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A STUDY OF

# Performance Measures Of Trouble Shooting Ability On Electronic Equipment

by
Rupert N. Evans
Lyman J. Smith

Prepared for
Personnel Analysis Division
Bureau of Naval Personnel
under
Contract No. N6-ori-07142
Project NR 153-124

University Of Illinois
College Of Education
Urbana, Illinois

1 October 1953

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## Abstract

This project was concerned with the construction of a performance test to be used in Navy Schools for Electronics Technicians. The procedure used in constructing and administering a performance test f[illegible] trouble shooting the SG-1b radar, the test itself, and data based on the administration of the test are reported.

This project was further concerned with a study of the administration of performance tests for electronics technicians. In accordance with this objective:

(1) A procedure for applying a special variation of sequential sampling to performance testing was developed, and published as a separate report.

(2) A series of "tab" items was developed and administered, and standardized tests were administered to the same group of Navy students who took the performance and tab tests described above. Personal data were also collected on these students in an attempt to discover relationships between these data and performance test scores. The procedure used in constructing the tests, the tests themselves, and partial data based on these instruments are reported.

(4) Temporary concealment of front panel indications on the equipments used for performance testing was employed in an effort to make observation of performance testing more objective.

Navy personnel were used in the final administration of all tests. The training program used for these personnel is described.

Data on inter-observer reliability, inter-scorer reliability, internal consistency reliability (coefficient alpha), face validity, and acceptability of tests to instructors and students are reported.

The results seem to indicate the following:

(1) With regard to the performance tests used, inter-observer and scorer reliabilities are remarkably high. Internal consistency reliability is adequate, but moderately low, due to the high rate of learning involved. Face validity and acceptance of the tests is quite high.

(2) With regard to "tab items," inter-scorer reliabilities are quite high. Internal consistency reliability is slightly lower than that of the performance test. Correlation with performance tests is moderately low, probably due in large part to the reliabilities of the two tests. Face validity is high, and acceptance of the tests is extremely good. Students and instructors consistently asked for more such tests. One of the problems involved in the estimation of reliability was the amount of learning which occurred during test administration, which suggests that the tab items may be even better as a teaching instrument than as an evaluation instrument.

## Acknowledgements

This report would not have been possible without the contributions of the many persons who helped in the planning, execution, and summarization of this research. Administrative and instructor personnel of the Training Command and Class A Electronics Technicians School, Great Lakes devoted much time to the planning and development of the tests used. Special mention should be made of Captain J. B. Williams, Lt. Commander A. J. Bosselet, Lt. Commander R. G. Harriman, and Charle Armstrong. Commander E. H. Dimpfel, Lt. Commander E. B. Steier, ETIc Boyes, Lt. (jg) Herman, and instructors of the Class A Electronics Technician's School, Treasure Island, made possible the final collection of data.

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A great many procedural and methodological steps in this study could not have been planned without the aid of Dr. E. D. Carstater, William Penn, and Robert Wood, of the Training Research Division, Bureau of Naval Personnel.

Dr. Lee Cronbach, University of Illinois, and Dr. Jacob Wolfowitz, Columbia University, were indispensable in the development of procedures to be used in sequential sampling.

We feel particularly indebted to the enlisted personnel and instructors at Great Lakes and Treasure Island for serving as subjects during the development and field trials of the tests, and for offering many helpful suggestions for test improvement.

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## INTRODUCTION AND OVERVIEW

Tasks which the Navy is expected to perform require that many types of electronic equipment function reliably within tolerance. Uses to which electronics equipment are being put are constantly increasing. Moreover, individual electronic devices grow more complex, especially as "operator convenience" demands are made. With naval operations so dependent upon the information and services provided by radio, radar, and other electronic equipment, the problem of maintenance becomes critical. One of the knotty problems facing naval administrators is that of knowing how to judge the effectiveness of maintenance personnel. In an attempt to learn more about technician effectiveness, research under Contract N6ori-07142 was conducted to develop and study suitable performance test measures for use with electronic technicians, particularly in the Navy school situation.

For the purpose of organizing this report, the study is broken into three phases. Phase I deals with planning the research and writing the test items which were used in phase II. During phase I, the study was more carefully defined than had been true of the original proposal and also was considerably delimited in scope. Another vital part of phase I involved trying out the performance test items at the same time giving team members of the project a chance to practice observing and

recording the behavior of student technicians as they responded to the performance test situation.

During phase II, data were collected on a group of graduating students from the Class A technician school at Treasure Island, San Francisco, California. A criterion measure of trouble-shooting was obtained through administration of the individual trouble-shooting performance tests developed during phase I, using the SG-1b surface search radar as a vehicle. Five and one-half hours were allotted per man to be used for performance testing. The remaining time (each man was made available for two working days) was used to administer a battery of reference tests as well as a paper form of trouble shooting test known as the "Tab Test."

An analysis of the data gathered during phase II constitutes phase III. The problems faced during this phase centered in: (a) assigning scores to each person on every test, (b) determining the accuracy of the scores, (c) finding the extent to which reference variables would predict the performance test, or criterion, and finally drawing conclusions that seemed to be implied by the data.

It is unfortunate that complete analysis of phase II data cannot be made in this report. Because of the sudden decision by the Bureau of Naval Personnel, not to renew contract Nonri-07142 as had been planned, the project team was forced into a sharp retrenchment in terms of what would be done as well as the timetable for doing it. As a result, this final report may

be looked upon as our best salvage efforts. Continued research on technician effectiveness is being carried on independently by one of the project members without Governmental support. This study is specifically in the area of criterion analysis and the prediction of the criterion by selected reference variables. When this analysis has progressed sufficiently a report of the findings will be submitted to the Bureau of Naval Personnel.

Since it was and is still felt that performance testing will always be seriously limited in usefulness until it is made more efficient, concurrent with working on the above problems an attempt was made to apply the theory of sequential analysis to performance testing. A rationale was developed and put to an empirical test using the data gathered in phase II. This phase of the study has been published as a separate technical report entitled A Suggested Use of Sequential Analysis in Performance Acceptance Testing.

In another attempt to improve the efficiency of performance testing, a limited exploration was made of the use of the "tab item" type of test. The "tab item," developed by Damrin, attempts to measure some of the same factors tapped by performance tests in the problem solving field. The results of this part of the study are reported in phase III.

## PHASE I EXPLORATORY

At the outset of the research program it was felt by the project members (one half-time director and one full-time research associate) that the validity of any results or conclusions would suffer if the initial planning was not well-founded in the actualities of the Electronics Technician training situation. It appeared obvious that the project members should have an awareness of the content or subject matter which is taught in a Class A Electronics Technician's School as well as an awareness of methods of instruction and problems of administration, so as to be able to see problems from the point of view of the students and staff. In order to become acquainted with the training situation, a preliminary conference was held between representatives from the ET school and the members of the project. Following this visit it was decided that the knowledges described above could best be gained by spending time in the service school as a student. It was feasible for only the full-time project member to do this and so approximately six weeks were spent with selected instructors at the Class A Technicians School, Great Lakes. Three weeks were spent in the study of fundamentals which composes the first twenty weeks of the course for electronics technicians. The fourth and fifth weeks' work was spent in receiver and transmitter phases respectively, while the sixth week was used for the study of radar. The six weeks spent as a student were extremely helpful in all subsequent

areas of work. The study was both theoretical and practical in that the project member actually built the major portion of the projects constructed by the students.

## Delimiting the Problem

The ultimate criterion for technician effectiveness is defined by the duties that are required of technicians. These duties are specified by the statement of qualifications for the ET rate. Fourteen practical factors are listed for a third class petty officer in the ET rate. A study of all duties of a third class ET as specified by the qualifications manual was clearly not within the limits of the present contract and considerable delimitation was necessary. Since a choice needed to be made among the duties performed by the ET, it was felt that study should be made of the more, rather than less significant duties. It was generally conceeded by technicians and other observers, that whatever else a man is, if he is not a good trouble shooter he is not a technician. This is not to say that the effectiveness of the technician in his total job is not modified by other capabilities. Trouble shooting simply appeared to be his most critical job. In order to have some check on the relevance of this hypothesis a survey was conducted among the staff at the ET school at Great Lakes in which the respondents were asked to indicate their concept of the importance of the jobs of the technician by placing practical factor requirements from the qualifications manual in rank order of importance. As may be seen from the results of this survey, reported in Table I, the hypothesis that trouble shooting is critical is given firm support.

TABLE I

Ranking of qualifications for Electronics Technician Third Class by Instructor and Administrative Personnel, Class A School for ET, Great Lakes. N= 56. *Qualifications judged to be closely related to trouble-shooting ability.

| RANK | ESSENTIAL FACTOR QUALIFICATIONS | MEAN RANK | S.D. |
|---|---|---|---|
| 1. | *Is able to properly use test equipment in electronics service work | 3.96 | 1.52 |
| 2. | Observes safety precautions in installation, operation and repair of electronic equipment | 4.02 | 3.72 |
| 3. | *Can draw and interpret schematic diagrams of electronic circuits; read and interpret electronic wiring and circuit diagrams found in manufacturers instruction books | 4.04 | 2.51 |
| 4. | *Can perform preventive maintenance and under close supervision perform casualty analysis and repairs to radio, radar, sonar and radiac equipment | 4.48 | 2.25 |
| 5. | *Can manipulate, (start, stop, calibrate and tune) radio, radar and sonar equipment | 4.98 | 3.15 |
| 6. | *Can locate and identify component parts by reference to associated circuit diagrams for radio, radar and sonar equipment | 5.26 | 2.01 |
| 7. | Can use and maintain hand tools and operate small portable power tools in electronics installation and repair | 7.14 | 1.64 |
| 8. | Is able to use the method of resuscitation a man unconscious from electrical shock and can administer treatment for electrical burns | 7.70 | 3.84 |
| 9. | Is able to locate and identify individual units of electric and electronic remote control systems associated with radio, radar, and sonar equipment | 7.74 | 2.41 |
| 10. | Is able to locate and identify the main, emergency and casualty power supply systems for radio, radar and sonar equipment | 8.30 | 2.14 |
| 11. | Is capable of operating emergency and portable power supply equipment, including internal combustion engines (both gas and diesel) used in connection with electronic equipment | 10.48 | 1.94 |
| 12. | Is able to locate shorts and grounds, and effect emergency repairs on pressurized and coaxial type transmission lines | 11.42 | 1.40 |
| 13. | Can locate leaks and make emergency repairs on pressurized transmission lines on own ship or station | 12.04 | 1.60 |
| 14. | Can send and receive International Morse Code (Knowledge of alphabet) | 13.88 | .60 |

Whereas study up to this point has been general, emphasis was now narrowed to an investigation of trouble shooting. A vehicle equipment for a preliminary exploration of the nature and range of trouble shooting behavior was built, using the schematic for the communications type superhetrodyne receiver built by the students in the latter weeks of the first phase of the Class A ET school. The subjects used for observation purposes were college students in electrical engineering and members of a university club for radio amateurs, who volunteered their time. The "troubles" used with the superhet receiver were chosen by a panel made up of the project staff members, plus an experienced chief electronics technician assigned to NROTC duty at the University of Illinois. It was intended that the problems be common or typical failures which would result in no output or simple distortion of output. Some examples of the type problems used were:

(a) open coupling capacitor between first and final audio stages

(b) defective mixer tube

(c) open cathode resistor in the power output stage

Fourteen men were observed while trouble shooting, and their behavior was recorded as it occurred as objectively as possible. By the time ten men had been observed on the superheterodyne equipment it seemed evident that the most common trouble shooting behaviors had been exhibited. No different methods of trouble shooting were observed in the next four men, so testing was discontinued. During this limited period of observation, it appeared that a small percentage of the subjects

exhibited marked symptoms of perseverance. They continued to make tests in stages of the equipment which could logically have been eliminated from consideration on the basis of information previously obtained. It appeared, further, that the stage in which they tended to continue to make unnecessary tests was the stage about which they knew the least.

## Tab Item Test

The tab item type of test was developed by Dr. Dora Damrin of the University of Illinois as a means of group testing of problem solving ability. Its three basic sections are:

(1) Statement of problem

(2) Series of questions about the problem, with answers covered by "tabs" of paper

(3) Series of possible solutions to the problem, with "correct" or "incorrect" covered by tabs of paper after each solution.

The subject gets answers to as many questions as he feels he needs in section 2 by pulling off the necessary tabs. When he feels he has the solution, he checks his answer by pulling a tab in section 3. If he is incorrect, he reinterprets the information he has gathered in section 2, or gathers additional information by pulling more tabs. This continues until the time limit expires, or he gets the correct answer.*

*For a more complete discussion, see Glazer, R., Damrin, D., and Gardner, F. The Tab Item: A Technique For The Measurement Of Proficiency In Diagnostic Problem Solving Tasks. Urbana, Illinois. Bureau of Educational Research, College of Education, University of Illinois. June, 1952.

Since trial of the "tab item" type of test was desired, the information gathered by observing men trouble shoot the superhet chassis was used to develop two experimental items of the tab form. (See appendix pg A) In other words the information made available to the testees through the tab item was that information sought by men actually trouble shooting the receiver, regardless as to whether the information was relevant or not. These items were administered to 37 staff and students of the Class A ET School, Great Lakes, on an individual basis. One minor change was made in the Damrin format. Instead of being cut and assembled individually, the tabs were diecut by machine, one page at a time, so that the tests could be assembled more rapidly. No time limit was imposed, but if a man was stymied after approximately 20 minutes on an item, he was given assistance by one of the project members. Perseveration was exhibited by certain subjects in almost exactly the same form described in the preceding section of this report.

Each man who took the tab test was asked to report his reactions immediately after having completed the two test items. It is certain that criticism of the instrument was somewhat biased due to the success or failure of the man attempting the tab item. However it was determined that face validity was extremely high. The overwhelming response was that the tab item would be an excellent device for training men or giving mass practice in logical trouble shooting problems. In general the conclusion from administering the trial items was that further study of the tab item was justified.

Study of radio receiver troubleshooting was discontinued at this point because radio receivers did not seem to offer as wide a range of problem solving situations as did, for example, radar. Radar involves, generally, all the problems of radio for the technician and in addition many others. For this reason it was believed possible to make generalizations from radar that could not be made from radio. The choice of a specific radar equipment was somewhat arbitrary, since the equipment to be used had to be available in sufficiently large numbers so as to release equipments for testing purposes. The SG-1b met this demand most easily and so became the testing vehicle. This particular radar was also the primary radar training vehicle in the Class A school and it was felt that the students had a better chance of having command of the theory of this equipment than of the other equipments studied briefly during the ET course.

## Choice of Experimental Performance Test Items

The task of performance test item writing was made easier because of the help given by instructors in radar phase at Great Lakes. Many valuable suggestions for items were made by this group. Other suggestions for items which at first glance appeared to be satisfactory, turned out to be impractical when compared with the criteria developed for screening performance items. The following criteria were developed for this purpose.

(1) Trouble should be one that occurs in practice

(a) the troubles which occur more frequently should make up the bulk of the items.

(b) troubles should cover a range of frequency of occurance

(c) an infrequent trouble is not hereby outlawed

(2) Trouble should be one that can be introduced into the equipment by an observer in less than 15 minutes

(3) Trouble should be one that does not damage a sizable portion of the equipment.

(4) Each of the various sections of the equipment should be represented; i.e. power supplies, video, trigger, etc.

(5) Trouble should not introduce unusual safety hazards such as shorting B plus to a sub-chassis

(6) Troubles should range in difficulty from very obvious to fairly obscure

(7) In general there should be groups of two or three items which have similar symptoms with different causes.

(8) No troubles of an intermittent type should be included.

(9) Only single troubles should be used--the symptoms of a given failure should be the result of one trouble.

(10) Visual indications of a nature not encountered in operation should be tolerated.

(An additional criterion that should have been a part of the original listing was: Trouble must produce the same symptoms each time it is introduced into the equipment. This did not hold true for one of the problems used, V-404, but this was not discovered until the data gathering phase had begun.)

In all, 30 different troubles of various types and having various chassis locations were identified for possible use in testing. These items appeared to meet all of the above criteria, but final evaluation had to depend upon the performance of the items in practice.

At this point, a second full-time man was added to the project staff, since it was foreseen that additional technical assistance would be needed in test development and administration.

## Production of Defective Parts

Difficulty was encountered when the production of defective parts was attempted. Since it is known that a high proportion of all failures in electronic equipments are tube failures, in accordance with criterion "1a", several tube failures were to be used. Common practice in the training situation is to produce an inoperative tube by cutting off the appropriate pins at the base. This proceedure, however, according to criterion 10 could not be tolerated since it short-circuits the whole trouble shooting proceedure by stimulating the testee to look for tubes with pins cut off rather than to use or practice a logical method for isolating troubles. Many different methods were attempted in an effort to produce defective tubes, including: heavy current overloads on the grid or plate (either improved tube performance or produced intermittents); silver conductive paint between pins to produce shorts (even when the silver was covered with black paint to minimize obvious appearances of tampering, the result was distinguishable); lacquer on certain pins (wore off in a short time and re-established electrical contact). The only completely satisfactory method involved removing the plastic tube base by boiling in water or the metal tube shield by banding, and then clipping the undesired leads close to the glass envelope.

Careful reassembly provided tubes which simulated defective tubes with the desired characteristics. Other components such as defective fuses (current overload); relays (a tiny, almost invisible piece of cellulose tape on one of the contacts); crystal (current overload); coils (current overload); and resistors (re-painting very high or very low value resistors, or drilling into side of large resistors) were quite easy to produce. It should be indicated that The Radio Corporation of America cooperated in the attempt to produce defective tubes, but the results were not entirely successful. This was through no fault of theirs, however, since only one attempt was made to provide such tubes and undoubtedly further efforts would have been rewarding. One disadvantage to having a company such as RCA provide defective tubes is that they are hesitent about printing their name on the tube. A tube without the usual markings is, after all, as conspicuous as a tube with pins cut off.

PHASE II

## RESEARCH DESIGN AND COLLECTION OF DATA

### Choice of Performance and Tab Items

Ten items were selected for use in performance testing, and ten tab items were desired for use as the tab test. Since the tab item reveals the answer to the testee as he completes the item, some of the tab items needed to be different from the performance items. It was decided to select five items which would be common and identical for the tab test and the performance test. In addition, five items would be selected for the tab test and five for the performance test that would involve similar sections of the equipment.

The items selected were as follows:

The sample item was common to both the tab test and the performance test. It was V-916-B, a tube.

Five Common Problems

(used on both tab and performance tests)

| Problem | | Difficulty (on performance test) |
|---|---|---|
| 1. V-909-B | (tube) | 91% |
| 2. F-904 | (fuse) | 21% |
| 3. V-902-50 | (tube) | 77% |
| 4. Y-301-50 | (crystal) | 58% |
| 5. T-909 | (transformer) | 42% |

Five Unique Problems

| Tab Test Problem | | Performance Test Problem | | |
|---|---|---|---|---|
| 1. V-410 | (tube) | K-404-A | (relay) | 40% difficulty |
| 2. V-308-50 | (tube) | V-310 | (tube) | 82% difficulty |
| 3. V-920-B | (tube) | V-406-A | (tube) | 93% difficulty |
| 4. V-401-A | (tube) | V-401-B | (tube) | 60% difficulty |
| 5. V-403-A | (tube) | V-404 | (tube) | 65% difficulty |

Tubes were used as troubles in some cases because of ease of insertion of the trouble. In both the performance test and the tab test, trouble shooting was confined to location of the faulty "stage". In the case of a tube, the "stage" involves the tube (or section of the tube, if there is more than one section), together with all associated capacitors and resistors. Thus the use of a faulty tube simulated many of the troubles associated with faulty resistors and capacitors.

Through the use of an item data sheet as is illustrated in the appendix pg. E, information about each of the test items was secured and recorded, using students at Great Lakes as subjects. This information aided in the final selection of items and was also used in writing the tab items.

A copy of each of the tab items is included in the appendix pg B . The problem of estimating difficulty of the tab items is unusual since the testee knows when he has solved the problem, and within the time limits given, the testee works, almost without exception, until he has the answer. Therefore, the customary proceedure of specifying difficulty according to the percent correct is inappropriate.

Since it was desirable to have the Bureau of Naval Personnel arrange with Treasure Island for a definite testing schedule, a suggested schedule was submitted to Bupers for approval and action. A copy of the proposed schedule is reproduced in the appendix pg. E .

## Development of Reference Tests

In addition to gathering data on trouble shooting behavior through performance and tab tests, it was considered desireable to obtain additional information on certain factors judged to be important in trouble shooting electronics equipment. The factors shown in Table II were developed through discussion with instructors at the Class "A" ET School, Great Lakes. The second column of Table II indicates certain tests, which were used in an attempt to measure the factors in the first column. The list in column two is not complete, since the project was not renewed for a second year as planned.

TABLE II
Factors Judged To Be Important In Trouble Shooting Electronic Equipment

| FACTORS | MEASURES |
|---|---|
| 1. Desire to be a technician. | none |
| 2. Common sense | Cardall Practical Judgement Test |
| 3. Necessary technical knowledge | Knowledge of Electronics Test I and Test II |
| 4. Ability to test hypotheses | none |
| 5. Ability to generate new hypotheses | Baldwin Inductive Reasoning Test |
| 6. Familiarity with equipment | *Familiarity with Equipment, Test I and Test II |
| 7. Choice of relevant data | none |
| 8. Interpretation of information | none |
| 9. Distraction by rare or unusual details | none |
| 10. Awareness of completion of problem | none |

*Constructed by Joseph Wenta and Lyman Smith of the project

Development of the reference tests, Knowledge of Electronics Part I and Part II, and Familiarity with Equipment (SG-1b), Part I and Part II, was carried out according to conventional test construction procedures.

First, an attempt was made to define what the tests would be expected to measure. For the Test of Familiarity, a measure was desired that would discriminate between those who would be hampered in trouble shooting problems by not knowing the location or availability of controls and adjustments on the SG-1b radar, and those who would not be hampered, since they would be in posession of the information. It was felt that this variable might contaminate performance test results.

The knowledge of Electronics test was developed as a broad measure to estimate the technician's competence in recognizing circuits, understanding circuit characteristics, knowledge and application of laws and principles, and computation of circuit values. It was felt that it was important to determine the part played by knowledge, since knowledge of electronics was regarded as a necessary but not sufficient requisite to successful trouble shooting. In other words, a technician might do a relatively poor job of repairing radar, if through lack of familiarity with the specific equipment, he needed excessive amounts of time to effect the repair. On the other hand, if the technician lacked knowledge of electronics, he would be able to solve most trouble shooting problems only by chance.

Second, the tests were administered to groups of electronics students at Great Lakes and item analysis techniques were used

to identify and revise poor items. An attempt was made to develop attractiveness of the distractor choices. Time permitted two successive revisions of the Familiarity test Part I and only one revision for the Knowledge test Part I & II and the Familiarity Test Part II.

A validation of the Familiarity test Part I was attempted in the following manner. It was found that chance response was given to most items by the Special Circuits group while the Radar group was able to choose the correct answer significantly more often than would be expected by chance. On the other hand, some items were answered as well by the Special Circuits group as the Radar Group and these items were discarded.

## Training of Performance Test Observers

Part of the Phase Two work of particular significance was the training period given to the performance test observers. Each of the observers was a first class or chief electronics technician with considerable experience on the SG-1b radar. These men were employed as instructors in the Class A school for electronics technicians at Treasure Island. Two days were allotted for observer training before the beginning of performance testing. It was necessary for four of the six observers to reacquaint themselves with the SG-1b radar. Two of the observers were currently instructing in the SG-1b radar portion of the training program. In order to facilitate the problem of relearning the equipment and the problem of learning the test problems, the observers were brought together and introduced to the observation sheet that they would use in

recording what the students did. While one of the project technicians served as a guinea pig, the observers practiced observing and recording the behavior that was exhibited. Questions that arose as to the meaning or interpretation of certain items in the observation sheet were answered. As soon as the general interpretation of the observation blanks was clear, the men paired off observing and recording each other's trouble shooting behavior. Most of the second day was spent in observation practice and trouble shooting with the objective kept in mind that each observer should be familiar with the symptoms to be expected from any given test problem. The final activity of the training program was to bring the observers together and have them record their observations of a man trouble shooting for purposes of making an inter-observer reliability estimate. Inspection of these data shows that there was disagreement among the observers, for example, as to what was the 15th step or the 31st step taken by the trouble shooter. On the other hand, each of the observers made exactly the same decisions with regard to the following questions:

a. Did the man effect solution of the problem?
b. If the man used all of the time allotted, was he working in the stage which contained the defective component?
c. What length of time (to the nearest minute) had elapsed when the problem was solved?

