U. S. NAVAL PERSONNEL RESEARCH ACTIVITY

SAN DIEGO, CALIFORNIA 92152

TECHNICAL BULLETIN STB 66-16 DECEMBER 1965

COMPARISON OF CONVENTIONAL AND PROGRAMED INSTRUCTION IN TEACHING AVIONICS FUNDAMENTALS

Alexander A. Longo
G. Douglas Mayo

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

NPRA
SAN DIEGO CALIFORNIA

AN ACTIVITY OF THE BUREAU OF NAVAL PERSONNEL

COMPARISON OF CONVENTIONAL AND PROGRAMED INSTRUCTION
IN TEACHING AVIONICS FUNDAMENTALS

by

Alexander A. Longo
G. Douglas Mayo

December 1965

PF017030401
Technical Bulletin STB 66-16

Submitted by

G. D. Mayo, Ph.D., Director, Branch Office, Memphis, Tennessee

Approved by

E. I. Jones, Ph.D., Director, Navy Training Research Laboratory
E. E. Dudek, Ph.D., Technical Director
G. W. Watson, Commander, USN
Officer in Charge

Distribution of this document is unlimited

U. S. Navy Training Research Laboratory
U. S. Naval Personnel Research Activity
San Diego, California 92152

ACKNOWLEDGEMENTS

In all studies conducted in a typical training situation, research personnel must receive substantial assistance from training personnel in order to carry out the design of the study. In the case of research pertaining to programed instruction, this dependence upon other personnel is even greater than ordinarily is true. This results, in part, from the time and effort required to produce acceptable programed material, a step which must be completed before a study of the type described herein can be conducted.

Therefore, the contribution of the Avionics Programed Instruction Team at the Naval Air Technical Training Center, Memphis, Tennessee is gratefully acknowledged. A special word of appreciation also is due to the instructional, testing, and supervisory personnel at the Avionics Fundamentals School, who contributed much time and effort to the implementation of the research design. Finally, the prompt and accurate processing of the data by Data Processing Department personnel at the Naval Air Station, Memphis, Tennessee is appreciated.

BRIEF

The study reported herein is one of a series which, considered as a whole, is designed to provide a general statement concerning the increase in training efficiency that may be expected from programed instruction technology within the Naval Air Technical Training Command. Individual studies, involving different course content and training conditions, must be conducted before a general statement of this type can be made.

This report compares the relative performance of 200 trainees taking 26 hours of conventional instruction in electronics fundamentals with 200 trainees covering the same subject matter in 19 hours, using programed instruction.

The subject matter consisted of electrical calculations, direct current circuits and direct current meters. These areas were programed by an electronics programing team in the Naval Air Technical Training Command. The programed material had a "built-in" time saving of 27% as compared with conventional instruction. The sample was divided into two groups equated on the basis of the students' performance in an earlier training course. The measures of performance used in the study consisted of two tests: a 50 item constructed response test and a 50 item multiple choice test.

The results of the study indicated that: (1) the basic electronics students learned a relatively large block of programed material to about the same degree but in substantially less time than was required by conventional instruction; (2) the constructed response examination, prepared for programed instruction purposes, exhibited satisfactory reliability; (3) the conventional and programed instruction groups did not differ significantly with respect to variability in performance; (4) the "90/90 performance level" of programed material decreased as a function of the amount of programed material tested at a given time.

CONTENTS

TABLES

COMPARISON OF CONVENTIONAL AND PROGRAMED INSTRUCTION IN TEACHING AVIONICS FUNDAMENTALS

A. The Problem and Its Background

Reducing training time without reducing the quality of the training product has become one of the more attractive approaches in recent years to improving training efficiency in the Naval Air Technical Training Command. Historically, relatively small gains have been made in the research area of training methods, with respect to improvement of student performance (DuBois and Manning, 1960). Recent research, however, in the field of programed instruction appears to hold promise of a "breakthrough" in training methods, with reduction in training time as a valuable dividend.

The Naval Air Technical Training Command has established an in-house capability to program those areas of technical training which appear best suited to this mode of instruction. A recent study on five programed booklets supported the hypothesis that learning at about the same level can be achieved by programed instruction in substantially less time than is required by conventional instruction (Mayo and Longo, 1966). In that study, 13 hours of conventional instruction on electrical physics were reduced to 9 hours of programed instruction with no loss in the quality of student performance. This represented a 31% time saving.

This is the second in a series of studies to provide information concerning the above hypothesis, as it applies to larger segments of programed material. This investigation examines 26 hours of conventional instruction on electrical calculations, direct current circuits, and direct current meters programed to 19 hours, for a time saving of 27%. The primary objective of the study is to provide information on the following question: Can students learn a fairly large sequence of programed material to about the same degree, but in a substantially shorter period of time, than is presently accomplished by conventional methods?

Other questions on which the investigation provides evidence follow:

a. Does the constructed response type examination, used to evaluate the programed material, have adequate reliability?

b. Is there a significant difference between the programed and conventional instruction groups in terms of variability on performance measures?

c. To what extent is the performance level, established in the development of a single program, maintained in a larger sequence of programed material?

B. Development of Programed Material

1. Programed Instruction Material

The programed instruction materials on electrical calculations, direct current circuits, and direct current meters were developed by a programing team in the Naval Air Technical Training Center, Memphis, Tennessee. The programing team consisted of three chief petty officers and one civilian educational specialist, all technically competent in the electronics area. All members of the team had received formal training, and experience in instructional programing.

a. The programed instruction set. The programed material pertained to subject matter appearing in the second and third weeks of the Avionics Fundamentals School, Class A. It consisted of nine individual programs, called sets, which were designed to replace 26 hours of conventional instruction with 19 hours of programed instruction. The titles of these sets were as follows:

(1) Mechanical Calculations
(2) Electrical Calculations
(3) Series Circuits
(4) Parallel Circuits
(5) Meter Movements and Scales
(6) Ammeters
(7) Voltmeters
(8) Ohmmeters
(9) Multimeters

