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RADIO AND SOUND BULLETIN

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ELIMINATION OF RADIO INTERFERENCE

INTRODUCTION

The large increase in the number and type of electromechanical equipments being installed aboard ships, together with the ever increasing number and type of radio/radar installations has resulted in a demand for the elimination of any radio interference produced by these equipments. The interference may not only restrict or prevent vital communications but may also divulge the position of a task unit to the enemy during periods of radio silence.

The Bureau of Ships has instituted a program for the elimination of this interference, and to this end has nominated a committee, composed of representatives of the various sections concerned, to study the problem, correlate the activities of the different groups, cooperate with equipment contractors, and furnish pertinent information on the subject to Naval ships and shore establishments.

It is planned that a series of articles will appear in this Bulletin on the following subjects:

1. Locating the source of interference.
2. Radio noise measurements.
3. Radio noise meters.
4. General rules for radio noise suppression.
5. Eliminating interference from small motors and generators.
6. Eliminating interference from large motors and generators.
7. Eliminating interference from ignition systems.
8. Eliminating interference from relays and other contact makers.
9. Eliminating interference from gas tube devices.
10. Eliminating interference from ordnance equipment.
11. Eliminating interference from radar equipment.
12. Measuring radio noise with an ordinary receiver, oscilloscope, and signal generator.
13. Design of screened rooms.
14. Attenuation measurements.

The first two topics are covered in this issue of the RADIO AND SOUND BULLETIN. A knowledge of the fundamentals underlying the above subjects should enable the military and civilian personnel of the Navy

to better cope with interference problems arising under their jurisdiction. The Bureau hopes to receive comments on these articles, and is also desirous of receiving reports on cases of interference including remedial measures taken and the results therefrom. Address all relative communications to Bureau of Ships, Code 925A.

LOCATING THE SOURCE OF INTERFERENCE

A. *Determining whether it is internal or external to the receiver.*—If the interference is being introduced into the receiver through the antenna system it will disappear or at least be greatly reduced, if the antenna is disconnected at the receiver input terminals or if the input terminals are short circuited. This naturally has no effect on noise arriving through the power line or being generated in the receiver itself except for internal noise that requires cross modulation of a carrier to make itself evident. This test is important when the interference sounds similar to tube noise or power supply hum. Care must be exercised in using this method with receivers designed for the higher frequencies since a short length of antenna lead or unshielded circuits may be sufficient to pick up large amounts of interference when the source is close to the receiver.

B. *Process of elimination.*—Having determined that the interference is being picked up by the antenna, it is then necessary to determine the exact source. One of the most effective methods is to turn off all equipment that is operating in the vicinity; if the interference stops each individual equipment may then be turned on, one at a time, and the results noted. It is better to start with all equipments off rather than stopping individual equipments when all others are operating because there is a possibility of one source being masked by other sources. A record of the time that the interference starts and stops is often of great help in spotting the offending equipment.

C. *Recognition methods.*—It is not always convenient to have all equipment turned off. An experienced investigator can often identify the source by the nature of the sound heard in the headphones or loudspeaker. Another method sometimes used by the trained men is observing the waveform on an oscilloscope connected to the receiver output. Considerable experience is required to make the most of these methods.

D. *"Snooping" methods.*—Most interference surveys require the use of a portable receiver (interference locators or radio noise meters). Where a large area is involved it is often advantageous to use a loop receiver as a direction finder, and attempt to locate the interference source by triangulation. This method fails when the interference is radiated from power lines at points remote from the equipments generating the interference; neither is it of much use aboard ship.

The most common method is to carry a radio noise meter about the suspected area and observe the intensity on the indicating meter. Noise sources usually have a large gradient in their immediate vicinity and it is often possible to walk up to the source of interference by proceeding in the direction of increasing readings.

After locating the offending equipment it is then necessary to determine what particular part of the equipment is responsible for the disturbance. This is done by a judicious use of any possible individual switches on various units of the equipment and by the use of probe antennas.

Probe antennas can be obtained (or made) in the form of small loops for magnetic pickup or a length of shielded cable with about 5 inches of the insulated inner conductor extending beyond the shield for electric pickup. The shield covering the leads to the probes should be connected to the case of the noise meter. Such small insensitive antennas will only be effective when they are brought up very close to the source and thus are of great aid in locating the actual source.

E. *List of potential sources of radio interference.*—In order to give some idea of the number and character of the possible sources of interference on board a large naval vessel a partial list is given here:

Main generators.
Driving motors.
Oil pump motors.
Water pump motors.
Air compressor motors.
Fan and blower motors.
Refrigeration motors.
Steering motors.
Calculating machines.
Shaft revolution counters.
Communication motor-generators.
Laundry equipment.
Machine shop.
Transmitter keying systems.
Interradio sounder circuits.
Teletype equipment.
Soda fountain mixers.
Galley equipment.
Barber shop equipment.
Medical and dental equipment.
Searchlight circuits.
Buzzer systems.
Arc welders.
Battery chargers.
Code practice equipment.
Fire alarms.
Telephone equipment.
Gunnery signal circuits.
Line control apparatus.
Radar equipment.
Sonar equipment.
Pitometer logs.
Gyro equipment.
Winch motors.
Rotating shafts.
Dead reckoning tracers.
Boiler feed signal system.
Lubricating oil low pressure alarms.
Telephone systems.
Radiating receivers.
Sound powered telephones.
Air lock belts.
Ventilation motor warning signals.
Oil burner telegraph systems.
Arcing incandescent lamps.
Auto-pulse fuel pumps.
Portable electric drills.
Fluorescent lamps.
Driving belts.
Electric typewriters.

In general:

All motors and generators.
All vibrating electrical contacts.
All gas tube rectifiers.
All poor electrical contacts.

All items in the above list are not necessarily trouble makers but they are potentially so. Even equipment that normally does not create interference may do so when defective or in bad condition. It is possible that many large sources are located below decks in such a way that they do not couple into receiving systems. However, they are still to be given consideration since the installation of wires or cables, for any purpose, that lead out of the compartment may pickup and reradiate interference that will be quite troublesome.

RADIO NOISE MEASUREMENTS

Interfering disturbances may have a waveform of almost any character from simple sine waves to waves of highly complicated shapes. The interfering effect of noise (at least its effect on the human ear) is usually considered to be proportional to its peak value. In order for an apparatus to indicate peak or quasi-peak values, consideration must be given to the following factors:

a. Bandwidth of the receiver.
b. Time constant of the integrating circuit.
c. Indicating meter constants.
d. Method of calibration.
e. Type and size of pickup antenna.
f. Method of use.

Only the first of these factors, the bandwidth of the receiver, appears in the instrument affected by the noise. The other factors are inherent in the design of the measuring equipment and will be considered in a later article on the subject of the radio noise meters. It is convenient to classify noise into two types; namely, *random* and *impulse*. Various combinations of the two types may be encountered.

Random noise is that due to the aggregate of a large number of elementary disturbances with random relative phases and with its energy not confined to a narrow band in the frequency spectrum. Noise from motors, generators, continuous arcs, etc., usually falls within this classification.

Impulse noise is that due to a single elementary disturbance or an aggregate of elementary disturbances with systematic relative phases and with its energy not confined to a narrow band in the frequency spectrum. It is a disturbance having an abrupt change and short duration or a succession of such disturbances, non-over-lapping. Ignition noise and other pulsed characters are of this type.

It has been found that the peak, effective, and average values of random noise are directly proportional to the square root of the bandwidth of the receiver. For impulse noise, the peak value is directly proportional to the bandwidth, the effective value is directly proportional to the square root of the bandwidth, and the average value is

independent of bandwidth. These relationships hold only for noise spectrums that are uniform over the receiver bandwidth. The ratio of the peak value to the effective value, or the peak value to the average value, varies greatly with the type of noise. It is usually very high for impulses—the lower the repetition rate, the higher the ratio.

To measure the bandwidth of a receiver for the purpose of comparing interference values, the voltage ratio

$$\frac{\text{Input at resonance}}{\text{Input off resonance giving same output}}$$

is squared and plotted on linear graph paper. The effective bandwidth then corresponds to the ratio of the integrated area under this curve to the area of a rectangle 1 kilocycle wide and having a height equal to the maximum response of the receiver. In general this value will differ from the conventional bandwidth value found by taking the half energy points.

In accordance with the above considerations, it is then possible to state the interference level in microvolts for a 1 kilocycle bandwidth (not microvolts per kilocycle). As pointed out at the beginning of this article the absolute determination of noise level involves many factors that make it difficult to accomplish with portable equipment. For this reason, certain compromises are necessary. Portable noise meters are available which are built to certain standard specifications and which indicate quasi-peak values which are more or less representative and duplicative when the equipments are properly used. These standard noise meters and their use will form the subject of another article.

EFFECT OF TROPICAL CONDITIONS ON R. F. TRANSMISSION LINES

Reports received indicate that under tropical conditions of high temperature, humidity, and fungus growth the efficiency of transmission lines and their fittings will be impaired. In some cases the lines may be rendered entirely inoperative.