Thus, inter-observer reliabilities on these three variables was 1.00. These variables were used in various combinations as criterion scores. If and when other variables are involved in criterion scoring, further estimates of inter-observer reliability would need to be made.

The training period also provided the time necessary to complete the physical arrangements necessary for performance testing. Oscilloscopes, schematics, and instruction books were provided at each equipment and sufficient vacuum tube voltmeters were made available so that when the students asked for one they could have it. Screens were put into place between equipments and over all meters and cathode ray tubes on each equipment. Defective parts were given a final check in the equipments. Stocks of spare parts which it was anticipated would be called for by the students were laid out in a desk drawer for the convenience of the observers.

## Final Administration of Tests

The population used in the final collection of data was located at Treasure Island, San Francisco, California. The men were selected alphabetically from Companies 5-53, 6-53, and 7-53. This provided the 50 to 60 men that had been requested. The final number of men tested was 57. The men were told that on specified days they would report to an indicated location for some special testing. No advance information was given as to the type of tests.

As is shown by pg E of the appendix, the men were handled in groups of six. Groups were used two at a time for two consecutive days until all men had been tested. In this way the testing was completed in 10 working days. The schedule for testing was as follows:

Isolation of equipment was accomplished by placing a screen between each of the equipments and then by separating the two rows of equipments by two long strips of brown paper that extended from 3 feet above the floor to about seven feet above the floor. Because of these screens, operations at any equipment were completely concealed from every other equipment.

Additional screens were placed on each equipment, covering up each meter and each cathode ray tube. These screens were removable, and were used in an attempt to aid the observers to get an accurate record of the behavior of each subject. Without the screens, subjects often made a rapid visual survey of front panel indications without being able to say just what they had looked for, or what they had noted. Obviously, under such conditions, an observer's record would be incomplete. These screens seemed to serve their purpose, and neither the subjects nor the observers found them distracting.

When a new group of six men reported for their first performance items, a properly functioning equipment was demonstrated to them and any questions they had were answered. When they had no more questions, each man was taken to a radar equipment, and joined by an observer who observed the student "warmup" on the sample item. Three spare equipments were disabled with test problems and as the men completed their sample items, they were shifted to the spare equipments. Meanwhile the sample problems in unused equipments were exchanged for test problems. Having nine equipments permitted four of the problems to be inserted in each of two equipment, while the ninth equipment contained

the fifth problem. Only five problems were used in any one testing period. The easiest problem was put in only one equipment, as generally the men would complete the easier problems in significantly less than the allotted 30 minutes.

As had been anticipated, equipments sometimes developed other symptoms than those desired. This was due to failure of one or more components in addition to the test problem. When this occurred, the testee was moved to another equipment having the same test problem. Observers were careful to see that the symptoms being presented to the student or testee were those that he should be getting. Sometimes, however, the observer did not become aware of this immediately, which tended to decrease homogeniety as measured by Coefficient Alpha for performance items.

Occasionally, observers reported that a man had completed a problem with ease not warranted by his other behavior. In such cases, they believed that there was a possibility that the man had obtained information about the test items prior to being given the test. In order to check on this, additional items had been selected which were felt to be quite difficult and which were given only when behavior was suspected. For these items there could be almost no chance of compromise. With one exception, the suspicion of the observers appeared to be unfounded.

The research design called for splitting the performance test items into two groups of five. One administration of the performance test was composed of the first five items while the

second administration was made up of the second five items. The individual items were given in random order with the exception of problem K-404-A. This was due to the fact that equipment modification for six equipments had resulted in some components being misidentified on the chassis.

The tab items and the written tests were administered by the same person for all groups. This person also accepted the responsibility for assembling each man's test data and for making sure that all of the data that were desired had been gathered for each individual. For this reason the problem of "missing test data" was not encountered.

## PHASE III: ANALYSIS OF THE DATA

Introduction: It was necessary to face several problems in order to analyze the data gathered in Phase II. These problems might be generally stated as:

a. assignment of scores and determination of reliability of scores for the:
   1. criterion--performance test
   2. tab test
   3. reference tests

b. determination of the predictive value of scores on the tab and reference tests.

Before treatment of the topics listed above is attempted, a background discussion of reliability will be provided using one method of scoring the criterion as an example. It is hoped that interpretation of the analysis will be facilitated for the reader. Following this section, discussion of other methods of scoring the criterion and scoring of the individual tests will be undertaken.

Reliability and the Criterion:

Criterion scoring was approached by an attempt to define trouble shooting logically. The question that needed answering was, "What things does the electronics technician need to do in order to be described as an effective "trouble-shooter"? The first approximation of that answer is that the technician must be capable of effecting solution of the diagnostic problem, whether or not he can effect subsequent repair of the equipment. This statement is highly unqualified and operates at the level of the technician receiving "one" or "zero" credit for each

problem. This scoring method may be labeled "go-no-go" scoring. For the discussion of reliability and the criterion we will use the go-no-go scoring for all men over all problems as an example.

In order to make any interpretation from test scores, or if it is desirable to make validity estimates, the accuracy of measurement must be specified. This accuracy of measurement is commonly spoken of as "The Reliability." "The Reliability" is placed in quotes to emphasize the fact that the term "reliability" is used to mean many things. With the criterion used in this particular study there are at least three separate estimates of error that it might be helpful to have in order to know the accuracy of the scores reported.

First, there is the need for an estimate of the error involved when observers attempt to record the behaviors which they watch the students exhibit. This estimate is made by asking several observers to record the behavior of one student and then comparing the records of the observers. This estimate might be specified as the inter-observer reliability.

The second estimate that might be considered would be the error introduced by judgment differences in interpreting the test record. This error takes on particular significance when the values of procedures or methods of attack need quantification. Due to the particular beliefs of one judge, his scoring will often differ from the score determined by another judge. This estimate might be known as inter-scorer reliability. It should be noted that variance due to the observer and the scorer

accumulate not as a result of what the person being tested does, but rather as a result of acts of the persons administering and scoring the test.

Finally, an estimate is needed to indicate the total amount of error variance that has arisen due to inconsistencies in the test questions, in the testing situation, and in the behavior of the person tested. This estimate will necessarily include observer and scorer errors. This accuracy may be estimated in several different ways:

1. coefficient of equivalence, which indicates precision of measurement of items of a particular type at a particular moment (equivalent forms or internal consistency)

2. coefficient of stability, which is a measure of the stability of a particular group of items over a period of time (test-retest method)

3. coefficient of stability and equivalence, which is a measure of both of the above (delayed parallel test method).

It is unfortunate that sometimes it has not been the practice in reporting performance test results to consider any estimate of total error variance. Rather, it appears common to report one type of estimate, for example, inter-observer reliability, and then let this pass in general as "The Reliability" of the test.

It seems in order to comment on the reliability estimates obtained using the "go-no-go" scoring method suggested above. An estimate of the inter-observer reliability indicates that from the checks made, all observers recorded the same information as to this pass fail data. The only conclusion that can be drawn is that inability of the observer to see and record

the same behaviors provides very slight, if any, contribution to the error variance. Second, for this scoring proceedure, no problem of judgement arises when a scorer looks at the record in order to answer the question "did the man effect solution of the problem." The estimate here, as with the one above, would be that in making this judgement there is little or no contribution of error variance to the scores.

The estimate of the total error variance tells quite a different story, however. Here it is desired to approximate the amount of variance that is common from one test item to another, or it might be looked upon as an estimate of how scores on this test and those obtained from another test composed of the same kinds of items would agree. Because of the nature of the performance test situation, the only suitable method of obtaining an estimate of the consistent behavior of the students was some form of internal consistency reliability (coefficient of equivalence). The choice made for this particular application has been coefficient alpha, "a general formula, of which a special case is the Kuder-Richardson coefficient of equivalence, is shown to be the mean of all split-half coefficients resulting from different splittings of a test".[1] Alpha for the go-no-go scoring method was found to be .40. This coefficient appears to be low when compared with those which are often seen reported; however, it must be cautioned that care be taken so that estimates of reliability are compared with their own kind.

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1. Cronbach, L. J. "Coefficient Alphaand the Internal Structure of Tests." Psychometrika, 1951, 16, 297-334.

It is of interest to look at the sources of error which are accounted for in this coefficient.

1. this estimate contains all of the observer and scorer inaccuracies (these are quite small in this case)

2. this estimate treats specific item variance as error variance.

   a. thus, when items measure different things, the effect is to produce nonconsistent behavior, and lower alpha

   b. the learning curve for this population--students in training-has not leveled off. Failure on one item tends to suggest to the student that he try a different attack or method of solution--again this produces non-consistent behavior, and lowers alpha.

3. this estimate assumes equal item difficulty. Since item difficulties were deliberately chosen to be unequal (to maximize validity), alpha is lowered.

Because of items 2 and 3 above, the coefficient alpha is almost certainly somewhat lower than a reliability coefficient obtained through a comparison of parallel halves. However, it is more realistic to estimate the lower bounds of equivalence than to find false security in a higher and possibly spurious estimate.

The general property of reliability is that the size of the estimate is in direct proportion to the length of the test. Only ten items have been given here, while we are accustomed to seeing coefficients reported which have been derived from tests of fifty items or more. By use of the Spearman-Brown formula we can estimate that a test of fifty items would result in an alpha of .77.

## Other criterion scoring methods

As has been described above, the first scoring method used with the criterion was the pass-fail dichotomy. Alpha here represented the extent to which technicians tended to be consistent in their success or failure. Evidence was now sought of additional consistent behavior. Again from a logical basis it was felt that among technicians who did solve trouble shooting problems, those who required less amounts of time were to be considered more effective than those requiring greater time. Therefore differential credit was assigned each man solving a problem according to the amount of time used. In order to do this, a distribution was made for each trouble shooting problem, using the number of minutes of time required as the variable. From this, five approximately equal divisions were made, so that as closely as possible, (with-in the limits of whole numbers) 20% of the successful technicians appeared in each division.

Any technician in the lower group was thus assigned a score of one; the next higher group a score of two; etc., so that scores on any item would range from 1 to 5 for those who solved the problem. Zero credit was assigned those technicians who failed to solve the problem.

Alpha was computed for this scoring method and found to be .44. Apparently the addition of a time bonus was helpful in increasing the consistency of the scorable trouble shooting behavior. The change from .40 to .44, however, could well have been within the limits of chance due to peculiarities of sampling. Additional checks on other samples would be required to see

whether the observed difference is real or chance. The logical defense of the time bonus seems sufficient, however, to warrent its inclusion.

Weighting for time was arrived at in a somewhat arbitrary way. However, alpha did not show any real variation for the various weightings tried and it was concluded that in general the simplest system which could be logically defended would be the one to use.

Further attempts to refine the criterion scoring were made by giving some credit to the technician who did not complete a problem in the time allotted but was working in the correct or "trouble" stage when 30 minutes had elapsed. It was felt that a real difference existed between the person who spent 30 minutes trying to solve a problem without success and the technician who also spent 30 minutes but was on the verge of solution.

Scoring by this, the final method, consisted of:

a. zero credit for failure to solve the problem within the time limit if at the end time limit the trouble had not been isolated to the correct stage.

b. one point credit for failure to complete solution of the problem within the 30 minutes time limit if isolation of the faulty stage had been accomplished

c. variable credit for successful solution of the problem according to amount of elapsed time. A minimum of 2 points and a maximum of 10 points could be accumulated.

Alpha for the final scoring was also .44 but again giving credit to the technician for locating the proper stage seemed logically defensible. In the section dealing with prediction of the criterion, this is the method of scoring used in the the determination of the criterion scores.

For all criterion scoring procedures, only information was used which did not require controversial judgments on the part of the scorer. Thus the error of measurement arising out of scorer and recorder variations were held to a minimum, making the criterion maximally interpretable.

Further analysis of the criterion which is under way at this writing suggests that two independent scores, each of which is more reliable than the total score, are obtainable. These have tentatively been described as "speed" and "accuracy". A complete report of this aspect of the criterion will be made as part of the continued research being undertaken by the junior author, without governmental financial support.

## Scoring and Reliability of the Tab Test

Scoring of the tab test was approached in the same manner as scoring the performance test. It seemed logical that the following factors should be considered in scoring:

a. Difficulty of the item
b. Time required to complete each tab item
c. Identification of malfunctioning unit of the set.
d. Identification of malfunctioning stage of the set..

Three additional factors were considered, but discarded.

e. Number of tabs pulled, total.
   It was felt that use of this factor would penalize the cautious technician, and reward jumping to a conclusion on the basis of insufficient information.

f. Number of tabs pulled in second section of tab test.
   This factor contributed little variance, and tended to decrease the tab test alpha when it was included.

g. Deviation from procedures prescribed by experts.
   No consensus could be reached on desireable procedures.

Values of alpha from .20 to .36 were obtained, using five different arbitrary weightings of one or more of factors a, b, c, or d above. Time did not permit an accurate determination of the optimum weights for these factors using the performance test as a criterion. Consequently, the weighting used was the one of the five arbitrary weightings which yielded the highest alpha. This combination involved the use of three levels of time, three levels of difficulty, and right or wrong on identification of the correct unit and stage.

During the development, and again in the final administration of the tab items, it was very noticeable that students and instructors generally were enthusiastic about this type of test. A typical student comment was, "Do you have any more tab tests I can take? This will really help me in trouble shooting." Apparently face validity was high.

Scoring and Reliability of the Knowledge of Electronics Test

Part of the variance in trouble shooting ability was thought to arise because of knowledge of electronics (or the lack of it). This knowledge may be described by such types of information as: knowing the theory of a given circuit, being able to recognize and identify particular circuits, knowing the function of components within typical circuits, etc. A test, in two parts, was developed in an attempt to measure questions of this kind. Part one was composed of fifty multiple choice items. Part II consisted of 46 true-false items. The items in Part II

were made up of questions covering 3 general circuit types, 15 items for each. The circuit types were: power supplies, amplifiers and oscillators. The test was given a pre-test trial and many items were eliminated or revised on the basis of this information. The alpha for this test of 95 items was found to be .81 before any additional item analysis was attempted.

Of all the reference tests, knowledge seems to account for the largest portion of the variance in the criterion. A Pearsonian r of .34 was found between the total knowledge test (95 items) and the criterion. (N= 57).

Scoring and Reliability of the Familiarity with Equipment Test

Observation of students attempting to do trouble shooting revealed that often their behavior appeared to be ineffective because they spent large amounts of time looking for a control switch or similar part of the equipment. The relative effectiveness of a technician is partly determined by the rate at which he is capable of diagnosing and repairing equipment. Since "control hunting" is particularly time consuming, a technician who exhibits this behavior may appear to be a poor technician when perhaps only a lack of familiarity with the specific experiment has prevented him from doing a top-notch job. This behavior was thought to explain a part of the variance in trouble shooting behavior, so a test called "Familiarity with Equipment (SG-1b Radar) was developed. Part I of this test was concerned with operating characteristics peculiar to the SG-1b radar, such as frequencies, power, number of stages of

a particular type, and the like. Part II was made up of two photographs of the SG-1b, on which technicians were asked to identify controls.

The test items were designed to be capable of being answered by those were familiar with the equipment and not being answered by the other persons on the basis of general knowledge. The items were given a pre-test run by administering them to a group of forty students who had studied the SG-1b Radar. A second group of forty students was tested one week prior to their study of the SG-1b. Finally the items were admistered to a small group of six radar instructors. All items that could be answered by the pre-Radar group significantly more often than could be expected by chance were discarded. If working with the equipment did not enable a technician to have answers to the items on a so-called familiarity test the items were evidently measuring something other than the usual type of familiarity. For this reason items that the Radar instructors did not find easy were discarded.

Items were revised in an attempt to eliminate distractors that did not operate, and item difficulty was determined from the post-radar group. The revised test was administered to students who had completed the SG-1b Radar phase. Minor regisions were made on the basis of this information.

The estimates of Alpha for the test of Familiarity were found to be .24 for Part I and .56 for Part II.

## Use of Other Tests and Course Grades

Data were gathered on the Cardall Practical Judgement Test, on the Baldwin Inductive Reasoning Test, and on course grades and Navy-administered tests listed in Table 3. Time did not permit a more complete analysis of any of these data.

TABLE 3

Alpha (Internal Consistency) and Intercorrelation of Tests and Navy Course Grades

| | Alpha | Intercorrelations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Perf. | Tab | Know. I | Know. II | Famil. I | Famil. II | Ind. Reas | Pract. J. | GCT |
| Project-constructed tests | | | | | | | | | | |
| Performance test | .44 | | | | | | | | | |
| Tab test | .36 | .07 | | | | | | | | |
| Knowledge of Electronics Part I | .81 | .24 | .36 | | | | | | | |
| Knowledge of Electronics Part II | | .38 | .31 | .54 | | | | | | |
| Familiarity with Equipment Part I | .24 | .12 | .24 | .41 | .36 | | | | | |
| Familiarity with Equipment Part II | .56 | .10 | .21 | -.03 | .14 | .23 | | | | |
| Standardized Tests | | | | | | | | | | |
| Inductive Reasoning | | .16 | .10 | .29 | .09 | .25 | -.16 | | | |
| Practical Judgement | | -.04 | -.01 | -.07 | -.12 | -.04 | .20 | .20 | | |
| Navy Administered Test | | | | | | | | | | |
| General Classification | | -.04 | | | | | | .55 | .20 | |
| Arithmetic | | .05 | | | | | | | | |
| Mechanical, Electrical | | .10 | | | | | | | | |
| Clerical | | .04 | | | | | | | | |
| Reading | | .22 | | | | | | | | |
| Physics | | .07 | | | | | | | | |
| Math | | .03 | | | | | | | | |
| Navy Electronics Course Grades | | | | | | | | | | |
| Theory, Av. Grade | .84 | .35 | | | | | | | | |
| Lab, Av. Grade | .48 | .40 | | | | | | | | |

## SUMMARY

An analysis of the data seems to support the following conclusions:

1. Additional use of performance testing in Navy schools for electronics technicians is feasible, particularly if sequential sampling is employed. The special variation of sequential analysis suggested in a separately published report, yielded a saving of over 50% in time and expense, with very little sacrifice of accuracy over the full length performance test.

2. Performance testing of trouble shooting ability has high face validity, and is recognized by Navy students as desireable for its learning value.

3. The tab test of trouble shooting ability has almost as high face validity as performance testing, and a far higher face validity than paper and pencil tests. While its cost is high compared with paper and pencil tests, it costs far less to administer than do performance tests on electronics equipment. It is the only test the authors have ever used which causes a large number of students to ask to take additional items.

4. While laboratory grades correlated most highly with the criterion (performance test scores) of all of the variables studied, the correlation (.40) was somewhat lower than expected. The relatively low reliability (alpha of .46 and .44, respectively) of these two variables almost certainly tended to be a limiting factor. If sequential sampling were used in performance testing, this should raise test reliability considerably if the same amount of testing time were used.

5. Inter-observer and inter-scorer reliabilities were quite high, on both the tab and performance tests. This is probably due in part to the relatively gross determinations which had to be made. It is believed that masking of meters and scopes during the performance test helped to eliminate subjectivity, and thus increase reliability, but this is not proved.

6. Interval consistency reliability (alpha) for both the tab and performance tests was adequate, but moderately low, due in large part to the high rate of learning involved, and to the small number of test items used.

7. Data were collected on a number of written tests, grades, and previous experience. These data were largely left un-analyzed, due to a sudden decision of the Bureau of Naval Personnel not to renew the contract, after previously indicating that they would do so.

8. Evidences of perseveration were found during each administration of tab item and performance tests. The effect of this variable on trouble shooting ability has not been sufficiently assessed.

## NOTE

The tab-tests reproduced on the following pages differ from the tests actually used by the contractor in the study in that the ~~left~~ right-hand column of each page of the tests was covered with opaque paper, so perforated that the subject could remove a tab opposite each item on a page. When a tab had been pulled by the subject only the information opposite that item was exposed. The information opposite the other items on the page could not be revealed by pulling any single tab. Further, each page of the original tests was printed on opaque paper so that the information printed on the pages and covered with the tabs could not be seen through the perforated tab paper.

The first three pages of each test providing the "front panel information" were printed on grey paper in contrast to the last or "answer" page printed on blue paper.

# APPENDIX A

## TWO EXPERIMENTAL FORMS OF THE TAB TEST

This test was based on a radio receiver constructed by Navy ETs. Each of these tab items is four pages in length. Each item of information in the right hand column of each page was covered by individual "tabs" of paper, which the testee could remove. The sequence in which tabs were pulled was recorded.

Each person tested was given a schematic of this communications-type superheterodyne receiver, plus a sheet showing normal pin voltages and resistance readings. The schematic for this set was taken from Section V, Part B, Sheet 115, of Oscilloscope Instruction Sheets, published by the Bureau of Naval Personnel, 1949.

TAB ITEM NO. 1

SYMPTOM: Very distorted output.

| I. General Checks | Information Revealed |
|---|---|
| 1. Turn up volume control. | Gain Slight, output remains distorted. |
| 2. Tune across band. | Output remains distorted at all frequencies. |
| 3. Feel tubes with fingers. | Operating temperature about normal. |
| **II. Voltage Checks** | |
| 4. AVC voltage. | Normal. |
| 5. Cathode to ground on 6F6. | 60 volts. |
| 6. B plus voltage. | 280 volts. |
| 7. Plate voltage on 6SQ7. | 88 volts. |
| 8. Screen voltage on 6F6. | 280 volts. |
| 9. Grid voltage on 6F6. | Normal |
| 10. Plate voltage of 6F6. | 280 volts. |
| **III. Resistance Checks** | |
| 11. Resistance to ground on 6SQ7 grid. | 125 K-ohms. |
| 12. Resistance of coupling condenser between 6SQ7 and 6F6. (Disconnect one end.) | Infinite resistance. |
| 13. Resistance to ground on 6F6 cathode. | Infinite resistance. |
| 14. Resistance to ground on 6F6 grid. | 470 K-ohms. |
| 15. Resistance across output Xformer. primary. | 280 ohms. |

| IV. Signal Injection Checks | Information Revealed |
|---|---|
| 16. Audio to 6SQ7 grid with antenna grounded. | Very distorted and weak. |
| 17. Audio to plate side of coupling condenser between 6F6 and 6SQ7. | No Output. |
| 18. Audio to grid of 6F6 with antenna grounded. | No Output. |
| 19. Audio to Plate of 6F6. | Normal Output. |
| 20. 456 K C Mod. to grid of 6SK7 Mixer. | Very distorted and weak. |
| 21. 456 KC Mod. to grid of 6SK7 IF. Amp. | No Output. |
| 22. 456 K C Mod. to Plate of 6SK7 Mixer. | No Output. |
| 23. 456 K C Mod. to plate of 6SK7 IF. Amp. | No Output. |
| **V. Tube Checks** | |
| 24. 6C5 Local Osc. | Normal. |
| 25. 6SK7 Mixer | Normal. |
| 26. 6SK7 IF Amp. | Normal. |
| 27. 6SQ7 Dect. and Audio Amp. | Normal. |
| 28. 6F6 Power Amp. | Normal. |

## SECTION B

## COMPONENTS

(Item 1)

### A. Audio Section

| | | |
|---|---|---|
| 29. | Defective speaker or speaker cable. | No. |
| 30. | Defective 6F6 tube. | No. |
| 31. | Defective condenser across primary of output Yformer. | No. |
| 32. | Defective cathode bypass condenser on 6F6. | No. |
| 33. | Defective cathode bias resistor on 6F6. | Yes. |
| 34. | Defective grid leak resistor on 6F6. | No. |
| 35. | Defective grid bypass condenser on 6F6. | No. |
| 36. | Defective Coupling Condenser between 6F6 and 6SQ7. | No. |
| 37. | Defective 6SQ7 tube. | No. |
| 38. | Defective plate load resistor on 6SQ7. | No. |
| 39. | Defective grid leak resistor on 6SQ7. | No. |

### B. IF Section

| | | |
|---|---|---|
| 40. | Defective 6SK7 IF Amp. tube. | No. |
| 41. | Defective Screen bypass Condenser on IF Amp. | No. |
| 42. | Defective cathode bias resistor on IF Amp. | No. |

IF Section Continued.

| | | |
|---|---|---|
| 43. | Defective Cathode bypass condenser on If Amp. | No. |
| 44. | Defective screen dropping resistor on IF Amp. | No. |

