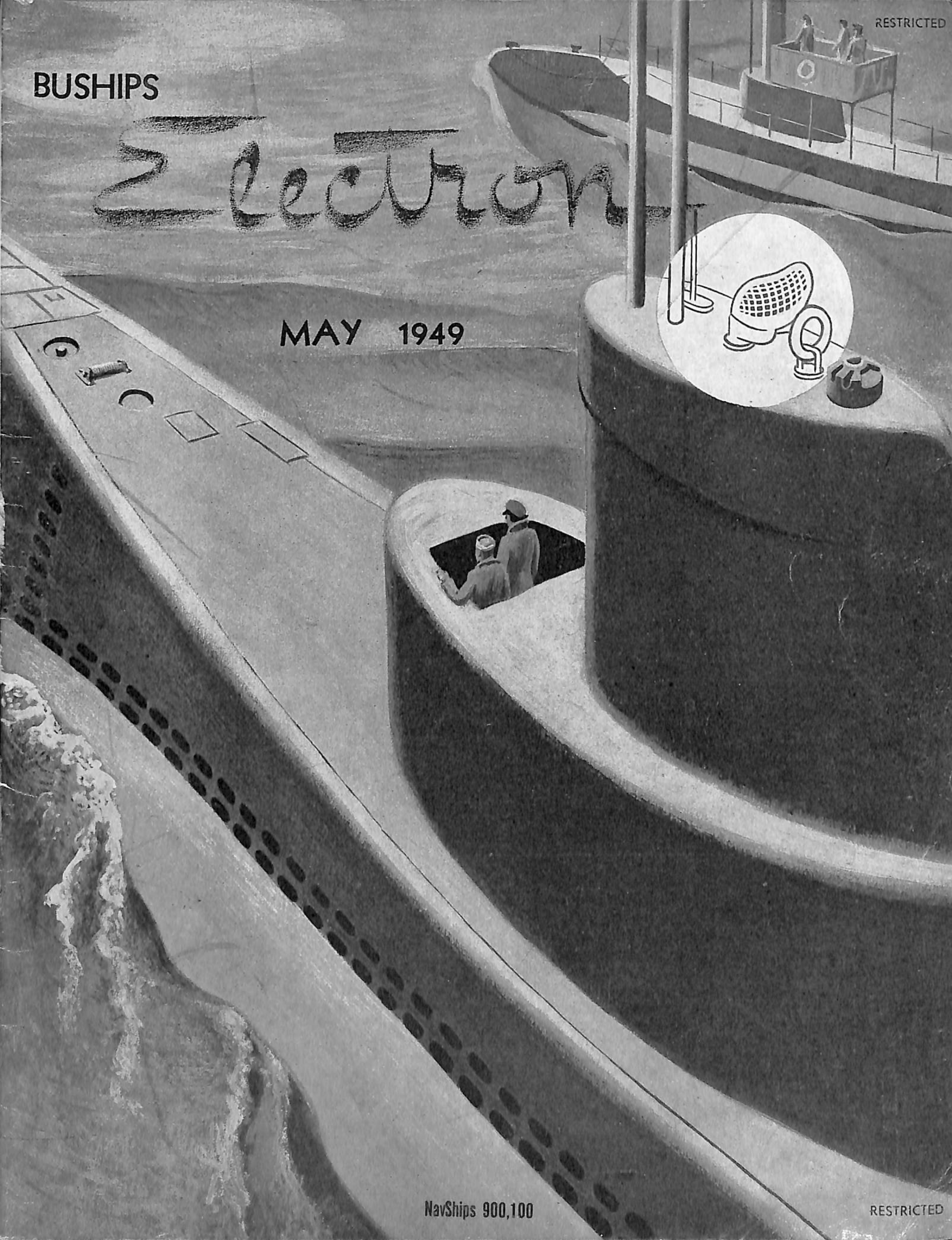
BUSHIPS

Electron

MAY 1949



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Conning tower and bridge of the USS Sailfish *(formerly the* USS Squalus*) located at Portsmouth Naval Base.*

ELECTRONICS INSTALLATIONS AND DEVELOPMENT AND THE PORTSMOUTH NAVAL SHIPYARD

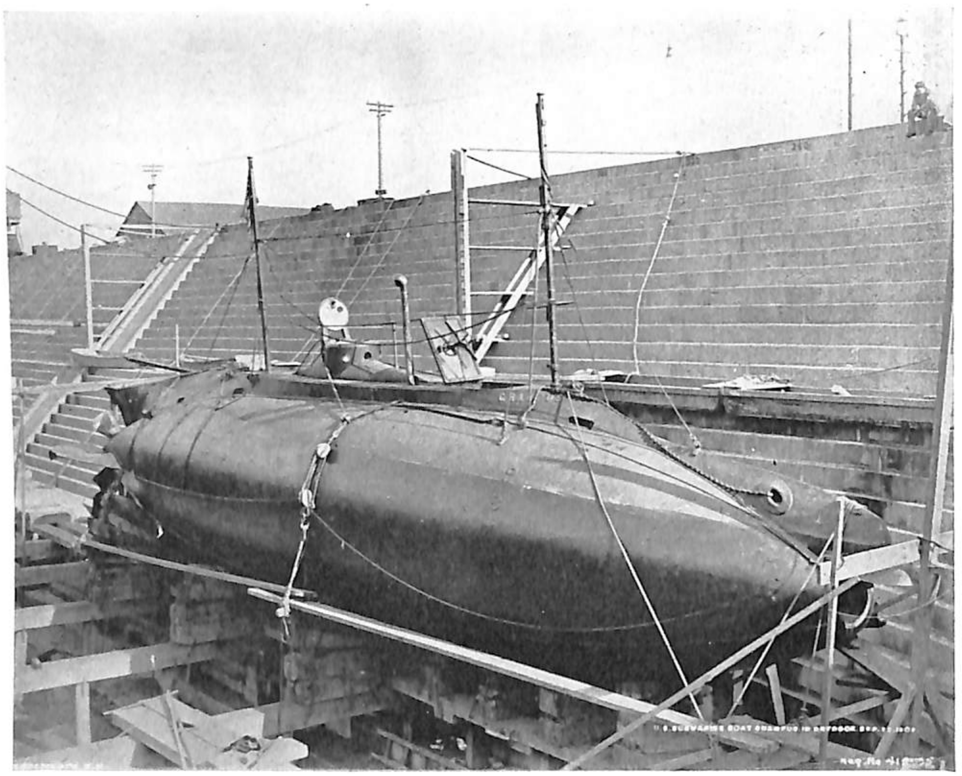
by E. E. Kintner, Lieut. Comdr, USN, *Ass't Planning and Estimating Sup't, Portsmouth Naval Shipyard,* and Edward E. Shapleigh, *Electrical and Electronics Section, Portsmouth Naval Shipyard.*

Perhaps few tracts of land of equal size have contributed much more to U. S. Naval electronics than the islands in the Piscataqua River upon which the Portsmouth Naval Shipyard is built. Electronics installations begin with the first shore radio station built at Portsmouth in 1903 and the first shipboard radio installation accomplished in 1904; they end (at present) with the recent completion of the newest SSR submarines.

On the other hand, the maritime history of these islands begins with their discovery in 1603 by Martin Pring, sailing as an explorer for a group of merchants in Bristol, England. When Pring visited the Piscataqua River with his 100-ton *Speedwell* and 50-ton *Discoverer* he reported that "the river Pishcataqua is a noble sheet of water and of great depth, with beautiful islands and heavy forests along its banks." Shortly thereafter, in 1605, Samuel de Champlain sighted the Isles of Shoals and sailed up the Piscataqua into Great Bay. Captain John Smith came to the Piscataqua in 1614 and produced the first charts of the area on which what now is Portsmouth, N. H. was called Hull, and Kittery and York on the opposite bank of the river were named Boston. The islands upon which the Portsmouth Shipyard is now built were used extensively by fishermen who stopped in the well protected Piscataqua to dry their fish and repair their nets, and were called the Puddington Islands after one of the fishermen. In 1645 the Puddington Islands were rented by Sir Ferdinando Gorgas to Thomas Fernald for the yearly sum of 2 shillings 6 pence. One of the islands was later sold in 1794 to William Dennett of Kittery for 500 pounds. It is Dennett's Island upon which the first United States Government shipyard in this area was built.

It was early realized that the Portsmouth area was immensely rich in fine shipbuilding timbers and as a result ship construction soon grew into an extensive industry in the area. Although many merchant and fishing vessels had been built previously, the first man-of-war was the *Falkland,* a 54-gun ship completed in 1694, and the first vessel built in America for the Royal Navy. The *Falkland* was later lost on the coast of Ireland in May 1699. In 1696 the *Bedford,* 32 guns, and in 1749 the *America,* 44 guns, were built for His Majesty's Navy. The *America* was considered one of the best frigates of the British Navy at that time.

When war broke out between the American Colonies and the mother country in 1775 Portsmouth, with its wide reputation and experience in shipbuilding, was chosen to build ships for the Continental Navy. First such ship was the *Raleigh,* 131 feet long, 697 tons, and carrying fifty-two 12-pounders. She was constructed by a private firm on what is now known as Badger's Island.



The U.S. Submarine Boat GRAMPUS in drydock at Portsmouth Naval Shipyard, 1908.

A year later in May 1777, John Paul Jones took command of the famous *Ranger* which was launched from the same ways on which the *Raleigh* was built. After sailing the *Ranger* to France and receiving in her the first salute to the American flag from a foreign nation, Jones sailed the *Ranger* into British home waters and captured the *Drake,* returning with her to Brest. It is interesting to note that Jones called the *Ranger* "a crank, clumsy ship with a gun deck but no armament above and a dull sailor" and he quickly relinquished his command of her for a better ship.

About this time it became evident that the Navy would require its own shipbuilding yards. Surveys were made of several sites in the Portsmouth area and Dennett's Island was purchased from William Dennett in 1800 for $5,500. This may be considered as the date of establishment of the Portsmouth Navy Yard. There were at that time only one large house and several useless shacks on the island. The large house was repaired and became the residence of the new Superintendent of the Government Reservation. This house, altered and repaired many times, has become the fine mansion now used as the Commander's Quarters, U. S. Naval Base, Portsmouth, and is the house in which Admiral David Farragut died in 1870.

With the end of hostilities between England and the United States the Colonial Government made no immediate efforts to improve shipbuilding facilities at Portsmouth. The impetus of the War of 1812, however, caused ship construction to be resumed, and the keel of a 74-gun ship, the *Washington,* was laid in March 1814. The *Washington* was the third line-of-battle ship launched in the United States and immediately took her place as the flagship of the United States Squadron in Europe.

Between the War of 1812 and the Civil War the shipyard continued to develop gradually, permanent brick buildings replacing many of the temporary wooden ones, and a floating drydock capable of handling ships up to 5,000 tons was commissioned in 1851. This dock continued in operation until 1907. Its work was taken over by a graving dock completed in the gut between Dennett's and Seavey's Islands. The material removed in order to build the graving dock was used as fill to join the two islands and at the present time the shipyard sprawls indiscriminately across both.

The Civil War brought a large number of ships to the Portsmouth Yard. In the year 1864 as many as 2,500 men were on the payroll at one time. The largest ship in the United States Navy during the war was the steel frigate *Franklin* constructed in the new ship house which was to be known until its destruction in a spectacular blaze in 1936 as the Franklin Ship House.

The first shore radio station was built at Portsmouth in 1903. The first installation was a Stone system. This was later replaced by a German built Slaby-Arco set. With this installation it was possible to communicate from Portsmouth to Cape Elizabeth and Cape Cod. Traffic to Boston had to be relayed by the Cape Cod station. Mr. G. E. Howell who reported to the station as an operator in 1904 is now an instrument maker in Shop 51.

As far as can be ascertained from the records the first shipboard radio installation at this shipyard was accomplished aboard the converted collier *U.S.S. Lebanon* in 1904. This vessel was assigned to the shipyard for the installation of a wireless equipment known as the Stone system. There are no complete records now available concerning the details of the system. It is known, however, that the shipyard provided the rigging and the space aboard ship.

In order to obtain the required antenna height the shipyard designed and installed new top-gallant masts for the fore and mainmasts. These had to be installed so that they could easily be lowered to permit the vessel to pass under the Brooklyn Bridge. The antenna itself was rigged from yard-arms on each of the masts. It consisted of 20 parallel rubber insulated wires spaced about a foot apart. A fan type downlead was dropped from the forward end of the antenna to the radio room abaft the chart-house. In 1916 when the shipyard made its first 20–kw Poulsen Arc installation on the armored cruiser *U.S.S. Washington,* it was thought that the acme of radio installation had been reached.

With the World War and the increased importance of submarines in Naval warfare the Navy Department desired to begin construction of submarines in a government shipyard. Previous to this time a submarine construction monopoly was held by two private companies. The first Navy constructed submarine, the L–8, was launched from Franklin Ship House on 23 April 1917, and became the forerunner of a long line of Portsmouth built submersibles. Portsmouth soon became established as a submarine specialty yard and was made the home yard for all submarines stationed on the Atlantic Coast, as well as construction yard for seven boats whose keels were laid between 26 March 1917 and 10 October 1918. Since its earliest submarine experience Portsmouth Shipyard has continued to gain knowledge and experience in submarine work and is still recognized as the East Coast center for construction and conversion of submarines.

Until 1917 all radio installations were made under the supervision of the electrical shop with the drafting room making radio installation and wiring plans as needed. In 1917 the shipyard was assigned its first radio engineer, Mr. Julius Martin, who came to the yard with the title "Radio Expert Aid."

Mr. Martin had been employed at the New York Naval Shipyard from 1892 to 1912 as Quarterman and Master Electrician. Being interested in the new field of "wireless" he obtained a position with the Marconi Company and supervised the installation of the first transatlantic wireless station at Sayville, Long Island. Mr. Martin was one of the first Radio Expert Aids employed by the Navy Department. He remained at Portsmouth until his retirement in 1933.

During Mr. Martin's employment he set up a radio laboratory, first in his office and later in Building 89. Except for a standard wavemeter and a Kolster Decremeter most of the test equipment was "home made." He built a 50-watt driver (Hartley circuit), and a transmitting tube tester. Later he obtained money to purchase a Wheatstone bridge, decade box and various meters. With this equipment he was able to make antenna measurements and such other tests as were required at that time.

From the time of Mr. Martin's retirement until the assigning of a Radio Material Officer in 1941 the work performed by Mr. Martin was assigned as additional duties to Mr. E. E. Shapleigh, radio engineer of the Planning Department. He, with the assistance of the radio personnel of Shop 51, carried on the installation, repair, inspection and testing of electronic equipment on ships built and overhauled and at the yard radio station.

The effect of submarines on the Pacific phase of World War Two is too well known to need reiteration here. The Portsmouth Yard alone contributed seventy-nine vessels to that vast undersea fleet which contributed so much to the defeat of the Japanese Empire. Since VJ Day Portsmouth has continued its leadership in the design and construction of the most modern subsurface vessels, including the first United States snorkel boat, the first guppies, and the first SSR's. It is at present engaged in designing and building the prototype of an entirely new class of high speed underwater boats which should enhance the Portsmouth reputation for the finest, safest, and most dependable of all the vessels in which men fight beneath the surface of the sea.

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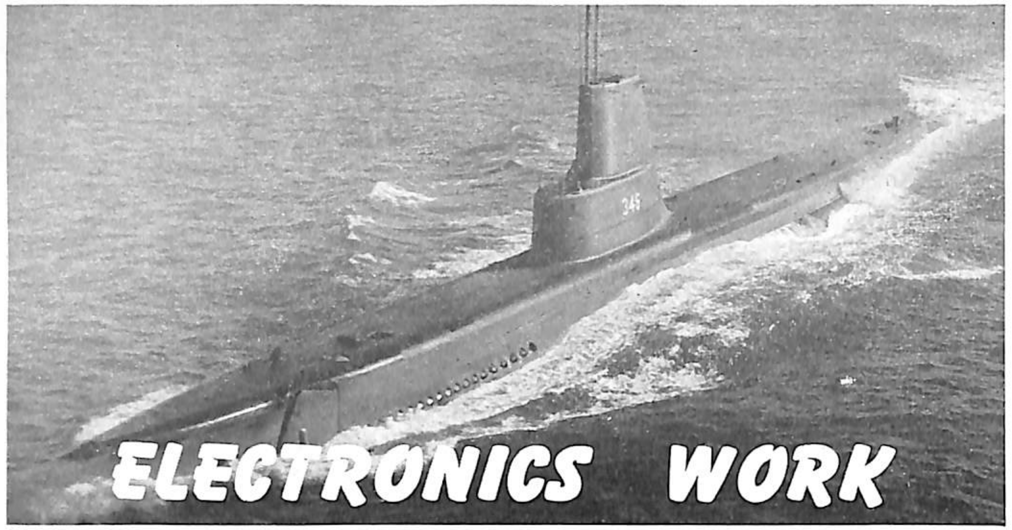


AT PORTSMOUTH NAVAL SHIPYARD

by William B. Bernard, Comdr., USNR,
Electronics Officer, Portsmouth Naval Shipyard

Portsmouth Naval Shipyard is unique. It specializes in submarines. It builds submarines, converts submarines and overhauls submarines. It does very little work on other types of vessels.

Since Boston Naval Shipyard is the maintenance agency for shore radio and Naval Reserve electronics installations, the Portsmouth Electronics Office is responsible only for ship electronics work. Over a period of many years Portsmouth did not have a Radio Material Office. When one was finally established just before World War II there was no civilian staff until contractors' field engineers were made available. After the termination of the field service contracts a group of three civil service engineers was established. All design, planning and material procurement are handled by the Planning Department. This makes it possible for the personnel of the Electronics Office to limit their activities mainly to test, inspection and technical advisory work.

When a submarine enters the yard for overhaul or alteration an arrival inspection is made by the engineers from the Electronics Office and a list of deficiencies is submitted to the Electronics Officer. A recommended repair list is made up using the deficiency list as a reference and the list is sent to Planning and Estimating to be used as a basis for issuing job orders.

The Electronics Officer or his representative attends the arrival conference where at present only the alteration items are discussed. In view of the increasing stringency of overhaul funds, however, it will probably soon be necessary to begin discussing repairs at the overhaul conference. Because of the severe shortage of trained electronics maintenance personnel in the forces afloat the Electronics Officer is extremely reluctant to reduce the amount of preventive maintenance below what is now accomplished during overhauls.

During the actual overhaul period the electronics engineers and the officers attached to the Electronics Office check on the progress and the quality of work, endeavor to alleviate difficulties such as material shortages and trade interferences, and act as liaison between the ship, the shop and the repair and design sections of the yard.

At the end of the overhaul the electronics engineers test all of the equipment and fill out test records which are filed with the rest of the electronics overhaul information. At least two engineers and the officer who has had charge of the electronic overhaul of the boat go along on the post repair trials. During this trip they make such operational tests as could not be made alongside the pier; they instruct the ship's personnel in the proper operation of equipments, especially newly installed equipments; and they check for defects which may show up after a few hours operation. They make up a list of defects of the electronic equipments which are then repaired by Shop 67 during the post-trial repair period.

