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FRONT COVER— Illustrating the terrifying effects of electric shock, the artist has pictured two causes of death: overheating and respiratory block. See page 12 for an interesting and educational article on the subject.

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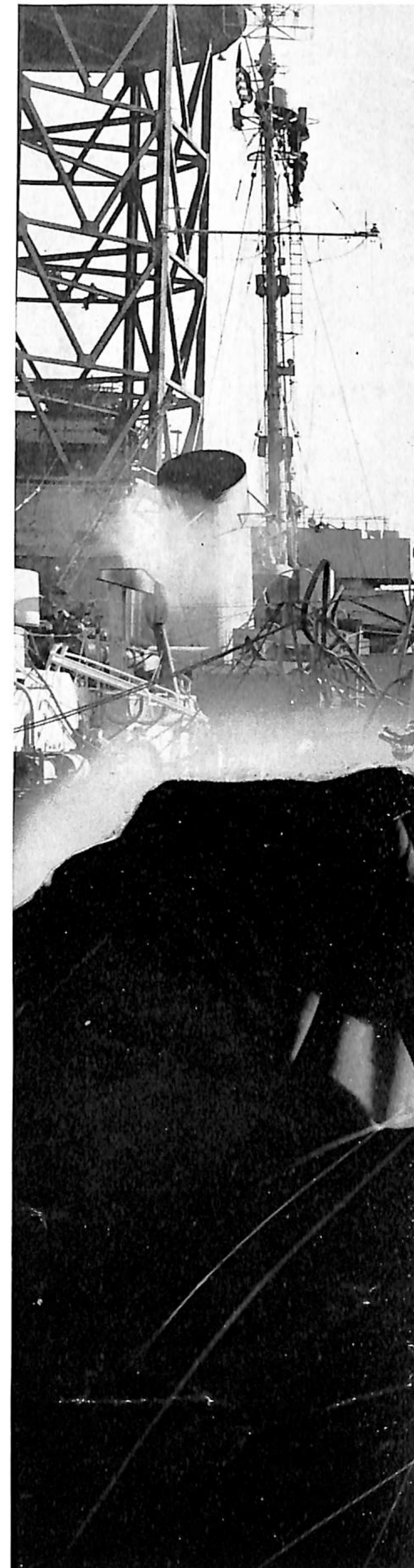
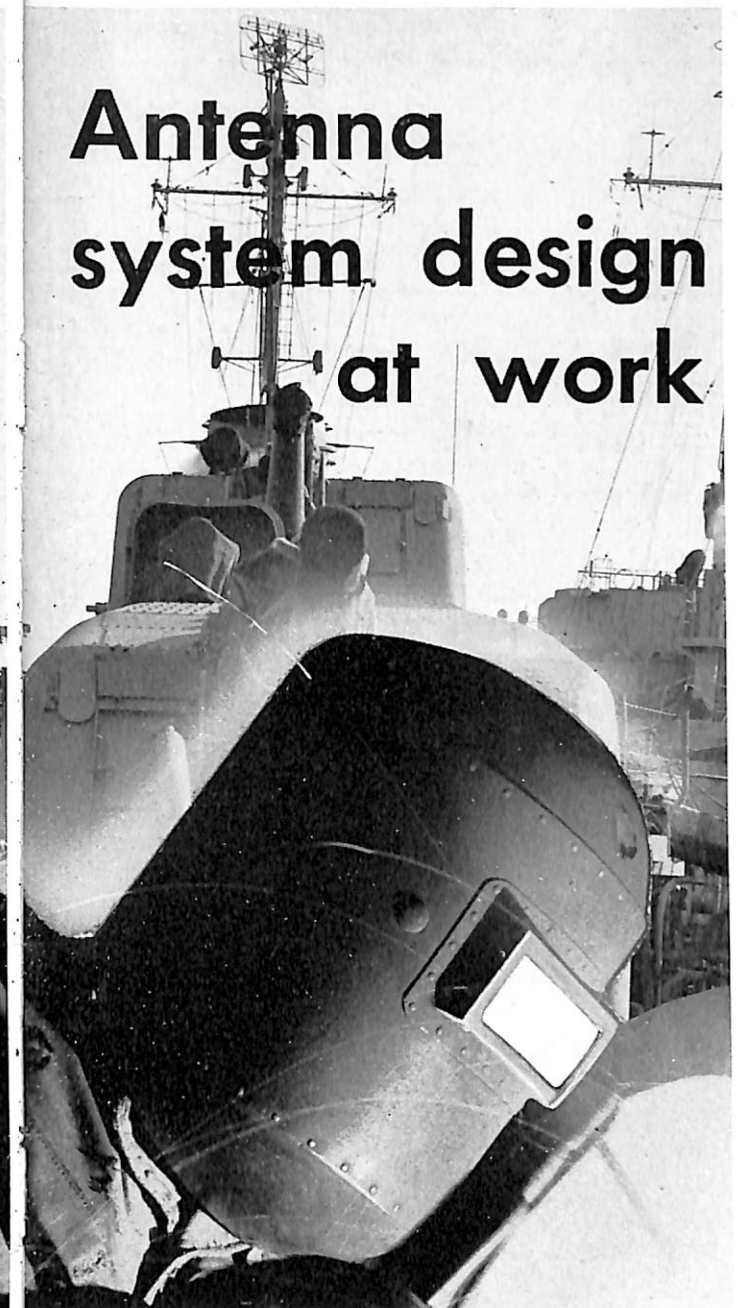
BUREAU OF SHIPS — NAVY DEPARTMENT





Antenna system design at work

By R. T. Brackett

■ In the preceding three articles of this series the need for better shipboard antenna performance has been described, the aims of the extensive development program undertaken by the navy to obtain such improved performance have been set forth, and some of the problems met in the course of the development and the methods utilized to solve these problems have been recounted. In this, the last of the series, is presented the story of the application of some of the concrete results already gleaned to an actual example—the arrangement and the individual characteristics of antennas on board a destroyer.

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INTRODUCTION

The current trend of antenna system development, the first fruits of the project of antenna development and improvement initiated by the Bureau of Ships, is best shown by a detailed example of the application of antenna systems engineering. For this purpose we shall examine in this article a proposed systems arrangement for a destroyer of the DD-692 Long Hull Class. It shows what may be achieved through careful and coordinated system planning, even at this relatively early stage.

The governing principle to be followed in the development of an antenna system was referred to in an earlier paper as the Systems Engineering Doctrine. We summarize it as follows:

"The assemblage of antennas on a naval vessel must be considered as an electronic system, whose performance is to be evaluated in terms of the con tribution of the whole system to the combat efficiency of the vessel. Regardless of potential enhancement of the performance of a particular antenna, no concessions shold be made to any one antenna in matters of design or location at the expense of the efficiency of the system as a whole."

In planning the Antenna Systems Engineering projects currently under way, the Bureau of Ships, with the assistance of the U. S. Navy Electronics Laboratory, is attempting to foresee future requirements for frequency channels and equipment type allowances. As these requirements change, the developmental program will be modified accordingly.

The primary operational requirements for the electronic equipment of each specific type of vessel are set forth by the Chief of Naval Operations. It is his prerogative to determine the minimum number of operating channels and the minimum acceptable range for radios operating on each channel. It is of course much easier to foresee future requirements than it is to forecast the nature of future equipments which will be developed to meet these requirements. Therefore, the Bureau of Ships has specified that currently-available equipments be utilized in present system arrangements. These will be modified by replacement of some items with others of more recent design which will become available at a future time. The task of the Laboratory is to specify antenna facilities for the equipment, together with transmission lines and distribution systems where needed.

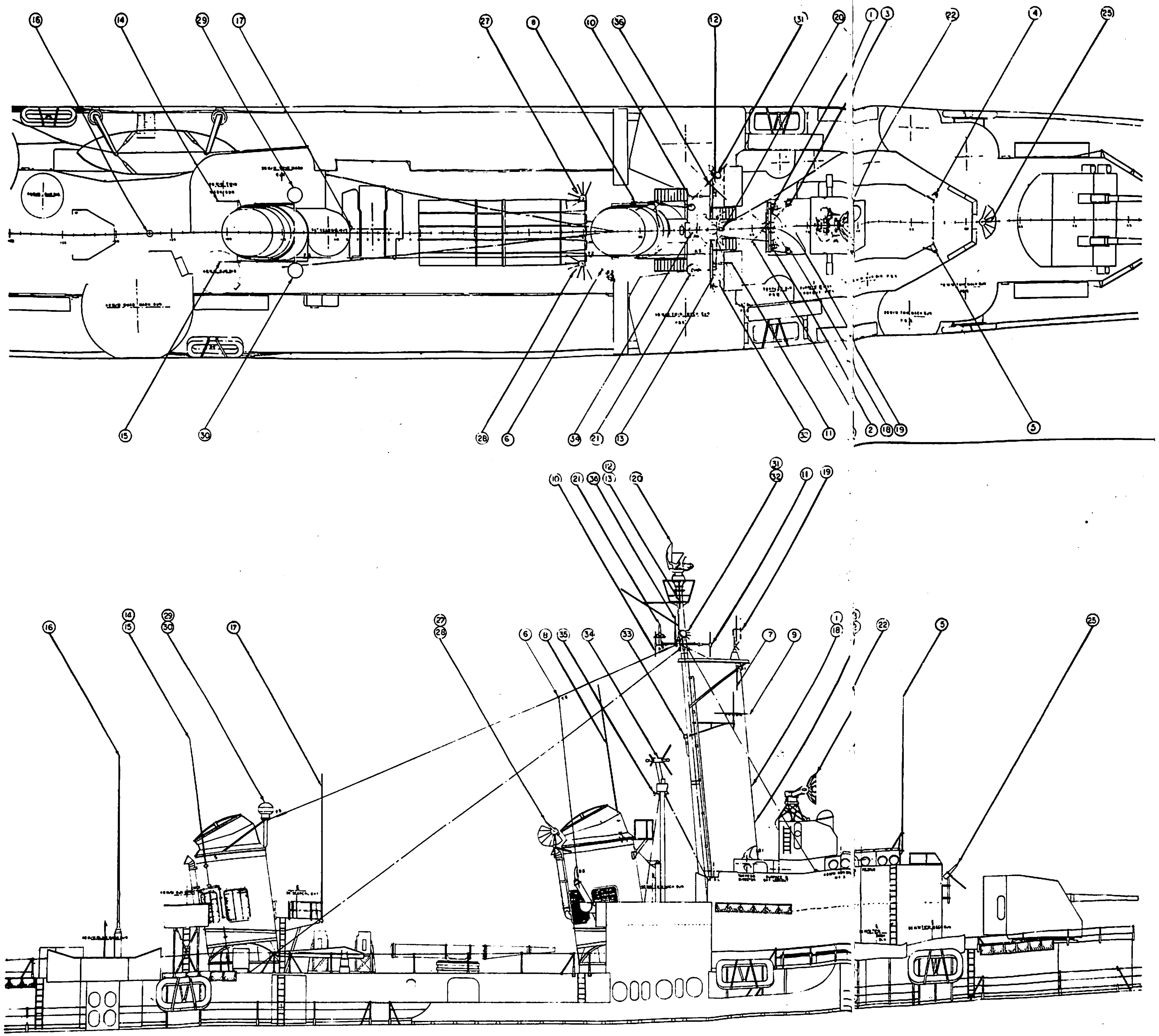

FIGURE 1—*Starboard profile of DD-692 Long Hull Class Destroyer. Proposed improved antenna rearrangement.*
FIGURE 2—*Same as figure 1, top view.*

TABLE I—*Key to Anntennas (Figures 1 and 2).*

Key	*Equipment*	*Key*	*Equipment*
1	Receiving	18	Receiving
2	Receiving	19	SR-6/BM
3	Receiving	20	SG-6
5	Receiving	21	BK
7	RBK	22	Mark 25
8	TBL	25	RCM
9	TBS	27	RCM
10	TDQ/RCK	28	RCM
11	TDQ/RCK	29	DBM
12	TDZ/RDZ	30	DBM
13	TDZ/RDZ	31	RCM
14	Receiving	32	RCM
15	Receiving	33	SPR-2
16	TBL	34	TDY-1
17	TCS	35	TDY-1
		36	MBF

DETAILED SYSTEM ARRANGEMENT

The proposed improved equipment type allowance for the DD-692 is listed in table II, and illustrated in figures 1 and 2, which show the placement of the various antennas, and to which frequent reference will be helpful throughout the remainder of this article. We now consider this in detail, concerning ourselves with the individual antennas.

We have remarked that reciprocal influences are exerted between an antenna and the surroundings in its neighborhood. Usually the results are not favorable. It can be shown that this influence extends approximately to a distance $\frac{1}{2}\ \lambda$. The larger areas are dominated by the longer-wave antennas: that is to say, those operating at medium and high frequencies. It seems logical therefore to complete the arrangement for these first, so as to establish the neighborhood within which the v-h-f and u-h-f antennas will have to operate. Most of the medium-and-high-frequency equipments are located in or near Radio Central. This space therefore provides a logical starting point.

