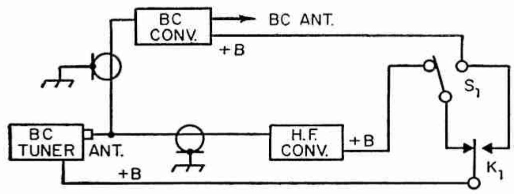


Fig. 19-44—Block diagram showing a switching system for the conelrad converter. K_1 represents a spare set of contacts on the change-over relay. S_1 is a s.p.d.t. toggle. With K_1 in the receiving position as shown, power from the broadcast receiver may be applied to either the b.c. converter or the ham-band converter. With K_1 in the transmitting position, power is applied to the broadcast converter for conelrad monitoring during transmitting periods.

The oscillator can be checked for proper frequency range by the use of a grid-dip meter before power is applied or, after power has been turned on, by listening on a communications receiver covering the 2-to-3 Mc. range.

Now connect an antenna to the input of the converter and connect the converter to the broadcast receiver. Set the broadcast receiver at 1500 kc. (or to the frequency normally used with the ham-band converter). Turn on the power and adjust C_4 and the slug of L_4 for a peak in noise (if you can't find a signal). Then adjust the slug of L_2 for maximum response.

Fig. 19-44 shows how the converter can be connected into a convenient switch system. (Originally described in *QST*, June, 1957).

Mobile Power Supply

By far the majority of amateur mobile installations depend upon the car storage battery as the source of power. The tube types used in equipment are chosen so that the filaments or heaters may be operated directly from the battery. High voltage may be obtained from a supply of the vibrator-transformer-rectifier type, a small motor generator or a transistor-transformer-rectifier system operating from the car battery.

Filaments

Because tubes with directly heated cathodes (filament-type tubes) have the advantage that they can be turned off during receiving periods and thereby reduce the average load on the battery, they are preferred by some for transmitter applications. However, the choice of types with direct heating is limited and the saving may not always be as great as anticipated, because directly heated tubes may require greater filament power than those of equivalent rating with indirectly heated cathodes. In most cases, the power required for transmitter filaments will be quite small compared to the total power consumed.

Plate Power

Under steady running conditions, the vibrator-transformer-rectifier system and the motor-generator-type plate supply operate with approximately the same efficiency. However, for the same power, the motor-generator's over-all efficiency may be somewhat lower because it draws a heavier starting current. On the other hand, the output of the generator requires less filtering and sometimes trouble is experienced in eliminating interference from the vibrator.

Transistor-transformer-rectifier plate supplies currently available operate with an efficiency of approximately 80 per cent. These compact, light-weight supplies use no moving parts (vibrator or armature) or vacuum tubes, and draw no starting surge current. Most transistorized supplies are designed to operate at 12 volts d.c. and some units deliver 125 watts or more.

Converter units, both in the vibrator and rotating types, are also available. These operate at 6 or 12 volts d.c. and deliver 115 volts a.c. This permits operating standard a.c.-powered equipment in the car. Although these systems have the advantage of flexibility, they are less efficient than the previously mentioned systems because of the additional losses introduced by the transformers used in the equipment.

Mobile Power Considerations

Since the car storage battery is a low-voltage source, this means that the current drawn from the battery for even a moderate amount of power will be large. Therefore, it is important that the resistance of the battery circuit be held to a minimum by the use of heavy conductors and good solid connections. A heavy-duty relay should be used in the line between the battery and the plate-power unit. An ordinary toggle switch, located in any convenient position, may then be used for the power control. A second relay may sometimes be advisable for switching the filaments. If the power unit must be located at some distance from the battery (in the trunk, for instance) the 6- or 12-volt cable should be of the heavy military type.

A complete mobile installation may draw 30 to 40 amperes or more from the 6-volt battery or better than 20 amperes from a 12-volt battery. This requires a considerably increased demand from the car's battery-charging generator. The voltage-regulator systems on cars of recent years will take care of a moderate increase in demand if the car is driven fair distances regularly at a speed great enough to insure maximum charging rate. However, if much of the driving is in urban areas at slow speed, or at night, it may be necessary to modify the charging system. Special communications-type generators, such as those used in police-car installations, are designed to charge at a high rate at slow engine speeds. The charging rate of the standard system can be increased within limits by tightening up slightly on the voltage-regulator and current-regulator springs. This should be done with caution, however, checking for excessive generator temperature or abnormal sparking at the commutator. The average 6-volt car generator has a rating of 35 amperes, but it may be possible to adjust the regulator so that the generator will at least hold even with the transmitter, receiver, lights, etc., all operating at the same time.

If higher transmitter power is used, it may be necessary to install an a.c. charging system. In this system, the generator delivers a.c. and works into a rectifier. A charging rate of 75 amperes is easily obtained. Commutator trouble often experienced with d.c. generators at high current is avoided, but the cost of such a system is rather high.

Some mobile operators prefer to use a separate battery for the radio equipment. Such a system can be arranged with a switch that cuts the auxiliary battery in parallel with the car battery for charging at times when the car battery is lightly loaded. The auxiliary battery can also be charged at home when not in use.

A tip: many mobile operators make a habit of carrying a pair of heavy cables five or six feet long, fitted with clips to make a connection to the battery of another car in case the operator's battery has been allowed to run too far down for starting.

The Automobile Storage Battery

The success of any mobile installation depends to a large extent upon intelligent use and maintenance of the car's battery.

The storage battery is made up of units consisting of a pair of coated lead plates immersed in a solution of sulphuric acid and water. Cells, each of which delivers about 2 volts, can be connected in series to obtain the desired battery voltage. A 6-volt battery therefore has three cells, and a 12-volt battery has 6 cells. The average stock car battery has a rated capacity of 600 to 800 watt-hours, regardless of whether it is a 6-volt or 12-volt battery.

Specific Gravity and the Hydrometer

As power is drawn from the battery, the acid content of the electrolyte is reduced. The acid content is restored to the electrolyte (meaning that the battery is recharged) by passing a current through the battery in a direction opposite to the direction of the discharge current.

Since the acid content of the electrolyte varies with the charge and discharge of the battery, it is possible to determine the state of charge by measuring the *specific gravity* of the electrolyte.

An inexpensive device for checking the s.g. is the hydrometer which can be obtained at any automobile supply store. In checking the s.g., enough electrolyte is drawn out of the cell and into the hydrometer so that the calibrated bulb floats freely without leaning against the wall of the glass tube.

While the readings will vary slightly with batteries of different manufacture, a reading of 1.275 should indicate full charge or nearly full charge, while a reading below 1.150 should indicate a battery that is close to the discharge point. More specific values can be obtained from the car or battery dealer.

Readings taken immediately after adding water, or shortly after a heavy discharge period will not be reliable, because the electrolyte will not be uniform throughout the cell. Charging will speed up the equalizing, and some mixing can be done by using the hydrometer to withdraw and return some of the electrolyte to the cell several times.

A battery should not be left in a discharged condition for any appreciable length of time. This is especially important in low temperatures when there is danger of the electrolyte freezing and ruining the battery. A battery discharged to an s.g. of 1.100 will start to freeze at about 20 degrees F., at about 5 degrees when the s.g. is 1.150 and at 16 below when the s.g. is 1.200.

If a battery has been run down to the point where it is nearly discharged, it can usually be fast-charged at a battery station. Fast-charging rates may be as high as 80 to 100 amperes for a 6-volt battery. Any 6-volt battery that will accept a charge of 75 amperes at 7.75 volts during the first 3 minutes of charging, or any 12-volt battery that will accept a charge of 40 to 45 amperes at 15.5 volts, may be safely fast-charged up to the point where the gassing becomes so excessive that electrolyte is lost or the temperature rises above 125 degrees.

A normal battery showing an s.g. of 1.150 or less may be fast-charged for 1 hour. One showing an s.g. of 1.150 to 1.175 may be fast-charged for 45 minutes. If the s.g. is 1.175 to 1.200, fast-charging should be limited to 30 minutes.

Care of the Battery

The battery terminals and mounting frame should be kept free from corrosion. Any corrosive accumulation may be removed by the use of water to which some household ammonia or baking soda has been added, and a stiff-bristle brush. Care should be taken to prevent any of the corrosive material from falling into the cells. Cell caps should be rinsed out in the same solution to keep the vent holes free from obstructing dirt. Battery terminals and their cable clamps should be polished bright with a wire brush, and coated with mineral grease.

The hold-down clamps and the battery holder should be checked occasionally to make sure that they are tight so the battery will not be damaged by pounding when the car is in motion.

Voltage Checks

Although the readings of s.g. are quite reliable as a measure of the state of charge of a normal battery, the necessity for frequent use of the hydrometer is an inconvenience and will not always serve as a conclusive check on a defective battery. Cells may show normal or almost normal s.g. and yet have high internal resistance that ruins the usefulness of the battery under load.

When all cells show satisfactory s.g. readings and yet the battery output is low, service stations check each cell by an instrument that measures the voltage of each cell under a heavy load. Under a heavy load the cell voltages should not differ by more than 0.15 volt.

A load-voltage test can also be made by measuring the voltage of each cell while closing the starter switch with the ignition turned off. In many cars it is necessary to pull the central distributor wire out to prevent the motor starting.

Electrolyte Level

Water is evaporated from the electrolyte, but the acid is not. Therefore water must be added to each cell from time to time so that the plates are always completely covered. The level should be checked at least once per week, especially during hot weather and constant operation.

Distilled water is preferred for replenishing, but clear drinking water is an acceptable substitute. Too much water should not be added, since the gassing that accompanies charging may force electrolyte out through the vent holes in the caps of the cells. The electrolyte expands with temperature. (From *QST*, August, 1955.)

Emergency and Independent Power Sources

Emergency power supply which operates independently of a.c. lines is available, or can be built in a number of different forms, depending upon the requirements of the service for which it is intended.

The most practical supply for the average individual amateur is one that operates from a car storage battery. Such a supply may take the form of a small motor generator (often called a dynamotor), a rotary converter, a vibrator-transformer-rectifier combination, or transistor supply.

Dynamotors

A dynamotor differs from a motor generator in that it is a single unit having a double armature winding. One winding serves for the driving motor, while the output voltage is taken from the other. Dynamotors usually are operated from 6-, 12-, 28- or 32-volt storage batteries and deliver from 300 to 1000 volts or more at various current ratings.

Successful operation of dynamotors requires heavy direct leads, mechanical isolation to reduce vibration, and thorough r.f. and ripple filtration. The shafts and bearings should be thoroughly "run in" before regular operation is attempted, and thereafter the tension of the bearings should be checked occasionally to make certain that no looseness has developed.

In mounting the dynamotor, the support should be in the form of rubber mounting blocks, or equivalent, to prevent the transmission of vibration mechanically. The frame of the dynamotor should be grounded through a heavy flexible connector. The brushes on the high-voltage end of the shaft should be by-passed with 0.002-μf. mica capacitors to a common point on the dynamotor frame, preferably to a point inside the end cover close to the brush holders. Short leads are essential. It may prove desirable to shield the entire unit, or even to remove the unit to a distance of three or four feet from the receiver and antenna lead.

When the dynamotor is used for receiving, a filter should be used similar to that described for vibrator supplies. A 0.01-μf. 600-volt (d.c.) paper capacitor should be connected in shunt across the output of the dynamotor, followed by a 2.5-mh. r.f. choke in the positive high-voltage lead. From this point the output should be run to the receiver power terminals through a smoothing filter using 4- to 8-μf. capacitors and a 15- or 30-henry choke having low d.c. resistance.

Vibrator Power Supplies

The vibrator type of power supply consists of a special step-up transformer combined with a vibrating interrupter (vibrator). When the unit is connected to a storage battery, plate power is obtained by passing current from the battery through the primary of the transformer. The circuit is made and reversed rapidly by the vibrator contacts, interrupting the current at regular intervals to give a changing magnetic field which induces a voltage in the secondary. The resulting square-wave d.c. pulses in the primary of the transformer cause an alternating voltage to be developed in the secondary. This high-voltage a.c. in turn is rectified, either by a vacuum-tube rectifier or by an additional synchronized pair of vibrator contacts. The rectified output is pulsating d.c., which may be filtered by ordinary means. The smoothing filter can be a single-section affair, but the output capacitance should be fairly large — 16 to 32 μf.

Fig. 19-45 shows the two types of circuits. At A is shown the nonsynchronous type of vibrator. When the battery is disconnected the reed is midway between the two contacts, touching neither. On closing the battery circuit the magnet coil pulls the reed into contact with one contact point, causing current to flow through the lower half of the transformer primary winding. Simultaneously, the magnet coil is short-circuited, deënergizing it, and the reed swings back. Inertia carries the reed into contact with the upper point, causing current to flow through the upper half of the transformer primary. The magnet coil again is energized, and the cycle repeats itself.

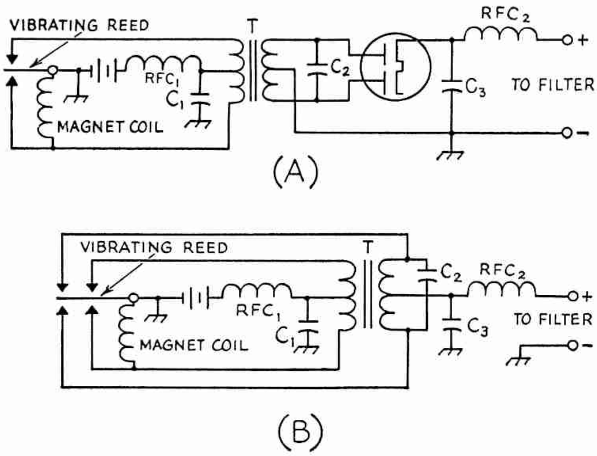


Fig. 19-45—Basic types of vibrator power-supply circuits. A—Nonsynchronous. B—Synchronous.

The synchronous circuit of Fig. 19-45B is provided with an extra pair of contacts which rectify the secondary output of the transformer, thus eliminating the need for a separate rectifier tube. The secondary center-tap furnishes the positive output terminal when the relative polarities of primary and secondary windings are correct. The proper connections may be determined by experiment.

The buffer capacitor, C_2, across the transformer secondary, absorbs the surges that occur on breaking the current, when the magnetic field collapses practically instantaneously and hence causes very high voltages to be induced in the secondary. Without this capacitor excessive sparking occurs at the vibrator contacts, shortening the vibrator life. Correct values usually lie between 0.005 and 0.03 μf., and for 250-300-volt supplies the capacitor should be rated at 1500 to 2000 volts d.c. The exact capacitance is critical, and should be determined experimentally. The optimum value is that which results in least battery current for a given rectified d.c. output from the supply. In practice the value can be determined by observing the degree of vibrator sparking as the capacitance is changed. When the system is operating properly there should be practically no sparking at the vibrator contacts. A 5000-ohm resistor in series with C_2 will limit the secondary current to a safe value should the capacitor fail.

Vibrator-transformer units are available in a variety of power and voltage ratings. Representative units vary from one delivering 125 to 200 volts at 100 ma. to others that have a 400-volt output rating at 150 ma. Most units come supplied with "hash" filters, but not all of them have built-in ripple filters. The requirements for ripple filters are similar to those for a.c. supplies. The usual efficiency of vibrator packs is in the vicinity of 70 per cent, so a 300-volt 200-ma. unit will draw approximately 15 amperes from a 6-volt storage battery. Special vibrator transformers are also available from transformer manufacturers so that the amateur may build his own supply if he so desires. These have d.c. output ratings varying from 150 volts at 40 ma. to 330 volts at 135 ma.

Vibrator-type supplies are also available for operating standard a.c. equipment from a 6- or 12-volt storage battery in power ratings up to 100 watts continuous or 125 watts intermittent.

"Hash" Elimination

Sparking at the vibrator contacts causes r.f. interference ("hash," which can be distinguished from hum by its harsh, sharper pitch) when used with a receiver. To minimize this, r.f. filters are incorporated, consisting of RFC_1 and C_1 in the battery circuit, and RFC_2 with C_3 in the d.c. output circuit.

Equally as important as the hash filter is thorough shielding of the power supply and its connecting leads, since even a small piece of wire or metal will radiate enough r.f. to cause interference in a sensitive amateur receiver.

The power supply should be built on a metal chassis, with all unshielded parts underneath. A bottom plate to complete the shielding is advisable. The transformer case, vibrator cover and the metal shell of the tube all should be grounded to the chassis. If a glass tube is used it should be enclosed in a tube shield. The battery leads should be evenly twisted, since these leads are more likely to radiate hash than any other part of a well-shielded supply. Experimenting with different values in the hash filters should come *after* radiation from the battery leads has been reduced to a minimum. Shielding the leads is not often found to be particularly helpful.

● UNIVERSAL VIBRATOR POWER SUPPLY

A vibrator-type power supply may be designed to operate from a storage battery only, or from either a battery or 115 volts a.c. Most late-model cars use 12-volt batteries, but there are still many cars with 6-volt systems in operation — a point that should be given due consideration where emergency operation is an objective.

The circuit of a universal power supply for emergency, mobile, or home-station use is shown in Fig. 19-46. The unit furnishes a d.c. output of 300 volts at 160 ma. and can be operated from any of the above-mentioned sources. Shifting from one power source to another is accomplished by plugging P_1 or P_2, connected to the selected source, into one of the two chassis connectors J_1 or J_2. The vibrator-primary current is 11.6 amperes with 6-volt input under loaded conditions, and 6.8 amperes with 12-volt input.