The usual steps in instructional programing were followed in the preparation of each programed set. This includes task analysis, statement of specific behavioral objectives or terminal behavior specifications, construction of criterion test items to measure each objective, actual program writing, and successive revisions of the program with samples of the target population until 90% of the students completing the program had achieved 90% of the objectives. This is referred to as the "90/90 performance level" or "90/90 criterion" in programed instruction. Several examples illustrating the behavioral objectives and programed material are contained in Appendix A.

b. The programed instruction package. The investigation included the nine programed sets indicated above. The nine sets were divided into three groups of closely related programed material called programed packages: Electrical Calculations, Direct Current Circuits and Direct Current Meters. These three packages were considered as a sequence of related programed material, called a block of programed instruction. This block of programed material included about 30% of the instructional hours in the second and third weeks of the 19 weeks Avionics Fundamentals course. Other activities such as laboratory work, reviews, and testing periods were not programed, but conducted in accordance with conventional procedures. Appendix B contains the master schedule indicating the order of presentation of the programed and conventional material for the two school weeks in question. The programed packages employed both linear and branching procedures, depending upon which was considered most appropriate by the programing team for the material being presented.

C. Method

1. Subjects. The sample consisted of 400 students entering the Avionics Fundamentals School, Class A, at the Naval Air Technical Training Center, Memphis, Tennessee, during the second week of July 1965 through the first week of August 1965. Only non-rated Navy and Marine Corps students were included.

2. Design. The study utilized a matched group design. The matching variable was the Aviation Fundamentals (AFUN(P)) School final grade, which previous research had indicated to be rather well correlated with performance in the Avionics Fundamentals School. This test correlated between .39 and .50 with the performance measures obtained in the present study, as shown in Table 1. Nearly perfect matching, including identical means (79.61) and standard deviations (7.29), was achieved by assigning essentially unselected personnel to the two treatment groups, and delaying actual matching (pairing of individuals) until after the completion of the segment of the course in which the study was conducted.

The two pools of students from which the matching was accomplished consisted of all members of the two treatment groups or pools, except a small number who had to be eliminated for non-academic reasons. In addition, a small number from the two pools of students could not be matched and were eliminated from the sample. The matching, of course, was made completely on the basis of the matching variable and without knowledge of the students' performance in the segment of the Avionics Fundamentals School in which the experiment was conducted. It was accomplished manually by matching cards from the two groups, the cards containing only the score on the matching variable and the name and service number of the student.

As noted previously, the students were divided into two groups prior to convening in the Avionics Fundamentals School: (a) the conventional instruction group (control), and (b) the programed instruction group (experimental). The students were assigned to these groups according to the class section to which they were assigned. Assignment to sections was accomplished alphabetically. Assignment of sections to the two treatment groups (pools) was accomplished as follows: section "A" of the first class was assigned to the programed group, section "B" to the conventional group, section "C" to the programed group, etc. The assignment of the sections in the three remaining classes to the two methods of instruction was also alternated with respect to the preceding class in counterbalanced fashion. The assignment of class sections to programed and conventional instruction is shown in Appendix C.

3. Administration of Programed Material. The programed material was administered by regular classroom instructors who previously had received instruction in presenting programed material. Written instructions, pertaining to the implementation of the study, also were given to the instructors. A resume of these instructions is contained in Appendix D. No special instructions were given to the students, since they had used programed materials in earlier course work. A suggested reading time, based upon the time required for approximately 90% of the students in the program validation sample to complete the program, was indicated on the first page of each programed booklet.

When considering the amount of programed material in terms of the suggested reading time, only $13\frac{1}{2}$ hours of instruction are involved. However, the material had to be assigned to regular one hour class periods which increased the administration time of the programed material to 19 hours. When more of the course is programed it is likely that more of the potential time reduction will be realized through adaptation of the classroom schedules to the materials. Students who could not complete a set in the time allotted on a particular day were required to complete it on their own time prior to the next school day. Students completing the program in less than the time allotted were permitted to use the extra time in a constructive manner, e.g., work on homestudy assignments.

4. Criteria. In order to provide a reasonably adequate criterion measure on which to base the comparison of the programed and conventional types of instruction two different tests were employed: a constructed response test based on the programed material and a multiple choice test based on the conventional material. Both tests were administered to both groups at the end of the experimental training period, the third week of Avionics Fundamentals School. The programed instruction test contained a sample of 50 items directly related to the specific behavioral objectives of the programed sets included in the investigation. The conventional instruction test also contained 50 items, essentially all of the items used by the school to measure achievement on the conventional material that subsequently was programed.

D. Results and Interpretation

The intercorrelations among the measures involved in the study are shown in Table 1. As indicated in the previous section, the correlations between the matching variable, Aviation Fundamentals School final grade, and the other measures ranged between .39 and .50. The correlation between the two measures of performance was moderately high at .78 and .79 within the conventional and programed groups respectively.

TABLE 1

Intercorrelations Within Programed and Conventional Instruction Groups (N = 200 in Each Group)

	Prog. Inst. Test		Conv. Inst. Test	
	Prog. Group	Conv. Group	Prog. Group	Conv. Group
AFUN(P) Grade	.45	.48	.50	.39
Prog. Inst. Test	-	-	.79	.78
Conv. Inst. Test	.79	.78	-	-

Table 2 contains the reliability coefficients for both tests for both groups. These were computed by means of the Kuder-Richardson Formula 20. The correlations range from .84 to .90, which is interpreted as satisfactory reliability for the purpose for which the tests are being used.

TABLE 2

Kuder-Richardson Reliability Coefficients for the Programed Instruction Constructed Response Test and for the Conventional Test

Instructional Group	Test	KR-20
Programed Group	Prog. Inst. Test[1]	.85
	Conv. Inst. Test[2]	.84
Conventional Group	Prog. Inst. Test	.90
	Conv. Inst. Test	.84

[1]Constructed response items
[2]Multiple choice items

A comparison of the programed group with the conventional group with respect to the programed instruction constructed response test and the conventional instruction test is shown in Table 3. The scores indicate the number of items answered correctly, out of 50, by the conventional group on the programed instruction test was 37.22 as compared with 38.50 answered correctly by the programed group. The mean number answered correctly, out of 50, on the conventional instruction examination by the conventional group and programed instruction group was 40.40 and 39.32 respectively. In neither instance was the difference between the two groups statistically significant at the .05 level, as indicated by the t test of significance. These results should be considered, however, in relation to the instructional time required for the two methods. The programed group had taken only 19 hours of programed instruction, as compared with 26 hours of conventional instruction received by the conventional group on the same subject matter. This represents a time reduction of 27%.