Topside clear areas near Radio Central extend forward of the foremast to frame 63 and aft of the foremast toward No. 2 stack. The largest antenna required will be for operation of one model TBL equipment at medium frequencies, which will necessarily occupy the largest available clear space. For this there is installed a single-wire flat top No. 6 between the yard at frame 83½ and the bracket on the stack at frame 113½, placed somewhat to

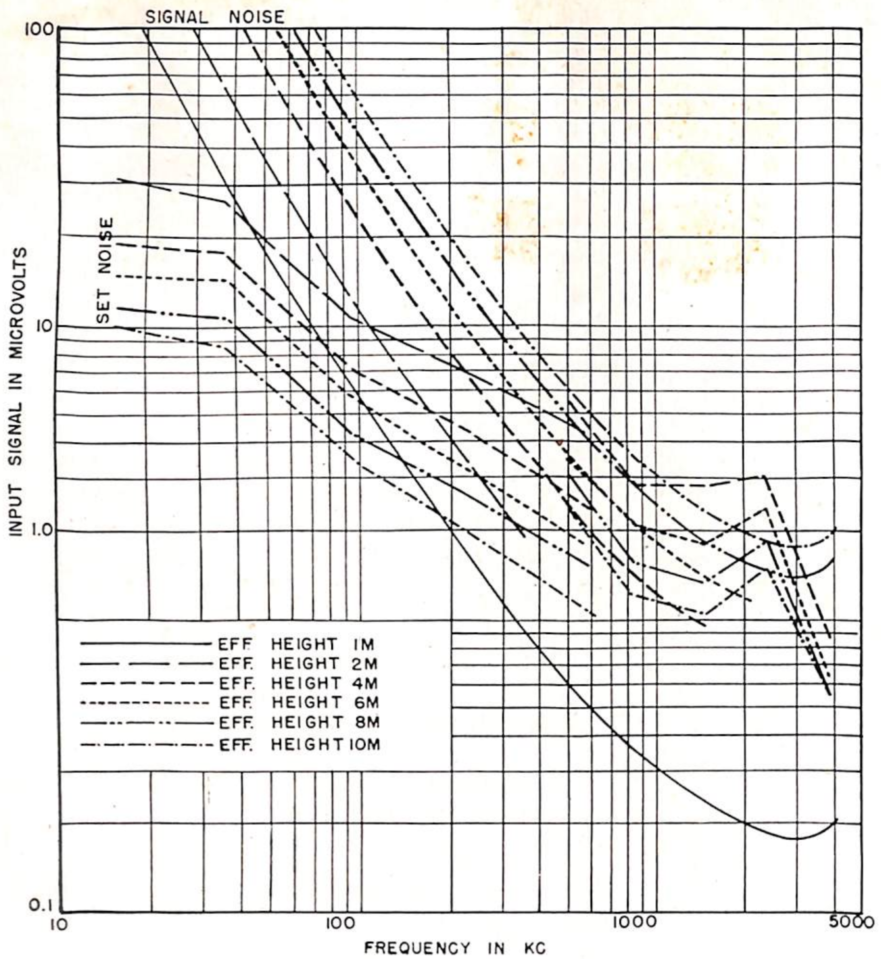

FIGURE 3 — *Average atmospheric noise in the San Diego area, and navy model receiver set noise, both plotted against frequency, for antennas of various effective heights.*

starboard of the centerline in order to clear the emergency halyard. The performance at medium frequencies could be improved somewhat by the employment of the usual two wires, port and starboard, but the gain would not be great. The performance at high frequencies would be somewhat impaired. TBL No. 1 in Radio Central is employed with this flat top together with the existing trunk, which terminates somewhat to starboard at frame 92½. The lead rises without forward rake, in order to increase the clearance between it and the receiving antennas over the pilot house top. The remaining TBL antenna, No. 16, is placed as far from the first as feasible. It is a whip antenna on the centerline at frame 127. To avoid hazard to personnel, the trunk is extended vertically seven feet above the deck and surmounted by a twenty-eight foot whip. Electrically the combination is a thirty-five-foot whip with an elevated driving point.

Antennas for the Model TCS Transmitting-Receiving Equipments do not receive such favored locations. The forward one, No. 8, is at frame 88, on the port side of the stack, while the after one, No. 17, is at frame F ½, on the port side of the searchlight platform.

In the shipboard tests the forward TBL antenna has given acceptable performance from medium frequencies up to about 12 Mc. The after TBL antenna performed well at 2 Mc and above, but is not to be used at 575 kc and below. Consequently, two medium-power channels are available in the sub-spectrum 2-12 Mc, while one is available throughout each of the two remaining portions of the range of the model TBL transmitting equipments. The low-power (TCS) antennas have not yet been tested.

We will next consider some factors governing the installation of the receiving antennas. It has long been felt that in a shipboard antenna installation the length limitations impose serious restrictions upon the performance of receiving antennas. Actually, such is not necessarily the case, as the following considerations will show:

Obviously, to be received clearly a signal must be strong enough to override noise. We may assume, therefore, that the incoming signal is stronger than the atmospheric noise, or it could not be received at all. It is sufficient, then, to employ an antenna only long enough so that the receiver can pick up atmospheric noise in the absence of signal. It automatically follows then that the signal can be heard in the receiver. Figure 3 is drawn for some typical navy receivers operating in the San Diego area with antennas of various effective heights. The jagged lines give set noise signal and the smooth curves average atmospheric noise signal, both as functions of frequency. From these curves it can be seen that as the effective height of the antenna is increased the set noise goes down and the atmospheric noise prevails throughout almost the complete range. Therefore in the San Diego area there is, on the average, little to be gained by employing a medium or high-frequency antenna of greater than four meters effective height. For a conventional installation and with short transmission lines this means from twenty-five to thirty-five feet of aerial conductor.

It may be observed that with such short antennas the receiver r-f gain control must be turned up higher. This is really not an objection, though to some it may seem so. All navy communications receivers are built with sufficient sensitivity so that at full gain the inherent set noise can be heard. If the antenna is sufficiently long so that atmospheric noise overrides set noise, then the set can pick up any signal which prevails over atmospheric noise. Where the r-f gain control is set is of little consequence. It is this consideration which has led us to accept rather short lengths for the m-f and h-f receiving antennas in this antenna-systems plan.

The next consideration is how, by proper employment of isolating resistors, the receiving equipments may be more judiciously paralleled.

Naval Research Laboratory studies have so far been conducted only on unmodified receiving equipments, and have led to the formulation of some specific rules, a few of which are as follows: a—No isolating resistor should be used when a single receiving equipment is employed on an antenna; b—The common 56-ohm value is acceptable for an isolating resistor, except when two RAK or two RBA equipments are connected in parallel; c—Usually two model RBA or two model RBC equipments will operate satisfactorily in parallel without isolating resistors; d—Two model RBB equipments require isolating resistors for satisfactory operation; e—A model RBB and a model RBC equipment require an isolating resistor for the model RBC for satisfactory operation of both equipments.

In figure 4 is shown how these principles have been incorporated into the instructions engraved on the distribution panels. For example, in diagram 4, applicable to Emergency Radio, it is seen that the upper three jacks are exactly alike, although they are marked differently. However, in going from single-equipment to parallel operation, the radioman automatically observes rules (a) and (e) above. He does not have to remember these rules; he does not have to make any decisions. He has only to follow the printed instructions. Two of these antennas, Nos. 4 and 5, are twenty-five-foot whips, located to port and starboard at frame 63, and bracketed off the pilot house top. The remaining four are closely-spaced pairs, Nos. 1 and 3 to port and Nos. 1 and 4 to starboard near frame 77, rising nearly vertically from the pilot house top to brackets off the SR-6 radar platform. These positions are selected well forward so as to reduce absorption of power from the transmitting antennas. Two more whip antennas, No. 29 and 30, are bracketed off No. 2 stack for receiving equipments in Emergency Radio. In this area it is not possible to obtain such good separation as forward.

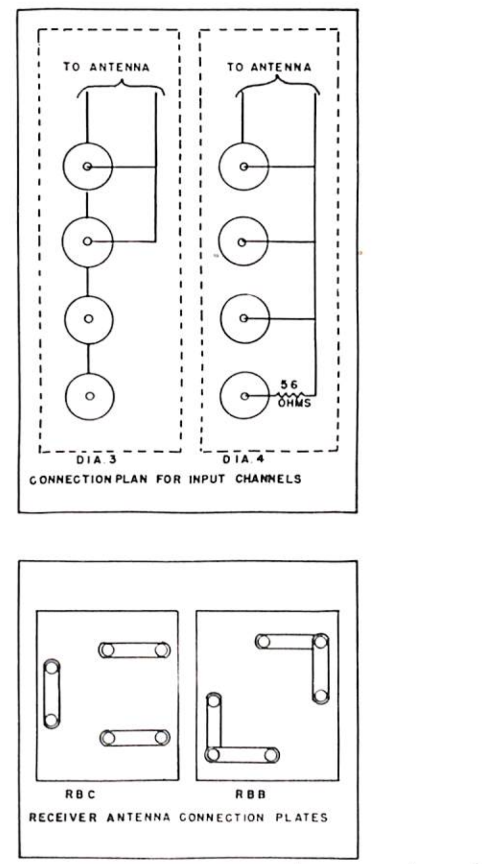

FIGURE 4—*Receiver transfer panel connections in Emergency Radio Room (antennas 14 and 15).*

The v-h-f channels for tactical circuits are currently employed by equipments which, while of established use, are retained on an interim basis. They will be superseded ultimately by the equipments operating on u-h-f channels. The TDZ/RDZ antenna assemblies, Nos. 12 and 13, will be found at masthead height, surmounted only by the SG-6 radar platform. It remains, however, to so locate v-h-f antennas that effective operation will be maintained.

The simplest procedure is to leave the TBS assembly, No. 9, in the present bracket forward of the mast and below the SR radar platform. The MBF and TDQ/RCK assemblies, Nos. 36, 10, and 11, may then be mounted on the yard. These positions have been tried in the past and have been found acceptable. The inverted monopole No. 7 beneath the SR-6 radar platform is used with the model RBK receiving equipment for RASER. It is so placed as to give moderate directivity at the frequencies involved, to facilitate homing upon the distress signal. One of the two radar antenna assemblies, either the SG-6 or the SR-6, may go atop the mast, while the other then goes on a bracket, forward of the mast. The weights of the two equipments are about the same. Also, in these particular surroundings the working circles are about the same. Consequently, mechanical considerations do not disclose any advantage to either arrangement. However, the operating wave length of the SR-6 is longer than that of the SG-6, and the antenna array of the former is larger also. Hence, by comparison, the mast will be a smaller obstruction to the SR-6 than to the SG-6. Because of this, and since the SG-6 can tolerate no interference with its zenith search, the SG-6 is placed atop the mast, and the SR-6 on the platform.

The Mark 25 and Mark 29 equipments are under the cognizance of the Bureau of Ordnance, and their locations are not yet shown on the antenna-systems plans. The antenna for the Model BM Interrogator-Responder is mounted in conjunction with the antenna assembly for the Model SR-6 Radar Equipment. A separate antenna for the model BK transponder is, for the present, mounted on the yard. The Laboratory has not yet considered antennas for the RCM equipments, and the present arrangement is shown without alteration.

CONCLUSION

Shipboard tests of experimental installations have shown that the above proposed improved arrangement possesses some distinct advantages, the more noticeable improvements being in the medium- and high-frequency antennas. The following notes are in addition to those already discussed: To begin with, the number of aerial conductors near Radio Central has been reduced, and the lengths of all conductors have been cut to the minimum for acceptable operation. This reduces interaction between antennas, which in turn somewhat reduces antenna directivity. Also, less of the power in the transmitting antennas is absorbed in the receiving antennas, as a result of which the signal strength is increased a little. The free use of whip type antennas has given cleaner rigging and neater appearance. Also, damage control is somewhat simplified, for the self-supporting whip can be erected in other locations if necessary. The principal advantage gained for the very-high-frequency antennas has been achieved through the reduction in number of equipments. The antenna assemblies which are used have been well dispersed, so as to reduce interaction and directivity, and occupy no positions contemplated for other antennas. Consequently, as the change-over from v-h-f to u-h-f takes place, the v-h-f antenna assemblies can be removed, if desired, with minimum disarrangement to the system as a whole.

It does not take a keen insight to perceive shortcomings in this proposed antenna system. The following are some of the more obvious: The close spacing of receiving antennas mounted by pairs (Nos. 1 and 3, and Nos. 2 and 18) is not entirely advantageous. There is crowding of the whip antenna in the neighborhood of the No. 2 stack. Intercoupling between antennas at high frequencies and below is still so great as to necessitate the employment of receiver protective devices. To elaborate upon these deficiencies would serve a less useful purpose than to consider the plans for future improvement of the system. Such plans are necessarily subject to drastic alteration, and setting them forth in the following paragraphs does not, of course, commit the Laboratory to their completion nor the Bureau of Ships to their acceptance.

A diligent search is being conducted for more compact medium and high-frequency antennas, preferably with broad-band characteristics. Some promise is offered by a folded monopole with a suitable terminating impedance at its far (grounded) extremity. Effective utilization of antenna structures will be sought through improvement of transmission and distribution facilities, and the development of techniques and equipments for multiplex operation. It should ultimately be possible to accommodate a given number of channels with a smaller number of antennas, which will result in considerable simplification of the antenna system.

It should again be emphasized that preceding paragraphs outline a purely tentative plan, one which may be superseded by the time this appears in print. In fact, the plan will be altered if any better procedure is suggested, for the Systems Engineering Department of the Navy Electronics Laboratory will continue in its assignment of developing better and better antenna systems for all classes of naval vessels, as a vital part of the Bureau of Ship's program of long-range and far-reaching research on antennas.

TABLE II—*Possible future equipment type allowance for vessels of the destroyer class.*

Allowance	*Name and Description of Item*
	Radio Central
2	Model RBA Series Receiving Equipment
2	Model RBB Series Receiving Equipment
2	Model RBC Series Receiving Equipment
1	Model RBO Series Receiving Equipment
1	Model RBK Series Receiving Equipment
2	Model RCK Series Receiving Equipment
2	Model RDZ Series Receiving Equipment
1	Model TBL Series Transmitting Equipment
1	Model TCS Series Transmitting-Receiving Equipment
1	Model TBS Series Transmitting-Receiving Equipment
2	Model TDO Series Transmitting Equipment
1	Model TDZ Series Transmitting Equipment
	Emergency Radio Station
1	Model RBA Series Receiving Equipment
1	Model RBB Series Receiving Equipment
1	Model RBC Series Receiving Equipment
1	Model TBL Series Transmitting Equipment
1	Model TCS Series Transmitting-Receiving Equipment
	Combat Information Center
1	Model RBS Series Receiving Equipment
	Pilot House
1	Model MBF Transmitting-Receiving Equipment
	Squadron Commander's Quarters
1	Model RBO Series Receiving Equipment
	Chart House
1	Model DAS Series Loran Equipment
	Radar Room
1	Large Surface Search Radar (Model SG-6)
1	Medium Air Search Radar (Model SR-6)
1	Model BK Series Transponder
1	Model BM Series Interrogator-Responder
	Main Battery Director
1	Radar Mark 25
	Mark 29 Control Rooms
2	Radar Mark 29
	Radar Countermeasures Room
1	Model RDO Series Receiving Equipment
1	Model AN/SPR-2 Receiving Equipment
1	Model TDY-1 Transmitting Equipment

GRID-BIAS BATTERIES FOR MODEL UP EQUIPMENT

Difficulty is being experienced in obtaining exact replacements for the Western Electric Company Type KS-7105 22.5-volt dry battery. This battery supplies grid-bias potential in the 24-volt regulated rectifier X-63673A, which is part of the Model UP Two-Tone Carrier Control System. In order to alleviate this condition, the Bureau of Ships is establishing initial stocks at Oakland and Bayonne of type BA-230/U batteries, which are the Army-Navy equivalent of the Western Electric Company Type KS-7105 batteries. Battery BA-230/U provides tapped voltages of 3, 4.5, 6, 9, 10.5, 16.5 and 22.5 volts. A 19.5-volt supply can be obtained, if desired, by connecting to the 3- and 22.5-volt terminals, and other voltages can be obtained in a similar manner.