Although the type of ship upon which the work is accomplished is limited to submarines the electronics work is far from dull and routine.

In addition to the regular repair work there are a number of alterations accomplished to the "overhaul" ships. These include installation of WFA–1 and QLA sonar; OMA noise level monitors and cavitation indicators; and comprehensive radar field changes such as #4—SS which adds delta bearing and range information and #7—SV which permits the presentation of SV information on the SS console. The shortage of sonar transducers also helps to keep life from becoming too placid. If we have a few bad heads of one type we must run a "shuttle" service to the Sonar Transducer Repair Facility, Boston, in order to have enough transducers repaired to get all the boats out in time.

Although the QLA electronic installations worked with no difficulties, the topside hydraulic training gear did not keep in proper adjustment. The high and low speeds in the opposite directions of rotation were not the same and the adjustments made for the speeds did not remain constant for any extended time. To correct this situation a test set-up was made in the laboratory and the performance of the training system was analyzed. As a result of these tests it was found that the difficulty lay in the relief and replenishing valve. When the valve was installed in a vertical position the weight of the steel shuttle in the valve was sufficient to prevent the valve from operating properly. It was recommended that the valve be installed in a horizontal position and a plastic shuttle was furnished to all ships equipped with this training gear by Portsmouth for use until the relief and replenishing valve could be relocated.

With the advent of snorkel it was made possible for a submarine to operate for extended periods with only the snorkel head exposed. Under these conditions the whip antenna is the only one which is above the surface of the water. This makes it necessary to use the whip for both transmitting and receiving. To obviate the need for the operator to leave his position and manually switch the antenna before and after each transmission, a time delay antenna switching relay was developed by one of the Portsmouth Naval Shipyard electronics engineers. When the transmitter is keyed this relay switches the antenna from the receiver to the transmitter. As long as the transmitter is being keyed in the normal fashion this relay stays operated. If the transmitter, however, is not keyed for a period of 3 to 5 seconds the relay will switch the antenna back to the receiver. This type of relay is now being procured by the Bureau of Ships for installation on all snorkel equipped submarines.

When it comes to conversions the guppies do not cause us any particular difficulties except that the snorkel operating gear crowds up a bit more the already overcrowded radio room; but the SSR's are full of headaches, both design and productionwise.

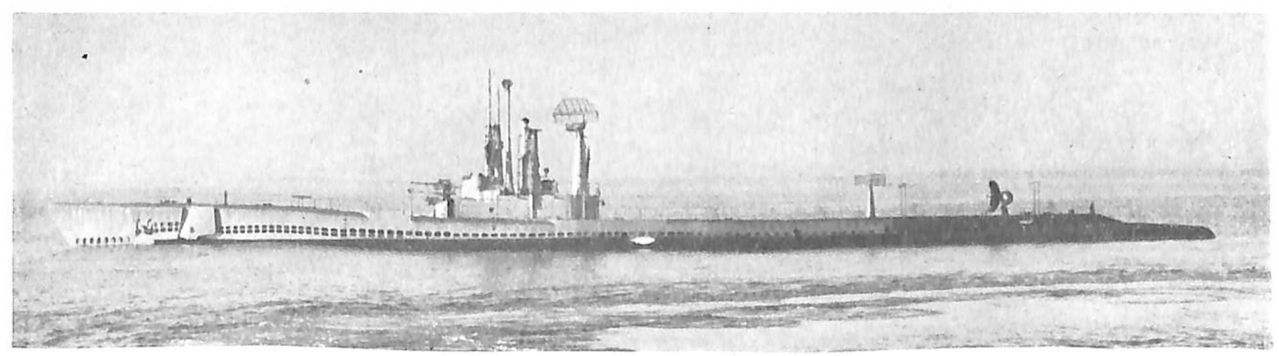
It is necessary to modify equipments designed for surface ship use before they can be used on a submarine. First the antenna must be made pressure-proof to stand deep submergence, then it must be made mechanically strong enough to withstand the hydrodynamic forces encountered when it is "dragged" under the water. It must also stand wave slap during surface operation through heavy seas. All these mechanical changes must leave the electrical characteristics unchanged. After the antenna has been "beefed up" and the heavy torque tube necessary to support and rotate it has been packed at the point of entrance to the pressure hull, the question is raised as to whether or not the original rotater will have adequate power to rotate the new antenna assembly. In one case the answer was found to be no. It was then necessary to design a new antenna drive system and a new control system.

To provide height finding it was necessary to build a completely new antenna, antenna training control system, and elevation drive and control systems, including a stable element.

The electronics work for new construction submarines is still very much in the design and guessing stage. We are doing design work on the items for which we have sufficient information. Many of the other electronic equipments to be installed are themselves in a design stage so on these we have to do a bit of guessing as to what size they will be, how much they will weigh and how much power they will consume.

Portsmouth has a manufacturing project for a 60″ retractable dome and associated hydraulic hoist equipment to be used for WFA–1 and QH series sonar equipments. This project is now in the test stage.

Looking toward the future it seems assured that submarines will become an increasingly important part of the national defense and that electronics will become increasingly important to submarines. We believe therefore that Portsmouth Naval Shipyard with its experience in submarines and submarine electronics will prove in the future, as it has in the past, that it is a vital unit in the Navy's organization.



USS REQUIN (SS–481), one of the latest type submarines.

MAINTENANCE AND OVERHAULS AT PORTSMOUTH

by E. H. CHAPMAN, *Foreman Shop 67, Portsmouth Naval Shipyard*

In 1915 a group of three men in the electrical shop were designated to do radio work. This was the original radio "gang." This group gradually grew until during World War II there were over 200 men engaged in what had become electronics work. The organization of Shop 67 was directed by the Navy Department and on 26 January 1948 Shop 67 was set up with an acting foreman under the supervision of the Master of Shop 51. On 18 August 1948 Shop 67 was established as an independent shop under a foreman responsible to the Production Officer and his branch superintendents.

Shop 67 installs and repairs radar, radio, sonar and MC systems aboard ships and it performs maintenance work on the base radio station and internal security radio units under direction of the Electronics Officer, Boston Naval Shipyard.

The electronics work is divided into inside or shop work and outside or ship work. The ship electronics work is further broken down into systems and a leading man is placed in charge of the work on each system. Each leading man is assigned a number of men for which he is responsible. If one leading man has a work load greater than can be handled by his regular number of men he may borrow men from another leading man. This system relieves the quarterman of the necessity for handling many of the small details associated with the distribution of manpower.

Because of the small amount of space available aboard the submarine a great deal of supervisory advance planning and close cooperation between the trades is necessary to permit an orderly completion of the work. Shop 67 is assisted in the solution of technical problems by the engineers from the electronics office.

During a ship's overhaul all radio and sonar receivers are taken to the shop and checked for proper alignment and sensitivity. Other small units needing repair are also brought to the shop. Units which cannot be removed without removing a "patch" are overhauled on the boat. Although theoretically such units as the TBL transmitter and the SS and SV–1 radar consoles can be broken down into units small enough to pass through a hatch, the breaking down usually entails more work than the overhaul.

In the shop we maintain, subject to the availability of equipment, a test set-up of sonar and radar equipment. This permits us to test individual units of equipment which have been overhauled before they are returned to the boat. It is the aim of Shop 67 to continue improving its facilities and services and satisfy its customers, the forces afloat.

MODELS DAS–1/–3 ANTENNA INPUT CHASSIS CONNECTORS

It has been noted that a possible point of failure in the Models DAS–1/–3 Radio Navigation Equipment is at the coaxial chassis connector J–302. This connector, Navy Type –49568, has a tendency to rotate when connecting the antenna cable plug. Through this process the soldered lead to the chassis connector is broken.

This condition can be corrected by replacing the Type –49568 receptacle J–302 with a Type –49194 receptacle. This is the type presently used on the Model DAS–4 equipment. If this change is made the antenna cable plug must also be changed. A Type –49195 plug should be used on the cable.

This change should be accomplished when repairs to these equipments are necessary. It will require the drilling of four holes for mounting the receptacle, and the filing of the receiver case hole to fit the square base of the receptacle.

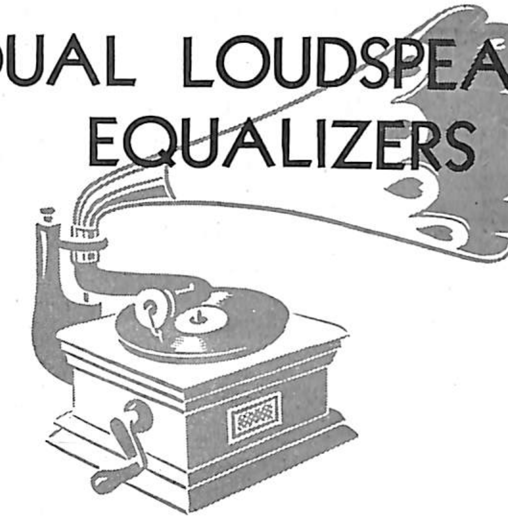
OPERATION OF TYPE –10695 SOLDER GUNS

It is requested that reports of operation of the Type –10695 Solder Guns under service conditions be submitted to the Bureau of Ships, Code 983. All vessels and shore activities having used this type of solder gun should submit at least one report.

The reports should include where possible information on the following items:

1—Type and average life of tip.
2—Average life of pilot lamp.
3—Effect of vibration on tip retaining nuts, etc.
4—Action and average life of switch.
5—Effect of heating on transformer.
6—Adequacy of molded parts for service.
7—Difficulties attributable to humidity, such as corrosion, etc.
8—Comparison of the performance of the guns with that of conventional soldering irons.
9—Total number of hours used to date.
10—Remarks and recommendations.

DUAL LOUDSPEAKERS, PICKUPS, EQUALIZERS AND AMPLIFIERS



by LIEUT. COMDR. CHARLES W. HARRISON, JR., USN
Electronics Design and Development Division, Bureau of Ships

The present paper is a sequel to an earlier investigation of high fidelity sound systems,[1] the primary purpose being to describe in detail the design, construction and adjustment of dual loudspeakers. A portion of the article is devoted to a few remarks concerning a new magnetic pickup, an equalized preamplifier, tone control, and a high power high fidelity amplifier suitable for use in wired program distribution service, or for use as a modulator in a medium power radio telephone transmitter.

SECTION I—DUAL LOUDSPEAKERS

Some of the more important attributes of a good loudspeaker are:

1—Uniform response over a wide frequency range.
2—Negligible distortion at all signal levels.
3—Uniform distribution of acoustic power over a large solid angle at all frequencies.
4—Reasonable electrical to acoustical power conversion efficiency.
5—Sufficient reserve power capacity to handle peak power contingencies.
6—High damping to improve linearity and insure faithful reproduction of transients.

In order to satisfy the above criteria for a high quality loudspeaker, the most satisfactory solution at present is to employ two or more speakers to cover the audio-frequency range. Although three-way speaker systems are entirely feasible, attention is focused here on two-way systems, largely because of the difficulty one encounters in correctly phasing more complicated speaker systems.

In a dual speaker it is customary to employ a direct radiator speaker mechanism with suitable baffle to cover the low-frequency range, and a high-frequency receiver (or driver) equipped with a sectoral horn to cover the high-frequency range. A frequency selective circuit, known as a dividing or cross-over network, is necessary to transmit the correct band of frequencies to the individual speakers. This network is usually placed between the output transformer of the amplifier and the voice coils of the speakers. (Alternatively, a cross-over network may be inserted in a low-level audio stage followed by a dual power amplifier for driving the speakers. One disadvantage of this latter system is that vacuum tube amplifiers do not maintain stable character-

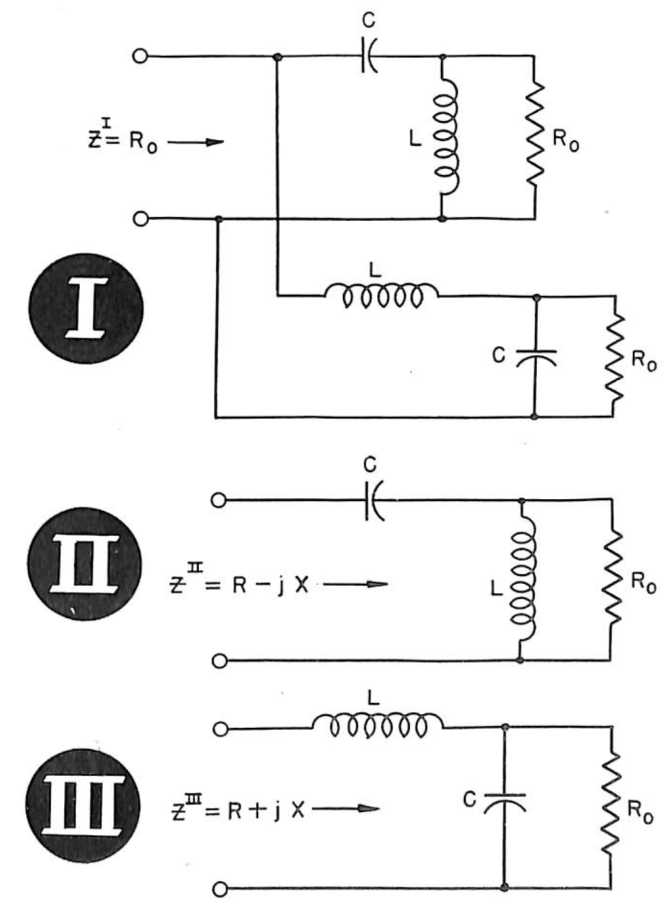


FIGURE 1.—*Circuit I—Constant-resistance dividing network, terminated in speakers of impedance R_o.*
Circuit II—High-pass filter branch.
Circuit III—Low-pass filter branch.

[1] Charles W. Harrison, Jr., "High Fidelity Sound Systems," BUSHIPS ELECTRON, pp. 18–26; December 1948.

istics over long periods of time and consequently high-frequency versus low-frequency balance between the speakers, as well as the required constant phase relationship between them, is not maintained.) A high-frequency attenuator, usually in the form of an L-pad, permits the achievement of a satisfactory balance between the outputs of the high-frequency and low-frequency speakers. (Once this balance adjustment has been made it need not be disturbed until the dual speaker is moved to a new location where different acoustic conditions prevail.)

Anyone who has ever used a dual loudspeaker will never settle for less. It gives a third dimensional effect to program material, i. e., provides "depth."

Design of Dividing Networks for Dual Loudspeakers

Basically a cross-over network consists of a low-pass and high-pass filter designed to work from a common voltage source. The low-pass filter should provide an attenuation of approximately 3 db at the cross-over frequency and 8 to 12 db per octave as the frequency is raised. The high-pass filter should provide an attenuation of approximately 3 db at the cross-over frequency and 8 to 12 db per octave as the frequency is lowered. Two types of dividing networks are in common use: the filter type and the constant-resistance type.

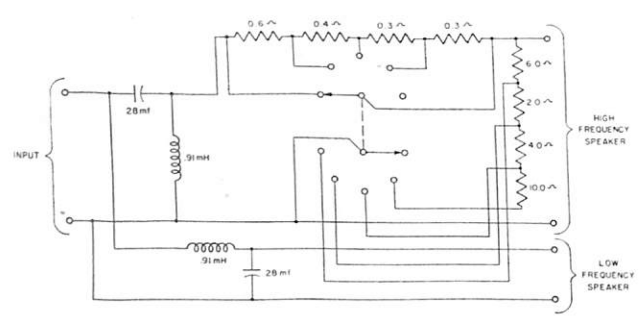


FIGURE 2.—*Schematic wiring diagram of the dividing network and adjustable L-attenuator used in the Western Electric 757A dual loudspeaker.*

The input impedance of a constant resistance dividing network is a pure resistance of constant value over the frequency range of interest, provided proper resistive loads are connected to the two pairs of output terminals. One constructional advantage of constant-resistance dividing networks is that capacitors of the same value, and inductors of the same value, are employed in both the low-pass and high-pass branches.

Circuit I of figure 1 represents a common form of constant resistance dividing network. The high-pass and low-pass branches are each terminated in a pure resistance R_o. R_o is the speaker impedance (assumed to be a pure resistance at all frequencies), or the input impedance of a properly designed L-attenuator terminated in a speaker of impedance R_o.

Circuits II and III, figure 1, represent the high- and low-pass branches of the dividing network, respectively, showing the proper positions of the capacitors and the inductors. At the cross-over frequency the power delivered to each speaker in a two-way system is the same. Since these circuits are ultimately connected in parallel and are therefore driven by a common voltage source, the input resistance of circuit II must equal the input resistance of circuit III at the cross-over frequency. This resistance is designated R. Further, the reactive component of the input impedance of circuit II must be the negative of the reactive component of the input impedance of circuit III. If this were not true, there would be no possibility of the parallel combination of these two impedances reducing to a pure resistance of value R_o. This reactance is designated X. With these facts in mind one writes the following equations concerning the circuits:

$$Z^{I} = R_o = \frac{R^2 + X^2}{2R} \quad \text{(1)}$$

$$Z^{II} = \frac{\omega_c^2 L^2 R_o}{R_o^2 + \omega_c^2 L^2} - j\left\{\frac{1}{\omega_c C} - \frac{\omega_c L R_o^2}{R_o^2 + \omega_c^2 L^2}\right\} \quad \text{(2)}$$

$$Z^{III} = \frac{R_o}{\omega_c^2 C^2 R_o^2 + 1} + j\left\{\omega_c L - \frac{\omega_c C R_o^2}{\omega_c^2 C^2 R_o^2 + 1}\right\} \quad \text{(3)}$$

Here $\omega_c = 2\pi f_c$, where f_c is the cross-over frequency.

