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**DEVELOPMENT OF  
A JOB SAMPLE TROUBLE-SHOOTING EXAMINATION**

**Series 1954 - Institute Report No. 1  
15 January 1954**

**Prepared for  
Office of Naval Research  
United States Navy  
Under  
Contract Number N8onr-69402**

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**INSTITUTE FOR RESEARCH IN HUMAN RELATIONS  
PHILADELPHIA**

THE DEVELOPMENT OF A JOB  
SAMPLE TROUBLE-SHOOTING EXAMINATION

Progress Report

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## ABSTRACT

This report describes the construction and content of a job sample trouble-shooting examination for aviation electricians. The job sample examination is based on the underlying processes followed by aviation electricians when they trouble-shoot on a piece of electrical apparatus. These underlying processes are:

1. Formulation of a series of hypotheses as to the cause of the malfunction.
2. Performance of actual electrical checks and equipment performance checks in order to substantiate or reject the hypotheses from (1) above.
3. Diagnosis of the cause of the malfunction from the information obtained from the electrical and equipment performance checks.
4. Performance of the actual work required to eliminate the cause of the discrepancy.

Four separate performance tests were developed, each of which measures the aviation electrician's achievement in one of these four areas. Since some of the skills involved in successfully completing the trouble-shooting battery are analogous to the skills involved in general electrical maintenance repair and replacement, it is believed that an aviation electrician's score on the battery also reflects his skill in these areas.

This project also developed and pretested a pool of items which may form the basis for the AE Written Examination, the purpose of which is to predict a trouble-shooting criterion.

At the outset the pool consisted of over 600 items. These items were administered to 399 aviation electricians on both the East and West coasts. The results from this test administration were analyzed. On the basis of this analysis the pool of items was reduced to 351 items. These 351 items are now ready for validation against the job sample trouble-shooting criterion.

## ACKNOWLEDGMENTS

We would like to acknowledge the contributions of the many who helped to make this research possible.

First, the research could never have been completed without the full, cooperative support given by Captain D. McCampbell, Commander C. Dodds, and other personnel at the Naval Air Technical Training Center, Jacksonville.

Other military personnel who deserve special mention are Lt. E. Dreiling and Lt. D. Hurlong, who assisted in the organizing of the administration of the pool of items for the AE Written Examination, as well as Lts. G. Herndon and H. Pitcher, who helped clarify our thinking in regard to the trouble-shooting process.

The job sample trouble-shooting criterion could never have been completed without the extremely valuable help of AEC G. Riley. Dr. Douglas Mayo at the Naval Air Technical Training Center, Memphis, made methodological suggestions throughout the research and helped to facilitate the statistical analyses.

Dr. W. C. Schaefer, Dr. F. K. Berrien and Dr. William H. Angoff made methodological and statistical suggestions throughout the research, and Dr. Berrien also critically reviewed the entire manuscript.

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## CHAPTER I

## INTRODUCTION AND OVERVIEW

Effective electrical maintenance of the modern Naval aircraft has become of primary concern because effective flying is dependent upon such maintenance. Furthermore, this maintenance need will increase for the aircraft of the foreseeable future. More and more, flight effectiveness and safety will depend upon the competence of the personnel in the Aviation Electrician's Mate rating (AE). How well these personnel fulfill the demands made upon them depends, to a very great extent, on the validity of the procedures used for their selection, classification, assignment, and training.

The validity of these procedures may be determined only after a standard or a criterion of proficiency has been established. Such a standard has not existed for the AE. For that matter, less than 15 years ago the AE did not exist. Today, because of the number of personnel involved and the type of maintenance work performed, it is one of the most critical ratings in naval aviation. The increasing need for AEs over a short period of time did not allow for the normal evolvement of standards of workmanship. Personnel were brought into the AE rating from surface and allied aviation ratings to fill the wartime needs. In conjunction, recruits from civilian life were given quick "massed" training which prepared them only for limited maintenance work on specific aircraft and equipment. Under these wartime conditions, it was impossible for adequate standards of electrical maintenance to develop.

Since the end of World War II, the section of the Manual of Qualifications for Advancement in Rating (NavPers 18068 Revised) having to do with the AE rating was revised (effective 1 July 1953) to make it more applicable to the maintenance of modern aircraft; standards and specifications for Naval aviation electrical wiring and installations, such as Military Specifications, MIL-E-7080, were set down officially; and the Naval Air Technical Training program was revised to meet these standards. What was still needed, however, was a means of determining how closely the personnel performing the electrical maintenance in the fleet approached these standards. The development of such a standard or criterion measure, the AE Job Sample Trouble-Shooting Performance Examination for the evaluation of this technical proficiency of AE, was the first major end product of the research here reported.

In many situations, the administration of the primary criterion, the AE Job Sample Trouble-Shooting Performance Examination, is not feasible because of personnel, time and material requirements. In order that a measure of known relationship with the primary criterion might be available for use in these situations, a start has been made on the construction of a paper-and-pencil test which will have a known correlation with the AE Job Sample Trouble-Shooting Performance Examination. The development of the items for this written test was the second major end product of the research here reported.

It should be pointed out, however, that these tests are measures of technical competence only. In no way can they be used to evaluate the AE as an instructor, as a leader, or in other such capacities.

## CHAPTER II

## DEVELOPMENT OF THE AE JOB SAMPLE TROUBLE-SHOOTING

## EXAMINATION --- THE PRIMARY CRITERION

The degree of success with which most Naval aviation activities carry out their missions is dependent to a considerable degree on the level of availability of their aircraft. The level of availability is, in turn, dependent on proficient maintenance of the aircraft. For this reason, the ultimate criterion of technical proficiency for the AE is the actual performance of correct electrical maintenance in operating activities.

Since it is currently impossible to obtain an objective measurement of on-the-job performance in all operating activities, the next best method is a sample of the AE's performance from which his total proficiency can be inferred.

The AE Job Sample Trouble-Shooting Examination, Form 1

In order to develop a realistic job sample, it was first necessary to define the AE's job in terms of what he does and the best method of doing it. Records and personnel of operating fleet squadrons were the logical sources of this information. From electrical shop maintenance logs, it was possible to determine what the maintenance job consists of and what the AE is supposed to do. Extensive interviews with AEs in the first three pay grades revealed what they considered the best methods.