MORE MICROFILM COPIES OF DRAWINGS

The Bureau of Ships has recently announced that microfilm copies of Electronics Division manufacturing and installation drawings of many equipments are now available. A list of these equipments appeared on page 16 of the January, 1948 issue of ELECTRON. Some recent additions to the list follow:

AN/APA-48	RDZ
AN/FPN-1 (XN-2)	TCZ-1/-2
AN/MRD-8	TDP-1
FRF/FRH	CDI-55180 Tuning Indicator
FSA	CAEK-51095 Hydrophone Assembly
MAR/RDR	

Microfilm copies of the drawings of any of these equipment can be obtained by submitting a request to the Chief of the Bureau of Ships, Code 932Bi, Nomenclature Control, Washington 25, D. C.

Modernization of Shore Radio Stations

■ The navy is underway on a program to completely modernize receiving facilities and techniques at shore radio activities. The equipments and circuits used at these activities during the war are now becoming obsolete due to peacetime curtailments and are in great need of improvement for efficient maintenance of both ship-shore and point to point communications. The present restrictions have left the Bureau with the problem of maintaining communications under the handicaps of weaker signals, fewer frequencies and a shortage of personnel and funds. The program, with the objective of achieving a better signal to noise ratio with less radiated power and more efficient use of available frequencies, is considered the solution.

The accomplishment of this objective involves primarily a reduction in noise at the receiving stations, and development of more efficient antenna systems. The reduction in noise, having the same effect as an increase in transmitter power, will enable communications to be maintained with less power and fewer frequencies at the transmitter end. Similarly, more efficient shore antenna systems will tend to minimize losses and thereby provide increases in signals.

The modernization, in addition to the provisions for noise abatement and improved receiving antenna systems, includes a standard signal distribution system and other supplementary items. Some of the individual items may seem to be unnecessary from an isolated viewpoint, but are very important factors in the fulfillment of the objective. Changes such as replacement of open wire transmission lines, new antenna systems, remote-controlled receivers and improved antenna multicouplers will be combined to form a system which will provide increased efficiency, flexibility, and reduced maintenance.

In the noise reduction campaign, the Bureau is in the process of installing RG-85/U solid dielectric r-f transmission line in place of the open wire lines with their noise pick-up potentialities and leakage. The new cable not only reduces the possibility of noise pick-up and leakage in the line itself, but being of such design that it can be buried in salt marsh and run under roads and runways also provides a means for locating antenna arrays in noise-free areas. A few installations have already been completed, and field reports indicate a considerable reduction in noise level. Another important feature of the RG-85/U cable is that its maintenance requirements are practically negligible.

The antenna program provides for remote locations, noise-free operation and greater azimuth coverage. This was considered necessary especially for ship-shore communications wherein the reduced power, less efficient shipboard antennas and fewer frequencies introduced conditions requiring more efficient antenna systems. The ship-shore teletype circuits required optimum diversity reception at shore station and therefore necessitated the maximum directional antenna azimuth coverage possible. At the joint point-to-point/ship-shore activities, the new signal distribution system will permit "borrowing" of point-to-point rhombics for special ship-shore requirements. This "borrowing" is possible up to a separation of 2000 feet by providing two trunk lines of RG-85/U cable between the two activities. Any signal strength reduction brought about by use of the cable will be more than compensated for by the signal-to-noise ratio gain, because a weak signal in the clear with less noise is conclusively proven better than a strong signal covered by interference. In either instance the "borrowing" of antennas will require the standardized fittings provided in the new distribution system.

Antenna arrangement also plays a large part in the program and it is recommended that, at ship-shore stations adjacent to or part of a point-to-point activity, the available antenna space be used to supplement the point-to-point antennas to provide 360 degree coverage of the azimuth if possible. The Bureau in this quest for additional coverage is awaiting a favorable report from the U. S. Naval Electronics Laboratory on the feasibility of double ending receiving rhombics. In line with this, it is anticipated that all new rhombic antenna arrays will be laid out with future double-ending in view. The program also includes the recommendation that all rhombic antennas be kept beyond a 200-foot radius to reduce noise pick-up, and at the same time make space available in the vicinity of the building for doublets and other small antennas.

Investigation on design of a broad band rhombic to cover the 20 to 40 Mc range and a system of polarized diversity is also getting attention. Preliminary reports on the polarized diversity system are promising and indicate that such a system will have application where antenna space is limited. Low frequency reception ashore is also sharing in the research field with the development of a remote-controlled barrage loop antenna assembly to be used in conjunction with a modified model RBA receiver capable of being tuned to 14 kc. The loop assembly will be equipped for remote tuning.

The largest item in the modernization is the new signal distribution system which has evolved from recommendations solicited from the field together with ideas of cognizant Bureau engineers and associated manufacturers. It is a system which provides standardized components for the distribution of r-f and a-f signal energy within the operating building. Designed for flexibility, it will handle the needs of the smallest and largest shore receiving station. Shipment of these systems began in November, 1947. Its overall details are described in an article appearing in the October, 1947, ELECTRON.

Remote-controlled receivers and antenna multicouplers are two of the more important supplementary items in the Bureau's program, and both are under extensive research. The study of remote control for receivers is not a new idea, as the Bureau has had the problem under research for some time. Recently a miniature control panel similar to the front panel of the model RBC was installed at Radio Central, Washington, and used to control a model RBC receiver at the Naval Radio Station, Arlington. The control, accomplished over one pair of metallic wires, included band change, vernier control, and scanning. Although wires were used in this test, the proposed system under development is to include control over radio links or tone lines. Production of such a remote control receiver is not anticipated for two years or more, but is mentioned here to indicate its projected requirement in the Bureau's overall planning.

Antenna multicouplers are not new to the navy either, as they are now in use. At present, however, they are far from satisfactory. They are sensitive to cross modulation and interference and therefore are restricting antenna expansion. The Bureau, being dissatisfied with such performance, is pressing research on a more efficient multicoupler which, in coordination with the RG-85/U cable, will enable the Bureau to expand the use of remote antennas and reduce the effects of noise. Also under development for this purpose is an improved broad band r-f amplifier which will eliminate the present restrictions on individual lengths of RG-85/U cable.

In the preceding discussion it is easily seen how each item in the modernization program dovetails with the others in accomplishing the objectives set forth in the project. Even the best system needs assistance, however, and it is recommended here that all activities render aid to this program by eliminating or suppressing local radio noise at or near shore radio receiving stations. It is desired that this be accomplished by eliminating the obvious sources of local interference where possible, rather than undertaking continuous and costly attempts to keep such noise sources under control. Installation instructions covering noise suppression of teletype equipment are being prepared by the Bureau for field distribution.

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INSTALLATION OF TYPE -66147 U-H-F ANTENNAS

The Bureau of Ships has been advised that a number of vessels having u-h-f equipment on board have the Navy Type -66147 Antenna Assemblies installed with the insulated rod pointing upward. This is incorrect; because of the design of the insulator, this arrangement permits moisture and dirt to collect in and around the dipole at the insulator.

An example of how such improper antenna installation affects performance of the associated equipment is contained in a report received in the Bureau. A vessel reported maximum ranges of only one-fifth normal during rainstorms.

Vessels having improperly-installed Type -66147 Antenna Assemblies should correct this condition at the earliest opportunity.

SUBSCRIPTION FEES FOR COMMERCIAL PUBLICATIONS

During World War II, the Bureau of Ships procured and distributed Electronics Technical Libraries to various major naval shipyards. Recently the Bureau has received requests for funds to be used to pay the annual renewal subscription fees for the "RCA Tube Handbook HB-3," which was included in these libraries. Since the Bureau of Ships has no program for the payment of annual renewal subscription fees for commercial publications, it is recommended that fees for these handbooks and similar commercial publications be paid locally and charged to yard maintenance funds.

WWV Broadcasts

IMPROVED SERVICE

■ Effective 30 January 1948, the technical broadcast service of the standard frequency station WWV of the National Bureau of Standards was enlarged in scope under a new schedule. Previous issues of the ELECTRON (July 1945, p. 16, and August 1947, p. 16) have carried stories describing the broadcast service and indicating its applications to naval activities.

There have been two major changes in the schedule:

1—The first change is that all of the standard broadcast frequencies are now propagated continuously, both day and night.

2—On most of the radio frequencies, the r-f carriers have been modulated by certain audio frequencies, alternately on for a period of four minutes, and off for one minute. The second change is that the whole schedule of alternations have been advanced one minute. Formerly the hour (and each five-minute interval after) was announced by shutting off the audio tone. Now the hour (and each five-minute interval following) is announced by turning on the tone.

The complete and up-to-date schedule of the service is given in table I, and is to supplant all schedules previously published in the ELECTRON.

Because of the possible confusion and opportunity for error which always follows cross-reference, it appears advantageous to briefly summarize here the new succession of the standard radio frequencies and their information-giving modulations, even though there will be some duplication of material already published. We shall consider these signals as they will be heard in a receiving set—under the actual conditions of use. The previous articles have already discussed the various individual uses of the modulations, and little is to be gained by recapitulating them here.

In brief: the eight standard radio frequencies are broadcast at 2.5, 5, 10, 15, 20, 25, 30, and 35 Mc. All of these frequencies are modulated by a series of short pulses which occur almost continuously once each second, and are heard as a succession of "tocks" sounding like the ticking of a clock; this ticking, familiar to anyone who has ever listened to WWV, is an outstanding characteristic which serves to identify the station. In addition, the radio frequencies are modulated by audio tones (440 cps, the standard musical pitch, for some frequencies; both 440 cps and 4000 cps for others; and neither for 35 Mc) which, as mentioned above, are alternately tuned on for four minutes, and off for one minute. The periods when the audio notes are off serve as intervals for including various announcements of three kinds: 1—telegraphic announcements heard at all "tone-off" intervals of the exact hour and minute when the tone will be next resumed, 2—voice announcements for station identification, immediately following the time announcement in code, on the hour and half-hour, and 3 — telegraphic announcements indicating whether a radio propagation disturbance is or is not in effect, immediately following the time announcement in code at 19 and 49 minutes past the hour.

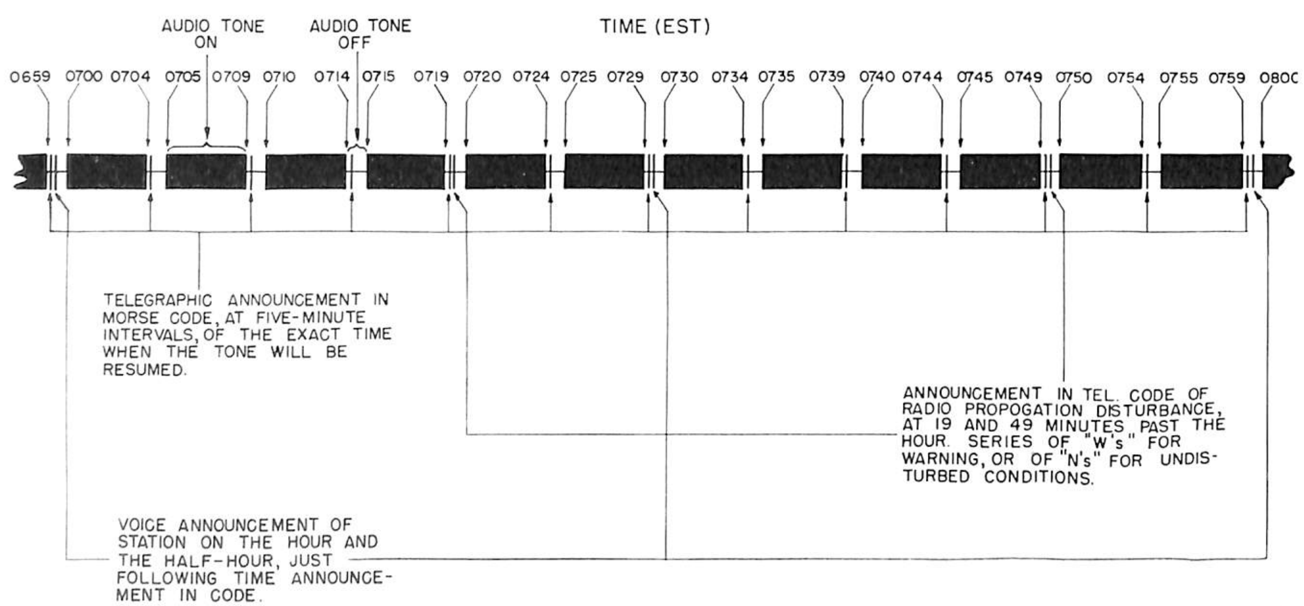

FIGURE 1—*Diagram of the sequence of modulations and signals carried on one of the WWV standard frequencies as they are heard on a receiver, for a full one-hour period. The "on-again, off-again" alterations of the audio tone are shown by inked-in blocks, and the various voice and code announcements are shown as vertical strikes or lines. The scale does not permit showing the one-second "tocks" or pulses, for which see figure 2.*

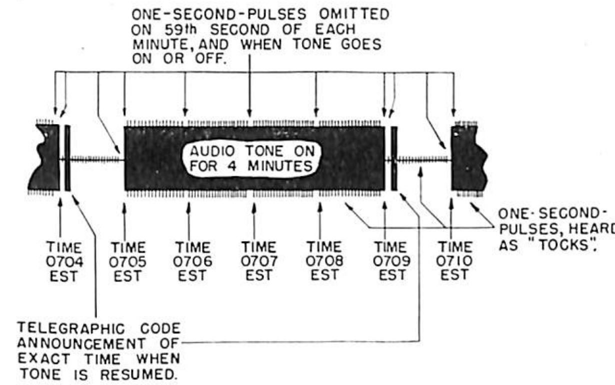

FIGURE 2—*Enlarged and detailed view of a typical five-minute interval in figure 1, showing the one-second "tocks," each of which is a short pulse consisting of a train of five complete sinusoidal oscillations.*

This schedule is carefully diagramed in figure 1 for a typical one-hour interval, from 0659 E. S. T. to 0800 E. S. T. This diagram and the associated diagrams show the exact details of the schedule. At 0659 E. S. T. the audio tone ceases, and within five seconds the figures "0,7,0,0" are heard in International Morse Code, meaning that the audio tone will come on again at 0700 E. S. T. This is followed by the voice station announcement; then is heard the ticking alone until 0700 when, as announced, on comes the audio tone. Both the tone and the steady ticking are heard together until 0704, when the tone goes off. (Note, however, that the minutes of 0701, 0702, and 0703 are indicated by the omission of a "tock".) Then is heard the code announcement "0,7,0,5," meaning that the tone is to be resumed at 0705 E. S. T.; this time the time announcement is the only announcement, and all that is heard until 0705 is the ticking. At 0705 the ticking is joined by the audio note, and both are heard until 0709, when off goes the audio note, and the time announcement "0,7,1,0" dutifully appears. The whole sequence is repeated throughout the hour, except that at 0719 and 0749 a series of "W's" or "N's" in code follow the time announcement and describe radio propagation conditions, and except that at 0729 and 0759 the voice station announcement follows the time announcement.