TABLE 3

Means and Standard Deviations for
Conventional and Programed Instruction Groups
(N = 200 for both groups)

Test	Means		t[1]	Standard Deviations		t
	Conv. Group	Prog. Group		Conv. Group	Prog. Group	
AFUN(P)[2]	79.61	79.61		7.29	7.29	
Prog. Inst.	37.22	38.50	1.95	7.55	7.05	1.01
Conv. Inst.	40.40	39.32	1.87	6.48	6.40	.17

[1]t value of 1.97 is required for significance at .05 level
[2]Matching variable

Table 3 also indicates that the t tests for differences in variability on the two tests were not significant. This statistic was computed primarily to investigate the influence of programed instruction on the variability of student performance. However, the finding also assists in interpretation of the results on differences between the means wherein it is assumed that the groups are from a common population. It has been speculated that programed instruction tends to restrict the variability of group performance. The results do not support this speculation.

The fourth question investigated was concerned with the extent to which the 90/90 criterion achieved on a programed set or small unit, is curtailed in a larger unit of programed instruction. Table 4 contains data relating to this question. It appears that the high criterion level of 90/90, achieved on the programed sets individually, decreases as a function of the number of sets (or programed hours) tested at a given time. The score distribution on a given programed set tends to have high negative skewness since each set is technically developed to provide almost perfect mastery. As expected, however, score distributions on several programed sets combined, exhibit greater variability and are more nearly normal as compared to performance on the programed sets considered singly.

TABLE 4

Performance Level of Programed Material by Amount of Programed Instruction Tested at a Given Time

Unit of Material	Time	Performance Level Achieved
Programed Set	2 hrs	90/90[1]
Programed Package	9 hrs (5 sets)	64/90[2]
Programed Block	19 hrs (9 sets)	22/90[3]

[1]Read as follows: 90% of students achieved 90% of objectives, etc.
[2]Results obtained in previous investigation
[3]Results obtained in present investigation

E. Summary of Findings

The primary question considered in the study was whether students can learn a fairly large sequence of programed material to about the same degree, but in a substantially shorter period of time, than is presently accomplished by conventional methods. Three other questions relating to the nature of programed material also were investigated. Evidence pertaining to the four questions is as follows:

1. Reduction in Training Time. It was found that basic electronics students can learn a fairly large block of material by means of programed instruction to about the same level, but in substantially less time than by conventional methods of instruction. The conventional and programed instruction groups demonstrated essentially equivalent achievement on both the constructed response and conventional tests. By design, however, the programed instruction material included a 27% time reduction. These results agree with the findings of a previous study wherein 13 hours of conventional material (i.e. half as much as included in the present study) was reduced to 9 hours of programed material (a 31% time reduction) without loss in instructional quality. The results of the two studies suggest that the amount of programed material does not adversely affect the statement that students using programed instruction learn as well as those taught by conventional instruction, and in substantially less time. Further research, will be required to fully verify this statement, however.

2. Reliability of the Constructed Response Test. The constructed response type examination, designed to measure the accomplishment of the

objectives of the programed material, exhibited satisfactory reliability. The Kuder-Richardson 20 coefficients for this test, as given to the programed group and conventional group, were .85 and .90, respectively. This reliability coefficient, however, pertains to a fairly large sequence of programed material (i.e. 19 hours). The reliability of short constructed response tests such as those employed in the validation of programed sets (i.e. 2 to 3 hours of programed material) remains to be investigated. Other research is being conducted along this line.

3. Variability of Performance. The results did not show any significant difference between the programed and conventional groups in terms of variability of performance. It has been speculated that programed instruction will tend to make a group very homogeneous, since each program is designed to meet a 90/90 criterion, or almost complete mastery. In the previous study, which examined a sequence of five programs, a significant reduction in variability in the case of the programed instruction material was observed which lent support to this speculation. It is possible that when a larger sequence of programed material is examined, individual differences in learning and retention begin to be exhibited once again, resulting in greater group dispersion. Some of the statistical difficulties associated with the narrow range of scores obtained on a programed set may not be as serious with larger sequences of programed material.

4. Performance Level of Programed Material. Performance of a programed set at the 90/90 level was found to decrease as a function of the number of programed hours (or sets) tested at a given time, as expected. A lowering of the 90/90 performance level may be a natural result of individual differences in retention when a large sequence of programed material is involved.

F. Implications

1. The programed material examined in this study was demonstrated to be effective in comparison with conventional modes of instruction. The instructional program used in the study currently is in use in the electronics fundamentals curriculum. The extension of programed instruction techniques to other appropriate electronics training areas, of a similar type, appears to be indicated.

2. Before a general statement can be made concerning the extent of increase in training efficiency that may be expected from programed instruction within the Naval Air Technical Training Command, other studies involving different course content and training conditions must be completed.

REFERENCES

DuBois, P. H. and Manning, W. H. _Methods of Research in Technical Training_, St. Louis: Department of Psychology, Washington University, January 1960. Nonr. 816(02). (Technical Report No. 3, Revised Edition)

Mayo, G. D. and Longo, A. A. Training Time and Programed Instruction, _Journal of Applied Psychology_, 1966 (in press).

APPENDIX A

SPECIFIC BEHAVIORAL OBJECTIVES AND A SAMPLE PAGE FROM THREE PROGRAMS

(In all cases, the sample page pertains to the first behavioral objective of each program)

ELECTRICAL CALCULATIONS

OBJECTIVES

SET 2A - WORK, POWER AND ENERGY (MECHANICAL)

1. The student will define potential energy.
2. The student will define kinetic energy.
3. The student will state the formula for work.
4. Given values of force and distance, the student will solve for work.
5. The student will define mechanical power.
6. The student will define mechanical horsepower.
7. Given work and time, the student will solve for power in terms of horsepower.