These sources showed that "trouble-shooting" is the critical type of maintenance performed by the AE. While it is not necessarily the major portion of the work, trouble-shooting is considered to be the ability that distinguishes between the proficient and the unproficient. For this reason the examination was built around trouble-shooting problems.

The first step was to compile lists of trouble-shooting problems that actually occurred in operating activities and the procedures that were used to solve them. On the supposition that these procedures were correct, a start was made on constructing a trouble-shooting job sample examination.

During the course of collecting the information for the construction of the job sample examination, the personnel interviewed were asked to nominate the best authorities on the duties of the AE rating who could act as final judges on the acceptability of the measure. Two experienced officers were named as clearly best qualified in this respect.

After the examination was completed, it was submitted on an informal basis to these two experts for their opinions as to the acceptability of the examination as a measure of technical proficiency for the AE. The experts did not find the examination acceptable.

Their major criticism was that the procedures used in the job-sample to determine the cause of discrepancies - observing the discrepancy and then making an "educated guess" as to the cause - were not correct, although these procedures are in common use in operating activities. In the opinions of these experts this is one of the great maintenance evils in many of the operating activities.

They pointed out that such methods of trouble-shooting, while very efficient in some cases, with respect to the time required to locate the discrepancy, are very uneconomical in the use of material and, in the long run, even in use of time. Furthermore, this "educated guess" method of maintenance is considered one of the primary reasons why much electrical equipment in perfect working order is turned into supply as damaged or defective; i.e., the guess is incorrect.

#### AE Job Sample Examination - Form II

The experts who rejected Form I of the AE Job Sample Trouble-Shooting Examination, supplied their definitions of the AE's job. The experts agreed that trouble-shooting is the ability that distinguishes between proficient and unproficient AEs, and also suggested the analysis which follows as a systematic approach to trouble-shooting. This systematic approach is preferred over the "educated guess" method.

### Analysis of Trouble-Shooting

To locate by system analysis and remedy the causes of malfunctions in any given system the AE must:

1. Hypothesize as to the cause of the malfunction.

To do this, the AE must have complete knowledge of the purpose and operation of the individual components of the system in question, the purpose and operation of the system as a whole, any interactions between the system in question and other systems, and the purpose and operation of the testing instruments and equipment to be used.

2. Perform actual electrical checks and equipment performance checks in order to substantiate or reject the hypotheses from (1) above.

The minimum requirements here are the utilization, in accordance with the Equipment Operation and Service Instructions and the Aircraft Handbook of Maintenance Instruction, of testing instruments, equipment, and equipment performance charts to check the components and pertinent systems.

3. Diagnose the cause of the malfunction from the information obtained in the electrical and equipment performance checks.

Here the AE mentally synthesizes the results from the second part with his pre-check hypotheses and deduces the cause of a malfunction.

4. Perform the actual work required to eliminate the cause of the discrepancy.

This involves skills and abilities in the use of hand and power tools, and equipment required to remove, install, adjust and repair the wiring and components of electrical systems in accordance with the Equipment Operation and Service Instructions and the Aircraft Handbook Maintenance Instructions.

Although these four steps are necessary to correct electrical discrepancies, the skills and abilities underlying the steps do not differ from those needed in preventive maintenance and service changes. Comparison also shows that the skills and abilities required of the AE as stated above are at least implicit in these four work steps. Therefore, it is at least partly correct that the AE who can effectively trouble-shoot can also effectively perform these duties. A description of the AE Job Sample Trouble-Shooting Examination is presented in Chapter III.

The AE Job Sample Trouble-Shooting Examination was constructed in four parts corresponding to the four steps necessary to locate by system analysis and remedy the cause of electrical discrepancies. It should be pointed out, however, that while two of these parts may appear to be paper-and-pencil tests, the paper-and-pencil aspect is merely a means of recording the AE's reasoning - the mental operations he performs in these steps.

## CHAPTER III

## DESCRIPTION OF THE AE JOB SAMPLE PERFORMANCE EXAMINATION

Sub-Test I - Determination of Possible Causes of Trouble

In order to test the AE's ability to formulate hypotheses on possible causes of electrical malfunctions, 24 discrepancies with accompanying wiring diagrams were assembled. For each discrepancy a list of possible causes was also gathered. The task of the examinee is to select those causes which could be responsible for each discrepancy. Sample items (wiring diagrams omitted) follow:

Discrepancy 1

Left aileron motor does not run with the control switch closed. There is normal operation on the right pump.

Proposed Causes

1. Wire CS38A18N has high resistance at the ground terminal.
2. Very low resistance at the ground terminal on wire CS3C4N.
3. Thermal switch contact has infinite resistance.
4. Control coil in main contact has connections reversed.
5. Wire CS7A18N installed on terminal "N" by mistake.
6. Condensor wire CS3B18N is open.
7. Condensor 1414 plates shorted together.

Discrepancy 3

Left starter will not energize. (Starter motor was bench checked and operation found to be normal.)

Proposed Causes

1. Fuse is blown.

2. Circuit breaker is open.
3. Open circuit on lead coming from power circuit to relay contacts.
4. Wire from circuit breaker is off of switch.
5. Fuel oil shut off switch has high resistance across contacts.
6. High resistance at solenoid terminal.
7. Open at ground terminal on power relay.
8. Open circuit on lead from fuse to power side of starter solenoid.
9. Ground lead from solenoid is broken.

#### Discrepancy 13

Invertor does not turn up.

#### Proposed Causes

1. Potentiometer shorted out.
2. Pitted stacks.
3. Open resistor.
4. Open ground leads.
5. Wire No. XV4A12 is open at the terminal.
6. Open in wire No. XP5A20.
7. Five ampere circuit breaker open.
8. Wire No. XP360 disconnected at the terminal strip.
9. Wire No. XP360 disconnected from positive terminal.

### Development of Sub-Test I

Entries made over a three month period in five electrical shop maintenance logs were analyzed to determine relative frequencies of various discrepancies. From this analysis 39 typical discrepancies evolved. Three chief aviation electricians separately rated each of the 39 discrepancies according to pay grade and applicability of rating structure as stated in NavPers 18068 (Revised). On the basis of these judgments and further discussion, fifteen discrepancies were eliminated as too hard or easy for a given pay grade; or as not required by the new rating structure. The final 24 discrepancies included six which were at a difficulty level appropriate for each of four Naval pay grades and were representative of several plane types.