Since the lines and fittings are designed to resist heat and humidity, these aspects are of minor importance taken by themselves. How-

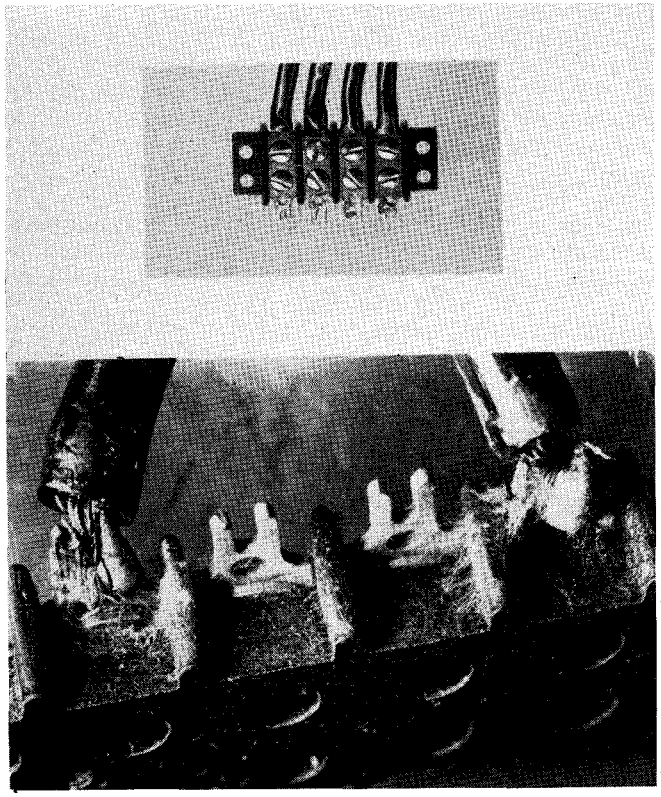

FIGURE 1.—A fungus contaminated terminal block.
—Bell Telephone Laboratories Photo.

ever, these conditions are aids to other causes of deterioration. Fungus growth will take place wherever spores of fungus can land and anchor and nutrition is available; moisture and spray containing nutrients are apparently sufficient to permit growth of spores into

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fungus. These attack organic material such as cotton, some cellulose acetates, rubber, etc. with primary and secondary effects, so far as performance is concerned.

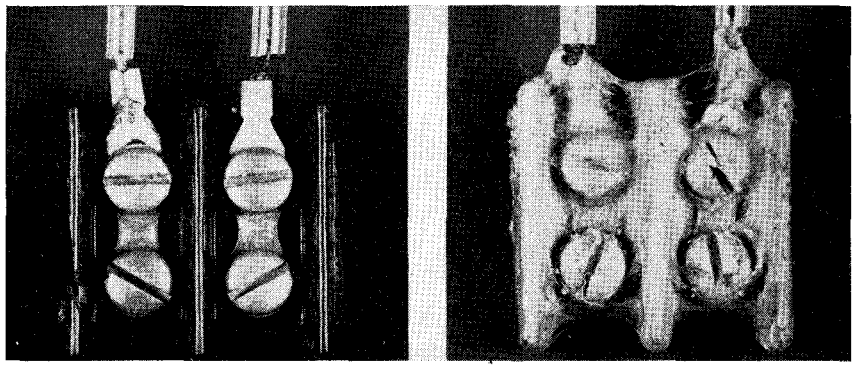

FIGURE 2.—A phenol plastic terminal block before and after exposure to fungus.
—Bell Telephone Laboratories Photo.

The primary effect is to destroy the mechanical and/or electrical characteristics of insulation by consuming the base materials as food. The secondary effects of the fungi can be equally destructive. The growth will act as a low resistance electrical path in normally high resistance components or between components. (See figs. 1 and 2.) It may serve to store moisture in portions of the equipment which should be dry. When the air filter system does not remove spores

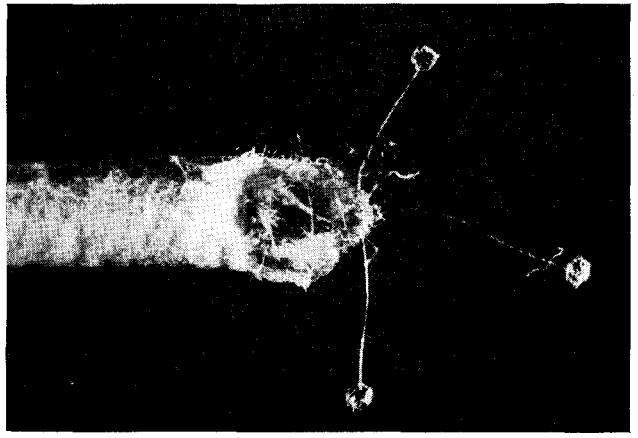

FIGURE 3.—Growth of fungus on exposed cotton at end of acetate coated insulated wire.
—Bell Telephone Laboratories Photo.

from the incoming air, fungus may grow inside beaded lines and eventually cause a short circuit. Fungus growing inside wave guides may change the inner dimensions sufficiently to shift frequency or alter the wave form.

Cotton jackets on cables not treated with fungicides are quickly destroyed. (See fig. 3.) Rubber jackets and rubber insulation become poor in protective and in electrical properties. Some synthetic resins such as "Vinylite," "Koroseal," and polyethylene are said to be resistant to degradation although they do not necessarily inhibit the growth of fungus. New specifications have replaced cotton with these synthetic resins where practicable. Fungicides are sprayed over all components where possible to minimize the effects. These help against some fungus, but the number and types encountered are many. Considerable study is still necessary although progress is being made. A new and central organization, headed by the National Defense Research Committee, is attacking the problem on many fronts with considerable hope for immediate, even if localized, solutions.

In tropical climates the problem of corrosion is always present, since moisture and high temperatures will accelerate this process. Therefore, it is essential that where dissimilar metals are in contact, either by design or by accident, they be kept dry, or be lacquered or varnished to keep the moisture away. Fungus growth over such bimetallic contact is dangerous. Aluminum and brass should be kept apart, where practicable. Iron, steel, or other ferrous alloys should be kept apart from brass, copper, or other nonferrous metals. Since this is not always possible for various reasons, the corrosion will be minimized when the section is dry.

Surface treatments for the alleviation of the above conditions have been and are being issued for "on-the-spot" treatment. Work is also being carried on to improve and modify equipments to make them more effective in all respects. New equipments are being treated on the assembly lines. Their tropical life may be expected to exceed by far that of previous equipments.

It is requested that field troubles in Naval or Marine Corps ground, ship, or air radio and radar equipments be reported as completely as possible, so that proper measures can be taken to improve the protection of existing and new equipments against tropical conditions.

ELECTRONIC PUBLICATIONS OF THE BUREAU OF SHIPS

Over a period of the last 3 years the Bureau of Ships has written, edited or published a large number of publications on electronic subjects. While these publications have been widely distributed, there will still be many activities which are not aware of all of them. Initial distributions will inevitably contain some omissions, and new activities in most cases will secure prior publications only by request. Therefore, it is the intention of this article to describe very briefly these various publications, so that ships and stations may become more familiar with the literature that exists and request copies if they can use them to advantage.

A word about these requests. It is obvious that these books and pamphlets have been printed so they can be used, and the Bureau wants as wide a distribution as is consistent with sound usage. By sound usage we mean enough copies so that they will be readily available to the people who need them for reading, reference or study. We don't mean a private copy for everyone. Limit your requests to the smallest number that can be used efficiently. In the case of Confidential books remember that only those whose duties require their use are permitted access, so in making request state very briefly the need for the publication.

> ***NOTE:*** *The Bureau is constantly hearing about Confidential books which are locked up and never see the light of day. Such security measures of course defeat the purpose of printing the material. Confidential publications must be readily available for reference and study to all personnel, officer or enlisted, who are concerned with the subject of the publication.*

Requests for these publications should be directed to the Bureau of Ships. Any exceptions to this are set forth under the specific publication. The most important exceptions are publications distributed through the Registered Publications System (Chief of Naval Operations). Before requesting any of these, be sure to contact the Issuing Office nearest you. You may already be on the allowance list, in which case no correspondence will be required.

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The following is a list of all current publications. Publications planned or in process of being printed are not included; they will be listed later. The title of the publication is listed in italics followed by the classification, short title, description and initial distribution.

PERIODICALS

Communication Equipment Maintenance Bulletin—Restricted—Navships 900,020. A medium for providing current maintenance information on shipboard radio communication equipment. Loose-leaf in form. Published approximately monthly. Also contains an "X" section devoted to advance base and shore equipment. Distributed to all ships (except small landing craft), Type and Force Commanders, advance bases and major shore activities.

Radar Installation Plan—Confidential—Contains current radar installation information. Loose-leaf in form. Additions published approximately monthly. Distribution limited primarily to installation activities.

Radar Maintenance Bulletin—Confidential—Navships 900,034. A medium for providing current maintenance information on shipboard radar. Loose-leaf in form; additions published approximately monthly. There are two editions—the complete edition (designated by "C") and small edition (designated by "S") which omits fire control and large search equipments and is distributed to submarines and smaller vessels. Distributed to all radar equipped vessels, schools, and maintenance activities.

Radio and Sound Bulletins—Restricted—Navships 900,011. A compilation of articles of general interest to radio personnel. Includes description of new equipments, general instructions and procedures; background information useful to training, maintenance and installation personnel; a section known as "The Forum" which provides a medium for expression of individual and "non-official" opinion. Published quarterly. Distribution direct to all activities concerned with radio.

