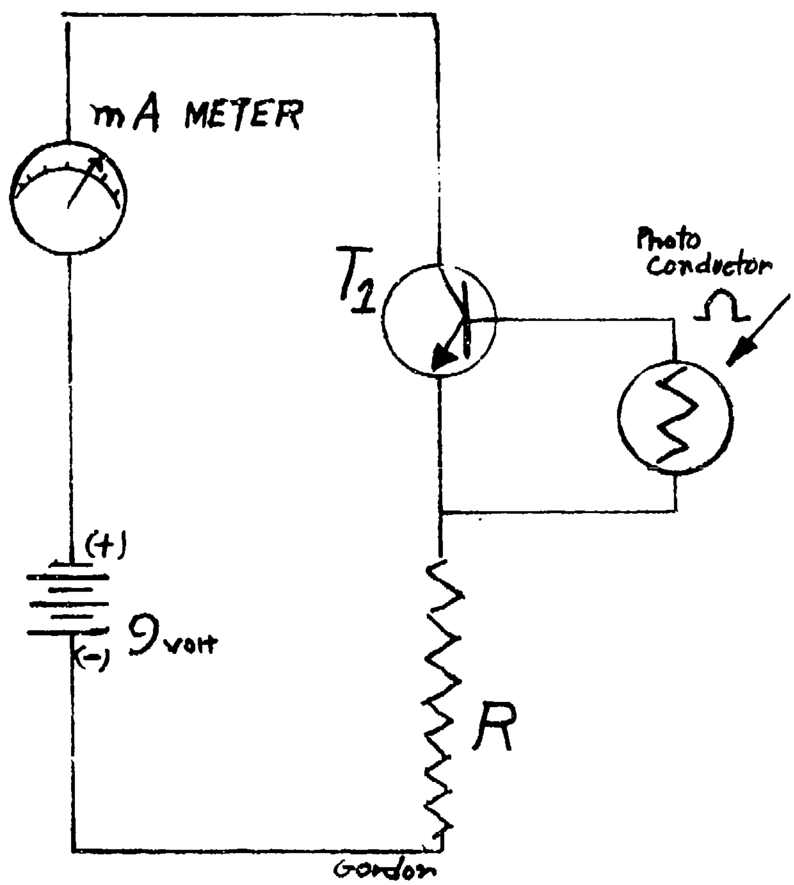


Figure D.2

Receiver for Radio Direction Finder

DETAILED TECHNICAL NOTES ON TRANSMITTER MODULATION

A very simple modulation scheme used in the demonstration model is shown in Figure D.3. A modulation bandwidth over 10KHz has been demonstrated with a low voltage incandescent lamp. Essentially any transmission mode (manual Morse, voice, printer, data, facsimile, etc.) can be simulated using this scheme as long as the bandwidth is less than 10 KHz. The modulation depth varies with frequency. A low frequency attenuation filter on the drive input line will probably provide a significant improvement in the quality of voice transmissions.

Another modulated light source is a light emitting diode. These devices are capable of very high modulation rates and are essentially monochromatic. However, their power output is relatively small and would not be as graphic to student observers or sufficient for use as an omnidirectional trnasmitter. They may be useful for high data rate directional multi-channel units. A conceptual design of a two channel system with frequency diversity is shown in Figure D.4.

DETAILED TECHNICAL NOTES ON OPTICAL FILTERS AND POLARIZERS

Both polarization and band-pass filtering techniques have been considered to provide frequency diversity. Use of polarizing material to separate communications and non-communications channels should prove very effective. The