### Sub-Test II - Performance of Checks

In order to test the aviation electrician's ability to perform the electrical checks necessary to substantiate or reject hypotheses on the causes of discrepancies, the Electrical Checks Testing Box (Figure 1) was constructed. This is a wooden box 18-1/2" x 12" x 3" covered by a metal lid. On the lid are three rows of five terminals connected in a series-parallel circuit with resistors included. The terminals are insulated from the metal lid and are connected by metal strips which form the circuit. Metal strips have been used instead of wires, because they have minimal resistances of their own, and because of the convenience with which resistors can be used with this type of conductor. This circuit simulates the type of live circuits found in operational aircraft. Current is supplied by an external source of power such as an APU (Auxiliary Power Unit) or a battery.

The task of the examinee is to perform a series of electrical checks on the box using the multimeter as a check instrument. The letters (Figure 1) designate terminals at which readings are to be taken. The numbers denote the resistors. Following each check the examinee is asked a question which probes into whether he understands the principles upon which electrical circuits operate. Sample items are:

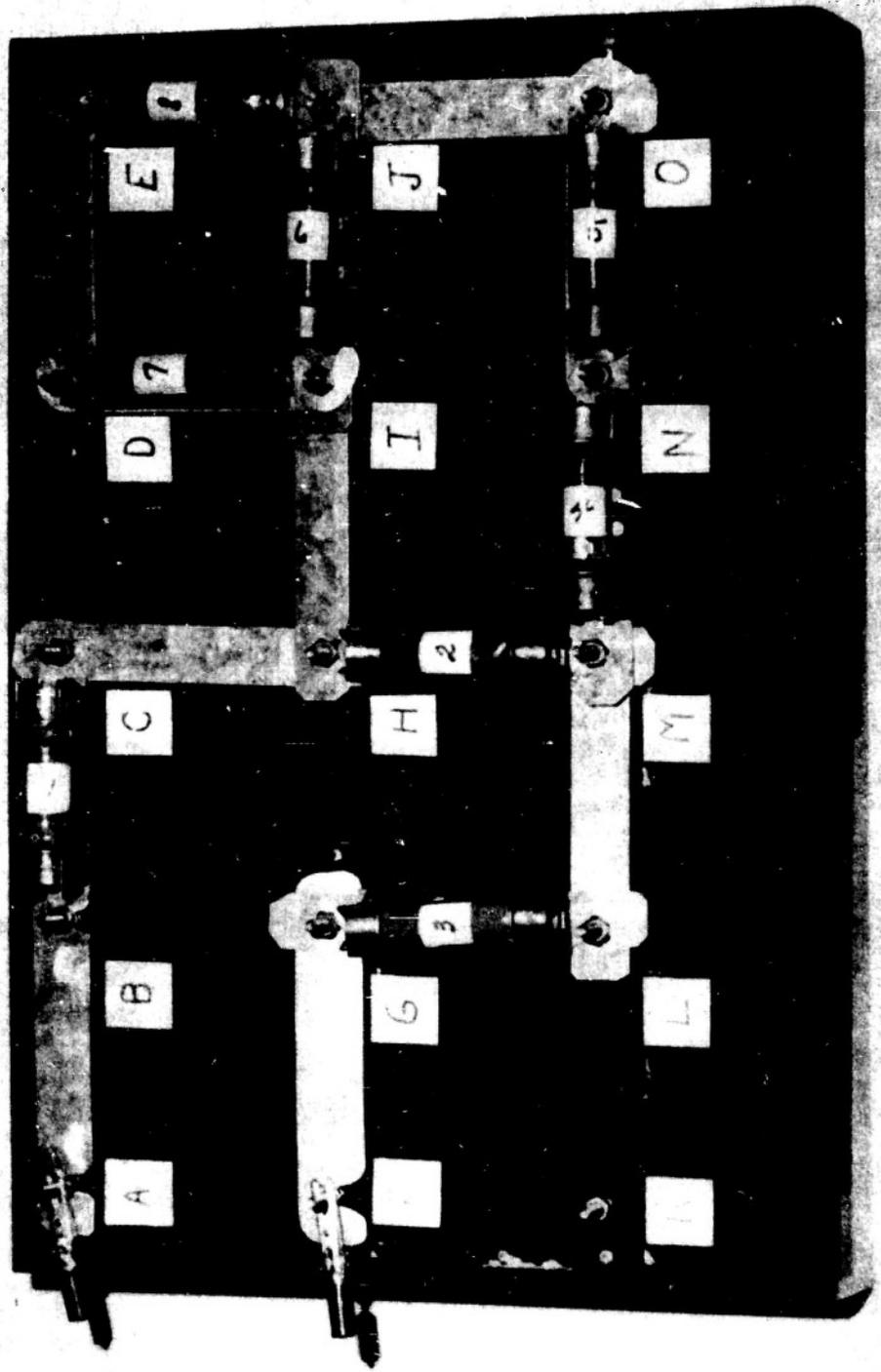


Figure 1  
Electrical Checks Testing Box

- Item 1. (a) Make a resistance check between I and J.  
Reading in Ohms \_\_\_\_\_.
- (b) If resistor #6 were replaced by a resistor of less ohms, you would expect your ohmmeter reading to be (the same) (greater) or (less).
- Item 6. (a) Make a voltage check between D and I.  
Reading in Volts \_\_\_\_\_.
- (b) If resistor #7 were replaced by a resistor of 20 more ohms and resistor #8 were replaced by a resistor of 20 less ohms, you would expect your voltmeter reading to be (the same) (greater) or (less).

An understanding of the principles upon which electrical circuits operate is fundamental to effective electrical maintenance. For instance, let us suppose that two lights, A and B, are connected in parallel. Light A is not burning; Light B is burning less bright than normally. Upon finding Light A out, it is reasonable for the AE to assume that it has burned out. This would increase the resistance. However, assuming a parallel circuit, this means that Light B should now burn more brightly, since it is carrying increased current. However, Light B is not burning brighter, but dimmer than normally. Hence, the conclusion is that the source of power is not putting out the required voltage. A voltmeter reading will confirm or deny this conclusion.

In summary, sub-test II yields information in regard to:

1. The AE's ability to use and read testing instrument.
2. The AE's understanding of the principle upon which electrical circuits operate.