On equating the resistive component of (2) to the resistive component of (3), it is found that at the cross-over frequency

$$\omega_c^2 L C = 1 \quad \text{(4)}$$

or

$$\omega_c L = \frac{1}{\omega_c C} \quad \text{(5)}$$

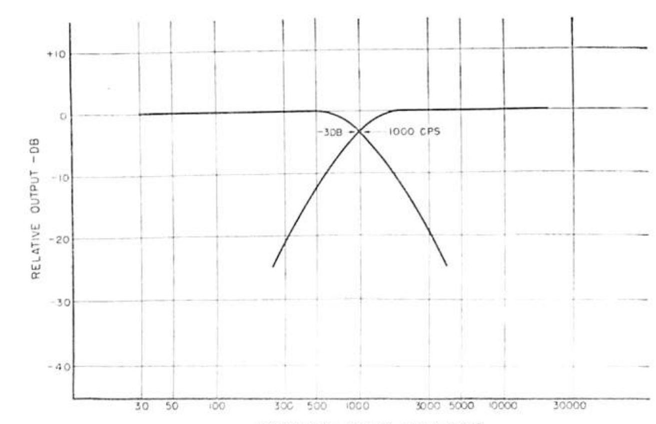


FIGURE 3.—*Band pass characteristic of dividing network (less the L-attenuator) shown in figure 2.*

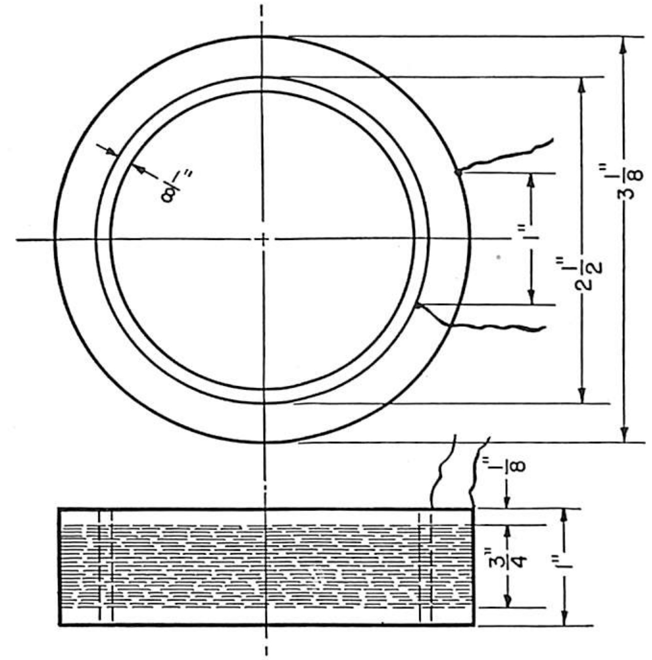


FIGURE 4.—*Constructional details for an air core coil having an inductance of approximately 0.91 mh.*

This same information could be obtained by equating the reactive component of (2) to the negative of the reactive component of (3).

The value of R and X as given by (2), or the value of R and X as given by (3) may be substituted in (1) to obtain a second relationship between L and C. This relationship, which is too complicated to be reproduced here, may be simplified immediately by use of (4), leaving an expression in terms of L, ω_c and R_o. Proceeding in this manner one finds that

$$L = \frac{R_o\sqrt{2}}{\omega_c} \quad \text{(6)}$$

and

$$C = \frac{1}{\omega_c R_o \sqrt{2}} \quad \text{(7)}$$

Equations (6) and (7) determine the values of inductance and capacity required in the cross-over network.

The input impedance of the dividing network is $Z^I = R_o$ at $f_c = \omega_c/2\pi$ provided $L = R_o\sqrt{2}/\omega_c$ and $C = 1/\omega_c R_o\sqrt{2}$. A logical question is whether the impedance Z^I remains precisely R_o for any frequency $f = \omega/2\pi$. To verify this point one determines the values of Z^{II} and Z^{III} at the frequency $f = \omega/2\pi$ from (2) and (3). This is accomplished by writing ω for ω_c throughout each expression. Next the values of L and C, as given by (6) and (7), are substituted in the relations. (Notice that L and C are both functions of ω_c rather than of ω.) Upon carrying out this procedure and using (1) it is found that the input impedance of the parallel combination of the high-pass and low-pass filters is R_o,

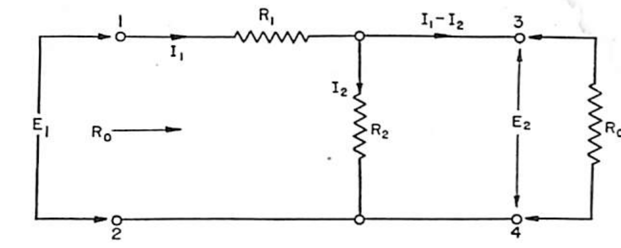


FIGURE 5.—*L-attenuator.*

when each filter branch is terminated in R_o, regardless of the frequency of the voltage source.

Good cross-over network design requires that air core coils be used, for if iron core coils are overloaded severe distortion results. Furthermore, the presence of iron or other metals in the vicinity of the coils is to be avoided. Orient the coils to minimize coupling. The minimum separation between coil centers should be 12 inches. It is suggested that the physical layout of the dividing network be an alternating longitudinal arrangement of coil and condenser grouping. The effective resistance of the coils should be low to minimize losses in the transmission band. Extremely low power factor condensers should be employed. It goes without saying that polarized (electrolytic) condensers have no place in dividing networks as alternating voltages are involved.

The choice of cross-over frequency is governed by a number of factors:

1—If the cross-over frequency is too high the solid angle coverage of the bass speaker may not be satisfactory in the frequency region just below the cross-over frequency.

2—If the cross-over frequency is too high it is difficult to minimize frequency modulation distortion generated by the bass speaker.

3—If the cross-over frequency is too low a comparatively large sectoral horn is required to achieve uniform response over the frequency range above the cross-over frequency.

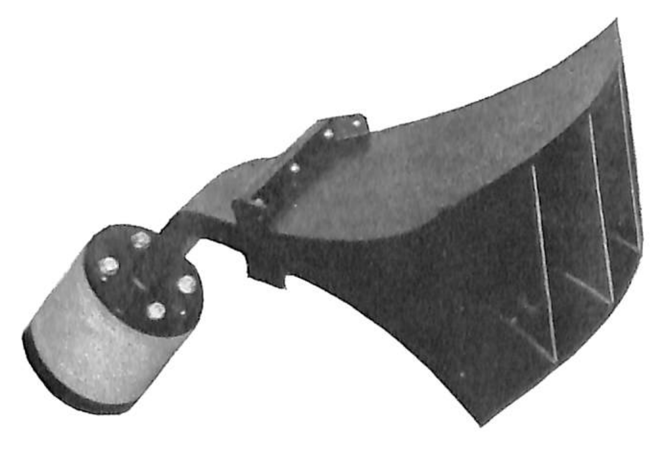


FIGURE 6.—*Western Electric 713C receiver coupled to the Western Electric KS-12024 horn.*

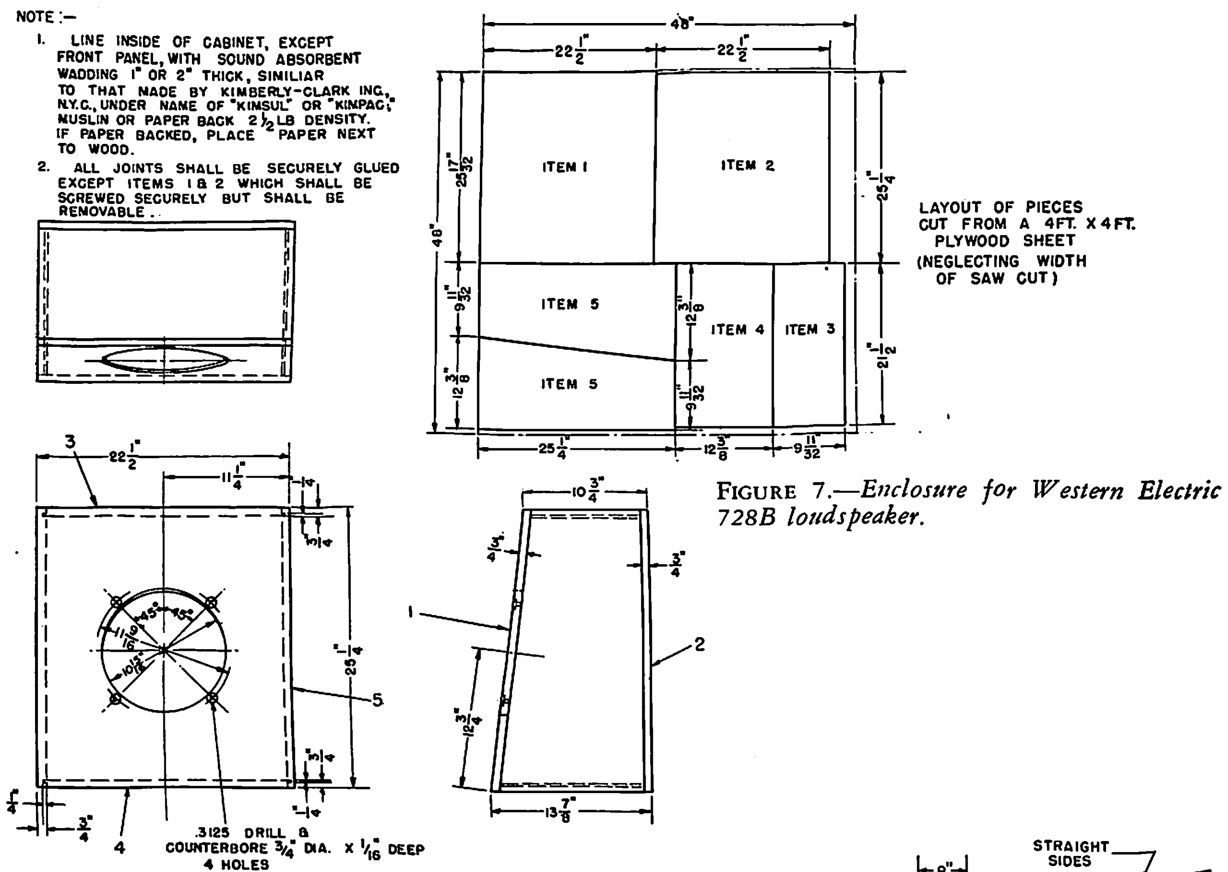


FIGURE 7.—*Enclosure for Western Electric 728B loudspeaker.*

4—If the cross-over frequency is too low the response of each speaker may not be flat in the region of cross-over, resulting in "cross-over dip." Cross-over dip is defined as a minimum (or possibly a null) in the sound intensity versus frequency characteristic of the dual loudspeaker in the vicinity of the cross-over frequency.

5—If the cross-over frequency is too low it becomes difficult to phase the two speakers from the point of view of proper placement of the high-frequency speaker in relation to the low-frequency speaker. (The wavelength of sound at room temperature is approximately 1.14 feet for a frequency of 1,000 cycles per second and 2.28 feet for a frequency of 500 cycles per second.)

6—If the cross-over frequency is too low the effects due to out-of-phase conditions between the base and treble speakers are unduly accentuated since they fall within the region of maximum energy transmission. (Curves of intensity versus frequency distribution for speech and music have a broad maximum in the frequency region 200 to 500 cycles per second.)

7—If the cross-over frequency is too low, a high frequency receiver of relatively high power capacity must be employed. (Curves of percent of intensity below a given frequency f versus the frequency f reveal that approximately 80 percent of the intensity

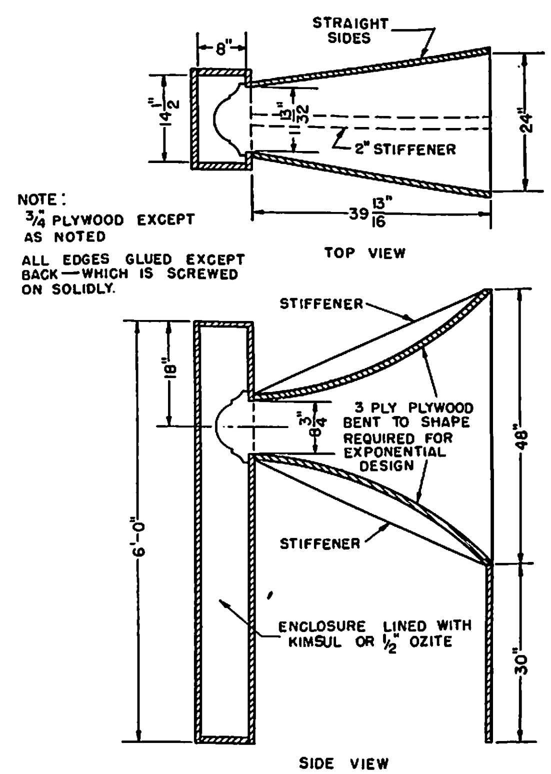


FIGURE 8.—*Exponential horn for use with Western Electric 754A or 728B speaker. The response is essentially flat down to 40 cycles per second. A cross-over frequency of approximately 800 cycles per second is required. A baffle is frequently used with this horn in theater installations.*

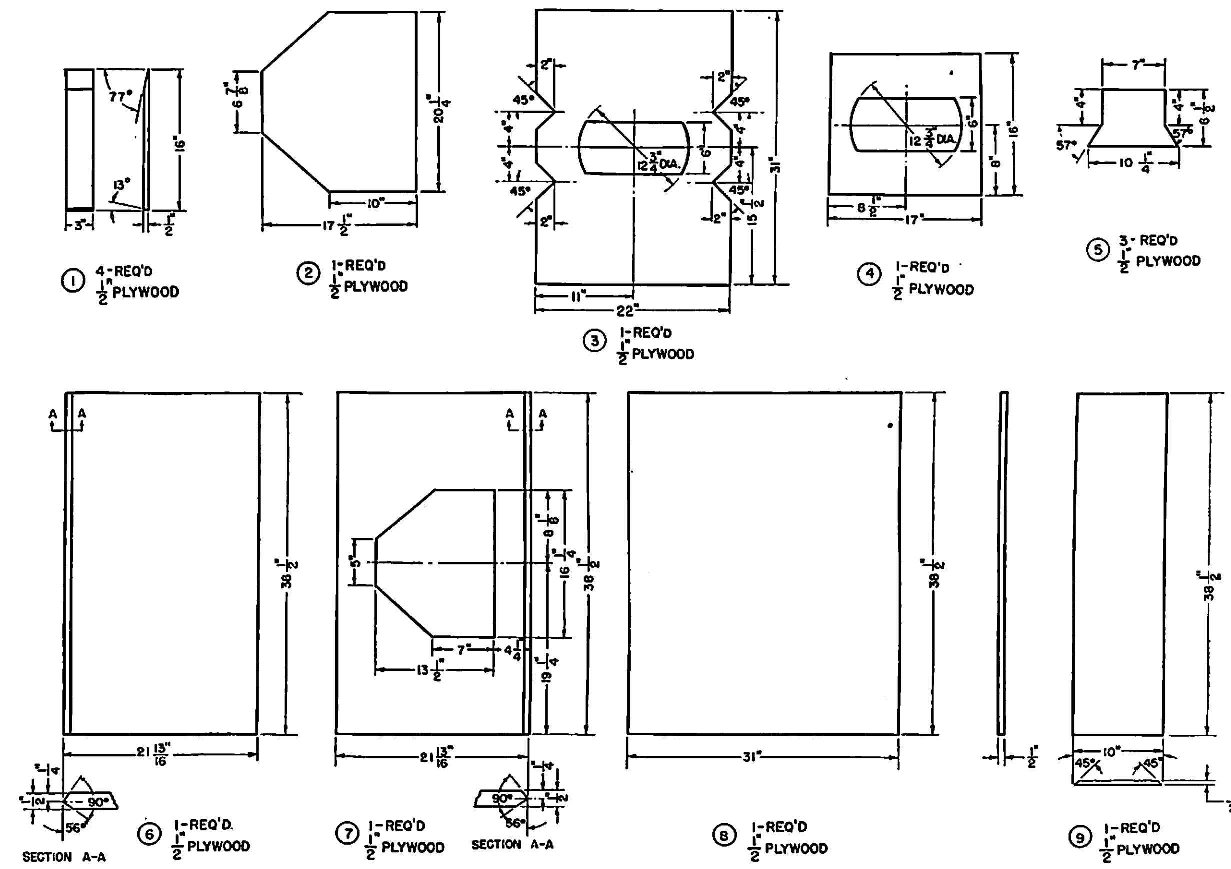


FIGURE 9.—*Details of Klipsch corner horn.*

of a sound wave consisting of speech and music (averaged) falls below a frequency of 1,000 cycles per second.)

8—If the cross-over frequency is too low very large values of inductance and capacity are required in the construction of a dividing network. This is an important consideration, for air core coils of high inductance are difficult to construct, and paper capacitors of 50 mf or so (even though of low-voltage rating) are expensive and bulky.

A compromise between all of the factors mentioned above appears to dictate a cross-over frequency of approximately 1,000 cycles per second. If, then, the bass speaker has a flat-response characteristic for at least four octaves below the cross-over frequency, and the treble speaker has a flat characteristic for four octaves above the cross-over frequency, the response of the dual loudspeaker will be essentially flat over the range 50 to 16,000 cycles per second.

As an example, design a constant-resistance dividing network for use with 4-ohm speakers. The required cross-over frequency is 1,000 cycles per second.

From (6) and (7),

$$L = \frac{4\sqrt{2}}{2\pi\,(1000)} = 0.90 \text{ mh}$$

$$C = \frac{1}{2\pi\,(1000)\,4\sqrt{2}} = 28.14 \text{ mf}$$

A circuit diagram of the dividing network and adjustable L-attenuator used in the Western Electric 757A dual loudspeaker is shown in figure 2. Slightly different values of L and C from those computed are employed in the illustration.

The band-pass characteristics of the filter sections are portrayed in figure 3. These data were determined by terminating each pair of output terminals of the dividing network in a resistance of 4 ohms, and computing the voltage developed across the resistors in terms of a unit potential impressed across the input terminals. It is seen that the low-pass and high-pass filter branches are each down approximately 3 db at the cross-over frequency.

The only remaining problem is the design of the air core inductors for the cross-over network. Figure 4 with the following notes provides the requisite information:

1—Total turns—105 (approximately).

Turns per layer $\begin{cases} \text{3 bottom layers—18 turns.} \\ \text{3 top layers—17 turns.} \end{cases}$

Inductance—mh 0.91 ± 5%.

Resistance—ohms 0.5 ± 10%.

2—External leads from coil should be 12 inches long.