TABLE I—*New schedule of WWV services (all radio frequencies broadcast continuously)*

Carrier Frequency (Mc)	*Power Output (kw)*	*Audio Frequency (cps)*
2.5	0.7	440
5.0	8.0	440
10.0	9.0	440 and 4000
15.0	9.0	440 and 4000
20.0	8.5*	440 and 4000
25.0	0.1	440 and 4000
30.0	0.1	440
35.0	0.1	None

* On first four work days after first Sunday of each month, power is 0.1 kw.

ELECTRONIC LOVE

If she wants a date—*Meter*
If she comes to call—*Receiver*
If she wants an escort—*Conductor*
If she's cheating—*Detector*
If she's fat—*Condenser*
If she's thin—*Feeder*
If she's extravagant—*Limiter*
If she's in error—*Rectifier*
If her hands are cold—*Heater*
If she fumes and sputters—*Insulator*
If she's ugly—*Transformer*
If she's "bossy"—*Resistor*
If she's too slow—*Accelerator*
If she's bored—*Exciter*
If she doesn't answer—*Interrogator*
If she refuses—*Rejector*

effects of electric SHOCK

*Reprinted from ELECTRONICS**

By H. A. POEHLER   *Westinghouse Electric & Mfg. Co.*

■ An electrical engineer's knowledge of the response to an applied electromotive force should not be limited to networks of resistance, capacitance, and inductance. It should include, also, the response of a human being. Unfortunately, the engineer usually knows little more than the layman about the latter subject, even though he is much more exposed to the hazards of electricity than is the average person. This article is written to acquaint the engineer with the basic principles of the effect of electricity on the human organism.

The first recorded death due to electricity was that of a stage carpenter at Lyon in 1879. He touched a 250-volt line. This, however, was not the first use of lethal electric potentials, for they were used as early as 1849 in the first performance of Meyerbeer's "Il Prophete," and in 1857 in lighthouses in England. As early as 1890, the electric chair was introduced by the state of New York. Here voltages of 1200 to 1700 volts were used. In electrocutions currents up to 8 amperes were sent through the victim's body for 3 to 8 minutes.

The death rate due to accidental electric shock was low at the beginning of the century, being about 200 a year in countries like England, the United States, and Germany. It rose rapidly, until in 1915 the rate was 0.8 per 100,000 annually. Since then it has remained quite constant, and at present is 1 per 100,000 per year.

CAUSES OF DEATH BY SHOCK

Death by electricity is due to one of three fundamental causes: a cessation of respiration due to a block in the part of the nervous system controlling breathing; a serious reduction of the circulation of the blood, due to ventricular fibrillation of the heart; or an over-heating of the body. Of the three, the second of these is the most dangerous, for there is no practical way of bringing a fibrillating heart into a normal beat. Of course death may be the result of a combination of the above causes, or due to complications, such as a broken neck, etc. The mechanisms of death will now be discussed in more detail.

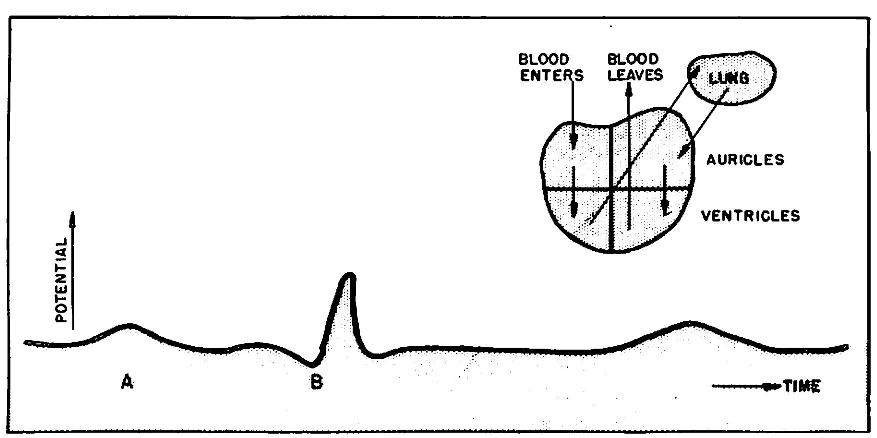

FIGURE 1 — *Electrocardiogram and diagram of normal heart.*

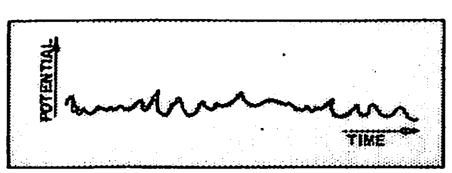

FIGURE 2 — *Electrocardiogram of a sheep's heart in ventricular fibrillation.*

VARIATIONS IN BODY RESISTANCE

In the layman's mind, (as well as in that of the engineer) a great deal of confusion exists as to whether the current or the voltage of the circuit is the determining factor in death. This is quite inexcusable, for as early as 1913[1] it was clearly understood that the current passing through a person's body (rather than the voltage applied) was the determining factor. The reason for the wide variation in voltage required to send a lethal current through a human body is that the resistance of the body varies from 1000 ohms when wet to 500,000 ohms when dry.

The resistance of the body is made up of the skin resistance and the internal resistance. The former is large when the skin is dry (70,000 to 100,000 ohms per sq. cm.), but falls to less than a hundredth of this value when wet. The internal resistance is low because the tendons, muscles, and blood are relatively good conductors.

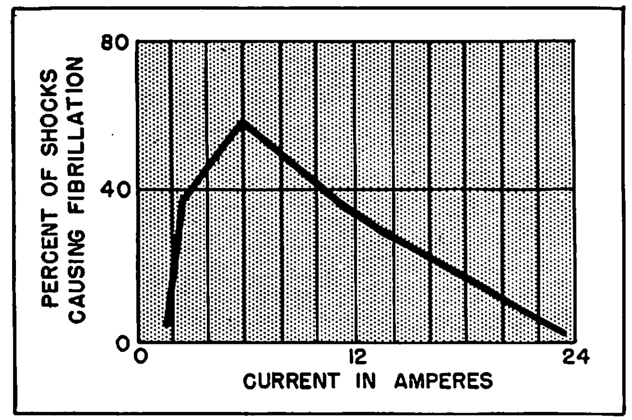

FIGURE 3—*Effect of electric current on susceptibility of sheep hearts to ventricular fibrillation. Each shock was applied for 0.03 sec at 60 cps, in the most sensitive part of the cycle.*

In high-voltage shocks serious burns are often produced because the high voltage punctures the outer skin. The body resistance then suddenly falls from a high value to the low value of the internal resistance.

It is understandable that the effect a given current will have depends on the current path through the body. It is found that the heart, the brain, and the spinal column are the three most critical regions.

EFFECT OF CURRENT MAGNITUDE

Let us consider the effects produced when the magnitude of a 60-cycle current is slowly increased. Numerous studies[2] have shown that the threshold of perception is 1 ma. In other words, currents less than 1 ma are not even felt, provided abnormally large current densities, as result from pinpoint contacts, are not produced.

Currents from 1 to 8 ma are perceptible, but not yet painful. When the currents reach a value of 8 to 15 ma they are painful, and cause an involuntary contraction, and muscular control is lost. Currents of 20 to 50 ma, passed between arms, or an arm and a leg, involve the chest muscles and breathing becomes difficult. Currents of 100 to 200 ma, when passed through the body in a path that involves the heart region, produce ventricular fibrillation (an uncoordinated beating of the various heart muscles).

Currents in excess of 200 ma produce burns; if they take a path involving the heart region, the heart action is suspended for the duration of the current passage, but generally is resumed at the end of this period.

If the path involves the part of the nervous system controlling respiration (such as hand to hand, hand to foot, head to hand, etc.) a block in the respiratory system is produced. If artificial respiration is applied, the body may resume its own breathing after as long as 8 hours; if the damage to the respiratory—controlling nervous system is severe, however, breathing may be suspended indefinitely.

VENTRICULAR FIBRILLATION

The phenomena of ventricular fibrillation and respiratory block deserve closer attention. Ventricular fibrillation is an uncoordinated contraction of the various heart muscles, which makes the heart practically useless as a pump. The phenomenon can better be understood by reference to the electrocardiogram and diagram of a normal heart in figure 1. The stimulus *A* corresponds to the contraction of the auricles, which contract together. The stimulus *B* corresponds to the contraction of the ventricles, which also contract together.

The electrocardiogram for ventricular fibrillation can easily be recognized, for it has the irregular pattern shown in figure 2[3]. Experimental work on human hearts in regard to fibrillation is of course impossible. But guinea pigs, rabbits, and sheep are also subject to fibrillation, so considerable work has been done with them.

The variation of the percentage of shocks causing fibrillation with the magnitude of the current

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passed through the body of a sheep is shown in figure 3[3]. Each point represents about 75 trials. Note that the susceptibility increases with current up to a maximum, and then decreases as the current is increased further. This is in agreement with observed data on man, for it has been observed that as the voltage increases on high-voltage shocks, the percent that can be resuscitated increases.

For shocks short in duration compared to a heart cycle, the probability of producing fibrillation varies with the part of the heart cycle in which the shock occurs. This is shown by the dash-dash curve superimposed on the electrocardiogram in figure 4. This sensitive phase represents the decreasing contraction of the heart muscles. At any other time, the heart is quite insensitive to shock.

DURATION OF SHOCK

Finally, the effect of shock length was studied. The results are plotted in figure 5. Note the sudden increase in susceptibility to fibrillation as the shock length approaches the length of the heart cycle. What happens to this curve as the shock length is decreased to much smaller values, say one microsecond, is an interesting question, but no authentic data is available on this subject.

RESUSCITATION PRINCIPLES

Numerous methods have been tried to bring a fibrillating heart back to a coordinated beat. Of these the method of counter shock first used by Abilgaard in 1775 to arrest fibrillation in cocks seemed the most promising. It has been used with success on guinea pigs and dogs. It consists of an application of a shock of high intensity and short duration through the heart. The obstacles encountered in trying to apply this to humans are: (1) difficulty in determining whether a heart is actually fibrillating; (2) the availability of proper facilities for applying the shock; (3) the counter shock, if improperly applied, may actually become the cause of the death. As a result, the recommended procedure in all cases of electric schock is to apply resuscitation immediately, and not attempt to apply counter shock.

In many cases of electric shock the victim becomes unconscious and stops breathing, but his heart keeps on beating. This is due to a break in the nervous system controlling respiration. The nerves are paralyzed by the currents and no longer transmit stimuli to the lungs. Here one difference between the operation of the heart and lungs becomes evident; the nervous center which controls the lungs is located in another organ, the brain.

The brain and heart must always be supplied with oxygen. If the oxygen supply ceases, the person first becomes unconscious. If the supply of oxygen to the brain is cut off for more than 5 to 8 minutes, damage is done to the Betz cells in the cortex of the brain. This damage is permanent and cannot be repaired by the body. If the person should be brought back to life his mental capacity will be impaired. Serious damage of this kind results in idiocy.

If the damage to the nervous system is not too severe, the block will pass away (0 to 8 hours) and the person will resume breathing of his own

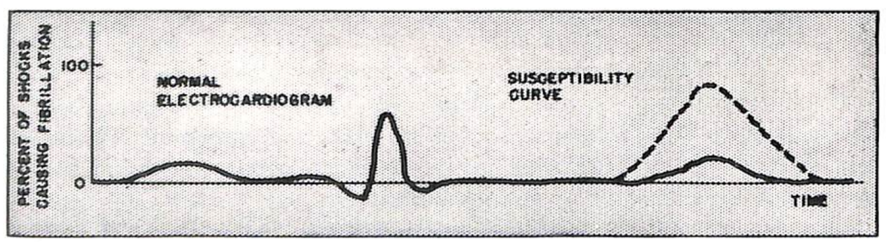


FIGURE 4 — *Effect of position of shock in cardiac cycle on susceptibility of sheep hearts to ventricular fibrillation.*

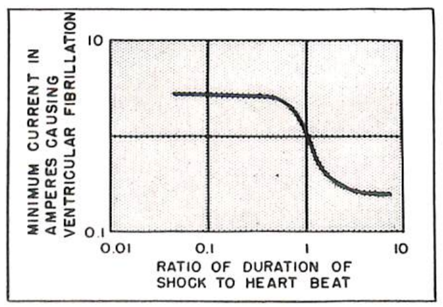


FIGURE 5—*Effect of duration of shock on threshold current for sheep.*

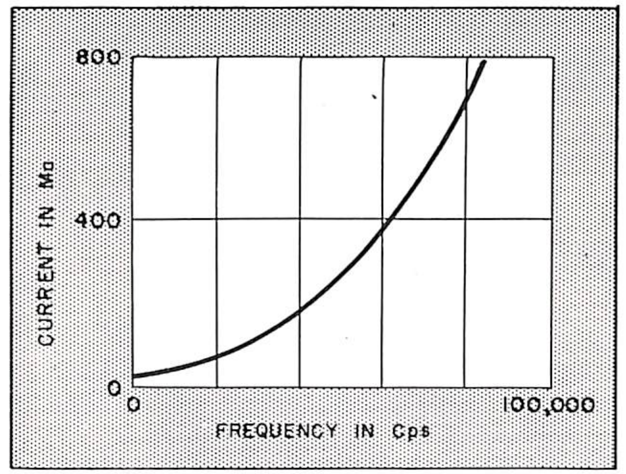


FIGURE 6—*Effect of frequency on tolerance current.*

accord, provided the person has been kept alive by supplying the vital cells of the body with oxygen in the meantime through artificial respiration. This explains the prescribed procedure in all cases of electric shock: apply artificial resuscitation immediately and continue until rigor mortis sets in.

In cases of severe damage to the cells of the nervous system controlling respiration (dislocation of the nuclei, swelling of the nucleoli, and cytoplasmic loss of granule) the natural breathing of the body is never resumed.[4]

The third cause of death is excessive heating of the body. The reason for death here is not obscure. The detailed mechanism of death is a medical matter and its discussion would lead us too far astray. It is sufficient to remark that death is due to the destruction by heat of some vital organ, or to hemorrhages, or to third-degree burns.

EFFECT OF FREQUENCY

A further characteristic of current that determines its effect on an organism is its frequency. A ready example is that of direct current and 60-cycle alternating current. The bearable direct current is about three times that of the 60-cycle current. This problem has been studied from two angles, one the maximum current which a person could stand before distress was caused and second, the amount of current required to kill laboratory animals.

The former method of attack was taken by A. E. Kennelly and E. F. Alexanderson[5]. Their data is summarized in figure 6. In each case the current was slowly increased until it was felt that further increase would cause distress. Note that the current that can be tolerated without distress rises rapidly with frequency.

Above 100,000 cps the only effect produced by the current was that of heat. The explanation that has been advanced for this behavior is that the alternations of the current are too rapid to have any effect on the nerve cells.