SUGGESTED READING TIME 50 MINUTES

8A

YOUR ANSWER: Potential energy.

Yes, this is true, but you missed half the picture. The pendulum possesses potential energy only as long as you are holding it to one side.

We have defined potential energy as stored energy, or energy of position. In the case of our pendulum, when you pull the pendulum bob to one side, you are storing potential energy by lifting the bob against the pull of gravity. As the bob swings downward and forward, the potential energy becomes kinetic. The kinetic energy released is sufficient to carry the bob upward again on the opposite side, thus storing up more potential energy.

Refer to figures 1 and 2 below.

Figure 1
Potential or stored energy.

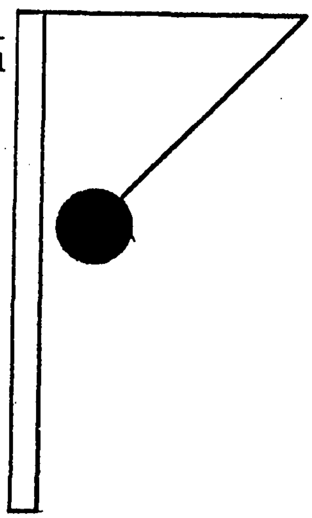
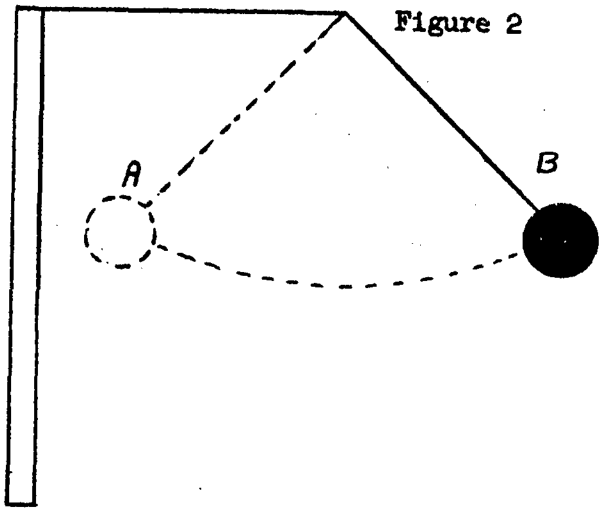


Figure 2



As the pendulum swings, the potential energy becomes kinetic energy, but at point "A" the kinetic energy is changed back to potential energy. As it swings back toward point "B", the potential energy again becomes kinetic energy.

Return to page 6A and select the more correct answer.

D.C. METERS

OBJECTIVES

SET 3 - VOLTMETERS

1. The student will write the definition of a voltmeter.

2. The student will write the definition of voltmeter sensitivity.

3. The student will write the formula used to solve for voltmeter sensitivity.

4. Given a circuit and several voltmeters, the student will select the voltmeter that will have the least "loading effect" on the circuit and write the reason for his selection.

5. The student will write the purpose of a "multiplier" used in a voltmeter.

6. Given a simple series circuit, containing a voltage source and three resistors labeled R_1, R_2 and R_3, the student will draw a voltmeter correctly connected to indicate the voltage drop across any one of the three resistors.

7. Given a drawing of a voltmeter with specified values of I_m and R_m, the student will solve the ohms/volt rating of the voltmeter.

8. Given a schematic of a multirange voltmeter, and given specified values of I_m and R_m, the student will solve for (1) the ohms/volt rating of the voltmeter, and (2) the value of the series resistors (R_s) required for each range.

SUGGESTED READING TIME 91 MINUTES

A voltmeter is a high-resistance device which is used to indicate potential difference, in volts, across a circuit or circuit component.

We say indicate (rather than measure) because, as you may well remember from your studies of meter movements and scales, all meters measure current. The meter scale is calibrated to convert the current reading directly to the unit we desire to read. In this lesson, we will be concerned with the volt.

A voltmeter is connected in parallel with the circuit, or circuit component, under test. See Figure 1.

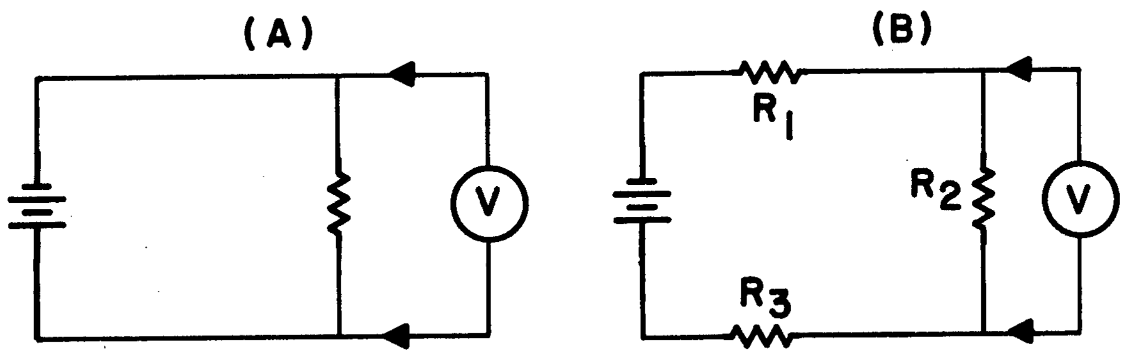


Figure 1.

In Figure 1A, the voltmeter indicates the entire circuit voltage. In Figure 1B, the voltmeter indicates only the voltage drop across R_2.

Now, complete this statement.