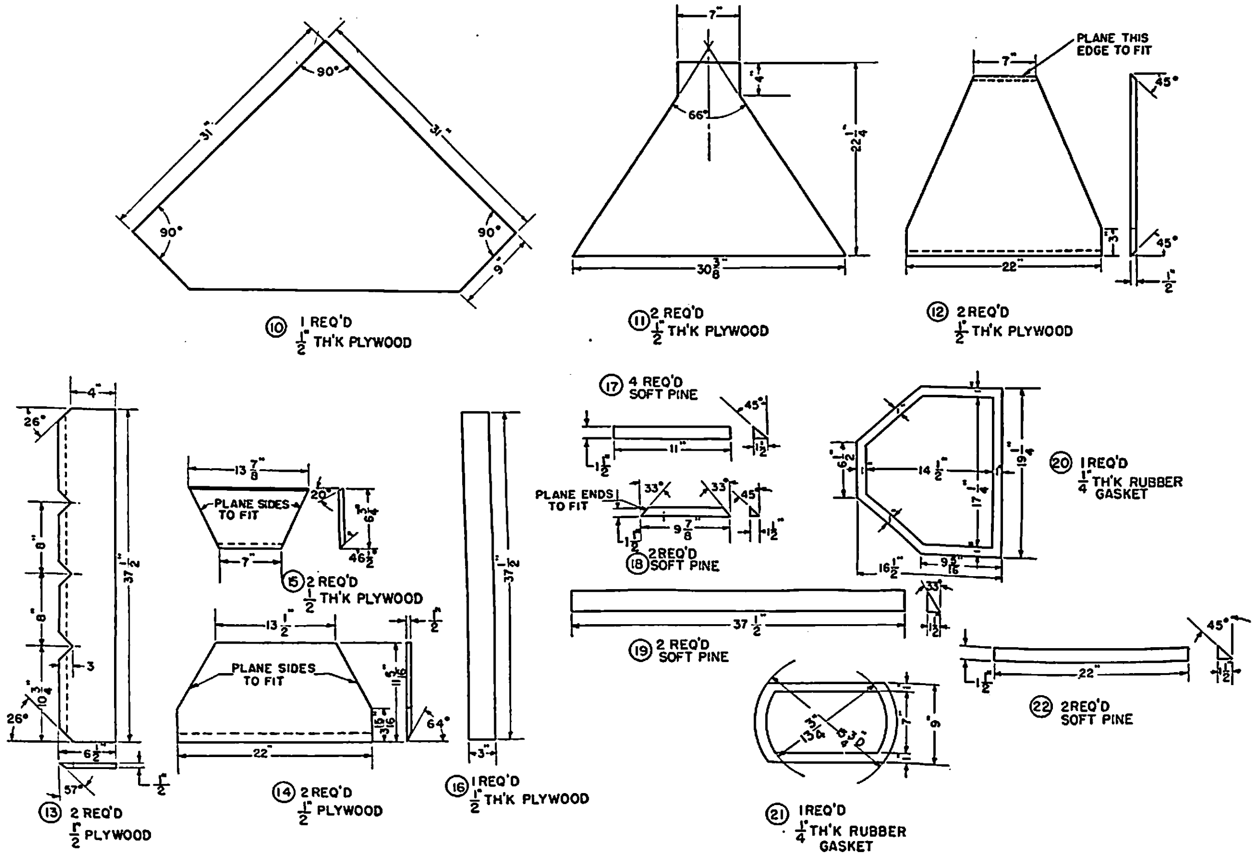


FIGURE 10.—*Same as figure 9.*

3—The outside diameter of the coil core is 2.5 inches.

4—Inset one layer of 0.005 x 1 inch Kraft paper between each layer of #18 AWG enameled copper wire.

5—Wrap outside of coil with 0.010 inch wrapping paper and cement edges down.

6—Dip complete coil in good varnish and then bake for 8 hours at approximately 240° F.

7—The number of turns should be adjusted to meet the specified inductance requirement.

Design of an L-Attenuator for Dual Loudspeakers

The high efficiency of a receiver coupled to a sectoral horn, compared to the low efficiency of a speaker mounted in an "infinite" flat baffle necessitates the use of an attenuator between the high-frequency receiver and the dividing network to achieve balance between the acoustic outputs of the two speakers. An attenuator for this purpose may take a variety of forms but the simplest, requiring only two resistors, is the L-pad. Referring to figure 5, R_1 and R_2 are the arms of the attenuator. The speaker impedance is represented by a resistance R_o. It is desired to calculate the values of R_1 and R_2 subject to the following conditions:

1—The input impedance of the network, looking right from the terminals 1, 2 shall be R_o with the speaker connected to terminals 3, 4.

2—The network R_1, R_2 shall provide a predetermined attenuation.

Let

$$\frac{E_1}{E_2} = \alpha \qquad (8)$$

Here E_1 is the voltage applied to terminals 1, 2 of the network, and E_2 is the voltage appearing across the terminals 3, 4, i. e. across the speaker terminals. Then

$$\text{db (attenuation)} = 20 \log_{10} \alpha \qquad (9)$$

Define the currents I_1 and I_2 as shown in the drawing. An application of Kirchhoff's Laws results in the following equations:

$$E_1 = I_1 R_1 + I_2 R_2 \qquad (10)$$

$$0 = (I_1 - I_2) R_o - I_2 R_2 \qquad (11)$$

$$I_1 = E_1/R_o \qquad (12)$$

Also by inspection

$$R_o = R_1 + \frac{R_o R_2}{R_o + R_2} \qquad (13)$$

Upon eliminating I_1 and I_2 from (10) and (11) and employing (8) and (12) one finds that

$$R_1 = R_o \left\{ \frac{\alpha - 1}{\alpha} \right\} \qquad (14)$$

and

$$R_2 = \left\{ \frac{R_o}{\alpha - 1} \right\} \qquad (15)$$

Equations (14) and (15), in combination with (8) and (9), enable one to completely design an L-attenuator of specified characteristics.

The writer procured two 25-watt 5-ohm adjustable resistors for use in the L-attenuator. Attenuations of 5 db and more are obtainable from this choice of resistors, and their wattage rating insures that the network has sufficient power handling capacity.

A convenient table, relating db attentuation and α is given below:

db	α
1	1.12
2	1.26
3	1.41
4	1.58
5	1.78
6	1.99
7	2.24
8	2.51
9	2.82
10	3.16

As an example, design an L-attenuator for use with a 4-ohm (resistance) speaker, providing 7 db attenuation.

From (9)

$7 = 20 \log_{10} \alpha$

or

$$\alpha = 10^{\frac{7}{20}} = 10^{0.35} = 2.24$$

From (14) and (15)

$$R_1 = 4 \left\{ \frac{2.24 - 1.0}{2.24} \right\} = 2.21 \text{ ohms}$$

$$R_2 = \left\{ \frac{4}{2.24 - 1.0} \right\} = 3.23 \text{ ohms}$$

The maximum attenuation provided by the adjustable L-pad shown in figure 2 is approximately 4.5 decibels ($\alpha = 1.667$).

Phasing Dual Loudspeakers

The problem of phasing loudspeakers is not unlike the problem of phasing the elements of an antenna array. The proper phasing of a dual loudspeaker is considered to be of tremendous importance for an improperly phased speaker will sound "muddy." As mentioned earlier, to avoid cross-over dip the acoustic outputs of the speakers must add directly at the cross-over frequency. Ordinarily the sectoral horn and driver are mounted above the direct radiator speaker, so that the axis of both speakers are parallel and are contained in the same vertical plane. (By definition the axis of a speaker coincides with its direction of maximum radiation.) The physical separation between speakers should be as small as the dimensions of the units permit. A horizontal positional shift of one-half wavelength of the high-frequency speaker with respect to the low-frequency speaker is sufficient to compensate for any possible phase condition. If the position of the high-frequency speaker is undesirable for any reason after the phasing has been accomplished, it may be moved one-half wavelength in either direction horizontally, provided the wires feeding the high-frequency speaker (or low-frequency speaker) are reversed.

It is possible to compute the required relative positions of the two speakers. To do this one must know the polarity of both speakers forming the acoustical array, and the phase shift in the cross-over network. The real difficulty in the analytical approach to the problem is that of knowing the position of the "virtual" diaphragm of the low-frequency speaker. It is easier to phase the speakers experimentally. The following procedure was adopted: A General Radio Type 759–B sound-level meter was procured. This instrument has an output meter reading directly in decibels. Columbia constant tone frequency recording No. 10004–M was used as a signal source to drive the dual loudspeaker at the cross-over frequency. A stroboscopic disc was employed to insure that the recording was turning at precisely 78 revolutions per minute. If the test is made in a live room, the sound intensity output of the speakers has an important bearing on the accuracy of measurement.

Tests show that the proper position of the high-frequency speaker with respect to the bass speaker may be readily determined to within 0.125 inches in a live room. The proper position is determined, of course, when the deflection of the db meter on the sound level meter is a maximum. It might be well to mention that the presence of scratch in the signal output of the speakers, when a Columbia constant tone record is employed as a signal source, makes the measurements subject to considerable error; accordingly every effort should be made to procure an audio oscillator for the tests. One important advantage of using a sound level meter for phasing the speakers is that the same meter may be used to determine the proper high-frequency versus low-frequency balance of the speakers. Usually the high-frequency receiver is operated from 2 to 3 db below the level of the low-frequency speaker. By noting the deflection in db of the sound level meter when the bass speaker is operated alone, and then the deflection of the db meter when the high-frequency speaker is operated alone, one is in a position to correctly adjust the L-attenuator to secure pleasing psychological balance. Observe that when one speaker is operated alone the

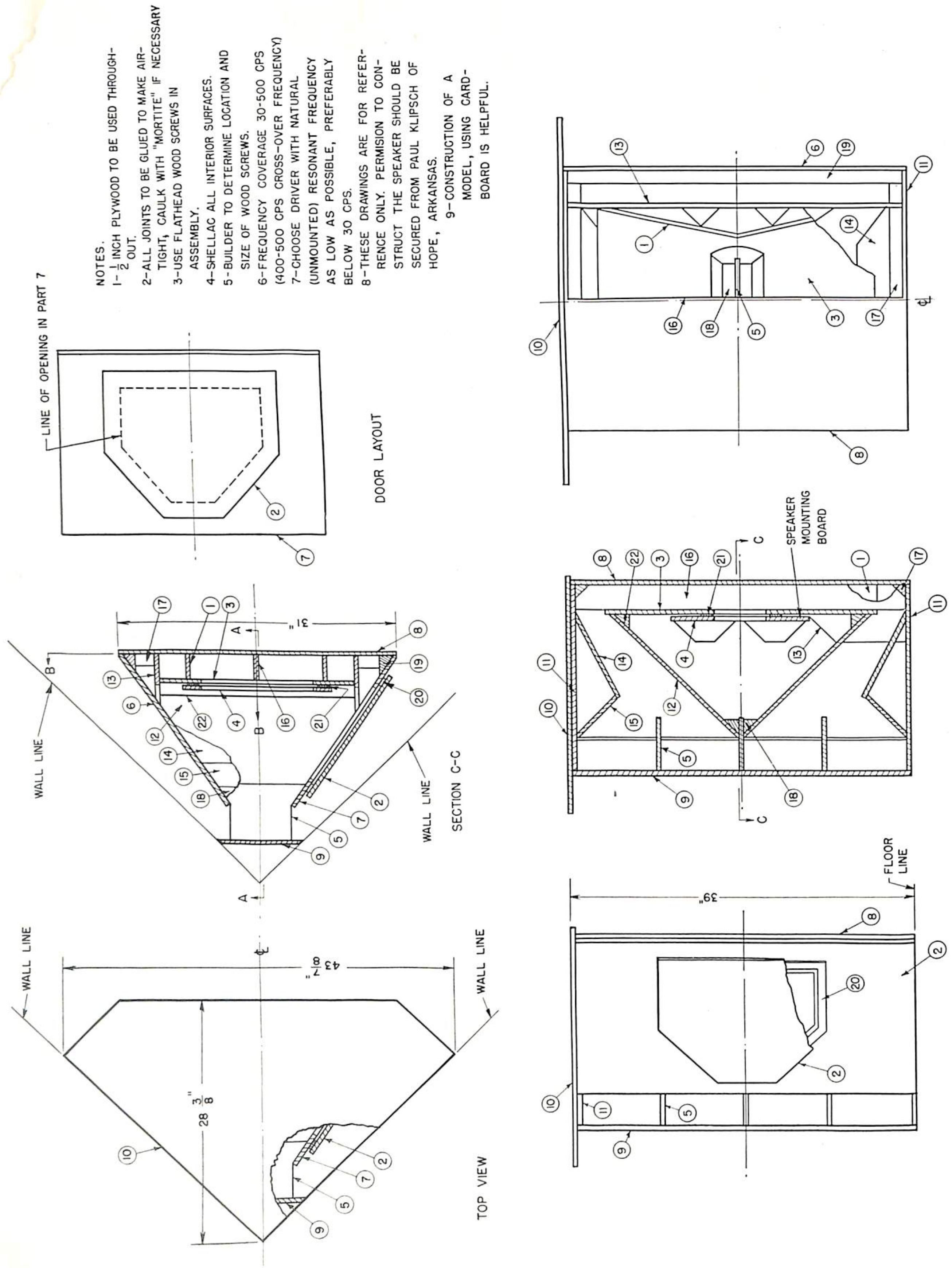


FIGURE 11.—*Assembly details, Klipsch corner horn.*

other channel of the cross-over network must be terminated with a resistor equal to the resistance of the speaker disconnected. Otherwise the input impedance to the cross-over network no longer resembles a resistance.

Basically a sound level meter consists of a microphone, audio amplifier and output meter. If a commercially manufactured sound level meter is not available for phasing the speakers it is suggested that one be constructed using any available microphone and amplifier. The load connected to the secondary winding of the output transformer might consist of a resistor of appropriate value in series with a thermocouple ammeter. High quality equipment is not essential for this application.

The writer was advised by authorities in the field of acoustics that the proper phasing of the speakers could be accomplished by ear. This was found difficult to do especially considering that a dead room was not available for the purpose. When the sectoral horn was positioned by instrument, a very marked increase in clarity of response was noted.

Because of the importance of correct phase relationship between the two speaker elements of a dual loudspeaker at the cross-over frequency, it is concluded that speaker systems employing widely separated elements cannot perform nearly as well as properly integrated speaker systems. It is difficult to see how dual speakers constructed in such a way as to take advantage of radiation from both the front and back sides of the diaphragm of the bass speaker can possibly give satisfactory performance. A dual speaker consisting, for example, of a sectoral horn with driver for treble, and a single diaphragm direct radiator speaker in a bass-reflex baffle for bass presents an almost insurmountable phasing problem.

Construction of Dual Loudspeakers

The design of constant-resistance cross-over networks and L-type attenuators has been discussed. It now remains

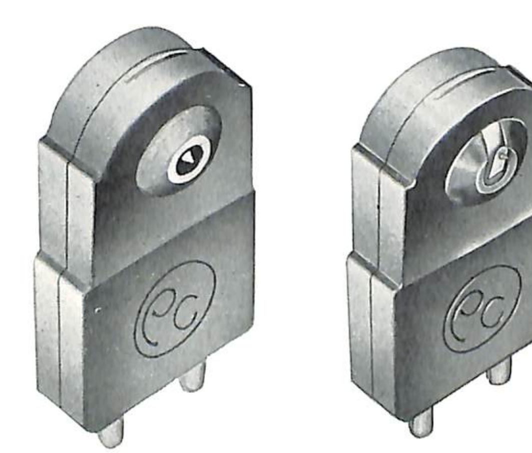


FIGURE 12.—*Pickering Model 120 cartridge (left) and quiet Model R-150 (right).*

to select a suitable high-frequency receiver and sectoral horn to cover the audio spectrum above the cross-over frequency, and a suitable direct radiator speaker mechanism with appropriate baffle to cover the audio spectrum below the cross-over frequency.

The writer procured a Western Electric 713C receiver with KS–12024 sectoral horn to cover the frequency range 1000 to 15,000 cycles per second. The KS–12024 horn provides a horizontal coverage angle of 50 degrees and a vertical coverage angle of 40 degrees. This solid angle of coverage is considered adequate for most applications. Other horns suitable for use with this receiver are available, including the KS–12025 and KS–12027 models, the latter being an integral part of the Western Electric 757A dual loudspeaker. If a W.E. 713C receiver is employed the cross-over frequency must be 800 cycles per second or higher. The accidental application of low-frequency voltage, even momentarily, to the receiver will probably prove disastrous. The diaphragm of this unit is virtually unloaded below 400 cycles per second when used with Western Electric horns.

If "triangles" are in the program material, the selection of the W.E. KS–12024 horn and W.E. 713C receiver will insure that they "stand out" in front of the orchestra. All high-frequency percussion instruments sound absolutely natural when reproduced by this equipment. Even violin "bow scratch" and immature soprano voice "needle scratch" come through with perfect clarity! Figure 6 is a photograph of a 713C receiver coupled to a KS–12024 horn.

A Western Electric 728B speaker, as described in the previous article,[1] was selected to cover the frequency range 60 to 1000 cycles per second. The bass response of this instrument, when used with the recommended enclosure shown in figure 7, is entirely adequate and affords naturalness in the reproduction. Persons not satisfied with the bass response of this speaker are not interested in an auditory sensation, but a chiropractic one! Actually there is very little bass in most live performances (orchestral as well as pipe organ) below 60 cycles per second, so if realism in the reproduction is desired excessive bass response should not be "manufactured" by the sound reproducing equipment.

Some experiments have been conducted using a W.E. 728B speaker in a baffle similar to that shown in figure 7 but of approximately 9 cubic feet volume. The consensus of opinion is that the apparent improvement in low-frequency response is not sufficient to justify the effort. Furthermore, as the volume of the enclosure behind the speaker is increased, the stiffness of the speaker is reduced. Accordingly, audible quality breakup will occur at a greatly reduced power input. For this reason an attempt to operate a high fidelity single diaphragm direct-radiator speaker in the wall between two rooms is doomed to failure, because in this case an entire room serves as the enclosure behind the speaker.

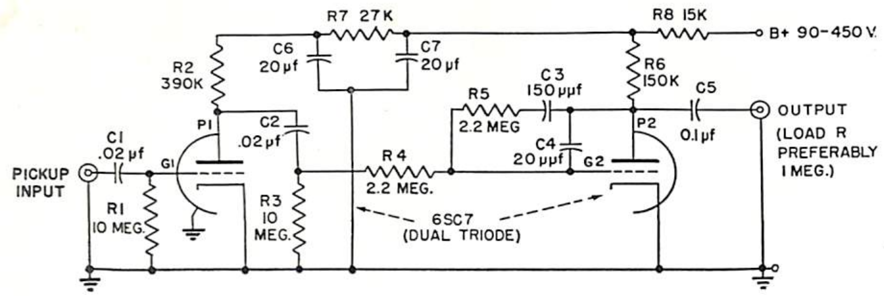


FIGURE 13 — *Preamplifier employing frequency selective feedback circuit to achieve equalization.*

A Western Electric 728B speaker with appropriate baffle reproduces nicely the turn-table rumble at the transmitting station, and this is considered satisfactory bass response.

Persons interested in very dramatic bass at all times and who desire to reproduce that low note that comes along every six months or so will want to akin themselves to the devil, and sprout at least two horns—sectoral for treble and exponential for bass.

A dimensional drawing of an exponential horn suitable for use with the Western Electric 754A or 728B speaker is shown in figure 8.

The taper of the horn (and hence the contour of the two stiffeners) is readily computed from the relation

$$A(x) = A(o)e^{mx} \qquad (16)$$

Here A(x) is the cross-sectional area of the horn at x distance from the throat. This area is taken at right angles with respect to the axis of the horn.

A(o) is the throat area.

m is the flaring constant,

$$m = 4\pi f_c/c \qquad (17)$$

where f_c is the flare cutoff frequency of the "corresponding" infinite exponential horn, and c is the velocity of sound taken at room temperature.

For the horn illustrated

$A(o) \simeq 100$ square inches.

$m = 0.0614$ reciprocal inches.

Equations (16) and (17) are based on the classical theory of the infinite exponential horn. It is not correct to conclude that the use of (16) and (17) for calculating the taper of the finite horn shown in figure 8 implies that poor performance is inevitable. For example, the theory of the infinite horn predicts a zero value for the acoustical resistance below the frequency f_c. The theory of the finite exponential horn shows that the acoustical resistance is not zero below the flare cutoff frequency, which means that the horn will transmit below this frequency. By actual measurement the response of the exponential horn described here is known to be essentially flat down to 40 cycles per second. Additionally, troublesome air column resonances predicted for infinite horns of comparable cross-sectional dimensions are entirely avoided in this design.