#### Development of Sub-Test II

In order to determine which of the many testing instruments used by the aviation electrician would be most acceptable for purposes of this examination, an attempt was made to find an instrument that met the criteria of:

1. Importance during actual trouble-shooting process.
2. Adaptability to testing purposes.
3. Availability at the squadron level.

A list of testing instruments used by the AE was compiled by two Chief Petty Officers. The chiefs used personal experience, consultation with other chiefs, and service change manuals as the basis for their list. The list of instruments was then checked for completeness by a third chief. The instruments on the final list were:

1. Multimeter
2. AC voltmeter
3. DC voltmeter
4. Ammeter
5. Megger
6. Wheelco Tester (thermocouple tester)
7. Generator vari-drive panel
8. G-1 automatic pilot tester
9. Portable Scorsly tester
10. Red Star field test set
11. C-1 field test set
12. Ignition harness tester
13. Gyro flux gate compass test kit
14. P-1 automatic pilot field tester
15. Field variable capacitance tester
16. Autosyn functional tester
17. Remote compass tester
18. Liquidometer
19. Turn and bench tester
20. Dead weight tester
21. Selsyn instrument tester
22. Thermometer test
23. Frequency meter
24. Wattmeter
25. Strobatic
26. Oscilloscope
27. Tube tester

Seven chiefs were separately asked to select from the list the five "most important" testing instruments required for performing the duties of the aviation electrician. Most important was defined in terms of:

1. Relative frequency of use of the instrument during trouble-shooting.
2. Criticalness of the instrument for performing the duties of the aviation electrician.
3. Actual operational usage of the instrument at the squadron level.

The three instruments which were most frequently chosen as one of the five "most important" were.

1. Multimeter (7)
2. General vari-drive test panel (4)
3. Red Star field test set (3)

A further intensive discussion was held on the merits of these three testing instruments in the light of the criteria. This resulted in the elimination of the generator vari-drive and the Red Star field test set. The generator vari-drive was eliminated because usually only one generator vari-drive is assigned to a squadron. Moreover, this piece of apparatus weighs approximately 300 pounds and is, therefore, impossible to carry around for testing purposes. Most important, however, is the fact that the generator vari-drive is not actually used in the trouble-shooting process but is used to correct a discrepancy after it is diagnosed. The Red Star field test set was eliminated because the set is composed of many tools and instruments each of which could form the basis of a separate test and because the tools in the set are not a means for testing circuits but rather a means for fixing a discrepancy. Multimeters, therefore, became the sole testing instrument employed.

#### Construction of Circuit

A chief aviation electrician cooperated with the Institute personnel during the construction of the AE Job Sample Trouble-Shooting Examination. This chief devised the series-parallel circuit and 10 ohmmeter, 10 voltmeter, and 10 ammeter problems for the circuit. Two other chiefs then checked the problems for accuracy and wording.

The particular series-parallel circuit was made up in the form shown in Figure 1 and is called the Electrical Checks Testing Box. It provides a level of complexity suitable for examination purposes. The wiring box has the advantage that it exposes a whole series-parallel circuit to the examinee. This exposure would be impractical on an aircraft. The questions were devised so that they cut across all pay grades and were worded so that the examinee was not required to know the value of the resistors in order to solve the problems.

Sub-Test II in its entirety is presented as Appendix A of this report.

### Sub-Test III - Diagnosis of Malfunctions

In sub-test III a man is given a discrepancy, plus the results of some checks. His task is to determine the one cause of the trouble.

Typical problems (wiring diagrams omitted) follow. A total of 24 similar problems are included in the test.

#### Discrepancy 1 (Wiring Diagram 1)

The left engine cylinder temperature indicator reads 20° lower than the right indicator. A calibration check of left indicator with a Wheelco cylinder temperature tester proves it to be properly calibrated.

Which one of the following is the cause of this discrepancy?

1. Low resistance between plus and minus of indicator leads.
2. A short in the right variable resistor.
3. The left variable resistor adjustment has slipped to low side.
4. Corrosion in the left firewall plug.
5. A break in B lead at the left firewall plug.
6. Open in Y lead between left firewall plug and thermocouple.

Discrepancy 11 (Wiring Diagram 11)

Low generator output. Generator warning light burns continuously. Voltage reading between GEN terminal of reverse current relay and ground is 18 volts with engine turning up at 1400 R.P.M.

Which one of the following is the cause of this discrepancy?

1. Plus and minus leads at voltmeter reversed.
2. Open between E of generator and ground.
3. High resistance between F+ and G+ of voltage regulator.
4. Internal short in reverse current relay between NEG and BAT terminals.
5. Open between L+ and L- of voltage regulator.
6. High resistance between NEG and SW terminals of reverse current relay.

Discrepancy 24 (Wiring Diagram 23)

The P-1 auto pilot fails to operate when auto pilot switch is turned on and clutch switch is pushed in. Movement of controller knobs causes no servo movements. Clutch switch knob remains "in" when pushed "in". All tubes of amplifiers are burning.

Given the above which one of the following is the cause of this discrepancy?

7. Short between F113K22 and F140A22 at gyro horizon control plug.
8. Short between terminals 8 and 9 of caging relay.
9. Short between F120A22 and F121A22. Between controller 'J' box and amplifier.
10. Lead F129A22 is open at amplifier plug.
11. Open in lead F68A22 at amplifier plug.
12. Open between I of aileron servo and ground.

### Criteria for Inclusion of Particular Discrepancies

On the basis of an analysis of erection and maintenance manuals, service change manuals, and the electrical shop maintenance logs of five squadrons, a comprehensive list of discrepancies was first drawn up. These discrepancies were then screened according to the following criteria:

1. Major systems involved in AE maintenance work.
2. Variability among types of aircraft.
3. Difficulty level.

#### 1. Major Systems Involved in AE Maintenance Work

Using the List of Military Specifications and Standards of the Bureau of Aeronautics as a guide, the field of AE maintenance work was broken down into six major areas. These six major areas were:

1. DC power supply and control
2. AC power supply and control
3. Interior and exterior lighting
4. Power plant
5. Instruments
6. Special materials and equipment

The analysis of entries made by the five squadrons in their electrical shop maintenance logs over a three month period revealed that their discrepancies were about equally divided between the first four and the last two areas. With this as a basis, it was decided that sub-test III should contain three discrepancies in each of the first four areas and six discrepancies in each of the last two areas.