Heater Connections

To adapt equipment for optional 6- or 12-volt operation, 6-volt tubes must be used with their heaters in series-parallel. Fig. 19-47 shows a typical example of connections. The tubes in the

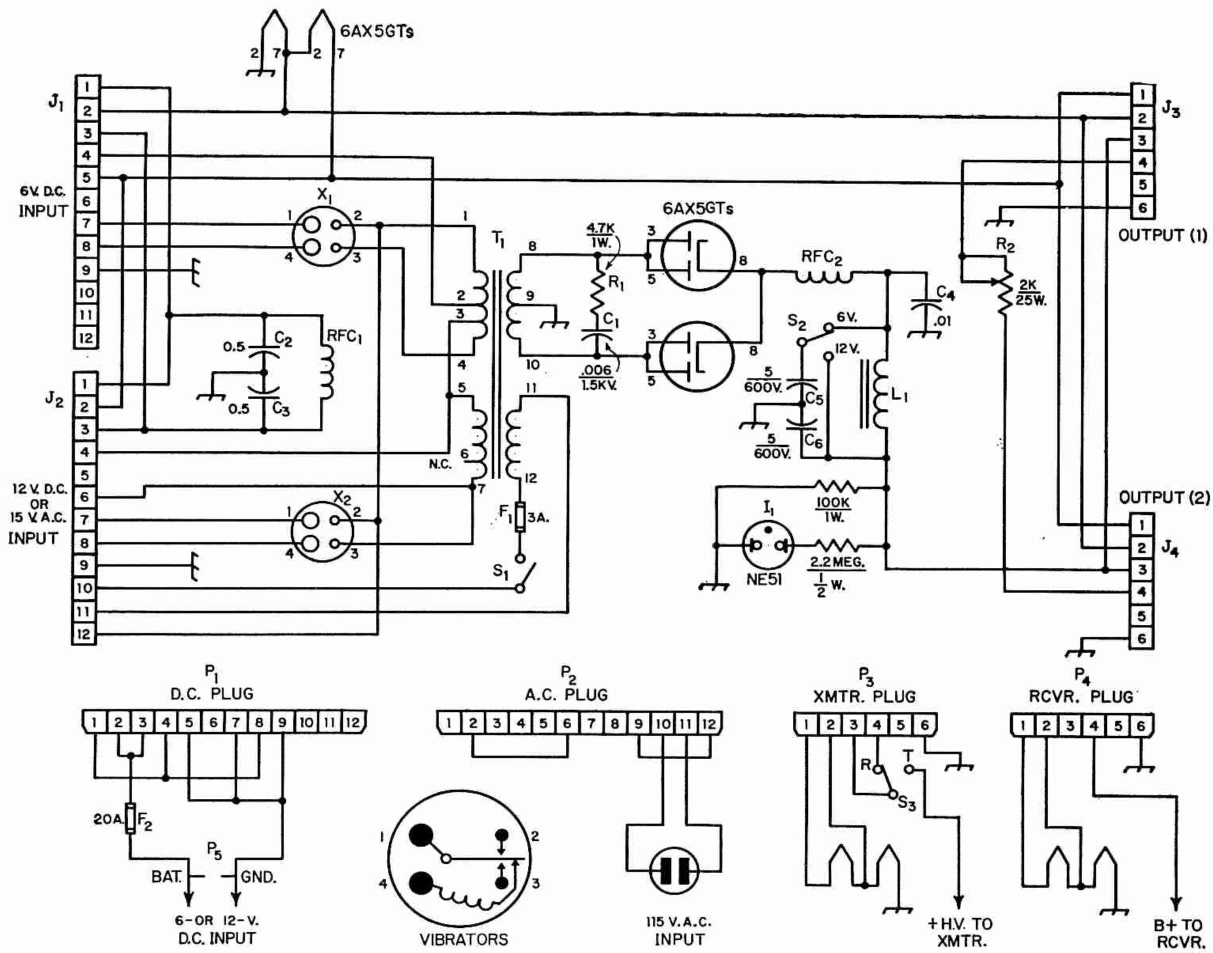


Fig. 19-46—Circuit of the universal power supply. All capacitances are in μf.

C_1—Buffer capacitor, tubular plastic.
C_2, C_3—Hash-filter capacitor, paper.
C_4—Hash-filter capacitor, disk ceramic.
C_5, C_6—Ripple-filter capacitor, 5 μf. or more, 600-volt oil-filled or electrolytic.
F_1—3-amp. cartridge fuse (Littlefuse type 3AG) in extractor-post mounting (Littlefuse 341001).
F_2—20-amp. cartridge fuse (Littlefuse type SFE) in in-line fuse retainer (Littlefuse 155020).
I_1—Neon pilot lamp.
J_1, J_2—12-contact male chassis connector (Cinch-Jones P-312-AB).
J_3, J_4—6-contact female chassis connector (Cinch-Jones S-306-AB).
L_1—5-h. 200-ma. 80-ohm filter choke (Merit C-1396, Stancor C-1411).
P_1, P_2—12-contact female cable connector (Cinch-Jones S-312-CCT).
P_3, P_4—6-contact male cable connector (Cinch-Jones P-306-CCT).
P_5—Cigar-lighter plug (Mallory R-675).
R_1—Buffer resistor.
R_2—Series voltage-dropping resistor for receiver, slider adjustable.
RFC_1—30 turns No. 14 enam., ½-inch diam., close-wound.
RFC_2—1-mh. r.f. choke (National R-300-U, Millen 34106).
S_1—S.p.s.t. toggle switch.
S_2—S.p.d.t. toggle switch.
S_3—S.p.d.t. toggle, or other, at transmitter.
T_1—Combination power transformer: 6-volt d.c. vibrator or 115 v. a.c. input; 300 volts, 160 ma.; 6.3 volts 3 amp.; 6.3-volt 4.5-amp. tap on vibrator primary (Merit P-3176). Numbered terminals are color-coded as follows: 1—heavy green; 2—yellow; 3—light green; 4—black; 5—brown; 6—blue; 7—white; 8—red; 9—red-yellow; 10—red; 11 and 12—black.
X_1—4-prong tube socket for 6-volt vibrator (Mallory 4501 vibrator).
X_2—4-prong tube socket for 12-volt vibrator (Mallory G4501 vibrator).

equipment should be divided into two groups whose heater-current ratings total as closely as possible the same value. The heaters in each group should be connected in parallel, and the two groups then connected in series. If it is impossible to arrive at a grouping that will have exactly the same total current, a resistor may be connected in parallel with the group drawing the smaller current as shown. The value of this resistor should be such that it will draw enough current at 6 volts to make up the difference between the two totals. One side of one group may be grounded to chassis but the other side of this group and both sides of the second group must be insulated.

Switching Circuits

Battery input connections are made through P_5 which plugs into a cigar-lighter socket in mobile service, F_2 is a fuse which is inserted in the

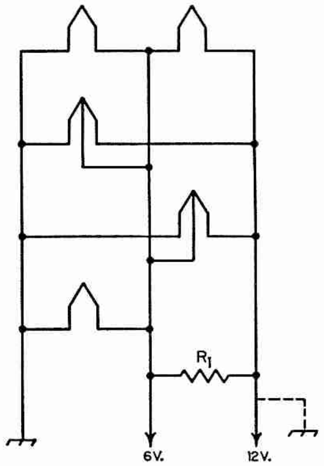


Fig. 19-47—Circuit showing typical series-parallel heater connections for 6-volt and 6/12-volt tubes. Resistor R_1 is used when necessary to balance the currents in the two branches as described in the text. The dashed line shows how the switching system connects all tubes in parallel for 6-volt operation by grounding.

cord between P_5 and P_1.

For 6-volt operation P_1 is plugged into J_1. For 12-volt operation P_1 is plugged into J_2. For 115-volt a.c. operation P_2 is plugged into J_2.

Positive high-voltage output from the supply is fed to Pins 3 on output connectors J_3 and J_4. The three heater connections are made through Pins 1, 2 and 6. The cable for transmitter plug P_3 has provision for connecting to a transmit-receive switch (S_3) at the transmitter. In the transmit position the plate voltage is fed to the transmitter. In the receive position the switch feeds the plate voltage, via Pin 4, through series voltage-dropping resistor R_2 to Pin 4 on the other output jack and thence to the receiver. It will be noticed that the same circuit results with P_3 and P_4 in either output jack.

Construction

The unit is constructed on a 7 × 12 × 3-inch chassis, with only the transformer and output connectors J_3 and J_4 above deck. The two rectifier tubes and both vibrators are mounted below deck for compactness and shielding. This leaves a clear area on top of the chassis for mounting a receiver or small transmitter. Adequate ventilation is provided by patterns of ¼-inch holes in the top of the chassis, directly over the rectifier tubes, and along the bottom edge of the chassis on both sides.

The pilot lamp, a.c. power switch and filter switch S_2 can be mounted on the front end of the chassis, with fuse F_1 and the input jacks at the other end. Shielding should be completed with a chassis bottom plate.

Operation

Although the circuit is arranged so that no damage will occur if a mistake is made, the input connectors should be plainly marked to avoid plugging a cable into the wrong socket.

Original description appeared in *QST*, Oct., 1957.)

TRANSISTOR POWER SUPPLIES

A mobile or portable power supply using transistors has high over-all efficiency at its rated power output. Since there are no moving parts there are few maintenance problems. Capacitors and resistors may occasionally need replacement, but if the transistors are operated within their electrical and thermal ratings, their life expectancy is in terms of years rather than hours.

In a transistor power supply, the transistors operate as electronic switches to interrupt the d.c. through the primary of the power transformer much like the mechanical vibrator does in a vibrator supply.

When voltage is applied to the power supply circuit, current will flow through the transistors; however, since no two transistors are precisely alike electrically, initially one will conduct a little more current than the other. This difference current or "starting" current will cause a small voltage to be induced in the transformer winding connected to the bases of the transistors. The polarity is such that the conducting transistor is biased to conduct even more heavily while the base of the other transistor is biased to cutoff. This process continues until the increasing current causes magnetic saturation of the transformer core, at which time the induced voltage drops to zero and there is no longer enough base bias to maintain the collector current. When this happens the current decreases, causing an induced voltage of opposite polarity. The process then reverses so that the previously nonconducting transistor starts to conduct and the previously conducting transistor becomes cut off. The result is an alternating current of square-wave form through the transformer primary. This in turn induces a stepped-up voltage in the h.v. secondary of the transformer.

The transistor supply is self-protecting against overload because if a short circuit or heavy overload occurs oscillations cease and the input current drops to a low value. The output voltage regulation is extremely good making the transistor supply especially useful as a source of plate or screen power for a single-sideband mobile or portable rig.

Transistor power transformers are available in both conventional and toroidal construction, with outputs ranging up to 150 watts. The circuit shown in Fig. 19-48, a typical transistor power supply, has an output of about 350 volts at 190 ma. It uses eight selenium rectifiers in a bridge circuit but four silicon-type power diodes having an inverse peak voltage rating of 800 volts or more could be substituted with a substantial saving in space. The center-tapped secondary of T_1 provides a half-voltage source that may be used simultaneously with the high voltage.

In a transistor power supply circuit that has not been properly designed, small spikes may appear on the leading edges of the square wave generated in the transistor power oscillator. Even though the spikes are of short duration they can cause punch-through of the transistor junction if the total voltage exceeds the transistor collector-to-emitter rating. The amplitudes

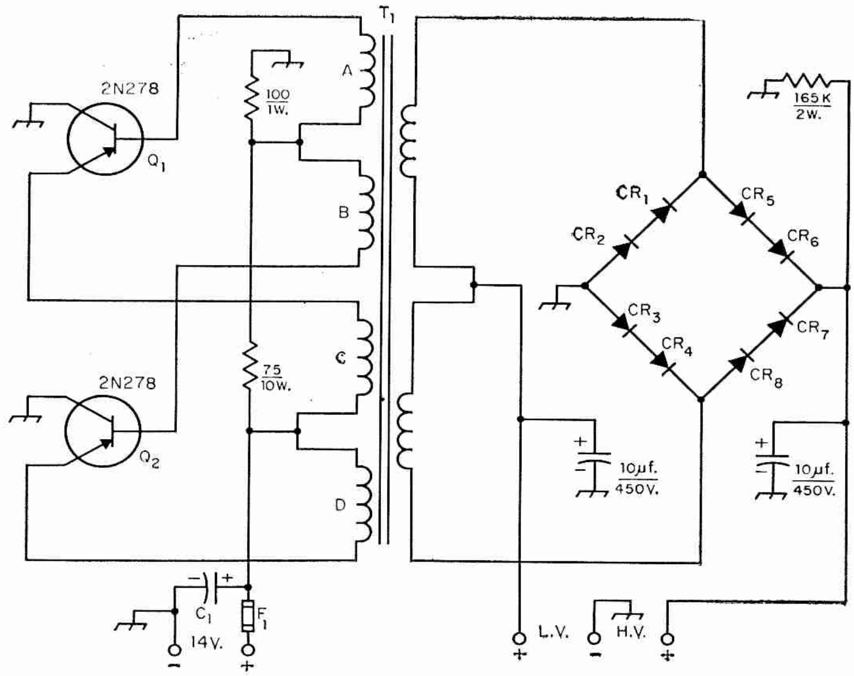


Fig. 19-48 — Circuit of the transistor power supply. Resistances are in ohms.

C_1—2000 μf., 15 volts (2 paralleled 1000 μf. electrolytics, Sprague TVA 1163).

CR_1 through CR_8—150 ma. selenium rectifier (Radio Receptor 5P1).

F_1—10- amp. fuse.

Q_1, Q_2—2N278 transistors.

T_1—Transistor power transformer (Sunair Electronics type 14-450-1).

of these spikes can be held to a safe value if the primary and secondary coils on the power transformer are tightly coupled (bifilar wound) and a large capacitor (C_1 in Fig. 19-48) is connected across the low voltage supply.

It is very important to provide good heat transfer from the mounting bases of the transistors to the chassis. The transistor junction temperature must not be allowed to exceed the manufacturer's ratings or thermal runaway will occur and the transistors will become useless. Layout of the parts is not critical. A conventional box type chassis may be used; the larger the surface area the better, since that means more rapid heat transfer from the transistors.

Since heat is the prime limiting factor in transistor power supply operation, placement of the unit in the car should have special consideration. Try to find a location away from high-temperature spots and in a well-ventilated area.

GASOLINE-ENGINE DRIVEN GENERATORS

For higher-power installations, such as for communications control centers during emergencies, the most practical form of independent power supply is the gasoline-engine driven generator which provides standard 115-volt 60-cycle supply.

Such generators are ordinarily rated at a minimum of 250 or 300 watts. They are available up to ten kilowatts, or big enough to handle the highest-power amateur rig. Most are arranged to charge automatically an auxiliary 6- or 12-volt battery used in starting. Fitted with self-starters and adequate mufflers and filters, they represent a high order of performance and efficiency. Many of the larger models are liquid-cooled, and they will operate continuously at full load.

The output frequency of an engine-driven generator must fall between the relatively narrow limits of 50 to 60 cycles if standard 60-cycle transformers are to operate efficiently from this source. A 60-cycle electric clock provides a means of checking the output frequency with a fair degree of accuracy. The clock is connected across the output of the generator and the second hand is checked closely against the second hand of a watch. The speed of the engine is adjusted until the two second hands are in synchronism.

Output voltage should be checked with a voltmeter since a standard 115-volt lamp bulb, which is sometimes used for this purpose, is very inaccurate.

Noise Elimination

Electrical noise which may interfere with receivers operating from engine-driven a.c. generators may be reduced or eliminated by taking proper precautions. The most important point is that of grounding the frame of the generator *and* one side of the output. The ground lead should be short to be effective, otherwise grounding may actually increase the noise. A water pipe may be used if a short connection can be made near the point where the pipe enters the ground, otherwise a good separate ground should be provided.

The next step is to loosen the brush-holder locks and slowly shift the position of the brushes while checking for noise with the receiver. Usually a point will be found (almost always different from the factory setting) where there is a marked decrease in noise.

From this point on, if necessary, bypass capacitors from various brush holders to the frame, as shown in Fig. 19-49, will bring the hash down to within 10 to 15 per cent of its

TABLE 19-III
Service life of some typical zinc-carbon cells and batteries

Cell or Battery	ASA Cell Size	Continuous service		4 hours per day service	
		ma.	hrs.	ma.	hrs.
1.5 v. pen light cell	AA	30	14	20	33
1.5 v. flash light cell	D	160	9	130	21
1.5 v. ignition cell	#6	500	43	500	80
45 v., 67.5 v., 90 v. B-battery	F30	18	9	16	14
	F40	19	15	17	24
	F70	20	35	24	47

original intensity, if not entirely eliminating it. Most of the remaining noise will be reduced still further if the high-power audio stages are cut out and a pair of headphones is connected into the second detector.

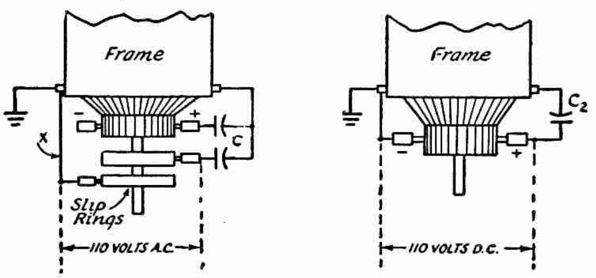


Fig. 19-49—Connections used for eliminating interference from gas-driven generator plants. C should be 1 μf., 300 volts, paper, while C_2 may be 1 μf. with a voltage rating of twice the d.c. output voltage delivered by the generator. X indicates an added connection between the slip ring on the grounded side of the line and the generator frame.

● POWER FOR PORTABLES

Dry Cell Batteries

Dry-cell batteries are a practical source of power for supplying portables or equipment which must be transported on foot. However, they are costly and have limited current capability. The zinc-carbon cells lose their power even when not in use, if allowed to stand idle for periods of a year or more. This makes them uneconomical if not used more or less continuously.

The mercury cell has a much higher ratio of ampere-hour capacity to volume at higher current densities than are obtainable from the conventional dry cell. Mercury batteries are well suited for emergency portable operation even after many months of storage.

Typical service life data for several types of zinc-carbon cells and batteries is given in Table 19-III. The figures show length of service time before the cell terminal voltage drops to 1.0 volt (in B-batteries, when individual cells reach 1.0 volt).

Mercury batteries and cells are available in several sizes and shapes. Some may be operated at current drains up in the ampere range and others are available in potentials in the hundreds of volts. A typical 1.35-volt mercury cell measuring only 2¼ × 2¼ × 2¾ inches, has a capacity of 43 ampere hours (maximum current 3 amperes). Cells of this type would be useful for filament or heater applications. A representative mercury B-battery has a voltage of 67.5 volts and a capacity of 3.6 ampere hours (maximum current 250 ma.). It measures about 3⅜ × 1½ × 10⅙ inches.

Construction Practices

TOOLS AND MATERIALS

While an easier, and perhaps a better, job can be done with a greater variety of tools available, by taking a little thought and care it is possible to turn out a fine piece of equipment with only a few of the common hand tools. A list of tools which will be indispensable in the construction of radio equipment will be found on this page. With these tools it should be possible to perform any of the required operations in preparing panels and metal chassis for assembly and wiring. It is an excellent idea for the amateur who does constructional work to add to his supply of tools from time to time as finances permit.

Several of the pieces of light woodworking machinery, often sold in hardware stores and mail-order retail stores, are ideal for amateur radio work, especially the drill press, grinding head, band and circular saws, and joiner. Although not essential, they are desirable should you be in a position to acquire them.