Radio Installation Bulletin—Restricted—Navships 900,022. A weekly publication containing current information on installation matters. Covers radio, sonar and radar. Distributed only to installation activities. Copies are distributed through Radio Materials Officers and requests to be placed on distribution list should be directed to them.

Shore Installation Notes—Restricted—Navships 900,030. Published biweekly. Contains current installation information on shore radio, radar and harbor detection equipment. Distributed to shore activities. Requests to be placed on mailing list should be directed to cognizant Radio Material Officer.

Sonar Bulletin—Restricted—Navships 900,025. A compilation of installation and maintenance information on sonar gear. Published approximately bimonthly. Latest edition is 4th edition. Distributed to all sonar equipped ships, maintenance activities, and schools.

NON-PERIODICAL

Catalogue of Naval Radio Equipment (Transmitters)—Confidential—(ENG 175—R. P. S.). A brief summary of the technical data on the more recent transmitters. Includes a brief description, photographs, table of component units, weights, dimensions, Navy type numbers, vacuum tube complement. 49 pages. Distributed to Commands, tenders, repair ships, installation and maintenance activities, and schools.

Catalogue of Naval Radio Equipment (Receivers, Direction Finders)—Confidential—(SHIPS 207—R. P. S.). A second volume of the "Transmitter Catalogue" containing similar information on receivers and direction finders. Both these volumes are being replaced by a single enlarged edition which will be available about 1 November, 1944. 65 pages. Distribution same as other catalogue.

Elements of Electricity and Radio—Restricted—Navships 900,012. A very elementary first text on the subject. Useful for review or introduction to the radio field. Covers briefly electricity and magnetism before going into vacuum tubes and their applications. More condensed than the usual radio texts. 205 pages. Distributed to larger ships and to schools.

Elements of Loran—Confidential—Navships 900,027. A general description of basic Loran principles prepared by Radiation Laboratory. Somewhat more advanced than the "Loran Handbook." 45 pages. Distributed to schools.

Harbor Detection Bulletin—Restricted—Navships 900,024. A compilation of installation and maintenance data not available in instruction books on harbor detection gear. 71 pages. Distributed to all Harbor Detection Units, Radio Material Officers, and harbor defense schools.

Impedance and Admittance Diagrams for Transmission Lines and Waveguides—Restricted—Navships 900,038. An advanced explanation of the theory, construction and use of impedance diagrams. Prepared by Radiation Laboratory. Of interest only to advanced technical personnel. 41 pages. Limited distribution to laboratories, schools, and Radio Material Officers.

Instructions for the Operation of SA Radar—Confidential—Navships 900,021. Simplified operating instructions for the SA Radar. Useful in training new operators and to supplement the operating portion of the instruction book. 26 pages. Distributed to ships having SA Radar and schools.

Instructions for the Operations of SC-1 Radar—Confidential. Same as SA Operating Instructions. 14 pages. Distributed to ships having SC and SC-1 Radar and schools.

Instructions for the Operation of SF/SF-1 Radars—Confidential—Navships 900,029. Same as SA Operating Instructions. 16 pages. Distributed to ships having SF Radar and to schools. RMO's have additional stocks for vessels not included in initial distribution.

Instructions for the Operation of SG Radar—Confidential. Same as SA operating Instructions. 16 pages. Distributed to ships having SG Radar and to schools.

Instructions for the Operation of SO Series Radars—Confidential—Navships 900,014. Same as SA Operating Instructions. 17 pages. Distributed to Radio Material Officers for issue to ships having SO Radar and to schools.

The Klystron—Restricted—Navships 903-7. A description of the theory and operation of the Klystron. Useful for providing technical personnel with a more complete background on this tube than is available in instruction books on equipments which utilize the tube. 44 pages. Distributed to all ships and to schools.

List of Navy Radio and Sonar Equipment—Confidential—(SHIPS 242—R. P. S.). A complete list of all Naval Equipment (excluding radar) arranged by model letter. Provides in tabular form such information as contractor, frequency range, power, type of emission and general usage. 97 pages. Distributed to Commands, schools, tenders, installation and maintenance activities.

Loran Handbook for Shipboard Operators—Confidential—(SHIPS 278—R. P. S.). A nontechnical description of fundamentals of Loran followed by detailed instructions on the operation of shipboard equipment. Contains an appendix

providing specific instructions for operation of the DAS-1/DAS-3 and LRN-1A Equipments. 68 pages. Distributed to all Loran equipped vessels and to schools.

Microwaves and Waveguides—Restricted—Navships 903-5. Pamphlet provides general history of the research in microwave field. Gives development of the waveguide from a two-wire line, modes of transmission, coupling and matching, and a few applications of the waveguide. 56 pages. Distributed to large ships, schools and maintenance activities.

Microwave Techniques—Confidential—Navships 900,028. Publication written at the Radiation Laboratory. A description of transmission lines, R. F. components and test equipment as used in high frequency applications. Useful only to those concerned with radar design and to other advanced technical personnel. 188 pages. Limited distribution to laboratories, advanced material schools and principal maintenance activities.

Notes on Servicing Radio and Sound Equipment—Restricted. A reference book for the servicing of sound equipment. Prepared by West Coast Sound School. 186 pages. Distributed to all Sonar Equipped Vessels and included in commissioning allowances.

Prediction of Sound Ranges from Bathythermograph Observations—Confidential—Navships 943-C2. Instructions for the application of surface vessel bathythermograph data to the operational use of sonar gear. 30 pages. Distributed to all surface vessels having sonar gear, A/S Schools and other A/S activities.

Radar Electronic Fundamentals—Restricted—Navships 900,016. An introductory radar text. Companion volume to Navships 900,017. 474 pages. Distribution same as Navships 900,017.

Radar Information Notes—Confidential—Navships 903-10. A compilation of comments and operational information drawn from Radar Monthly Performance Reports. Eight issues have been published but only Issue No. 8 is current. Previous issues expired and destroyed. Distributed to radar equipped vessels.

Radar System Fundamentals—Confidential—Navships 900,017. A text book on radar with emphasis on function of actual circuits. Written in nonmathematical language. Valuable as a reference for technical personnel. 394 pages. Distributed to all ships having radar and to shore activities concerned with radar training, installation or maintenance.

Radio Frequency Transmission Lines—Restricted—Navships 900,008. Discusses the infinite line, reflection, standing waves, nonresonant lines, resonant lines, types of transmission lines, characteristic impedance. Nonmathematical. 44 pages. Distributed to large ships, schools, and maintenance activities.

SA Instructional Diagrams—Confidential—Navships 903-6. SA Radar Schematics are broken down into small functional components. Blank pages for notes are supplied. Useful in instruction and maintenance. 100 pages. Distributed to ships having SA Radar, schools, and maintenance activities.

SC/SK Instructional Diagrams—Confidential—Navships 903-9. Same as SA Diagrams. Covers SC series up to SC-3 but SC-3 is not complete. 105 pages. Distributed to ships having SC/SK Radar, schools and maintenance activities.

Sonar Equipment Log—Restricted—Navships 900,023. A book of blank forms for keeping a complete history of sonar equipment. 246 pages. Distributed to all ships having sonar. Available through Radio Material Officers.

Sound Material Handbook—Restricted. A condensed reference on basic radio, designed as an aid in the maintenance of sonar equipment. 402 pages. Distributed to all sonar equipped vessels and included in commissioning allowances.

Submarine Listening Ranges—Confidential—Navships 943-G. Manual for the prediction of listening ranges, sonic and supersonic, for submarines and surface

vessels. 18 pages. Distributed to all vessels having sonar gear, A/S Schools and other A/S activities.

Timing Circuits—Confidential—Navships 900,013. A fairly advanced engineering text on timing circuits used in radar equipments. Prepared by Radar School at M. I. T. 68 pages. Distributed to radar equipped ships, advanced radar schools, and maintenance activities.

Use of Submarine Bathythermograph Observations—Confidential—Navships 943-F. Instructions for the application of submarine bathythermograph data to the operational use of sonar gear and to ballasting and diving operations. 68 pages. Distributed to all submarines and submarine schools. Pages 1-6 and 15-40 of the August 1943 edition of this publication have been replaced by a new edition dated February 1944.

Use of Submarine Bathythermograph Observations as an Aid to Diving Operations—Confidential—Navships 900,018. Revision of a portion of "Use of Submarine Bathythermograph Observations." 13 pages. Distributed to all submarines and submarine schools.

ADDITIONAL TUBE TEST DATA FOR MODEL OZ SERIES TUBE ANALYZER

Test data on additional tube types as measured on the Model OZ series tube analyzers has recently been received from the manufacturer. This information does not appear in the instruction books furnished with the equipment. In order that these books may be brought up to date, the table is duplicated on a following page to permit removal from this Bulletin and insertion in the instruction book.