## 2. Variability Among Airplanes

Aircraft can be classified generally as being of one of three types - single reciprocation engine, multi-reciprocation engine, and jet engine. Current Naval aircraft were categorized by a chief using erection and maintenance manuals as guides into these classes. The categorization was checked over for completeness and accuracy by a second chief. Discrepancies from as many aircraft and aircraft types as possible are included in sub-test III. In this manner no examinee is unduly penalized because of unfamiliarity with a single aircraft type.

## 3. Difficulty Level

The pay grade level of each discrepancy was determined in the following manner. The list of discrepancies was presented to five separate chiefs. The chiefs were well grounded in the requirements of NavPers 18068 (Revised) and with this as a guide, graded each discrepancy as to pay grade level. A comparison of judgments eliminated many discrepancies as too simple or too complex for a given pay grade.

The distribution of discrepancies by plane type, pay grade level and system represented in the final test is presented in Table 1.

## Sub-Test IV - Performance of Manual Skills

The purpose of sub-test IV is to test the AE on his ability to perform the actual work required to eliminate the cause of a discrepancy, once the cause has been ascertained. In order to test this ability the Basic Skills Test Box was constructed. Figure 2 shows two Basic Skills Test Boxes joined together. The box simulates in miniature an aircraft section and the components found therein. A simulated motor, control relay, control cable, ribs, lightening holes, fuel line and junction box are included. The inside of the box is zinc chromated and the components labeled. Holes one inch apart are drilled throughout the periphery of the device. The purpose of these holes is to permit the AE to attach clamps as needed. The task of the examinee is to solder wires to the 8-pin cannon plug and to run the wires through their components as

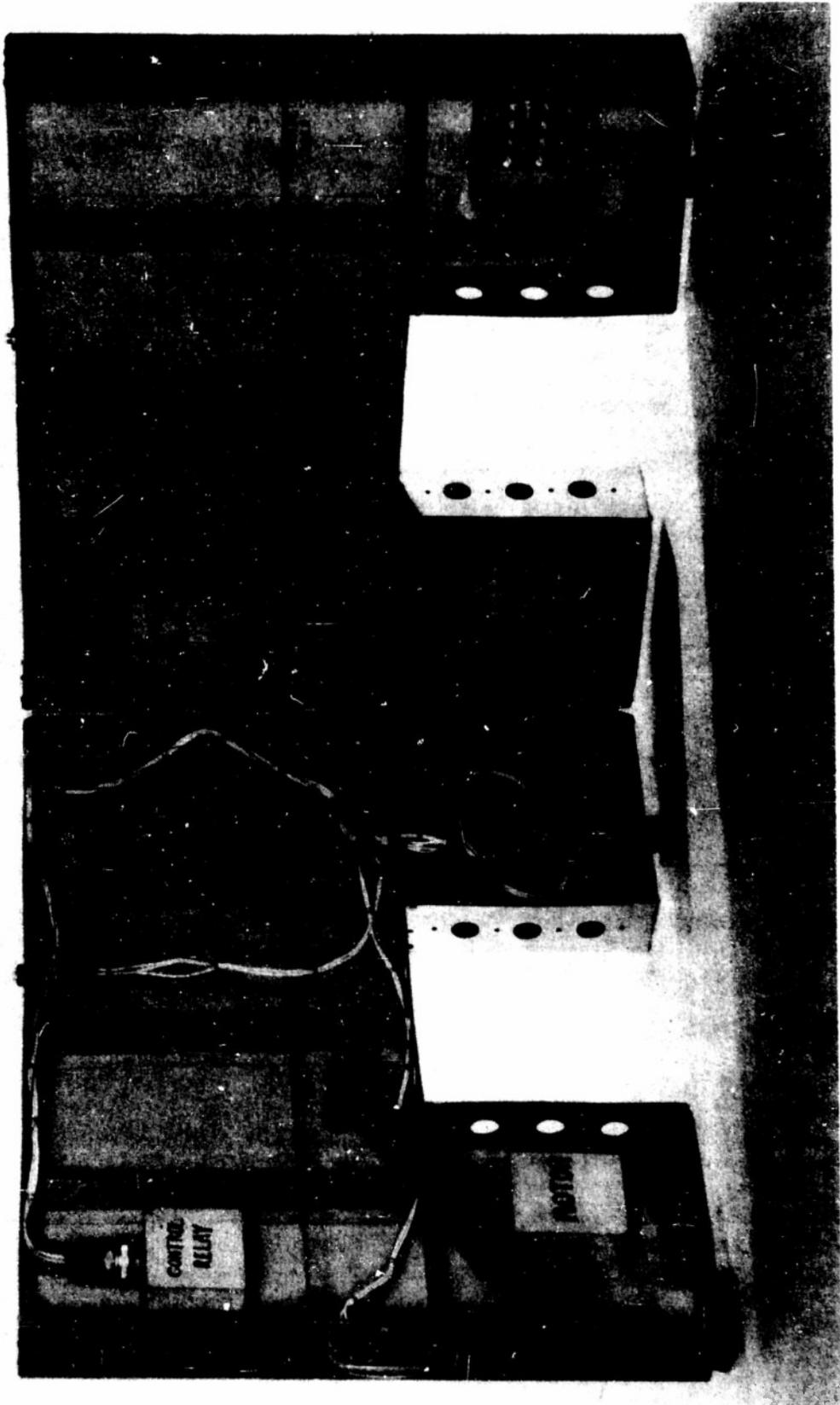


Figure 2  
Basic Skills Test Box(es)

Table 1

Distribution of Discrepancies by Pay Grade Level, System and  
Plane Type in Sub-Test III

Name of Airplane	Type of Plane*	Pay Grade	Systems Represented
P2V-6	M	E-6 E-5 E-6 E-3 E-4 E-5	DC Power Supply & Control AC Power Supply & Control Instruments Instruments Special Materials & Equipment Special Materials & Equipment
P2V-5	M	E-4 E-3	Power Plant Power Plant
AD-4	S	E-4	DC Power Supply & Control
AM-1	S	E-4 E-4	DC Power Supply & Control AC Power Supply & Control
AJ-1	M	E-5	AC Power Supply & Control
PBM-5A	M	E-3	Interior & Exterior Lighting
P5M-1	M	E-3 E-5 E-6	Interior & Exterior Lighting Instruments Special Materials & Equipment
F9F-5	S-J	E-3 E-5 E-4	Interior & Exterior Lighting Power Plant Instruments
F4U-5	S	E-4	Instruments
F3D-2	M-J	E-5 E-6	Instruments Special Materials & Equipment
AJ-2P	M	E-6	Special Materials & Equipment
AJ-2P	M	E-6	Special Materials & Equipment

\* M = Multi engine  
S = Single engine  
S-J = Single Jet  
M-J = Multi Jet

indicated on a schematic (Figure 3). The skills involved in the successful completion of this task are soldering, use of tools, knowledge of the principles of safe wiring, selection of the proper size nuts, bolts, clamps, wires, etc., reading and working from schematic wiring diagrams, employment of insulating techniques, fabrication of cables, installation of terminal strips, and connections, etc. These are the actual skills used in repairing or replacing a defective component in the operational situation.