INDISPENSABLE TOOLS

Long-nose pliers, 6-inch.
Diagonal cutting pliers, 6-inch.
Wire stripper.
Screwdriver, 6- to 7-inch, ¼-inch blade.
Screwdriver, 4- to 5-inch, ⅛-inch blade.
Scratch awl or scriber for marking lines.
Combination square, 12-inch, for laying out work.
Hand drill, ¼-inch chuck or larger, 2-speed type preferable.
Electric soldering iron, 100 watts, ¼-in. tip.
Hack saw, 12-inch blades.
Center punch for marking hole centers.
Hammer, ball-peen, 1-lb. head.
Heavy knife.
Yardstick or other straightedge.
Carpenter's brace with adjustable hole cutter or socket-hole punches (see text).
Large, coarse, flat file.
Large round or rat-tail file, ½-inch diameter.
Three or four small and medium files—flat, round, half-round, triangular.
Drills, particularly ¼-inch and Nos. 18, 28, 33, 42 and 50.
Combination oil stone for sharpening tools.
Solder and soldering paste (noncorroding).
Medium-weight machine oil.

ADDITIONAL TOOLS

Bench vise, 4-inch jaws.
Tin shears, 10-inch, for cutting thin sheet metal.
Taper reamer, ½-inch, for enlarging small holes.
Taper reamer, 1-inch, for enlarging holes.
Countersink for brace.
Carpenter's plane, 8- to 12-inch, for woodworking.
Carpenter's saw, crosscut.
Motor-driven emery wheel for grinding.
Long-shank screwdriver with screw-holding clip for tight places.
Set of "Spintite" socket wrenches for hex nuts.
Set of small, flat, open-end wrenches for hex nuts.
Wood chisel, ½-inch.
Cold chisel, ½-inch.
Wing dividers, 8-inch, for scribing circles.
Set of machine-screw taps and dies.
Dusting brush.
Socket punches, esp. ⅝", ¾", 1⅛" and 1¼".

Twist Drills

Twist drills are made of either high-speed steel or carbon steel. The latter type is more common and will usually be supplied unless specific request is made for high-speed drills. The carbon drill will suffice for most ordinary equipment construction work and costs less than the high-speed type.

While twist drills are available in a number of sizes those listed in bold-faced type in Table 20-I will be most commonly used in construction of amateur equipment. It is usually desirable to purchase several of each of the commonly used sizes rather than a standard set, most of which will be used infrequently if at all.

Care of Tools

The proper care of tools is not alone a matter of pride to a good workman. He also realizes the energy which may be saved and the annoyance which may be avoided by the possession of a full kit of well-kept sharp-edged tools.

Drills should be sharpened at frequent intervals so that grinding is kept at a minimum each time. This makes it easier to maintain the rather critical surface angles required for best cutting with least wear. Occasional oilstoning of the cutting edges of a drill or reamer will extend the time between grindings.

The soldering iron can be kept in good condition by keeping the tip well tinned with solder and not allowing it to run at full voltage for long periods when it is not being used. After each period of use, the tip should be removed and cleaned of any scale which may have accumulated. An oxidized tip may be cleaned by dipping it in sal ammoniac while hot and then wiping it clean with a rag. If the tip becomes pitted it should be filed until smooth and bright, and then tinned immediately by dipping it in solder.

Useful Materials

Small stocks of various miscellaneous materials will be required in constructing radio apparatus, most of which are available from hardware or radio-supply stores. A representative list follows:

Sheet aluminum, solid and perforated, 16 or 18 gauge, for brackets and shielding.
½ × ½-inch aluminum angle stock.
¼-inch diameter round brass or aluminum rod for shaft extensions.
Machine screws: Round-head and flat-head, with nuts to fit. Most useful sizes: 4–36, 6–32 and 8–32, in lengths from ¼ inch to 1½ inches. (Nickel-plated iron will be found satisfactory except in strong r.f. fields, where brass should be used.)
Bakelite, lucite and polystyrene scraps.
Soldering lugs, panel bearings, rubber grommets, terminal-lug wiring strips, varnished-cambric insulating tubing.
Shielded and unshielded wire.
Tinned bare wire, Nos. 22, 14 and 12.

Machine screws, nuts, washers, soldering lugs, etc., are most reasonably purchased in quantities of a gross.

● CHASSIS WORKING

With a few essential tools and proper procedure, it will be found that building radio gear on a metal chassis is no more of a chore than building with wood, and a more satisfactory job results. Aluminum is to be preferred to steel, not only because it is a superior shielding material, but because it is much easier to work and to provide good chassis contacts.

The placing of components on the chassis is shown quite clearly in the photographs in this *Handbook*. Aside from certain essential dimensions, which usually are given in the text, exact duplication is not necessary.

Much trouble and energy can be saved by spending sufficient time in planning the job. When all details are worked out beforehand the actual construction is greatly simplified.

Cover the top of the chassis with a piece of wrapping paper or, preferably, cross-section paper, folding the edges down over the sides of the chassis and fastening with adhesive tape. Then assemble the parts to be mounted on top of the chassis and move them about until a satisfactory arrangement has been found, keeping in mind any parts which are to be mounted underneath, so that interferences in mounting may be avoided. Place capacitors and other parts with shafts extending through the panel first, and arrange them so that the controls will

TABLE 20-I
Numbered Drill Sizes

Number	*Diameter (mils)*	*Will Clear Screw*	*Drilled for Tapping Iron, Steel or Brass**
1	228.0	—	—
2	221.0	12–24	—
3	213.0	—	14–24
4	209.0	12–20	—
5	205.0	—	—
6	204.0	—	—
7	201.0	—	—
8	199.0	—	—
9	196.0	—	—
10	193.5	10–32	—
11	191.0	10–24	—
12	189.0	—	—
13	185.0	—	—
14	182.0	—	—
15	180.0	—	—
16	177.0	—	12–24
17	173.0	—	—
18	**169.5**	**8–32**	—
19	166.0	—	12–20
20	161.0	—	—
21	159.0	—	10–32
22	157.0	—	—
23	154.0	—	—
24	152.0	—	—
25	149.5	—	10–24
26	147.0	—	—
27	144.0	—	—
28	**140.0**	**6–32**	—
29	**136.0**	—	**8–32**
30	128.5	—	—
31	120.0	—	—
32	116.0	—	—
33	**113.0**	**4–36, 4–40**	—
34	111.0	—	—
35	**110.0**	—	**6–32**
36	106.5	—	—
37	104.0	—	—
38	101.5	—	—
39	099.5	3–48	—
40	098.0	—	—
41	096.0	—	—
42	**093.5**	—	**4–36, 4–40**
43	089.0	2–56	—
44	086.0	—	—
45	082.0	—	3–48
46	081.0	—	—
47	078.5	—	—
48	076.0	—	—
49	073.0	—	2–56
50	**070.0**	—	—
51	067.0	—	—
52	063.5	—	—
53	059.5	—	—
54	055.0	—	—

*Use one size larger for tapping bakelite and hard rubber.

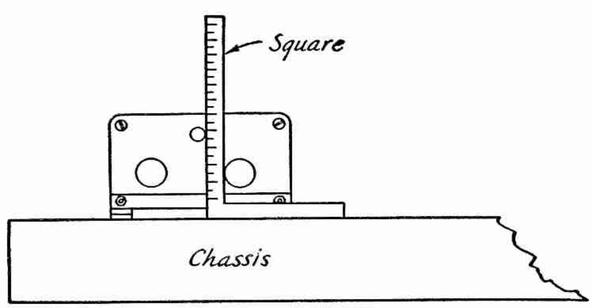


Fig. 20-1—Method of measuring the heights of capacitor shafts, etc. If the square is adjustable, the end of the scale should be set flush with the face of the head.

form the desired pattern on the panel. Be sure to line up the shafts squarely with the chassis front. Locate any partition shields and panel brackets next, and then the tube sockets and any other parts, marking the mounting-hole centers of each accurately on the paper. Watch out for capacitors whose shafts are off center and do not line up with the mounting holes. Do not forget to mark the centers of socket holes and holes for leads under i.f. transformers, etc., as well as holes for wiring leads. The small holes for socket-mounting screws are best located and center-punched, using the socket itself as a template, after the main center hole has been cut.

By means of the square, lines indicating accurately the centers of shafts should be extended to the front of the chassis and marked on the panel at the chassis line, the panel being fastened on temporarily. The hole centers may then be punched in the chassis with the center punch. After drilling, the parts which require mounting underneath may be located and the mounting holes drilled, making sure by trial that no interferences exist with parts mounted on top. Mounting holes along the front edge

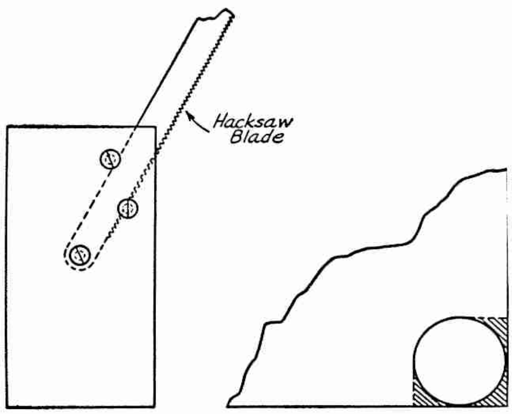


Fig. 20-2—To cut rectangular holes in a chassis corner, holes may be filed out as shown in the shaded portion of B, making it possible to start the hack-saw blade along the cutting line. A shows how a single-ended handle may be constructed for a hack-saw blade.

of the chassis should be transferred to the panel, by once again fastening the panel to the chassis and marking it from the rear.

Next, mount on the chassis the capacitors and any other parts with shafts extending to the panel, and measure accurately the height of the center of each shaft above the chassis, as illustrated in Fig. 20-1. The horizontal displacement of shafts having already been marked on the chassis line on the panel, the vertical displacement can be measured from this line. The shaft centers may now be marked on the back of the panel, and the holes drilled. Holes for any other panel equipment coming above the chassis line may then be marked and drilled, and the remainder of the apparatus mounted. Holes for terminals etc., in the rear edge of the chassis should be marked and drilled at the same time that they are done for the top.

Drilling and Cutting Holes

When drilling holes in metal with a hand drill it is important that the centers first be located with a center punch, so that the drill point will not "walk" away from the center when starting the hole. When the drill starts to break through, special care must be used. Often it is an advantage to shift a two-speed drill to low gear at this point. Holes more than ¼ inch in diameter may be started with a smaller drill and reamed out with the larger drill.

The chuck on the usual type of hand drill is limited to ¼-inch drills. Although it is rather tedious, the ¼-inch hole may be filed out to larger diameters with round files. Another method possible with limited tools is to drill a series of small holes with the hand drill along the inside of the diameter of the large hole, placing the holes as close together as possible. The center may then be knocked out with a cold chisel and the edges smoothed up with a file. Taper reamers which fit into the carpenter's brace will make the job easier. A large rat-tail file clamped in the brace makes a very good reamer for holes up to the diameter of the file, if the file is revolved counterclockwise.

For socket holes and other large round holes, an adjustable cutter designed for the purpose may be used in the brace. Occasional application of machine oil in the cutting groove will help. The cutter first should be tried out on a block of wood, to make sure that it is set for the correct diameter. The most convenient device for cutting socket holes is the socket-hole punch. The best type is that which works by turning a take-up screw with a wrench.

The burrs or rough edges which usually result after drilling or cutting holes may be removed with a file, or sometimes more conveniently with a sharp knife or chisel. It is a good idea to keep an old wood chisel sharpened and available for this purpose.

Rectangular Holes

Square or rectangular holes may be cut out by making a row of small holes as previously described, but is more easily done by drilling a ½-inch hole inside each corner, as illustrated in Fig. 20-2, and using these holes for starting and turning the hack saw. The socket-hole punch and the square punches which are now available also may be of considerable assistance in cutting out large rectangular openings.

● CONSTRUCTION NOTES

If a control shaft must be extended or insulated, a flexible shaft coupling with adequate insulation should be used. Satisfactory support for the shaft extension can be provided by means of a *metal* panel bearing made for the purpose. Never use panel bearings of the non-metal type unless the capacitor shaft is grounded. *The metal bearing should be connected to the chassis with a wire or grounding strip.*

This prevents any possible danger of shock.

The use of fiber washers between ceramic insulation and metal brackets, screws or nuts will prevent the ceramic parts from breaking.

STANDARD METAL GAUGES

Gauge No.	*American or B. & S.*[1]	*U. S. Standard*[2]	*Birmingham or Stubs*[3]
1	.2893	.28125	.300
2	.2576	.265625	.284
3	.2294	.25	.259
4	.2043	.234375	.238
5	.1819	.21875	.220
6	.1620	.203125	.203
7	.1443	.1875	.180
8	.1285	.171875	.165
9	.1144	.15625	.148
10	.1019	.140625	.134
11	.09074	.125	.120
12	.08081	.109375	.109
13	.07196	.09375	.095
14	.06408	.078125	.083
15	.05707	.0703125	.072
16	.05082	.0625	.065
17	.04526	.05625	.058
18	.04030	.05	.049
19	.03589	.04375	.042
20	.03196	.0375	.035
21	.02846	.034375	.032
22	.02535	.03125	.028
23	.02257	.028125	.025
24	.02010	.025	.022
25	.01790	.021875	.020
26	.01594	.01875	.018
27	.01420	.0171875	.016
28	.01264	.015625	.014
29	.01126	.0140625	.013
30	.01003	.0125	.012
31	.008928	.0109375	.010
32	.007950	.01015625	.009
33	.007080	.009375	.008
34	.006350	.00859375	.007
35	.005615	.0078125	.005
36	.005000	.00703125	.004
37	.004453	.006640626	....
38	.003965	.00625	....
39	.003531	....	....
40	.003145	....	....

[1] Used for aluminum, copper, brass and nonferrous alloy sheets, wire and rods.
[2] Used for iron, steel, nickel and ferrous alloy sheets, wire and rods.
[3] Used for seamless tubes; also by some manufacturers for copper and brass.

Cutting and Bending Sheet Metal

If a sheet of metal is too large to be cut conveniently with a hack saw, it may be marked with scratches as deep as possible along the line of the cut on both sides of the sheet and then clamped in a vise and worked back and forth until the sheet breaks at the line. Do not carry the bending too far until the break begins to weaken; otherwise the edge of the sheet may become bent. A pair of iron bars or pieces of heavy angle stock, as long or longer than the width of the sheet, to hold it in the vise will make the job easier. "C"-clamps may be used to keep the bars from spreading at the ends. The rough edges may be smoothed up with a file or by placing a large piece of emery cloth or sandpaper on a flat surface and running the edge of the metal back and forth over the sheet.

Bends may be made similarly. The sheet should be scratched on both sides, but not so deeply as to cause it to break.

Finishing Aluminum

Aluminum chassis, panels and parts may be given a sheen finish by treating them in a caustic bath. An enamelled container, such as a dishpan or infant's bathtub, should be used for the solution. Dissolve ordinary household lye in cold water in a proportion of ¼ to ½ can of lye per gallon of water. The stronger solution will do the job more rapidly. Stir the solution with a stick of wood until the lye crystals are complete dissolved. Be very careful to avoid any skin contact with the solution. It is also harmful to clothing. Sufficient solution should be prepared to cover the piece completely. When the aluminum is immersed, a very pronounced bubbling takes place and ventilation should be provided to disperse the escaping gas. A half hour to two hours in the solution should be sufficient, depending upon the strength of the solution and the desired surface.

Remove the aluminum from the solution with sticks and rinse thoroughly in cold water while swabbing with a rag to remove the black deposit. Then wipe off with a rag soaked in vinegar to remove any stubborn stains or fingerprints. (See May, 1950, *QST*, for a method of coloring and anodizing aluminum.)

Soldering

The secret of good soldering is in allowing time for the *joint*, as well as the solder, to attain sufficient temperature. Enough heat should be applied so that the solder will melt when it comes in contact with the wires being joined, without touching the solder to the iron. Always use rosin-core solder, never acid-core. Except where absolutely necessary, solder should never be depended upon for the mechanical strength of the joint; the wire should be wrapped around the terminals or clamped with soldering terminals.

When soldering crystal diodes or carbon re-

DECIMAL EQUIVALENTS OF FRACTIONS

1/32	.03125	17/32	.53125
1/16	.0625	9/16	.5625
3/32	.09375	19/32	.59375
1/8	.125	5/8	.625
5/32	.15625	21/32	.65625
3/16	.1875	11/16	.6875
7/32	.21875	23/32	.71875
1/4	.25	3/4	.75
9/32	.28125	25/32	.78125
5/16	.3125	13/16	.8125
11/32	.34375	27/32	.84375
3/8	.375	7/8	.875
13/32	.40625	29/32	.90625
7/16	.4375	15/16	.9375
15/32	.46875	31/32	.96875
1/2	.5	1	1.0

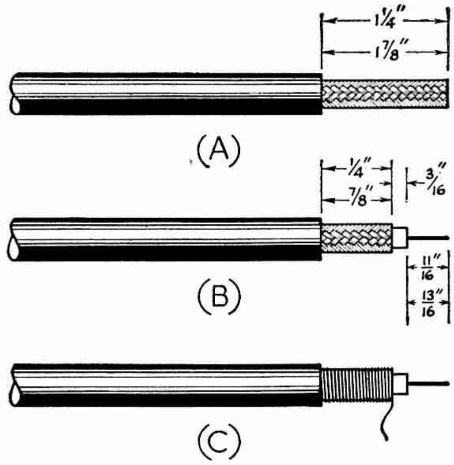


Fig. 20-3—Cable-stripping dimensions for Jones Type P-101 plugs. Smaller dimensions are for ¼-inch plugs, the larger dimensions for ½-inch plugs. As indicated in C, the remaining copper braid is wound with bare or tinned wire and then tinned, to make a snug fit in the sleeve of the plug. Hold a hot iron to the sleeve after the cable is inserted to solder the sleeve to the braid.

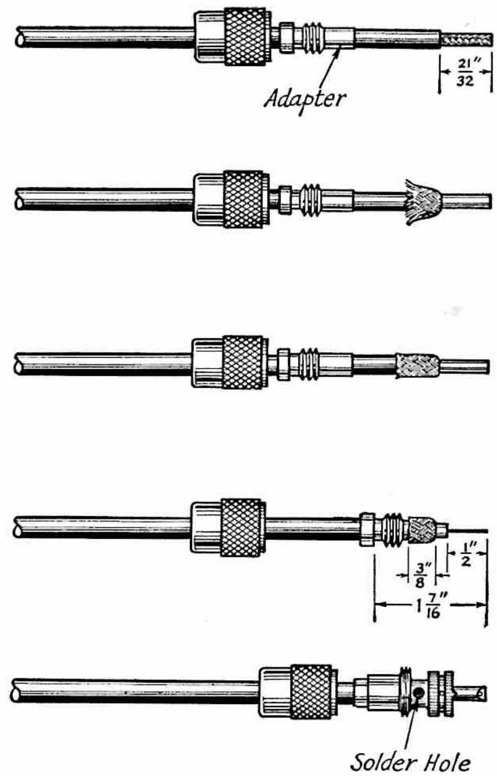


Fig. 20-5—Method of assembling ¼-inch cable, Amphenol Type 83-1SP (PL-259) plug and adapter.

sistors in place, especially if the leads have been cut short and the resistor is of the small ½-watt size, the resistor lead should be gripped with a pair of pliers up close to the resistor so that the heat will be conducted away from the resistor. Overheating of the resistor while soldering can cause a permanent resistance change of as much as 20 per cent. Also, mechanical stress will have a similar effect, so that a small resistor should be mounted so that there is no appreciable mechanical strain on the leads.