A voltmeter ______________________.

measures current	page 3A
measures voltage	page 6A

D.C. METERS

OBJECTIVES

SET 4 - OHMMETERS

1. The student will write the definition of an ohmmeter.

2. The student will list the three major components of a basic ohmmeter.

3. The student will list the two types of ohmmeters.

4. The student will write the purpose of the current-limiting resistor (R_L) in an ohmmeter circuit.

5. The student will write the purpose of the "zero adjust" rheostat (R_A) in an ohmmeter circuit.

6. Given an ohmmeter circuit with selected values of E, R_M, I_M, and R_L, the student will solve for the value of R_A.

7. Given an ohmmeter circuit with selected values of E, R_M, I_M, R_L, and R_A, the student will solve for the value of the unknown resistor, R_X.

8. The student will list the four safety precautions to be observed when using an ohmmeter.

SUGGESTED READING TIME 60 MINUTES

1A	
	1. An ohmmeter is an instrument designed to indicate electrical resistance. An instrument designed to indicate electrical resistance is called an ________________.
ohmmeter	2. An ohmmeter is an instrument designed to indicate electrical ____________.
resistance	3. An ohmmeter is an instrument designed to indicate ____________ ____________.
electrical resistance	4. An ohmmeter is an instrument designed to __________ electrical resistance.
indicate	5. An ohmmeter is an instrument designed to __________ __________ __________.
indicate electrical resistance	6. Write the definition of an ohmmeter. ____________________ ______________________________ ______________________________ ______________________________

Continue on next page.

2A

ANSWER: An ohmmeter is an instrument designed to indicate electrical resistance.

An ohmmeter consists of a d.c. meter movement, which was discussed in an earlier lesson, with a few added features. The added features are:

1. a d.c. source of potential (usually a 3-volt battery).
2. one or more resistors (one of which is variable).

A simple ohmmeter circuit is shown in Figure 1.

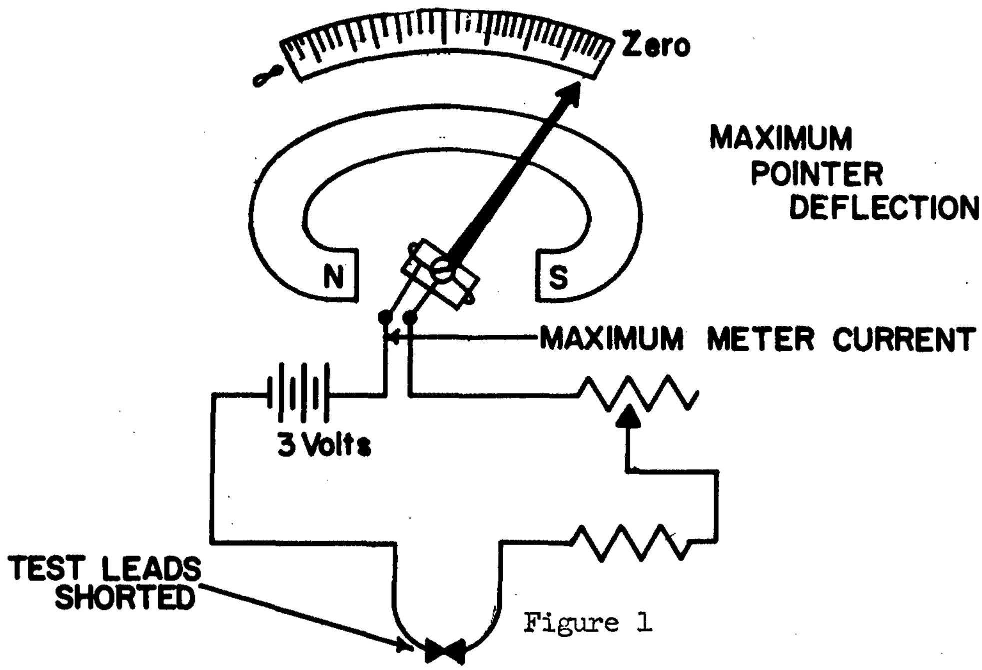


Figure 1

The ohmmeter pointer deflection is controlled by the amount of battery current passing through the moving coil.

An ohmmeter consists of ______ ______ major components.

Three Page 6A

Two Page 4A

APPENDIX B

MASTER SCHEDULE FOR PROGRAMED AND CONVENTIONAL GROUPS

MASTER SCHEDULE
(Programed Group)

SECOND WEEK — July 1965

Day	Type	Hour	Subject
Monday			
	Lab	41	Installation of Coded Resistors
		42	
		43	
		44	
		45	
	Class	46	Conversion of Electrical Units
		47	
		48	
Tuesday			
	Class	49	Conversion of Electrical Units (Drill)
		50	
	Lab	51	Safety Wiring
		52	
	Class	53	Moral Guidance
* (P-11-2A)	Class	54	Work, Power, and Energy (Mechanical)
* (P-11-2B)	Class	55	Work, Power, and Energy (Electrical)
* (P-11-2B)	Class	56	Work, Power, and Energy
Wednesday			
	Class	57	Conversion of Electrical Units (Drill)
	Class	58	Coaxial Connectors
	Lab	59	Coaxial Connectors
		60	
* (P-111-1)	Class	61	Series Circuits
*		62	
*		63	
*		64	
Thursday			
* (P-111-2)	Class	65	Parallel Circuits
*		66	
*		67	
	Class	68	Batteries, Care and Safety
		69	Organized Athletics
		70	
	Class	71	Avionics Rating Familiarization
		72	
Friday			
	Class	73	Series-Parallel Circuits
		74	
		75	
	Class	76	Series-Parallel Circuits (Drill)
	Class	77	Progress Test
	Class	78	Magnetism
	Class	79	Electro Magnetism
		80	