### Scoring

The scoring sheet used in conjunction with this test is presented in Appendix B. It can be seen that the examinee is scored in this test on the quality of his final product. The emphasis in scoring is based upon the consensus of opinion of four chief aviation electricians who were thoroughly indoctrinated in the test task and its purpose. These chiefs were asked to rate each area scored on the basis of five, ten, or fifteen points. If three of the four chiefs agreed on the weight of a given area that emphasis was accepted as the weight assignable to the area in question. If two of the chiefs assigned one weight to an area and the other two chiefs assigned another weight, an average was then taken as the scoring emphasis for that area.

### Pre-Test of the AE Job Sample Performance Examination

All four sub-tests in the AE Job Sample Trouble-Shooting Examination were pre-tested on from five to twelve examinees. As a result of the pre-testing, examinee and examiner instructions were clarified, time limits were revised, equipment was modified, and unclear wordings and technical errors which escaped the proof reading of the chief petty officers were revised.

The complete AE Job Sample Trouble-Shooting Examination is now revised and ready for administration in the fleet situation.

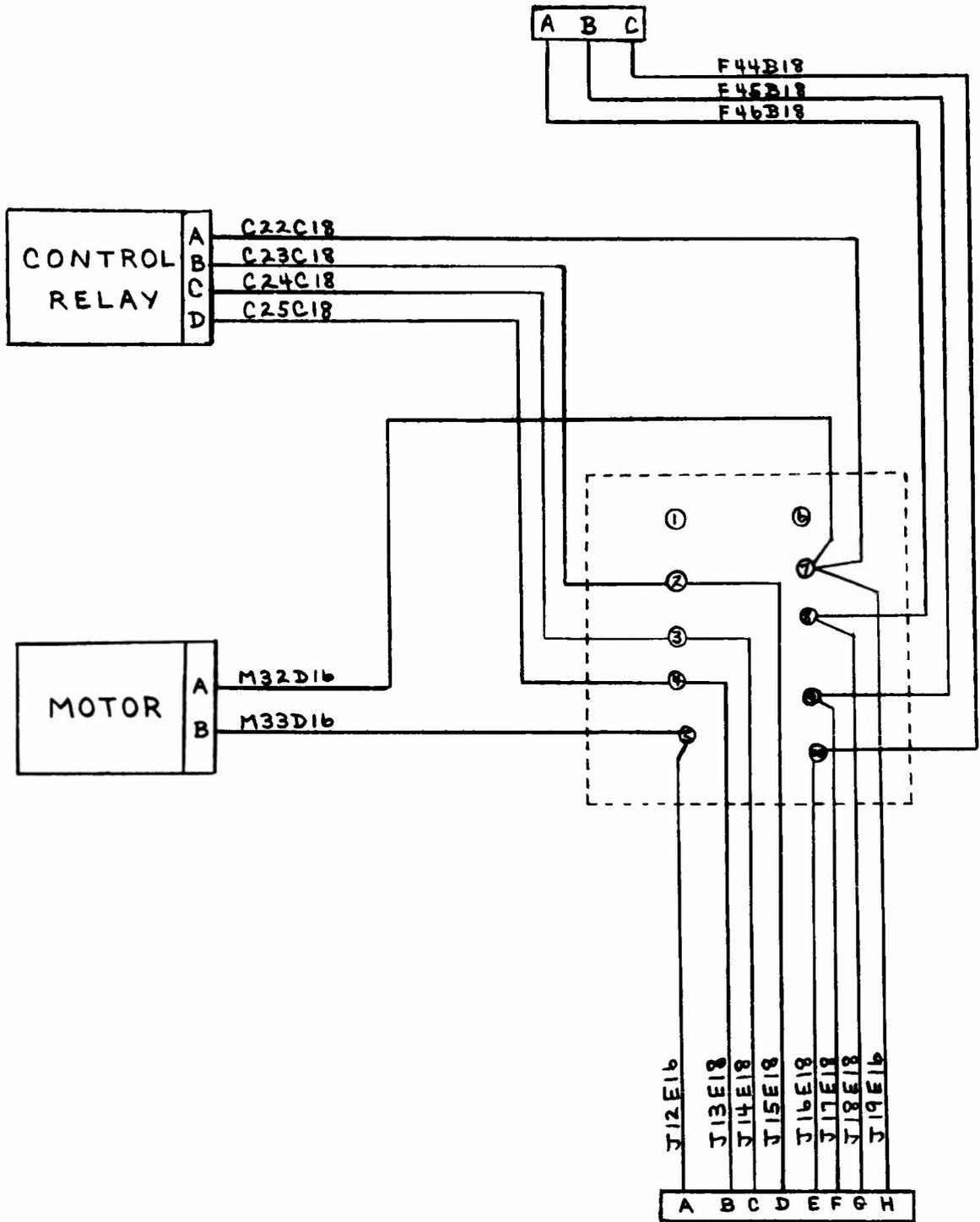


Figure 3  
Schematic for Basic Skills Test Box

## CHAPTER IV

## THE DEVELOPMENT OF THE AE WRITTEN EXAMINATION

Because the job-sample performance examinations are difficult to administer routinely a substitute measure is necessary to measure job proficiency. For this purpose a multiple-choice written examination is usually the most valuable, provided it is correlated with job sample scores. Accordingly, a pool of about 351 items was developed.