Tube type	Socket	Select.		Fil. (volts)	Potent.		Mut. cond.	Press	Notations
		A	B		L	R			
1A3	Blk. min	10	5	1.5	0	0		Diode	Also press 117N7 button.
1L4	Blk. min	1	7	1.5	43	16	1025	Ampl	Short on 4–5.
2C21	7-pin	10	3	6.3	51	14	1375	Ampl	Plt. No. 1.
2C21	7-pin	3	3	6.3	51	14	1375	Ampl	Plt. No. 2.
2C22	8-pin blk	7	2	6.3	67	11	3000	Ampl	(*).
2X2	4-pin	7	1	2.5	0	0		Rect. Std	OK over 1000*.
3A4	Blk. min	11	2	1.1	0	0		Diode	Short on 3–4–5.
3A5	Blk. min	8	8	3	60	12	2000	Ampl	Short on 4–5, Plt. No. 1.
3A5	Blk. min	6	2	3	60	18	2000	Ampl	Plt. No. 2, Short on 4–5.
3D6	Loktal	6	2	1.5	61	30	2100	Ampl	Short on 1.
5R4GY	8-pin blk	4	11	5	40	0		Rect. Std	Plt. No. 1.
5R4GY	8-pin blk	5	11	5	40	0		Rect. Std	Plt. No. 2.
6AB7	8-pin blk	4	2	6.3	69	0	3500	Ampl	
6AG5	Red min	1	9	6.3	67	0	3000	Ampl	Short on 4–5.
6AK5	Red min	1	9	6.3	71	0	4500	Ampl	Short on 4–5.
6C4	Ivory min	2	9	6.3	67	20	3000	Ampl	
6J6	Red min	1	2	6.3	72	0	5000	Ampl	Plt. No. 1.
6J6	Red min	11	8	6.3	72	0	5000	Ampl	Plt. No. 2.
802	7-pin	10	3	6.3	60	18	2000	Ampl	(*).
816	4-pin	7	1	2.5	20	0		Rect. Std	(*).
837	7-pin	10	3	12.6	71	0	4000	Ampl	(*).
958	Acorn	9	7	1.1	47	34	1200	Ampl	Short on 4–5.
959	Acorn	6	7	1.1	14	23	600	Ampl	Short on 4–5.
9006	Ivory min	2	9	6.3	20	0		Diode	Short on 4–5.

NOTE.—A star (*) appearing in "Notations" column indicates that the *plate cap* of the tube should be connected to the *upper left contact* of the 6-pin socket.

THIS PAGE MAY BE REMOVED FOR INSERTION IN THE INSTRUCTION BOOK

Tube type	Socket	Select.		Fil. (volts)	Potent.		Mut. cond.	Press	Notations
		A	B		L	R			
1A3	Blk. min	10	5	1.5	0	0		Diode	Also press 117N7 button.
1L4	Blk. min	1	7	1.5	43	16	1025	Ampl	Short on 4–5.
2C21	7-pin	10	3	6.3	51	14	1375	Ampl	Plt. No. 1.
2C21	7-pin	3	3	6.3	51	14	1375	Ampl	Plt. No. 2.
2C22	8-pin blk	7	2	6.3	67	11	3000	Ampl	(*).
2X2	4-pin	7	1	2.5	0	0		Rect. Std	OK over 1000*.
3A4	Blk. min	11	2	1.1	0	0		Diode	Short on 3–4–5.
3A5	Blk. min	8	8	3	60	12	2000	Ampl	Short on 4–5, Plt. No. 1.
3A5	Blk. min	6	2	3	60	18	2000	Ampl	Plt. No. 2, Short on 4–5.
3D6	Loktal	6	2	1.5	61	30	2100	Ampl	Short on 1.
5R4GY	8-pin blk	4	11	5	40	0		Rect. Std	Plt. No. 1.
5R4GY	8-pin blk	5	11	5	40	0		Rect. Std	Plt. No. 2.
6AB7	8-pin blk	4	2	6.3	69	0	3500	Ampl	
6AG5	Red min	1	9	6.3	67	0	3000	Ampl	Short on 4–5.
6AK5	Red min	1	9	6.3	71	0	4500	Ampl	Short on 4–5.
6C4	Ivory min	2	9	6.3	67	20	3000	Ampl	
6J6	Red min	1	2	6.3	72	0	5000	Ampl	Plt. No. 1.
6J6	Red min	11	8	6.3	72	0	5000	Ampl	Plt. No. 2.
802	7-pin	10	3	6.3	60	18	2000	Ampl	(*).
816	4-pin	7	1	2.5	20	0		Rect. Std	(*).
837	7-pin	10	3	12.6	71	0	4000	Ampl	(*).
958	Acorn	9	7	1.1	47	34	1200	Ampl	Short on 4–5.
959	Acorn	6	7	1.1	14	23	600	Ampl	Short on 4–5.
9006	Ivory min	2	9	6.3	20	0		Diode	Short on 4–5.

NOTE.—A star (*) appearing in "Notations" column indicates that the *plate cap* of the tube should be connected to the *upper left contact* of the 6-pin socket.

607735—44——3

FIELD MODIFICATION OF MODEL OF–1 EQUIPMENT TO OBTAIN USABLE OPERATING CHARACTERISTICS

Tests conducted by the Naval Research Laboratory on the performance characteristics of the Model OF–1 radio interference locating equipment indicated that the equipment in its original condition was not usable for its intended purpose. However, with certain minor modifications, it is possible to obtain usable operating characteristics.

Any person or activity capable of carrying out the specified changes is authorized to perform the modifications which are as follows:

(*a*) Use original tubes if possible; if the 1D5GP tubes are damaged, replace only with tubes selected for the following characteristics as measured on a General Radio Vacuum tube bridge type 561–C or equivalent: a plate current of 0.4 ma. or higher, and a transconductance of 145 or higher with 2.0V on the filament, 85V on the plate, 62V on the screen grid, and −6.15V on the control grid. If the bridge is not available, the tubes should be tested on a Navy Model OD Vacuum Tube Analyzing Equipment.

(*b*) Move attenuator and mount near attenuator switch to permit shortest possible lead lengths. (Less than one-half inch to the "X100" step if possible.)

(*c*) Pad "X100" step of attenuator (C–113) with sufficient capacity to permit correct adjustment at 1 mc. with 15 mmf. dummy in antenna lead. (125–225 mmf.)

(*d*) The load on the type 1P1 ballast tube must be adjusted to permit regulation of the filament voltage at 2.0 V. as the "A" voltage drops from 3.0 V. to 2.4 V. (Do not rely on OF–1 meter for "A" voltage measurements.) Proper adjustment usually can be made by paralleling R–120 with another resistor in the range 40 to 100 ohms. The correct value must be determined by trial for each set. This adjustment will apply only to the individual 1P1 and particular set of tubes employed. A replacement in either may require a new adjustment.

(*e*) Change the battery in the a–v–c bias to 3 V. Use the **Z** cell originally in parallel with the d. c. amplifier bias and connect it in series with a–v–c bias.

(*f*) Cut out multiple grounds on the coupled wave traps; i. e., cut the ground bus running from the common terminal of C–114 and C–115 to

the selector switch. Leave only one ground lead as shown in figure 4 of the instruction book.[1]

(*g*) Connect R–118 and R–119 in parallel. This can be done readily by shorting between "X" and "A" contacts of switch S–105 rear.

(*h*) Disconnect the screen lead of V–101 from its contact at the screen of the V–102 socket and connect V–101 to the positive terminal of the G–10 socket through a 30-ohm resistor.

(*i*) Disconnect the 1st i–f screen lead from its contact at the front section of the selector switch (S–107) and connect it directly to the positive terminal of the G–10 socket.[1]

(*j*) Cut out the wire that runs from the screen of the 1st i–f socket to one end of R–133. Connect that end of R–133 to the positive terminal of the G–10 socket.[1]

(*k*) Disconnect the lead from R–115 to the rear section of the attenuator switch at R–115 and connect this lead to the positive terminal of the G–10 socket through a 330-ohm resistor. (R–115 is no longer used.)

(*l*) Replace R–134 with a 375-ohm resistor or connect 500 ohms in parallel with R–134.

(*m*) Connect a 1,000-ohm resistor in series with R–133.

(*n*) Check alignment of i–f transformers and if necessary to realign, follow the instruction book for Model OF–1.

(*o*) Realign r–f section. Follow procedure in instruction book.

(*p*) Align i–f rejection circuit. Follow procedure in instruction book.

(*q*) Align output meter. Use procedure given in paragraph (*x*).

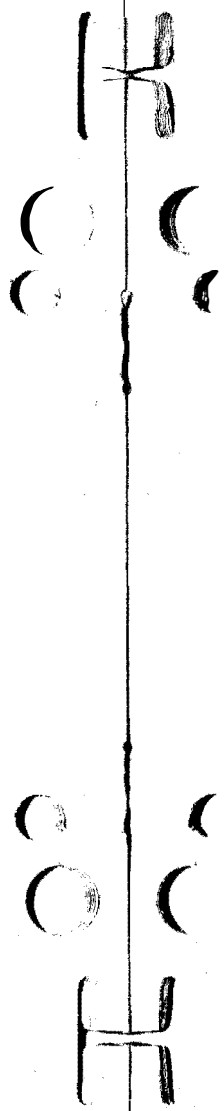
(*r*) Connect 5 mmf. in parallel with C–105 if necessary to increase gain at the lower end of band C.

(*s*) Check meter scale tracking on at least three frequencies on each band. If the set is in proper alignment, it should be quite uniform over all frequencies on the "X" and "A" bands, and within 10 percent error on all frequencies on "B" and "C" bands.