C. Mixer Osc. Section

| | | |
|---|---|---|
| 45. | Defective 6SK7 mixer tube. | No. |
| 46. | Defective screen bypass condenser or Mixer. | No. |
| 47. | Defective cathode bias resistor on Mixer. | No. |
| 48. | Defective cathode bypass condenser on Mixer. | No. |
| 49. | Defective 6C5 Osc. tube. | No. |
| 50. | Defective Osc. feed coupling condenser. | No. |
| 51. | Defective Plate dropping resistor to 6C5. | No. |
| 52. | Antenna lead broken at antenna coil. | No. |

D. Power Supply

| | | |
|---|---|---|
| 53. | Defective 80 rectifier tube. | No. |
| 54. | Defective power Xformer. | No. |
| 55. | Defective filter condenser. | No. |
| 56. | Defective filter choke. | No. |

TAB ITEM NO. 2

SYMPTOM: Receiver output completely dead, no hiss, no hum.

| | I. General Checks | Information Revealed |
|---|---|---|
| 1. | See that antenna is connected. | Properly connected. |
| 2. | Check loud speaker connection. | Properly connected. |
| 3. | Turn up volume control. | No Output. |
| 4. | Tune across band. | No Output. |
| 5. | Feel of tubes with fingers. | Normal temperature. |
| | II. Voltage Checks | |
| 6. | B plus supply. | 240 volts. |
| 7. | Plate voltage on 6F6. | 240 volts. |
| 8. | Screen voltage on 6F6. | 240 volts. |
| 9. | Plate voltage on 6SQ7. | 82 volts. |
| 10. | Plate voltage on 6SK7 IF Amp. | 240 volts. |
| 11. | Voltage at pin 8 on 6F6. | 10 volts. |
| 12. | Voltage at pin 5 on IF amp. | 3.5 volts. |
| | III. Resistance Checks | |
| 13. | Cathode to ground on 6F6. | 330 Ohms. |
| 14. | Grid to ground on 6F6. | 470 K-ohms. |
| 15. | Resistance across coupling condenser between 6SQ7 and 6F6. (one end disconnected) | Infinite Resistance. |
| 16. | Grid to ground on 6SQ7. | 1 Megohm. |
| 17. | Across output Xformer primary. | Zero resistance. |

(Item 2)

| III. Resistance Checks (continued) | Information Revealed |
|---|---|
| 18. Screen to ground on IF Amp. | 140 K-ohms. |
| 19. Cathode to ground on IF Amp. | 680 ohms. |
| 20. Across secondary of output Xformer | Less than 1 ohm. |
| 21. Resistance of speaker coil. | 3 ohms. |
| **IV. Tube Checks** | |
| 22. 6F6. | Normal. |
| 23. 6SQ7. | Normal. |
| 24. 6SK7 IF Amp. | Normal. |
| 25. 6SK7 Mixer. | Normal. |
| 26. 6C5 Local Osc. | Normal. |
| 27. 80 Rectifier. | Normal. |
| **V. Signal Injection Checks** | |
| 28. Inject audio at plate of 6F6. | No output. |
| 29. Inject audio at grid of 6F6. | No output. |
| 30. Inject audio at plate of 6SQ7. | No output. |
| 31. Inject audio at grid of 6SQ7. | No output. |
| 32. Inject 456 Mod. RF at diode plate of 6SQ7. | No output. |
| 33. Inject 456 Mod. RF at plate of IF Amp. | No output. |
| 34. Inject 456 Mod. RF at grid of IF Amp. | No output. |
| 35. Inject 456 Mod. RF at plate of Mixer. | No output. |

COMPONENTS

(Item 2)

A. Audio Section

| | | |
|---|---|---|
| 36. | Defective speaker or speaker cable. | NO |
| 37. | Defective 6F6 tube. | NO |
| 38. | Defective condenser across primary of output Xformer. | YES |
| 39. | Defective cathode bypass condenser on 6F6. | NO |
| 40. | Defective cathode bias resistor on 6F6. | NO |
| 41. | Defective grid leak resistor on 6F6. | NO |
| 42. | Defective grid bypass condenser on 6F6. | NO |
| 43. | Defective coupling condenser between 6F6 and 6SQ7. | NO |
| 44. | Defective 6SQ7 tube. | NO |
| 45. | Defective plate load resistor on 6SQ7. | NO |
| 46. | Defective grid leak resistor on 6SQ7. | NO |

B. IF Section

| | | |
|---|---|---|
| 47. | Defective 6SK7 IF Amp. tube. | NO |
| 48. | Defective Screen bypass condenser on IF Amp. | NO |
| 49. | Defective cathode bias resistor on IF Amp. | NO |
| 50. | Defective cathode bypass condenser on IF Amp. | NO |
| 51. | Defective screen dropping resistor on IF Amp. | NO |

(Item 2)

C. Mixer-Osc. Section

| | | |
|---|---|---|
| 52. | Defective 6SK7 Mixer tube. | NO |
| 53. | Defective screen bypass condenser on mixer. | NO |
| 54. | Defective cathode bias resistor on Mixer. | NO |
| 55. | Defective cathode bypass condenser on Mixer. | NO |
| 56. | Defective 6C5 Osc. tube. | NO |
| 57. | Defective Osc. feed coupling condenser. | NO |
| 58. | Defective plate dropping resistor to 6C5. | NO |
| 59. | Antenna lead broken at antenna coil. | NO |

D. Power Supply

| | | |
|---|---|---|
| 60. | Defective 80 rectifier tube. | NO |
| 61. | Defective power transformer. | NO |
| 62. | Defective filter condenser. | NO |
| 63. | Defective filter choke. | NO |
| 64. | Shorted bleeder resistor. | NO |

# APPENDIX B

## TAB ITEMS USED IN GATHERING DATA AT TREASURE ISLAND

This test was based on the SG-1b radar. Instructions for test administration, the sample tab item, and ten tab items on which scores were recorded at Treasure Island are included in this section of the appendix. Each item is four pages in length. Each item of information in the right hand column of each page was covered by individual tabs of paper, which the testee could remove. These tabs were die-cut by machine, and pasted over the items, one page at a time. A sample of the die-cut tabs is included in this section of the appendix.

The code for item numbers is as follows:

| Code | Item Number |
|---|---|
| 59087 | Sample |
| 66190 | 1 |
| 68299 | 2 |
| 69378 | 3 |
| 66497 | 4 |
| 67576 | 5 |
| 69675 | 6 |
| 67784 | 7 |
| 69873 | 8 |
| 67972 | 9 |
| 69091 | 10 |

The procedures used in administering this test are described in the main body of the report.

## INSTRUCTIONS FOR TAB TEST ADMINISTRATOR

1. Before distributing test supplies to the examinees, instruct them that upon receiving their supplies they are not to open any of the envelopes.

2. Distribute to each man:
   (a) 1 pkt. of tab tests (11 envelopes)
   (b) 1 SG-1b Study Guide
   (c) pencil (if he does not have one)

3. When all have received their supplies, READ "Take your instruction sheets and follow me while I read the general instructions aloud." (Instructor reads the six-item instruction sheet to the students.)

4. Examiner READ the following additional instructions to the students.

"This is a test of your ability to trouble-shoot a SG-1b radar equipment. The test requires that you locate the chassis that contains the defective part. Since the test is quite different from any that you have taken before, you will need to listen very carefully to all directions.

"Now take out the sample problem which is in the envelope at the top of your pile. Do not do anything yet but follow me carefully as I explain the contents of these pages. The form of this problem is exactly like that of all of the others in this test.

"At the top of the first page next to the word SYMPTOM, (examiner points) you will find a brief description of a trouble that has occurred in an SG-1b radar equipment. The rest of pages one, two and three contain a series of check procedures which you may use to locate the cause of the trouble. To the right of each check is a white paper tab. Under the tab appears the result of performing the check. The results are what you would obtain if you actually performed the check in a SG-1b which had the described trouble.

"You will notice that there are two sections to each problem. The first section consists of three pages and is printed on gray paper. The second section consists of one page and is printed on blue paper. Pages 1 and 2 give information which is available from the three scopes on the SG-1b. Page 3 provides meter information, echo box information, and finally, miscellaneous information. In general, the first three pages provide what would be called 'Front Panel Information.'

"Scope information for both positions of the signals/markers switch and both the 15 and 75 thousand yard ranges are available. Read the heading carefully to make sure that you are actually going to get the information you desire by pulling any of the tabs. For example, if you wanted to see the monitor scope in the receive position, and the 15,000 yard range, you would pull Tab #3. If you wished to see the range scope in signals position with 15,000 yard range, you would pull Tab #8. Pulling Tab #15 would show the PPI Scope with markers in the 75,000 yard range. Notice that a remote PPI presentation is available but only in signals position and using the 15,000 yard range.

"When you have gathered suffiaient information to solve the problem, (by pulling the appropriate tabs) you may check yourself by pulling the tab opposite the chassis which you think contains the defective part. The answer under the tabs on the BLUE sheet, which is Part II, will contain either a 'yes' or a 'no.' If you find a 'yes' under the tab pulled in Section II, your diagnosis has been correct and the problem has been solved. If you find a 'no' under the tab pulled in the second section (Blue), your diagnosis has been wrong and you should go back to the first section, and collect more information by pulling additional check tabs and/or reinterpreting the information already gathered. Keep working until you find the 'yes' tab in the Blue section.

"In order to score this test it is necessary to know the order in which you pull the tabs. You are to record this sequence or order by numbering the white part of the sheet to the left of the tab before you pull it off. Please be very careful to number the sequence properly as it is very important.

"As soon as you have solved a problem by finding a 'yes' in the blue section, you should write in the space provided on the blue sheet the stage within the chassis that you believe is causing the trouble. When you have done this, the problem is completed and you should hold up your hand to indicate to the examiner that you are finished. The examiner will write the time you finish on the Blue sheet next to your name. Then put your four sheets back into the brown envelope and wait until it is time for the next problem.

"Now let us solve the sample problem together. The symptom indicates that there is no video on the PPI Scope. With only this information we cannot isolate the trouble to any one of the chassis. Therefore we must gather additional information. Let's pull Tab #9. Before you pull the tab, write the number 1 to the

left of the tab to indicate to the scorer that this was the first tab that was pulled. The information under this tab shows us that on the Range Scope with the signals/markers switch in the signals position we have sweep, range step, but no video.

"A person might jump to the conclusion here that the receiver is defective. The receiver (300 chassis) is number 32 on the Blue sheet. Pull this tab. Before you pull this tab, however, write number 2 to the left of the tab to indicate that this was the second tab pulled. Observe that there is a 'NO' under this tab, indicating that this unit is not defective. In pulling this tab, we have jumped to a conclusion too rapidly and without sufficient information at hand. We pulled a 'NO' tab when this would have been unnecessary if more information had been gathered before pulling the unit tab. We must go back now to see how the problem should have been solved.

"Remember that we know that there is no video on the Range Scope or the PPI Scope but sweep and range step appear on the range scope. A good check to make here would be to look at the Monitor Scope in the receive position. Let's pull Tab #4. Before you pull the tab write the number 3 to the left of the tab to indicate that this is the third tab to be pulled. Now look at the results of this check. We see that sweep, grass and video are present -- in other words we have a normal scope presentation. With this information, we know that the transmitter, the antenna, the Modulation Generator, and the receiver all must be in operation as well as the power supplies that feed them. A stage in the video channel would now be suspected and one which is common to only the range scope and the PPI Scope. The block diagram shows us that V-916-B is the only stage that fits this description. Since this stage is indicated by a 900 chassis number, it is a part of the Range and Train Indicator. Pull the tab opposite number 38 on the Blue sheet. Before you pull the tab write the number 4 to the left of the tab to indicate that this is the fourth tab that was pulled. Under this tab we find a 'YES'. The problem, therefore, has been solved. Since we feel sure that V-916-B is the faulty stage, we write V-916-B in the proper space (Examiner points). You now raise your hand to tell the examiner that you have finished and he will write down the time near your name at the bottom of the blue sheet.

"Your job in this test is to find the 'YES' tab in the unit (Blue) section by pulling as many information tabs as you need and as few unit tabs as possible. The most desirable solution of each problem would be to pull but one unit tab, and then find a 'YES' under it. Remember that it is essential that you write down the sequence number before you pull the tab.

"What are your questions?"

GENERAL INSTRUCTIONS FOR PERSONS TAKING THE TAB ITEM TEST

(One Copy for Each Man)

1. Only one trouble is used for each problem.

2. You may have the use of the study guide in any way that you please. Most likely the block diagram near the front (pp 1-3 and 1-4) will be of most help.

3. If there is a question as to which chassis any given component is in, refer to the number of the component. For example, a part with a 300 number is part of the receiver chassis.

4. You are to assume that the equipment was operating properly and then suddenly went off the air.

5. For all problems the adjustments are set for normal operation.

6. For all problems, the range step switch is <u>on</u> unless other wise indicated.

SYMPTOM: No video on the PPI Scope

SCOPE INFORMATION

A. Monitor Scope (Signals/Markers switch in the SIGNALS position)

1. Trigger - - - - - - - - - - - - - - -
(Using fast sweep)



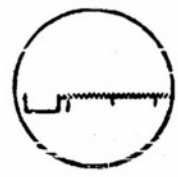
2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



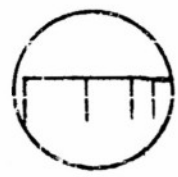
4. Receive position - - - - - - - - - -
(75,000 yard range)



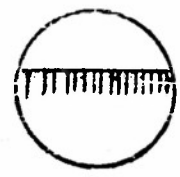
---

B. Monitor Scope (Signals/Markers switch in the MARKERS position)

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - - -
(75,000 yard range)



---

C. Remote PPI Scope

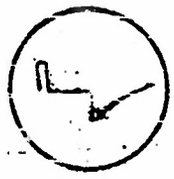
7. Signals - - - - - - - - - - - - - - -
(15,000 yard range)



 SCOPE INFORMATION CONT.

D. RANGE SCOPE

8. Signals position - - - - - - - - -
(15,000 yard range)



9. Signals position - - - - - - - - -
(75,000 yard range)



10. Markers position - - - - - - - - -
(15,000 yard range)



11. Markers position - - - - - - - -
(75,000 yard range)



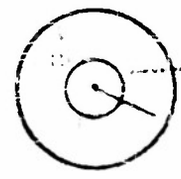
---

F. PPI SCOPE

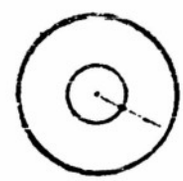
12. Signals position - - - - - - - - -
(15,000 yard range)



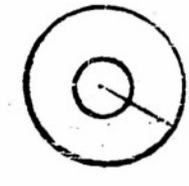
13. Signals position - - - - - - - - -
(75,000 yard range)



14. Markers position - - - - - - - - -
(15,000 yard range)



15. Markers position - - - - - - - - -
(75,000 yard range)



## METER INFORMATION

**Meter 102**

16. Driver Current - - - - - - - - - - - zero

**Meter 103**

17. Magnetron Current Drain - - - - 24 ma

18. Total Current Drain - - - - - - - 35 ma

**Meter 301**

19. Oscillations Indicator - - - - - 29 scale divisions

**Meter 901**

20. Line Voltage - - - - - - - - - - 112

**Meter 902**

21. Magnetron Current - - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - 6 ma

23. RF Monitor - - - - - - - - - - -

## ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - unable to determine

25. Relative Power Out - - - - - - - 46 ua

26. Frequency Spectrum - - - - - - - normal

27. Output Frequency - - - - - - - - 3025 mc

## MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - minus .8 v.

29. Expanded Sweep on "A" Scope - - unable to determine

30. Antenna Rotation - - - - - - - - normal

## MAJOR UNITS

| | |
|---|---|
| 31. Transmitter (100 chassis) | no |
| 32. Receiver (300 chassis) | no |
| 33. Modulation Generator (400 chassis) | no |
| 34. Receiver Power Supply (500 chassis) | no |
| 35. Modulation Gen Power Supply (600 chassis) | no |
| 36. Antenna System (700 chassis) | no |
| 37. Control Amplifier (800 chassis) | no |
| 38. Range and Train Indicator (900 chassis) | yes |
| 39. PPI Adaptor (1000 chassis) | no |

59087

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble. An example of an answer as it might be given would be:

V-404, Cathode Follower



NAME_____ PROBLEM NUMBER_____

SYMPTOM: No Markers on the PPI Scope

SCOPE INFORMATION

A. Monitor Scope (Signals/Markers switch in the SIGNALS Position)

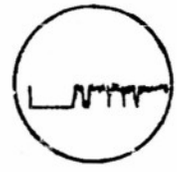
1. Trigger - - - - - - - - - - - - - - -
(Using fast sweep)



2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



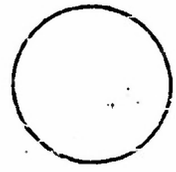
4. Receive position - - - - - - - - -
(75,000 yard range)



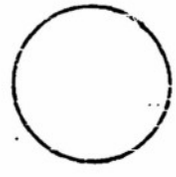
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B. Monitor Scope (Signals/Markers switch in the MARKERS position)

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - -
(75,000 yard range)



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C. Remote PPI Scope

7. Signals - - - - -
(15,000 yard range)



SCOPE INFORMATION CONT.

D. RANGE SCOPE

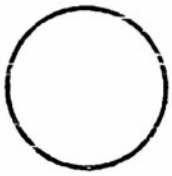
8. Signals position - - - - - - - -
(15,000 yard range)



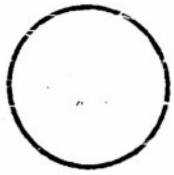
9. Signals position - - - - - - - -
(75,000 yard range)



10. Markers position - - - - - - - -
(15,000 yard range)



11. Markers position - - - - - - - -
(75,000 yard range)



E. PPI SCOPE

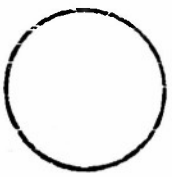
12. Signals position - - - - - - - -
(15,000 yard range)



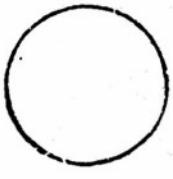
13. Signals position - - - - - - - -
(75,000 yard range)



14. Markers position - - - - - - - -
(15,000 yard range)



15. Markers position - - - - - - - -
(75,000 yard range)



## METER INFORMATION

Meter 102

16. Driver Current - - - - - - - - - - zero

Meter 103

17. Magnetron Current Drain - - - - 24 ma

18. Total Current Drain - - - - - - 35 ma

Meter 301

19. Oscillations Indicator - - - - - 28 saale divisions

Meter 901

20. Line Voltage - - - - - - - - - - 117

Meter 902

21. Magnetron Current - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - 4 ma

23 RF Monitor - - - - - - - - - - - normal

## ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - 6100 yards

25. Relative Power - - - - - - - - - 51 ua

26. Frequency Spectrum - - - - - - - normal

27. Oupput Frequency - - - - - - - - 3025 mc

## MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - minus .8 v

29. Expanded Sweep on "A" Scope - - normal

30. Antenna Rotation - - - - - - - - normal

MAJOR UNITS

| | |
|---|---|
| 31. Transmitter (100 chassis) | no |
| 32. Receiver (300 chassis) | no |
| 33. Modulation Generator (400 chassis) | yes |
| 34. Receiver Power Supply (500 chassis) | no |
| 35. Modulation Gen Power Supply (600 chassis) | no |
| 36. Antenna System (700 chassis) | no |
| 37. Control Amplifier (800 chassis) | no |
| 38. Range and Train Indicator (900 chassis) | no |
| 39. PPI Adaptor (1000 chassis) | no |

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

68190

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404, Cathode Follower



NAME _____ PROBLEM NUMBER _____

SYMPTOM: No video on the PPI Scope

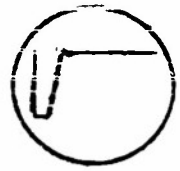
SCOPE INFORMATION

A. Monitor Scope (Signals/Markers switch in the SIGNALS position)

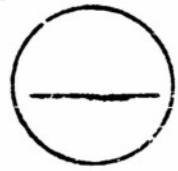
1. Trigger - - - - - - - - - - - - - -
(Using fast sweep)



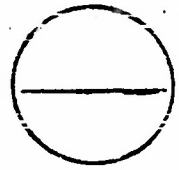
2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



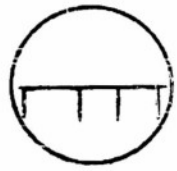
4. Receive position - - - - - - - - -
(75,000 yard range)



---

B. Monitor Scope (Signals/Markers switch in the MARKERS position)

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - -
(75,000 yard range)



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C. Remote PPI Scope

7. Signals - - - - - - - - - - - - - -
(15,000 yard range)



SCOPE INFORMATION CONT.

D. RANGE SCOPE

8. Signals position - - - - - - -
(15,000 yard range)



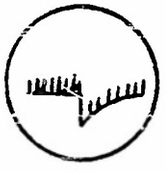
9. Signals position - - - - - - - -
(75,000 yard range)



10. Markers position - - - - - - - -
(15,000 yard range)



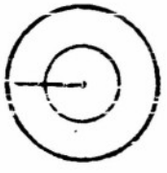
11. Markers position - - - - - - - -
(75,000 yard range)



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E. PPT SCOPE

12. Signals position - - - - - - - -
(15,000 yard range)



13. Signals position - - - - - - - -
(75,000 yard range)



14. Markers position - - - - - - - -
(15,000 yard range)



15. Markers position - - - - - - - -
(75,000 yard range)

15 markers showing - also range ring

## METER INFORMATION

Meter 102

16. Driver Current - - - - - - - - - - zero

Meter 103

17. Magnetron Current Drain - - - - - 24 ma

18. Total Current Drain - - - - - - - 35 ma

Meter 301

19. Oscillations Indicator - - - - - - 28 scale divisions

Meter 901

20. Line Voltage - - - - - - - - - - - 117 v

Meter 902

21. Magnetron Current - - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - - 6 ma

23. RF Monitor - - - - - - - - - - - - normal

## ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - - unable to determine

25. Relative Power - - - - - - - - - - 47 ua

26. Frequency Spectrum - - - - - - - - normal

27. Output Frequency - - - - - - - - - 3000 mc

## MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - zero

29. Expanded Sweep on "A" Scope - - normal

30. Antenna Rotation - - - - - - - - - normal

## MAJOR UNITS

| | |
|---|---|
| 31. Transmitter (100 chassis) | no |
| 32. Receiver (300 chassis) | yes |
| 33. Modulation Generator (400 chassis) | no |
| 34. Receiver Power Supply (500 chassis) | no |
| 35. Modulation Gen Power Supply (600 chassis) | no |
| 36. Antenna System (700 chassis) | no |
| 37. Control Amplifier (800 chassis) | no |
| 38. Range and Train Indicator (900 chassis) | no |
| 39. PPI Adaptor (1000 chassis) | no |

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68299

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404, Cathode Follower



NAME_____ PROBLEM NUMBER _____

SYMPTOM: No video on the Range Scope

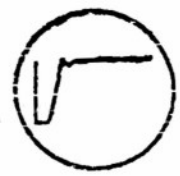
## SCOPE INFORMATION

A. MONITOR SCOPE (Signals/ Markers switch in the SIGNALS POSITION

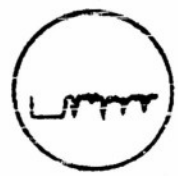
1. Trigger - - - - - - - - - - - - - - -
(Using fast sweep)



2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



4. Receive position - - - - - - - - -
(75,000 yard range)



---

B. MONITOR SCOPE (Signals/Markers switch in the MARKERS POSITION

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - -
(75,000 yard range)



---

C. REMOTE PPI SCOPE

7. Signals - - - - - - - - - - - - - -
(15,000 yard range)



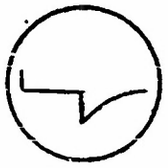
SCOPE INFORMATION CONT.