The AE Item Pool

To obtain the large number of items necessary for development of the pool, two major sources were used: the examination files of the AE School, NATTC, Jacksonville, and the 4 January 1952, AE 1, 2, and 3, Advancement in Rating Examinations. Five chief petty officer instructors at the AE Schools selected the items. In all, 655 multiple-choice items were obtained from these two sources.

These items were administered to 399 AEs who were about equally divided between Pacific Coast and Atlantic Coast activities. A breakdown of this sample by pay grade is shown in Table 2.

Table 2

Distribution by Pay Grade of AE's Who Took 665 Items

<u>Pay Grade</u>	<u>Number</u>
E-6	29
E-5	32
E-4	156
E-3	<u>182</u>
TOTAL	399

From the results of this administration, an index of the difficulty level of each item was obtained. Each incorrect response (distractor) was also analyzed in terms of the number of examinees attracted to it. Item-test correlations were obtained from each item. Items with difficulty levels greater than .95 or less than

.05 were eliminated from the pool.\* Distractors which attracted too many or too few responses were rewritten in some cases and in other cases the items containing these distractors were eliminated from the pool. Items with low or negative item-test correlations were also discarded.

While the item analysis was being made, the revision of the AE qualifications in NavPers 18068 became effective. Simultaneously it became apparent that there was a need for a pool of items which would be applicable for testing in order to predict success in the various phases of the AE "B" school. Therefore five chief petty officers were asked to review the items in order to determine their applicability under the newly revised rating structure as well as their applicability to "B" school phases. In some instances no items related to the 53 examination subjects listed in sections 202 and 203, for the AE in the revised NavPers 18068 while for other subjects there were as many as 66 items. It was, therefore, necessary that some new items be written and other items be eliminated to obtain even coverage across subject categories. Five officers and warrant officers with long experience with AE work added items to those subject areas that were not adequately sampled. Because of time and personnel requirements these new items were not pre-tested or analyzed.

#### Future Research

The revised pool of items, all of which relate by content to examination subjects of the revised NavPers 18068 as well as to the phases of "B" School, is now ready for administration in order to determine how these items relate to the AE Job Sample Trouble-Shooting Examination. In the next phase of the research, there will also be a determination of the relationship between AE "A" School grades and fleet proficiency as measured by the AE Job Sample Trouble-Shooting Examination. Moreover, the items in the pool will be categorized according to the phases of the AE "B" School, and norms worked out, if possible by pay grade, for each category. The relationship between the AE Job Sample Trouble-Shooting Examination and Basic Battery Test Scores, as well as the relationship between the Job Sample Examination and the competitive advancement in rating examination, may also be determined.

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To conserve space the item analysis data are not included in this report. They can be obtained, however, on inter-library loan from The Records Librarian, Institute for Research in Human Relations, 2224 Locust Street, Philadelphia, Pa.

## APPENDIX A

In Appendix A is presented Sub-Test II of the AE Job Sample Trouble-Shooting Examination. It is not possible to present Sub-Tests I and III in their entireties because these sub-tests contain security information.

## INFORMATION SHEET - SUB-TEST II

WHAT IS THIS BOX?

On the lid of this box is a series-parallel circuit made of metal strips. Resistors are included in the circuit. The circuit is the same as any wiring circuit, for it can carry electricity.

WHY USE METAL STRIPS INSTEAD OF ACTUAL WIRES?

1. The metal strips have no resistance of their own; therefore, they won't affect your readings with the multimeter.
2. This type of box makes it easy to give clear and simple instructions.
3. The points at which you take readings are more accessible.
4. The box is sturdy, and can take a beating. Don't abuse the privilege however.

WHAT IS THE PURPOSE OF THIS TEST?

1. Whether you know how to use the multimeter.
2. To determine whether you know how to reason, when presented with actual problems on a circuit. A reading doesn't mean much, unless you can interpret its implications.

WHAT AM I SUPPOSED TO DO?

You will be given a sheet with problems and spaces for filling in answers.

Let us look at the example on sheet #1. First it says: "Take an ohmmeter reading between B & C." You can see there is a resistor between those points. You will obtain a reading of 45 ohms. You can see the man marked 45 ohms in Example A. The second part of the question says: "If resistor #1 was replaced by a resistor of less ohms, you would expect this reading to be the (same, higher, lower) than the reading you actually obtained. As you can see the man wrote in the word "Lower".

WHY IS IT LOWER?

If there were less resistance between points B and C, then you would get a lower ohmmeter reading. Therefore, the reading you would expect would be lower than the one you actually obtained with your multimeter.

You will have 10 ohmmeter problems and 10 voltmeter problems.

USE YOUR HEAD!

Sometimes your answer might be the same or higher. Check the appropriate box!!

HOW MUCH TIME DO I HAVE?

ONE HOUR - This is more than you probably will need. So do careful, correct work. Your readings must be accurate to within ±5%.

ANSWER ALL QUESTIONS!!

## SUB-TEST II

OHMMETER CHECKSExample:

- (a) Make a resistance check between B and C. (45)
- (b) If resistor #1 were replaced by a resistor of less ohms, you would expect your reading to be the (same, higher, lower) than your original ohmmeter reading. *Lower*
1. (a) Make a resistance check between I and J.  
(b) If resistor #6 were replaced by a resistor of less ohms, you would expect your ohmmeter reading to be - - - - -.
  2. (a) Make a resistance check between I and N.  
(b) If resistor #8 were replaced by a resistor of more ohms, you would expect your ohmmeter reading to be - - - - -.
  3. (a) Make a resistance check between A and I.  
(b) If resistor #2 were replaced by a resistor of less ohms, you would expect your ohmmeter reading to be - - - - -.
  4. (a) Make a resistance check between H and M.  
(b) If resistor #3 were replaced by a resistor of more ohms, you would expect your ohmmeter reading to be - - - - -.
  5. (a) Make a resistance check between C and E.  
(b) If resistor #4 were replaced by a resistor of more ohms, you would expect your ohmmeter reading to be - - - - -.
  6. (a) Make a resistance check between H and O.  
(b) If resistor #1 were replaced by a resistor of less ohms, you would expect your ohmmeter reading to be - - - - -.
  7. (a) Make a resistance check between B and G.  
(b) If resistor #5 were replaced by a resistor of less ohms, you would expect your ohmmeter reading to be - - - - -.
  8. (a) Make a resistance check between F and N.  
(b) If resistor #7 were replaced by a resistor of more ohms, you would expect your ohmmeter reading to be - - - - -.