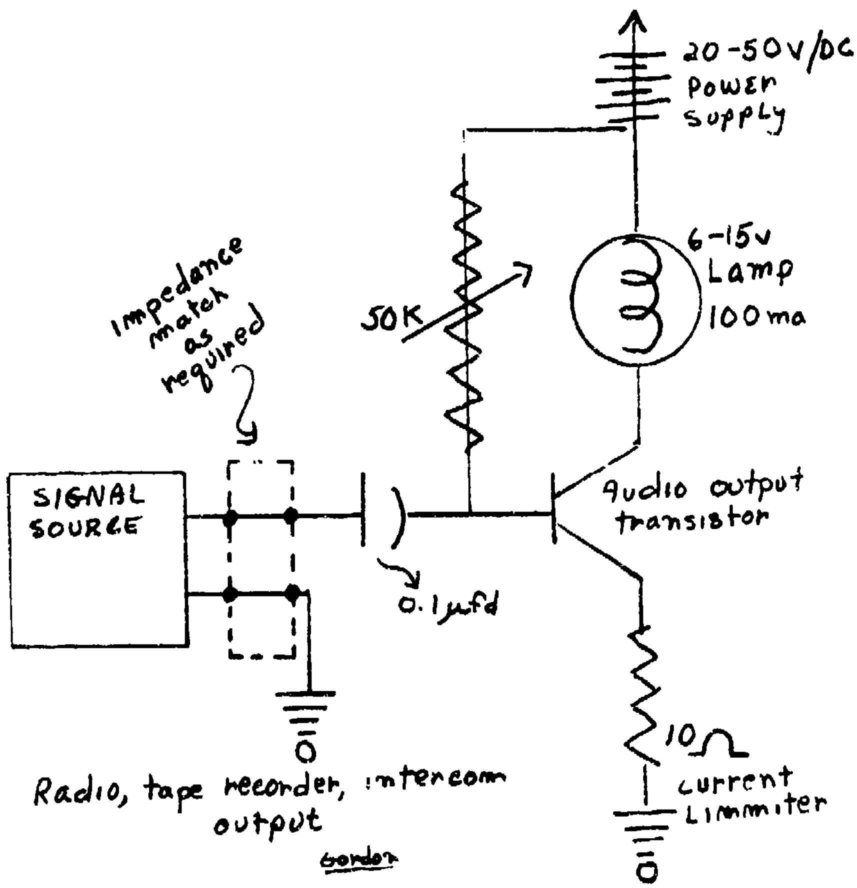


Figure D.3

Transmitter Modulation

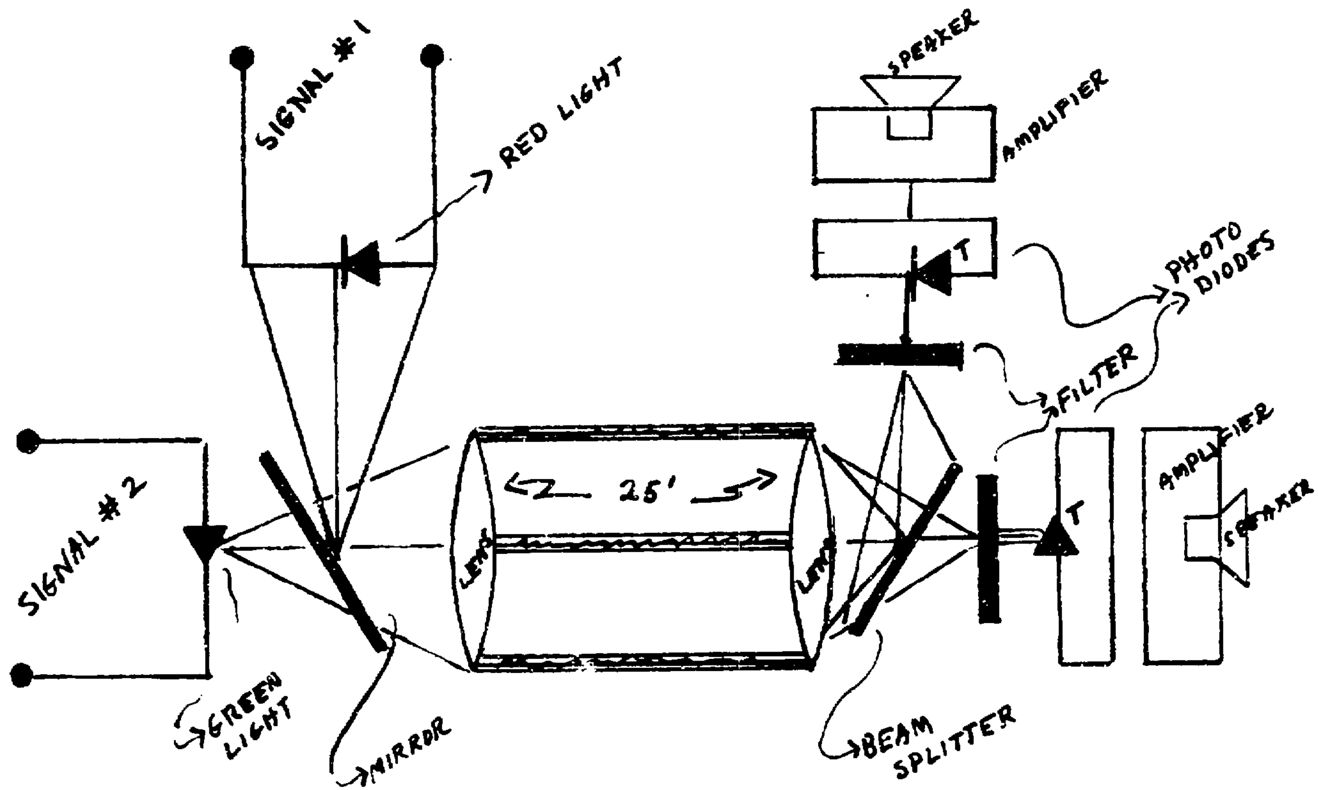


Figure D.4

Two Channel Modulated System
With Frequency Diversity

properties of low cost plastic color filters were investigated. When red, blue, and green plastic filters are used on receiving diodes and indicator lamps, it is possible to provide sufficient discrimination. Since there is a large number of transmitting lamps radiating over large solid angles, the filters on these devices must be as simple and inexpensive as possible. One slightly more sophisticated source of filtering material is the Wrattan filters manufactured by Kodak for commercial photography. These are also an absorptive type material which can provide four or five independent color bands. Interference filters are extremely expensive even in moderate quantities (typically fifty to one hundred dollars for one square inch, depending on the width of the bandpass). They are also sensitive to the incident angle of the radiation. For these reasons they are not appropriate for use with the transmitting lamps. The plastic laminated color filters and polarizers are subject to one common defect. They both transmit the near infrared radiation which is within the response range of the silicone photodiodes. Since the transmitting lamps are high temperature black body sources, they emit a substantial amount in the near infrared and thus the color filters and polarizers do not provide the intended discrimination. As an example, the radiation from a transmitter with a green filter can be received with a photodiode covered with a red filter because the infrared radiation is passed by both filters without attenuation. There are photodiodes which do not respond in the near infrared which remedy this problem. A more attractive solution is the use of an additional filter on the receivers to block the infrared radiation. In this case an expensive filter may be necessary since the number of receivers is limited and the area of each is very small. The entire array of receivers can be filtered with one or two square inches of material. If desired, the near infrared can also provide an independent frequency band which is not visible to student observers. This possibility may be of interest in the future. A simple experiment determined that infrared blocking filters used in 35 mm projectors are of sufficient quality to provide the infrared filtering required for this application. To date, infrared interference has not disrupted simulation but rather has more closely simulated normal high frequency (HF) and very high frequency (VHF) background noise.

The filters on the receivers are arranged as a series of shutter type arrangements which can be moved in front of the receiver diodes by remote control using a simple electromagnet. A conceptual drawing of the transmitter-receiver filtering process is provided in Figure D.5.

A more realistic tuning process for the student intercept operators is provided by a rotating prism, remotely controlled by a reversible direct current motor. This also provides a solution to the problem of near infrared radiation reaching the receiver. The infrared radiation may be excluded by limiting the maximum rotation