D. RANGE SCOPE

8. Signals position - - - - - - - - - (15,000 yard range)



9. Signals position - - - - - - - - - (75,000 yard range)



10. Markers position - - - - - - - - - (15,000 yard range)



11. Markers position - - - - - - - - - (75,000 yard range)



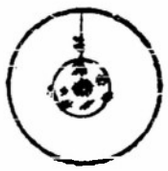
---

E. PPI SCOPE

12. Signals position - - - - - - - - - (15,000 yard range)



13. Signals position - - - - - - - - - (75,000 yard range)



14. Markers position - - - - - - - - - (15,000 yard range)



15. Markers position - - - - - - - - - (75,000 yard range)

15 markers showing - also range ring

## METER INFORMATION

**Meter 102**

16. Driver Current - - - - - - - - - - zero

**Meter 103**

17. Magnetron Current Drain - - - - 24 ma

18. Total Current Drain - - - - - - 34 ma

**Meter 301**

19. Oscillations Indicator - - - - - 26 scale divisions

**Meter 901**

20. Line Voltage - - - - - - - - - - 111 v.

**Meter 902**

21. Magnetron Current - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - 6 ma

23. RF Monitor - - - - - - - - - - normal

24. Ring Time - - - - - - - - - - - 5700 yards

25. Relative Power - - - - - - - - - 53 ua

26. Frequency Spectrum - - - - - - - normal

27. Output Frequency - - - - - - - - 3000 mc

28. Voltage at Metering Jack 303 - - minus .8 v

29. Expanded Sweep on "A" Scope - - normal

30. Antenna Rotation - - - - - - - - normal

## MAJOR UNITS

| | |
|---|---|
| 31. Transmitter (100 chassis) | no |
| 32. Receiver (300 chassis) | no |
| 33. Modulation Generator (400 chassis) | no |
| 34. Receiver Power Supply (500 chassis) | no |
| 35. Modulation Gen. Power Supply (600 chassis) | no |
| 36. Antenna system (700 chassis) | no |
| 37. Control Amplifier (800 chassi) | no |
| 38. Range and Train Indicator (900 chassis) | yes |
| 39. PPI Adaptor (1000 chassis) | no |

69378

Nowyou have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404, Cathode Follower



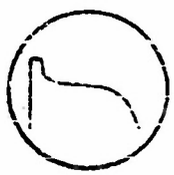
NAME_____ PROBLEM NUMBER _____

SYMPTOM: No video on the PPI Scope

## SCOPE INFORMATION

A. MONITOR SCOPE (Signals/Markers switch in the SIGNALS POSITION

1. Trigger - - - - - - - - - - - - - - -
(Using fast sweep)



2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



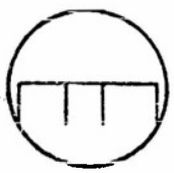
4. Receive position - - - - - - - - -
(75,000 yard range)



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B. MONITOR SCOPE (Signals/Markers switch in the MARKERS POSITION

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - -
(75,000 yard range)



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C. REMOTE PPI SCOPE

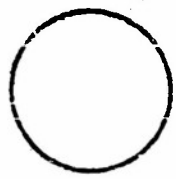
7. Signals - - - - - - - - - - - - - - -
(15,000 yard range)



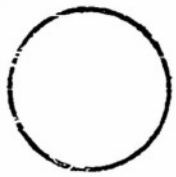
SCOPE INFORMATION

D. RANGE SCOPE

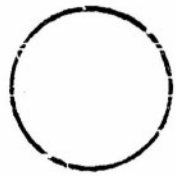
8. Signals position - - - - - - - -
(15,000 yard range)



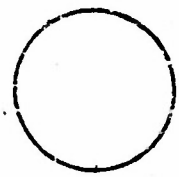
9. Signals position - - - - - - - -
(75,000 yard range)



10. Markers position - - - - - - - -
(15,000 yard range)



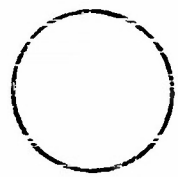
11. Markers position - - - - - - -
(75,000 yard range)



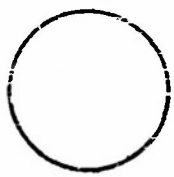
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E. PPI SCOPE

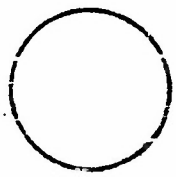
12. Signals position - - - - - - - -
(15,000 yard range)



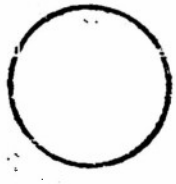
13. Signals position - - - - - - - -
(75,000 yard range



14. Markers position - - - - - - - -
(15,000 yard range)



15. Markers position - - - - - - - -
(75,000 yard range)



## METER INFORMATION

Meter 102

16. Driver Current - - - - - - - - - - zero

Meter 103

17. Magnetron Current Drain - - - - 24 ma

18. Total Current Drain - - - - - - - 33 ma

Meter 301

19. Oscillations Indicator - - - - - 29 scale divisions

Meter 901

20. Line Voltage - - - - - - - - - - - 112

Meter 902

21. Magnetron Current - - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - - 6 ma

23. RF Monitor - - - - - - - - - - - - normal

## ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - - unable to determine

25. Relative Power - - - - - - - - - - 54 ua

26. Frequency Spectrum - - - - - - - normal

27. Output Frequency - - - - - - - - - 3000 mc

## MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - minus .7 v

29. Expanded Sweep on "A" Scope - - unable to determine

30. Antenna Rotation - - - - - - - - - normal

## MAJOR UNITS

| | |
|---|---|
| 31. Transmitter - - - - - - - - - - (100 chassis) | no |
| 32. Receiver - - - - - - - - - - - (300 chassis) | no |
| 33. Modulation Generator - - - - - (400 chassis) | no |
| 34. Receiver Power Supply - - - - - (500 chassis) | no |
| 35. Modulation Gen Power Supply - - (600 chassis) | no |
| 36. Antenna System - - - - - - - - (700 chassis) | no |
| 37. Control Amplifier - - - - - - - (800 chassis) | no |
| 38. Range and Train Indicator - - - (900 chassis) | yes |
| 39. PPI Adaptor - - - - - - - - - - (1000 chassis) | no |

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

68437

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404, Cathode Follower



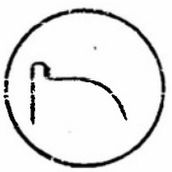
NAME_____ PROBLEM NUMBER_____

SYMPTOM: No video on the Range Scope

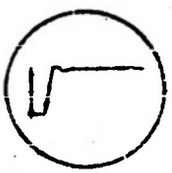
SCOPE INFORMATION

A. MONITOR SCOPE (Signals/Markers switch in the SIGNALS POSITION

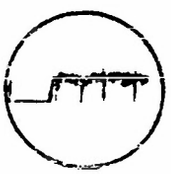
1. Trigger - - - - - - - - - - - - -
(Using fast sweep)



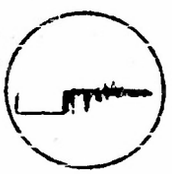
2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



4. Receive position - - - - - - - - -
(75,000 yard range)



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B. MONITOR SCOPE (Signals/Markers switch in the MARKERS POSITION

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - -
(75,000 yard range)



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C. REMOTE PPI SCOPE

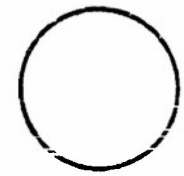
7. Signals - - - - - - - - - - - - - -
(15,000 yard range)



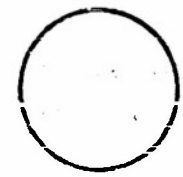
SCOPE INFORMATION CONT.

D. RANGE SCOPE

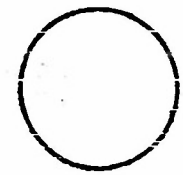
8. Signals position - - - - - - - -
(15,000 yard range)



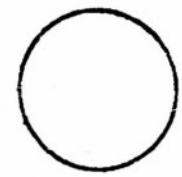
9. Signals position - - - - - - - -
(75,000 yard position)



10. Markers position - - - - - - - -
(15,000 yard range)



11. Markers position - - - - - - - -
(75,000 yard range)



---

E. PPI SCOPE

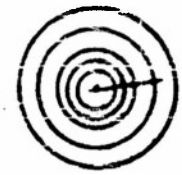
12. Signals position - - - - - - - -
(15,000 yard range)



13. Signals position - - - - - - - -
(75,000 yard range)



14. Markers position - - - - - - - -
(15,000 yards range)



15. Markers position - - - - - - - -
(75,000 yard range)

15 markers showing - also range ring

## METER INFORMATION

**Meter 102**

16, Driver Current - - - - - - - - - - zero

**Meter 103**

17. Magnetron Current Drain - - - - 24 ma

18. Total Current Drain - - - - - - 33 ma

**Meter 301**

19. Oscillations Indicator - - - - - 28 scale divisions

**Meter 901**

20. Line Voltage - - - - - - - - - - 112v

**Meter 902**

21. Magnetron Current - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - 6 ma

23. RF Monitor - - - - - - - - - - - normal

## ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - - 5100 yards

25. Relative Power - - - - - - - - - 48 ua

26. Frequency Spectrum - - - - - - - normal

27. Output Frequency - - - - - - - - 3000 mc

## MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - minus .7 v

29. Expanded Sweep on "A" Scope - - unable to determine

30. Antenna Rotation - - - - - - - - normal

## MAJOR UNITS

| | |
|---|---|
| 31. Transmitter (100 chassis) | no |
| 32. Receiver (300 chassis) | no |
| 33. Modulation Generator (400 chassis) | no |
| 34. Receiver Power Supply (500 chassis) | no |
| 35. Modulation Gen Power Supply (600 chassis | no |
| 36. Antenna System (700 chassis) | no |
| 37. Control Amplifier (800 chassis) | no |
| 38. Range and Train Indicator (900 chassis) | yes |
| 39. PPI Adaptor (1000 chassis) | no |

67576

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404, Cathode Follower



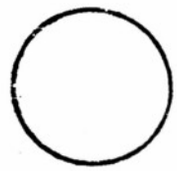
NAME_____ PROBLEM NUMBER_____

SYMPTOM: No video on the PPI Scope

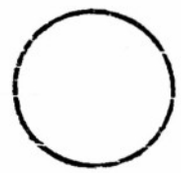
## SCOPE INFORMATION

A. MONITOR SCOPE (Signals/Markers switch in the SIGNALS POSITION

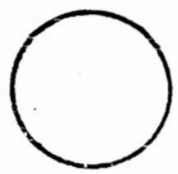
1. Trigger - - - - - - - - - - - - - - -
   (Using fast sweep)



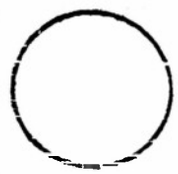
2. Modulation pulse - - - - - - - - -
   (Using fast sweep)



3. Receive position - - - - - - - - -
   (15,000 yard range)



4. Receive position - - - - - - - - -
   (75,000 yard range)



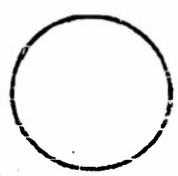
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B. MONITOR SCOPE (Signals/Markers switch in the MARKERS POSITION

5. Receive position - - - - - - - - -
   (15,000 yard range)



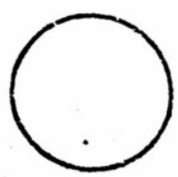
6. Receive position - - - - - - - - -
   (75,000 yard range)



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C. REMOTE PPI SCOPE

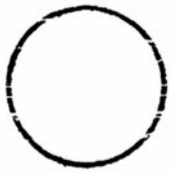
7. Signals - - - - - - - - - - - - - - -
   (15,000 yards range)



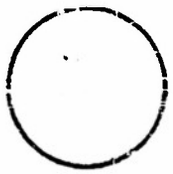
SCOPE INFORMATION CONT.

D. RANGE SCOPE

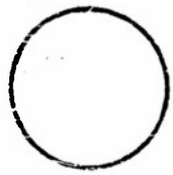
8. Signals position 6 - - - - - - - -
(15,000 yard range)



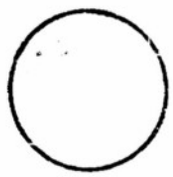
9. Signals position - - - - - - - - -
(75,000 yard range)



10. Markers position - - - - - - - -
(15,000 yard range)



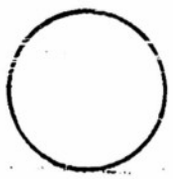
11. Markers position - - - - - - - -
(75,000 yard range)



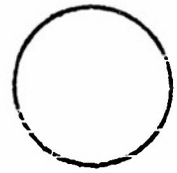
---

E. PPI SCOPE

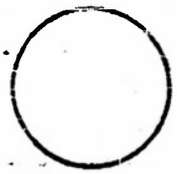
12. Signals position - - - - - - - -
(15,000 yard range)



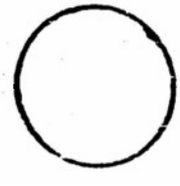
13. Signals position - - - - - - - -
(75,000 yard range)



14. Markers position - - - - - - - -
(15,000 yard range)



15. Markers position - - - - - - - -
(75,000 yard range)



## METER INFORMATION

**Meter 102**

16. Driver Current - - - - - - - - - - zero

**Meter 103**

17. Magnetron Current Drain - - - - zero

18. Total Current Drain - - - - - - zero

**Meter 301**

19. Oscillations Indicator - - - - - 25 scale divisions

**Meter 901**

20. Line Voltage - - - - - - - - - - 112

**Meter 902**

21. Magnetron Current - - - - - - - zero

22. Tuning Indicator - - - - - - - - 25 ma., no dip

23. RF Monitor - - - - - - - - - - - zero

## ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - unable to determine

25. Relative Power - - - - - - - - - zero

26. Frequency Spectrum - - - - - - - unable to determine

27. Output Frequency - - - - - - - - unable to determine

## MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - minus .8 v.

29. Expanded Sweep on "A" Scope - - unable to determine

30. Antenna Rotation - - - - - - - - normal

## MAJOR UNITS

31. Transmitter - - - - - - - - - - - no
(100 chassis)

32. Receiver - - - - - - - - - - - - no
(300 chassis)

33. Modulation Generator - - - - - - yes
(400 chassis)

34. Receiver Power Supply - - - - - - no
(500 chassis)

35. Modulation Gen Power Supply - - no
(600 chassis)

36. Antenna System - - - - - - - - - no
(700 chassis)

37. Control Amplifier - - - - - - - - no
(800 chassis)

38. Range and Train Indicator - - - no
(900 chassis)

39. PPI Adaptor - - - - - - - - - - no
(1000 chassis)

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

69675

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major unit you believe is causing the "trouble. An example of an answer as it might be given would be:

V-404, Cathode Follower



NAME_____ PROBLEM NUMBER_____

SYMPTOM: No video on the Range Scope

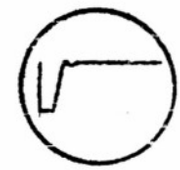
SCOPE INFORMATION

A. MONITOR SCOPE (Signals/Markers switch in the SIGNALS POSITION

1. Trigger - - - - - - - - - - - - - - -
(Using fast sweep)



2. Modulation Pulse - - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



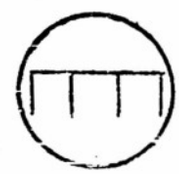
4. Receive position - - - - - - - - -
(75,000 yard range)



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B MONITOR SCOPE (Signals/Markers switch in the MARKERS POSITION

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - -
(75,000 yard range)



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C. REMOTE PPI SCOPE

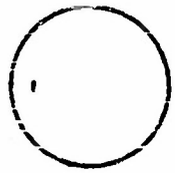
7. Signals - - - - - - - - - - - - - - -
(15,000 yard range)



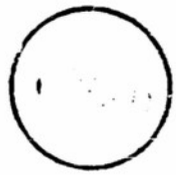
SCOPE INFORMATION CONT.

D. RANGE SCOPE

8. Signals position - - - - - - - - (15,000 yard range)



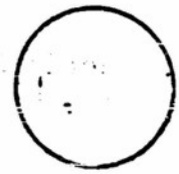
9. Signals position - - - - - - - - (75,000 yard range)



10. Markers position - - - - - - - - (15,000 yard range)



11. Markers position - - - - - - - - (75,000 yard range)

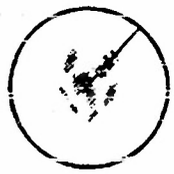


E. PPI SCOPE

12. Signals position - - - - - - - - (15,000 yard range)



13. Signals position - - - - - - - - (75,000 yard range)



14. Markers position - - - - - - - - (15,000 yard range)



15. Markers position - - - - - - - - (75,000 yard range)

15 markers showing - no range ring

## METER INFORMATION

Meter 102

16. Driver Current - - - - - - - - - - zero

Meter 103

17. Magnetron Current Drain - - - - 24 ma

18. Total Current Drain - - - - - - 34 ma

Meter 301

19. Oscillations Indicator - - - - - 26 scale divisions

Meter 901

20. Line Voltage - - - - - - - - - - 114v.

Meter 902

21. Magnetron Current - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - 5 ma

23. RF Monitor - - - - - - - - - - - normal

## ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - unable to determine

25. Relative Power - - - - - - - - - 49 ua

26. Frequency Spectrum - - - - - - - normal

27. Output Frequency - - - - - - - - 3000 mc

## MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - minus .7 v.

29. Expanded Sweep on "A" Scope - - unable to determine

30. Antenna Rotation - - - - - - - - normal

MAJOR UNITS

| | |
|---|---|
| 31. Transmitter - - - - - - - - - - (100 chassis) | no |
| 32. Receiver - - - - - - - - - - - (300 chassis) | no |
| 33. Modulation Generator - - - - - (400 chassis) | no |
| 34. Receiver Power Supply - - - - - (500 chassis) | no |
| 35. Modulation Gen Power Supply - - (600 chassis) | no |
| 36. Antenna System - - - - - - - - (700 chassis) | no |
| 37. Control Amplifier - - - - - - - (800 chassis) | no |
| 38. Range and Train Indicator - - - (900 chassis) | yes |
| 39. PPI Adaptor - - - - - - - - - - (1000 chassis) | no |

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67784

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404, Cathode Follower

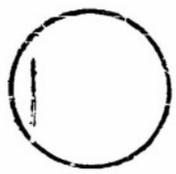
NAME_____ PROBLEM NUMBER_____

SYMPTOM: No video on the PPI Scope

SCOPE INFORMATION

A. MONITOR SCOPE )Signals/Markers switch in the SIGNALS POSITION

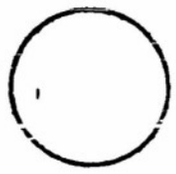
1. Trigger - - - - - - - - - - - - - -
(Using fast sweep)



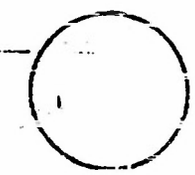
2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



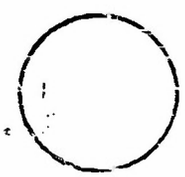
4. Receive position - - - - - - - - -
(75,000 yard range)



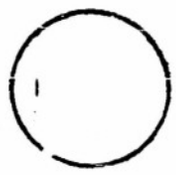
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B. MONITOR SCOPE (Signals/Markers switch in the MARKERS POSITION

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - -
(75,000 yard range)



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C. REMOTE PPI SCOPE

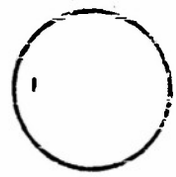
7. Signals - - - - - - - - - - - - - -
(15,000 yard range)



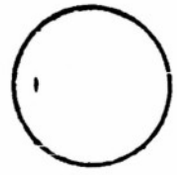
SCOPE INFORMATION CONT.

D. RANGE SCOPE

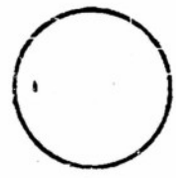
8. Signals position - - - - - - - - -
(15,000 yard range)



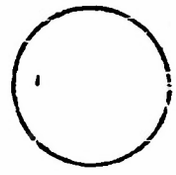
9. Signals position - - - - - - - - -
(75,000 yard range)



10. Markers position - - - - - - - - -
(15,000 yard range)



11. Markers position - - - - - - - - -
(75,000 yard range)



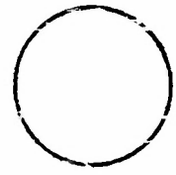
---

E. PPI SCOPE

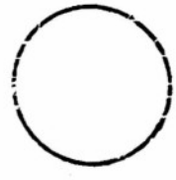
12. Signals position - - - - - - - - -
(15,000 yard range)



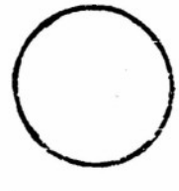
13. Signals position - - - - - - - - -
(75,000 yard range)



14. Markers position - - - - - - - - -
(15,000 yard range)



15. Markers position - - - - - - - - -
(75,000 yard range)



METER INFORMATION

Meter 102

16. Driver Current - - - - - - - - - zero

Meter 103

17. Magnetron Current Drain - - - - 24 ma

18. Total Current Drain - - - - - - 33 ma

Meter 301

19. Oscillations Indicator - - - - - 26 scale divisions

Meter 901

20. Line Voltage - - - - - - - - - - 115

Meter 902

21. Magnetron Current - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - 6 ma

23. RF Monitor - - - - - - - - - - - normal

ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - unable to determine

25. Relative Power - - - - - - - - - 53 ua

26. Frequency Spectrum - - - - - - - normal

27. Output Frequency - - - - - - - - 3000 mc

MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - minus .8 v.

29. Expanded Sweep of "A" Scope - - unable to determine

30. Antenna Rotation - - - - - - - - normal

## MAJOR UNITS

| | |
|---|---|
| 31. Transmitter - - - - - - - - - - (100 chassis) | no |
| 32. Receiver - - - - - - - - - - - (300 chassis) | no |
| 33. Modulation Generator - - - - - (400 chassis) | yes |
| 34. Receiver Power Supply - - - - - (500 chassis) | no |
| 35. Modulation Gen Power Supply - - (600 chassis) | no |
| 36. Antenna System - - - - - - - - (700 chassis) | no |
| 37. Control Amplifier - - - - - - - (800 chassis) | no |
| 38. Range and Train Indicator - - - (900 chassis) | no |
| 39. PPI Adaptor - - - - - - - - - - (1000 chassis) | no |

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

69873

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404, Cathode Follower



NAME_____ PROBLEM NUMBER_____

SYMPTOM: No video on the PPI Scope

SCOPE INFORMATION

A. MONITOR SCOPE (Signals/Markers switch in the SIGNALS POSITION

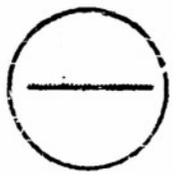
1. Trigger - - - - - - - - - - - - - - -
(Using fast sweep)



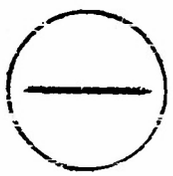
2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



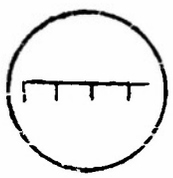
4. Receive position - - - - - - - - -
(75,000 yard range)



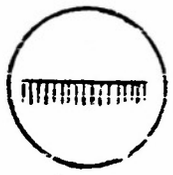
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B. MONITOR SCOPE (Signals/Markers switch in the MARKERS POSITION

5. Receive position - - - - - - - - -
(15,000 yard range)



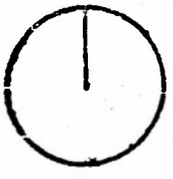
6. Receive position - - - - - - - - -
(75,000 yard range)



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C. REMOTE PPI SCOPE

7. Signals - - - - - - - - - - - - - -
(15,000 yard range)



SCOPE INFORMATION CONT.