The heating effect of the higher-frequency currents is used to advantage in diathermy machines where frequencies of 500,000 to 1,000,000 cps with currents of 0.5 to 5 amperes are used. A second application is electrosurgery. Here a platinum needle and a large electrode are used. The needle produces such a high current density that the tissues are completely destroyed by heat.

The second line of attack was taken by A. G. Conrad and H. W. Haggard[6]. They studied the currents necessary to cause death for shocks of different durations at various frequencies. Their results on rats are summarized in figure 7. Note that the amount of current required to kill increases with the frequency.

These results as well as those of W. Kouwenhoven, D. Hooker and E. Lotz[7] show that the frequencies that are the most dangerous are those in the neighborhood of 60 cps.

Let us turn our attention to the number of electrical accidents that actually occur, and the percentage of them that turn out to be fatal. An

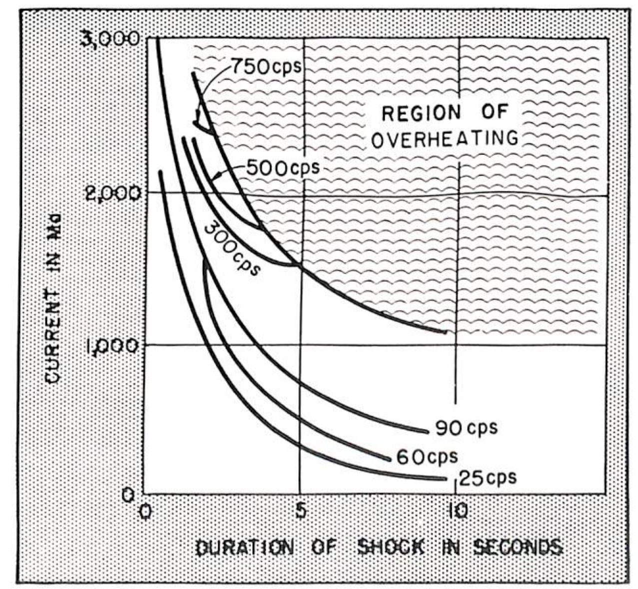


FIGURE 7—*Minimum currents necessary to cause death from shocks of different duration at several frequencies.*

analysis by E. Krohne[8] of 848 electrical accidents in Germany from 1930 to 1935 showed that 314 involved voltages under 500 volts with an average fatality rate of 15%. The remaining 534 received voltages over 500 volts, with a fatality rate of 33%.

W. McLachlan[9] gives more detailed information based on the studies of 475 cases where electricity alone was the cause of deaths, not lack of resuscitation, broken necks, burns, etc. (Data by Krohne includes all these cases, hence this difference must be kept in mind when comparing the figures. The difference is particularly noticeable at high voltages, where death from burns, etc., is more probable.)

McLachlan's figures are based on U. S. and Canadian industrial accidents, and divide the accidents according to the potential of the circuit involved.

RECORD OF ACCIDENTS BY POTENTIAL OF CIRCUIT INVOLVED

Volts	*Total Cases*	*Successful Revival*
0-749	65	63%
750-4999	212	65%
5000-39,999	167	69%
40,000 and over	26	88%

Note that the danger does not necessarily increase with the voltage. This is due to two reasons: first, the muscular reaction is more pronounced at high voltages, making it more likely that the person will be thrown clear of the circuit: secondly, as data on animals has shown, the heart is not thrown into fibrillation by very large currents (greater than 250 ma).

Segregation of these cases according to the method of clearing revealed that of 282 who fell clear, 70 percent were successfully revived; of 179 who were pulled clear from the circuit, 63 percent were revived. This may appear puzzling at first, for one would expect the difference to be more pronounced. Remember, however, that it takes only a shock of a fraction of a minute to throw the heart into a fatal fibrillation or to cause a respiratory block. After that, the effect is a heating of the body. It is true that if the heating is very severe, it may cause damage to the cells of the nervous system or severe burns, but often it is not.

The data by McLachlan shows that if resuscitation is instituted soon after the accident, the fatality can be reduced to 33 percent. This is in agreement with the figure of 23 percent obtained by Kawaranura in a study in Japan; the figure of 23 percent obtained by Baraita in a study in France; and the average fatality rate for 1930-1935 in Germany of 24 percent quoted earlier.

Jex-Blake[1] summarizes in a practical form in table I much of the data presented in this paper.

LIFE-SAVING PRECAUTIONS

We will close with a few practical pointers:

1—Don't entertain a false feeling of security by believing that resuscitation can always bring a person back to life after an electric shock. If the heart is thrown into fibrillation (and this is quite possible) for all practical purposes death is instantaneous.

2—In case of electric shock, apply artificial resuscitation immediately. Do not delay to summon a doctor but try to get help while resuscitating the victim.

3—Never handle electric circuits with wet hands or when feet are wet.

4—If there is no other means of rescue, use your foot rather than your hand to free the victim from the live circuit.

5—When working on high voltage, be sure the floor is not a good conductor (as far as electric shock is concerned, a concrete floor is a good conductor).

6—When handling high-voltage circuits, it is a good rule to keep your left hand in your pocket.

7—Don't work in a position where your head is likely to become a conductor in an electric shock.

TABLE I—*Results of a brief exposure to a-c potentials.*

Body Resistance Assumed to be	*100 volts*	*1000 volts*	*10,000 volts*
Very low, with good contact (About 1,000 ohms)	Certain death; slight burns	Probable death; marked burns	Survival; burns & other sequelae; very severe
Higher (About 10,000 ohms)	Painful shock; no injury	Certain death; burns probably slight	Probable death; severe burns
High with bad contact (About 100,000 ohms)	Scarcely felt	Painful shock, but no severe injury	Certain death; burns slight if resistance remains high

References:

(1) Jex-Blake, A. J. P., The Goulstonian Lectures on Death by Electric Currents and by Lightning, British Med. Jrl., 1, p. 425, 492, 590, and 601, 1913.

(2) Dalziel, C. F. and Lagen, J. B., Effects of Electric Current on Man, Elec. Eng., 60, No. 2, p. 63.

(3) Ferris, L., King, B., Spence, P., and Williams, H., Effects of Electric Shock on the Heart, Elec. Eng., 55, p. 498, 1936.

(4) Langworthy, O. R., Nerve Cell Injury in Cases of Human Electrocution, Journal American Medical Assn., 95, p. 1107, July 12, 1930.

(5) Kennelly, A. E., and Alexanderson, E. F., The Physiological Tolerance of A.C. to 100,000 Cycles, Electrical World, 56, p. 154, 1910.

(6) Conrad, A. G. and Haggard, H. W., Experiments in Fatal Electric Shock, Elec. Eng. 53, p. 399, March, 1934.

(7) Kouwenhoven, W., Hooker, D., and Lotz, F., Electric Shock, Effects of Frequency, Elec. Eng., 55, p. 384.

(8) Krohne, E., Betriebserfahrungen mit Erdungs und Schutzschaltungs-Einrichtung in der gross-staedlichen. Electrizitaetzsversorgung, ETZ, 58, p. 1153, 1937.

(9) McLachlan, W., Electric Shock; Interpretation of Field Notes, Jrl. Industrial Hygiene, XII No. 8, p. 291, Oct. 1930.

Type of Approach	Last Month	To Date
Practice Landings	**5,680**	**82,960**
Landing Under Instrument Conditions	**303**	**4,321**

ANOTHER G.C.A. "SAVE"

G.C.A. has again demonstrated its merit under near-emergency conditions.

It all happened during the late afternoon of January 15. A Totem Airlines PBY was en-route to Seattle from Alaska, bound for Boeing Field. Included among its passengers was a four-month-old infant in an incubator. At Boeing Field was an ambulance which was to meet the plane and take the baby to a specialist for emergency treatment.

But the plane could not land at Boeing Field. Neither could it land at any other commercial fields in the Seattle area. All fields were shrouded by fog.

The Sand Point Naval Air Station, near Seattle, was considerably below normal instrument minimums. The G.C.A. unit offered its services, however, and brought the plane into the field. With a ceiling of 200 feet and visibility of one-half of a mile, the pilot, coached by the G.C.A. unit, brought his plane safely to rest.

Earlier in the day, with the weather but little better, two scheduled VR-5 arrivals, an Army C-47, and a Trans-Aslaska Airlines DC-3 were all landed without incident under radar direction.

PROCUREMENT OF SPECIAL G.C.A. PARTS

Certain parts peculiar to Ground Control Approach equipment (AN/MPN-1A) are becoming more difficult to secure. Where delay is experienced in obtaining such parts and the requirement is considered urgent, requisition should be made to the Mare Island Naval Shipyard and/or the Philadelphia Naval Shipyard.

UNPRINTABLE REMARKS

The following was included in a recent GCA maintenance report:

Location of trouble . . . . . Unknown
Symptoms . . . . . No high voltage on Channel B
Locate Procedure . . . Everything we could think of
Probable cause . . . . . ??????
Remedy . . . . . After 14 hrs. of checks, it suddenly worked!
Remarks . . . . . Unprintable!

IMPROVED CRYSTAL OVENS FOR U-H-F EQUIPMENTS

■ After a lapse of several months, shipment of crystal ovens for Models MAR, RDZ and TDZ u-h-f radio receiving and transmitting equipments was resumed in July, 1947. Additional improvements have been incorporated in the ovens shipped since that date. These improvements include changes in the thermostats and heater windings, to make operation more positive with less work on the part of the thermostat (i.e., an even temperature is maintained with fewer cycles of operation).

The new ovens are supplied under Contracts NXsr-86362, NOBsr-39267, and NOBsr-40253, and have the navy type number embossed on the cover. Ovens manufactured from December, 1945, through November, 1946, are designated Navy Type No. CFT-40148, and those from July, 1947, through December, 1947, are designated CFT-40148A.

A complete resume of the color-coding of all these ovens is given in Table I.

When a Type CFT-40148 oven is used, a check should be made to determine whether or not it is heating properly. After a few minutes of operation, the oven should feel very hot to the hand. If it does not, the thermostat can be checked by removing the oven from its socket and connecting short leads to heater pins, W, Y and Z. Then the oven is replaced. This is shown in figures 1 and 2. Next, either two 12-volt pilot lamps or two voltmeters are connected as shown in figure 3. Now the equipment is turned on. The lamp or voltmeter across pins W and Z (the low side) should

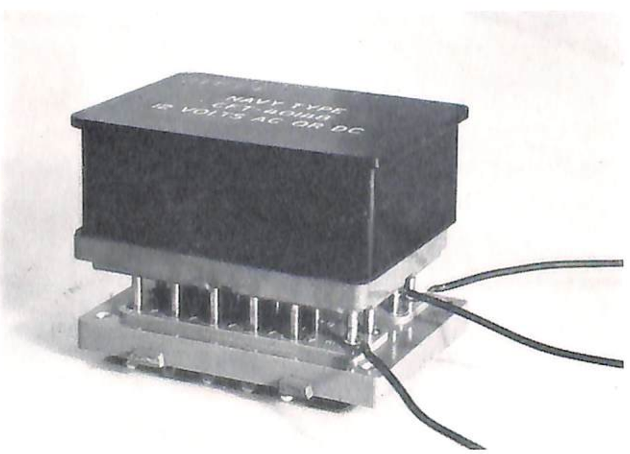


FIGURE 2—*Crystal oven and leads in place in socket.*

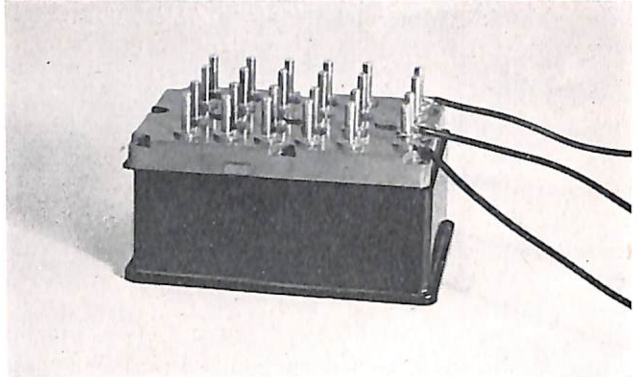


FIGURE 1—*Bottom view of crystal oven showing test leads connected to heater pins W, Y, Z.*

TABLE I

Month of Manufacture	*Screw Nearest Heater Pins*	*Screw Farthest From Heater Pins*
December 1945	Red	Blue
January 1946	Red	Yellow
February 1946	Red	Green
March 1946	Blue	Yellow
April 1946	Blue	Blue
May 1946	Brown	Brown
June 1946	Red	Red
July 1946	White	White
August 1946	Black	Black
September 1946	Orange	Orange
October 1946	Yellow	Yellow
November 1946	Gray	Gray
December 1946 through June 1947	None shipped	
July 1947	Green	White
August 1947	Red	White
September 1947	Brown	White
October 1947	Black	Black
November 1947	Yellow	White
December 1947	Blue	White
January 1948	None	shipped
February 1948	Green	Black
March 1948	Red	Black
April 1948	Brown	Black
May 1948	Yellow	Black
June 1948	Blue	Black
July 1948	Green	Red

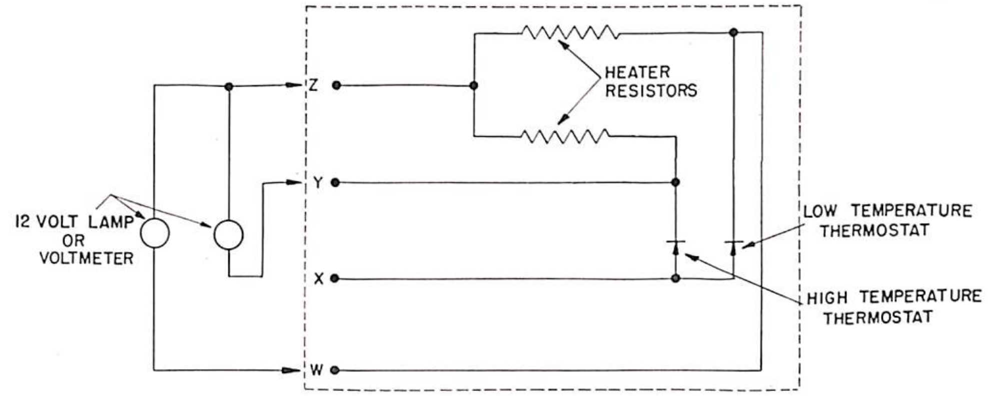


FIGURE 3—*Simplified heater circuit of crystal oven, with indicators connected to test thermostats.*

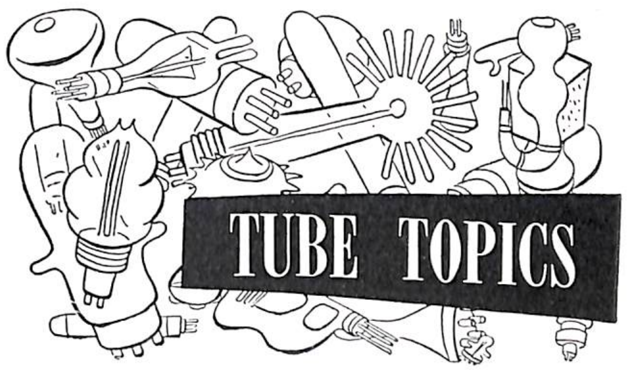
go out or register zero after a few minutes of warming up. The lamp or voltmeter across pins Y and Z (the high side) should continue to register for a few minutes after the low side has cut off, and then should begin to cycle, indicating that the thermostat is maintaining the oven at an even temperature.