SUB-TEST II

OHMMETER CHECKS

- 9. (a) Make a resistance check between D and J.  
 (b) If resistor #1 were replaced by a resistor of less ohms, you would expect your ohmmeter reading to be - - - - -.
- 10. (a) Make a resistance check between E and L.  
 (b) If resistor #2 were replaced by a resistor of less ohms, you would expect your ohmmeter reading to be - - - - -.

VOLTAGE CHECKS

- 1. (a) Make a voltage check between I and J.  
 (b) If resistor #2 were replaced by a resistor of more ohms, you would expect your voltmeter reading to be - - - - -.
- 2. (a) Make a voltage check between C and G.  
 (b) If resistor #3 were replaced by a resistor of less ohms, you would expect your voltmeter reading to be - - - - -.
- 3. (a) Make a voltage check between H and M.  
 (b) If resistor #1 were replaced by a resistor of less ohms, you would expect your voltmeter reading to be - - - - -.
- 4. (a) Make a voltage check between N and O.  
 (b) If resistor #4 were replaced by a resistor of more ohms, you would expect your voltmeter reading to be - - - - -.
- 5. (a) Make a voltage check between D and I.  
 (b) If resistor #7 were replaced by a resistor of 20 more ohms and resistor #8 were replaced by a resistor of 20 less ohms, you would expect your voltmeter reading to be - - - - -  
 - - - - -
- 6. (a) Make a voltage check between B and F.  
 (b) If resistor #4 were replaced by a resistor of 15 more ohms and resistor #5 were replaced by a resistor of 25 less ohms, you would expect your voltmeter reading to be - - - - -  
 - - - - -

SUB-TEST II

VOLTAGE CHECKS

7. (a) Make a voltage check between M and N.  
 (b) If resistor #6 were replaced by a resistor of more ohms,  
 you would expect your voltmeter reading to be - - - - -.
  
8. (a) Make a voltage check between E and J.  
 (b) If resistor #3 were replaced by a resistor of less ohms,  
 you would expect your voltmeter reading to be - - - - -.
  
9. (a) Make a voltage check between C and M.  
 (b) If resistor #7 were replaced by a resistor of 50 less ohms  
 and resistor #3 were replaced by a resistor of 50 more ohms,  
 you would expect your voltmeter reading to be - - - - -  
 - - - - -
  
10. (a) Make a voltage check between G and H.  
 (b) If resistor #3 were replaced by a resistor of 25 more ohms,  
 you would expect your voltmeter reading to be - - - - -.

APPENDIX B

In Appendix B is presented the scoring sheet for Sub-Test IV of the AE Job Sample Trouble-Shooting Examination.

## APPENDIX B

## SCORING SHEET FOR SUB-TEST IV

SOLDERING:

1. Are leads hand tight? (Pull by hand) Minus 1 point for each loose lead.
2. Has solder shorted two terminals? (Visually inspect) Every two terminals shorted - Minus 1 point.
3. Are ends of wires near soldering points burned? Each burned wire - Minus 1 point.
4. Is it a neat job? Solder splashed in box or around spaghetti - Minus 3 points.

SPAGHETTI:

5. Does each lead at plug or receptacle have spaghetti? Each missing piece - Minus 1 point (Maximum 8 points).
6. Is spaghetti at 8 pin cannon plug tied - Minus 2 points if not tied.

JUNCTION BOX:

7. Are lugs securely held by nuts on terminals? (Test by hand) Each loose nut - Minus 1 point (Maximum 8 points).
8. Are wires lashed before each branch off to new terminal? Minus 1 point for each branch not lashed. (Maximum 3 points).
9. Do wires pull loose from lugs? Each loose lead - Minus 1 point.
10. Have lugs been broken by improper crimping? (If wires have been pulled loose in item #9, count only remaining lugs.) Each broken lug - Minus 1 point.

11. Is insulation flush with the lug?  
Each bare wire - Minus 1 point (Maximum 8 points).

LASHING:

12. Do knots flick open with thumb nail test? (Spot check five knots in a row) Each loose knot - Minus 1 point (Maximum 5 points).
13. Are knots spaced 5" or more apart?  
Each pair more than 5" apart - Minus 1 point (Maximum 5 points).
14. Are wires tied 2" or closer to a component (motor, etc.)?  
Each over 2" - Minus 1 point (Maximum 4 points).
15. Do knots slide? (Spot check 5 - if none slide - discontinue)  
Each loose knot - Minus 1 point (Maximum 5 points).

CLAMPS:

16. Are clamps tight? (Check by hand)  
Each loose clamp - Minus 1 point.
17. Are clamps close enough? (Does wire touch bulkhead when stretched by hand) Each contact area - Minus 1 point.
18. Are clamps of right size? (Pull wire by hand) If it slides - Minus 1 point.
19. Are grommets 3/4" (Visually inspect)  
Each wrong size - Minus 1 point.

ROUTING OF WIRE:

20. Are wires turned at an angle more than \_\_\_\_\_ of its diameter.  
Each excessive angle - Minus 1 point.
21. Is wire properly clamped, so it cannot be chafed by movement of control cable? (Stretch with hand)  
Each possible contact area - Minus 5 points.
22. Can wires touch fuel line? (Stretch by hand)  
If so - Minus 5 points.

23. Do, or can, wires lay on fuel line?  
If so - Minus 10 points.
24. Do, or can, wires touch simulated motor or simulated control relay?  
Minus 5 points for motor - Minus 5 points for relay.
25. Are groups of wires routed together, tied before each branch off? - Minus 1 point (Maximum 2 points).
26. Is more wire used than necessary? (Is wire doubled up)  
Each doubling up area - Minus 1 point.

CANNON PLUGS:

27. Are cannon plugs hand tight on receptacle?  
Each loose cannon plug - Minus 1 point.
28. Are adapters tight? (Wiggle wires - They must not have free play inside adapter)  
Each loose adapter - Minus 1 point.

CONTINUITY CHECKS:

29. Is there continuity between plugs and receptacle?  
(Check using ohmmeter)  
Each pin lacking continuity - Minus 1 point.

WASTEPAPER BASKET:

30. Each piece of wire over 12" long - Minus 1 point  
(Maximum 3 points).
31. Lugs - 3 to 5 lugs - Minus 1 point.  
6 to 10 lugs - Minus 2 points.