*Programed classes

MASTER SCHEDULE

SECOND WEEK (Conventional Group) July 1965

Day	Type	Hour	Subject
Monday			
	Lab	41 42 43 44 45	Installation of Coded Resistors
	Class	46 47 48	Conversion of Electrical Units
Tuesday			
	Class	49 50	Conversion of Electrical Units (Drill)
	Lab	51 52	Safety Wiring
	Class	53	Moral Guidance
		54	Conversion of Electrical Units (Drill)
	Class	55 56	Work, Power, and Energy
Wednesday			
	Class	57	Work, Power, and Energy (Drill)
	Class	58	Coaxial Connectors
	Lab	59 60	Coaxial Connectors
	Class	61 62 63 64	Series Circuits
Thursday			
	Class	65 66	Series Circuits (Drill)
	Class	67 68	Parallel Circuits
	Class	69 70	Parallel Circuits (Drill)
	Class	71	Batteries, Care and Safety
	Class	72	Series-Parallel Circuits
Friday			
	Class	73	Parallel Circuits (Drill)
	Class	74 75	Series-Parallel Circuits
	Class	76	Series-Parallel Circuits (Drill)
	Class	77	Progress Test
	Class	78	Magnetism
	Class	79 80	Electromagnetism

MASTER SCHEDULE
(Programed Group)

THIRD WEEK — July 1965

Day	Type	Hour	Subject
Monday			
	Class	81	Organized Athletics
		82	
	Class	83	Combination Series-Parallel Circuits
		84	
	Class	85	Combination Series-Parallel Circuits (Drill)
		86	
		87	
		88	
Tuesday			
	Class	89	Combination Series-Parallel Circuits (Drill)
	Class	90	Voltage Dividers
		91	
	Class	92	Voltage Dividers (Drill)
* (P-V-1)	Class	93	Meter Movements and Scales
*		94	
* (P-V-2)	Class	95	D.C. Ammeters
*		96	
Wednesday			
	Lab	97	Use of Ammeters
		98	
* (P-V-3)	Class	99	D.C. Voltmeters
*		100	
	Lab	101	Use of Voltmeters
		102	
	Class	103	Organized Athletics
* (P-V-4)	Class	104	Ohmmeters
Thursday			
* (P-V-5)	Class	105	Multimeters
*		106	
	Lab	107	Use of Multimeters
		108	
		109	
		110	
COMPARATIVE STUDY	Class	111	Test - Crit. 50 Ques.
		112	
Friday			
	Class	113	Review
		114	
	Class	115	Test, Record
		116	
	Lab	117	Performance Test
		118	
COMPARATIVE STUDY	Class	119	Test - 50 Prog. Mat. (Conv.Test)
		120	

*Programed classes

MASTER SCHEDULE
(Conventional Group)

THIRD WEEK — July 1965

Day	Type	Hour	Subject
Monday			
	Class	81 82	Electrical Measurements
	Class	83 84	Combination Series Parallel
	Class	85 86 87 88	Combination Series Parallel (Drill)
Tuesday			
	Class	89 90	Voltage Dividers
	Class	91	Voltage Dividers (Drill)
	Class	92 93 94	Meter Movements and Scales
	Class	95	D.C. Ammeters
	Class	96	D.C. Ammeters (Drill)
Wednesday			
	Lab	97 98	Use of Ammeters
	Class	99	D.C. Voltmeters
	Class	100	D.C. Voltmeters (Drill)
	Lab	101 102	Use of Voltmeters and Ammeters
	Class	103	Ohmmeters
	Class	104	Ohmmeters (Drill)
Thursday			
	Class	105	Multimeters
	Class	106	Multimeters (Drill)
	Lab	107 108 109 110	Use of Multimeters
COMPARATIVE STUDY	Class	111 112	Test - Crit. 50 Ques.
Friday			
	Class	113 114	Review
	Class	115 116	Test, Record
	Lab	117 118	Performance Test
COMPARATIVE STUDY	Class	119 120	Test - 50 Prog. Mat. (Conv. Test) Test

APPENDIX C

ASSIGNMENT OF CLASS SECTIONS TO PROGRAMED* AND CONVENTIONAL* INSTRUCTION

CLASS	SECTIONS A	B	C	D	E	F
I	P	C	P	C	P	C
II	C	P	C	P	C	P
III	P	C	P	C	P	C
IV	C	P	C	P	C	P

*P - Programed Instruction
*C - Conventional Instruction

APPENDIX D

RESUME OF INSTRUCTIONS TO INSTRUCTORS

A comparative study will be performed on four classes beginning 19 July 1965. These special instructions for these four classes are to control, as much as possible, the conditions existing, and the attitude of the students during this period so that the comparative study results will be as valid as possible.

1. The review material included in the programed booklet is to be ignored for the purposes of this study.

2. The regular homework will be assigned.

3. For maximum learning, all of the suggested reading time listed in the programed package should be used on the programed material.

4. Adhere to the new Master Schedule for weeks 2 and 3. The time indicated on the master schedule includes introduction and conclusion time when needed.

5. Individual student questions on any material (including programed material) are to be answered in the normal manner whenever they arise.

6. On scheduled reviews where a whole week or three weeks is reviewed to prepare for a test, the programed material will also be reviewed, but given its natural weight in the discussion.

7. Time set aside on the master schedule to review smaller units of material will not be used to review programed material.

8. Night school will be conducted in the normal manner with no changes.

9. Make no mention to students of a comparative study. The implementation is to be done in a manner that implies to the student that he is no different from the class before him or after him.

10. The general approach to these instructions is that all the time allotted to a package by the master schedule must be used as efficiently as possible, using the program as another training aid for the instructor. Time allocated to study and review of other material must be used for that purpose and not for programed material.