Trouble is sometimes experienced in soldering to the pins of coil-forms or male cable plugs. It helps first to tin the inside of the pins by applying soldering paste to the hole, and then flowing solder into the pin. Then immediately clear the solder from the hot pin by a whipping motion or by blowing through the pin from the inside of the form or plug. Before inserting the wire in the pin, file the nickel plate from the tip. After soldering, round the solder tip off with a file.

When soldering to sockets, it is a good idea to have the tube or coil form inserted to prevent solder running down into the socket prongs. It also helps to conduct the heat away when soldering to polystyrene sockets, which often soften under the heat of the iron.

Wiring

The wire used in connecting up amateur equipment should be selected considering both the maximum current it will be called upon to handle and the voltage its insulation must stand without breakdown. Also, from the consideration of TVI, the power wiring of all transmitters should be done with wire that has a braided shielding cover. Receiver and audio circuits may also require the use of shielded wire at some points for stability, or the elimination of hum.

No. 20 stranded wire is commonly used for most receiver wiring (except for the high-

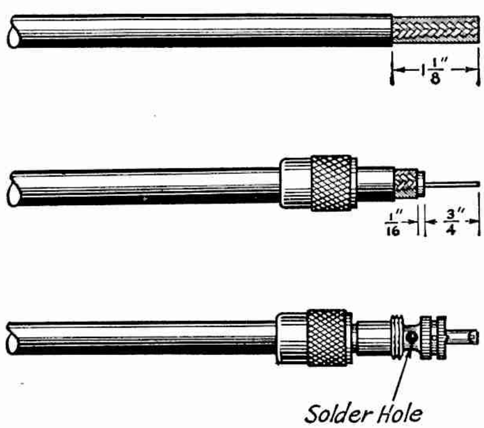


Fig. 20-4—Dimensions for stripping ½-inch cable to fit Amphenol Type 83-1SP (PL-259) plug.

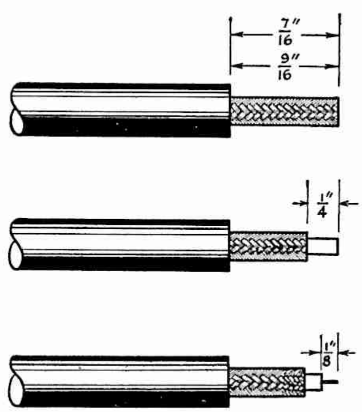


Fig. 20-6—Stripping dimensions for Amphenol 82-830 and 82-832 plug-in connectors. The longer exposed braid is for the first type.

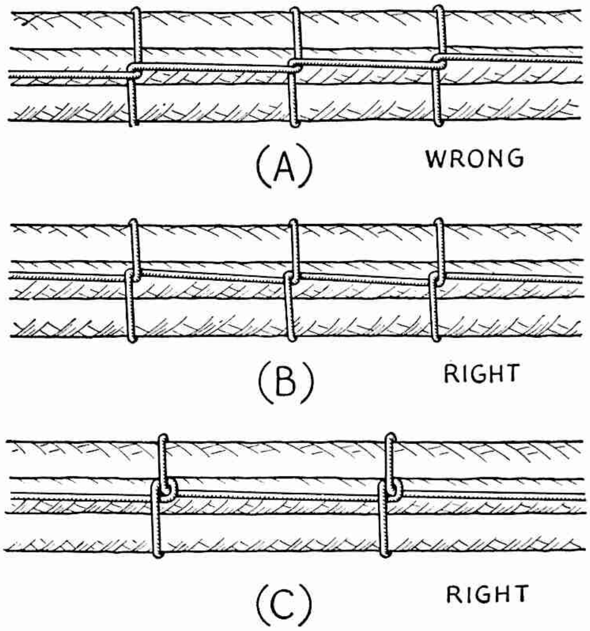


Fig. 20-7—Methods of lacing cables. The method shown at C is more secure, but takes more time than the method of B. The latter is usually adequate for most amateur requirements.

frequency circuits) where the current does not exceed 2 or 3 amperes. For higher-current heater circuits, No. 18 is available. Wire with cellulose acetate insulation is good for voltages up to about 500. For higher voltages, thermoplastic-insulated wire should be used. Inexpensive wire strippers that make the removal of insulation from hook-up wire an easy job are available on the market.

In cases where power leads have several branches in the chassis, it is convenient to use fiber-insulated tie points or "lug strips" as anchorages or junction points. Strips of this type are also useful as insulated supports for resistors, r.f. chokes and capacitors. High-voltage wiring should have exposed points held to a minimum, and those which cannot be avoided should be rendered as inaccessible as possible to accidental contact or short-circuit.

Where shielded wire is called for and capacitance to ground is not a factor, Belden type 8885 shielded grid wire may be used. If capacitance must be minimized, it may be necessary to use a piece of car-radio low-capacitance lead-in wire, or coaxial cable.

For wiring high-frequency circuits, rigid wire is often used. Bare soft-drawn tinned wire, sizes 22 to 12 (depending on mechanical requirements), is suitable. Kinks can be removed by stretching a piece 10 or 15 feet long and then cutting into short lengths that can be handled conveniently. R.f. wiring should be run directly from point to point with a minimum of sharp bends and the wire kept well spaced from the chassis or other grounded metal surfaces. Where the wiring must pass through the chassis or a partition, a clearance hole should be cut and lined with a rubber grommet. In case insulation becomes necessary, varnished cambric tubing (spaghetti) can be slipped over the wire.

In transmitters where the peak voltage does not exceed 2500 volts, the shielded grid wire mentioned above should be satisfactory for power circuits. For higher voltages, Belden type 8656, Birnbach type 1820, or shielded ignition cable can be used. In the case of filament circuits carrying heavy current, it may be necessary to use No. 10 or 12 bare or enameled wire, slipped through spaghetti, and then covered with copper braid pulled tightly over the spaghetti. The chapter on TVI shows the manner in which shielded wire should be applied. If the shielding is simply slid back over the insulation and solder flowed into the end of the braid, the braid usually will stay in place without the necessity for cutting it back or binding it in place. The braid should be burnished with sandpaper or a knife so that solder will take with a minimum of heat to protect the insulation underneath.

R.f. wiring in transmitters usually follows the method described above for receivers with due respect to the voltages involved.

Power and control wiring external to the transmitter chassis preferably should be of shielded wire bound into a cable. Fig. 20-7 shows the correct methods of lacing cables.

To give a "commercial look" to the wiring of any unit, run any cabled leads along the edge of the chassis. If this isn't possible, the cabled leads should then run parallel to an edge of the chassis. Further, the generous use of bakelite tie points (mounted parallel to an edge of the chassis), for the support of one or both ends of a resistor or fixed capacitor, will add to the appearance of the finished unit. In a similar manner, "dress" the small components so that they are parallel to the panel or sides of the chassis.

Winding Coils

Close-wound coils are readily wound on the specified form by anchoring one end of a length of wire (in a vise or to a doorknob) and the other end to the coil form. Straighten any kinks in the wire and then pull to keep the wire under slight tension. Wind the coil to the required number of turns while walking toward the anchor, always maintaining the slight tension on the wire.

To space-wind the coil, wind the coil simultaneously with a suitable spacing medium (heavy thread, string or wire) in the manner described above. When the winding is complete, secure the end of the coil to the coil-form terminal and then carefully unwind the spacing material. If the coil is wound under suitable tension, the spacing material can be easily removed without disturbing the winding. Finish the space-wound coil by judicious applications of Duco cement, to hold the turns in place.

● COMPONENT VALUES

Values of composition resistors and small capacitors (mica and ceramic) are specified throughout this *Handbook* in terms of "preferred values." In the preferred-number sys-

TABLE 20-II
Standard Component Values

20% Tolerance	10% Tolerance	5% Tolerance
10	10	10
		11
	12	12
		13
15	15	15
		16
	18	18
		20
22	22	22
		24
	27	27
		30
33	33	33
		36
	39	39
		43
47	47	47
		51
	56	56
		62
68	68	68
		75
	82	82
		91
100	100	100

tem, all values represent (approximately) a constant-percentage increase over the next lower value. The base of the system is the number 10. Only two significant figures are used. Table 20-II shows the preferred values based on tolerance steps of 20, 10 and 5 per cent. All other values are expressed by multiplying or dividing the base figures given in the table by the appropriate power of 10. (For example, resistor values of 33,000 ohms, 6800 ohms, and 150 ohms are obtained by multiplying the base figures by 1000, 100, and 10, respectively.)

"Tolerance" means that a variation of plus or minus the percentage given is considered satisfactory. For example, the actual resistance of a "4700-ohm" 20-per-cent resistor can lie anywhere between 3700 and 5600 ohms, approximately. The permissible variation in the same resistance value with 5-per-cent tolerance would be in the range from 4500 to 4900 ohms, approximately.

Only those values shown in the first column of Table 20-II are available in 20-per-cent tolerance. Additional values, as shown in the second column, are available in 10-per-cent tolerance; still more values can be obtained in 5-per-cent tolerance.

In the component specifications in this *Handbook*, it is to be understood that when no tolerance is specified the *largest* tolerance available in that value will be satisfactory.

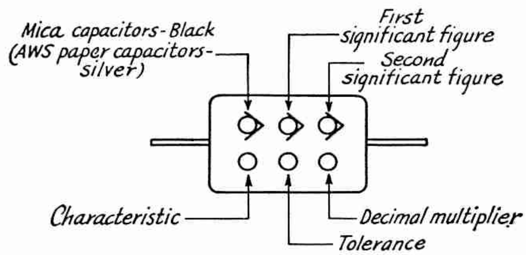
Values that do not fit into the preferred-number system (such as 500, 25,000, etc.) easily can be substituted. It is obvious, for example, that a 5000-ohm resistor falls well within the tolerance range of the 4700-ohm 20-per-cent resistor used in the example above. It would not, however, be usable if the tolerance were specified as 5 per cent.

COLOR CODES

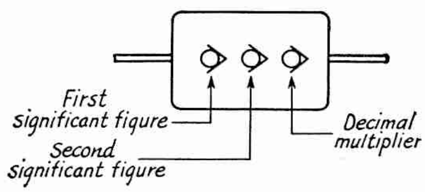
Standardized color codes are used to mark values on small components such as composition resistors and mica capacitors, and to identify leads from transformers, etc. The resistor-capacitor number color code is given in Table 20-III.

Fixed Capacitors

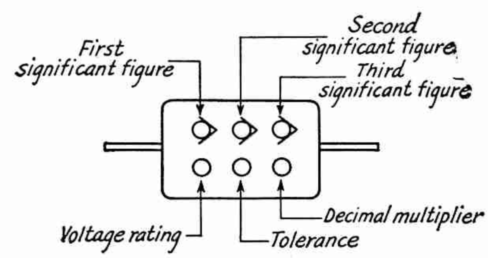
The methods of marking "postage-stamp" mica capacitors, molded paper capacitors, and tubular ceramic capacitors are shown in Fig. 20-8. Capacitors made to American War Standards or Joint Army-Navy specifications



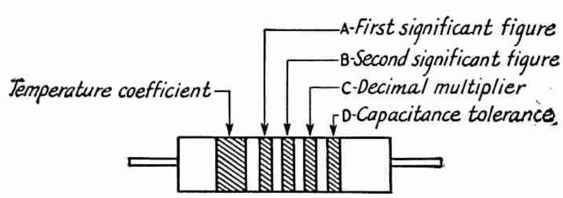
AWS and JAN fixed capacitors



EIA 3-dot 500-volt, ±20% tolerance only



EIA 6-dot



Fixed ceramic capacitors

Fig. 20-8—Color coding of fixed mica, molded paper and tubular ceramic capacitors. The color code for mica and molded paper capacitors is given in Table 20-III. Table 20-IV gives the color code for tubular ceramic capacitors.

are marked with the 6-dot code shown at the top. Practically all surplus capacitors are in this category. The 3-dot EIA code is used for capacitors having a rating of 500 volts and ±20% tolerance only; other ratings and tolerances are covered by the 6-dot EIA code.

Examples: A capacitor with a 6-dot code has the following markings: Top row, left to right, black, yellow, violet; bottom row, right to left, brown, silver, red. Since the first color in the top row is black (significant figure zero) this is the AWS code and the capacitor has mica dielectric. The significant figures are 4 and 7, the decimal multiplier 10 (brown, at right of second row), so the capacitance is 470 μμf. The tolerance is ± 10%. The final color, the characteristic, deals with temperature coefficients and methods of testing (see Table 20-V on page 505).

A capacitor with a 3-dot code has the following colors, left to right: brown, black, red. The significant figures are 1, 0 (10) and the multiplier is 100. The capacitance is therefore 1000 μμf.

A capacitor with a 6-dot code has the following markings: Top row, left to right, brown, black, black; bottom row, right to left, black, gold, blue. Since the first color in the top row is neither black nor silver, this is the EIA code. The significant figures are 1, 0, 0 (100) and the decimal multiplier is 1 (black). The capacitance is therefore 100 μμf. The gold dot shows that the tolerance is ± 5% and the blue dot indicates 600-volt rating.

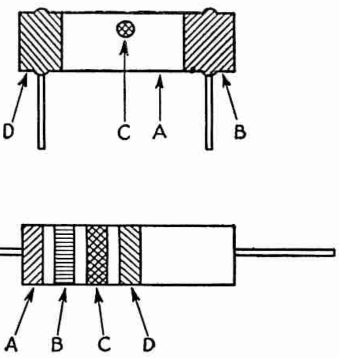
Ceramic Capacitors

Conventional markings for ceramic capacitors are shown in the lower drawing of Fig. 20-8. The colors have the meanings indicated in Table 20-IV. In practice, dots may be used instead of the *narrow* bands indicated in Fig. 20-8.

Example: A ceramic capacitor has the following markings: Broad band, violet; narrow bands or dots, green, brown, black, green. The significant figures are 5, 1 (51) and the decimal multiplier is 1, so the capacitance is 51 μμf. The temperature coefficient is − 750 parts per million per degree C., as given by the broad band, and the capacitance tolerance is ± 5%.

Fixed Composition Resistors

Composition resistors (including small wire-wound units molded in cases identical with the composition type) are color-coded as shown in Fig. 20-9. Colored bands are used on resistors having axial leads; on radial-lead resistors the colors are placed as shown in the drawing. When bands are used for color coding the body color has no significance.



Fixed composition resistors

Fig. 20-9—Color coding of fixed composition resistors The color code is given in Table 20-III. The colored areas have the following significance:

A—First significant figure of resistance in ohms.
B—Second significant figure.
C—Decimal multiplier.
D—Resistance tolerance in per cent. If no color is shown the tolerance is ±20%.

Examples: A resistor of the type shown in the lower drawing of Fig. 20-9 has the following color bands: A, red; B, red; C, orange; D, no color. The significant figures are 2, 2 (22) and the decimal multiplier is 1000. The value of resistance is therefore 22,000 ohms and the tolerance is ±20%.

A resistor of the type shown in the upper drawing has the following colors: body (A), blue; end (B), gray; dot, red; end (D), gold. The significant figures are 6, 8 (68) and the decimal multiplier is 100, so the resistance is 6800 ohms. The tolerance is ±5%.

I.F. Transformers

Blue — plate lead.
Red — "B" + lead.
Green — grid (or diode) lead.
Black — grid (or diode) return.

NOTE: If the secondary of the i.f.t. is center-tapped, the second diode plate lead is green-and-black striped, and black is used for the center-tap lead.

TABLE 20-III
Resistor-Capacitor Color Code

Color	*Significant Figure*	*Decimal Multiplier*	*Tolerance (%)*	*Voltage Rating**
Black	0	1	–	—
Brown	1	10	1*	100
Red	2	100	2*	200
Orange	3	1000	3*	300
Yellow	4	10,000	4*	400
Green	5	100,000	5*	500
Blue	6	1,000,000	6*	600
Violet	7	10,000,000	7*	700
Gray	8	100,000,000	8*	800
White	9	1,000,000,000	9*	900
Gold	–	0.1	5	1000
Silver	–	0.01	10	2000
No color	–	—	20	500

* Applies to capacitors only.

TABLE 20-IV
Color Code for Ceramic Capacitors

Color	*Significant Figure*	*Decimal Multiplier*	*Capacitance Tolerance*		*Temp. Coeff. p.p.m./deg C.*
			More than 10 μμf. (in %)	*Less than 10 μμf. (in μμf.)*	
Black	0	1	± 20	2.0	0
Brown	1	10	± 1		— 30
Red	2	100	± 2		— 80
Orange	3	1000			— 150
Yellow	4				— 220
Green	5		± 5	0.5	— 330
Blue	6				— 470
Violet	7				— 750
Gray	8	0.01		0.25	30
White	9	0.1	± 10	1.0	500

PILOT-LAMP DATA

Lamp No.	*Bead Color*	*Base (Miniature)*	*Bulb Type*	*RATING*	
				Volts	*Amp.*
40	Brown	Screw	T-3¼	6–8	0.15
40A[1]	Brown	Bayonet	T-3¼	6–8	0.15
41	White	Screw	T-3¼	2.5	0.5
42	Green	Screw	T-3¼	3.2	**
43	White	Bayonet	T-3¼	2.5	0.5
44	Blue	Bayonet	T-3¼	6–8	0.25
45	*	Bayonet	T-3¼	3.2	**
46[2]	Blue	Screw	T-3¼	6–8	0.25
47[1]	Brown	Bayonet	T-3¼	6–9	0.15
48	Pink	Screw	T-3¼	2.0	0.06
49[3]	Pink	Bayonet	T-3¼	2.0	0.06
[4]	White	Screw	T-3¼	2.1	0.12
49A[3]	White	Bayonet	T-3¼	2.1	0.12
50	White	Screw	G-3½	6–8	0.2
51[2]	White	Bayonet	G-3½	6–8	0.2
—	White	Screw	G-4½	6–8	0.4
55	White	Bayonet	G-4½	6–8	0.4
292[5]	White	Screw	T-3¼	2.9	0.17
292A[5]	White	Bayonet	T-3¼	2.9	0.17
1455	Brown	Screw	G-5	18.0	0.25
1455A	Brown	Bayonet	G-5	18.0	0.25

[1] **40A** and **47** are interchangeable.
[2] Have frosted bulb.
[3] **49** and **49A** are interchangeable.
[4] Replace with No. **48.**
[5] Use in 2.5-volt sets where regular bulb burns out too frequently.
* White in G.E. and Sylvania; green in National Union, Raytheon and Tung-Sol.
** 0.35 in G.E. and Sylvania; 0.5 in National Union, Raytheon and Tung-Sol.