D. RANGE SCOPE

8. Signals position - - - - - - - - - (15,000 yard range)



9. Signals position - - - - - - - - - (75,000 yard range)



10. Markers position - - - - - - - - - (15,000 yard range)



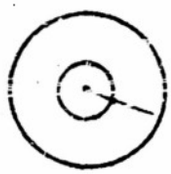
11. Markers position - - - - - - - - - (75,000 yard range)



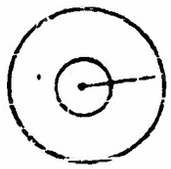
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E. PPI SCOPE

12. Signals position - - - - - - - - - (15,000 yard range)



13. Signals position - - - - - - - - - (75,000 yard range)



14. Markers position - - - - - - - - - (15,000 yard range)



15. Markers position - - - - - - - - - (75,000 yard range)

15 markers showing also range mark

## METER INFORMATION

16. Driver Current - - - - - - - - - zero

17. Magnetron Current - - - - - - - 24 ma

18. Total Current Drain - - - - - - 31 ma

19. Oscillations Indicator - - - - - zero

20. Line Voltage - - - - - - - - - - 117 v

21. Magnetron Current - - - - - - - 24 ma

22. Tuning Indicator - - - - - - - - 30 ma., no dip

23. RF Monitor - - - - - - - - - - - normal

## ECHO BOX INFORMATION

24. Ring Time - - - - - - - - - - - unable to determine

25. Relative Power - - - - - - - - - 53 ua

26. Frequency Spectrum - - - - - - - normal

27. Output Frequency - - - - - - - - 3000 mc

## MISCELLANEOUS INFORMATION

28. Voltage at Metering Jack 303 - - minus .4 v

29. Expanded Sweep on "A" Scope - - normal

30. Antenna Rotation - - - - - - - - normal

MAJOR UNITS

| | |
|---|---|
| 31. Transmitter (100 chassis) | no |
| 32. Receiver (300 chassis) | yes |
| 33. Modulation Generator (400 chassis) | no |
| 34. Receiver Power Supply (500 chassis) | no |
| 35. Modulation Gen. Power Supply- (600 chassis) | no |
| 36. Antenna System (700 chassis) | no |
| 37. Control Ampli ier (800 chassis) | no |
| 38. Range and Train Indicator (900 chassis) | no |
| 39. PPI Adaptor (1000 chassis) | no |

67972

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404, Cathode Follower



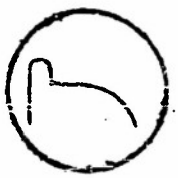
NAME_____ PROBLEM NUMBER_____

SYMPTOM: No range spot on the PPI Scope

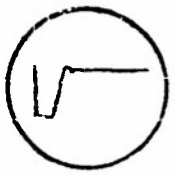
SCOPE INFORMATION

A. MONITOR SCOPE (Signals/Markers switch in the SIGNALS POSITION

1. Trigger - - - - - - - - - - - - - -
(Using fast swsep)



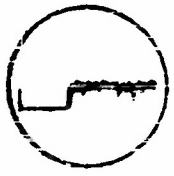
2. Modulation pulse - - - - - - - - -
(Using fast sweep)



3. Receive position - - - - - - - - -
(15,000 yard range)



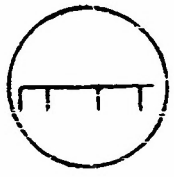
4. Receive position - - - - - - - - -
(75,000 yard range)



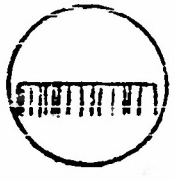
---

B. MONITOR SCOPE (Signals/Markers switch In the MARKERS POSITION

5. Receive position - - - - - - - - -
(15,000 yard range)



6. Receive position - - - - - - - - -
(75,000 yard range)



---

C. REMOTE PPI SCOPE

7. Signals - - - - - - - - - - - - - -
(15,000 yard range)



SCOPE INFORMATION

D. RANGE SCOPE

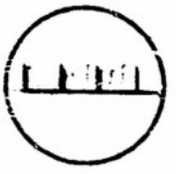
8. Signals position - - - - - - - - -
(15,000 yard range)



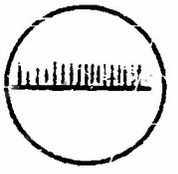
9. Signals position - - - - - - - - -
(75,000 yard range)



10. Markers position - - - - - - - - -
(15,000 yard range)



11. Markers position - - - - - - - - -
(75,000 yard range)



---

E. PPI SCOPE

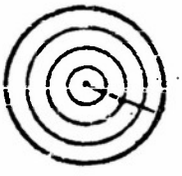
12. Signals position - - - - - - - - -
(15,000 yard range)



13. Signals position - - - - - - - - -
(75,000 yard range)



14. Markers position - - - - - - - - -
(15,000 yard range)



15. Markers position - - - - - - - - -
(75,000 yard range)

15 markers showing no range ring

## METER INFORMATION

| | |
|---|---|
| **Meter 102** | |
| 16. Driver Current | zero |
| **Meter 103** | |
| 17. Magnetron Current | 24 ma |
| 18. Total Current Drain | 31 ma |
| **Meter 301** | |
| 19. Oscillations Indicator | 26 scale divisions |
| **Meter 901** | |
| 20. Line Voltage | 114 v |
| **Meter 902** | |
| 21. Magnetron Current | 24 ma |
| 22. Tuning Indicator | 6 ma |
| 23. RF Monitor | normal |

## ECHO BOX INFORMATION

| | |
|---|---|
| 24. Ring Time | unable to determine |
| 25. Relative Power | 49 ua |
| 26. Frequency Spectrum | normal |
| 27. Output Frequency | 3000 mc |

## MISCELLANEOUS INFORMATION

| | |
|---|---|
| 28. Voltage at Metering Jack 303 | minus .8 v |
| 29. Expanded Sweep on "A" Scope | normal |
| 30. Antenna Rotation | normal |

MAJOR UNITS

| | |
|---|---|
| 31. Transmitter (100 chassis) | no |
| 32. Receiver (300 chassis) | no |
| 33. Modulation Generator (400 chassis) | no |
| 34. Receiver Power Supply (500 chassis) | no |
| 35. Modulation Gen Power Supply (600 chassis) | no |
| 36. Antenna System (700 chassis) | no |
| 37. Control Amplifier (800 chassis) | no |
| 38. Range and Train Indicator (900 chassis) | yes |
| 39. PPI Adaptor (1000 chassis) | no |

69091

Now you have found in which Major Unit the "trouble" lies. In the space below, tell what stage within this Major Unit you believe is causing the "trouble". An example of an answer as it might be given would be:

V-404 Cathode Follower



NAME_____ PROBLEM NUMBER_____

# APPENDIX C

## FAMILIARITY WITH EQUIPMENT TEST (Parts I and II) (SG1b Radar)

Part I of this test consists of one page of instructions, six pages of questions, and an answer sheet. Part II consists of one page of instructions, two photographs of the SG1b radar, and an answer sheet.

## FAMILIARITY WITH EQUIPMENT
(SG-1b)

DIRECTIONS: This is a test of your familiarity with the SG-1b radar equipment. The test consists of two parts. Part I is made up of 35 general multiple choice questions which we are asking you to answer from memory. Part II contains 20 questions of the matching type which are also to be answered from memory. The SG-1b radar is the only equipment that is involved. DO NOT MAKE ANY MARKS OF ANY KIND ON THE QUESTION SHEETS.

### PART I

In Part I for each question there are given five possible answers. You are to pick out what you believe to be the correct answer and fill in the space under its letter on the separate answer sheet. The fifth choice or answer for each question reads: "no correct answer given." This choice should be used when you believe that none of the first four choices correctly answers the question that has been asked. Please attempt to answer every question. Two sample questions like those in Part I are shown below.

EXAMPLE X

What is the main use made of the SG-1b radar equipment?

(a) fire control
(b) air search
(c) surface search
(d) zenith search
(e) no correct answer given

EXAMPLE Y

Which unit of the SG-1b is sometimes referred to as the "console"?

(a) modulation generator
(b) transmitter
(c) RF assembly
(d) receiver
(e) no correct answer given

SAMPLE OF ANSWER SHEET

| | a | b | c | d | e |
|---|---|---|---|---|---|
| X | ( ) | ( ) | (●) | ( ) | ( ) |
| Y | ( ) | ( ) | ( ) | ( ) | (●) |

In Example X, surface search is the correct answer so the space under the letter for surface search, c, has been filled in on the sample answer sheet above.

In Example Y, the correct answer has not been given so the space under the letter for no correct answer given has been filled in on the sample answer sheet above.

1. What is the output frequency at which the transmitter unit of the SG-1b radar operates?

(a) 30 mc
(b) 1,000 mc
(c) 3,000 mc
(d) 10,000 mc
(e) no correct answer given

2. How many stages of IF amplification are used in the SG-1b radar equipment?

(a) two
(b) four
(c) six
(d) eight
(e) no correct answer given

3. How many switches must be turned on so that returned echos will be visible on the scopes, starting from the completely secured position?

(a) two
(b) three
(c) four
(d) five
(e) no correct answer given

4. What should the magnetron current meter reading normally be for the SG-1b radar?

(a) 16 ma
(b) 24 ma
(c) 30 ma
(d) 36 ma
(e) no correct answer given

5. How many power supplies does the range and train indicator contain?

(a) one
(b) two
(c) three
(d) four
(e) no correct answer given

6. What is the proper output from the range mark cathode follower (V-412)?

(a) positive pips approximately 30 usec apart
(b) positive pips approximately 105 usec apart
(c) negative pips approximately 30 usec apart
(d) negative pips approximately 105 usec apart
(e) no correct answer given

7. What is the bandwidth of the SG-1b radar receiver unit?

(a) 10 kc
(b) 1.5 mc
(c) 2.8 mc
(d) 30 mc
(e) no correct answer given

8. What is the approximate length of the component Y-301-50?

(a) one inch or less
(b) one to two inches
(c) two to three inches
(d) three to four inches
(e) no correct answer given

9. Which one of the following tube types is used in the SG-1b radar as a low voltage rectifier (400 volts or less)?

(a) 5Z3
(b) 5Y3GT
(c) 6X5
(d) 80
(e) no correct answer given

10. What type multivibrator is used in the generation of range markers?

(a) free running
(b) Eccles-Jordan
(c) electron coupled
(d) one shot
(e) no correct answer given

11. What is the maximum speed of antenna rotation in RPM for the SG-1b radar equipment?

(a) eight
(b) sixteen
(c) twenty-four
(d) thirty-two
(e) no correct answer given

12. On which chassis is the component "R 407" located?

(a) radar receiver
(b) range and train indicator
(c) transmitter
(d) modulation generator
(e) no correct answer given

13. What adjustment is made by use of "R 129"?

(a) intensity on the PPI scope
(b) bias on the isolation rectifier tube
(c) intensity on the "A" scope
(d) "A" scope astigmatism
(e) no correct answer given

14. What is the approximate apparent power input to the SG-1b radar equipment?

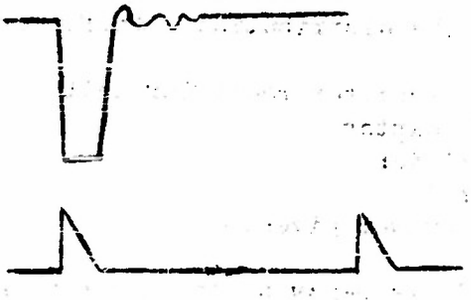
(a) 2.8 KVA
(b) 3.5 KVA
(c) 6 KVA
(d) 40 KVA
(e) no correct answer given

15. What is the maximum calibrated range of the SG-1b radar equipment?

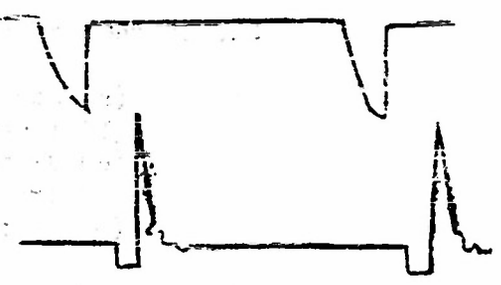
(a) 40,000 yards
(b) 160,000 yards
(c) 200,000 yards
(d) 400,000 yards
(e) no correct answer given

16. Which of the following is the proper wave form for the modulation return pulse?

(a)



(b)



(c)



(d)



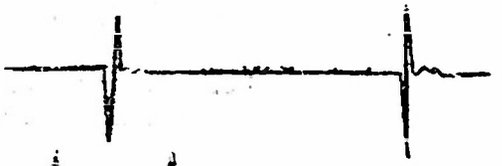
(e) no correct wave form shown

17. Which of the following is the proper wave form for the output from the repetition rate oscillator?

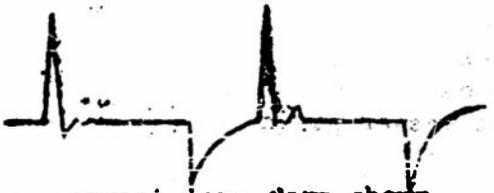
(a)



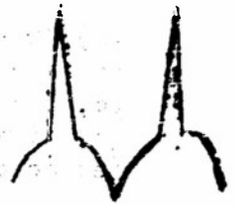
(b)



(c)



(d)



(e) no correct wave form shown

18. What type receiver is used in the SG-1b radar equipment?

(a) Autodyne
(b) regenerative
(c) super-regenerative
(d) superhetrodyne
(e) no correct answer given

19. Which of the following chassis has a control that can be used to vary the repetition rate?

(a) transmitter
(b) range and train indicator
(c) receiver
(d) control amplifier
(e) no correct answer given

20. What is the proper input to the keyer tubes in the SG-1b radar equipment?

(a) positive pulses 2 usec in duration
(b) positive pulses 50.5 usec in duration
(c) positive pulses 105 usec in duration
(d) positive pulses 1250 usec in duration
(e) no correct answer given

21. On what chassis is the distribution transformer located?

(a) modulation generator rectifier unit
(b) remote PPI adapter
(c) driver rectifier
(d) transmitter
(e) no correct answer given.

22. What is the natural frequency of the range mark oscillator (V407)?

(a) 30 kc
(b) 32.78 kc
(c) 30 mc
(d) 32.78 mc
(e) no correct answer given.

23. How quickly should returned echos be observed on the scopes after turning on all necessary switches?

(a) 30 seconds
(b) one minute
(c) two minutes
(d) five minutes
(e) no correct answer given

24. What type [illegible] tubes are used in the SG-1b radar equipment?

(a) 807
(b) 2050
(c) 833
(d) 304TH
(e) no correct answer given

25. What is the approximate diameter of the PPI scope on the SG-1b radar?

(a) 5 inches
(b) 7 inches
(c) 9 inches
(d) 12 inches
(e) no correct answer given

26. The "PPI" scope has
(a) electromagnetic deflection and requires 9KV for operation
(b) electrostatic deflection and requires 9 KV for operation
(c) electromagnetic deflection and requires 6 KV for operation
(d) electrostatic deflection and requires 6 KV for operation
(e) no correct answer given

27. On what chassis would the component "V-303" be located?

(a) modulation generator
(b) control amplifier
(c) receiver power supply
(d) transmitter
(e) no correct answer given

28. What is the normal magnitude of the keep-alive voltage?

(a) plus 700 volts
(b) plus 900 volts
(c) minus 700 volts
(d) minus 900 volts
(e) no correct answer given

29. The wave gate operates at what frequency?

(a) one-half the repetition rate
(b) twice the repetition rate
(c) equal to the repetition rate
(d) one-third the repetition rate
(e) no correct answer given

30. If the operator wished to vary the receiver gain, on which of the following chassis would he find the proper control?

(a) RF assembly
(b) range and train indicator
(c) transmitter
(d) control amplifier
(e) no correct answer given

31. Approximately how many fuses of all types are used in the SG-1b radar equipment?

(a) five
(b) fifteen
(c) twenty
(d) twenty-five
(e) no correct answer given

32. What is the peak power output for the SG-1b radar equipment?

(a) 40 KW
(b) 80 KW
(c) 300 KW
(d) 400 KW
(e) no correct answer given

33. Which of the following can be measured with the RF signal monitor on the SG-1b radar equipment?

(a) the approximate ringing time
(b) the approximate relative receiver gain
(c) the approximate IF bandwidth
(d) the approximate frequency of the klystron
(e) no correct answer given

34. When the range step switch is turned on, the effect is noticed on what scope or scopes?

(a) only on the "A" scope
(b) only on the PPI scope
(c) on the "A" scope and PPI scope
(d) on the "A" scope, PPI scope and the Monitor scope
(e) no correct answer given

35. What is the purpose of the crystal (Y-401) in the range mark oscillator circuit?

(a) it is the source of range markers
(b) it is a source of signal for the oscillator
(c) it stabilizes the oscillator
(d) it provides a trigger for the circuit
(e) no correct answer given

FAMILIARITY WITH EQUIPMENT (SG-1b)
PART I

1. ( )( )( )( )( )
2. ( )( )( )( )( )
3. ( )( )( )( )( )
4. ( )( )( )( )( )
5. ( )( )( )( )( )
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7. ( )( )( )( )( )
8. ( )( )( )( )( )
9. ( )( )( )( )( )
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12. ( )( )( )( )( )
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14. ( )( )( )( )( )
15. ( )( )( )( )( )
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24. ( )( )( )( )( )
25. ( )( )( )( )( )
26. ( )( )( )( )( )
27. ( )( )( )( )( )
28. ( )( )( )( )( )
29. ( )( )( )( )( )
30. ( )( )( )( )( )
31. ( )( )( )( )( )
32. ( )( )( )( )( )
33. ( )( )( )( )( )
34. ( )( )( )( )( )
35. ( )( )( )( )( )

NAME _____

FAMILIARITY WITH EQUIPMENT
(SG-1b)

PART II

On the next two pages are illustrations of two units of the SG-1b radar equipment. You will be asked to locate various meters, switches and controls on these units. The parts which you are to identify are listed on a separate answer sheet. These items may be answered by selecting the numbered arrow that corresponds to the part in question and writing the arrow number in the blank to the left of the item. If any of the items ask you to locate a part that is not indicated by an arrow, write the letters "NI" (for "Not Indicated") in the blank as the answer.

FOR EXAMPLE:

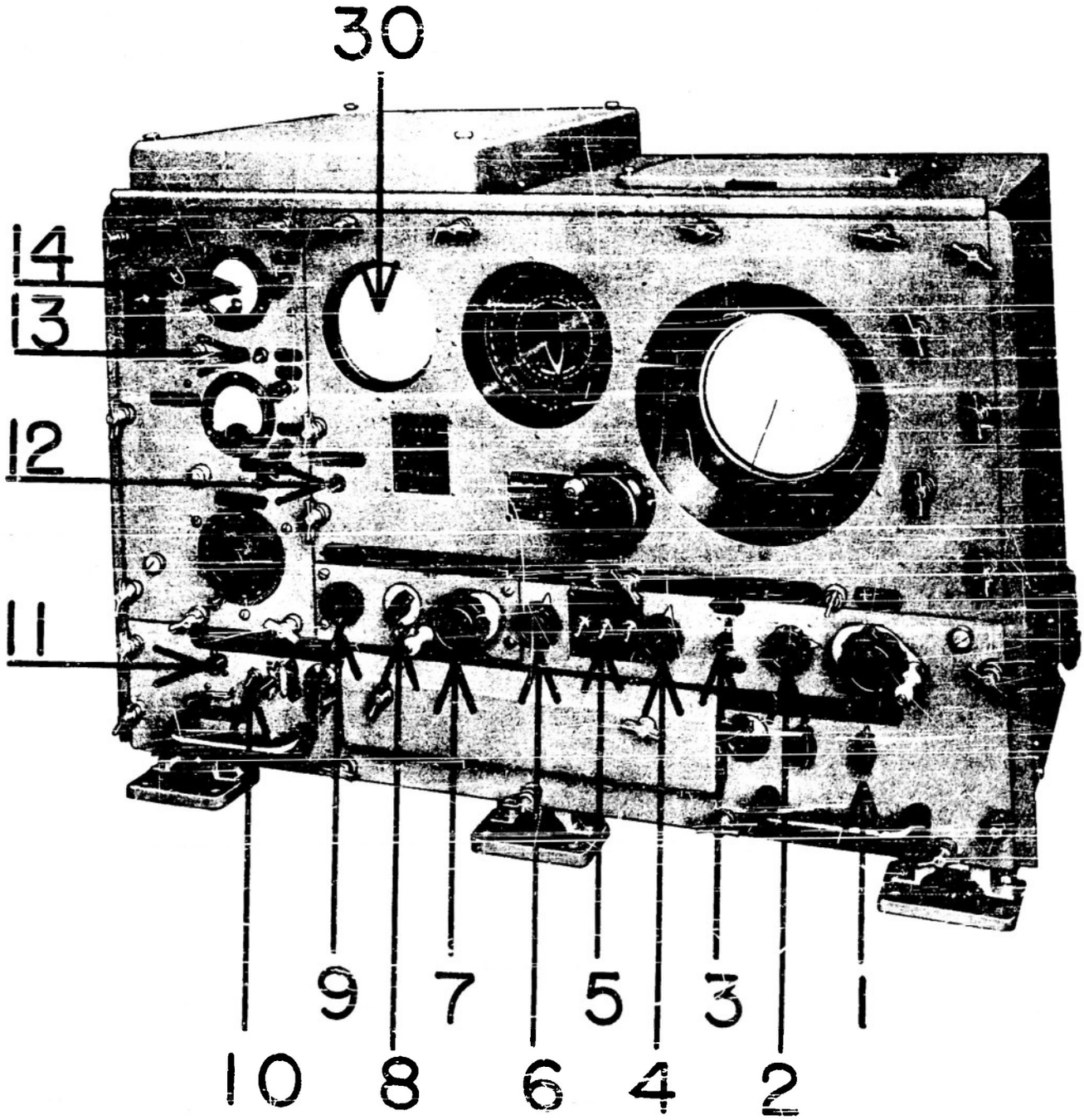
What is the number of the arrow that points to the:

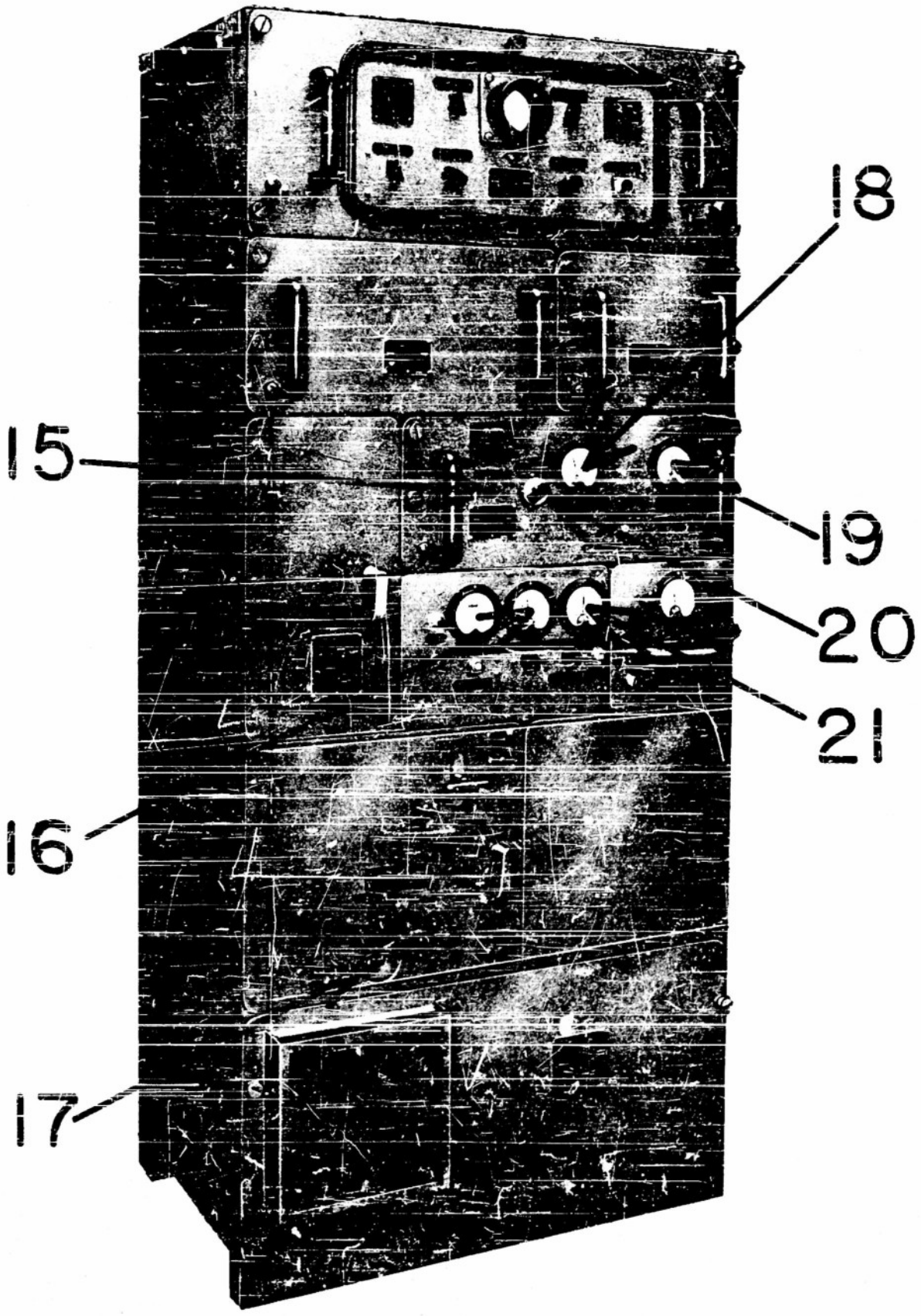
30 R. Range Scope

NI S. PPI Scope

The arrow numbered 30, points to the range scope so the number 30 has been written in the blank for sample item "R".

There is no arrow pointing to the PPI Scope so the letters "NI" have been written in the blank for sample item "S."