(*t*) If the output meter tracks differently at frequencies on the "X" band than at 1 mc. where it was aligned, the trouble is probably due to regeneration. To correct, tune the OF–1 to 300 kilocycles and without signal input observe the meter as the gain is advanced to maximum. A large meter deflection, 50 microvolts to full scale, indicates regeneration. Tune C–114 and C–115 for minimum deflection.

(*u*) Many factors influence the accuracy of the meter scale tracking at higher frequencies. The i–f resonance curve should be round topped and symmetrical. The oscillator should track perfectly at all frequencies and should have excellent frequency stability within the normal changes in plate and grid voltages which occur with various input signal levels and gain settings. An r–f trimmer and a mixer

[1] This change is in wiring only and does not involve a change in the schematic.



trimmer of proper capacity range are necessary to assure alignment of tuned circuits over the entire range of frequencies of each band. The ballast tube should be capable of maintaining a constant filament voltage. As none of these factors are met or wholly provided for in the design of the OF–1, errors in meter scale tracking are possible at spot frequencies within bands "B" and "C." The "X" and "A" bands have sufficient adjustments for good oscillator tracking. Uniform meter scale tracking results at all frequencies within the "X" and "A" bands. Insufficient adjustments on bands "B" and "C" result in nonuniform meter scale tracking.

(*v*) Calibration data should be taken in accordance with the instruction book of the OF–1. Any changes in tubes or alignment that affect scale spread of the meter made after calibration will necessitate new calibration curves.

(*w*) The following changes are suggested to improve the ease with which calibration adjustments can be made: Replace the tapered 2 megohm potentiometer R-130, used as gain control, with a 2 megohm linear potentiometer. Connect 100 ohms in parallel with R-132, the input control.

(*x*) The following procedure for scale alignment of the output meter is suggested in place of the procedure given in the OF–1 instruction book.

(1) Turn ATTENUATOR switch to ADJ. ZERO and set the meter needle to read 0 by adjusting the ZERO knob.

(2) Turn ATTENUATOR switch to 1. Apply a 100 microvolt signal at approximately 1,000 kc. to the ANT. and GND terminals. Tune the equipment to this frequency by means of the FREQUENCY and R. F. TRIMMER knobs. Adjust the GAIN knob for a meter reading of 100 microvolts. Set the signal generator for 1,000 microvolts and adjust R–127 for a meter reading of 1,000 microvolts. Repeat the gain adjustment at 100 microvolts input and the R–127 adjustment at 1,000 microvolts input until the 100 and 1,000 microvolt marks on the meter are in alignment with the signal generator.

(3) Decrease the signal generator output to 10 microvolts and check the reading of the meter. If the meter reads low, obtain a new zero adjustment in the manner given in (4).

(4) With the ATTENUATOR switch on ADJ, turn the ZERO knob counterclockwise to a position near its limit and turn R–128 clockwise part of a turn. This will unbalance the meter which must be made to read 0 by adjusting R–129.

(5) A change in R-129 upsets the previous 100 to 1,000 microvolt alignment of the meter, so repeat (2) and again check the reading for 10 microvolts input as in (3).

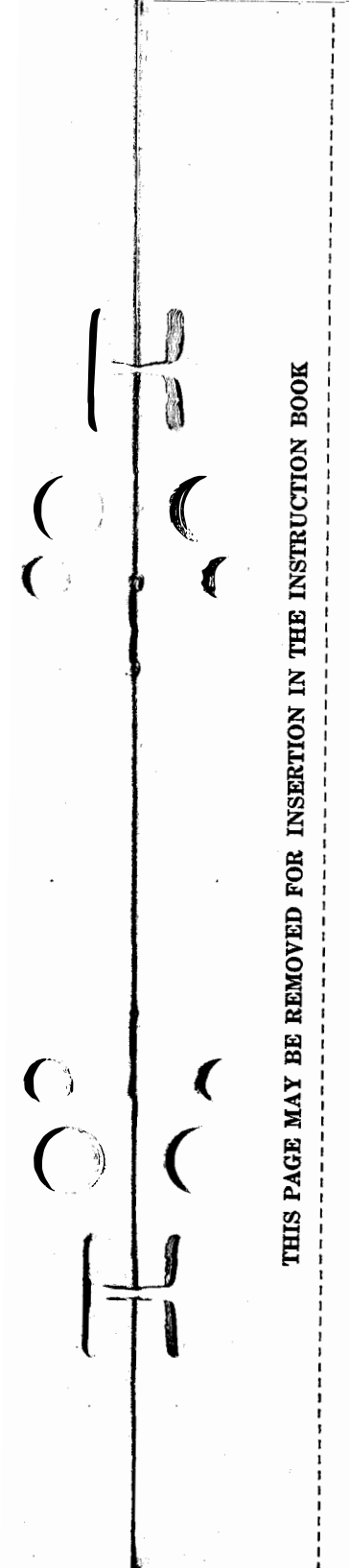
(6) If the 10 microvolt reading is still low, repeat (4) and (5).

(7) When a 10–100–1,000 microvolt meter alignment is obtained, check the readings at 40 and 400 microvolt inputs. If a low reading is obtained for a 40 microvolt input and a high reading is obtained for a 400 microvolt input, repeat (4) and (5), making adjustment of R-131 and R-128 in the same manner as when 10 microvolts read low.

(8) This may cause the meter to read high for a 10 microvolt signal. If so, repeat (4) and (5) until the percent error at the 40 and 400 microvolt levels is the same as the percent error at the 10 microvolt level. With matched tubes, selected for the OF–1, this will give meter scale tracking within 5 percent over the entire reading range of the scale.

(9) If the above procedure fails to yield good meter scale tracking, switch 1D5GP tubes in the r–f and two i–f stages to obtain a better match of tubes in the a–v–c stages. Then repeat alignment procedure above.

A revised schematic incorporating the field changes plus correction of a few errors in the original drawing is printed herewith. It is repeated on a following page to permit removal from this Bulletin and insertion in the instruction book.



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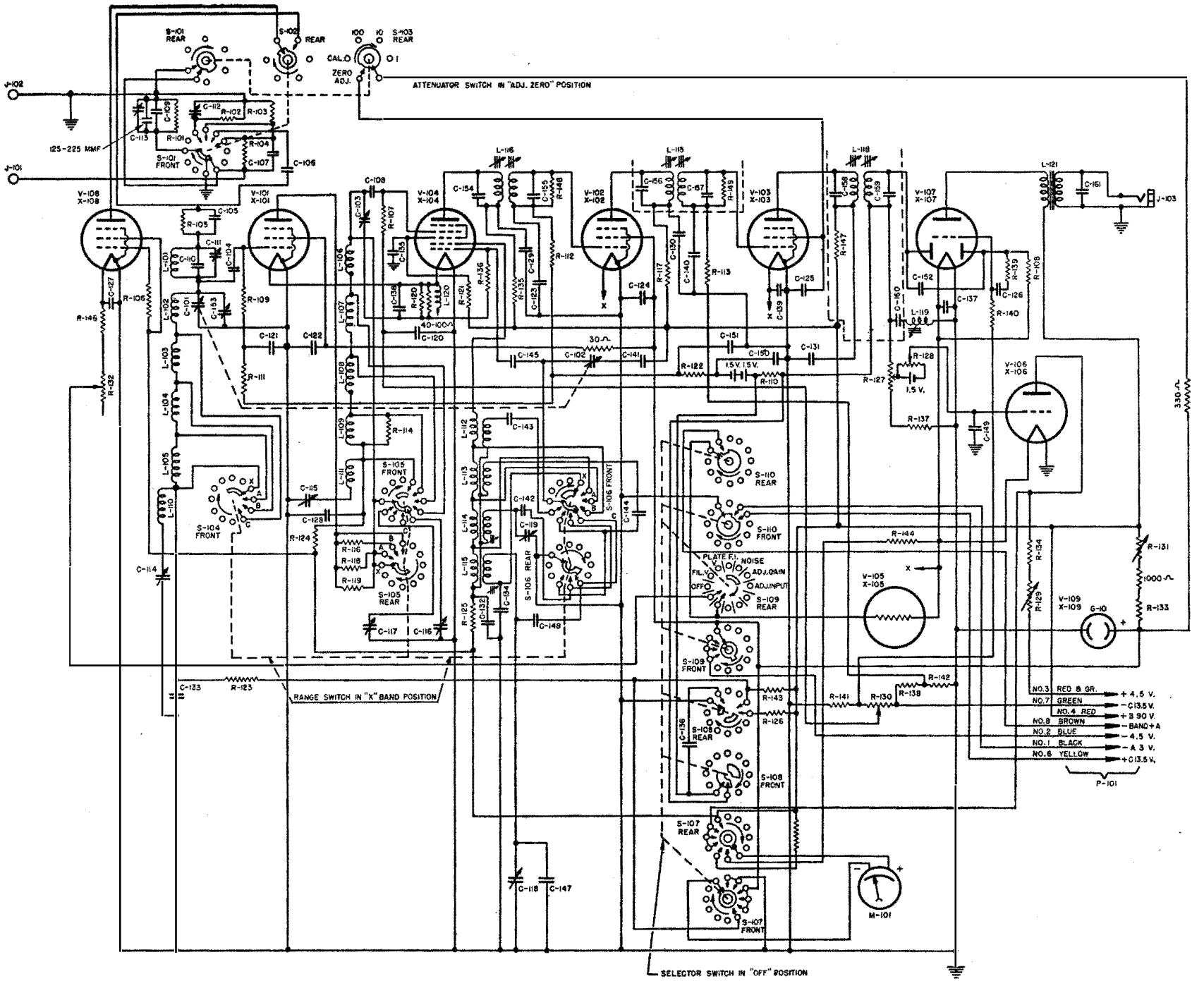

MODEL OF-1 SCHEMATIC

JOINT ARMY-NAVY SPECIFICATIONS FOR RADIO AND RADAR COMPONENTS AND MATERIALS

1. The Bureau of Ships and the Signal Corps, under the auspices of the Army-Navy Electronics Standards Agency [1] in Red Bank, N. J., have developed a number of joint specifications and standards covering radio, radar and sonar components and materials.