Activities should use all of the old type ovens before starting to use the new ones. Defective ovens should not be surveyed, but instead returned to the Supply Officer in Command, NSD, Clearfield, Utah, Attention: Electronics Supply Officer, and marked "For disposition by the Bureau of Ships."

REPLACING MECHANICAL TELETYPE TIMERS

The Bureau of Ships has on hand a quantity of Western Electric Company Type KS-15206 List I Electronic Timers, as procured under Contract NOBsr-30097. These electronic timers are to be used to replace similar mechanical timers used with Model UF Portable Carrier Control System, and the Models AN/FGC-1, AN/FGC-1A and AN/FGC-1B Radioteletype Terminay Equipments in those cases where the mechanical timers have failed.

Four timers are used in each Model UF equipment, and one time in each AN/FGC-1, AN/FGC-1B equipment. The Bureau of Ships will supply additional station spares, if requested, in amounts based on the total number of timers in use at a given location. These timers are available for issue on request to the Bureau of Ships, Code 955c, and an adequate stock of spare timers will be maintained by the Bureau at naval supply depots. It is desired, however, that requests for spare timers include a statement as to the total number of timers in use per location. Because of the rugged construction of these timers, and the long trouble-free service expected from them, these requests should in no case call for more than five percent spares.



MEASURING SET AMPLIFIER

The Western Electric Company Model 13A Transmission Measuring Set and the Navy Type CW-60063 Transmission Measuring Set, as supplied with the Navy Models UP and UN Carrier Control Systems respectively, for use where portable apparatus is required to measure received testing power, use a type 25A6 amplifier tube which is now obsolete. If replacements for this tube are not available from normal sources of supply, a type 25L6GT/G can be substituted. In order to retain overall accuracy when this is done, however, recalibration of the instrument is required. Calibration should be accomplished using a 100-cycle source accurately adjusted so that it will furnish an output power of one milliwatt when fed into a 600-ohm load.

WANT SOME STANDARD EQUIPMENT?

ANEESA

Reprinted from SIGNAL CORPS MESSAGE AND SIGNALEER

■ One of the most important yet least heard of agencies connected with the military is the Army-Navy Electronic and Electrical Standards Agency, a joint activity of the Army, the Air Force and the Navy, concerned with standardization of materials and components used in electronic and communications equipment.

It coordinates the requirements of the armed forces, establishes standards, defines minimum service life and quality, and prepares specifications describing the standards. These latter are periodically reviewed to keep them abreast of changing service requirements and of developments in the art of electronics and communications, as disclosed by field reports, industrial research, and laboratory investigation and test.

The research and field reports are implemented by qualification testing. The manufacturer's production is continually tested and evaluated under the specifications. Procurement for both governmental and non-governmental end use is directed toward standard materials and components. Thus, the manufacturer has an incentive to develop his product, and the purchaser a warranty that the product is standard in size and performance.

The benefits of the program are immediate and far reaching. Under the standardization program, dry battery life is increased 25 per cent on the average; 22 crystal holder types requiring 125 electrical specifications shrink to three holder types and six electrical specifications; the multitudinous thermosetting plastic molding compounds of widely variable types are screened down to some 130 compounds in 19 types; less than 900 of the 2,500 known tube types are used, and procurement is directed at some 200 preferred types; one molded mica capacitor replaces 14; 3,7000 standard meter types are sufficient to cover the applications formerly requiring some 37,000 non-standard types; more than half the existing resistor numbers are eliminated; protective coatings make equipments operative under tropical conditions, and greatly increase their life.

Other examples: Formerly there were 120 different types of telephone plugs in use. Now there are 14. Telephone jacks formerly numbered about 400 different types, but this number has been reduced to 39.

The first phase—simplification of types and sizes of materials and components of critical application, and improvement of their performance—is largely accomplished. Production has been increased because of fewer types and sizes; supply inventories have been reduced, field replacement facilitated, service life increased, interchangeability insured, and savings effected in strategic and critical raw materials.

ANEESA is now engaged in the second phase—the extension of the program to cover materials basic to the production of quality components of wider application, greater complexity, and unpredictable performance. It is a phase that requires continued evaluation of industry's products to aid in the further improvement of the products when necessary. It guides procurement, both governmental and non-governmental, toward standard materials and components by study of the application, the publication of lists of standard materials and components, and by the establishment of preferred lists of standard components. It keeps standards active and current, abreast of service requirements and of developments in the manufacturing art, by amendment and revision based upon laboratory investigation and test, engineering analysis of improvements in design and production techniques, and research and analysis.

The final phase—industrial mobilization—is yet to come.

Conversion from normal production in time of emergency is time-consuming and difficult. It waits upon the development of military standards, as distinct from normal industrial standards. It is complicated by the need for evaluating production against military standards to determine compliance, and to indicate wherein improvements must be made in the product in cases of non-compliance.

CG-21ACN MOTOR DYNAMO AMPLIFIER UNIT NAMEPLATE

The Bureau of Ships has been advised that the Navy Type CG-21ACN Motor Dynamo Amplifier Unit of the Model SP Radar Equipment was supplied with a nameplate reading "CG-21ACH" instead of "CG-21ACN." Nameplates bearing the correct type number are now available for all Model SP Radar Equipments.

SP-equipped vessels are requested to requisition new nameplates from the Electronics Officer at any of the following naval shipyards:

Boston	Mare Island
New York	San Francisco
Philadelphia	Terminal Island
Puget Sound	Norfolk

The new nameplates do not bear the serial numbers of the equipments to which they are to be attached. Before each new nameplate is installed, therefore, the appropriate equipment serial number must be stamped on it in the blank space provided.

REPLACEMENT OF CRYSTALS

An official field change affecting all serial numbers of the Wavemeter Test Set AN/UPM-2 has been issued.

The change involves the substitution of a different type silicon crystal. The JA type 1N21 crystals are replaced with 1N25 crystals. This is necessary because the high peak-power outputs of certain equipments with which the test set is used make failure of the 1N21 crystals a frequent occurrence.

In anticipation of this field change a substantial quantity of the 1N25 crystals has been procured. The new crystals may be obtained at the Ships Supply Branch, Oakland, and at the Electronics Supply Branch, Bayonne. The number of crystals to be replaced in each test set is seven: two in active use, and five spares contained in a receptacle fastened to the cover.

The replacement is easily made. Further details will appear in C.E.M.B.

RETENTION OF MODEL FRC CONVERTRS

With the advent of new models of frequency-shift converters, the Model FRC Frequency-Shift Receiver Converter Equipment has generally been considered to be obsolete. In this case the classification of "obsolete" is in name only; the equipment is as satisfactory from an operating standpoint as any other now installed in ships.

It was recently brought to the attention of the Bureau that many ships and installing activities have been removing the FRC converters and replacing them with FRA's. This is not, in general, desirable. Model FRC converters are considered as substitutes for the model FRG's, which were previously authorized, and are not to be replaced by model FRA converters without specific authorization by the Bureau.

The Bureau now has several new types of frequency-shift converters in the design stage which are expected materially to improve teletype communications. One type is the CV-57/URR, which is a single channel i-f input type. Two of these units, together with a type CM-14 diversity combining-unit, will comprise an AN/URA-6. This dual unit will have the operating characteristics of the present model FRF converter, but will be reduced considerably in size and weight.

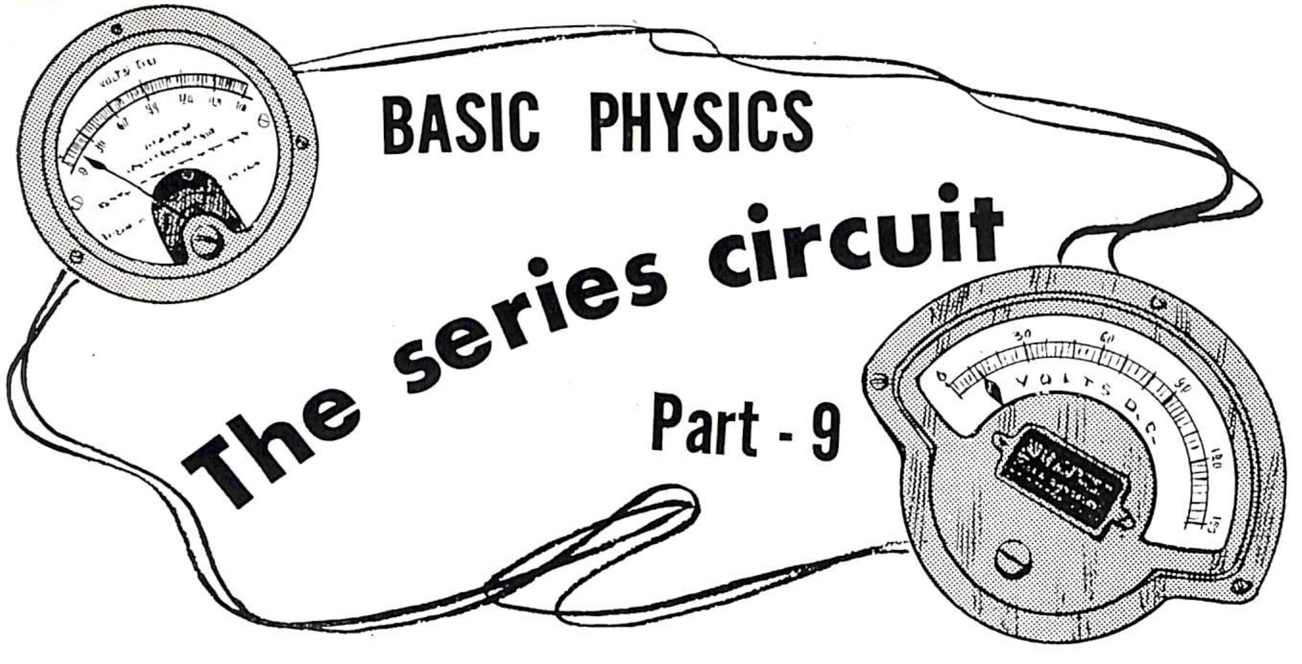
The corresponding audio types are the CV-60/URR single unit and the AN/URA-8 dual unit. The latter converter merely consists of two CV-60/URR units and a CM-14/URR combining unit. The AN/URA-8 will operate somewhat like the FRC in that it will have provisions for two audio inputs, thus providing the very desirable diversity features.

None of these new equipments will be in production prior to 1950, however. It can readily be seen therefore that it is most desirable to keep the model FRC converters in use until that time.

WE HEAR THAT—

Sargraves Electronics, Ltd., of England, is now set up to turn out 370,000 two-tube radios per year using the new "printed-circuit" techniques. Molded forms with grooves or narrow channels for resistors or conductors are sprayed with resistive or conductive material; face-milling machines shave off the excess coating, leaving the resistive or conductive material intact in the grooves. At present, two-tube regenerative receivers for export are rolling off the lines, but the mass-production line can be set up to spew forth four-tube superheterodynes using the UA/5 "all-stage" tube. The two-tube receivers are built and tested at the remarkable rate of three a minute. Incidentally, an article will be forthcoming soon in the ELECTRON describing the new "printed-circuit" techniques which are attracting so much favorable attention.

V-h-f marches forward in industry as well as in the navy. Between three and five million dollars worth of v-h-f- radiotelephone equipment for railroad use will be installed in 1948, a recent survey by the Association of American Railroads shows. As an accessory to main-line operation, lightweight walkie-talkie sets are planned for production starting in June.



BASIC PHYSICS

The series circuit

Part - 9

■ Electrical circuits are quantitatively analyzed in terms of the electric charge, difference of potential, current, resistance, work, and power. It has been shown that Ohm's Law presents these factors in the simple relation I = E/R, which is the fundamental law of all electrical circuits. As knowledge of electrical phenomena increases, the relation between voltage and current will be seen to be ever more complex.

This chapter will be concerned with the application of Ohm's Law to simple electrical circuits. Thorough mastery of the ideas presented herein is essential if danger of "bogging down" in the future study of complex circuits is to be avoided.

Accuracy of Circuit Solution. In the early study of Ohm's Law, a common fault is to strive for a degree of accuracy far in excess of that actually required in practical work.

Mathematical solutions of circuits are based upon the ideal concept that for any given circuit *E, I,* and *R* are absolute constants, but from the practical view point, *E, I,* and *R* are at best little more than good approximations.

There are a number of factors that justify this looser approach in practical work. Consider the following: A current flowing through a resistance generates heat, and resistance is known to vary with temperature. Resistance, then, is a constant only under ideal conditions. The e.m.f. developed across the output terminals of a source will vary with the load current because of the internal resistance of the source. The eletromotive-force of the source is constant only if the load current is constant. A variation in resistance will cause a variation in load current which in turn causes a change in electromotive force. These variable factors may be taken into account when solving a circuit, but to do so increases the complexity of solution. The methods by which they are taken into account are refinements, studied best after the more fundamental principles are mastered.

It will be found that if a circuit is properly designed and operated, the assumption that E, I, and R are constants will yield sufficient accuracy for the great majority of circuit solutions. Whether or not this assumption is justified depends upon the nature of the problem and is best judged on the basis of experience.

Also keep this in mind: Many circuit solutions are based upon measurements made with electrical instruments. No electrical meter should ever be assumed to be 100% accurate. The cost of electrical instruments depends primarily upon the degree of accuracy required. A laboratory-type voltmeter capable of measuring voltages accurate to 0.1% may cost ten or twenty times as much as a general-service instrument in which the desired accuracy is of the order of ±2%. It follows then that measured electrical values must be considered as nothing more than good approximations.

A third factor that must be considered in the accuracy of circuit solution is the manufacturer's "tolerance." For economic reasons, it is desirable that the manufacturer be permitted to construct circuit elements that are accurate only within reasonable limits. For example, in the manufacture of resistance the manufacturer may be allowed a tolerance of ±1%. This means a 100-ohm resistance will be satisfactory if it has a resistance between 90 and 110 ohms. The cost of such a resistance is much less than one in which specifications demand a resistance between 99.9 and 100.1 ohms, and it generally follows that the greater the tolerance, the lower the cost of production. In practical work tolerances as great as ±20% are often permitted. Therefore a resistor marked "100 ohms" should be assumed to have a resistance only approximately equal to the rated value.