30
14
13
12
11
9
7
5
3
1
10
8
6
4
2


18
15
19
20
21
16
17

FAMILIARITY WITH EQUIPMENT
SG-1b)

QUESTIONS PART II

_____1. Main Switch

_____2. STC Control

_____3. Driver Current Meter

_____4. Dial light Intensity Control

_____5. Range Step Switch

_____6. Expanded Sweep Switch

_____7. Overload Reset

_____8. Line Current Meter

_____9. Signals/Markers Switch

_____10. Bearing Control Crank

_____11. Standby/On Switch

_____12. Oscillations Indicator

_____13. Range Crank

_____14. Receiver Gain

_____15. Range Scope Astigmatism Control

_____16. Local Oscillator Tuning

_____17. IAVC Control

_____18. Transmitter Battle-Short Switch

_____19. Radiation Switch

_____20. Transmitter Power Variac

NAME _____

# APPENDIX D

## KNOWLEDGE OF ELECTRONICS
(Part I and Part II)

Part I of this test consists of twelve pages of questions, plus an answer sheet. Part II consists of four pages of questions, plus an answer sheet.

# KNOWLEDGE OF ELECTRONICS

DIRECTIONS: This is a test of your knowledge of electronics. The questions all involve basic circuits and knowledge. You will find that some of the questions are very easy and most likely some will be quite difficult. It has been intended to ask questions over any of the material you have studied in ET School. This test is in TWO parts. DO NOT MAKE ANY MARKS OF ANY KIND ON THE QUESTION SHEETS.

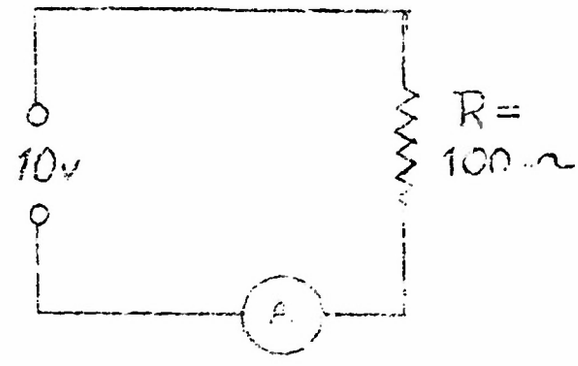
## PART I

In Part I each question is provided with 5 possible answers or choices. You are to choose the answer that you believe to be the most correct and fill in the space under its letter on the separate answer sheet. The fifth choice or answer for each question reads "no correct answer given". This choice should be used when you believe that none of the first four choices correctly answer the question that has been asked. Please attempt to answer every question. Two sample questions for Part I are shown below.

PLEASE READ EACH QUESTION CAREFULLY

EXAMPLE M

Given the circuit at the right, what is the amount of current flowing through the circuit?




(a) 10 amp
(b) 1 amp
(c) 0.1 amp
(d) .01 amp
(e) no correct answer given

EXAMPLE N

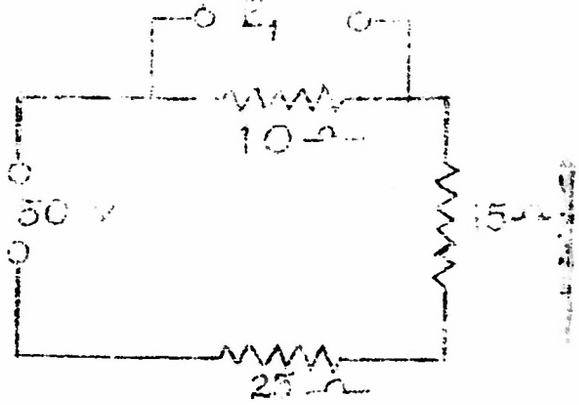
What kind of component is represented by the symbol L-137?

(a) a relay
(b) a motor
(c) a resistor
(d) a capacitor
(e) no correct answer given

M. (a)(b)(c)(d)(e)

N. (a)(b)(c)(d)(e)

1. In the accompanying circuit, what is the value of $E_1$?




(a) 10 volts
(b) 15 volts
(c) 16.67 volts
(d) 25 volts
(e) no correct answer given

2. A class "C" amplifier is one which:

(a) is biased well above cutoff
(b) is biased at cutoff
(c) is biased below cutoff
(d) is biased at zero
(e) no correct answer given

3. In a F.M. receiver, what is the purpose of the limiter stage which usually preceeds the detector circuit?

(a) the limiter stage eliminates all signals except the carrier frequency of the station to which the receiver is tuned
(b) the limiter stage eliminates the presence of any amplitude modulation the carrier may have acquired between the transmitter and the limiter stage
(c) the limiter is primarily to attenuate the signal to prevent blasting in the case of very strong signals
(d) the limiter is used to limit phase modulation
(e) no correct answer given

4. Given a transformer with unity coupling. The input voltage is 440 volts. The primary winding has 5280 turns. The secondary has 2760 turns. Ignoring losses, what would be the output voltage?

(a) 220 volts
(b) 230 volts
(c) 760 volts
(d) 880 volts
(e) no correct answer given

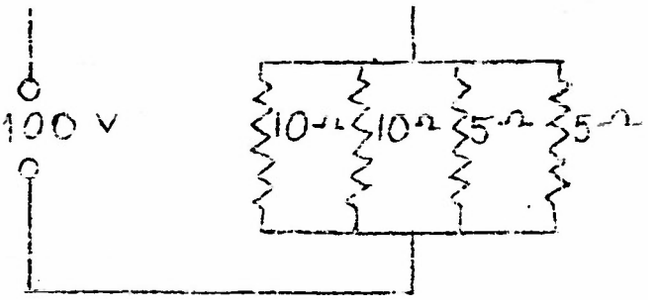
5. The spot intensity produced in a cathode ray tube can be increased by

(a) decreasing the second anode voltage
(b) decreasing the bias voltage applied to the grid
(c) increasing the voltage applied to the vertical deflection plates
(d) applying a higher positive voltage to the cathode of the tube
(e) no correct answer given

6. Given a 40 mh coil and a 9 uf capacitor, at what frequency will they resonate?

(a) 1.989 kc
(b) 3.979 kc
(c) 3.6 kc
(d) they will not resonate at any frequency
(e) no correct answer given

7. Given the accompanying circuit, what is the total resistance?

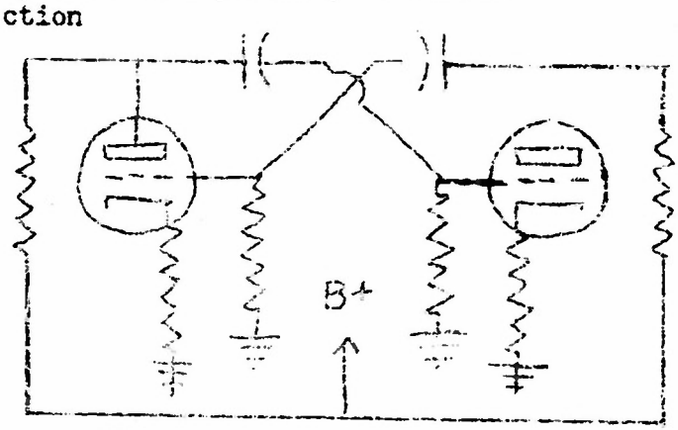



(a) 1.67 ohms
(b) 3.75 ohms
(c) 7.5 ohms
(d) 30 ohms
(e) no correct answer given

8. In alternating current circuits:

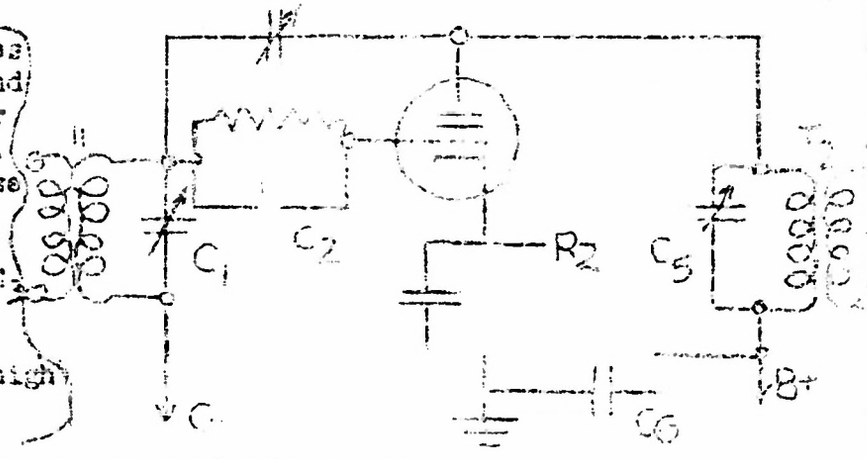
(a) the current is constantly changing value
(b) the voltage is constantly changing value
(c) the voltage remains constant, but the current changes both its value and direction
(d) the voltage is periodically changing value and polarity while the current is changing value and direction
(e) no correct answer given

9. What kind of circuit is shown at the right?




(a) an Eccles-Jordan multivibrator
(b) a free-running multivibrator
(c) an electron coupled multivibrator
(d) a plate-coupled, one-shot multivibrator
(e) no correct answer given

10. The circuit at the right goes into sporadic oscillation and continues to oscillate after the input signal is removed. What is the most likely cause of the trouble?




(a) improper adjustment of $C_1$
(b) shorted $C_6$
(c) open primary of $T_2$
(d) C minus voltage is too high
(e) no correct answer given

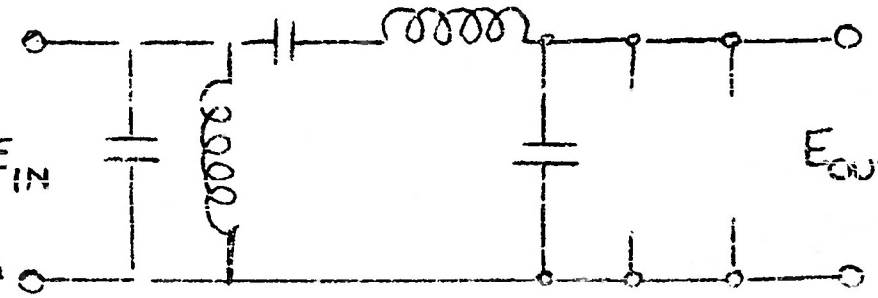
11. Why is the VTVM the most accurate type of voltmeter?

(a) the output impedance of the vacuum tube is so great that a small change in input creates a great change in the output
(b) the meter movement is much more sensitive than those used by other types of meters
(c) it has a high internal resistance which lowers the shunting effect of the voltmeter
(d) the VTVM makes use of more ranges so that you can choose a range that will give you a center scale reading
(e) no correct answer given

12. Given an inductance of 0.4 mh. and a frequency of 100 kc., find the inductive reactance.

(a) 40 ohms
(b) 125.664 ohms
(c) 150.797 ohms
(d) 251.328 ohms
(e) no correct answer given

13. What type of circuit is represented at the right?

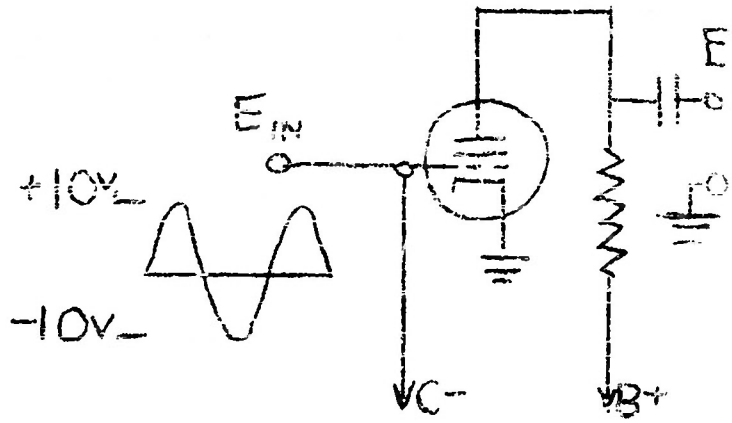



(a) a band-pass filter
(b) a low-pass filter
(c) a hi-pass filter
(d) a band-reject filter
(e) no correct answer given

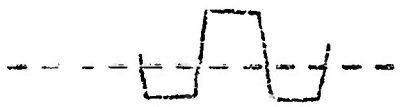
14. Given a capacitor of 0.5 uf. and a frequency of 5 kc., what would be the capacitive reactance?

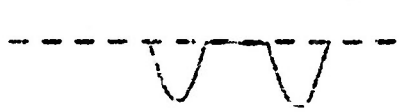
(a) .016 ohms
(b) .064 ohms
(c) 15.71 ohms
(d) 63.66 ohms
(e) no correct answer given

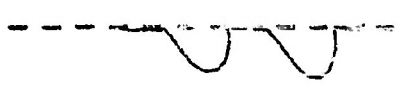
15. With the circuit at the right which is biased just below cutoff, what would be the output waveform?




(a) 

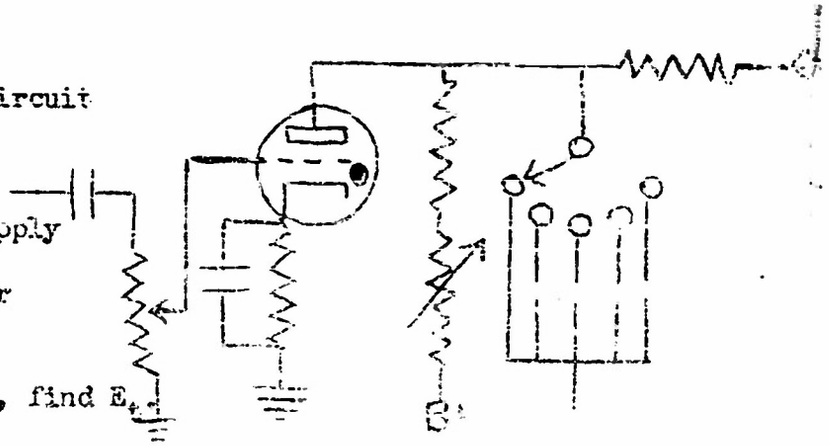
(b) 

(c) 

(d) 

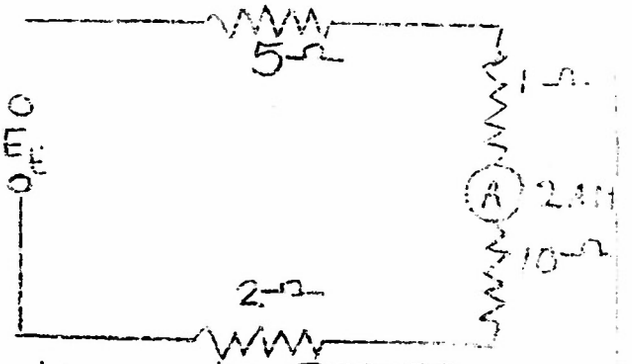
(e) NO CORRECT WAVEFORM SHOWN

16. Where might the accompanying circuit be used?



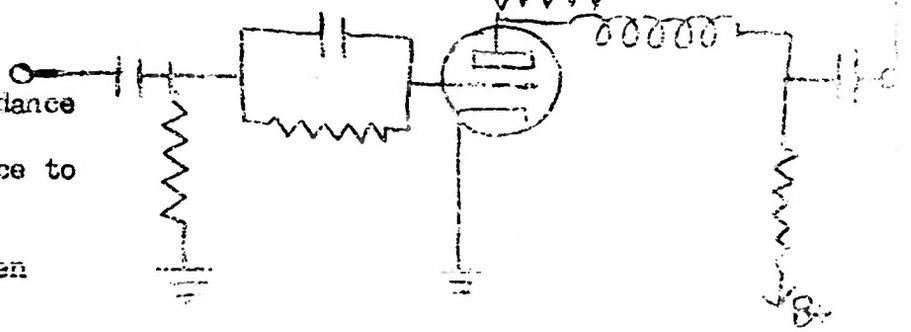
(a) test oscilloscope
(b) voltage regulated power supply
(c) random noise generator
(d) super-regenerative receiver
(e) no correct answer given

17. Given the circuit at the right, find $E_{out}$



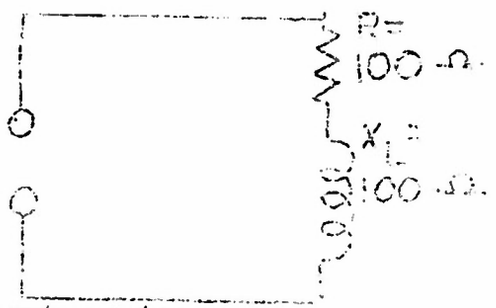

(a) 9 volts
(b) 36 volts
(c) 72 volts
(d) 90 volts
(e) no correct answer given

18. What is the purpose of the coil in the circuit at the right?




(a) to eliminate phase shift
(b) to act as a high impedance to audio frequencies
(c) to act as low impedance to RF frequencies
(d) to act as an RF choke
(e) no correct answer given

19. Given the circuit at the right, find the impedance of the circuit.

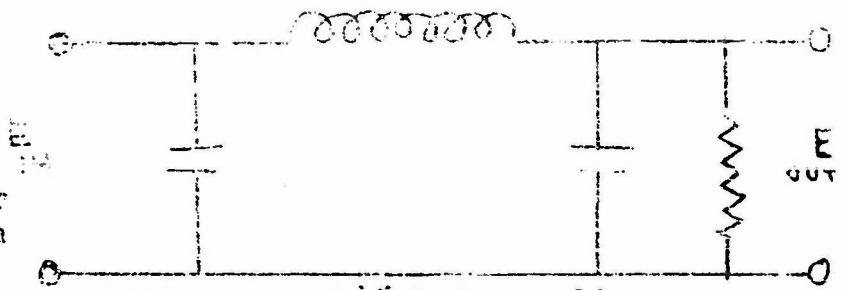



(a) 70.7 ohms at an angle of 45°
(b) 141.4 ohms at an angle of 45°
(c) 141.4 ohms at an angle of -45°
(d) 200 ohms at an angle of 90°
(e) no correct answer given

20. Decreasing the negative bias on a sawtooth generator using a gas triode (thyratron) will have what effect?

(a) decrease the output frequency
(b) increase the output frequency
(c) increase the amplitude of the output
(d) have no effect on the output
(e) no correct answer given

21. What type of circuit is represented at the right?

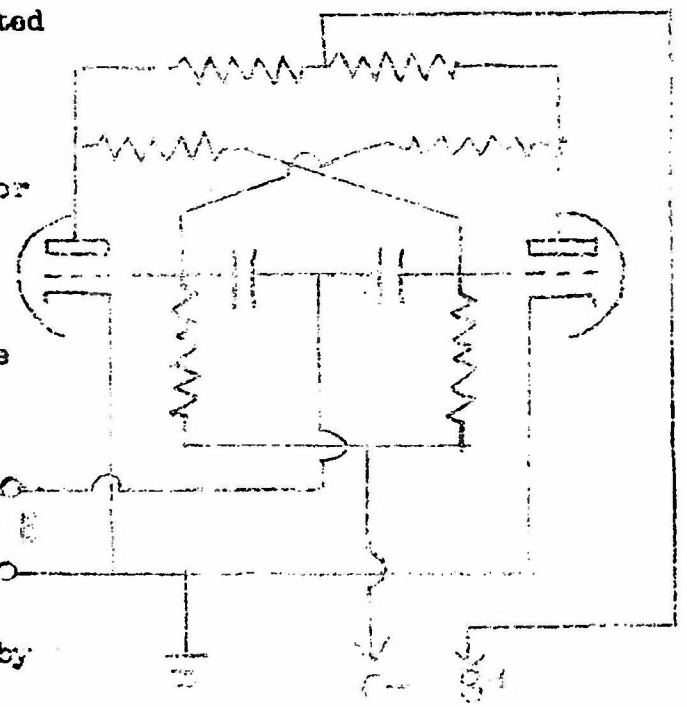


(a) a band-pass filter
(b) a low-pass filter
(c) a hi-pass filter
(d) a band-rejection filter
(e) no correct answer given

22. A potential of 15 volts across a resistance of 45 K-ohms would cause how many amperes of current to flow?

(a) .112 amp.
(b) .333 amp.
(c) .675 amp.
(d) 3.00 amp.
(e) no correct answer given

23. What type of circuit is represented at the right?

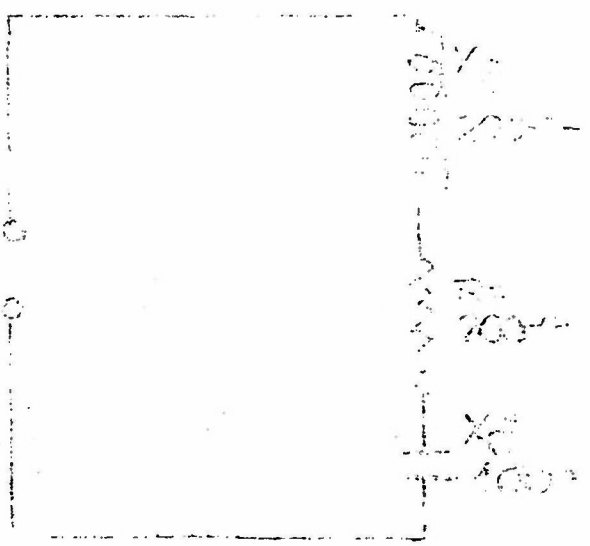


(a) a free-running multivibrator
(b) a self-pulsing oscillator
(c) an Eccles-Jordan multivibrator
(d) a single-swing blocking oscillator
(e) no correct answer given

24. The most important fact about the circuit shown in problem 23 is that:

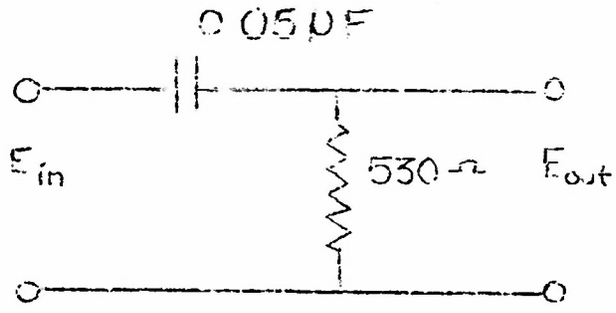
(a) it will not work
(b) it gives one cycle of output for each trigger pulse
(c) it will operate only with a positive trigger
(d) it can be synchronized only by a string of negative pulses
(e) no correct answer given

25. Given the circuit at the right, find the total impedance.



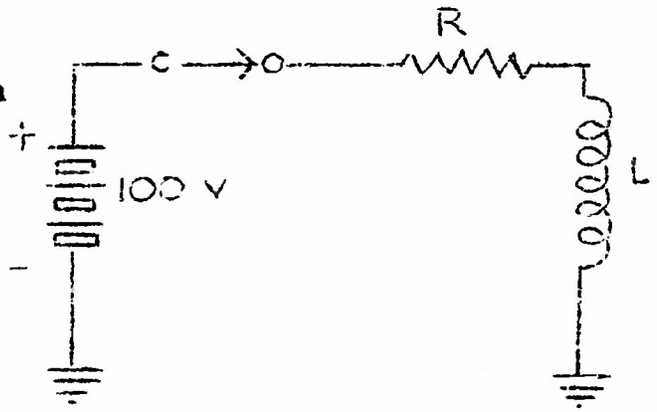
(a) 200 ohms at an angle of -90°
(b) 282.9 ohms at an angle of -45°
(c) 283 ohms at an angle of -50°
(d) 500 ohms at an angle of -56°
(e) no correct answer given

26. If a 60 cycle sine wave were applied to the circuit at the right, what would be the output?



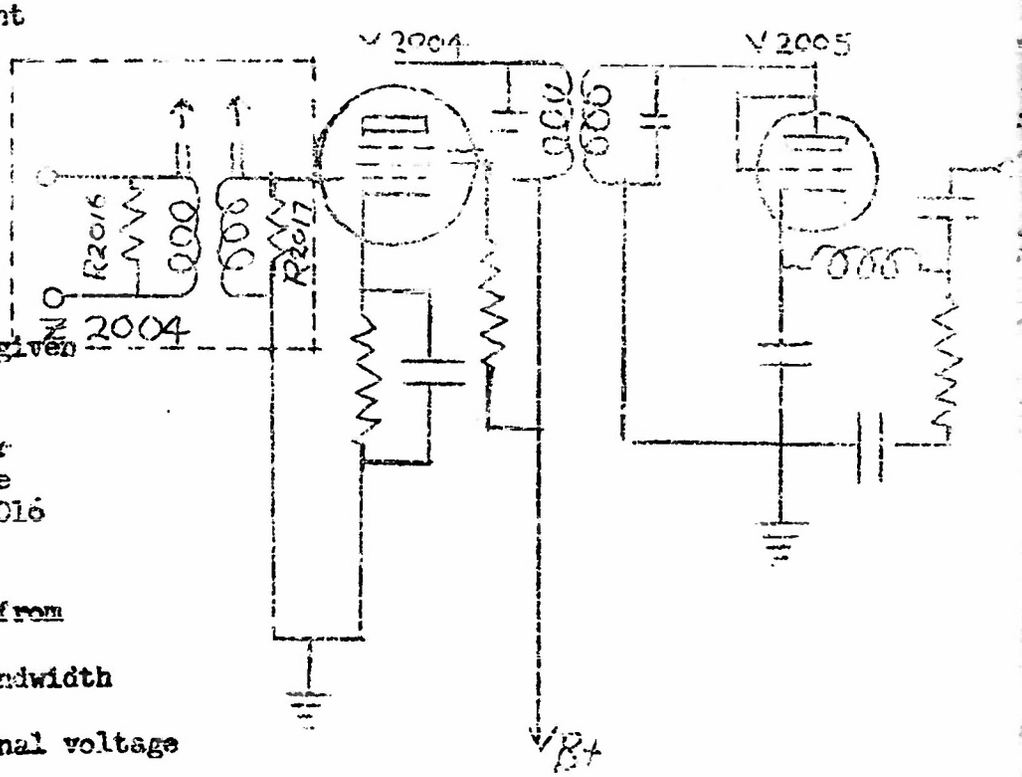

(a) a series of sharp voltage spikes
(b) a slightly distorted square wave
(c) a sine wave out of phase with the input
(d) a very highly distorted sine wave
(e) no correct answer given

27. In the circuit shown at the right, at one L/R time after the application of the battery voltage, what will be the voltage across R?