2. In addition to providing specifications where in some cases none existed, these joint specifications and standards are accomplishing numerous other results advantageous to the Army, Navy and manufacturers, briefly as follows:

Uniform terminology and type designation.
Interchangeability of parts.
Common stock pile and reduction of total inventory.
Increase of production.
Single Army-Navy inspection.
Single Army-Navy qualification testing.
Coordination of production among manufacturers.
Higher over-all quality.

3. To facilitate the use of standard components the Army-Navy Electronics Standards Agency has published a "Standard Components List" (3d edition, 10 June 1944). This is a book containing 80 pages of information compiled primarily for the guidance of contracting officers and prime contractors in the procurement of standard components for electonic equipment. The "List" comprises materials and components which, having been tested and considered satisfactory with respect to the qualification test requirements of the applicable standards, have been granted qualification approval by the Bureau of Ships, the Signal Corps, or both. There is an index to manufacturers of approved materials and components and, in addition, those acceptable upon approval of the contracting officer. Also there is a list of components under approved specifications which are stocked by the Electronic Research Supply Agency. The "Standard Components List" is revised periodically and a new edition issued as additional information warrants. Copies of this list may be obtained from the Bureau of Ships (Code 930D).

4. The following tabulation lists in the first column the specifications issued as JAN specifications or as (Proposed) JAN specifica-

[1] A complete summary of the background, purposes and procedure of the Army-Navy Electronics Standards Agency was given in the Bureau of Ships Radio and Sound Bulletin, No. 14, Apr. 1, 1944, on pp. 4–7.

tions, and in the second column jointly approved American War Standards ready for conversion to (Proposed) JAN specifications. Any of these may be used for procurement or design purposes. Together with these there are listed the specifications which ANESA has in the development stage, as indicated in the third column "In Progress," that will emerge as (Proposed) JAN specifications for procurement purposes and for processing as JAN specifications.

Joint Army-Navy specifications for radio and radar components and materials

[As of 1 August 1944]

Component or material	JAN or (Pro.) JAN	American War Standard	In Progress
CAPACITORS			
Fixed mica-dieletric	JAN-C-5		
Fixed paper-dielectric		C75. 16—1944	(JAN-C-25).
Fixed ceramic-dielectric	JAN-C-20		
Dry electrolytic			X.
Variable trimmer			X.
Molded paper-dielectric			X.
INSULATORS			
Steatite, radio	JAN-I-8		
Glass, radio	JAN-I-9		
Porcelain, radio	JAN-I-21		
Glass-bonded mica, radio	JAN-I-7		
Ceramic materials, class L	JAN-I-10		
Ceramic materials, class H	JAN-I-12		
METERS AND ACCESSORIES			
2½- and 3½-inch meters [1]		C39. 2—1944	JAN-I-6.
Shock-testing mechanism	JAN-S-44		
Ammeter shunts		C39. 5—1943	
RF thermocouple converters		C39. 4—1943	
External meter resistors		C75. 5—1943	
PLASTICS			
Laminated thermosetting			
Sheets and plates	JAN-P-13		
Molded thermosetting	JAN-P-14		
RESISTORS			
Fixed composition	JAN-R-11		
Fixed wire-wound (low tempeature)			X.
Fixed wire-wound (power type)	JAN-R-26		
Fixed wire-wound accurate			X.
Variable composition			X.
Variable wire-wound (low temperature)	JAN-R-19		
Power-type W-W rheostats	JAN-R-22		
MISCELLANEOUS			
Banana plugs (positive locking)			X.
Batteries, dry	JAN-B-18		
Cable, RF	JAN-C-17		
Crystal units CR-1	JAN-C-16		
Crystal units CR-2			X.
Dynamotors	JAN-D-24		
Fuses			X.
Moisture and fungus resistant treatment			
Plugs and jacks, telephone type			X.
Plugs and recept. multicontact			X.
RF choke coils			X.

[1] Use Bureau of Ships 17-I-12 (INT).

Joint Army-Navy specifications for radio and radar components and materials—Continued.

Component or material	JAN or (Pro.) JAN	American War Standard	In Progress
Sockets, lamp and assemblies			X.
Sockets, vacuum tube, miniature	JAN-S-28		
Switches, rotary			X.
Switches, sensitive			X.
Switches, toggle		C75.15—1944	(JAN-S-23).
Switches, vacuum	JAN-S-57		
Transformers and inductors			X.
Tubes, radio electron	JAN-1A		
Vibration mounts			X.
Vibrators			X.
Wire, hook-up			X.

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NEW CONTAINERS FOR TYPE CWL-861 ELECTRON TUBES

The new and old shipping containers for the Type CWL–861 Electron Tube is shown in figure 1.

In order to conveniently test this tube for continuity without removing it from the container, the Westinghouse Electric & Manufacturing Co. recommends that the bottom of the case (the end opposite the handle) be opened. The test can then be made as illustrated in figure 2. After testing, the container should be carefully resealed with tape.

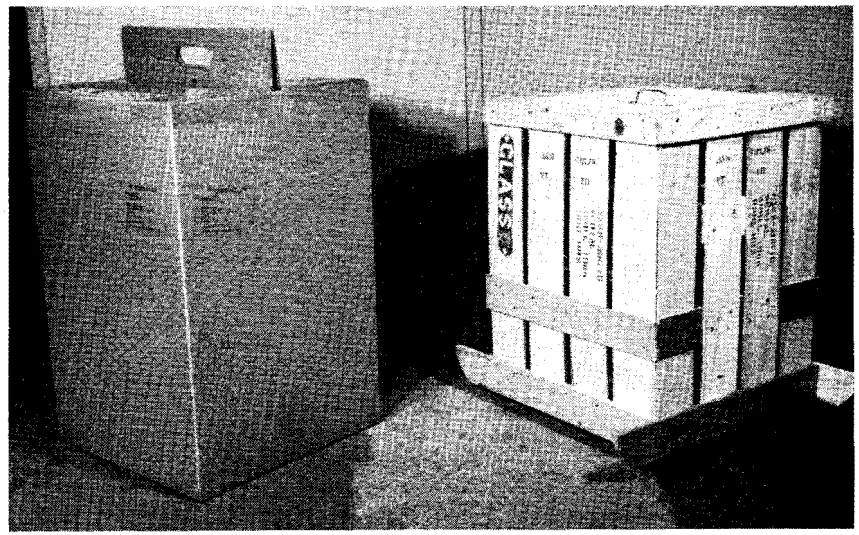


FIGURE 1.—Old (right) and new (left) containers for the Type CWL–861 Electron Tube.

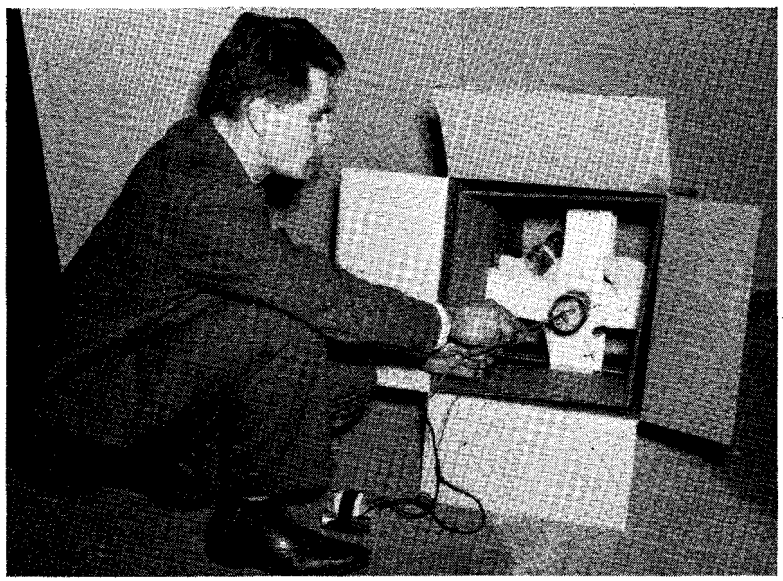


FIGURE 2.—Method of testing Type CWL–861 Electron Tube without removing it from the shipping container.

CORRECTION TO PRELIMINARY INSTRUCTION BOOK FOR MODULATOR-ADAPTOR, TYPE RF–9/UPT

The following Corrections should be made in the preliminary instruction book for Modulator-Adaptor, Type RF—9/UPT:

Page 1.—First line of paragraph 2.1. Between the words "the" and "second" insert the words "first or".