In calculating the taper of the stiffeners it must be remembered that the side walls of the horn possess a linear taper. This fact must be taken into account when computing the dimensions of an area at an arbitrary distance x from the throat of the horn. A cross-over frequency of 800 cycles per second is recommended. The treble might well be supplied by a Western Electric 713C receiver with KS–12025 horn. Alternatively two type KS–12024 horns may be bolted together to afford 100 degree horizontal angle coverage.

Another baffle which puts a speaker in the theater class is the Klipsch corner horn. This type horn (along with the exponential horn described above) not only propagates "pear-shaped" bass tones but also enables the listener to determine which end of the "pear" comes out first! Complete plans for construction are shown in figures 9 to 11 inclusive. The Klipsch corner horn cuts off at approximately 500 cycles per second, so that a cross-over frequency of from 300 to 400 cycles per second should be selected. This fact necessitates employment of a special receiver and large sectoral horn to cover the audio-frequency range above the cross-over frequency. Large values of L and C are required in the construction of a suitable cross-over network. It is very important that the resonant frequency of the bass speaker employed in the Klipsch corner horn be very low.

After many careful listening tests it is concluded that it would be an exceedingly difficult matter to improve much on the overall response of the Western Electric 757A dual loudspeaker.

Before leaving the subject of the construction of dual loudspeakers mention should be made of the fact that speaker grill cloth must be selected with great care.

Although it is possible for certain grill cloths to boost the treble approximately ½ db in the region 12,000 to 15,000 cycles per second,[2] in most instances a loss of from 1 db to 20 db obtains. It goes without saying that a loss of even 10 db in the frequency range 8,000 to 15,000 cycles per second completely nullifies the purpose of a dual loudspeaker. The best solution to the grill problem appears to be that of coating brass mesh (0.047 inch diameter wire by 0.120 inch opening) with beige taupe long fibre rayon flock.

SECTION II—PICKUPS, EQUALIZERS AND AMPLIFIERS

Pickups

Subsequent to the writing of the former article on sound systems the writer had an opportunity to test the following magnetic reproducers, all equipped with diamond styli:

G.E. cartridge with 0.0025 inch radius stylus.

G.E. cartridge with 0.003 inch radius stylus.

Pickering Model 120 cartridge with 0.0025 inch radius stylus.

Pickering Model R–150 quiet type cartridge with 0.0025 inch radius stylus.

Pickering Model R–150 quiet type cartridge with 0.003 inch radius stylus.

In the previous paper it was implied that needle talk, i. e., acoustic energy radiated directly by the pickup mechanism, the tone arm or from an area of the rotating record in the immediate vicinity of the stylus, was considered excessive in the case of the Pickering and Clarkstan reproducers. Apparently high needle talk was confined to early production models of the standard Pickering cartridge. With the introduction of the quiet type Pickering reproducer, needle talk has been virtually eliminated, although the frequency response of this model is not as good as the frequency response of the standard cartridge. For the cartridge tested, this fact was not apparent, however, even when playing English Decca full frequency range recordings.

[2] This interesting fact was brought to the attention of the writer by Captain D. C. Redgrave, Jr., USN, Director of the Material Laboratory, New York Navy Yard, in a private communication.

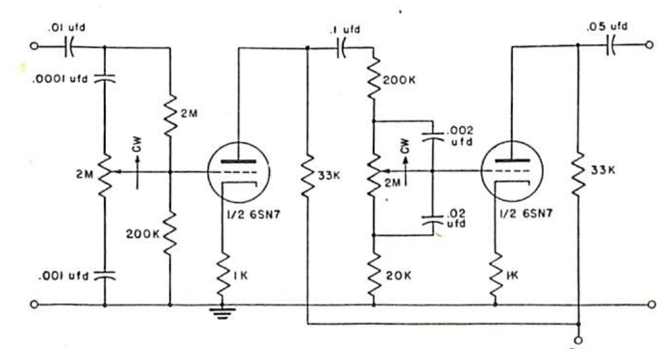


FIGURE 14.—*Two stage tone control.*

Figure 12 illustrates two types of Pickering reproducers. To the left is shown the standard Model 120, and to the right the quiet model. One great advantage of the quiet type cartridge is that the stylus may be replaced without returning the pickup to the factory. This is of particular importance when sapphire styli are employed. The cantilever support for the needle wedges into the cartridge proper as shown.

The following conclusions are drawn as a result of the tests:

1—Needle scratch is higher for a 0.0025 inch radius stylus than for a 0.003 inch radius stylus when playing standard shellac recordings.

2—Needle scratch appears to be slightly higher for a diamond stylus than it is for a sapphire stylus of the same radius.

For playing transcriptions such as those supplied by the Armed Forces Radio Service, the G.E. cartridge with 0.003 inch radius diamond tip was found superior to all reproducers tried from the point of view of chatter, followed by the Pickering quiet type reproducer equipped with 0.003 inch radius diamond tip. In all tests a needle pressure of approximately 5 grams was employed.

The writer considers the Pickering quiet type reproducer equipped with 0.003 inch radius diamond stylus highly satisfactory for playing standard commercially available recordings. If a very light pickup is used for manually playing records, the same reproducer equipped with a sapphire stylus should prove entirely satisfactory.

Equalized Preamplifier

A schematic wiring diagram of an equalized preamplifier capable of giving good performance when used with a Pickering or G.E. reproducer is given in figure 13. Frequency selective feedback accomplishes equalization of the recording. The turnover frequency at the low end is governed by the relation

$$R_5 = \frac{1}{2\pi f\, C_3} \qquad (18)$$

Since $R_5 = 2.2$ megohms, and $C_3 = 150$ µµf, the turnover frequency is f = 482 cycles per second. A 3 db rise occurs at this point, and approaches 6 db rise per octave as the frequency is decreased since the impedance of the series combination of R_5 and C_3 approaches the reactance of X_{C3} and this reactance doubles every octave. Above the turnover frequency the impedance of the series combination of R_5 and C_3 becomes predominantly resistive, approaching R_5 in value as the frequency is raised. The response of the amplifier then becomes essentially flat (provided the condenser C_4 is disconnected).

At moderately high frequencies the condenser C_3 may be regarded as absent from the circuit, i. e., short cir-

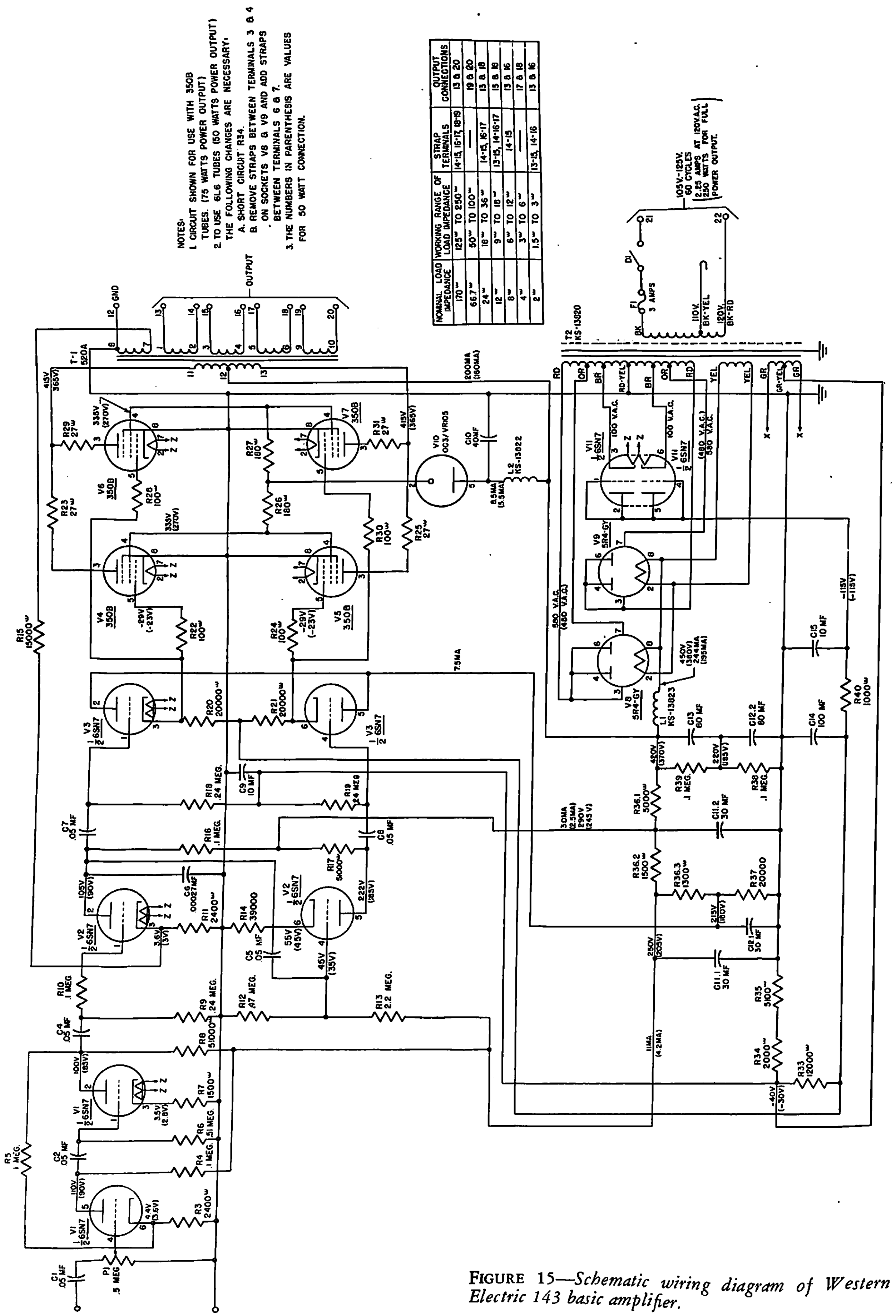


FIGURE 15—*Schematic wiring diagram of Western Electric 143 basic amplifier.*

cuited, resulting in R_5 paralleling C_4. At low frequencies C_4 has no significant effect on the performance of the equalized preamplifier; however, when

$$R_5 = \frac{1}{2\pi f C_4} \quad \text{.........................} \quad (19)$$

3 db attenuation occurs in the high-frequency response of the amplifier, and approaches 6 db per octave as the frequency is raised because the impedance of the parallel combination of R_5 and C_4 becomes predominantly the reactance X_{C4}.

Since $R_5 = 2.2$ megohms, and $C_4 = 20$ $\mu\mu f$, the high-frequency turnover point is $f = 3617$ cycles per second. If no treble cut is desired the condenser C_4 should be omitted from the circuit.

It is apparent that by choosing R_5, C_3 and C_4 in a judicious manner almost any desired equalization curve may be obtained (within limits). The overall gain of the equalized amplifier is about the same as that afforded by the modified G.E. preamplifier discussed in the previous paper. Before leaving the subject of equalized amplifiers employing frequency selective feedback circuits to accomplish equalization,[3] it might be well to mention that the hum level may be reduced on occasion by biasing the heaters of all tubes plus 30 to 40 volts.[1] This is accomplished by connecting the center tap of the filament heating transformer to the plate voltage through a bleeder network and then by heavily by-passing the center tap to ground. This method of reducing hum is particularly effective in equalizer-amplifier circuits involving cathode resistors in the selective feed-back path which are not by-passed.

Tone Control

A tone control circuit, capable of providing approximately 20 db bass or treble equalization, is shown schematically in figure 14. The high frequency equalizer works into the grid circuit of the first tube ($\frac{1}{2}$ 6SN7). Because of the high reactance of the condensers employed, the bass response of the amplifier is independent of the position of the left-hand potentiometer shaft, but the treble response is dependent on the shaft position. Similarly, the low frequency equalizer works into the grid circuit of the second tube ($\frac{1}{2}$ 6SN7). Because of the low reactance of the condensers employed in this circuit, the treble response is constant and independent of the position of the right-hand potentiometer shaft, but the bass response is dependent on the shaft position.

When both potentiometers are set in their mid-position the loss in each equalizer is approximately 20 db, and is independent of frequency. However, the gain of each amplifier stage is approximately 20 db, hence the overall gain of the tone control is essentially unity.

The voltage applied to the input terminals of this tone control should not exceed 3 volts, peak.

It is to be remembered that a tone control is a distortion amplifier.[4] For this reason the use of a tone control in a high fidelity sound system is a questionable practice. By employment of a tone control one tacitly admits that deficiencies exist in the hearing, in the sound system, or in the record being played.

High Power High Fidelity Amplifier

A schematic wiring diagram of the basic Western Electric 143 series amplifier is shown in figure 15. When 4 6L6 tubes are employed in the output stage of this amplifier in lieu of W.E. 350B tubes, a continuous power output of 50 watts is available. The frequency response is within ± 1 db from 50 to 15,000 cycles per second, and the gain is about 50 db. When used to drive a W.E. 728B or 757A speaker at 30 watts, harmonic and intermodulation distortion are practically nonexistent.

Several features of the amplifier are worthy of special note:

1—The power output stage is driven by a push-pull cathode follower.

2—The phase-inverter is the same as that used in the W.E. 142 basic amplifier.[5]

3—The screen potentials of the W.E. 350 tubes (or 6L6 tubes) are stabilized.

4—Fixed bias is used in the driver and output stages.

5—The nominal impedance of the output transformer (primary side) is 2,000 ohms. This is reduced by feedback to 600 ohms.[6]

The inductance of the KS–13822 retardation coil is 3 henries at its rated current of 165 milliamperes d. c. As used in the 143 amplifier a maximum of 8.5 milliamperes flows, and for this current the inductance is about 8 henries. The inductance of the KS–13823 choke coil is 5 henries at its rated current of 300 milliamperes d. c.

The W.E. 143 basic amplifier makes an excellent modulator for a medium power high quality radio telephone transmitter. Additional equipment needed includes a transformer designed to match a 200-ohm line to class C load, and a suitable microphone with pre-amplifier.

Acknowledgment

Mr. John N. Hall of the Electronics Design and Development Division reviewed this manuscript, and checked all drawings for errors.

[3] See figure 6 of reference 1.

[4] The word "amplifier" is used advisedly, for many tone controls have approximately unit gain.

[5] See figure 3 of reference 1.

[6] The nominal impedance of the output transformer (primary side) used in the W.E. 142 basic amplifier is 6,500 ohms. The actual impedance when the feed-back path is connected is 1,340 ohms.

COMMERCIAL, TECHNICAL, ELECTRONICS BOOKS

Commercial textbooks on the subjects of radio, electronics, mathematics and electricity, such as those noted in the accompanying list, are furnished to ship and station libraries by the Bureau of Naval Personnel.

Not all the titles listed are provided for each ship or station library but a representative selection is included in each at the time of commissioning. New titles and new editions of books in these technical fields are distributed from time to time in the monthly issues of new books. Requests for replacement of worn or lost material and any special titles or additional books desired for libraries should be directed to the Bureau of Naval Personnel. These will be provided insofar as funds permit.

Although funds for the procurement of new technical books and books for recreational reading during the current fiscal year are limited to approximately fifty-five cents per capita, this amount is being supplemented by redistribution of used copies. It is suggested that the Bureau of Naval Personnel be informed if ships' libraries are deficient in material on electronics, radio and technical subjects. Titles on hand in each library should be listed in order that supplementary books may be sent, and any particular titles desired should be enumerated.

Although it is not possible to maintain and issue a stock of all books in this field, it is desirable that a representative selection of outstanding publications on these subjects be available to Naval personnel through ship or station libraries. No allowance list has been published since the list is continually under revision. New titles are being added from time to time and older ones dropped as they become outdated. The allowance for different types of ships and stations depends upon the number of personnel served by the library and the particular mission of the activity.

LIST OF BOOKS

MATHEMATICS—applied to electrical engineering and radio

- Cooke—Mathematics Essential to Electricity
- Cooke—Mathematics for Electricians and Radiomen
- Kuehn—Mathematics for Electricians
- Smith—Applied Mathematics
- Sokolnikoff—Higher Mathematics for Engineers

ELECTRICITY—selected

- Abott—National Elec. Code Handbook
- Audel—New Electrical Library, 12 volumes
- Croft—American Electricians Handbook
- Gulliksen—Industrial Electronics
- Hund—High Frequency Measurements
- M.I.T.—Applied Electronics
- Pender—Electrical Engineers Handbook, 2 volumes
- Pender—Standard Handbook for Electrical Engineers
- Timbie—Basic Electricity

AVIATION—selected

- McIntosh—Radio Navigation for Pilots
- Morgan—Aircraft Radio and Elec. Equipment

RADIO

- Abbot—Handbook of Broadcasting, 2nd ed.
- Albert—Electrical Communication
- Albert—Electrical Fundamentals of Communication
- Albert—Fundamentals of Telephony
- Almstead—Radio Fundamentals
- Almstead—Radio Material Guide
- ARRL—Antenna Book
- ARRL—Radio Amateur's Handbook
- AT&T—Principles of Elec. Applied to Telephone
- Brainard—Ultra-High Frequency Techniques
- Burns—Radio
- Cameron—Servicing Sound Equipment
- Camm—Radio Engineer's Pocket Book
- Caverly—Primer of Electronics
- Duncan—Radio Telegraphy & Telephony
- Dunlap—Electrical and Radio Dictionary
- Dunlap—Radar: What it is and How it Works
- Eastman—Fundamentals of Vacuum Tubes
- Eddy—Aeronautic Radio
- Eddy—Television
- Everitt—Fundamentals of Radio
- Fink—Principles of Television Engineering
- Fink—Radar Engineering
- Floherty—Behind the Microphone
- Ghirardi—Modern Radio Servicing
- Ghirardi—Radio Physics Course
- Ghirardi—Radio Troubleshooter's Handbook
- Hall—Radar Aids to Navigation
- Harper—Rhombic Antenna Design
- Hartshorn—Radio-Frequency Measurements
- Harvard U. Cruft Lab.—Electronic Circuits and Tubes
- Henney—Principles of Radio, 4th ed.
- Henney—Radio Engineering Handbook
- Hicks—Principles & Practices of Radio Servicing
- Hoag—Basic Radio
- Hund—Frequency Modulation
- Jordan—Fundamentals of Radio
- Kiver—Television Simplified
- Kiver—Ultra High Frequency Radio Simplified
- Marcus & Horton—Elements of Radio

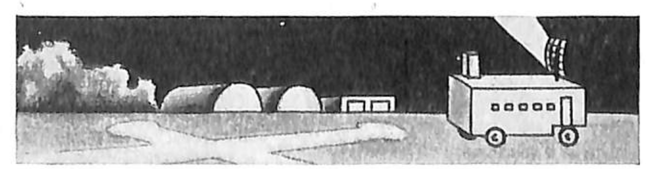
- Manly—Drakes Electrical and Radio Dict.
- Millman—Electronics
- Mills—Electronics
- M.I.T.—Loran: Long Range Navigation
- M.I.T. Radar School—Principles of Radar, 2nd ed.
- Morecroft—Elements of Radio Communication
- Morecroft—Principles of Radio Communication
- Morgan—Aircraft Radio
- Moyer—Radio Construction and Repairing
- Nilson—Practical Radio Communication
- Nilson—Radio Code Manual
- Nilson—Radio Operating Questions and Answers
- RCA—Air Cooled Transmitting Tubes
- RCA—Receiving Tube Manual
- RCA—Radio Fundamentals
- RCA—Radio Handbook (11th ed. 3 volumes)
- RCA—Reference Data for Radio Engineers
- Reich—Principles of Electron Tubes
- Reich—Theory and Application of Electronic Tubes
- Rider—Cathode Ray Tube at Work
- Rider—Frequency Modulation
- Rider—Servicing Superheterodynes
- Roberts—Aviation Radio
- Roberts—Radar Beacons
- Robinson—Radio Telegraphy & Telephony
- Sandretto—Principles of Aeronautical Radio Engineering
- Sarbacher—Hyper and Ultra High Frequency Engineering
- Slurzberg—Electrical Essentials of Radio
- Smith—Radio Handbook
- Sterling—Radio Manual
- Terman—Fundamentals of Radio
- Terman—Radio Engineering, 1940 ed.
- Terman—Radio Engineer's Handbook
- Tyler—Telecasting and Color
- Watson—Understanding Radio
- Whinnery—Fields and Waves in Modern Radio

HOW MUCH DOES GCA COST?