(a) 9 volts
(b) 37 volts
(c) 63 volts
(d) 91 volts
(e) no correct answer given

28. The circuit at the right is used in a radar receiver. What is the purpose of the stage containing V-2004?

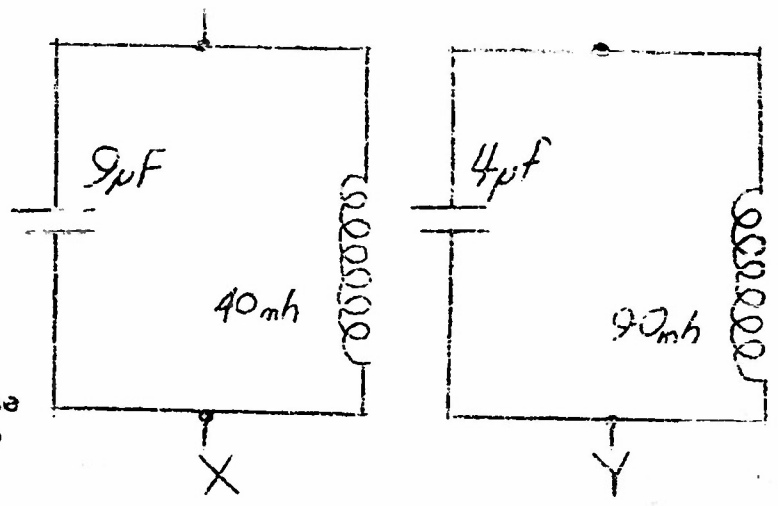



(a) audio IF amplifier
(b) video limiter
(c) video IF amplifier
(d) audio detector
(e) no correct answer given

29. In the circuit used for problem 28, what is the primary purpose of R-2016 and R-2017?

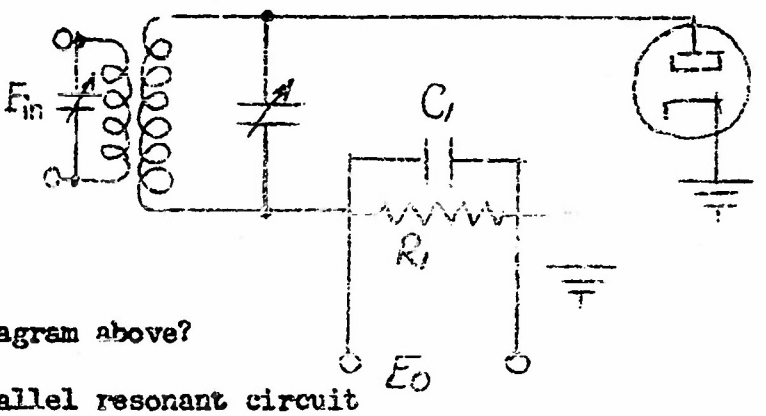
(a) to prevent V-2004 from oscillating
(b) to decrease the bandwidth of Z-2004
(c) to develop the signal voltage for V-2004
(d) to act as a plate load for the preceding stage
(e) no correct answer given

30. Given the two tank circuits at the right, which are resonant at the same frequency:




(a) X would be preferred for most applications
(b) Y would be preferred for most applications
(c) neither X nor Y would be practical due to the high inductance
(d) there would be no difference in the operation of the two circuits
(e) no correct answer given

31. What type of circuit is represented by the diagram at the right?

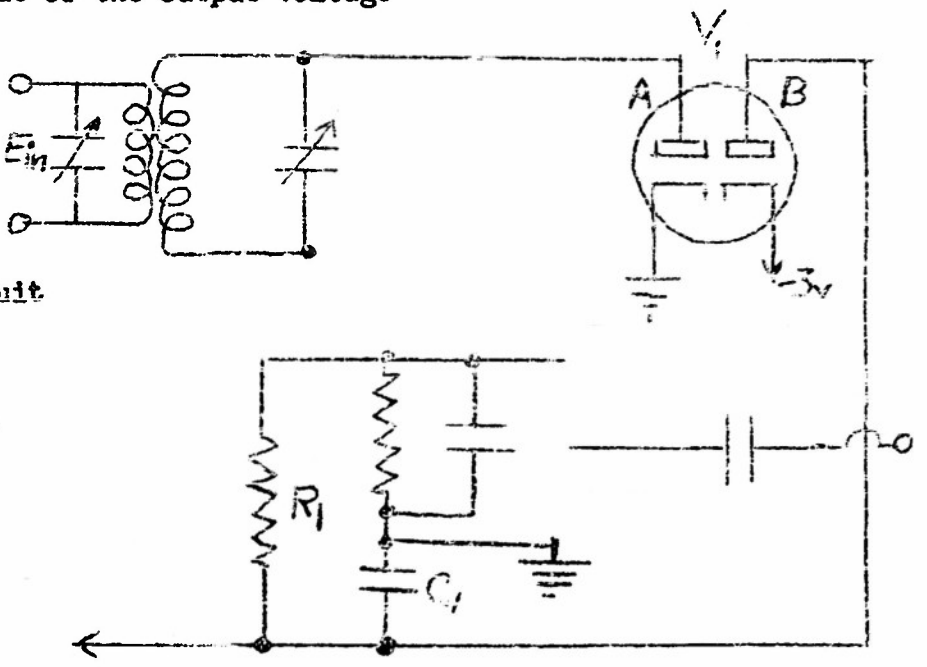



(a) a positive limiter
(b) a Foster-Seeley discriminator
(c) a diode detector
(d) a negative clamper
(e) no correct answer given

32. What is the purpose of $C_1$ in the diagram above?

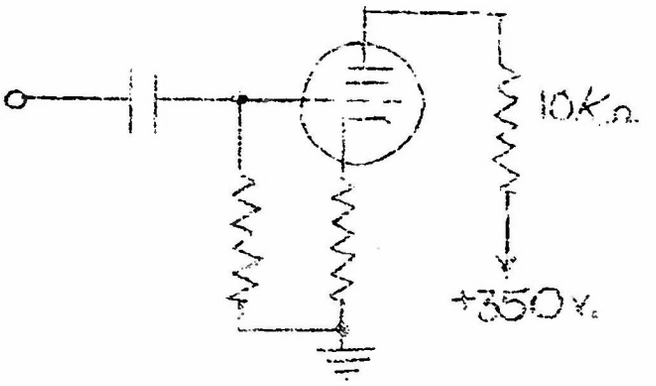
(a) to act with $R_1$ in forming a parallel resonant circuit
(b) to develop a phase shift for a discrimination-integration network
(c) to maintain a constant positive reference voltage for the following stage
(d) to filter 60 cycle hum out of the output voltage
(e) no correct answer given

33. In the circuit at the right, what is the purpose of the network composed of $R_1$, $C_1$ and V-1B?



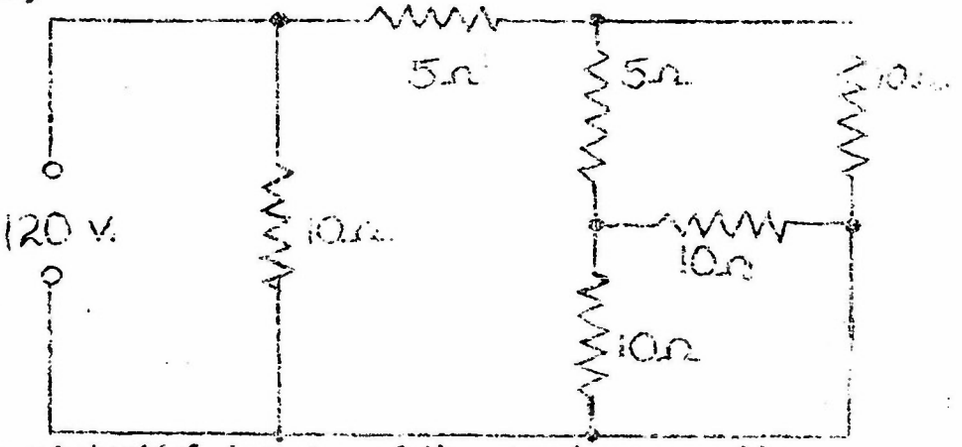

(a) time variation gain circuit
(b) simple automatic volume control
(c) separate audio channel
(d) delayed automatic volume control
(e) no correct answer given

34. In the accompanying circuit, $I_p$ varies from 6ma to 10ma. What will be the variation of $E_p$ during this period?




(a) 100 to 60 volts
(b) 250 to 290 volts
(c) 290 to 250 volts
(d) 60 to 100 volts
(e) no correct answer given

35. Given the accompanying circuit, find $R_{total}$?

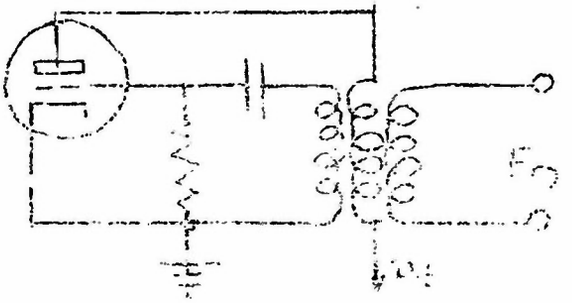



(a) 5 ohms
(b) 5.24 ohms
(c) 6 ohms
(d) 6.55 ohms
(e) no correct answer given

36. What would be the effect of a substantial decrease of the magnetron magnetic field?

(a) the plate current would decrease
(b) the frequency of the output would increase
(c) the plate current will increase
(d) a slight increase in the tuning range of the magnetron will occur
(e) no correct answer given

37. What type circuit is shown at the right?



(a) Hartley oscillator
(b) electron coupled oscillator
(c) Colpitts oscillator
(d) blocking oscillator
(e) no correct answer given

38. It is desired to double the frequency of a symmetrical output, plate-coupled, free-running multivibrator without sacrificing the symmetrical output. How may this be accomplished?

(a) double the value of both coupling capacitors
(b) double the value of one coupling capacitor
(c) halve the value of both coupling capacitors
(d) halve the value of one coupling capacitor
(e) no correct answer given

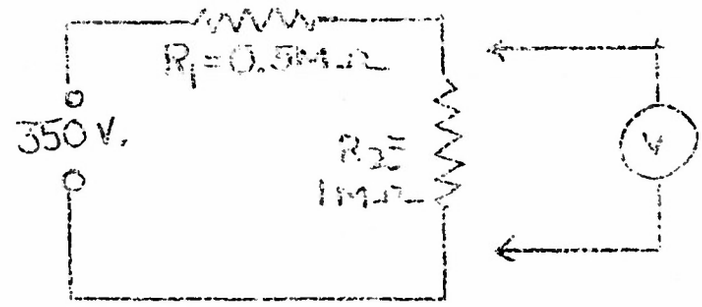
39. A jittery, erratic sweep on an indicator 'scope is normally an indication of which of the following possible troubles?

(a) defective clamping in the sweep amplifier
(b) insufficient limiting
(c) varying gain
(d) unstable B plus or line voltage
(e) no correct answer given

40. Cathode followers have what important characteristic?

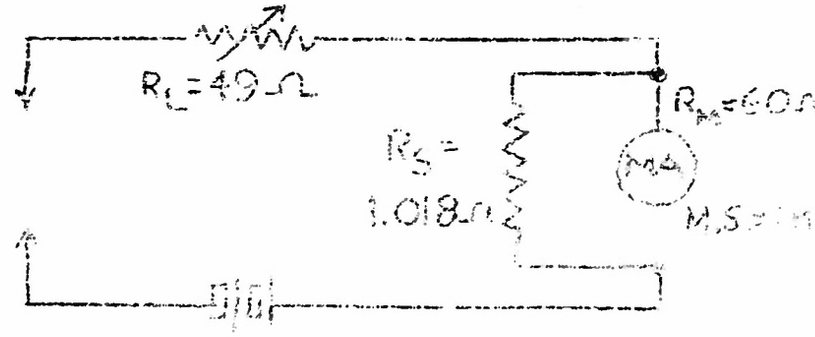
(a) high voltage gain
(b) 180° phase shift
(c) high power gain
(d) no power gain
(e) no correct answer given

41. In the accompanying circuit, if a 2000 ohm/volt voltmeter with a full/scale reading of 500 volts were placed across $R_2$ what would be the voltage reading?



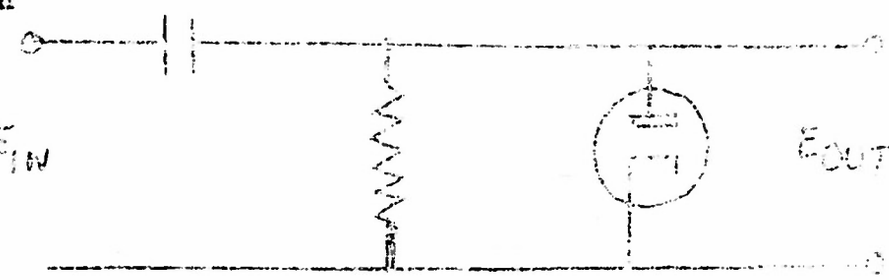

(a) 117 volts
(b) 111 volts
(c) 175 volts
(d) 294 volts
(e) no correct answer given

42. Given the ohmmeter circuit at the right, what would be the mid-scale reading of the meter?



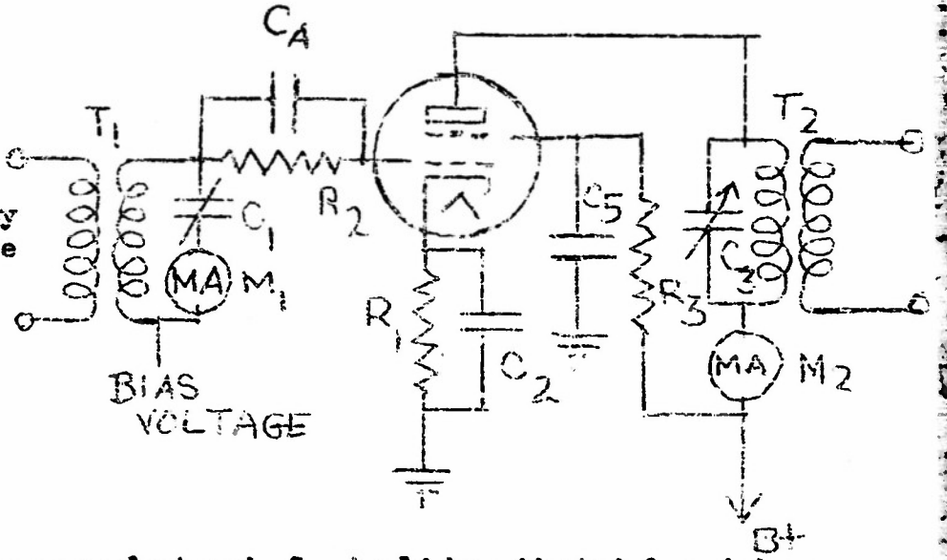

(a) 1 ohm
(b) 50 ohms
(c) 60 ohms
(d) 100 ohms
(e) no correct answer given

43. What type of circuit is shown at the right?




(a) positive limiter
(b) positive clamper
(c) negative clamper
(d) negative limiter
(e) no correct answer given

44. The circuit at the right represents an intermediate stage in a transmitter. Which one of the following statements is true?




(a) if the input frequency is correct, $C_1$ must be tuned for minimum reading on $M_1$

(b) if the grid tank is properly tuned, $C_2$ should be adjusted for maximum reading on $M_2$

(c) if the grid circuit is properly tuned, $C_3$ should be adjusted for minimum reading on $M_2$

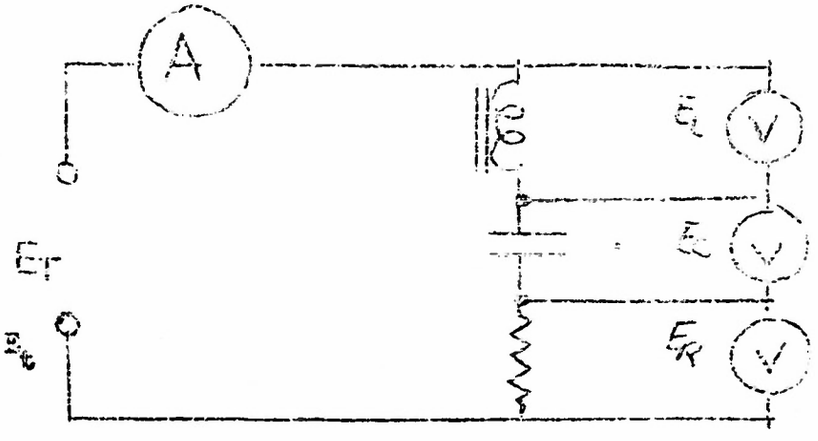
(d) if the input frequency is correct, $C_1$ should be tuned for zero reading on $M_1$

(e) no correct answer given

45. Using the same circuit shown for problem number 44, operation is normal for a short period after equipment is turned on, then failure occurs. $M_1$ indicates normal input and $M_2$ indicates no output. A new tube does not remedy the trouble. What is the most likely cause of the trouble?

(a) shorted $C_4$
(b) open secondary of $t_1$
(c) shorted $C_5$
(d) open $R_3$
(e) no correct answer given

46. Using the circuit shown at the right, which of the following would be true at the resonant frequency?

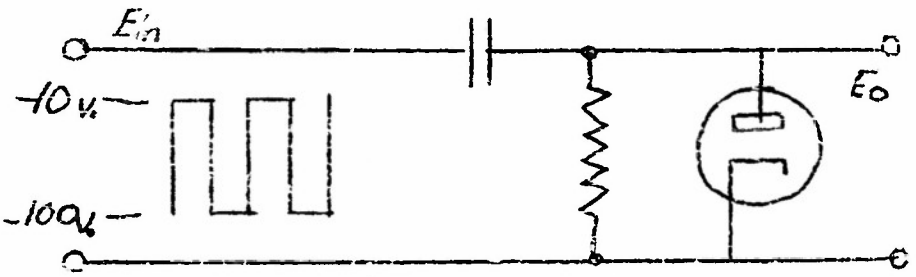


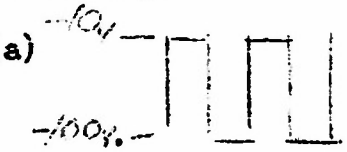

(a) $E_C$ equals $E_R$
(b) $E_R$ equals $E_t$
(c) I equals zero and $E_L$ equals $E_t$
(d) $E_L$ equals $E_t$
(e) no correct answer given

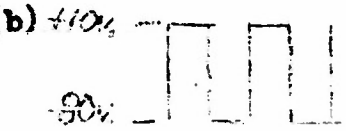
47. A differentiator circuit has a capacity of o.l mfd. and a resistance of 10 K-ohms. If the time of one laternation of the input signal is 1000 micro seconds, the time constant of the circuit is considered to be:

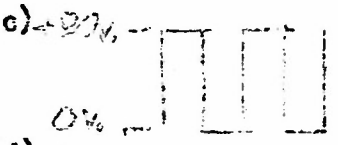
(a) long
(b) very short
(c) very long
(d) medium
(e) no correct answer given

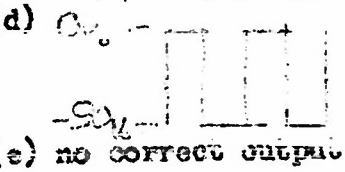
48. Which output would be correct for the circuit that is shown at the right?




(a) 


(b) 


(c) 

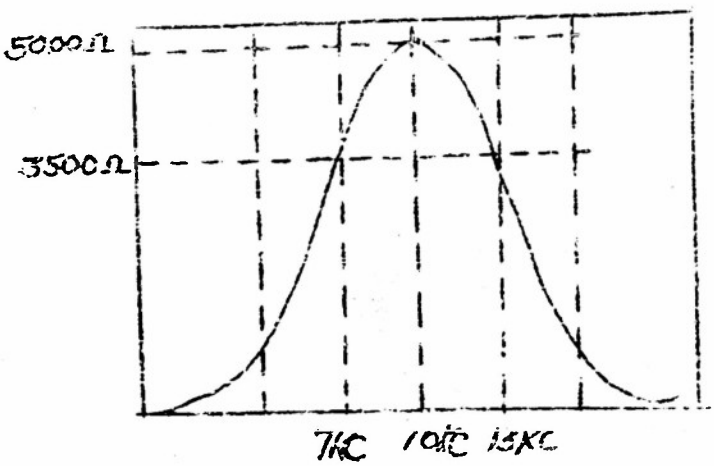

(d) 


(e) no correct output given

49. What determines the frequency of a magnetron oscillator?

(a) the resonant frequency of the LC components in the grid circuit
(b) ionizing potential
(c) voltage between plate and ground
(d) the potential between cathode and ground
(e) no correct answer given

50. The diagram at the right represents the impedance curve of a tuned circuit. Which of these statements is true?




(a) the bandwidth of the circuit must be less than 2 kc.
(b) 7 kc. falls within the bandwidth frequencies of the circuit
(c) 13 kc. falls above the bandwidth frequencies of the circuit
(d) the bandwidth of the circuit is at lease 6 kc.
(e) no correct answer given

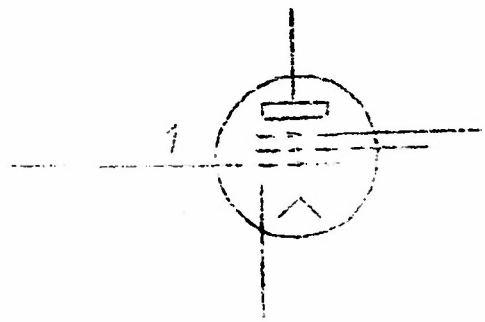
KNOWLEDGE OF ELECTRONICS PART I

| | a | b | c | d | e |
|---|---|---|---|---|---|
| 1. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 2. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 3. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 4. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 5. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 6. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 7. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 8. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 9. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 10. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 11. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 12. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 13. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 14. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 15. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 16. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 17. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 18. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 19. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 20. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 21. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 22. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 23. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 24. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 25. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 26. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 27. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 28. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 29. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 30. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 31. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 32. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 33. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 34. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 35. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 36. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 37. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 38. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 39. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 40. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 41. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 42. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 43. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 44. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 45. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 46. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 47. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 48. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 49. | ( ) | ( ) | ( ) | ( ) | ( ) |
| 50. | ( ) | ( ) | ( ) | ( ) | ( ) |

NAME _____

KNOWLEDGE OF ELECTRONICS
PART II

In Part II, there are three circuits. Each circuit is accompanied by 15 statements about the circuit. You are to decide whether the statements are true or false. Indicate your choice by filling in the space under T or F on the separate answer sheet. Please attempt to answer every question but DO NOT make WILD Guesses. A question that is part true and part false should be marked false. Two sample questions are shown below.