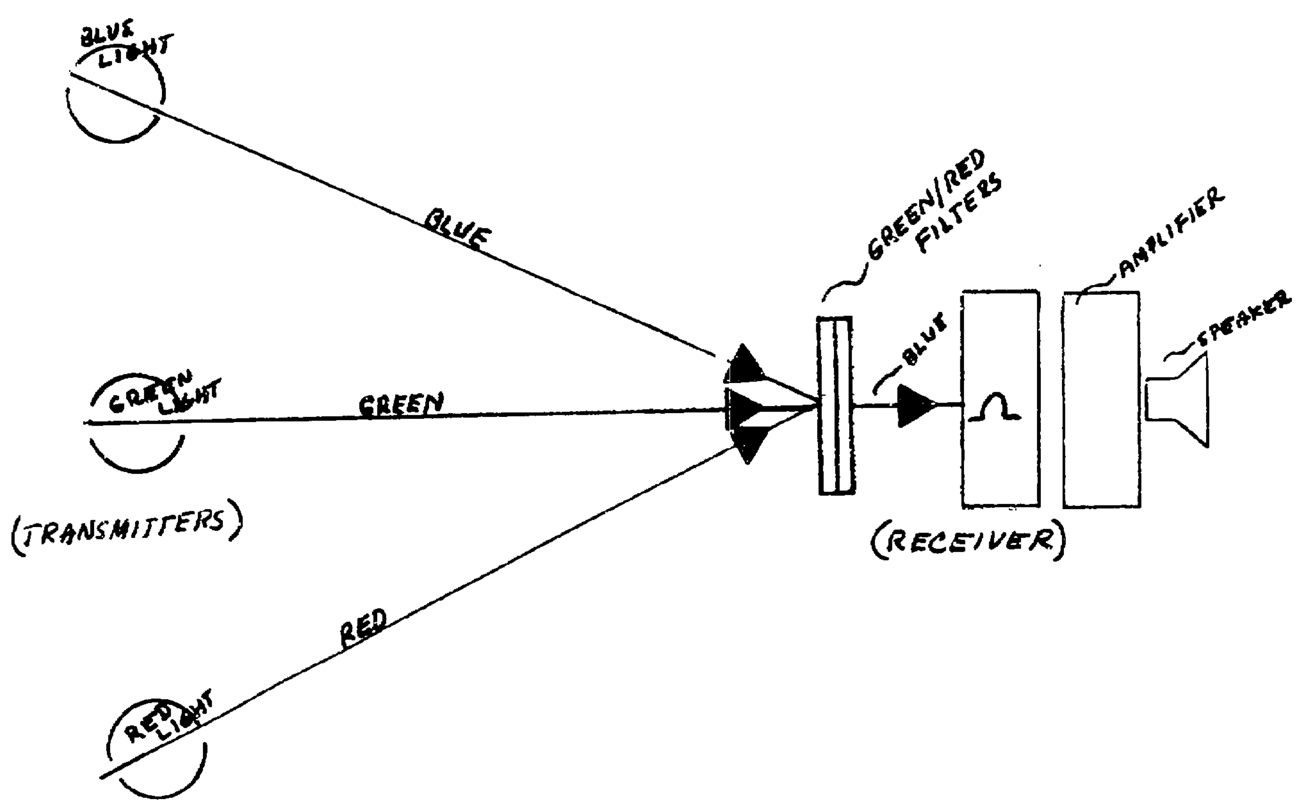


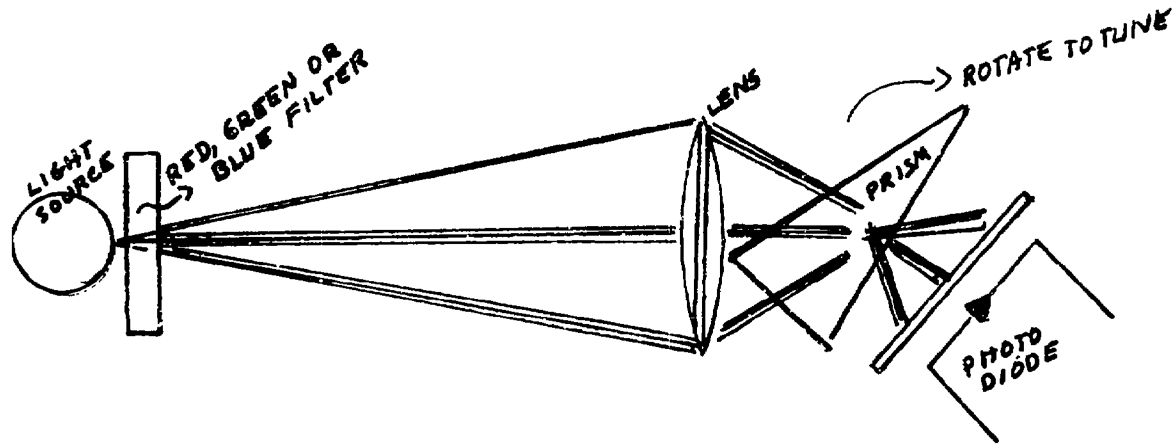
Figure D.5

Transmitter-Receiver Filtering Process

angle of the prism. A conceptual drawing of this scheme of tuning is shown in Figure D.6. The implementation of a directional receiver is straight forward. The extension to omnidirectional receivers (or at least wide angle receivers) will require further development. However, due to the extreme diode sensitivity, it is likely that a scheme can be devised since the optical train need not be very efficient in collecting incoming radiation.