It should be evident that, in practical work, striving for a high degree of mathematical accuracy is a waste of time and effort. Experience indicates that mathematical accuracy to three significant figures is quite satisfactory, and strikes a happy medium between calculated and measured values. The student is therefore urged to cultivate the "three-significant-figure" habit in all circuit work.

Special Considerations. The experienced engineer is inclined to use many electrical terms rather loosely, a practice that can be quite confusing to the student who has concentrated upon explicit definitions of such terms. A standard nomenclature of basic electrical terms, however, is very desirable in the early study of Ohm's Law to insure clarity and brevity of explanation and to avoid possible misunderstanding. Explantion may be further simplified by making certain practical assumptions that will eliminate some of the refinements of solution. Later it will be necessary to reconsider these assumptions in greater detail.

In this chapter the term "difference of potential" will be used to describe the electric force developed across a resistance by the action of the current. The existence of a difference of potential will then depend upon whether or not a current has been established. The term "electromotive force," abbreviated "e.m.f.," will refer to the electric force developed across the output terminals of the source. The internal resistance of the source will be assumed to be zero unless it is otherwise stated, so that th e.m.f. is constant in magnitude. Only electromotive-forces of fixed polarity will be considered. An e.m.f. of constant magnitude and unchanging polarity will establish a *uni-directional* or *direct* current in a resistive circuit. If the circuit resistance is constant in magnitude, the current will have constant amplitude. It will be assumed that all resistances are capable of dissipating heat as rapidly as it is generated by the action of the current. On this basis the temperature of the resistance will remain constant, and variations of resistance with temperature may be ignored. It will also be assumed that the connecting leads are of sufficient size that they contribute little to the total resistance of the circuit. All resistance in the circuit will be assumed to be concentrated in the circuit elements rather than distributed through all parts of the circuit. As instruction proceeds, the student will learn that the majority of these assumptions are quite practical and are often taken for granted by the experienced engineer. In some cases, as would be expected, these assumptions do not hold, but the cases will aways be pointed out to the student.

Meaning of Circuit Solution. Mathematical solution of circuit is of little value unless it tells us something about the circuit. In general, a circuit is said to be solved when it is possible to predict the energy distribution in all parts of the circuit or in that part of the circuit in which interest centers. Such predictions are usually made in terms of the values of E, I, and R but may be made as well in terms of Q, W, and P.

Ohm's Law describes the state of electrical equilibrium that must exist in all energized electrical circuits. Complete circuit equilibrium can exist only if all parts of the circuit are in equilibrium. This statement may be taken to mean that a complete circuit satisfies Ohm's Law only when all parts of the circuit satisfies the law. On this basis, applying Ohm's Law to a circuit leads to two conclusions:

1—The *total* current through a circuit will vary directly as the e.m.f. applied across the circuit, and inversely as the *total* resistance of the circuit.

2—The current through *any part* of a circuit varies directly as the difference of potential across *that part,* and inversely as the resistance of *that part.*

It should be evident that Ohm's Law may be used to determine an unknown circuit factor only when two factors are known. R may be found if E and I are known, E may be found if I and R are known, I may be found if E and R are known. Greatest difficulty often lies in the determination of the known factors. Keep in mind, when working with part of a circuit, that the values of E, I, and R must be used which specifically apply to just that part.

Types of Circuits. Circuits may be broadly classified as simple and complex. In general, simple circuits are solved by the simple relation I = E/R. Complex circuits are less readily solved by this simple relation, and recourse must be had to *Kirchhoff's Laws,* which are logical extensions of Ohm's

Law and are basic laws for solving complex networks.

Simple circuits are usually classified in terms of the arrangement of elements in the load circuit. An arrangement such that only one current path exists through the load is called a *series circuit.* Figure 1A shows a typical series arrangement, the arrows indicating the direction of electron movement through the load.

An arrangement of circuit elements such that more than one current path exists in the load is called a *parallel* circuit. A typical parallel circuit is shown in figure 1B. A hybrid arrangement of series and parallel circuit elements, such as that shown in figure 1C, for example, is called a *series-parallel* circuit.

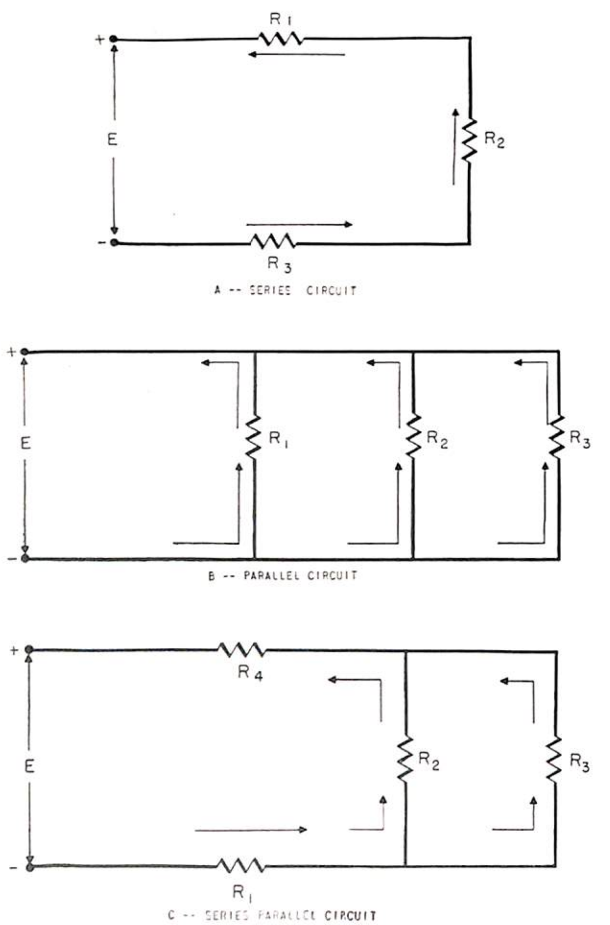


FIGURE 1

THE SERIES CIRCUIT

In applying Ohm's Law to simple circuits it is necessary to make use of certain axioms peculiar to the type of circuit. These axioms are of particular importance in extending the law of complex circuits. An axiom is a self-evident truth or universally-accepted deduction. A corollary of an axiom is a logical deduction based upon the truth of the axiom. The student should thoroughly memorize the axioms of series and parallel circuits.

Current Axiom. In the series circuit there is only one current-path and, for electrical equilibrium to exist throughout the circuit, it is essential that the number of electrons passing any given point in the circuit be identical to the number simultaneously passing through all other points; otherwise electrons would pile up at some point in the circuit. This requirement is described in *the curent axiom: the current is the same in all parts of a series circuit.* In figure 2, A_1, A_2, A_3, and A_4 represent ammeters placed at various points in the series circuit. No matter what e.m.f. is applied across the circuit, or what the total resistance of the circuit may be, the readings of all the meters will be identical. If either the e.m.f or the circuit resistance changes, the meter readings will change, but they will always change in unison. It follows then that the current in a series circuit may be measured by connecting an ammeter in the circuit at *any point.*

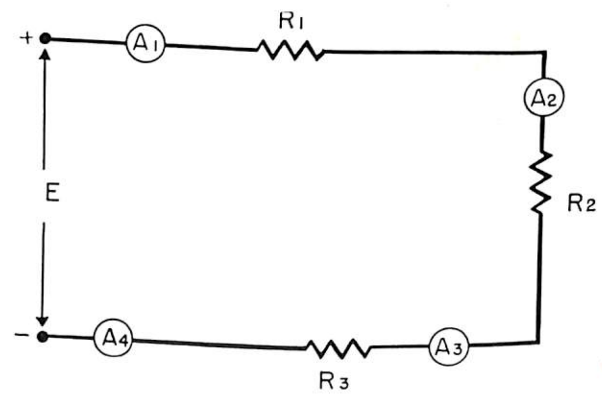


FIGURE 2

A word of caution concerning ammeters is in order at this point. All electrical meters must be considered as costly and delicate instruments. Meter accuracy is a function of careful construction and delicate balancing of the meter movement. A mechanical shock or momentary electrical overload may completely destroy this delicate balance. Repair and adjustment of electrical meters usually requires special tools and skill beyond the ability of the average technician. The ammeter is an instrument designed to measure the amplitude of an electric current. It has very low internal resistance, which permits full-scale readings even when the e.m.f. applied across its terminals is only a few thousandths of a volt. Because of this very low internal resistance, inserting a meter in a circuit scarcely affects the resistance of the circuit. For that reason, it is customary to assume that an ammeter has zero internal resistance. The fact that an ammeter is fully energized by a few thousandths of a volt should not be ignored. *An ammeter must always be connected in series with the circuit.* This means *the circuit must be opened to insert the meter.*

A second important factor relating to ammeters is concerned with the maximum calibrated current rating shown on the scale of any given meter. Before inserting a meter in a circuit, it is necessary to make certain that the maximum current indicated on the calibrated scale of the meter is at least equal to, or greater than, the maximum current to be expected in the circuit. Failure to give full consideration to these factors governing the use of ammeters will inevitably lead to reprimand, severe personal criticism and, most important, a ruined instrument.

The Resistance Axiom. The resistance axiom of a series circuit may be derived from the current axiom. The rate at which the series circuit current accomplishes work in a resistance R is given by

$$P = I^2R.$$

In figure 3 the rate at which work is done in R_1 is

$$P_1 = I^2R_1$$

in R_2 is

$$P_2 = I^2R_2,$$

and in R_3

$$P_3 = I^2R_3.$$

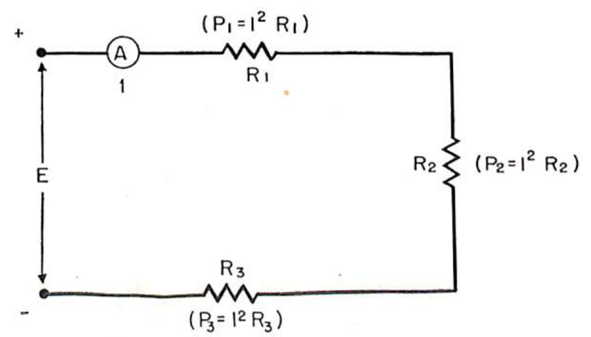


FIGURE 3

Since I is the same in all parts of a series circuit, work is being accomplished simultaneously in all three resistances, so the total rate at which work is being accomplished in the circuit is

$$P = P_1 + P_2 + P_3 = I^2R_1 + I^2R_2 + I^2R_3 = I^2(R_1 + R_2 + R_3).$$

It is possible to visualize this work as being accomplished in a single resistance instead of three resistances. Let R_e ("e" for effective) represent a resistance such that the current I accomplishes work at the rate P described above.

Then

$$P = I^2R_e = I^2(R_1 + R_2 + R_3).$$

Dividing by I^2,

$$R_e = R_1 + R_2 + R_3,$$

which indicates that the total resistance of a series circuit is equal to the sum of all the individual resistances around the circuit. The total resistance of a series circuit is called the "equivalent resistance," and is that value of resistance that may be substituted for the entire load circuit without causing any change in the circuit current.

The Voltage Axiom. By Ohm's Law the voltage drop across a resistance is equal to the product of the current and resistance. In the study of Newton's Law of Forces, it was learned that, for every applied force, there must be generated an equal and opposite force. When an e.m.f. is applied across R, it establishes a current I of such amplitude that the product IR represents a force equal, but acting in a direction opposite to the e.m.f

Thus

$$E = IR_e,$$

where E is the e.m.f. applied across a series circuit having an equivalent resistance R_e and I is the current established in the circuit. Since

$$R_e = R_1 + R_2 + R_3 \ldots\ldots,$$

then

$$E = IR_e = I(R_1 + R_2 + R_3 \ldots\ldots)$$
$$E = IR_1 + IR_2 + IR_3 \ldots\ldots$$

which states *the sum of all the voltage drops around a series circuit is equal to the applied e.m.f.*

A corollary of the voltage axiom leads to Kirchhoff's Voltage Law.

If

$$E = IR_1 + IR_2 + IR_3 \ldots\ldots,$$

then

$$E - IR_1 - IR_2 - IR_3 \ldots\ldots = 0$$

Kirchhoff's Voltage Law states: *The algebraic sum of all the differences of potential around a closed* *conducting path is equal to zero.* The voltage drops are considered negative since they represent electrical potentials in opposition to the applied e.m.f. The electromotive-force applied around a closed path establishes a current of such magnitude that all the generated voltage-drops added together constitute an opposing force just equal to the applied force.

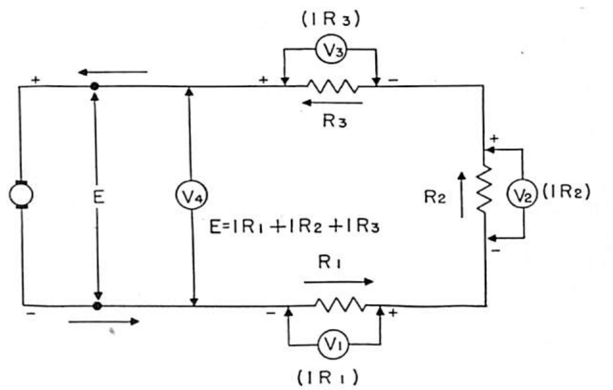


FIGURE 4

Figure 4 illustrates the voltage axiom of the series circuit. V_1, V_2, V_3, and V_4 are voltmeters, electrical instruments designed to measure the difference of potential between any two points. V_1 is conncted across R_1 and hence reads the voltage drop IR_1. V_2 reads IR_2, and V_3 reads IR_3. V_4 is connected across the source terminals and hence reads the e.m.f. generated by the source. The sum of the readings of V_1, V_2, and V_3 will always be equal to the reading of V_4.

The voltmeter is essentially a sensitive ammeter with a very high internal resistance, so that the current through this resistance measures the voltage applied to the terminals of the meter. The most important precaution to observe in using a voltmeter is to make sure that the maximum scale reading of the instrument is at least equal to, or greater than the difference of potential to be expected between the two points to which the meter is connected. If this precaution is not observed, a voltmeter will burn out just as readily as an ammeter.

Either a direct-current ammeter or a direct-current voltmeter may be used to determine the polarity of any two points in a circuit, but the voltmeter is the more useful instrument because it may be connected to the circuit without the necessity of first opening the circuit. *Direct-current instruments are said to be polarized because they must be connected in the circuit with due regard to polarity. The positive terminal of a polarized instrument should always be connected to the point of highest absolute potential. The basic rule is positive to positive and negative to negative.* If the meter is incorrectly connected, it will tend to read in the reverse direction. In general, an instrument will not be damaged by being connected in a position of reversed polarity unless the potential across its terminals is in excess of that which produces full scale reading, but it is much better to connect it properly in the first place.