SAMPLE CIRCUIT

QUESTIONS

P. The vacuum tube shown above is a pentode.

Q. The element marked "1" is the plate.

SAMPLE OF THE ANSWER SHEET

P. ( T ) ( F )

Q. ( T ) ( F )

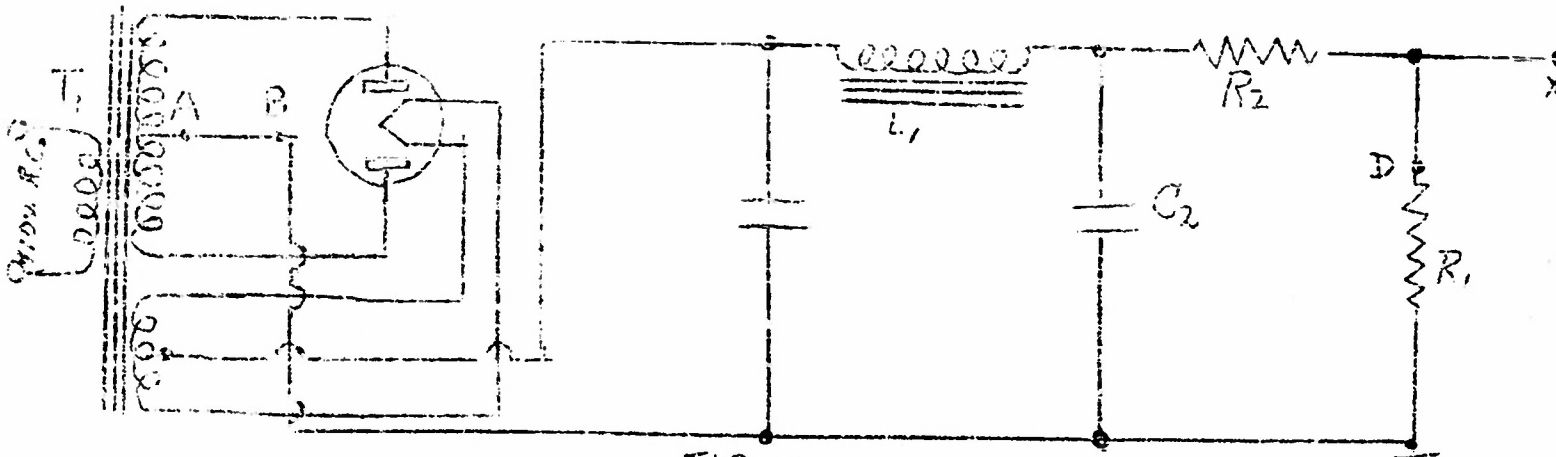



FIG. 1

1. $R_1$ prevents the power supply from being overloaded.
2. $R_1$ increases the current rating of the power supply.
3. $R_1$ decreases the available output voltage at point X.
4. $R_2$ is primarily a safety device for the power supply.
5. If $R_1$ were open, the circuit would continue to operate.
6. The purpose of $R_1$ is to discharge $C_1$ and $C_2$ after the power is turned off.
7. Point A on the secondary of $T_1$, alternates at potentials above and below ground.
8. If $C_1$ were open, excessive hum would be noticed as well as increased voltage at point X.
9. If $R_2$ were shorted, most likely the rectifier would burn out.
10. After the power is turned on, the negative side of $R_1$ is at point B.
11. The circuit shown in figure 1 is a full wave rectifier with a condenser input filter.
12. Condenser $C_1$ charges every half cycle.
13. The electron flow is from B to A at the transformer secondary.
14. The filtering system that is used in figure 1 would be satisfactory for use as a power supply for a master oscillator.
15. If the output of the above power supply is much lower than normal, the vacuum tube is most likely at fault.

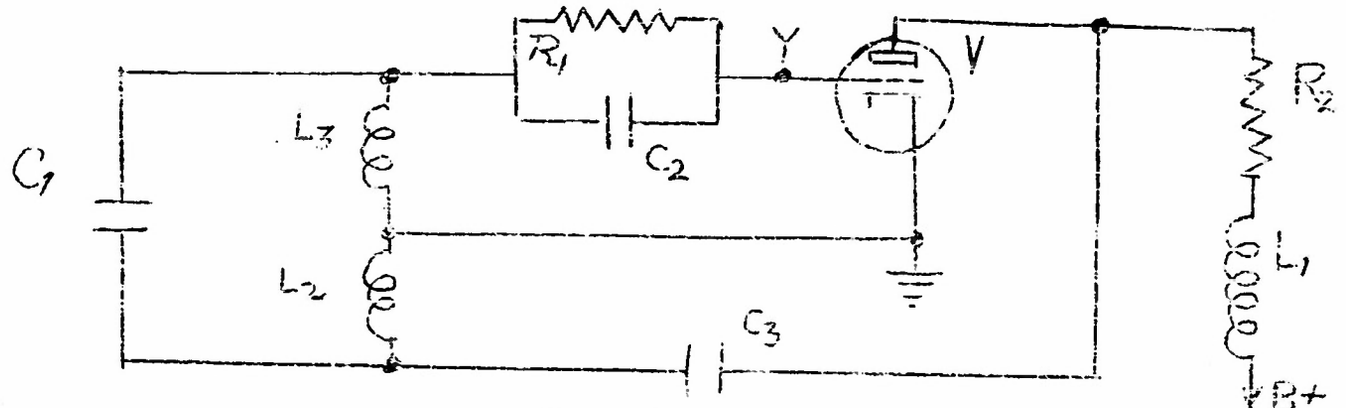



FIG. 2

16. The circuit shown in figure 2 is a Colpitt's oscillator.

17. The circuit shown in figure 2 is self-biased.

18. If the circuit in figure 2 is to operate properly $V_1$ must operate on the lower portion of the Eg-Ip curve.

19. $R_1$ would be called a series grid leak.

20. $C_2$ acts as a D. C. block.

21. As the circuit is drawn in figure 2, $R_2$ serves the same purpose as $L_1$ and therefore one or the other could be removed and the circuit would continue to operate.

22. When a vacuum tube is used as in the above circuit, its action is really that of rectification.

23. The grid is driven positive and beyond cut-off with each alternation.

24. When operating, the circuit in figure 2 normally operates class $AB_2$.

25. The circuit in figure 2 could be used as a master oscillator in a communications transmitter.

26. With the circuit in figure 2, an increase of plate voltage is accompanied by a decrease in plate current, providing B/ remains constant.

27. In figure 2, the purpose of $C_2$ is both that of coupling and blocking.

28. The components $C_3$ and $L_2$ compose part of a feedback network in figure 2.

29. A practical check which may be used to determine if the circuit in figure 2 is operating is to measure the D.C. voltage at point Y.

30. The circuit in figure 2 will not oscillate unless the B/ supply is well regulated.

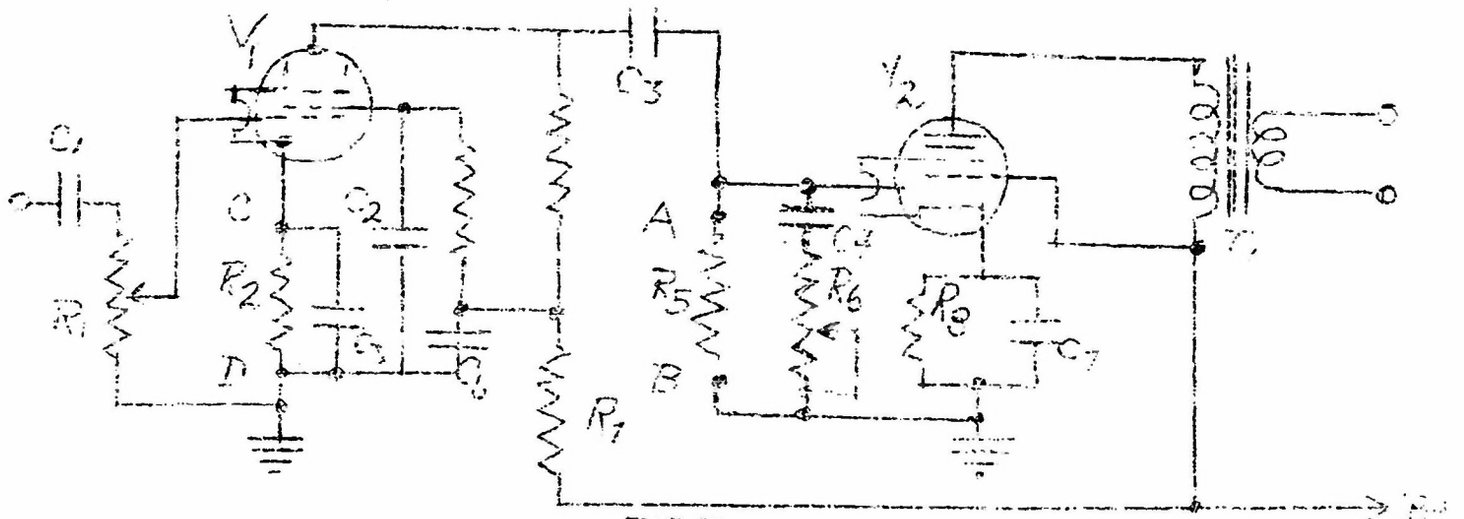



FIG 3

31. The stage $V_1$ is primarily a voltage amplifier and should operate so that plate current flows during the entire input cycle.

32. If fidelity is to be maintained, $V_2$, the power amplifier, must be operated as a class 'A' amplifier.

33. Contact bias has been employed for stage $V_1$.

34. A good tube choice for $V_1$ would be a sharp cut-off pentode.

35. The gain of the circuit in figure 3 would be increased by the removal of $C_7$ but with a resulting increase in distortion.

36. The type of coupling used between $V_1$ and $V_2$ is desirable because of the relatively good frequency response that is obtained at a fairly low production cost.

37. The color code on $R_2$ is; orange, brown, silver. If the resistor is within specified tolerance it will measure between 297 and 363 ohms.

38. If $R_2$ were one megohm, and no signal were applied, $V_1$ would most likely be biased below cut-off.

39. Through $R_5$ the electrons will always flow in one direction and the direction will be from A to B.

40. If $C_8$ were open, the IR drop across $R_2$ would vary in phase with the signal.

41. If the control arm of $R_7$ were set at the extreme top, the high frequency response would be attenuated.

42. If $R_3$ were to open, operation of $V_1$ would continue for a short period, then cease.

43. Increasing the value of $C_7$ would actually increase the high frequency response.

44. The purpose of $R_{4}$, in figure 3, is to offer a high impedance across which the input signal will appear.

45. $C_6$ prevents $V_1$ and $V_2$ from having a common plate circuit impedance.

KNOWLEDGE OF ELECTRONICS PART II

| | | |
|---|---|---|
| 1. (T) (F) | 16. (T) (F) | 31. (T) (F) |
| 2. (T) (F) | 17. (T) (F) | 32. (T) (F) |
| 3. (T) (F) | 18. (T) (F) | 33. (T) (F) |
| 4. (T) (F) | 19. (T) (F) | 34. (T) (F) |
| 5. (T) (F) | 20. (T) (F) | 35. (T) (F) |
| 6. (T) (F) | 21. (T) (F) | 36. (T) (F) |
| 7. (T) (F) | 22. (T) (F) | 37. (T) (F) |
| 8. (T) (F) | 23. (T) (F) | 38. (T) (F) |
| 9. (T) (F) | 24. (T) (F) | 39. (T) (F) |
| 10. (T) (F) | 25. (T) (F) | 40. (T) (F) |
| 11. (T) (F) | 26. (T) (F) | 41. (T) (F) |
| 12. (T) (F) | 27. (T) (F) | 42. (T) (F) |
| 13. (T) (F) | 28. (T) (F) | 43. (T) (F) |
| 14. (T) (F) | 29. (T) (F) | 44. (T) (F) |
| 15. (T) (F) | 30 (T) (F) | 45. (T) (F) |

NAME_____

KNOWLEDGE OF ELECTRONICS PART II

| | | |
|---|---|---|
| 1. (T) (F) | 16. (T) (F) | 31. (T) (F) |
| 2. (T) (F) | 17. (T) (F) | 32. (T) (F) |
| 3. (T) (F) | 18. (T) (F) | 33. (T) (F) |
| 4. (T) (F) | 19. (T) (F) | 34. (T) (F) |
| 5. (T) (F) | 20. (T) (F) | 35. (T) (F) |
| 6. (T) (F) | 21. (T) (F) | 36. (T) (F) |
| 7. (T) (F) | 22. (T) (F) | 37. (T) (F) |
| 8. (T) (F) | 23. (T) (F) | 38. (T) (F) |
| 9. (T) (F) | 24. (T) (F) | 39. (T) (F) |
| 10. (T) (F) | 25. (T) (F) | 40. (T) (F) |
| 11. (T) (F) | 26. (T) (F) | 41. (T) (F) |
| 12. (T) (F) | 27. (T) (F) | 42. (T) (F) |
| 13. (T) (F) | 28. (T) (F) | 43. (T) (F) |
| 14. (T) (F) | 29. (T) (F) | 44. (T) (F) |
| 15. (T) (F) | 30 (T) (F) | 45. (T) (F) |

NAME _____

# APPENDIX E

## PERSONAL DATA SHEET AND SCHEDULING AT TREASURE ISLAND

The personal data sheet was filled out by each man taking tests at Treasure Island.

The information scheduling includes the original request for testing time, and the final testing schedule.

NAME _____

1. Did you come to this school from recruit training or from a ship or other duty station? (specify which)

Recruit training _____

Ship _____ (what kind) _____

Other duty station _____ (where) _____

2. If you did not come to this station directly from recruit training, what duties have you performed in the Navy and for how long?

| DUTIES | LENGTH OF TIME |
|---|---|
| | |
| | |
| | |
| | |
| | |

3. What jobs have you held in civilian life? (list them)

| | |
|---|---|
| | |
| | |
| | |

4. Have you ever worked with electronics equipment either in the Navy or civilian life?

YES _____ NO _____

5. If the answer to Question 4 is "yes" tell what equipment you have worked with and for approximately how long.

| EQUIPMENT | LENGTH OF TIME |
|---|---|
| | |
| | |
| | |
| | |
| | |

PROPOSED TESTING SCHEDULE
Contract No. N6 ori 07142
University of Illinois - Bureau of Naval Personnel
Testing to Begin on or about 1 May 1953

1. General Requirements for Subjects
   a. Minimum desirable number of subjects -- fifty (50)
   b. Schooling desired -- Graduation from Class "A" ET school, or at least completion of radar training in a Class "A" ET school.
   c. Naval experience desired -- No experience as an ET subsequent to graduation from a Class "A" ET school.
   d. Pay grade range desirable -- None above ET3.

2. General Requirements for Equipment and Space to be Available at the Testing Facility
   a. Radar sets needed -- A minimum of two (2) SG-1b sets in operating condition. Six (6) would be desirable.
   b. Room for administration of paper and pencil tests -- Space and desks or chairs with arms for testing one group at one time. For group size, see 3d below.

3. Schedule for Testing
   a. First Day

| | 0823 | 0830 | 1130 | 1130 | 1600 |
|---|---|---|---|---|---|
| Group Ia | SAMPLE ITEM | FIVE PERFORMANCE ITEMS | LUNCH | | FIVE PERFORMANCE ITEMS |
| Group IIa | SAMPLE ITEM | TEN TAB ITEMS | | | STANDARD TESTS |

   b. Second Day

| | | | | |
|---|---|---|---|---|
| Group IIa | SAMPLE ITEM | TEN TAB ITEMS | LUNCH | STANDARD TESTS |
| Group Ia | SAMPLE ITEM | FIVE PERFORMANCE ITEMS | | FIVE PERFORMANCE ITEMS |

   c. If group size is equal to twenty-five (25) or less, the above schedule will be repeated. That is, the schedule for the first day will be duplicated on the third day, fifth day, etc.; the schedule for the second day will be duplicated for the fourth day, sixth day, etc.
   d. Group size will be limited by the number of SG-1b radars available, and by the number of trained performance

test observers. One observer and one radar will be needed for each subject in a group. Two performance test observers will be supplied by the contractor. If more than two SG-1b radars are available, additional observers can be trained by the contractor from available Class "A" school radar instructors or other ETs with comparable experience on the SG-1b. This training for observers will require two (2) days full time preceding the start of testing.

e. Number of days of testing time will equal fifty (50) divided by group size.

f. No Navy -- supplied observer will be needed for more than two days plus the number of days of testing time.

g. No subject will be needed for more than two (2) consecutive days.

FINAL SCHEDULE FOR TESTING
CLASS A SCHOOL FOR ELECTRONICS TECHNICIANS
TREASURE ISLAND

| | | | |
|---|---|---|---|
| FIRST DAY | | | |
| | AM | Section A - Tab tests | Section B - Performance |
| | PM | Section A - Performance | Section B - Written Tests |
| SECOND DAY | | | |
| | AM | Section A - Performance | Section B - Tab Test |
| | PM | Section A - Written Tests | Section B - Performance |
| THIRD DAY | | | |
| | AM | Section C - Written Tests | Section D - Performance |
| | PM | Section C - Performance | Section D - Tab tests |
| FOURTH DAY | | | |
| | AM | Section C - Performance | Section D - Written Tests |
| | PM | Section C - Tab tests | Section D - Performance |
| FIFTH DAY | | | |
| | AM | Section E - Tab tests | Section F - Performance |
| | PM | Section E - Performance | Section F - Tab tests |
| SIXTH DAY | | | |
| | AM | Section E - Performance | Section F - Written Tests |
| | PM | Section E - Written Tests | Section F - Performance |
| SEVENTH DAY | | | |
| | AM | Section G - Tab tests | Section H - Performance |
| | PM | Section G - Performance | Section H - Written Tests |
| EIGHTH DAY | | | |
| | AM | Section G - Performance | Section H - Tab tests |
| | PM | Section G - Written tests | Section H - Performance |
| NINTH DAY | | | |
| | AM | Section I - Written tests | Section J - Performance |
| | PM | Section I - Performance | Section J - Tab tests |
| TENTH DAY | | | |
| | AM | Section I - Performance | Section J - Written |
| | PM | Section I - Tab tests | Section J - Performance |

Each section was originally scheduled for six men, but three men were unable to continue the tests, and dropped out, so that the total number of men tested completely was 57. Each section used a different sequence of performance and tab items.

# APPENDIX F

## OBSERVER SHEETS FOR PERFORMANCE TEST ITEMS

Forms similar to the first sheet included in this Appendix were prepared for each section of the SG-1b radar. These forms were used to record voltages, current drain, scope presentations, and similar sorts of information for each defective component which was used in performance and tab items.

The second sheet in this section was used by performance test observers to record the sequence of behavior by testees. The right hand column was used to record time started, time stopped, sequence number on which testee was working at 5, 10, 15, 20, 25, and 30 minutes after the beginning of the test, and the time at which the problem was solved.

The orientation discussion for students was given to each observer, during the observer training program, and was repeated for each new group of students.

| RANGE AND TRAIN INDICATOR | DEFECTIVE COMPONENT Values |
|---|---|
| Line Voltage | |
| Xmitter Power Out | |
| Rec. Tune | |
| Range Scope | |
| Sweep | |
| Grass | |
| Video | |
| Markers | |
| Expanded Sweep | |
| Range Step | |
| PPI Scope | |
| Sweep | |
| Rotation | |
| Video | |
| Markers | |
| Range Spot or Ring | |
| Modulation Generator | |
| Monitor Scope | |
| Receive Position | |
| Grass | |
| Video | |
| Sweep | |
| Markers | |
| Modulation Pulse | |
| Markers Position | |
| Signals Position | |
| Trigger | |
| Markers Position | |
| Signals Position | |
| Jack 303 | |
| Tuning Indic. | |
| Oscillation Indic. | |
| Xmitter Current | |
| Total DC drain | |
| Driver current | |
| Ring time | |
| Frequency Spec. | |
| Relative Power Out | |
| Frequency | |

NAME _____

PROBLEM NUMBER _____ SEQUENCE NUMBER _____

OBSERVER _____

TIME:
START _____

STOP _____

---

"A" SCOPE _____

"PPI" SCOPE _____

MONITOR SCOPE
RECEIVER _____

MOD. PULSE _____

TRIGGER _____

WALL LEVER SWITCH _____

MAIN SWITCH _____

STANDBY/ON SWITCH _____

EMERGENCY BATTLE SHORT _____

RADIATION _____

RADIATION POWER CONTROL _____

OVERLOAD RESET _____

TRANS/REC TUNE METER _____

REC.TUNE/NORMAL SWITCH _____

RECEIVER GAIN _____

RANGE SWITCH _____

SIGNALS/MARKERS SWITCH _____

TUNING INDICATOR METER _____

OSCILLATIONS IND. METER _____

LOOKS AT SET(GENERAL) _____

LOOKS AT SCHEMATIC/BLOCK _____

WAITS FOR EQUPT TO WARM UP _____

| | |
|---|---|
| 5 | |
| 10 | |
| 15 | |
| 20 | |
| 25 | |
| 30 | |

SOLVES PROBLEM

_____

_____ _____

_____ _____

_____ _____

_____ _____

DISCUSSION WITH STUDENT TEST SUBJECTS
CLASS A SCHOOL FOR ELECTRONICS TECHNICIANS, TREASURE ISLAND

"My name is Lyman Smith and this is Mr. Joseph Neata. We are representatives of the University of Illinois who are working under contract through the Bureau of Naval Personnel. The Navy is interested in learning more about the job of performance testing. They regard performance tests as important because among other things, they believe that performance tests are a fair way of judging how good or how poor a technician is at trouble shooting. We have developed a series of performance test items using the radar vehicle which you studied, SG-1b.

" At this point it is necessary that we study and investigate the test items themselves. Now, obviously, this is difficult unless some persons, in this case technicians, take the test. This points specifically to the reason why we are here at Treasure Island. As it happens, each of you has been selected as a part of the group that can help us by taking these tests. In general, we are asking two things of you. First, we would like you to take a series of performance test items on the SG-1b. Second, we would like you to take a number of other tests of the paper and pencil type. We think you will find these interesting. One of the paper and pencil tests is quite novel.

"Now let me emphasize that the grades you make on these tests will have absolutely no effect on: your grades in class, the duty to which you may be assigned after graduation, whether or not you participate in activities on the base, whether or not you get liberty or leave; in fact these tests will not be scored until some time after you have left this base. I cannot emphasize this point too strongly. We just want your best effort to do as well as you are capable of doing on each test.

"Since we will be giving these tests to a number of men, some of whom you will know, some others whom you may not know, we are asking that you do not discuss these tests or what you do during the next two days with anyone. This means at chow, in the barracks, on liberty -- in fact anywhere. I realize that I am asking a great deal of you by this request, but it is perhaps of greater significance than anything else I will say to you. If, for example, we get, not your individual responses, but rather responses that have been arrived at by some group decision, the information we get by giving these tests will be useless. The Bureau has invested a sizeable sum in terms of time and money for this study. By now nearly two man years have been invested in this project. This step, giving the tests, is about the final step. I think you can

easily see why it is [illegible] you do not reveal any of the activities of the [illegible] After the complete testing program is over [illegible] next (this) week, of course it will be perf[illegible] discuss the tests.

"Now as to the p[illegible] themselves. You should regard a test item as [illegible] operational situation. By this I mean, just [illegible] are the ET aboard a destroyer and the SG-[illegible] off the air. The OD calls the ET, you, and asks [illegible] it. Now we are asking that you do the same [illegible] laboratory that you would do aboard that destro[illegible] this and information, use test equipment, consu[illegible] schematics, or whatever you feel necessary. [illegible] pment is concerned, anything is available t[illegible] ment or need, with the exception of consult[illegible] rated ET will be wi[illegible] you as you attempt t[illegible] formance test items. will be there for tw[illegible] first job is to obser[illegible] and record the thing[illegible] do them. Notice that we are not asking the [illegible] judgments about what you have done, but rathe[illegible] check of what you do. recorder has been i[illegible] is silent as possible feel you will probe[illegible] there after a few m[illegible] If you need some ma[illegible] job of the obse[illegible] to get that materia[illegible]

"We are giving you a t[illegible] this by about to work on each item. We e[illegible] you will find so[illegible] lems easy and some others q[illegible] difficult. You may or may solve all problems, but ple[illegible] your best. One other t[illegible] there is a shorting bar aw[illegible] with each equipment. Ple[illegible] use it. We would like to h[illegible] many live ETs when we leave as we found when we came. [illegible] not use the shorting b[illegible] the observer will jog your m[illegible]. I think it pertinent to remind you that there are t[illegible] with extremely high vol[illegible] age, as well as others with [illegible] high voltage. There approximately 15,000 volts a[illegible] in the transmitter dram[illegible] Don't trust the drop bar to [illegible] protected you from danger[illegible] make sure you get the large [illegible] er and to be on the safe side, anything else inside. [illegible] her area of high voltage is the 6,000 and 2,000 vol[illegible] dies for the [illegible] on the range and train indic[illegible]

"We hope you find the [illegible] furthermore hope you enjoy [illegible] can be done quite easily in [illegible] should not be difficult.

"On the half days when [illegible] will take them in this room. [illegible] you will be working with the [illegible] spent in the laboratory.

"Now, what questions do [illegible] have?"