TABLE 20-V
Capacitor Characteristic Code

Color Sixth Dot	*Temperature Coefficient p.p.m./deg. C.*	*Capacitance Drift*
Black	± 1000	±5% + 1 μμf.
Brown	± 500	± 3% + 1 μμf.
Red	+ 200	± 0.5%
Orange	+ 100	± 0.3%
Yellow	− 20 to + 100	± 0.1% + 0.1 μμf.
Green	0 to + 70	± 0.05% + 0.1 μμf.

A.F. Transformers

Blue — plate (finish) lead of primary.
Red — "B" + lead (this applies whether the primary is plain or center-tapped).
Brown — plate (start) lead on center-tapped primaries. (Blue may be used for this lead if polarity is not important.)
Green — grid (finish) lead to secondary.
Black — grid return (this applies whether the secondary is plain or center-tapped).
Yellow — grid (start) lead on center-tapped secondaries. (Green may be used for this lead if polarity is not important.)

NOTE: These markings apply also to line-to-grid and tube-to-line transformers.

Loudspeaker Voice Coils

Green — finish.
Black — start.

Loudspeaker Field Coils

Black and Red — start.
Yellow and Red — finish.
Slate and Red — tap (if any).

Power Transformers

1) Primary Leads .... *Black*
If tapped:
Common .... *Black*
Tap .... *Black and Yellow Striped*
Finish .... *Black and Red Striped*
2) High-Voltage Plate Winding .... *Red*
Center-Tap ... *Red and Yellow Striped*
3) Rectifier Filament Winding .... *Yellow*
Center-Tap .. *Yellow and Blue Striped*
4) Filament Winding No. 1 .... *Green*
Center-Tap .. *Green and Yellow Striped*
5) Filament Winding No. 2 .... *Brown*
Center-Tap. *Brown and Yellow Striped*
6) Filament Winding No. 3 .... *Slate*
Center-Tap ... *Slate and Yellow Striped*

COPPER-WIRE TABLE

Wire Size A.W.G. (B & S)	Diam. in Mils[1]	Circular Mil Area	Turns per Linear Inch[2]				Turns per Square Inch[2]			Feet per Lb.		Ohms per 1000 ft. 25° C.	Current Carrying Capacity[3] at 700 C.M. per Amp.	Diam. in mm.	Nearest British S.W.G. No.
			Enamel	S.S.C.[4]	D.S.C.[5] or S.C.C.[6]	D.C.C.[7]	S.C.C.	Enamel S.C.C.	D.C.C.	Bare	D.C.C.				
1	289.3	83690	—	—	—	—	—	—	—	3.947	—	.1264	119.6	7.348	1
2	257.6	66370	—	—	—	—	—	—	—	4.977	—	.1593	94.8	6.544	3
3	229.4	52640	—	—	—	—	—	—	—	6.276	—	.2009	75.2	5.827	4
4	204.3	41740	—	—	—	—	—	—	—	7.914	—	.2533	59.6	5.189	5
5	181.9	33100	—	—	—	—	—	—	—	9.980	—	.3195	47.3	4.621	7
6	162.0	26250	—	—	—	—	—	—	—	12.58	—	.4028	37.5	4.115	8
7	144.3	20820	—	—	—	—	—	—	—	15.87	—	.5080	29.7	3.665	9
8	128.5	16510	7.6	—	7.4	7.1	—	—	—	20.01	19.6	.6405	23.6	3.264	10
9	114.4	13090	8.6	—	8.2	7.8	—	—	—	25.23	24.6	.8077	18.7	2.906	11
10	101.9	10380	9.6	—	9.3	8.9	87.5	84.8	80.0	31.82	30.9	1.018	14.8	2.588	12
11	90.74	8234	10.7	—	10.3	9.8	110	105	97.5	40.12	38.8	1.284	11.8	2.305	13
12	80.81	6530	12.0	—	11.5	10.9	136	131	121	50.59	48.9	1.619	9.33	2.053	14
13	71.96	5178	13.5	—	12.8	12.0	170	162	150	63.80	61.5	2.042	7.40	1.828	15
14	64.08	4107	15.0	—	14.2	13.8	211	198	183	80.44	77.3	2.575	5.87	1.628	16
15	57.07	3257	16.8	—	15.8	14.7	262	250	223	101.4	97.3	3.247	4.65	1.450	17
16	50.82	2583	18.9	18.9	17.9	16.4	321	306	271	127.9	119	4.094	3.69	1.291	18
17	45.26	2048	21.2	21.2	19.9	18.1	397	372	329	161.3	150	5.163	2.93	1.150	18
18	40.30	1624	23.6	23.6	22.0	19.8	493	454	399	203.4	188	6.510	2.32	1.024	19
19	35.89	1288	26.4	26.4	24.4	21.8	592	553	479	256.5	237	8.210	1.84	.9116	20
20	31.96	1022	29.4	29.4	27.0	23.8	775	725	625	323.4	298	10.35	1.46	.8118	21
21	28.46	810.1	33.1	32.7	29.8	26.0	940	895	754	407.8	370	13.05	1.16	.7230	22
22	25.35	642.4	37.0	36.5	34.1	30.0	1150	1070	910	514.2	461	16.46	.918	.6438	23
23	22.57	509.5	41.3	40.6	37.6	31.6	1400	1300	1080	648.4	584	20.76	.728	.5733	24
24	20.10	404.0	46.3	45.3	41.5	35.6	1700	1570	1260	817.7	745	26.17	.577	.5106	25
25	17.90	320.4	51.7	50.4	45.6	38.6	2060	1910	1510	1031	903	33.00	.458	.4547	26
26	15.94	254.1	58.0	55.6	50.2	41.8	2500	2300	1750	1300	1118	41.62	.363	.4049	27
27	14.20	201.5	64.9	61.5	55.0	45.0	3030	2780	2020	1639	1422	52.48	.288	.3606	29
28	12.64	159.8	72.7	68.6	60.2	48.5	3670	3350	2310	2067	1759	66.17	.228	.3211	30
29	11.26	126.7	81.6	74.8	65.4	51.8	4300	3900	2700	2607	2207	83.44	.181	.2859	31
30	10.03	100.5	90.5	83.3	71.5	55.5	5040	4660	3020	3287	2534	105.2	.144	.2546	33
31	8.928	79.70	101	92.0	77.5	59.2	5920	5280	—	4145	2768	132.7	.114	.2268	34
32	7.950	63.21	113	101	83.6	62.6	7060	6250	—	5227	3137	167.3	.090	.2019	36
33	7.080	50.13	127	110	90.3	66.3	8120	7360	—	6591	4697	211.0	.072	.1798	37
34	6.305	39.75	143	120	97.0	70.0	9600	8310	—	8310	6168	266.0	.057	.1601	38
35	5.615	31.52	158	132	104	73.5	10900	8700	—	10480	6737	335.0	.045	.1426	38–39
36	5.000	25.00	175	143	111	77.0	12200	10700	—	13210	7877	423.0	.036	.1270	39–40
37	4.453	19.83	198	154	118	80.3	—	—	—	16660	9309	533.4	.028	.1131	41
38	3.965	15.72	224	166	126	83.6	—	—	—	21010	10666	672.6	.022	.1007	42
39	3.531	12.47	248	181	133	86.6	—	—	—	26500	11907	848.1	.018	.0897	43
40	3.145	9.88	282	194	140	89.7	—	—	—	33410	14222	1069	.014	.0799	44

[1] A mil is 1/1000 (one-thousandth) of an inch. [2] The figures given are approximate only, since the thickness of the insulation varies with different manufacturers. [3] 700 circular mils per ampere is a satisfactory design figure for small transformers, but values from 500 to 1000 C.M. are commonly used. For 1000 C.M./amp. divide the circular mil area (third column) by 1000; for 500 C.M./amp. divide circular mil area by 500. [4] Single silk-covered. [5] Double silk-covered. [6] Single cotton-covered. [7] Double cotton-covered.

Measurements

It is practically impossible to operate an amateur station without making measurements at one time or another. Although quite crude measurements often will suffice, more refined equipment and methods will yield more and better information. With adequate information at hand it becomes possible to adjust a piece of equipment for optimum performance quickly and surely, and to design circuits along established principles rather than depending on cut-and-try.

Measuring and test equipment is valuable during construction, for testing components before installation. It is practically indispensable in the initial adjustment of radio gear, not only for establishing operating values but also for tracing possible errors in wiring. It is likewise needed for locating breakdowns and defective components in existing equipment.

The basic measurements are those of current, voltage, and frequency. Determination of the values of circuit elements — resistance, inductance and capacitance — are almost equally important. The inspection of waveform in audio-frequency circuits is highly useful. For these purposes there is available a wide assortment of instruments, both complete and in kit form; the latter, particularly, compare very favorably in cost with strictly home-built instruments and are frequently more satisfactory both in appearance and calibration. The home-built instruments described in this chapter are ones having features of particular usefulness in amateur applications, and not ordinarily available commercially.

In using any instrument it should always be kept in mind that the accuracy depends not only on the inherent accuracy of the instrument itself (which, in the case of commercially built units is usually within a few per cent, and in any event should be specified by the manufacturer) but also the conditions under which the measurement is made. Large errors can be introduced by failing to recognize the existence of conditions that affect the instrument readings. This is particularly true in certain types of r.f. measurements, where stray effects are hard to eliminate.

Voltage, Current, and Resistance

D.C. MEASUREMENTS

A direct-current instrument — voltmeter, ammeter, milliammeter or microammeter — is a device using electromagnetic means to deflect a pointer over a calibrated scale in proportion to the current flowing. In the **D'Arsonval** type a coil of wire, to which the pointer is attached, is pivoted between the poles of a permanent magnet, and when current flows through the coil it causes a magnetic field that interacts with that of the magnet to cause the coil to turn. The design of the instrument is usually such as to make the pointer deflection directly proportional to the current.

A less expensive type of instrument is the **moving-vane** type, in which a pivoted soft-iron vane is pulled into a coil of wire by the magnetic field set up when current flows through the coil. The farther the vane extends into the coil the greater the magnetic pull on it, for a given change in current, so this type of instrument does not have "linear" deflection — that is, the scale is cramped at the low-current end and spread out at the high-current end.

The same basic instrument is used for measuring either current or voltage. Good-quality instruments are made with fairly high **sensitivity** — that is, they give full-scale pointer deflection with very small currents — when intended to be used as voltmeters. The sensitivity of instruments intended for measuring large currents can be lower, but a highly sensitive instrument can be, and frequently is, used for measurement of currents much greater than needed for full-scale deflection.

Panel-mounting instruments of the D'Arsonval type will give a smaller deflection when mounted on iron or steel panels than when mounted on nonmagnetic material. Readings may be as much as ten per cent low. Specially calibrated meters should be obtained for mounting on such panels.

VOLTMETERS

Only a fraction of a volt is required for full-scale deflection of a sensitive instrument (1 milliampere or less full scale) so for measuring voltage a high resistance is connected in series with it, Fig. 21-1. Knowing the current and the resistance, the voltage can easily be calculated from Ohm's Law. The meter is calibrated in terms of the voltage drop across the series resistor or **multiplier.** Practically any desired full-scale

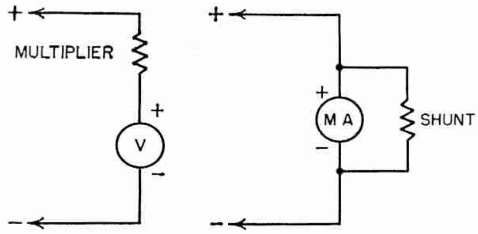


Fig. 21-1—How voltmeter multipliers and milliammeter shunts are connected to extend the range of a d.c. meter.

voltage range can be obtained by proper choice of multiplier resistance, and voltmeters frequently have several ranges selected by a switch.

The sensitivity of the voltmeter is usually expressed in "ohms per volt." A sensitivity of 1000 ohms per volt means that the resistance of the voltmeter is 1000 times the full-scale voltage, and by Ohm's Law the current required for full-scale deflection is 1 milliampere. A sensitivity of 20,000 ohms per volt, another commonly used value, means that the instrument is a 50-microampere meter. The higher the resistance of the voltmeter the more accurate the measurements

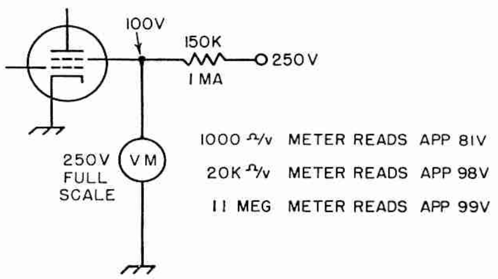


Fig. 21-2—Effect of voltmeter resistance on accuracy of readings. It is assumed that the d.c. resistance of the screen circuit is constant at 100 kilohms. The actual current and voltage without the voltmeter connected are 1 ma. and 100 volts. The voltmeter readings will differ because the different types of meters draw different amounts of current through the 150-kilohm resistor.

in high-resistance circuits. This is because the current flowing through the voltmeter will cause a change in the voltage between the points across which the meter is connected, compared with the voltage with the meter absent, as shown in Fig. 21-2.

Multipliers

The required multiplier resistance is found by dividing the desired full-scale voltage by the current, in amperes, required for full-scale deflection of the meter alone. Strictly, the internal resistance of the meter should be subtracted from the value so found, but this is seldom necessary (except perhaps for very low ranges) because the meter resistance will be negligibly small compared with the multiplier resistance. An exception is when the instrument is already provided with an internal multiplier, in which case the multiplier resistance required to extend the range is

$$R = R_m(n - 1)$$

where R is the multiplier resistance, R_m is the total resistance of the instrument itself, and n is the factor by which the scale is to be multiplied. For example, if a 1000-ohms-per-volt voltmeter having a calibrated range of 0–10 volts is to be extended to 1000 volts, R_m is $1000 \times 10 = 10{,}000$ ohms, n is $1000/10 = 100$, and $R = 10{,}000(100-1) = 990{,}000$ ohms.

If a milliammeter is to be used as a voltmeter, the value of series resistance can be found by Ohm's Law:

$$R = \frac{1000E}{I}$$

where E is the desired full-scale voltage and I the full-scale reading of the instrument in milliamperes.

Accuracy

The accuracy of a voltmeter depends on the calibration accuracy of the instrument itself and the accuracy of the multiplier resistors. Good-quality instruments are generally rated for an accuracy within plus or minus 2 per cent. This is also the usual accuracy rating of the basic meter movement.

When extending the range of a voltmeter or converting a low-range milliammeter into a voltmeter the rated accuracy of the instrument is retained only when the multiplier resistance is precise. Precision wire-wound resistors are used in the multipliers of high-quality instruments. These are relatively expensive, but the home constructor can do quite well with 1% tolerance composition resistors. They should be "derated" when used for this purpose — that is, the actual power dissipated in the resistor should not be more than ¼ to ½ the rated dissipation — and care should be used to avoid overheating the body of the resistor when soldering to the leads. These precautions will help prevent permanent change in the resistance of the unit.

Ordinary composition resistors are generally furnished in 10% or 5% tolerance ratings. If possible errors of this order can be accepted, resistors of this type may be used as multipliers. They should be operated below the rated power dissipation figure, in the interests of long-time stability.

MILLIAMMETERS AND AMMETERS

A microammeter or milliammeter can be used to measure currents larger than its full-scale reading by connecting a resistance **shunt** across its terminals as shown in Fig. 21-1. Part of the current flows through the shunt and part through the meter. Knowing the meter resistance and the shunt resistance, the relative currents can easily be calculated.

The value of shunt resistance required for a given full-scale current range is given by

$$R = \frac{R_m}{n - 1}$$

where R is the shunt, R_m is the internal resistance of the meter, and n is the factor by which the original meter scale is to be multiplied. The internal resistance of a milliammeter is preferably determined from the manufacturer's catalog, but if this information is not available it can be measured by the method shown in Fig. 21-3. Do not attempt to use an ohmmeter to measure the internal resistance of a milliammeter; the instrument may be ruined by doing so.

Homemade milliammeter shunts can be constructed from any of the various special kinds of resistance wire, or from ordinary copper wire if no resistance wire is available. The Copper Wire Table in this *Handbook* gives the resistance per 1000 feet for various sizes of copper wire. After computing the resistance required, determine the smallest wire size that will carry the full-scale current (250 circular mils per ampere is a satisfactory figure for this purpose).

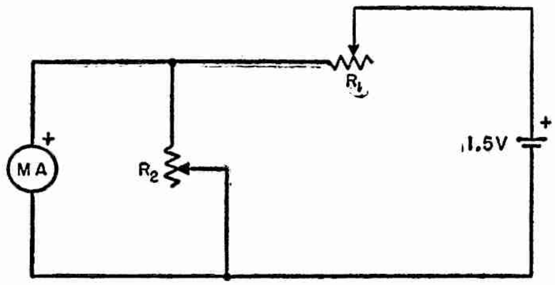


Fig. 21-3—Determining the internal resistance of a milliammeter or microammeter. R_1 is an adjustable resistor having a maximum value about twice that necessary for limiting the current to full scale with R_2 disconnected; adjust it for exactly full-scale reading. Then connect R_2 and adjust it for exactly half-scale reading. The resistance of R_2 is then equal to the internal resistance of the meter, and the resistor may be removed from the circuit and measured separately. Internal resistances vary from a few ohms to several hundred ohms, depending on the sensitivity of the instrument.

Measure off enough wire to provide the required resistance. Accuracy can be checked by causing enough current to flow through the meter to make it read full scale without the shunt; connecting the shunt should then give the correct reading on the new range.