That is not a fair question, for the answer is a negative quantity. *G.C.A. does not cost; it saves.*

A fairly typical report of the operating costs of a G.C.A. unit was given in the G.C.A. Unit No. 10 Maintenance Report for December, 1948.

Type of Approach	Last Month	To Date
Practice Landings	8,578	192,342
Landings Under Instrument Conditions	419	8,519



This unit estimated its total cost of operation for the year at $70,975.00. This estimate included salaries of personnel, the cost of the unit's housing (including depreciation), and depreciation of the expensive equipment as well as maintenance and repair costs and power supplied.

Fairly typical, also, was the total number of approaches made on this unit's coaching. Out of the total of 4,594 approaches, five "saves" were made of aircraft which could not have landed safely by any means other than this G.C.A. unit. The "saves" included three civilian aircraft (a PBY with 9 passengers, a DC–3 with 9 passengers, and an SNB with 5 passengers) and two military aircraft (a C–47 and an A–26).

There are some who say that human lives are priceless and that any expense is justified if human lives are saved. To be a little more practical, we may say that human lives are priceless and therefore can not enter into a mathematical analysis. This being so, we are left with only the replacement costs of the planes and their equipment to be considered here.

But the replacement cost of *one C–47*, about $175,000, is *more than double* the total cost of operating the G.C.A. unit for an *entire year*. If only one large plane is saved for every two G.C.A. units in operation, the cost of operating the units is more than justified.

When judged in this light, the "G.C.A. Box Score" takes on a new meaning.

Henceforth, let us ask, "How much does G.C.A. save?"

The following bit of valuable information has been mentioned before but is passed along again, because of its importance.

Ships equipped with radar are cautioned that under certain sea conditions small bergs and growlers of a size sufficient to damage a vessel may not be detected, due to being obscured by the sea swell or scope clutter.

INSTRUCTION PAMPHLET FOR SUBMARINE PERISCOPE ANTENNA

Portsmouth Naval Shipyard has prepared preliminary instruction pamphlets (No. B-6002) for the Dual Purpose Periscope Antenna installed in various submarines. These pamphlets have been distributed as shown below, with the request that cognizant type commanders furnish three copies to each submarine equipped with the periscope antenna. Additional copies may be obtained by writing ComSubLant or ComSubPac.

Bureau of Ships	2 copies
U.S.N. Underwater Sound Lab.	6 copies
ComSubLant	18 copies
ComSubPac	30 copies
ComNavShipydBoston	2 copies
ComNavShipydPhila	2 copies
ComNavShipydChasn	2 copies
ComNavShipydMare	2 copies
ComNavShipydSanFran	2 copies
ComNavShipydPearl	2 copies

CATALOGUE OF NAVY TYPE ELECTRONIC MATERIAL NOW AVAILABLE

Distribution of a new Navy type number book, the "Catalogue of Navy Type Electronic Material," NavShips 900,109(A), has begun and recipients will soon have the largest accumulation of data on electronic material ever compiled by the Bureau of Ships. The catalogue consists of eight volumes, of which Volumes I through VII are *restricted* and Volume VIII is *confidential.*

The catalogue is the culmination of five years of intensive effort on the part of the Electronics Divisions to compile the most comprehensive and most accurate publication on Navy electronic parts and components possible. Starting with the old Navy type number book, NavShips 900,109, which this catalogue supersedes, the information has been greatly expanded, and arranged in a more usable form. In addition, a cross index has been added which makes it possible for the user to enter the catalogue with other than a Navy type or Army-Navy designation.

Volume I of the catalogue is a cross reference listing of all known equivalent numbers (such as the JAN, ESO stock number, Standard Navy stock number, ASO stock number, Signal Corps stock number, manufacturers' and contractors' numbers) to the Navy type or Army-Navy designation. It also contains an additional JAN to Standard Navy stock number cross index.

Volumes II through VIII are arranged in sequence by Navy type or Army-Navy designation and include a JANAP 109 description for each item, the applicable specifications, drawings, JAN, stock and commercial reference numbers, as well as the equipments in which each item is used.

It is planned to maintain the loose leaf catalogue by issuing supplements periodically. Comments on and requests for the catalogue should be addressed to the Chief of the Bureau of Ships, Attention Code 963.

CUTTING ANTENNA CABLE FOR MODELS DAK, DAQ, AND DAU SERIES EQUIPMENTS

The following information on the cutting of antenna cables for the Models DAK, DAQ, and DAU series equipments should be placed in all appropriate current instruction books and all associated installation manuals.

The three lengths of RG-24/U twin co-axial cable to be used between the base of the loop and the junction box should be of the same electrical length to assure the same electrical phase conditions for each cable. Past experience has indicated that adequate match in electrical length can be achieved by accurately cutting these cables to the same physical length, if the RG-24/U cable is in good condition. Whenever possible, however, this cable should be drawn from stock, instead of using any cable originally supplied with the equipments.

After they are cut the cables should be installed in accordance with the proper instruction book.

Iowa Class Battleships

Sirs:

I am a regular reader of ELECTRON but it disturbs me greatly to read of the Missouri class of battleships as mentioned in your article on Rear Admiral Haeberle in the December issue. As an *Iowa* (*BB-61*) sailor of several years experience I believe that this class of battleships is officially referred to as the Iowa or BB-61 class.

E. P. SMITH, LIEUT. COMDR., USN

Navy Secretary,
Committee on Navigation,
Research and Development Board,
Washington 25, D. C.

ESB, SSD, NSC, Norfolk

Sirs:

We read the March issue of ELECTRON with great interest and wish to thank you for the grand job you did with the layout. Everyone at ESB enjoyed the articles so very much that we would appreciate your sending us ten extra copies of that issue.

As you can realize that everyone is very anxious to read it first hand, you can see what we are up against at present as we have received only two copies.

We really do appreciate your kindness in giving us so much space and wish to thank you again for your splendid efforts.

W. F. WADEWITZ (EDO) USN

Electronics Supply Branch,
Ships Supply Depot,
U. S. Naval Supply Center,
Norfolk 11, Virginia

U-H-F and Radar Propagation

Sirs:

Mr. Buggy's analysis of u-h-f and radar propagation calculations in the February issue of ELECTRON was extremely interesting and no doubt will be referred to often when such calculations are necessary. For this reason, I think that a few serious typographical errors should not be overlooked.

The simplification of (1) $d = \sqrt{2\ hr_e}$ to (2) $d = 1.225h$ was obviously erroneous. It is apparent that Mr. Buggy intended that (2) should have been $d = 1.225\sqrt{h}$ because in calculating for the 100-foot antenna his result could only have been obtained by taking the square root of h.

By the same token, Equation (4) should have been $d = d_1 + d_2 = 1.225\ (\sqrt{h_1} + \sqrt{h_2})$, and on Page 25, where Mr. Buggy's equations have been corrected to account for refraction, the same errors are present.

LESTER H. FINK

Equipment Specialist (Electronics),
Ships Supply Depot,
Naval Supply Center,
Oakland 4, California

Sirs:

In reply to the letter of Lester H. Fink, who commented upon the omission of certain square roots in my article "Some Interesting Aspects of U-H-F and Radar Propagation" appearing in the February ELECTRON, I wish to correct several typographical errors.

1—equation (2) should read $d = 1.225\sqrt{h}$

2—the line above equation (3) should read $h = 100$ ft.

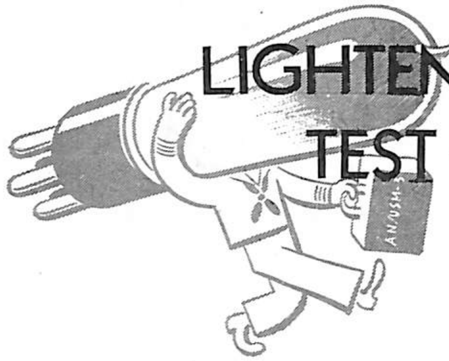
3—in equation (4) and the two lines above, all references to h, or h_2 should be to $\sqrt{h}$, or $\sqrt{h_2}$ respectively.

4—near the top of page 25 in the right hand column:
line 8 should read $d = 1.414\sqrt{h}$
line 13 should read $d = 1.414(\sqrt{h_1} + \sqrt{h_2})$

The examples are correct as worked out in the article.

RODMAN V. BUGGY

Electronics Laboratory,
Philadelphia Naval Shipyard,
Philadelphia, Pennsylvania



LIGHTENING THE LOAD TEST-TOOL SET AN/USM-3

by I. PLOTKIN, *Electronics Ship and Amphibious Division, Bureau of Ships*

One of the most difficult tasks of the electronics technician aboard ship is to carry the many and varied pieces of electronic test equipment to spaces containing electronic equipment which must be repaired. This task becomes particularly troublesome if an electronic system is being checked whose units are in different spaces aboard ship, especially in the initial phases of trouble-shooting where the defect must be localized.

With this thought in mind, the Bureau of Ships is pioneering in the design and development of small and miniaturized test equipment. The miniature Signal Generator SG-18/U and Detector-Amplifier Assembly AN/UPA-1A are in stock and have been issued in place of their large counterparts, the Navy Model OCD Signal Generator and Detector-Amplifier AN/UPA-1.

The latest and most important step in the direction of lightening the load of the technician and making emergency troubleshooting easier is the development of Test-Tool Set AN/USM-3 which will shortly be distributed to the fleet.

This test-tool set was expressly designed for the emergency repair of electronic equipment aboard Naval vessels. It is not to be allowed or used at shore stations since the number procured was based only on shipboard requirements. A small number of these test-tool sets have also been procured for the Marine Corps.

The Test-Tool Set AN/USM-3 is supplied in a box whose dimensions are 10½ by 10 by 7 inches and whose total weight is 23 lbs. It is shown in figures 1 and 2. The "D" rings on the sides are for use when the technician wishes to attach a shoulder strap to aid in carrying the set when going through hatches and up and down ladders.

The contents of this set are listed below and shown (for a preproduction model) in figure 3:

1—Tube Tester TV-4/U
2—Signal Tracer TS-673/U
3—Interference Generator SG-23/U
4—Voltage Indicator-Probe ID-265/U
5—R-F Indicator-Probe ID-263/U
6—Resistance Indicator-Probe ID-264/U
7—Decade Resistor TS-672/U
8—Decade Capacitor TS-621/U
9—Test Prods MX-933/U and MX-934/U
10—Technician's Handbook
11—Telephone Receivers Navy Type -491898
12—Extension Rod (Symbol O-904)
13—2-inch and 4-inch Screwdrivers (Symbols H-902 and H-901)
14—Combination Straight and Phillips Stubby Screwdriver (Symbol H-903)
15—Long Nose Pliers
16—Side Cutting Pliers
17—Insulated Tweezers (Symbol H-915)
18—Pilot Light Extractor (Symbol H-916)
19—Combination Alignment Screwdriver and Tuning Wand (Symbol H-917)
20—Pen-Type Soldering Iron (Symbol H-919)
21—Neon Test Light (Symbol I-901)
22—Flashlight with Lucite Extension and Mirror (Symbols O-901, O-902 and O-903)
23—Hexagonal Wrench Set (Symbols H-902 to H-909)
24—Socket Wrench Set and Handle
25—Fuse Puller
26—Banana to Pin Tip Jack Adapters, Alligator Clips and Spade Lugs
27—Various other test leads and accessories.

As can be seen from figure 2, the items listed above are very compactly fitted into the small space of the case. Every cubic inch has been scientifically filled so that the necessary material may be packed into the smallest volume.

Tube Tester TV-4/U is an ultra compact emission type tube tester and capacity meter complete with a tube data index all securely fastened to the case of the test-tool set. It tests all common receiving tubes with 4, 5, 6, 7 (large and small) prong; octal; loctal; 7 and 9 pin miniatures; 5 and 7 pin acorn bases. Cathode leakage can be checked as well as short and open circuits for individual elements. The tube tester is shown in operating position in figure 4 with a tube being tested.

Signal Tracer TS-673/U is shown in figure 5 with its accessories. It is a variable gain amplifier and output meter. The amplifier will amplify audio voltages from 47 to 15,000 cycles. Test Prod MX-933/U is used when signal tracing audio voltages. Test Prod MX-934/U will detect the amplitude modulation of radio frequencies up to approximately 400 megacycles. An r-f signal of 0.005 volts modulated 50% will give an

FIGURE 1—*Test-Tool Set AN/USM-3—cover closed.*

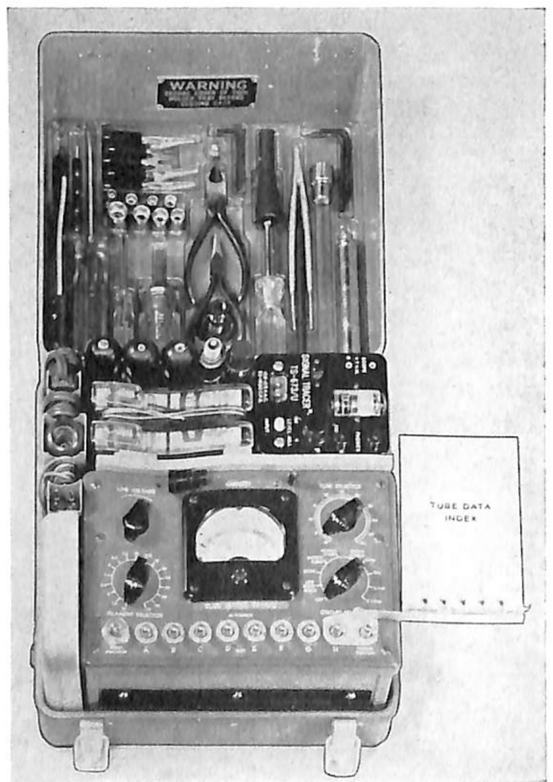
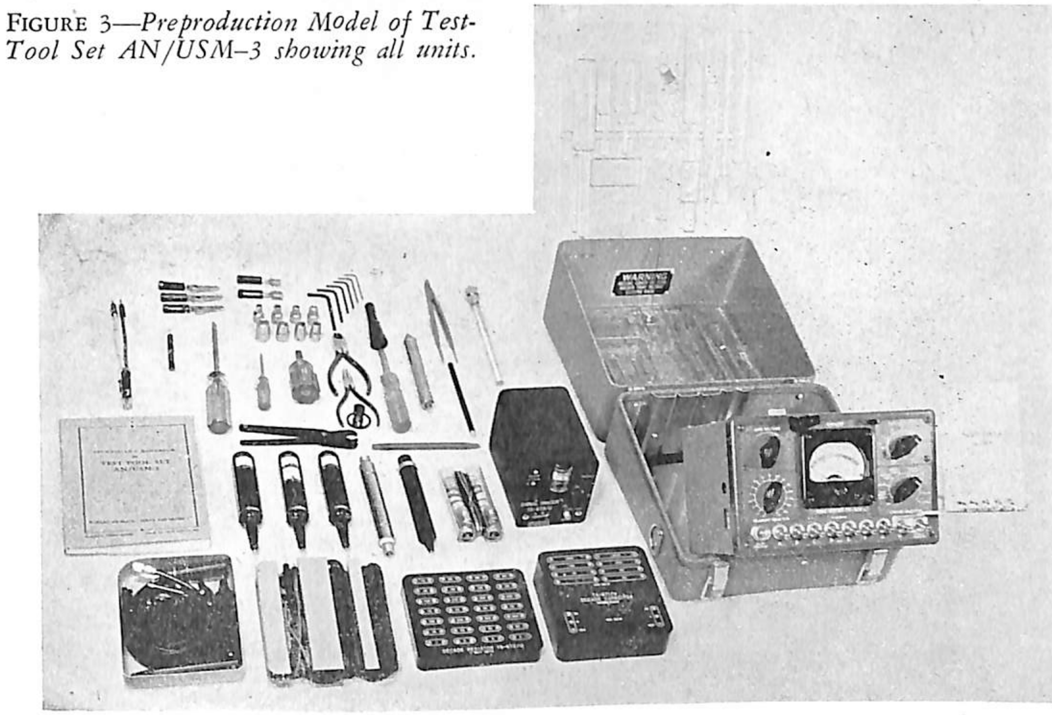


FIGURE 2—*Test-Tool Set AN/USM-3—cover open.*

FIGURE 3—*Preproduction Model of Test-Tool Set AN/USM-3 showing all units.*



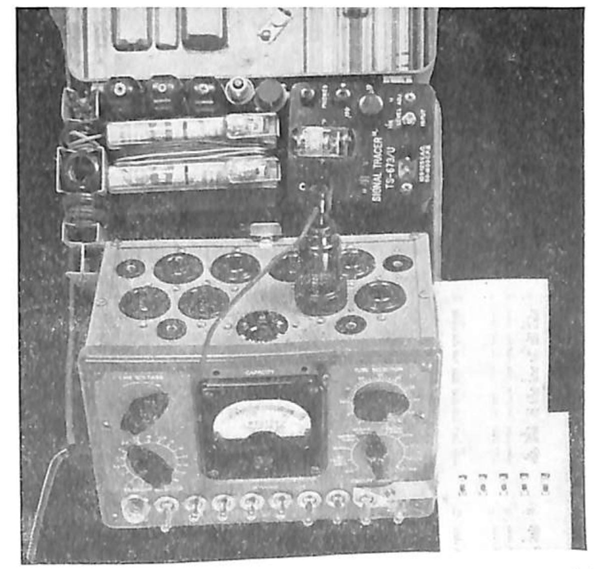


FIGURE 4—*Tube Tester TV-4/U in operating position with tube in socket.*

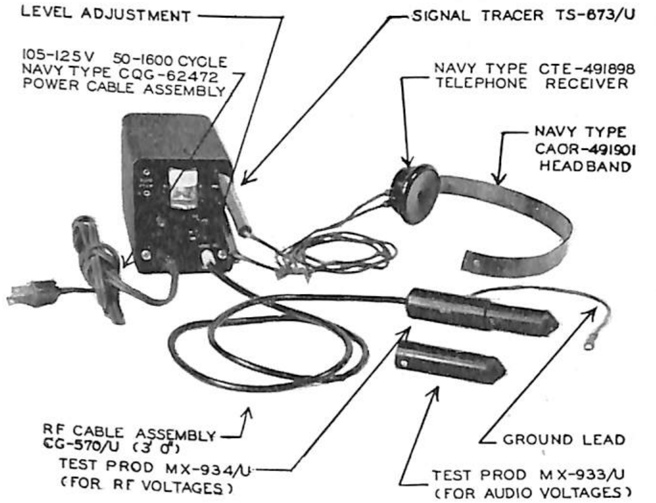


FIGURE 5—*Signal Tracer TS-673/U with its accompanying accessories, Telephone Receiver CTE-491898, Test Prod MX-934 (connected to signal tracer) and Test Prod MX-933 in the foreground.*

audible output in the telephone receiver. It is shown in operation in figure 6.