Page 2.—Last line of second paragraph in section 3.3.1. Change "100 Kc" to "115 Kc".

Page 3.—First sentence of second paragraph in section 4.2. Between the words "first" and "stage" insert the words "or second".

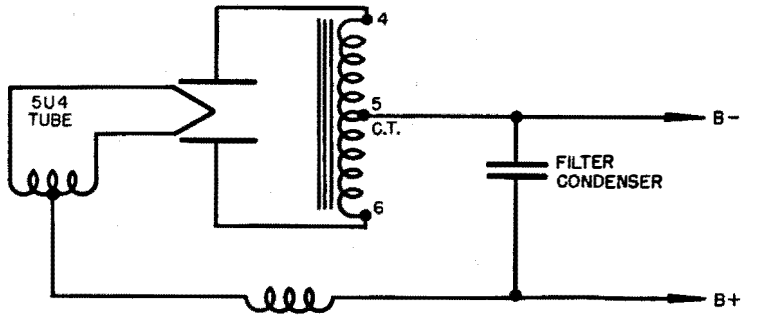
Page 3. Between the second and third paragraphs of section 4.2 insert the following:

> **Note:** In some equipments the plug should be in the first 6AC7 socket; in the second in others. If the video gain is high and the first tube is used, then the drive will be too great and the modulation will always be too high. On the other hand the plug in the second stage of a low gain system will not give sufficient modulation. In the new gas tube video systems now being introduced into many equipments there is only one stage of video amplification.

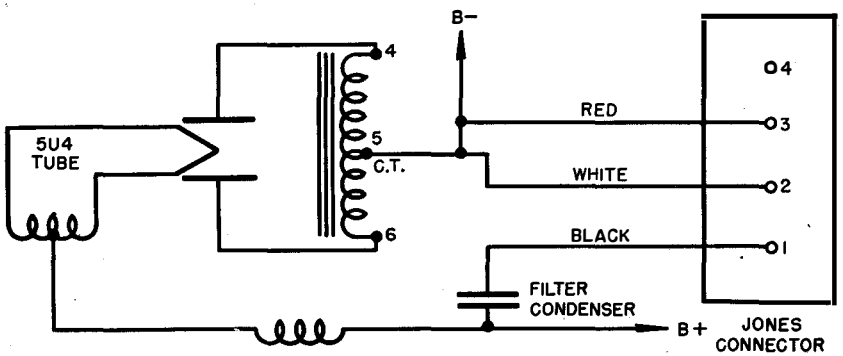
Page 3.—Delete the entire second and third paragraphs of section 4.2.1.

Page 4.—Fourth sentence of first paragraph of section 4.3. Change the word "decreases" to "increases".

Page 9.—Correct schematic of Mandrel—AN/APT–3 (upper section of fig. 3) as follows:



Page 9.—Correct schematic of Mandrel—AN/APT–3 (lower section of fig. 3) as follows:



Page 10.—Delete the entire page (fig. 4).

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CORRECTION TO ARTICLE ON FM EQUIPMENTS

An article containing some maintenance notes on Galvin FM radio equipment was published in Radio and Sound Bulletin No. 15. The Radio Material Officer at Navy Yard Mare Island, has called the Bureau's attention to an error in the paragraph on "Receiver Alignment", page 43. Starting with the twenty-third line the paragraph should read as follows:

> Now using a fairly strong unmodulated input signal, tune the T8R discriminator transformer "Low" adjustment to maximum meter reading. Then de-tune to ⅔ maximum reading by turning the "Low" adjustment in the direction of the arrow. Next, turn the METER SWITCH to position "4" and tune T8R "High" adjustment to zero. This completes the discriminator adjustment.

FIELD DISTRIBUTION OF INSTRUCTION BOOKS

The following is a partial list of the radio and sonar instruction books which have been supplied to Radio Material Officers for further distribution to ships and stations. Copies may be obtained by visiting or writing the nearest radio material office. Instruction books for radar equipments are for the most part distribution through the Registered Publications System and carry ENG or SHIPS short titles. These publications are available at the various Registered Publications Issuing Offices. Consult the R. P. S. allowance list (RPS 6A) before writing to the Bureau of Ships.

DAG	RAK–8/RAL–8	RBO–2
DP–15	RAO–5	TAJ–19
LM–11	RAS–4	TBK–8/TBK–10
LM–12	RAS–5	TBK–12
NJ–3/NJ–9	RBA–1–2–3	TBX–6
NK–2	RBF–3	TCA–1
NMA/NMB–2	RBJ	TCB–1
NMC	RBJ–4	TCC–3
OAP	RBL–4	TCC–4
OS–2/OS–3	RBL–5	TCS–5
QBG	RBO	YG
QCL–7/QCL–8	RBO–1	WEA

Type CCL–211014/CCL–211018 Motor Generators.
Type CCL–21914 Motor Alternator Sets.
Type CCL–21920 Motor Alternator Sets.
Type CCL–21923 Motor Alternator Sets.
Type CKB–23411 Mixer Calibrator Units.
Type CKB–50172 Antenna Multicoupler Units.
Type CQA–55098 BDI.

THE FORUM

AN INFORMAL DISCUSSION OF COMMUNICATION MATERIAL MATTERS OF INTEREST TO THE SERVICE

The purpose of THE FORUM is to provide a means for publishing informal comments by members of the naval service on matters of interest to others in the radio field. These contributions need not have official status, and thus a medium is offered for the expression of personal opinion and observation. Comments, suggestions, experiences, difficulties, and other items concerning radio equipment are welcome at all times. Material of this kind is not only interesting to other radio personnel but is of great value to the Bureau.

Contributions may be prepared as informally as desired. They should be forwarded via the commanding officer to the Radio and Sound Bulletin, Bureau of Ships (Code 993), Navy Department, Washington, D. C.

A RADIO INSTRUCTION PANEL

B. H. Spilmer, Chief Radio Electrician, USNR, U. S. S. *Mackinac*

While endeavoring to instruct students in the basic fundamentals of radio, it was found that their progress was greatly impeded by having nothing tangible with which to work. Lack of imagination in many cases made any amount of careful explanation ineffective, and the limited amount of equipment for practical demonstration aboard ship made it difficult to present the subject in an interesting manner. Thus it was decided to mount sufficient parts in such a manner that the student could observe them and their action in various circuits involving resistance, inductance, capacitance, and the vacuum tube. While this idea is by no means new, it is felt that others confronted with educational problems aboard ship may be interested in seeing what has been done on a relatively small scale to train radio personnel.

In order to obtain the necessary parts for the undertaking, the "Junk Box" and an old personal radio were robbed. The parts are mounted on a piece of quarter-inch plexiglass, 20 inches long and 12 inches high. (See figs. 1, 2, and 3.) The plexiglass is secured to a wooden frame which serves to hold the panel in an upright position

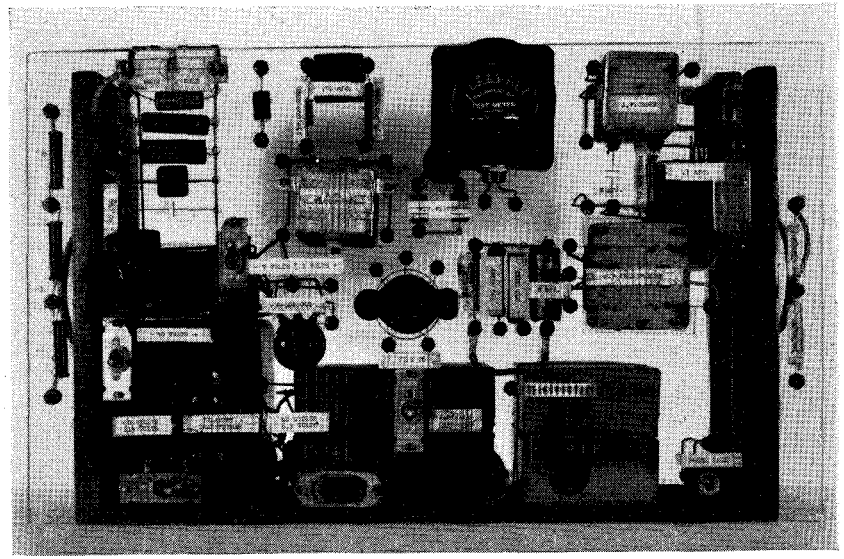

FIGURE 1.—Front view of instruction panel.