DETAILED TECHNICAL NOTES ON RADAR SIMULATION

Figure D.7 contains the schematic approach used in a radar simulation unit. In essence, it consists of a transmitting lamp and a photo-sensitive device focused on the same volume in space. Mechanical drives and position readouts provide information on the azimuth of detectable targets. Either a high intensity lamp or a simple strobe lamp will suffice. This configuration operates exactly like a radar with one exception. The distances are so short that there is no possibility of acquiring range information. Since it is not possible to provide sophisticated processing of the return signals, the student is faced with a continuous stream of return signals which he is unable to interpret. This is equivalent to the reception of ground clutter in conventional radar. In order to provide a graphic display it is necessary to tag those items which appear as distinguishable targets to the radar operator. This is accomplished by



NOTE:

The tuning scheme can be made omnidirectional in one axis by using a cylindrical lens to focus on the vertical axis only and using prism dispersion in the same axis so that there will be no directional sensitivity in the horizontal axis.

Figure D.6

Tuning Scheme

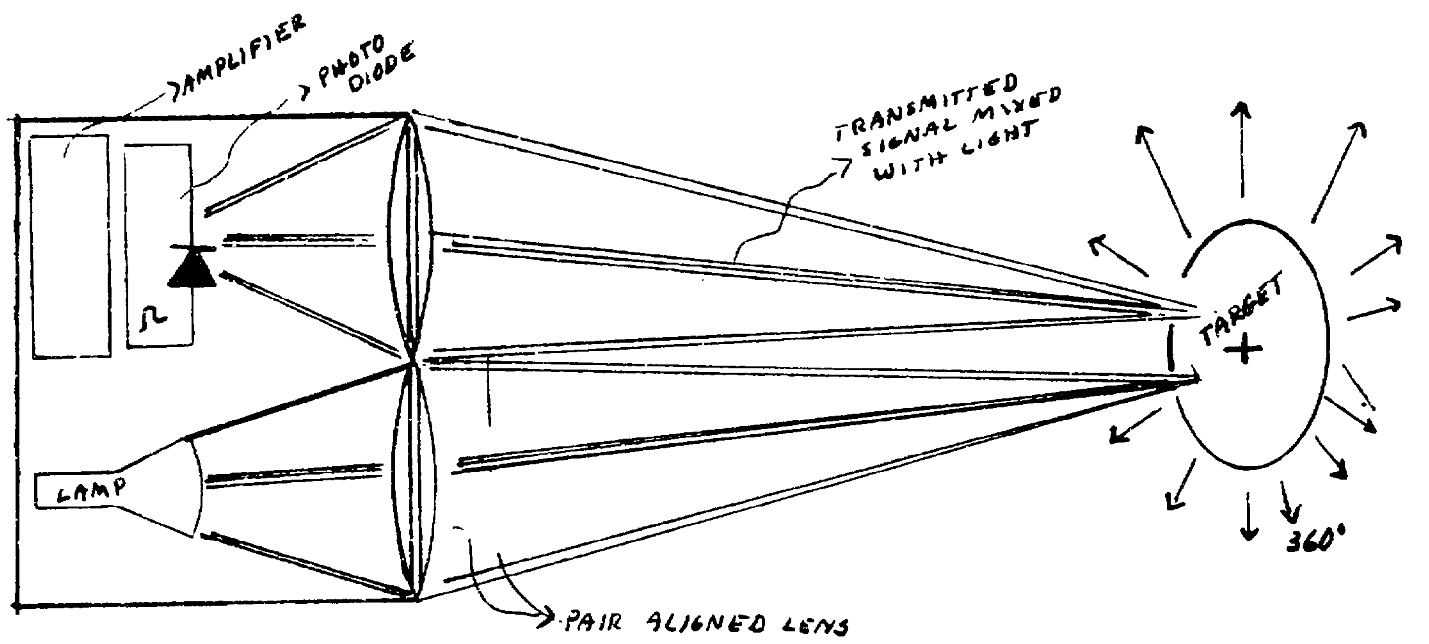


Figure D.7

Radar Simulation

using a small piece of narrow angle reflective tape (Scotchlite) on targets. This material is similar to the reflective tape used on auto bumpers except that it reflects over a very narrow angle in the direction of the incoming light. See Figure D.8. To an observer of the simulation board, the Scotchlite tape will appear to be no brighter than displays on the board; however, the radar receives an extremely strong signal due to the directionality of the reflection. Placing a piece of color filter in front of some targets also provides the ability to simulate the effect of a moving target indicator radar function. By a careful choice in the size of the Scotchlite used, it is possible to retain some ground clutter in the radar picture. An even more interesting possibility is to control the radar lamp power at the instructor console. During the initial stages of the problem low power is provided. Under these circumstances only the strong signals from the reflective tape are received making the operation quite easy. As the problem progresses, the power is increased so that more and more ground clutter becomes detectable with the fixed gain receiver.

MISCELLANEOUS TECHNICAL NOTES

Definite consideration is given to the lighting used while the optical simulation equipment is in operation. Room lights can be a significant contributor to noise in the optical receivers. Flourescent lights produce a very loud