Interference Generator SG-23/U, shown in figure 7, is a buzzer-type generator in a probe case. The buzzer operates at approximately 2,000 cycles but harmonics extend up to over 400 megacycles. The generator has a built-in capacity type attenuator and is completely shielded except at the tip. It may be used with very sensitive receivers. Figure 7 shows the interference generator in operation. Together with the signal tracer described above it provides a complete signal tracing outfit for practically all audio and radio-frequency circuits.

The Voltage Indicator-Probe ID-265/U shown in

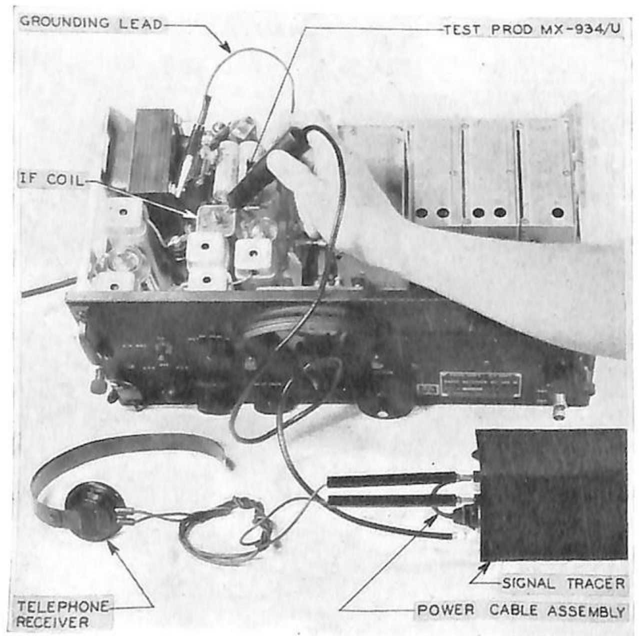


FIGURE 6—*Signal Tracer TS-673/U and its accessories in operation.*

FIGURE 7—*From left to right—Preproduction Models of Interference Generator SG-23/U, Voltage Indicator-Probe ID-265/U, R-F Indicator-Probe ID-263/U and Resistance Indicator-Probe ID-264/U.*

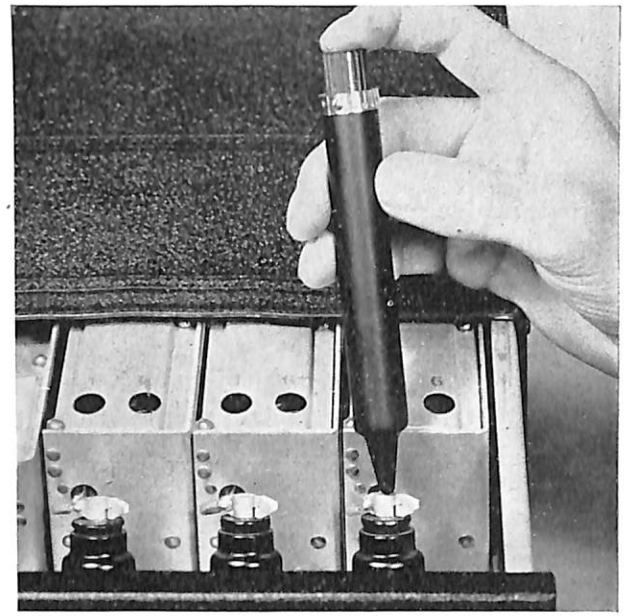


FIGURE 8—*Using Interference Generator SG-23/U to put a signal on the grid of a tube.*

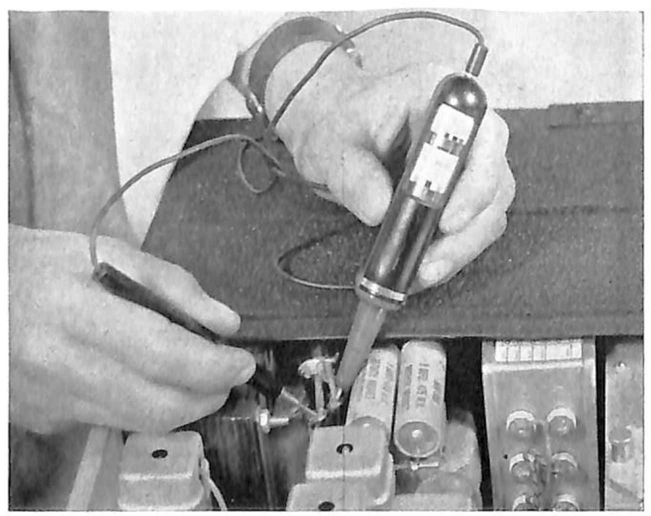


FIGURE 9—*Using Voltage Indicator-Probe ID-265/U to measure line voltage.*

figure 7 is a high impedance voltage indicator which shows whether a voltage is a. c. or d. c. and indicates its magnitude up to 440 volts. The frequency range of the instrument is from 10 to 10,000 cycles. The voltage scale is marked at the commonly used voltages of 55, 110, 220, and 440. Figure 8 shows the voltage indicator-probe in operation.

The R-F Indicator-Probe ID-265/U shown in figure 7 is used to indicate the presence of r-f fields of relatively large magnitudes such as those around transmitters. It deflects 25% of full scale for one volt of r. f. with the hand capacitance of the operator supplying the return r-f connection. An extension rod (symbol O-904) is provided to reach into deep chassis and high voltage areas. Figure 10 shows the r-f indicator-probe in operation.

Resistance Indicator-Probe ID-264/U is shown being used in figure 11. It is a conventional battery-operated ohmmeter circuit arranged in a convenient probe housing, and can measure up to approximately 10,000 ohms.

Decade Resistor TS-672/U shown in figure 12 consists of twenty-eight resistors whose values are such that

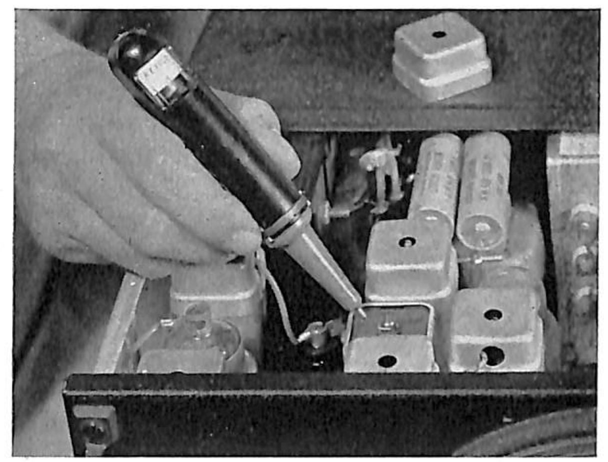


FIGURE 10—*Using the r-f indicator-probe to check an oscillator.*

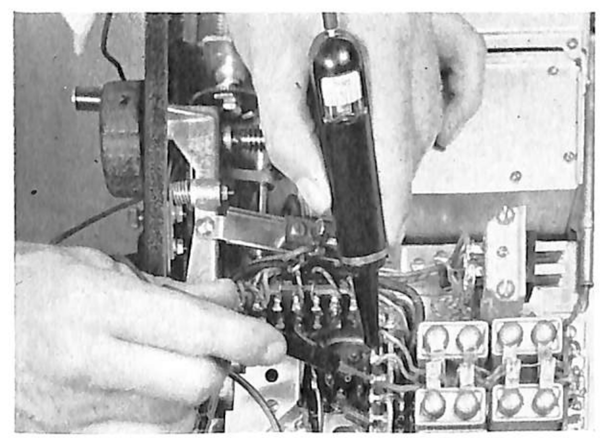


FIGURE 11—*Preproduction Model of Resistance Indicator-Probe ID-264/U being used to measure resistances.*

any resistance value from 1 ohm to 12 megohms can be used in steps of one ohm. All resistors are rated at two watts and are ± 5% in nominal value.

Decade Capacitor TS-671/U also shown in figure 12 enables the technician to substitute capacitor values from 0.0001 to 48 microfarads. Figure 13 shows the decade capacitor being used to substitute for a suspected open capacitor. The paper capacitors are rated at 600 volts, the electrolytics at 400 volts. Almost any resistor or capacitor may be checked by substitution with these decade boxes. By using them in combination practically any RC combination may be duplicated.

One of the novel features of this test-tool set is the inclusion of a "Technician's Handbook" as an integral part of the set. The handbook contains essential descriptive information for the operation of the set, a discussion of circuit testing theory, mathematical data, electrical formulas and other useful information. Typical uses, applications and limitations of the set are emphasized.

Some of the tools and accessories supplied are worthy of mention. The normal small versions of various pliers, screwdrivers, insulated tweezers, neon test light and various adapters, clips and plugs are included.

A rubber pilot light extractor for both small and large pilot lights to help prevent technicians with sweaty fingers from tearing their hair out; a quick-heating pen-

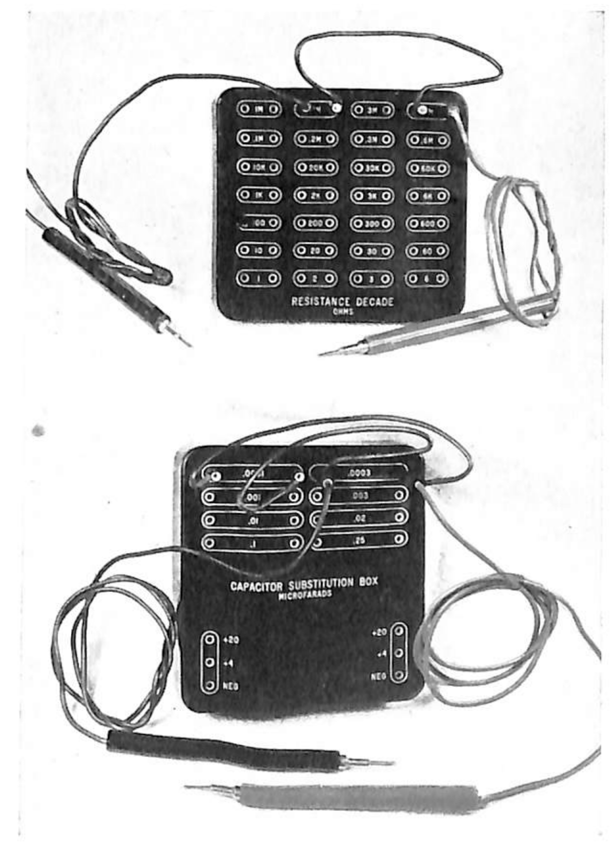


FIGURE 12—*Preproduction Models of Decade Resistor TS-672/U (top) and Decade Capacitor TS-671/U (bottom).*

type soldering iron with both a chisel and pointed tip to reach those hard-to-get-at places; and an alignment screwdriver containing slugs so that it can act as a tuning wand, are also supplied.

There is a pen-type flashlight for illuminating dark chassis. A Lucite extension allows the light to be concentrated in the lower regions of deep chassis. In order to look around corners and behind components, an insulated mirror is supplied to slip on the end of the Lucite extension. This enables the technician to both illuminate and see practically any portion of an equipment that the Lucite extension can reach.

This test-tool set has been under development for some time, and much thought, time and effort have gone into its design. Both the instruction book and the technician's handbook have been critically reviewed in order to make the set as useful as possible to the technician. Many applications of the various units in the set are described. The Bureau of Ships is interested in receiving the comments of technicians on the usefulness of the set, additional applications, etc. A Navships 383 Failure Report Form and the franked envelope supplied may be used to informally submit these comments to the Bureau of Ships.

The initial allowance of this new test-tool set is necessarily limited. The present allowance of the set is shown below:

3-AD	1-AOG	2-BB	1-DMS
1-AE	1-AP	2-CA	1-LC(FF)
1-AF	1-APA	1-CL(6000T)	1-LSD
1-AG88-89	1-APD	2-CL(10,000T)	1-LSM
4-AGC	3-AR	2-CV	1-LSM(R)
1-AGS	2-ARG	3-CVB	1-LST
1-AH	3-ARH	1-CVE	1-PC
1-AK	2-ARL	1-CVL	1-PCE

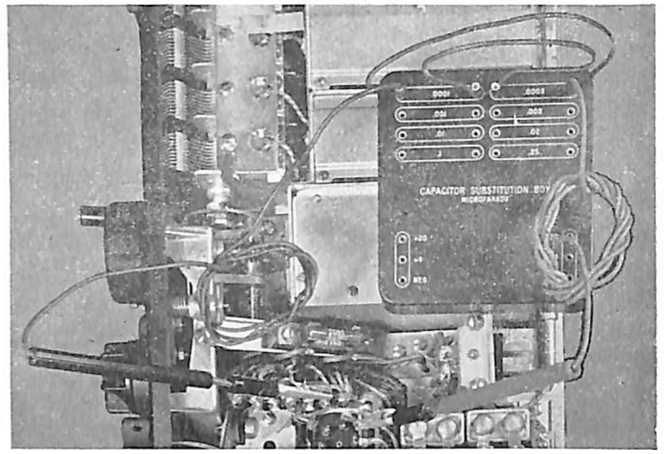


FIGURE 13—*Preproduction Model Decade Capacitor TS-672/U being used to substitute for a suspected open capacitor.*

1-AKA	1-ARS	1-DD	1-PCE(R)
1-AKS	3-AS	1-DDE	1-PCS
1-AM	1-ASR	1-DDK	1-SS
1-AMS	1-AV	1-DE	1-SSO
1-AO	1-AVP	1-DM	1-SSR

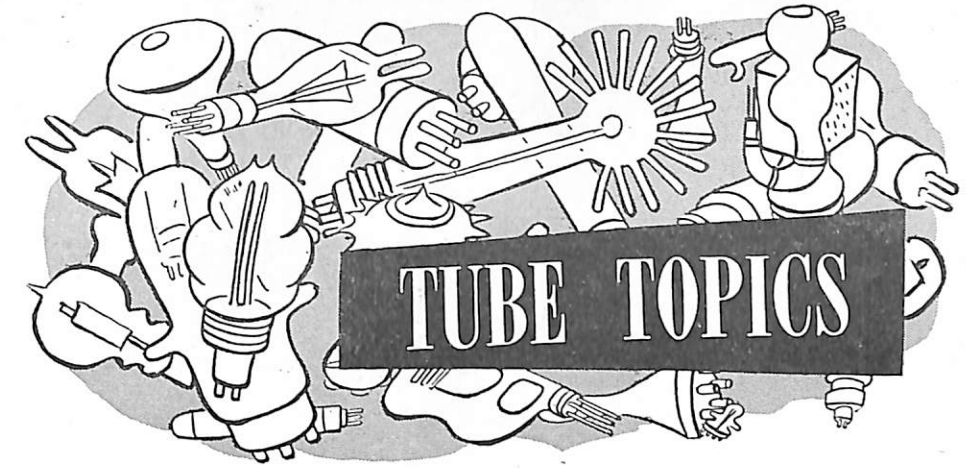
The test-tool set is an expensive equipment and should be treated as such. It should be used at every opportunity so that each technician will become familiar with the various components and tools and the proper methods of handling them. Then, in an emergency, trouble can be located and repairs made in a minimum of time.

Each ship will be held strictly accountable for the test-tool sets on board. The number of sets is limited and full use should be made of each set.

COMING!

SPECIAL RADIAC ISSUE OF "ELECTRON"

Many requests have been received by the Bureau of Ships for the special Radiac issue of BuShips Electron announced in the June 1948 Electron. In answer to these requests we wish to state that this special issue has not yet been published. This special issue will carry a comprehensive story on the Navy's new radiac equipment and a good deal of background material on the story of the atomic bomb and the subject of nuclear physics. The story will be called "The ET Looks at Radiac" and will bear the short title NavShips 900,146. Notice to the service will be made when the publication is ready for distribution. Distribution to most activities will be automatic. Requests for this publication should not be submitted to District Publications and Printing Offices until notice from the Bureau is received that it is available.



RUGGED ELECTRON TUBES

Rugged versions of many of the generally used types of receiving tubes now are available for field use. These tubes have been developed by the receiving tube manufacturing industry under contract with the Bureau of Ships. The tubes have been designed to withstand high impact type shocks, prolonged vibration, and storage under conditions of high humidity.

Much effort has been made to keep the electrical characteristics and physical dimensions of the rugged tubes within the same limits as the commercial prototypes. Even so, a compromise had to be made on this feature to get good rugged designs for some types. The types 5U4WG, 2A3W, 6L6WGA and 807W have larger diameter bases than the regular non-rugged types. The rugged 5Y3WGT rectifier tube has a heater type cathode for mechanical strength. The types 5670 and 5814 (rugged versions of types 2C51 and 12AU7) have 350- and 175-milliampere heaters, respectively. When these types are used as replacements for the 2C51 and 12AU7, care should be exercised to be sure that the filament transformer can handle the additional load. Tests to date indicate that the other rugged types are electrically and mechanically interchangeable with their commercial prototypes.