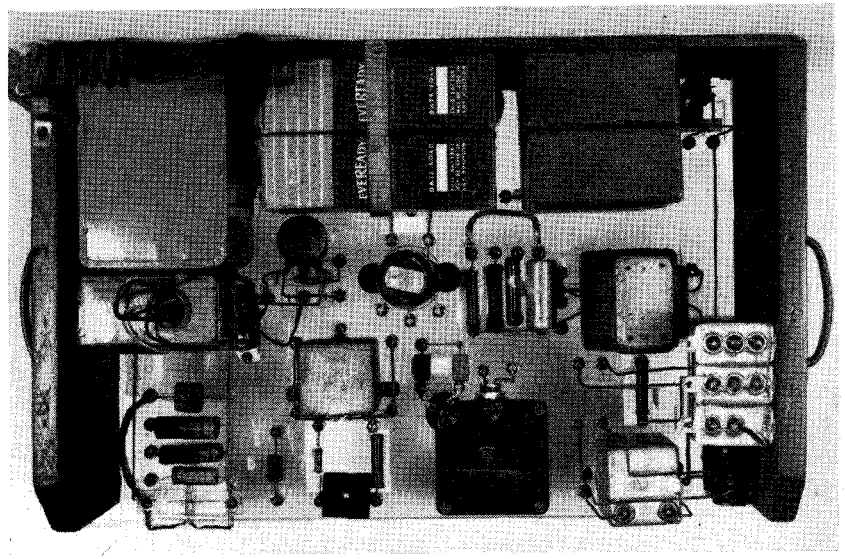

FIGURE 2.—Back view of instruction panel.

and contains the necessary batteries and heater supply transformer. The connections from each part are brought through to the front of the panel with brass machine screws to permit interconnection by short jumper wires. On the front of the panel a standard symbol is engraved over each part, thus allowing the student to associate the two more readily. A schematic diagram is given in figure 4.

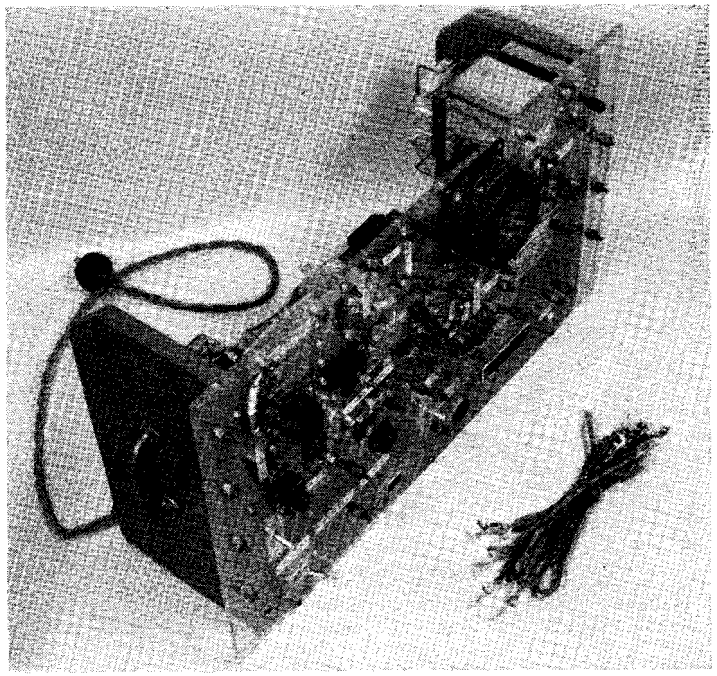

FIGURE 3.—Oblique front view of instruction panel.

The instruction panel was designed so that the student could first study the basic radio components separately, and then observe their action in audio frequency circuits. Its basic element is a single stage audio amplifier, employing either resistance or transformer-coupled input and output. Provisions are included to allow the use of either a cathode bias resistor or variable battery grid bias. The tube used is a type 76 triode which obtains its heater voltage from a transformer mounted on the frame. Two separate 90-volt battery supplies are provided, each consisting of two Eveready Mini-Max type No. 482 "B" batteries. Two 7½ volt "C" batteries are connected across a 500,000 ohm potentiometer to provide a variable grid bias ranging from zero to plus or minus 7½ volts. An aircraft type milliammeter (0–35 ma.) is mounted on the front of the panel, and is usually left connected in the plate circuit of the vacuum tube.

On the upper left hand portion of the panel are mounted the parts for a neon-bulb saw-tooth oscillator, the frequency of which may be varied between 40 and 9,000 cycles per second. The neon bulb used is one of the "fuse indicator" type which fires at approximately 70 volts. One of the 90-volt power supplies mentioned above is permanently connected to the saw-tooth oscillator through a toggle switch. The output of this oscillator is used to excite the grid of the amplifier. Using a vacuum tube voltmeter and an oscilloscope, the voltage and wave-forms may be checked at any point in the circuit. This

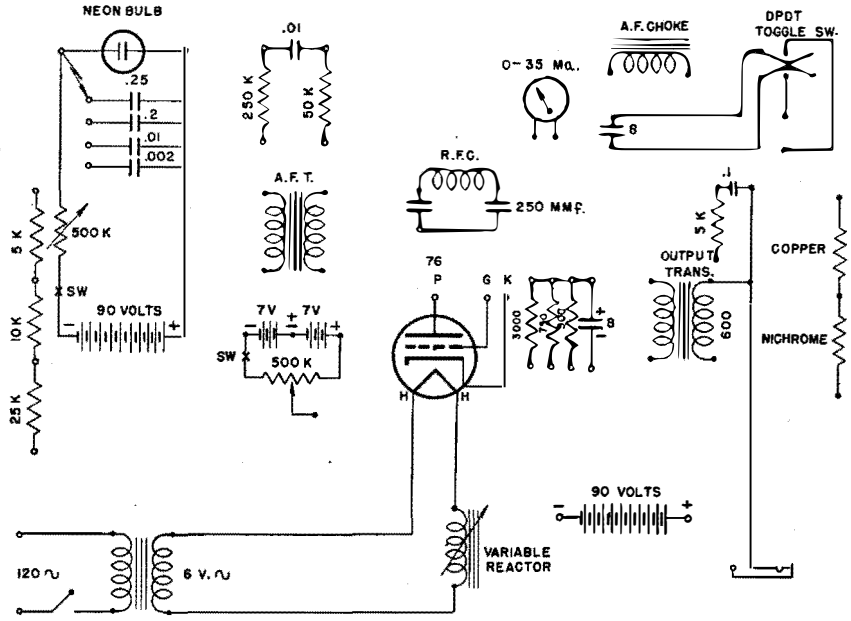

FIGURE 4.—Schematic diagram.

makes it possible to give a step-by-step demonstration of the function of each part in the oscillator and amplifier circuits. By coupling the outputs of an external audio oscillator and the saw-tooth oscillator to the grid circuit, the vacuum tube may be used as an audio "mixer" to give a simple demonstration of the heterodyne action and harmonics. The theory of "feed-back" can be explained by constructing a simple audio oscillator circuit around the triode and audio transformer.

On the extreme right-hand edge of the panel are mounted two small coils of wire, one of copper and one of nichrome. These are used to demonstrate the resistance properties of the two metals. When the principles of resistance are thoroughly understood, the various other resistors are pointed out and measured, and the different types noted.

On the extreme left, three resistors are mounted which form a simple voltage-divider network. By connecting one of the 90-volt battery supplies across the network and placing external loads at various points, the effects on the voltage at any given point is easily shown. In working out several problems involving this voltage-divider, the student obtains a clear picture of the action involved. The voltage-divider was included because most men have great difficulty in thoroughly understanding its function and varied uses as well as its drawbacks in certain applications.

The variable reactor shown in the diagram was made by winding approximately two hundred turns of #24 enameled copper wire on a one-inch form. This form is cemented in a hole cut in the panel near the bottom and center. By inserting various metals as a core, the voltage drop across the coil can be measured for each type of core material used. This demonstrates the effects of inductance and the magnetic properties of different metals. When another coil of wire is placed around the inserted core, the effects of mutual induction can be observed. A pair of earphones connected across the latter coil serves as an indicator. The effects of coupling are shown by varying the coupling between the two coils and noting the changing response in the earphones.

In the upper right-hand corner is mounted an 8 microfarad paper condenser and a double-pole-double-throw toggle switch. As will be noted in the diagram, the switch is so connected to the condenser that the polarity of an applied voltage may be rapidly reversed, thus simulating the action of an alternating current. By connecting an ohmmeter across the terminals of the switch as a combination indicator and voltage supply, the effects of rapidly reversing the polarity of voltage applied across the condenser can be seen, making the explanation of capacitance and its effects in a circuit more readily understandable. When a vacuum tube voltmeter is connected across the condenser terminals, the current can be seen to "lead" the voltage as the condenser is charged.

The type 76 triode is employed to show the theory of vacuum tube operation and characteristic analysis. For this demonstration external voltmeters are used to measure the plate and grid voltages as they are varied. The extreme sensitivity of the control grid can be impressively shown by watching the plate meter vary as the hand is brought near a short piece of wire connected to the control grid. The flow of grid current with and *without* plate or grid voltage applied has proven of special interest to the men in their study of electron theory. Also the vacuum tube has been much easier for the men to understand after the above experiments.

In general the instruction panel described has proven extremely helpful in training technical personnel. The two factors of particular value are: the time saved by having this collection of parts accessible as a small unit, and the clarity and ease with which the functions of the various parts and circuits are shown. The panel is complicated enough to prepare men for working with more complex equipment in the future. As the student becomes familiar with the parts and their uses, his interest is increased for further experimentation and study.

Bureau comment.—This type of demonstrator is generally recognized as a valuable training aid. The ingenuity in salvaging otherwise useless components for this purpose is highly commendable. Attention is invited to the last paragraph which states that "the panel is complicated enough to prepare men for working with more complex equipment." This is important to bear in mind in constructing demonstrators or experimental set-ups. Frequently the purpose of these layouts is defeated by streamlining to the point that the student fails to grasp the significance of the experiments he is performing.

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