DISTRIBUTION LIST

Technical Bulletin (STB)

Navy Training Research Laboratory

Director of Manpower Requirements and Utilization
OASD(M) SS&R
3D970 The Pentagon
Washington, D. C. 20350

Air University Library
Maxwell Air Force Base
Alabama 36112

United States Army Personnel Research Office
Office, Chief Research and Development
Department of the Army
Washington, D. C. 20315

Chief, Bureau of Medicine and Surgery
Navy Department
(Attn: Code 513)
Washington, D. C. 20390

Chief, Bureau of Medicine and Surgery
Navy Department
(Attn: Code 33D)
Washington, D. C. 20390

Chief, Bureau of Yards and Docks
Navy Department
(Attn: Code 50312)
Washington, D. C. 20390

Career Development Division
DCS/P Headquarters USAF
Tempo Building 8
Washington, D. C. 20330

Superintendent
U.S. Naval Postgraduate School
Monterey, California 93940

Chief of Naval Air Technical Training (Attn: Code 34)
U. S. Naval Air Station
Memphis, Tennessee 38115

Chief of Naval Air Reserve Training
U. S. Naval Air Station
Glenview, Illinois 60026

Chief, Bureau of Ships
Navy Department (Attn: Code 364C)
Washington, D. C. 20360

Chief of Naval Operations (OP-03T)
Navy Department
Washington, D. C. 20350

Chief of Naval Operations
(OP-07T16)
Room 5E621
Navy Department
Washington, D. C. 20350

Chief of Naval Air Training
U. S. Naval Air Station
Pensacola, Florida 32508

Chief Psychiatry and Neurology
OTSG-DA
Room 1062, Main Navy Building
Washington, D. C. 20315

Commandant
U. S. Army War College
(Attn: Library)
Carlisle Barracks
Pennsylvania 17013

Commanding Officer
U. S. Fleet Sonar School
U. S. Naval Base
Key West, Florida 33040

Commanding Officer
U. S. Fleet Anti-Submarine
Warfare School
San Diego, California 92147

Commanding Officer
U. S. Naval Examining Center
Building 2711
U. S. Naval Training Center
Great Lakes, Illinois 60088

Commanding Officer
U. S. Naval Officer Candidate
School
U. S. Naval Base
Newport, Rhode Island 02844

Commanding Officer
U. S. Naval School of Aviation
Medicine
U. S. Naval Aviation Medical
Center
(Attn: Psychology Lab)
Pensacola, Florida 32512

Commanding Officer
U. S. Naval Submarine Medical
Center
U. S. Naval Submarine Base
New London
Groton, Connecticut 06342

Commanding Officer
Service School Command
(Attn: 38)
U. S. Naval Training Center
San Diego, California 92133

Commanding Officer and Director
U. S. Naval Training Device
Center (Attn: Code 55)
Port Washington, New York 11050

Director of Research
HumRRO No. 6 (Aviation)
P. O. Box 428
Fort Rucker, Alabama 36362

Director of Research
HumRRO Division No. 5
(Air Defense)
P. O. Box 6021
Fort Bliss, Texas 79916

Director
U. S. Naval Personnel Research
Laboratory
Washington Navy Yard
Washington, D. C. 20390
(3 copies)

Directorate for Armed Forces
Information and Education
Attn: Research and Evaluation
Building T-7, Room 210
Washington, D. C. 20301

Educational Advisor
Building 300
Service School Command
U. S. Naval Training Center
Great Lakes, Illinois 60088

U. S. Army Enlisted Evaluation
Center
P. O. Box 16499
Fort Benjamin Harrison
Indiana 46249

Headquarters Air Force Systems
Command Office
(Assistant for Bioastronautics -
SCGB)
Andrews Air Force Base
Washington, D. C. 20311

Headquarters U. S. Air Force
(AFPCPCA)
Room 4413, Munitions Building
Washington, D. C. 20330

Headquarters, U. S. Marine Corps
G-1 Division (Code AQIB)
Washington, D. C. 20380

Headquarters
SAC (OA)
Offutt Air Force Base
Nebraska 68113

Human Factors and Operations
Research Division Office
Chief of Research and
Development
Navy Department
Washington, D. C. 20310

Human Factors Operations
Research Laboratory
Air Force Systems Command
Bolling Air Force Base
Washington, D. C. 20332

Officer Personnel Research and
Review Branch
P. O. Station 2-16
U. S. Coast Guard Headquarters
Washington, D. C. 20226

Director of Research
HumRRO Division #2 (Armor)
Fort Knox, Kentucky 40121

Director of Research
HumRRO Division #4 (Infantry)
P. O. Box 2086
Fort Benning, Georgia 31905

Officer in Charge
U. S. Navy Medical Neuro-
psychiatric Research Unit
San Diego, California 92152

Chief of Naval Research
Navy Department
Washington, D. C. 20360

Operations Evaluation Group
Office of the Chief of Naval
Operations (OP03EG)
Navy Department
Washington, D. C. 20350

Science Division
Directorate of Science and
Technology DCS/Research
and Development
Headquarters, U. S. Air Force
Washington, D. C. 20330

Superintendent (P)
U. S. Coast Guard Academy
New London, Connecticut 06320

Technical Reference Library
U. S. Naval Medical Research
Institute
National Naval Medical Center
Bethesda, Maryland 20014

Library
6570th Personnel Psychology
Laboratory (AMD)
Box 1557
Lackland Air Force Base
Texas 78236

Commanding Officer
Air Force Personnel Laboratory
ASD (AFSC)
Lackland Air Force Base
San Antonio, Texas 78558

Commander
Personnel Research Laboratory
Aerospace Medical Division
Air Force Systems Command
Lackland Air Force Base
Texas 78242

Commanding Officer and Director
U. S. Navy Electronics Laboratory
San Diego, California 92152

Chief of Naval Personnel (Pers-A3)
Navy Department
Washington, D. C. 20370 (15 copies)

Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314
(20 copies)

Commandant, FIRST Naval District
495 Summer Street
Boston, Massachusetts 02210

Commandant, THIRD Naval District
90 Church Street
New York, New York 10007

Commandant, FOURTH Naval District
Philadelphia, Pennsylvania 19112

Commandant, FIFTH Naval District
Norfolk, Virginia 23511

Commandant, SIXTH Naval District
U. S. Naval Base
Charleston, South Carolina 29408

Commandant, EIGHTH Naval District
New Orleans, Louisiana 70140

Commandant, NINTH Naval District
Building #1
Great Lakes, Illinois 60088

Commandant, TENTH Naval District
FPO New York 09550

Commandant, ELEVENTH Naval District
San Diego, California 92130

Commandant, TWELFTH Naval District
Federal Office Building
50 Fulton Street
San Francisco, California 94102