Current Measurement with a Voltmeter

A current-measuring instrument should have very low resistance compared with the resistance of the circuit being measured; otherwise, inserting the instrument will cause the current to differ from its value with the instrument out of the circuit. (This may not matter if the instrument is left permanently in the circuit.) However, the resistance of many circuits in radio equipment is quite high and the circuit operation is affected little, if at all, by adding as much as a few hundred ohms in series. In such cases the voltmeter method of measuring current, shown in Fig. 21-4, is frequently convenient. A voltmeter — or low-range milliammeter provided with a multiplier and operating as a voltmeter — having a full-scale voltage range of a few volts, is used to measure the voltage drop across a comparatively high resistance acting as a shunt. The formula previously given is used for finding the proper value of shunt resistance for a given scale-multiplying factor, R_m in this case being the multiplier resistance.

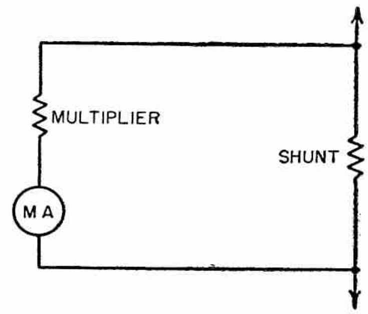


Fig. 21-4—Voltmeter method of measuring current. This method permits using relatively large values of resistance in the shunt, standard values of fixed resistors frequently being usable. If the multiplier resistance is 20 (or more) times the shunt resistance, the error in assuming that all the current flows through the shunt will not be of consequence in most practical applications.

D.C. Power

Power in direct-current circuits is determined by measuring the current and voltage. When these are known, the power is equal to the voltage in volts multiplied by the current in amperes. If the current is measured with a milliammeter, the reading of the instrument must be divided by 1000 to convert it to amperes.

RESISTANCE MEASUREMENTS

Measurement of d.c. resistance is based on measuring the current through the resistance when a known voltage is applied, then using Ohm's Law. A simple circuit is shown in Fig. 21-5.

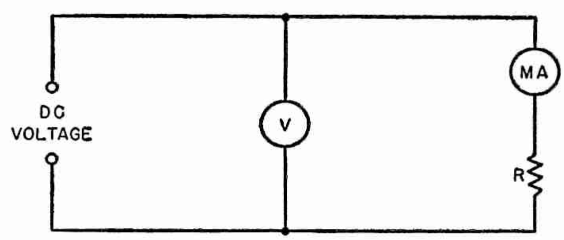


Fig. 21-5—Measuring resistance with a voltmeter and milliammeter. If the approximate resistance is known the voltage can be selected to cause the milliammeter, *MA*, to read about half scale. If not, additional resistance should be first connected in series with *R* to limit the current to a safe value for the milliammeter. The set-up then measures the total resistance, and the value of *R* can be found by subtracting the known additional resistance from the total.

The internal resistance of the ammeter or milliammeter, *MA*, should be low compared with the resistance, *R*, being measured, since the voltage read by the voltmeter, *V*, is the voltage across *MA* and *R* in series. The instruments and the d.c. voltage should be chosen so that the readings are in the upper half of the scale, if possible, since the percentage error is less in this region.

An **ohmmeter** is an instrument consisting fundamentally of a voltmeter (or milliammeter, depending on the circuit used) and a small dry battery as a source of d.c. voltage, calibrated so the value of an unknown resistance can be read directly from the scale. Typical ohmmeter circuits are shown in Fig. 21-6. In the simplest type, shown in Fig. 21-6A, the meter and battery are connected in series with the unknown resistance. If a given deflection is obtained with terminals *A-B* shorted, inserting the resistance to be measured will cause the meter reading to decrease. When the resistance of the voltmeter is known, the following formula can be applied:

$$R = \frac{eR_m}{E} - R_m$$

where R is the resistance under measurement,

e is the voltage applied (*A-B* shorted),

E is the voltmeter reading with R connected, and

R_m is the resistance of the voltmeter.

The circuit of Fig. 21-6A is not suited to measuring low values of resistance (below a hundred ohms or so) with a high-resistance voltmeter. For such measurements the circuit of Fig. 21-6B can be used. The milliammeter should be a 0–1 ma. instrument, and R_1 should be equal to the battery voltage, e, multiplied by 1000. The unknown resistance is

$$R = \frac{I_2 R_m}{I_1 - I_2}$$

where R is the unknown,

R_m is the internal resistance of the milliammeter,

I_1 is the current in ma. with R disconnected from terminals *A-B*, and

I_2 is the current in ma. with R connected.

The formula is approximate, but the error will be negligible if e is at least 3 volts so that R_1 is at least 3000 ohms.

A third circuit for measuring resistance is shown in Fig. 21-6C. In this case a high-resistance voltmeter is used to measure the voltage drop across a reference resistor, R_2, when the unknown resistor is connected so that current flows through it, R_2 and the battery in series. By suitable choice of R_2 (low values for low resistance, high values for high-resistance unknowns) this circuit will give equally good results on all resistance values in the range from one ohm to several megohms, provided that the voltmeter resistance, R_m, is always very high (50 times or more) compared with the resistance of R_2. A 20,000-ohms-per-volt instrument (50-μamp. movement) is generally used. Assuming that the current through the voltmeter is negligible compared with the current through R_2, the formula for the unknown is

$$R = \frac{eR_2}{E} - R_2$$

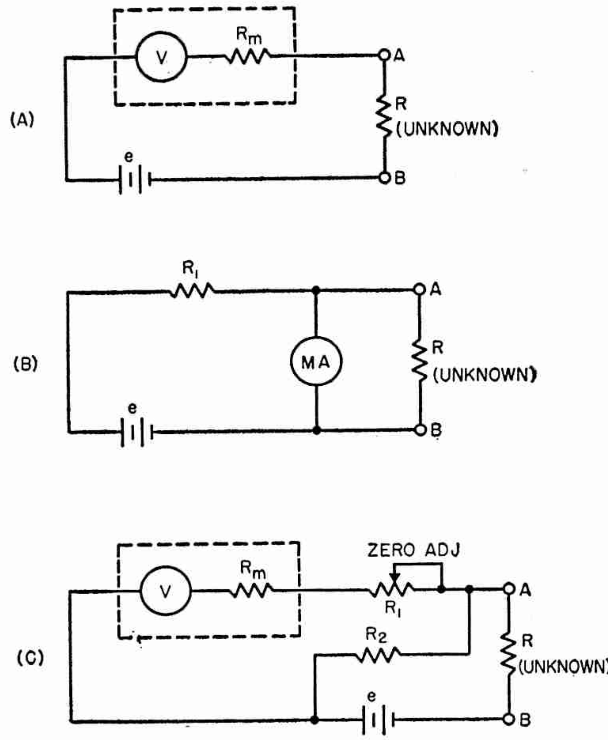


Fig. 21-6—Ohmmeter circuits. Values are discussed in the text.

where R and R_2 are as shown in Fig. 21-6C,

e is the voltmeter reading with *A-B* shorted, and

E is the voltmeter reading with R connected.

The "zero adjuster," R_1, is used to set the voltmeter reading exactly to full scale when the meter is calibrated in ohms. A 10,000-ohm variable resistor is suitable with a 20,000-ohms-per-volt meter. The battery voltage is usually 3 volts for ranges up to 100,000 ohms or so and 6 volts for higher ranges.

A. C. Measurements

Several types of instruments are available for measurement of low-frequency alternating currents and voltages. The better-grade panel instruments for power-line frequencies are of the **dynamometer** type. This compares with the D'Arsonval movement used for d.c. measurements, but instead of a permanent magnet the dynamometer movement has a field coil which, together with the moving coil, is connected to the a.c. source. Thus the moving coil is urged to turn in the same direction on both halves of the a.c. cycle.

Moving-vane type instruments, described earlier, also are used for a.c. measurements. This is possible because the pull exerted on the vane is in the same direction regardless of the direction of current through the coil. The calibration of a moving-vane instrument on a.c. will, in general, differ from its d.c. calibration.

For measurements in the audio-frequency range, and in applications where high impedance is required, the **rectifier-type** a.c. instrument is generally used. This is essentially a sensitive d.c. meter, of the type previously described, provided with a rectifier for converting the a.c. to d.c. A typical rectifier-type voltmeter circuit is shown in Fig. 21-7. The half-wave meter rectifier, CR_1, is frequently of the copper-oxide type, but crystal diodes can be used. Such a rectifier is not "perfect" — that is, the application of a voltage of reversed polarity will result in a small current flow — and so CR_2 is used for eliminating the effect of reverse current in the meter circuit. It does this by providing a low-resistance path across CR_1 and the meter during the a.c. alternations when CR_1 is not conducting.

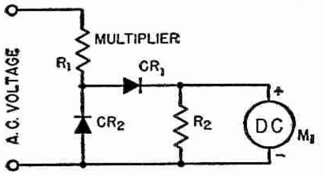


Fig. 21-7—Rectifier-type a.c. voltmeter circuit, with "linearizing" resistor and diode for back-current correction.

Resistor R_2 shunted across M_1 is used for improving the linearity of the circuit. The effective resistance of the rectifier decreases with increasing current, leading to a calibration scale with nonuniform divisions. This is overcome to a considerable extent by "bleeding" several times as much current through R_2 as flows through M_1 so the rectifier is always carrying a fairly large current.

Because of these expedients and the fact that with half-wave rectification the average current is only 0.45 times the r.m.s. value of a sine wave producing it, the impedance of a rectifier-type voltmeter is rather low compared with the resistance of a d.c. voltmeter using the same meter. Values of 1000 ohms per volt are representative, when the d.c. instrument is a 0–200 microammeter.

The d.c. instrument responds to the average value of the rectified alternating current. This average current will vary with the shape of the a.c. wave applied to the rectifier, and so the meter reading will not be the same for different wave forms having the same maximum values or the same r.m.s. values. Hence a "wave-form error" is always present unless the a.c. wave is very closely sinusoidal. The actual calibration of the instrument usually is in terms of the r.m.s. value of a sine wave.

Modern rectifier-type a.c. voltmeters are capable of good accuracy, within the wave-form limitations mentioned above, throughout the audio-frequency range.

COMBINATION INSTRUMENTS — THE V.O.M.

Since the same basic instrument is used for measuring current, voltage and resistance, the three functions can readily be combined in one unit using a single meter. Various models of the "v.o.m." (volt-ohm-milliammeter) are available commercially, both completely assembled and in kit form. The less expensive ones use a 0-1 milliammeter as the basic instrument, providing voltmeter ranges at 1000 ohms per volt. The more elaborate meters of this type use a microammeter — 0-50 microamperes, frequently — with voltmeter resistances of 20,000 ohms per volt. With the more sensitive instruments it is possible to make resistance measurements in the megohms range. A.c. voltmeter scales also are frequently included.

The v.o.m., even a very simple one, is among the most useful instruments for the amateur. Besides current and voltage measurements, it can be used for checking continuity in circuits, for finding defective components before installation — shorted capacitors, open or otherwise defective resistors, etc. — shorts or opens in wiring, and many other checks that, if applied during the construction of a piece of equipment, save much time and trouble. It is equally useful for servicing, when a component fails during operation.

THE VACUUM-TUBE VOLTMETER

The usefulness of the **vacuum-tube voltmeter (v.t.v.m.)** is based on the fact that a vacuum tube can amplify without taking power from the source of voltage applied to its grid. It is therefore possible to have a voltmeter of extremely high resist-

C_1, C_3—0.002- to 0.005-μf. mica.
C_2—0.01 μf., 1000 to 2000 volts, paper or mica.
R_1—1 megohm, ½ watt.
R_2 to R_5, inc.—To give desired voltage ranges, totaling 10 megohms.
R_6, R_7—2 to 3 megohms.
R_8—10,000-ohm variable.
R_9, R_{10}—2000 to 3000 ohms.
R_{11}—5000- to 10,000-ohm control.
R_{12}—10,000 to 50,000 ohms.
R_{13}, R_{14}—App. 25,000 ohms. A 50,000-ohm slider-type wire-wound can be used.
R_{15}—10 megohms.
R_{16}—3 megohms.
R_{17}—10-megohm variable.
M—0-200 μamp. to 0-1 ma. range.
V_1—Dual triode, 6SN7 or 12AU7.
V_2—Dual diode, 6H6 or 6AL5.

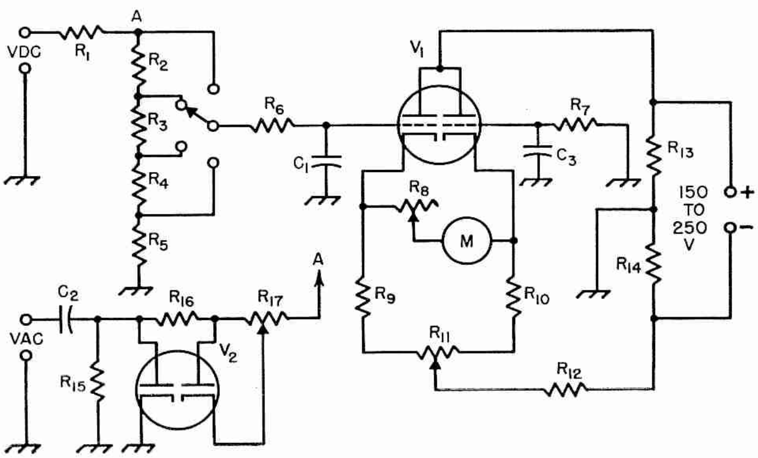


Fig. 21-8—Vacuum-tube voltmeter circuit.

ance, and thus take negligible current from the circuit under measurement, without using a d.c. instrument of exceptional sensitivity.

The v.t.v.m. has the disadvantage that it requires a source of power for its operation, as compared with a regular d.c. instrument. Also, it is susceptible to r.f. pick-up when working around an operating transmitter, unless well shielded and filtered. The fact that one of its terminals is grounded is also disadvantageous in some cases, since a.c. readings in particular may be inaccurate if an attempt is made to measure a circuit having both sides "hot" with respect to ground. Nevertheless, the high resistance of the v.t.v.m. more than compensates for these disadvantages, especially since in the majority of measurements they do not apply.

While there are several possible circuits, the one commonly used is shown in Fig. 21-8. A dual triode, V_1, is arranged so that, with no voltage applied to the left-hand grid, equal currents flow through both sections. Under this condition the two cathodes are at the same potential and no current flows through M. The currents can be adjusted to balance by potentiometer R_{11}, which takes care of variations in the tube sections and in the values of cathode resistors R_9 and R_{10}. When a positive d.c. voltage is applied to the left-hand grid the current through that tube section increases, so the current balance is upset and the meter indicates. The sensitivity of the meter is regulated by R_8, which serves to adjust the calibration. R_{12}, common to the cathodes of both tube sections, is a feed back resistor that stabilizes the system and makes the readings linear. R_6 and C_1 form a filter for any a.c. component that may be present, and R_6 is balanced by R_7 connected to the grid of the second tube section.

To stay well within the linear range of operation the scale is limited to 3 volts or less in the average commercial instrument. Higher ranges are obtained by means of the voltage divider formed by R_1 to R_5, inclusive. As many ranges as desired can be used. Common practice is to use 1 megohm at R_1, and to make the sum of R_2 to R_5, inclusive, 10 megohms, thus giving a total resistance of 11 megohms, constant for all voltage ranges. R_1 should be at the probe end of the d.c. lead to minimize capacitive loading effects when measuring d.c. voltages in r.f. circuits.

Values to be used in the circuit depend considerably on the supply voltage and the sensitivity of the meter, M. R_{12}, and R_{13}–R_{14}, should be adjusted by trial so that the voltmeter circuit can be brought to balance, and to give full-scale deflection on M with about 3 volts applied to the left-hand grid. The meter connections can be reversed to read voltages that are negative with respect to ground.

A.C. Voltage

For measuring a.c. voltages the rectifier circuit shown at the lower left of Fig. 21-8 is used. One section of the double diode, V_2, is a half-wave rectifier and the second half acts as a balancing device, adjustable by R_{17}, to eliminate contact potential effects that would cause a residual d.c. voltage to appear at the v.t.v.m. grid.

The rectifier output voltage is proportional to the peak amplitude of the a.c. wave, rather than to the average or r.m.s. values. Since the positive and negative peaks of a complex wave may not have equal amplitudes, a different reading may be obtained on such wave forms when the voltmeter probe terminals are reversed. This "turnover" effect is inherent in any peak-indicating device, but is not necessarily a disadvantage. The fact that the readings are not the same when the voltmeter connections are reversed is an indication that the wave form under measurement is unsymmetrical. In some measurements, as in audio amplifiers, a peak measurement is more useful than an r.m.s. or average-value measurement because amplifier capabilities are based on the peak amplitudes.

The scale calibration usually is based on the r.m.s. value of a sine wave, R_8 being set so that the same scale can be used either for a.c. or d.c. The r.m.s. reading can easily be converted to a peak reading by multiplying by 1.41.

INSTRUMENT CALIBRATION

When extending the range of a d.c. instrument, calibration usually is necessary—although resistors for voltmeter multipliers often can be purchased to close-enough tolerances so that the new range will be accurately known. However, in calibrating an instrument such as a v.t.v.m. a known voltage must be available to provide a starting point. Fresh dry cells have an open-circuit terminal voltage of approximately 1.6 volts, and one or more of them may be connected in series to provide several calibration points on the low range. Gas regulator tubes in a power supply, such as the 0C3, 0D3, etc., also provide a stable source of voltage whose value is known within a few per cent. Once a few such points are determined the voltmeter ranges may be extended readily by adding multipliers or a voltage divider as appropriate.

Shunts for a milliammeter may be adjusted by first using the meter alone in series with a source of voltage and a resistor selected to limit the current to full scale. For example, a 0-1 milliammeter may be connected in series with a dry cell and a 2000-ohm variable resistor, the latter being adjusted to allow exactly 1 milliampere to flow. Then the shunt is added across the meter and its resistance adjusted to reduce the meter reading by exactly the scale factor, n. If n is 5, the shunt would be adjusted to make the meter read 0.2 milliampere, so the full-scale current will be 5 ma. Using the new scale, the second shunt is added to give the next range, the same procedure being followed. This can be carried on for several ranges, but it is advisable to check the meter on the highest range against a separate meter used as a standard, since the errors in this process tend to be cumulative.

Measurement of Frequency

ABSORPTION FREQUENCY METERS

The simplest possible frequency-measuring device is a resonant circuit, tunable over the desired frequency range and having its tuning dial calibrated in terms of frequency. It operates by extracting a small amount of energy from the oscillating circuit to be measured, the frequency being determined by the tuning setting at which the energy absorption is maximum (Fig. 21-9).