In direct-current work, it is standard practice to use a color scheme to indicate polarity. Red is the universally accepted color for indicating positive polarity. ("Red is for hot.") Black is most often used to indicate negative polarity, but other colors except red are sometimes used in place of black. In many cases polarity may be indicated by plus and minus signs. Quite often only a single sign is used. For example one terminal of a meter may be marked (+), which automatically indicates that the other must be (−).

Solution of Series Circuits. The foregoing axioms of the series circuit plus Ohm's Law are the tools for solving series circuits. Skill in solution comes only from practice. The following examples will serve to illustrate the general methods of solution. In studying the examples, concentrate on the reason for each step rather than the arithmetical operations involved.

EXAMPLES

Problem: What current will be established in a resistance of 15 ohms by an e.m.f. of 80 volts?

Solution: $I = \frac{E}{R} = \frac{80}{15} = 5.33$ a.

Problem: What e.m.f. is required to establish a current of 12 amperes in a resistance of 1.5 ohms?

Solution: $E = IR = 12 \times 1.5 = 18$ v.

Problem: A generator delivers a current of 50 amperes at an e.m.f. of 660 volts. What is the resistance of the load?

Solution: $R_e = \frac{E}{I} = \frac{660}{50} = 13.2$ ohms.

Note that this solution does not indicate the nature of the load. It simply indicates the load acts exactly like a series circuit of 13.2 ohms equivalent resistance.

Problem: An e.m.f. of 120 volts establishes a current of 4.5 amperes in a soldering iron. What is the equivalent resistance of the soldering iron?

Solution: $R = \frac{E}{I} = \frac{120}{4.5} = 26.7$ ohms.

Problem: In the preceding problem at what rate is electrical energy converted to heat energy in the iron?

Solution: $P = EI = 4.5 \times 120 = 540$ watts.

Note also $P = I^2R = \frac{E^2}{R}$. However, $P = EI$ requires the least arithmetical work.

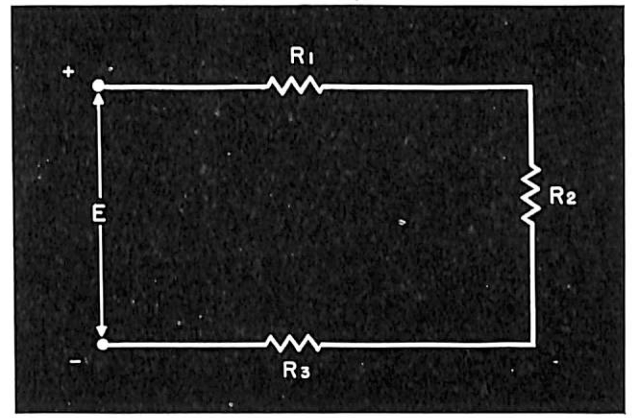


FIGURE 5

Problem: In figure 5, $R_1 = 6$ ohms, $R_2 = 2$ ohms, and $R_3 = 4$ ohms. What e.m.f. is required to establish a current of 2.2 amperes?

Solution: $R_e = R_1 + R_2 + R_3 = 6 + 2 + 4 =$ 12 ohms.

$E = IR_e = 2.2 \times 12 = 26.4$ volts.

Problem: In figure 5, $R_1 = 2.5$ ohms, $R_2 = 3.6$ ohms, and $R_3 = 1.2$ ohms. Source e.m.f. $= 120$ volts. Determine circuit current and check results by voltage axiom.

Solution: $R_e = R_1 + R_2 + R_3 = 2.5 + 3.6 + 1.2 = 7.3$ ohms.

$I = \frac{E}{R} = \frac{120}{7.3} = 16.4$ a.

Check: $E = IR_1 + IR_2 + IR_3 = (16.4 \times 2.5) + (16.4 \times 3.6) + (16.4 \times 1.2) = 41.0 + 59.0 + 19.7 = 120$ v.

Problem: In figure 5, $R_1 = 3$ ohms, $R_2 = 4$ ohms, $R_3 = 6$ ohms. If the voltage drop across R_2 is 32 volts, determine circuit current and e.m.f.

Solution: $IR_2 = 32.$

$I = \frac{32}{R_2} = \frac{32}{4} = 8$ a.

$R_e = R_1 + R_2 + R_3 = 3 + 4 + 6 = 13$ ohms.

$E = IR_e = 8 \times 13 = 104$ volts.

Problem: An e.m.f. of 440 volts moves a charge of 576 coulombs through a resistance R in 8 seconds. What is the resistance of R?

Solution: $I = \frac{Q}{t} = \frac{576}{8} = 72$ a.

$R = \frac{E}{I} = \frac{440}{72} = 6.11$ ohms.

Problem: A current of 5 amperes in a resistance of 16 ohms for 20 seconds will accomplish what work?

Solution: $P = I^2R = 5^2 \times 16 = 400$ watts.

$W = Pt = 400 \times 20 = 8000$ watt-seconds $=$ 8000 joules.

Problem: At what rate is work accomplished in a circuit if the source supplies 2.1 amperes at a pressure of 90 volts?

Solution: $P = EI = 90 \times 2.1 = 189$ watts.

Problem: What power is developed in a resistance of 6 ohms by a current of 0.5 ampere?

Solution: $P = I^2R = 0.5^2 \times 6 = 0.25 \times 6 =$ 1.5 watts.

Problem: At 100-watt ohm resistance has power-dissipation rating of 60 watts. What is the maximum voltage that may be applied across the resistance without exceeding the rated power dissipation?

Solution: $P = \frac{E^2}{R}$

$PR = E^2$

$E = \sqrt{PR} = \sqrt{60 \times 100} = \sqrt{6000} = 77.4$ volts

Problem: An industrial power plant is designed to supply 3000 amperes at 460 volts. If the overall cost of production of electrical energy is 1.3 cents per kilowatt-hour, what is the cost of operating the plant at full output 8 hours per day for 30 days?

Solution: $P = EI = 460 \times 3000 = 1{,}380{,}000$ watts $= 1380$ kw.

$t = 8 \times 30 = 240$ hours.

$W = Pt = 1830 \times 240 = 331{,}200$ kw-hr.

Cost $= 331{,}200 \times 0.013 = \$4305.60$

Analysis of the Series Circuit. Greatest interest in the series circuit lies in the simplicity of circuit solution and the fact that any two-terminal network may be reduced to an equivalent series circuit.

From the standpoint of the distribution of electrical energy, the series circuit has several limitations, the disadvantage of which will be discussed only briefly.

The series circuit often acts as a constant-current variable-voltage circuit, which means that in order to maintain a constant current in this type circuit, the e.m.f. must be varied each time a change is made in the circuit resistance. Of course there is nothing restricting the series circuit to such behavior, but it often is of this type. A 120-volt, 60-watt incandescent lamp will burn at rated brilliancy when the voltage applied across the lamp is 120 volts and the current through it is 60/120 or 0.5 ampere. If two such lamps are connected in series, it will be necessary to double the e.m.f to 240 volts to obtain proper operation of each lamp. Each time a lamp is added to or removed from the circuit, it will be necessary to readjust the e.m.f.

Two devices not designed for the same current will not function properly in series. For example, a 120-volt, 75-watt lamp requires a current of 0.625 ampere for proper operation. If such a lamp be connected in series with a 120-volt, 60-watt lamp (which requires 0.5 ampere) it will be impossible to adjust the line e.m.f. so that both lamps burn at rated brilliancy. If the e.m.f. is adjusted so that the current is 0.625 ampere, the 75-watt lamp will function properly, but the 60-watt lamp will be overloaded. If the e.m.f is adjusted to supply a current of 0.5 ampere, the 75-watt lamp will not receive sufficient energy.

The series circuit is particularly susceptible to circuit faults. If one lamp in a series-connected group burns out, the circuit will be opened, de-energizing all the other lamps. If one lamp should short-circuit, the voltage across the other lamps will rise, causing them to be overloaded. Thus a short-circuit of one piece of apparatus in a series circuit may endanger all the other equipments in the circuit.

A final practical disadvantage of series circuits is that operating a large number of devices in series requires in practically all cases large values of e.m.f. High voltages introduce serious problems of insulation both in the circuit and in the source. In addition, the high voltages represent a very

EXERCISES, PART 9

1. In a simple series circuit such as figure 1A, R_1 is 15 ohms, R_2 is 27 ohms, and R_3 is 40 ohms

(a) Find the applied e.m.f. if the voltage drop across R_1 is 19 volts.

(b) What is the applied e.m.f. when the current through R_2 develops 312 watts?

(c) What is the voltage drop across R_1 and R_2 when 24 volts is the e.m.f.?

2. How much current is drawn by a 1.35-kw electric heater when used on the 110-volt line?

3. The voltage drops across the resistors in figure 5 are measured as follows: R_1, 33 volts; R_2, 18 volts; and R_3, 56 volts. Calculate circuit current and watts dissipated in R_1 and R_2 if the power dissipated in R_3 is 112 watts.

4. What quantity of charge is passed through a 60-watt mazda lamp across a 110-volt d-c line in 1.2 minutes?

5. How much work is done in heating a room with a 110-volt, 900-watt electric heater for 2 hours and 20 minutes?

6. If electric power is sold at the rate of 7½¢ per kilowatt hour, what is the cost of heating in question 5?

7. In a series circuit, 24 volts is applied across two resistors. R_1 is found to be 4 ohms and R_2 is dissipating 32 watts. What is the resistance of R_2?

ANSWERS TO QUESTIONS, PART 8

1. Movement of electrons.
2. 1 milliampere.
3. 1 microampere.
4. (a) 0.156 ohms.
   (b) 2778 ohms.
5. (a) 350 mv.
   (b) 45.6 ma.
   (c) 3.768 kw.
   (d) 6270 volts.
   (e) 2.238 kw-hr.
6. (a) Increase.
   (b) Increase.
7. (d) is the correct statement.
8. False.
9. 1.275 microamperes.
10. (a) 442 joules.
    (b) 4185 joules.
    (c) 369×10^3 joules.
    (d) 716×10^2 joules.
    (e) 45×10^3 joules.

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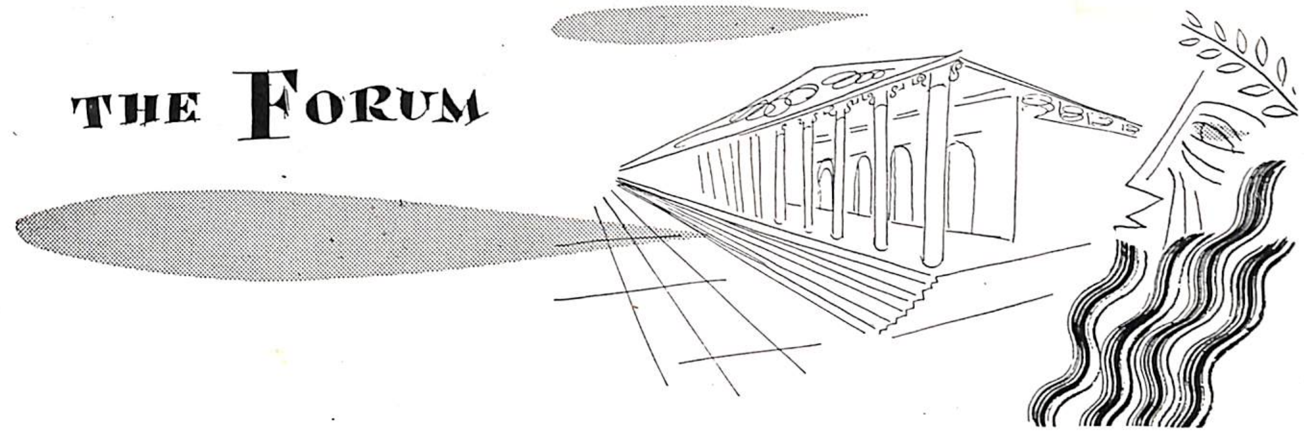
THE FORUM



VACUUM TUBE RECORDS AND SIGNAL GENERATORS

Electronics Officer, U. S. S. Bronx (APA-236)

This letter is written in an attempt to gain clarification of a confusing situation. Various training units and inspecting parties have not improved matters by quoting from letters they have seen on the subject, but which they cannot find.

Responsible persons have stated that vacuum tubes are not classified "Title B" unless they cost fifty dollars or more. Is this correct? Must tube history cards be kept for all Title B tubes? If so, what is the recommended method of keeping them for Title B tubes that have no serial numbers?

We are maintaining history cards on all tubes costing more than five dollars. Those without serial numbers are held as spares. When we have to start using these tubes without serial numbers, however, some of them will undoubtedly end up with the wrong history, due largely to the turnover of personnel aboard. Will all future Title B tubes have serial numbers, eliminating this trouble?

Another item of concern to us is that our new test equipment allowance does not list a signal generator. Under the old allowance, this class vessel rated an LAK or similar type equiment. Is this new allowance in error? It seems rather impractical for us not to rate a signal generator.

Bureau Comment: Article 67–275 of Chapter 67 of the Bureau of Ships Manual (1944) classified vacuum tubes valued at five dollars and under as Title C, and those valued at more than five dollars as Title B. This separation is being cancelled, and the next revision of Chapter 67 will not make this distinction. The Bureau no longer considers any tubes as being in expenditure account 12,000 (old Title B), but now allows them to be handled as old Title C tubes were handled.

The Bureau does not require tube history cards to be maintained aboard ship since it is Bureau policy not to use service life guaranteed tubes aboard ship. This policy is stated in Paragraph 6 of BuShips letter EN28/A2-11 (980b) Serial U-980-334 dated 16 September 1946 and published as Item 46-1954 in the Navy Department Semi-Monthly Bulletin of 30 September 1946 and in the Navy Department Bulletin NAVEXOS P-457 of July-December 1946 on Page 390. Paragraph 6 states, "It is the Bureau's present policy not to use any service life guaranteed tubes aboard ship. However, many tubes originally bought under old guarantees may still be aboard. These should be handled as nonguaranteed tubes."

The recommended method of keeping history records of all tubes is to enter all replacements on the Electronic Equipment History Card (NAVSHIPS 536) of the equipment in which the tube is installed. An article appearing on page 12 of the February, 1948 ELECTRON gave the details of this system.

All test equipment allowances are undergoing revision, and the new APA allowances will list signal generators. The Bureau of Ships appreciates your interest in these matters and solicits further questions and comments.

Woe is me!

Pictured above is an ETM trying to do a job recommended by BuShips ELECTRON, with the magazine locked up in a safe.

It is the desire of the Bureau that the magazine be shown to all concerned personnel. This includes civilians and enlisted men.