Commandant, THIRTEENTH Naval District
Code 51
Seattle, Washington 98115

Commandant, FOURTEENTH Naval District
Box 110
FPO San Francisco 96610

Commandant, FIFTEENTH Naval District
FPO New York 09580

Commandant, SEVENTEENTH Naval District
FPO Seattle 98790

Commander
Fleet Training Group, Code 51
Attn: Training Officer
FPO San Francisco 96610

Headquarters
Air Force Systems Command
USAF Andrews Air Force Base
Washington, D. C. 20331

Commandant
Naval District Washington, D. C.
Washington Navy Yard
Washington, D. C. 20390

Deputy Assistant Secretary of Defense
(Special Studies and Requirements)
The Pentagon 3D970
Washington, D. C. 20350

District Inspector General
Commandant ELEVENTH Naval District
San Diego, California 92130

Inspector General
Chief of Naval Personnel
Navy Department
Washington, D. C. 20340

Officer in Charge
U. S. Naval Training Devices Center
Attn: Code 50F
Orlando, Florida 32800

Chief, Training and Procurement Division
Coast Guard Headquarters
Washington, D. C. 20226

Mr. Mark Colburn
Office of Assistant Secretary of Defense
(Special Studies & Requirements)
The Pentagon - 3D970
Washington, D. C. 20350

Scientific Director
Naval Submarine Medical Center
Naval Submarine Base, New London
Groton, Connecticut 06342

Science Research Associates, Inc.
259 East Erie Street
Chicago, Illinois 60611

Psychological Abstracts
1333 - 16th Street, N.W.
Washington, D. C. 20036

Mr. Paul Brown
Office of the Chief of Naval
(OP-01B1) Room 4E487
Navy Department
Washington, D. C. 20350

Director, HumRRO
300 North Washington Street
Alexandria, Virginia 22314

Chief of Naval Personnel
(Attn: Assistant Director Naval
Manning, Personnel Selections)
Naval Headquarters
Ottawa, Ontario, Canada

Directorate of Personnel
Research and Selection
Room 3003 "B" Building
Canadian Forces Headquarters
Ottawa, Ontario, Canada

Human Factors Research, Inc.
1112 South Crenshaw Boulevard
Los Angeles, California 90019

Human Factors Research, Inc.
3040 State Street
Santa Barbara, California 93105

Head, Personnel and Training
Branch
Psychological Sciences Division
Office of Naval Research
Washington, D. C. 20360

Education Research Project
Center for Documentation and
Communication Research
Western Reserve University
10831 Magnolia Drive
Cleveland, Ohio 44106

Dunlap and Associates, Inc.
Darien, Connecticut 06821

Division of Behavioral Sciences
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D. C. 20037

Director
Behavioral Sciences Department
Naval Medical Research Institute
Bethesda, Maryland 20014

Electronics Personnel Research
Group
University of Southern California
University Park
Los Angeles, California 90007

Defense Research Member
Canadian Joint Staff
2450 Massachusetts Avenue, N.W.
Washington, D. C. 20008

Chief of Personnel Research
Staff
Office of Personnel
U. S. Department of Agriculture
Washington, D. C. 20250

Dr. S. Rains Wallace
Chief of Behavioral and Social
Science Division
Office of the Assistant Director
Department of Defense
Washington, D. C. 20301

Applied Psychological Services
Science Center
404 East Lancaster Avenue
Wayne, Pennsylvania 19087

Applied Psychology Corp.
3717 North 27th Street
Arlington, Virginia 22207

Director of Research
HumRRO Division No. 3
(Recruit Training)
P. O. Box 787
Presidio of Monterey
California 93940

6570 AMRL (MRPT, Library)
Wright-Patterson Air Force
Ohio 45433

Dr. Robert Glaser
American Institute for Research
Department of Psychology
University of Pittsburgh
Pittsburgh, Pennsylvania 15213

American Institute for Research
Project Talent Office
1808 Adams Mill Road, N.W.
Washington, D. C. 20009

Director of Research
HumRRO Division No. 5
(Air Defense)
P. O. Box 6021
Fort Bliss, Texas 79916

Acquisition Section
National Library of Medicine
Bethesda, Maryland 20014

University of California at
Los Angeles
Attn: Library
405 Hilgard
Los Angeles, California 90024

Director for Long Range Studies
Institute of Naval Studies
545 Technology Square
Cambridge, Massachusetts 02139

University Library
University of California,
San Diego
La Jolla, California 92037

CIA Medical Staff/AES
2430 E Street, N.W.
Washington, D. C. 20505

Chief of Naval Air Technical Training
(Code 34)
Naval Air Station
Memphis, Tennessee 38115 (50 copies)

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
U. S. Naval Personnel Research Activity San Diego, California 92152	UNCLASSIFIED 2b GROUP

3. REPORT TITLE

COMPARISON OF CONVENTIONAL AND PROGRAMED INSTRUCTION IN TEACHING AVIONICS FUNDAMENTALS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Longo, Alexander A.
Mayo, G. Douglas

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1965	31	2

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. PF017030401	Technical Bulletin STB 66-16
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. AVAILABILITY/LIMITATION NOTICES

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Naval Personnel (Pers-A3) Navy Department Washington, D.C. 20370

13. ABSTRACT

This study is one of a series of investigations involving a variety of course content and training conditions where programed instruction will be compared with conventional classroom instruction to provide information about the general utility of programed instruction.

Here the performance of 200 trainees taking 26 hours of conventional instruction in electrical calculations, direct current circuits, and direct current meters is compared with the performance of 200 trainees taking 19 hours of programed instruction on the same content.

Results indicate: (1) The basic electronics students learned a relatively large block of programed material to about the same degree but in substantially less time than was required by conventional instruction; (2) the constructed response examination, prepared for programed instruction purposes, exhibited satisfactory reliability; (3) the conventional and programed instruction groups did not differ significantly with respect to variability in performance; (4) the "90/90 performance level" of programed material decreased as a function of the amount of programed material tested at a given time.

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2*a*. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2*b*. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7*a*. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7*b*. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8*a*. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8*b*, 8*c*, & 8*d*. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9*a*. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9*b*. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ______________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ______________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ______________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.