Such an instrument is not capable of very high

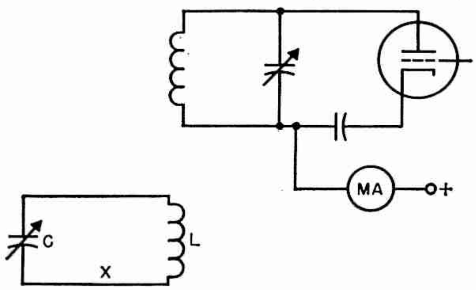


Fig. 21-9—Absorption frequency meter and a typical application. The meter consists simply of a calibrated resonant circuit *LC*. When coupled to an amplifier or oscillator the tube plate current will rise when the frequency meter is tuned to resonance. A flashlight lamp may be connected in series at *X* to give a visual indication, but it decreases the selectivity of the instrument and makes it necessary to use rather close coupling to the circuit being measured.

accuracy, because the Q of the tuned circuit cannot be high enough to avoid uncertainty as to the exact dial setting and because any two coupled circuits interact to some extent and change each others' tuning. Nevertheless, the **absorption frequency meter** or "wavemeter" is a highly useful instrument. It is compact, inexpensive, and requires no power supply. There is no ambiguity in its indications, as is frequently the case with the heterodyne-type instruments described later.

When an absorption meter is used for checking a transmitter, the plate current of the tube connected to the circuit being checked can provide the necessary resonance indication. When the frequency meter is loosely coupled to the tank circuit the plate current will give a slight upward flicker as the meter is tuned through resonance. The accuracy is greatest when the loosest possible coupling is used.

A receiver oscillator may be checked by tuning in a steady signal and heterodyning it to give a beat note as in ordinary c.w. reception. When the frequency meter is coupled to the oscillator coil and tuned through resonance the beat note will change. Again, the coupling should be made loose enough so that a just-perceptible change in beat note is observed.

An approximate calibration for the meter, adequate for most purposes, may be obtained by comparison with a calibrated receiver. The usual receiver dial calibration is sufficiently accurate. A simple oscillator circuit covering the same range as the frequency meter will be useful in calibration. Set the receiver to a given frequency, tune the oscillator to zero beat at the same frequency, and adjust the frequency meter to resonance with the oscillator as described above. This gives one calibration point. When a sufficient number of such points has been obtained a graph may be drawn to show frequency *vs.* dial settings on the frequency meter.

INDICATING FREQUENCY METERS

The plain absorption meter requires fairly close coupling to the oscillating circuit in order to affect the plate current of a tube sufficiently to give a visual indication. However, by adding a rectifier and d.c. microammeter or milliammeter, the sensitivity of the instrument can be increased to the point where very loose coupling will suffice for a good reading. A typical circuit for this purpose is given in Fig. 21-10, and Figs. 21-11 and 21-12 show how such an instrument can be constructed.

The rectifier, a crystal diode, is coupled to the tuned circuit L_1C_1 through a coupling coil, L_2, having a relatively small number of turns. The step-down transformer action from L_1 to L_2 provides for efficient energy transfer from the high-impedance tuned circuit to the low-impedance rectifier circuit. The number of turns on L_2 can be adjusted for maximum reading on the d.c.

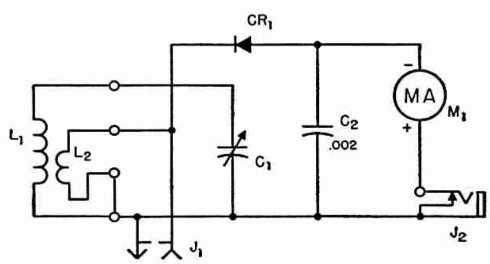


Fig. 21-10—Circuit diagram of indicating frequency meter.

C_1—50-$\mu\mu$f. variable (Johnson 50R12).
C_2—0.002-μf. disk ceramic.
CR_1—General purpose germanium diode (1N34, etc.)
J_1—Phono jack.
J_2—Closed-circuit phone jack.
M_1—D.c. microammeter or 0-1 milliammeter.

	Coil Data		Coil
Freq. Range	*Turns, L_1*	*Turns, L_2*	*Length, In.*
3-6 Mc.	60	5	close-wound
6-12 Mc.	29	5	1¼
12-25 Mc.	13	2	1
23-50 Mc.	5¼	1	½
50-100 Mc.	1½	½	¼
90-225 Mc.	See below		

All except 90–225-Mc. coil wound with No. 24 enam. wire on 1-inch diameter 4-prong forms (Millen 45004). L_2 interwound at bottom of L_1, using smaller wire where necessary. The 90–225-Mc. coil consists of a hairpin loop of No. 14 tinned wire just clearing the bottom of the coil form, which is cut to ⅝-inch length. L_2 is a similar hairpin of No. 16 wire bent over so it almost touches L_1.

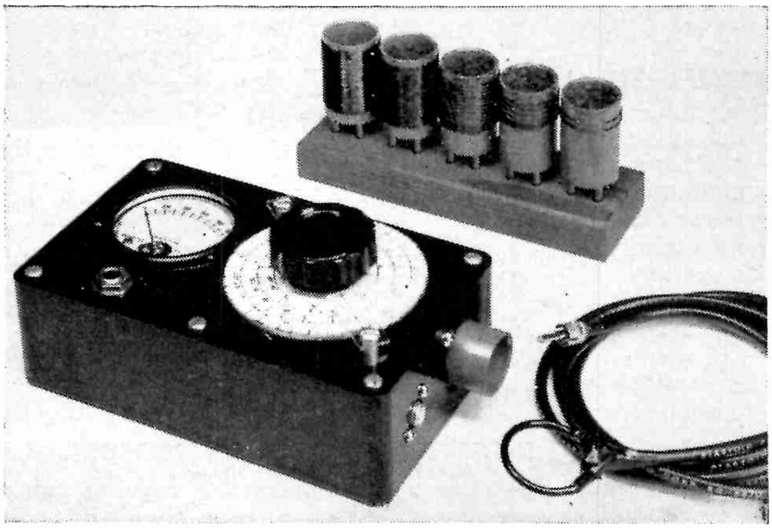


Fig. 21-11—The indicating frequency meter, plug-in coils, and pick-up cables. The meter is built in a bakelite meter case measuring 6¼ × 3¾ × 2 inches. The 3-inch dial is cut from a piece of aluminum and has a paper hand-calibrated scale cemented on. Hairline indicators are clear plastic mounted on small metal pillars. A 2-inch d.c. instrument is used. Pick-up loops are one turn of No. 14, spaghetti covered, soldered to the ends of the cables. The longer cable (5 feet) is useful to 30 Mc.; the shorter (13 inches) can be used for the full frequency range. Both are RG-58/U.

milliammeter; when doing this, use a fixed value of coupling between L_1 and the source of energy. The proper number of turns for this purpose will depend on the sensitivity of M_1. The coil dimensions given in Fig. 21-10 are for a 0-500 microammeter but will also be satisfactory for a 0-1 milliammeter. Less than optimum coupling is preferable, in most cases, since heavy loading lowers the Q of the tuned circuit L_1C_1 and makes it less selective. The coupling is reduced by reducing the number of turns on L_2.

The meter can be used with a pick-up loop and coaxial line connected to J_1. Energy picked up by the loop is fed through the cable to L_2 and thence coupled to L_1C_1. This is a convenient method of coupling to circuits where it would be physically difficult to secure inductive coupling to L_1. The pick-up cable should not be self-resonant, as a transmission-line section, at any frequency within the range in which it is to be used, so two cable lengths are provided. The longer one is useful up to 30 Mc. and the shorter at all frequencies up to the maximum useful frequency of the instrument (225 Mc.).

By plugging a headset into the output jack (phones having 2000 ohms or greater resistance should be used for greatest sensitivity) the frequency meter can be used as a monitor for modulated transmissions.

The bakelite case is a desirable feature since the instrument can be brought close to circuits being checked without the danger of short-circuiting any of their wiring. This could occur with a metal-cased unit.

In addition to the uses mentioned earlier, a meter of this type may be used for final adjustment of neutralization in r.f. amplifiers. For this purpose the pick-up loop may be loosely coupled to the plate tank coil. In this case L_1 may be removed from its socket and the meter used as an untuned rectifier. This reduces the sensitivity and insures that the r.f. pickup is only from the tank coil to which the loop is closely coupled.

THE SECONDARY FREQUENCY STANDARD

The **secondary frequency standard** is a highly stable low-power oscillator generating a fixed frequency, usually 100 kc. It is nearly always crystal-controlled, and inexpensive 100-kc. crystals are available for the purpose. Since the harmonics are multiples of 100 kc. throughout the spectrum, some of them can be compared di-

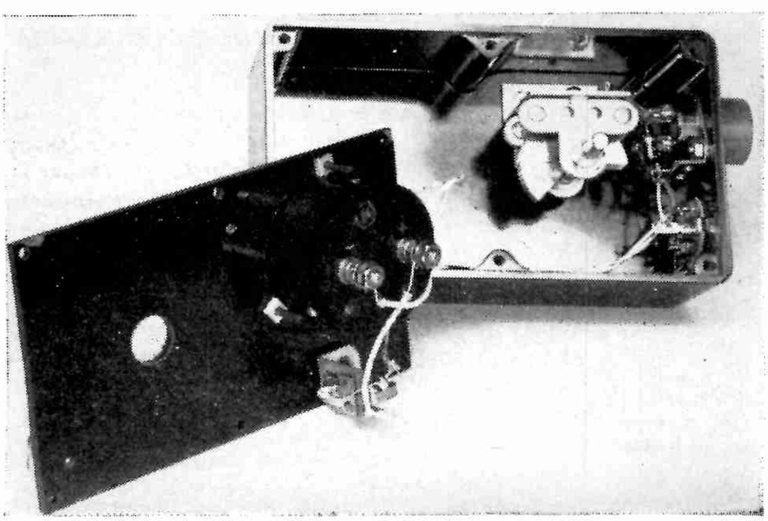


Fig. 21-12—Inside the wavemeter. Only the milliammeter and phone jack are mounted on the removable panel. The tuning capacitor is mounted vertically on an aluminum bracket fastened to the bottom of the case. The crystal diode is mounted between a coil-socket prong and a tie point. The phono jack for the pick-up cables is at the lower right.

rectly with the standard frequencies transmitted by WWV.

The edges of most amateur bands also are exact multiples of 100 kc., so it becomes possible to determine the band edges very accurately. This is an important consideration in amateur frequency measurement, since the only regulatory requirement is that an amateur transmission be inside the assigned band, not on a specific frequency.

Manufacturers of 100-kc. crystals usually supply circuit information for their particular crystals. The circuit given in Fig. 21-13 is representative, and will generate usable harmonics up to 30 Mc. or so. The variable capacitor, C_1, provides a means for adjusting the frequency to exactly 100 kc. Harmonic output is taken from the circuit through a small capacitor, C_5. There are no special constructional points to be observed in building such a unit.

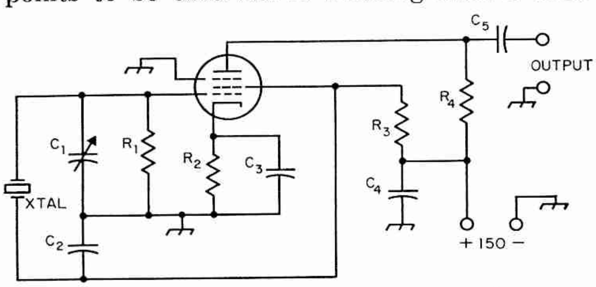


Fig. 21-13—Circuit for crystal-controlled frequency standard. Tubes such as the 6SK7, 6SH7, 6AU6, etc., are suitable.

C_1—50-μμf. variable.
C_2—150-μμf. mica.
C_3, C_4—0.01-μf. ceramic.
C_5—22-μμf. mica.
R_1—0.47 megohm, ½ watt.
R_2—1000 ohms, ½ watt.
R_3—0.1 megohm, ½ watt.
R_4—0.15 megohm, ½ watt.

Power for the tube heater and plate may be taken from the supply in the receiver with which the unit is to be used. The plate voltage is not critical, but it is recommended that it be taken from a VR-150 regulator if the receiver is equipped with one.

Sufficient signal strength from the standard usually will be secured if a wire is run between the output terminal connected to C_5 and the antenna post on the receiver. At the lower frequencies a metallic connection may not be necessary.

Adjusting to Frequency

The frequency can be adjusted exactly to 100 kc. by making use of the WWV transmissions tabulated later in this chapter. Select the WWV frequency that gives a good signal at your location at the time of day most convenient. Tune it in with the receiver b.f.o. off and wait for the period during which the modulation is absent. Then switch on the 100-kc. oscillator and adjust its frequency, by means of C_1, until its harmonic is in zero beat with WWV. The exact setting is easily found by observing the slow pulsation in background noise as the harmonic comes close to zero beat, and adjusting to where the pulsation disappears or occurs at a very slow rate. The pulsation can be observed even more readily by switching on the receiver's b.f.o., after approximate zero beat has been secured, and observing the rise and fall in intensity (not frequency) of the beat tone. For best results the WWV signal and the signal from the 100-kc. oscillator should be about the same strength. It is advisable not to try to set the 100-kc. oscillator during the periods when the WWV signal is tone-modulated, since it is difficult to tell whether the harmonic is being adjusted to zero beat with the carrier or with a sideband.

Using the Standard

Basically, the 100-kc. standard provides a means for indicating the exact receiver dial settings at which frequencies that are multiples of 100 kc. are to be found. The harmonics of the standard can thus be used to check the dial calibration of a receiver, and many of the better-grade communications receivers either include a 100-kc. oscillator for this purpose or have provision for installing one as an accessory. The actual frequency of at least one 100-kc. point in a given amateur band must be known, of course, but this is generally an easy matter since the activity in amateur bands usually makes identification of the band-edge "marker signal" quite simple. After one frequency is known, the consecutive 100-kc. harmonic signals are simply counted off from it.

Although the 100-kc. standard does not make possible the exact measurement of a frequency, it is readily possible to determine whether or not the signal is in a particular 100-kc. segment. If the unknown signal tunes in between, say, 21,200 and 21,300 kc., as indicated by the marker signals in the receiver, its frequency obviously lies between those two figures. For purposes of complying with the amateur regulations it is usually sufficient to know that the signal is above, or below, some specified 100-kc. point, since the edges of the amateur bands or sub-bands usually are at such points. If a close measurement is desired a fairly good estimate usually can be made by counting the number of dial divisions between two 100-kc. points and dividing the number into 100 to find how many kilocycles there are per dial division.

In using the receiver to check one's own transmitting frequency it is necessary to take special precautions to reduce the strength of the signal from the transmitter to the point where it does not overload the receiver nor create spurious responses that could be taken for the actual signal. This invariably means that the receiving antenna must be disconnected from the receiver, and it may be necessary, in addition, to short-circuit the receiver's antenna input terminals. Try to reduce stray pickup to such an extent that the transmitter's signal is no stronger than normal incoming signals at the regular gain-control settings. With some receivers this may

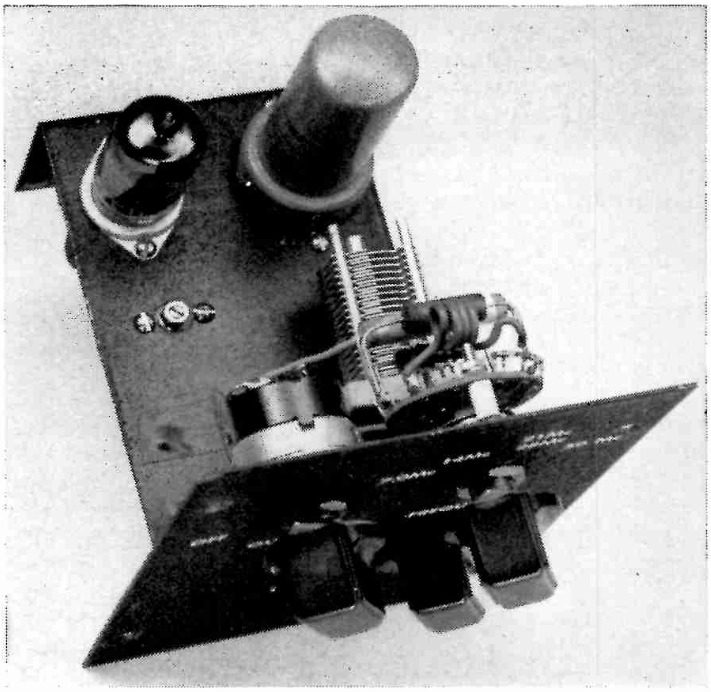


Fig. 21-14—A 100-kc. frequency standard and harmonic amplifier. The crystal in this unit is in the metal-tube type envelope. Power and r.f. output connections are taken through the rear chassis lip.

require additional shielding around the signal-frequency circuits, and perhaps filtering of the a.c. and speaker leads where they leave the chassis, to prevent energy picked up on these leads from getting into the front end of the receiver.

Frequency Standard with Harmonic Amplifier

The frequency standard shown in Figs. 21-14 through 21-16 includes a tuned amplifier to increase the strength of the higher harmonics, and incorporates a crystal-diode sawtooth generator to make the harmonic strength reasonably uniform throughout the usable frequency spectrum of the instrument. It will produce useful calibration signals at 100-kc. intervals up to about 60 Mc. The strength of a particular harmonic may be peaked up by selecting the proper amplifier tuning range with S_2 and adjusting C_4 for maximum output. A gain control, R_2, is included for adjusting the output signal to the desired level.

The 100-kc. oscillator uses the triode section of a 6AN8, while the amplifier uses the pentode section of the same tube. Power required for the unit is 150 volts at 10 ma. and 6.3 volts at 0.45 amp. This may be taken from the accessory socket of a receiver, or a special supply easily can be made using a TV "booster" transformer (such as the Merit P-3046 or equivalent).

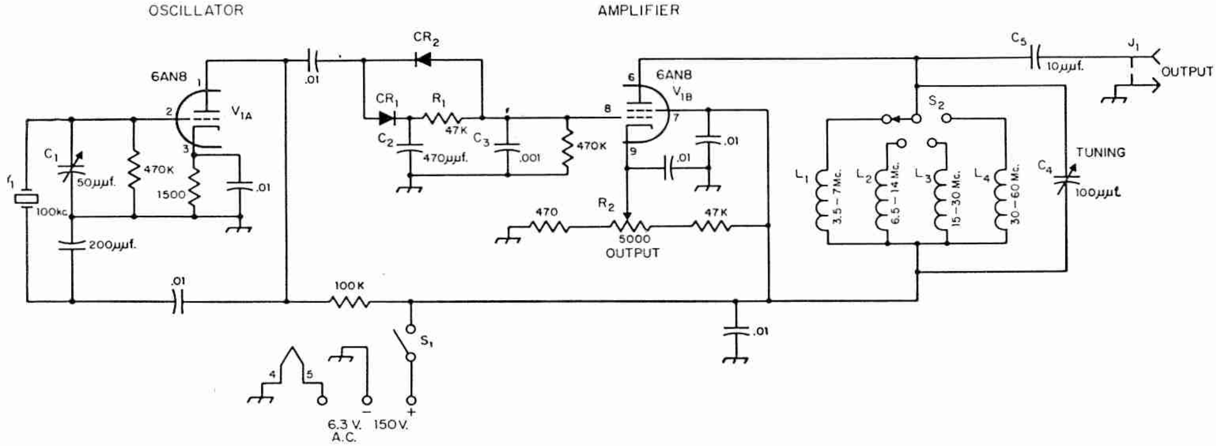


Fig. 21-15—Circuit of the 100-kc. crystal calibrator. Unless otherwise indicated, capacitances are in µf., resistances are in ohms, resistors are ½ watt.