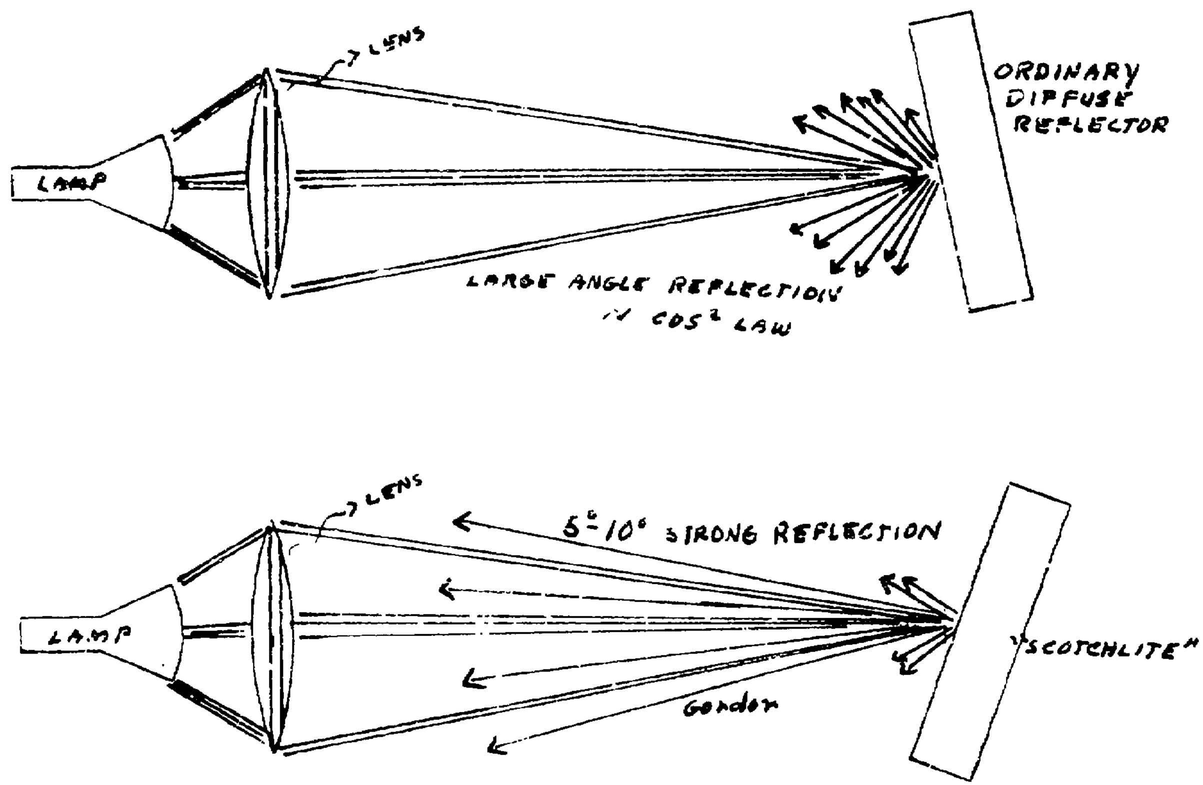


Figure D.9

Use of Scotchlite Reflective Tape
in Radar Signals

120 Hz signal. Incandescent lamps produce a 60 Hz signal; however, it is not nearly as loud as the 120 Hz signal of flourescent lights. Direct current light sources are white noise sources. The direct current illumination level can be very high before the white noise becomes a significant problem. High background illumination can saturate the photodiode circuits even if the noise from the illumination is not a problem. One approach to consider is the use of incandescent lamps with a variable power source and 60 Hz notch filters on the receiver electronics. This will allow relatively high light levels and will allow the amount of interference to be set at the desired level. Use of flourescent lights should be discouraged. Both optical and electrical interference are difficult problems to solve. This influence does, however, provide an excellent opportunity to use controlled white light interference created by the flourescent lights to simulate the effect created on communications by the electromagnetic pulse (EMP) of nuclear detonations. It permits the simulation of the nuclear battlefield with respect to communications. The flourescent light starters are especially effective in this regard.