Listed below are the types and status of rugged receiving tubes developed to date:

Type	*Manufacturer*	*Status*
2A3W	Sylvania	Ready for production
5U4WG	Sylvania	In production
6L6WGA	Sylvania	In production
6SL7W	Sylvania	In production
6SN7W	Sylvania	Being design checked
807W	Sylvania	In small scale production
7F8W	Sylvania	In production
28D7W	Sylvania	Ready for production
6X5WGT	Sylvania	In production
6SJ7WGT	Raytheon	In production
6J5WGT	Raytheon	In production
12J5WGT	Raytheon	In production
6AK5W	Raytheon and Tung Sol	In production
6AS6W	Raytheon	Ready for production
6C4W	Raytheon	Ready for production
6J6W	Raytheon	Ready for production
6SA7WGT	Raytheon	Ready for production
5Y3WGT	General Electric	Ready for production
6SK7W	General Electric	Ready for production
5670 (Rugged 2C51)	General Electric	Small scale production
5814 (Rugged 12AU7)	General Electric	Small scale production
6AQ5W	General Electric	Ready for production
6AL5W	Chatham, Raytheon	In production at Chatham
6H6WGT	Chatham	In production
2050W	Chatham	In production
OC3/VR105W	Chatham	Ready for production
OD3/VR150W	Chatham	Ready for production
5R4WGY	Chatham	Ready for production
6X4W	Tung Sol	In production
6AC7W	RCA	In production

On many of the types having a status other than "In production" the Bureau may be able to supply small quantities (less than 50 tubes). Some of the types are not in production because of insufficient demand for a production run. Other types are awaiting the fabrication of production dies.

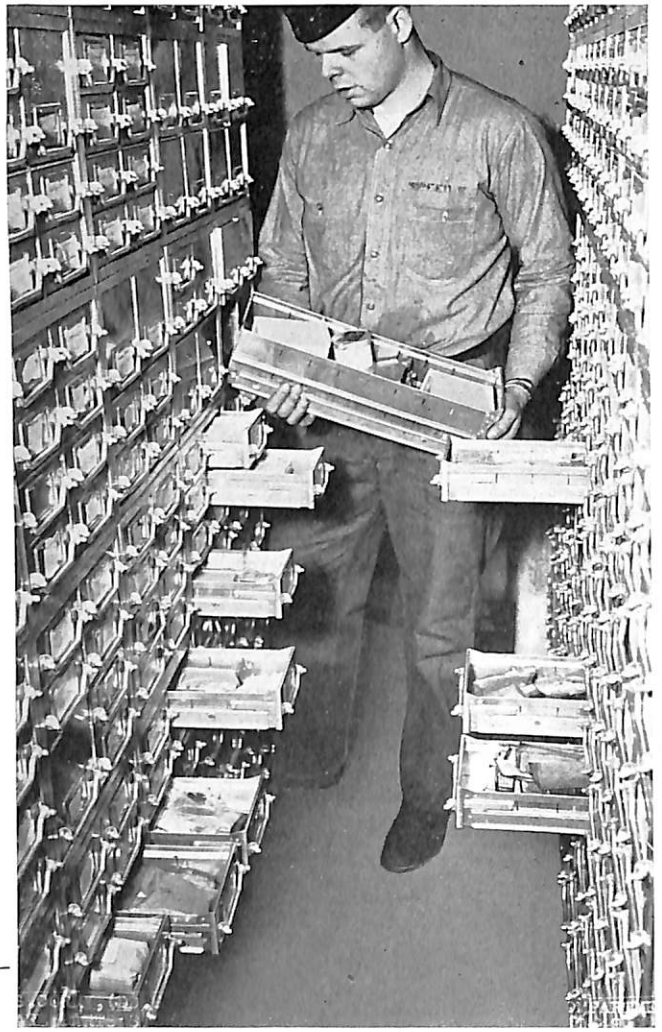
ELECTRON TUBE TYPE 6AN5

The manufacturer of electron tube Type 6AN5 has furnished the Bureau of Ships with test data indicating that the average operating life of the tubes is now more than 5000 hours. The high grid emission that limited the average life of tubes produced in 1947 to only a few hundred hours has been corrected.

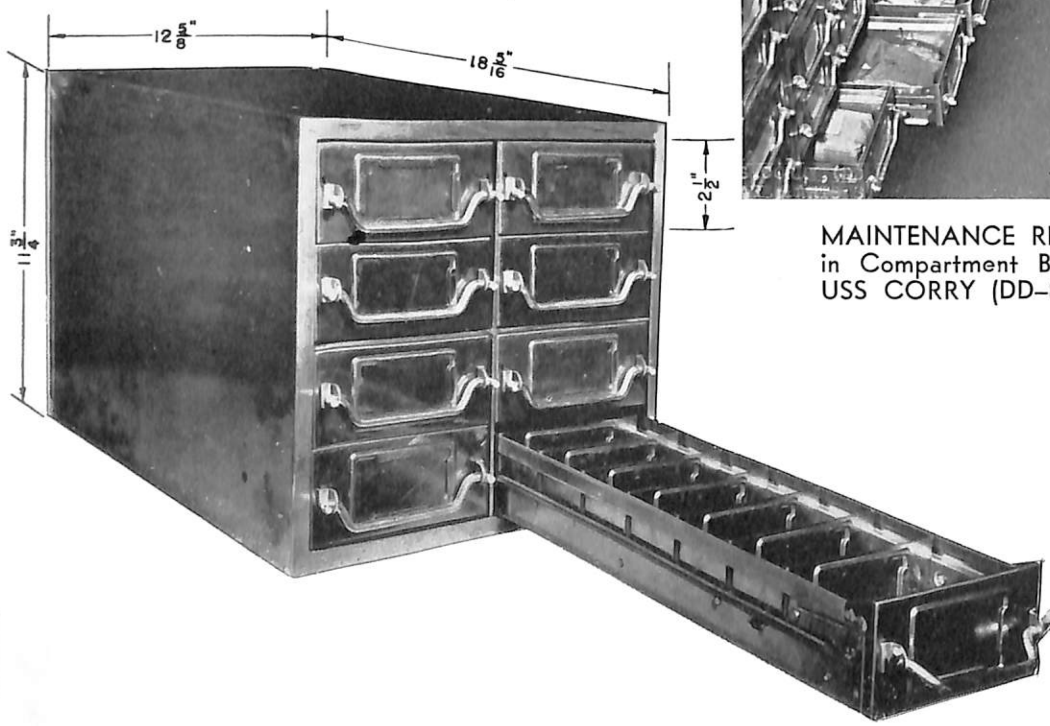
BUSHIPS ELECTRONICS REPAIR PARTS PROGRAM

The Bureau of Ships has been actively engaged in carrying out the Electronic Spare-Parts Program outlined in the May 1947 issue of ELECTRON. As a matter of fact about eighty percent of the fleet has received electron tube allowances from the Bureau. Twenty submarines have been converted to the new repair parts system (see *U.S.S. Runner* photos), and recently the *U.S.S. Corry* had the necessary bins installed to house the smaller parts listed on the vessel's allowance (see *U.S.S. Corry* photos).

The tremendous task of stock numbering all parts used in electronic equipment is practically completed. A new stock number, the Standard Navy Stock Number, is being used in the allowances, and appropriate cross references to circuit symbols are being provided by the Bureau. Address any comments concerning the program to the Bureau of Ships, Attention Code 873.



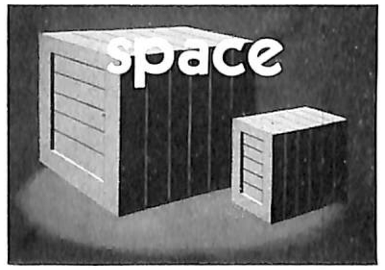
MAINTENANCE REPAIR PARTS BINS in Compartment B–201A aboard the USS CORRY (DD–817).



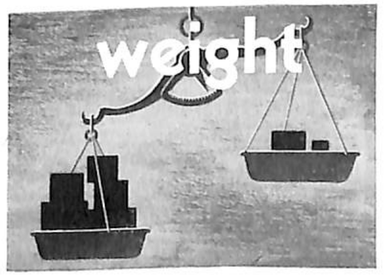
SAMPLE BIN (Note: Two 2½" drawers can be replaced by one 5" drawer.)

Savings

achieved through the conversion of the USS RUNNER to the Buships Electronics Maintenance Repair Parts Program



BEFORE 165 Cubic Feet
AFTER . . 30 Cubic Feet



BEFORE . . . . 2800 Lbs.
AFTER . . . . . 400 Lbs.

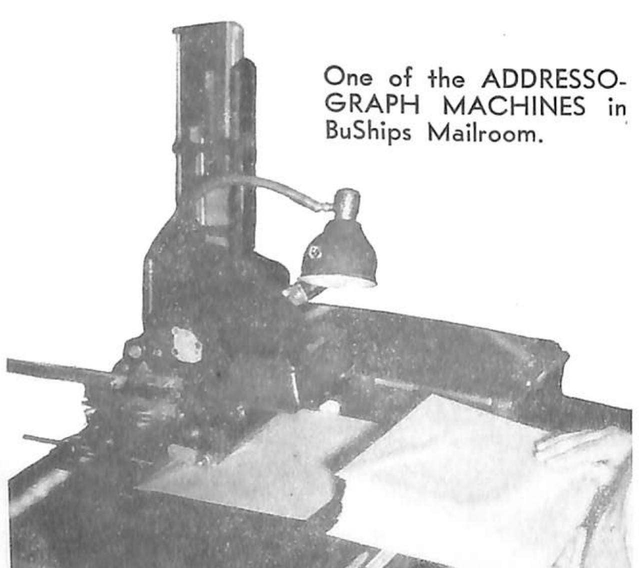
BEFORE . . . 9000 Items
AFTER . . . . 2300 Items

POST RE-MARKS

U.S. NAVY APR 9 11 PM 1949

ON ELECTRON DISTRIBUTION

Distribution of miscellaneous letters, reports, and publications to far-flung Navy activities is a problem into which has gone a tremendous amount of thought and experimentation. There are many thousands of different addresses, many hundreds of different types and kinds of activities. To these addresses and activities are mailed hundreds of tons of little packages and letters each month. Each envelope must be addressed, and the address must be exactly right. In the case of periodicals, the same list of addresses must be used each month, or each quarter. But ten periodicals will have ten lists of addresses; and different letters or reports will have different distribution lists.



One of the ADDRESSOGRAPH MACHINES in BuShips Mailroom.

It is obviously impractical to write all those addresses by hand or typewriter. Some system must be used which is faster and requires less personnel.

The best system yet devised employs standard distribution lists and Addressograph machines. The standard lists are published by the Chief of Naval Operations and include every Navy activity in commission, sorted in various ways. One of the lists includes all battleships; another, all cruisers. Another list includes all Naval communication stations; another, all shipyards. Force and type commanders are listed in one list; all commissary stores in another. The Addressograph is a machine which can stamp the address of an activity on an envelope after a plate has been made for that address. When a plate is made for each address included in one of the standard lists, the machine can address a separate envelope for each different activity listed.

The Bureau of Ships addresses about 25,000 envelopes this way each month. ELECTRON alone is distributed to about 2,000 different addressees.

How, then, if we use this system, is it possible to give one battleship ten copies of ELECTRON when another battleship gets only four? If AG's are on our list for five copies, how can one particular AG get only one? The answer is that they can't, without a great deal of extra effort on the part of mail room personnel in digging out individual cards for the exceptions.

Obviously this system is not perfect. As human beings we can only approach perfection. Imperfections in this system show up when two or more activities find themselves located in the same geographical place. If your vessel normally gets three copies of ELECTRON, and your Division Commander, who is using your ship as his flagship, gets one copy, it appears that your vessel is getting four copies. If your Squadron Commander, who gets two copies, is also using your vessel as his flagship, then it appears that your ship is literally swamped with copies of ELECTRON. But it is not practicable to reduce the number your particular vessel gets, nor to remove the two flags from the distribution list. It is more economical to destroy the extra copies. It is not economical to spend a dollar's worth of effort to save a quarter's worth of publications.

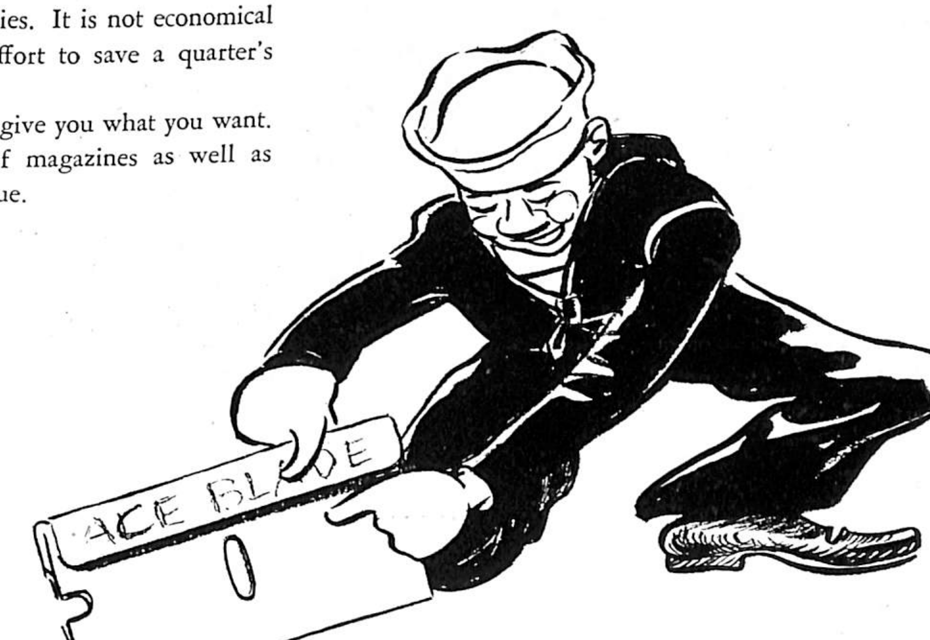
Notwithstanding, we want to give you what you want. That applies to the quantity of magazines as well as to the literary content of each issue.

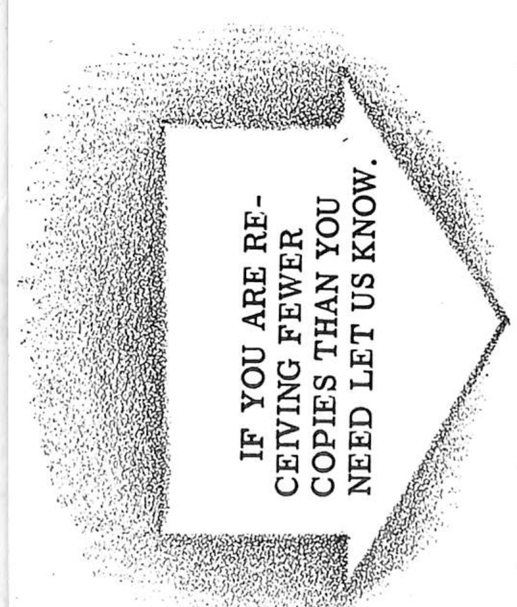
On the back cover of this issue you will find a franked card to tear out. We want you to fill out and mail *one card* for your activity. If your activity gets more than one copy of ELECTRON, then forget all the cards but one.

Fill in the card completely. In the case of ships, be sure to include the ship's name and number (example, *U.S.S. Errol, AG–133*). Show the number of copies you are now receiving, and the number you want us to send.

On receipt of these cards we will make a concerted effort to improve the quantities of ELECTRON sent to all Navy activities, either by increasing or decreasing the numbers of copies.

By doing this we hope to save time in the mailing of ELECTRON, and administrative difficulty in maintaining adequate distribution lists. We hope at the same time to reduce the number of activities receiving an improper number of copies of the magazine.





QUANTITY NOW BEING RECEIVED ______

DATE ______

QUANTITY DESIRED IN THE FUTURE ______

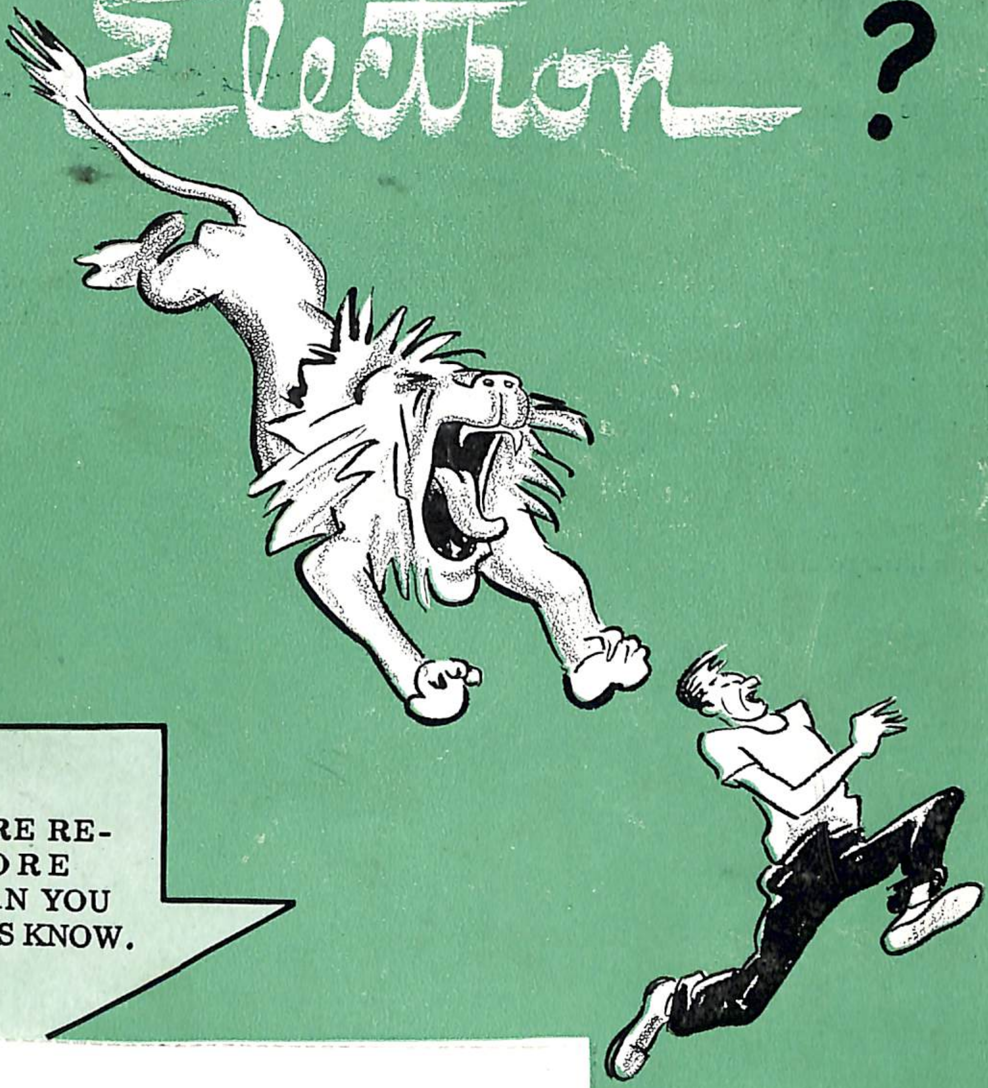
CUT OUT MAILING LABEL FROM YOUR ELECTRON ENVELOPE AND PASTE IT HERE

ABOVE ADDRESS SHOULD BE CORRECTED AS MARKED

SIGNATURE ______

RESTRICTED

HAVE NO FURTHER NEED FOR Electron ?



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COPIES THAN YOU
NEED LET US KNOW.

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