Simple experiments and demonstrations have portrayed the graphic nature of the optical simulators and provide adequate insight for instructors to develop various optical geometries for both classroom demonstrations and TOC operation. Figure D.9 gives a few simple examples of common antenna patterns.

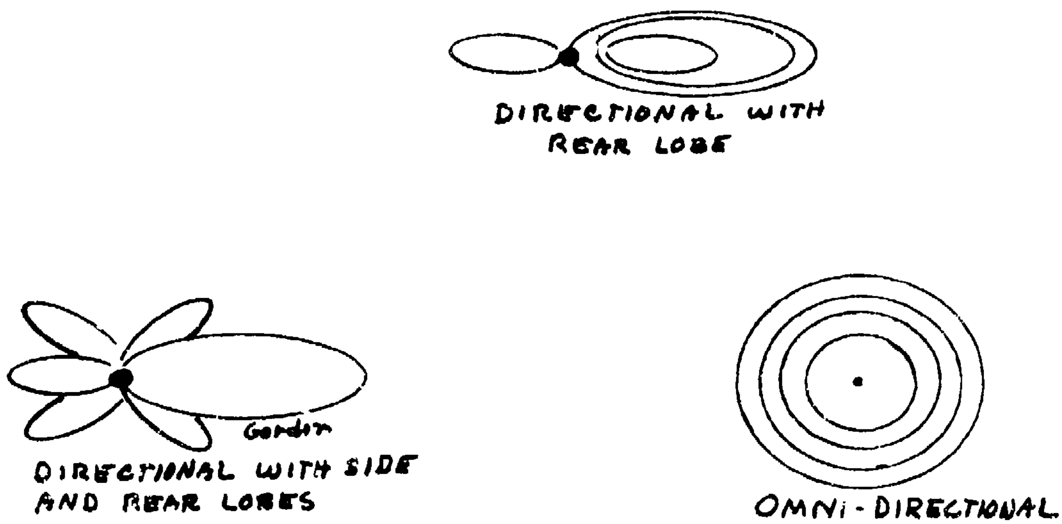


Figure D.9

Antenna Patterns

Up to this point little effort has been given to mechanical design or system installation. This area cannot be neglected during the design phases of the individual components. Background electrical and optical noise, cross-talk and switching transients can become overwhelming problems once a number of devices are operated simultaneously and wiring is extended over a large area.

There are numerous optical sensors which are manufactured commercially. None of these items are tailored to the TOC operation. It was possible to modify these devices for use in the TOC. The TOC also benefitted from existing commercial circuit designs. The greatest benefit of using modified commercial devices is the superior packaging techniques and long term reliability of the electronics. The primary drawback is the size of the commercial packages and in some instances the prices are not representative of the technology required due to low volume sales. Edmund Scientific Company of Barrington, New Jersey, has proven to be a primary source of supply for electro-optic components used in the TOC.

APPENDIX E

REFERENCES ON SIMULATION

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