C_1—50-µµf. midget variable (Hammarlund MAPC-50).
C_4—100-µµf. variable (Hammarlund HF-100).
CR_1, CR_2—1N34A.
J_1—Phono jack.
L_1—3.5-7 Mc., 10 µh. (National R-33 r.f. choke).
L_2—6.5-14 Mc., 4.7 µh. (IRC type CL-1 r.f. choke).
L_3—15-30 Mc., 1.0 µh. (IRC type CL-1 r.f. choke).
L_4—30-60 Mc., 0.22 µh.; 4 turns No. 20 plastic-insulated wire, ⅜-inch diam.
R_2—5000-ohm potentiometer (Mallory U-14).
S_1—S.p.s.t., mounted on R_2 (Mallory US-26).
S_2—1-section, 1-pole, 4-position miniature phenolic rotary switch (Centralab PA-1000).
Y_1—100-kc. crystal.

The standard is built in a 4 × 5 × 6 inch chassis-type box. R_2 and S_2 are mounted on the panel, with the amplifier plate coils mounted on S_2. The remaining components are mounted on the chassis, C_4 being insulated from it because its plates are above ground for d.c. For the same reason, an insulated shaft extension is used for front-panel control of C_4.

Connection between the standard and the receiver can be made through a wire from the hot terminal of J_1 to the antenna input post on the receiver. Depending on how well the receiver is shielded, such a wire may not be needed at the lower-frequency end of the range.

The Heterodyne Frequency Meter

The heterodyne frequency meter is a variable-frequency oscillator designed to be as stable as possible and to be capable of being accurately calibrated. Solid mechanical construction and a good dial are particularly important. In general, the design of such an instrument will be similar to that of the v.f.o.'s described in Chapter 6 on transmitters. Usually, the oscillator will cover a frequency range of approximately 1750 to 2000 kc. so that its harmonics will fall in the various amateur bands. It is used with the receiver in much the same way as the 100-kc. standard, except that in making a measurement the frequency-meter tuning is adjusted until the signal from it is in zero beat with the signal to be measured. The two signals are then on exactly the same frequency, which can be read from the calibration of the frequency meter.

The best method of calibrating a heterodyne frequency meter is to note the dial points at which its signal is in zero beat with consecutive 100-kc. points from a secondary standard. These points may then be plotted on graph paper and a smooth curve drawn through them to give the calibration at frequencies inside the 100-kc. intervals. The calibration preferably should be made on a high range. Points at 100-kc. intervals on 28 Mc., for example, are equivalent to 50-kc. intervals on 14 Mc., 25-kc. intervals on 7 Mc., and so on, since the meter is operating on lower-order harmonics on the lower bands.

More Precise Methods

The methods described above are quite adequate for the primary purpose of amateur frequency measurements — that is, determining whether or not a transmitter is operating inside the limits of an amateur band, and the approximate frequency inside the band. For measurement of an unknown frequency to a high degree of accuracy more advanced methods can be used. Accurate signals at closer intervals can be obtained by using a multivibrator in conjunction with the 100-kc. standard, and thus obtaining signals at intervals of, say, 10 kc. or some other integral divisor of 100. Temperature control is frequently used on the 100-kc. oscillator to give a high order of stability (Collier, "What Price Precision?", *QST*, September and October, 1952). Also, the secondary standard can be used in conjunction with a variable-frequency interpolation oscillator to fill in the standard intervals (Woodward, "A Linear Beat-Frequency Oscillator for Frequency Measurement," *QST*, May, 1951). An interpolation oscillator and standard can be combined in one instrument. One application of this type was described in *QST* for May, 1949 (Grammer, "The Additive Frequency Meter").

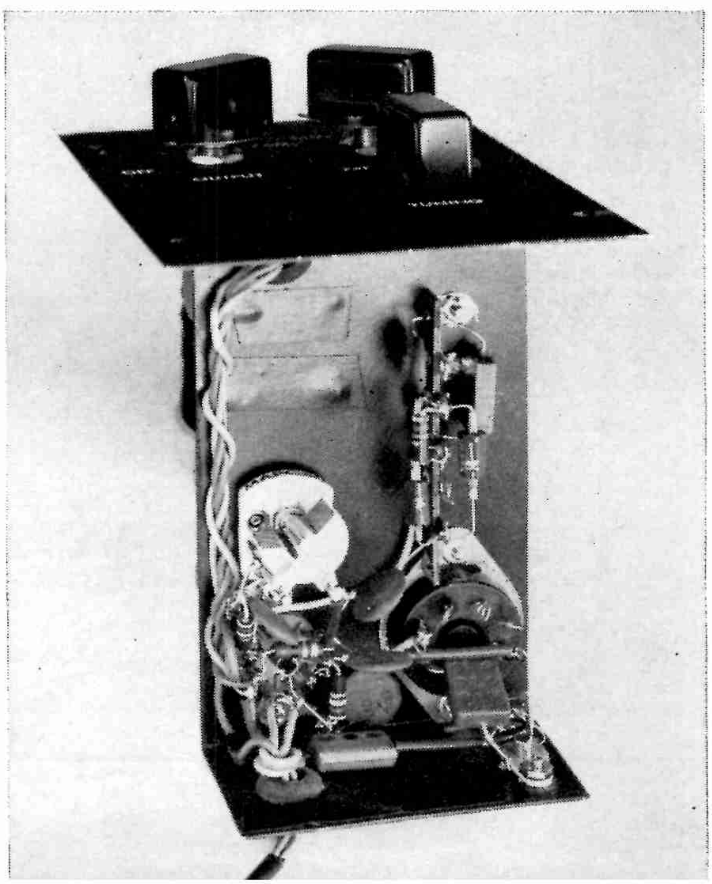
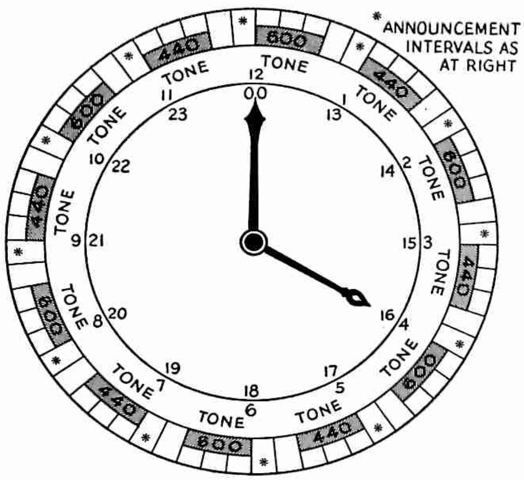
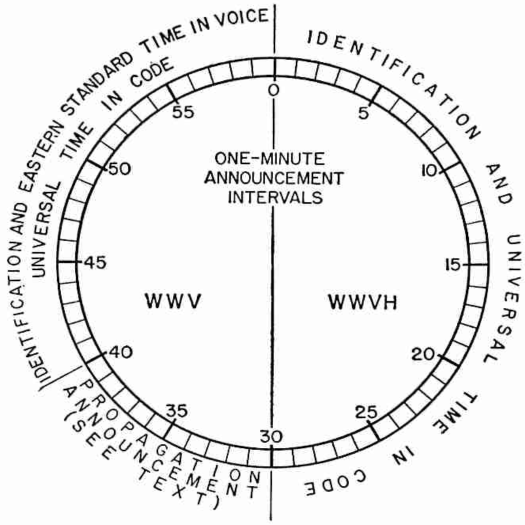


Fig. 21-16—Underneath the frequency-standard chassis. The saw-tooth harmonic-generating network is on the strip at the upper right. The small trimmer-type capacitor at the left is C_1. Other components are mounted where convenient.

STANDARD FREQUENCIES AND TIME SIGNALS





The Central Radio Propagation Laboratory of the National Bureau of Standards maintains two radio transmitting stations, WWV near Washington, D.C., and WWVH at Puunene, T.H., for broadcasting standard radio frequencies of high accuracy. WWV broadcasts are on 2.5, 5, 10, 15, 20 and 25 megacycles per second, and those from WWVH are on 5, 10, and 15 Mc. The radio-frequency signals are modulated by pulses at 1 cycle per second, and also by standard audio frequencies alternating between 440 and 600 cycles per second as shown by the accompanying chart.

Transmissions are continuous, with the following exceptions: The WWV transmissions are interrupted for a 4-minute period beginning at approximately 45 minutes after the hour; the WWVH transmissions are interrupted for a 3-minute period beginning approximately 10 seconds after the hour and each 15 minute interval thereafter. WWVH is also silent each day for a 34-minute period beginning at 1900 Universal Time.

Accuracy

Transmitted frequencies are accurate within 1 part in 100 million. The WWV transmissions are generally stable to 1 part in a billion in any given day, although this is not guaranteed. Frequencies are based on an atomic standard, and daily corrections to the transmitted frequencies are subsequently published each month in the *Proceedings of the Institute of Radio Engineers*.

Time Signals

The 1-c.p.s. modulation is a 5-millisecond pulse at intervals of precisely one second, and is heard as a tick. The pulse transmitted by WWV consists of 5 cycles of 1000 cycle tone; that transmitted by WWVH consists of 6 cycles of 1200-cycle tone. On the WWV transmissions, the 440- or 600-cycle tone is blanked out beginning 10 milliseconds before and ending 25 milliseconds after the pulse. On the WWVH transmissions, the pulse is superimposed on the tone. The pulse on the 59th second is omitted, and for additional identification the zero-second pulse is followed by another 100 milliseconds later.

Propagation Notices

During the announcement intervals at 19½ and 49½ minutes after the hour, propagation notices applying to transmission paths over the North Atlantic are transmitted from WWV on 2.5, 5, 10, 15, 20, and 25 Mc. Similar forecasts for the North Pacific are transmitted from WWVH during the announcement intervals at 9 and 39 minutes after the hour.

These notices, in telegraphic code, consist of the letter N, W, or U followed by a number. The letter designations apply to propagation conditions as of the time of the broadcast, and have the following significance:

W — Ionospheric disturbance in progress or expected.
U — Unstable conditions, but communication possible with high power.
N — No warning.

The number designations apply to expected propagation conditions during the subsequent 12 hours and have the following significance:

Digit	*Forecast*
1	Impossible
2	Very Poor
3	Poor
4	Fair to Poor
5	Fair
6	Fair to Good
7	Good
8	Very Good
9	Excellent

Special Transmissions During the International Geophysical Year

The special broadcasts instituted during the International Geophysical Year may be continued through part or all of 1960. These broadcasts include information on IGY "Alerts" and "Special World Intervals." The broadcasts from WWV are at 4½ and 34½ minutes past the hour and those from WWVH are at 14 and 44 minutes past the hour. Each such transmission is preceded by the letters "AGI" in International Morse Code. The code used for the information is as follows:

5 A's — State of alert.
5 E's — No state of alert.
5 S's — Special World Interval begins at 0001Z the following day.
5 T's — Special World Interval terminates at 2359Z.
3 long dashes — Special World Interval in progress.

Test Oscillators and Signal Generators

THE GRID-DIP METER

The **grid-dip meter** is a simple vacuum-tube oscillator to which a microammeter or low-range milliammeter has been added for reading the oscillator grid current. A 0-1 milliammeter is sensitive enough in most cases. The grid-dip meter is so called because if the oscillator is coupled to a tuned circuit the grid current will show a decrease or "dip" when the oscillator is tuned through resonance with the unknown circuit. The reason for this is that the external circuit will absorb energy from the oscillator when both are tuned to the same frequency; the loss of energy from the oscillator circuit causes the feedback to decrease and this in turn is accompanied by a decrease in grid current. The dip in grid current is quite sharp when the circuit to which the oscillator is coupled has reasonably high Q.

The grid-dip meter is most useful when it covers a wide frequency range and is compactly constructed so that it can be coupled to circuits in hard-to-reach places such as in a transmitter or receiver chassis. It can thus be used to check tuning ranges and to find unwanted resonances of the type described in the chapter on TVI. Since it is its own source of r.f. energy it does not require the circuit being checked to be energized. In addition to resonance checks, the grid-dip meter also can be used as a signal source for receiver alignment and, as described later in this chapter, is useful in measurement of inductance and capacitance in the range of values used in r.f. circuits.

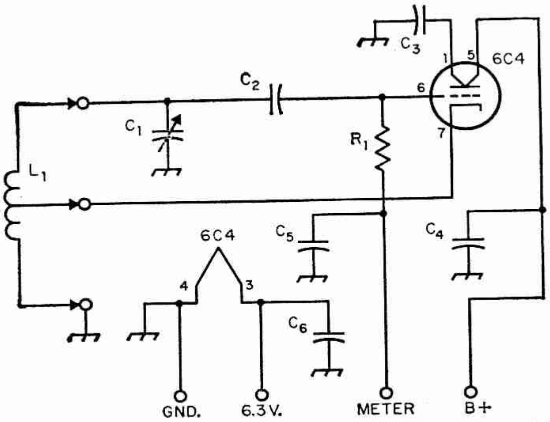


Fig. 21-17—Circuit diagram of the grid-dip meter.

C_1—50-$\mu\mu$f. midget variable (Hammarlund HF-50).
C_2—100-$\mu\mu$f. ceramic.
C_3, C_4, C_6—0.001-μf. disk ceramic.
C_5—0.01-μf. disk ceramic.
R_1—22,000 ohms, ½ watt.

Coil Data, L_1

Freq. Range	*Turns*	*Wire*	*Diameter*	*Turns/inch*	*Tap**
1.59- 3.5 Mc.	139	32 enam.	¾ in.	Close-wound	32
3.45- 7.8 Mc.	40	32 enam.	¾ in.	Close-wound	12
7.55-17.5 Mc.	40	24 tinned	½ in.‡	32	14
17.2-40 Mc.	15	20 tinned	½ in.‡	16	5
37 -85 Mc.	4	20 tinned	½ in.‡	16	1⅓
78 -160 Mc.	Hairpin of No. 14 wire, ⅜ in. spacing, 2 inches long including coil form pins. Tapped 1½ in. from ground end.				

Coil forms are ¾-in. diameter.
* Turns from ground end.
‡ B. & W. Miniductor or equivalent mounted inside coil form.

The circuit of Fig. 21-17 is representative, although practically any oscillator circuit that will operate over the desired frequency range may be used. An instrument to cover both low and very high frequencies must be constructed with short, direct r.f. leads. With ordinary care in this respect there should be little difficulty in getting satisfactory operation up to 150 Mc.

The power supply for the grid-dip meter may be included with the oscillator, but since this increases the bulk and weight a separate supply is often desirable. The power supply shown in Fig. 21-18 uses a miniature power transformer with a selenium rectifier and a simple filter to give approximately 120 volts for the oscillator plate. The potentiometer R_2 is for adjustment of plate voltage. This is desirable because in any grid-dip meter the grid current may vary over wide limits in different parts of the frequency range, with fixed plate voltage.

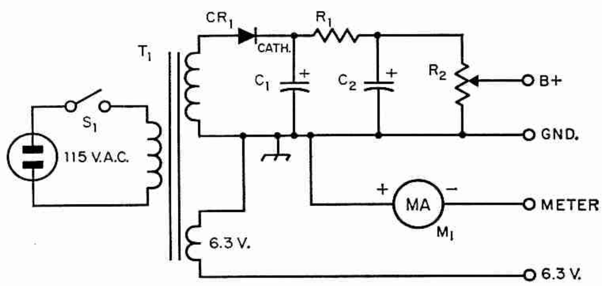


Fig. 21-18—Circuit diagram of the power supply for the grid-dip meter.

C_1, C_2—16-μf. electrolytic, 150 volts.
R_1—1000 ohms, ½ watt.
R_2—0.1-megohm potentiometer.
T_1—Power transformer, 6.3 volts and 125 to 150 volts. (Merit P-3046 or equivalent.)
CR_1—20-ma. selenium rectifier.
M_1—0–1 d.c. milliammeter.

The instrument may be calibrated by listening to its output with a calibrated receiver. The calibration should be as accurate as possible, although "frequency-meter accuracy" is not required in the applications for which a grid-dip meter is useful.

The grid-dip meter may be used as an indicating-type absorption wavemeter by shutting off the plate voltage and using the grid and cathode of the tube as a diode. However, this type of circuit is not as sensitive as the crystal-detector type shown earlier in this chapter, because of the high-resistance grid leak in series with the meter.

In using the grid-dip meter for checking the resonant frequency of a circuit the coupling should be set to the point where the dip in grid current is just perceptible. This reduces interaction between the two circuits to a minimum and gives the highest accuracy. With too-close

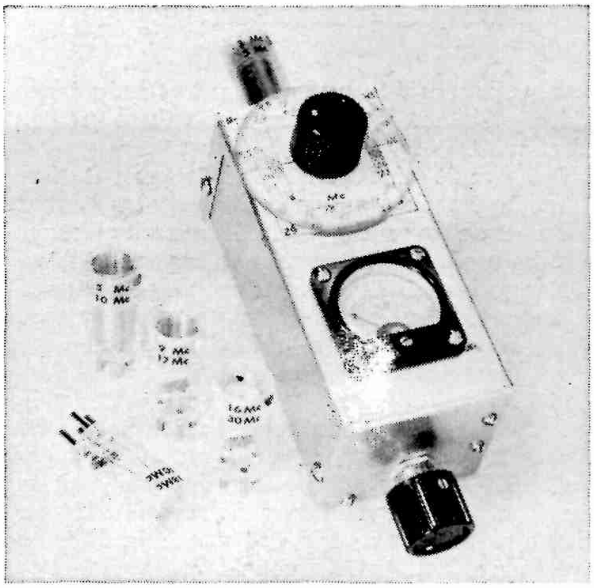


Fig. 21-19—Transistor circuit-checker or "grid-dip meter" covering 3 to 40 Mc. in five ranges. The circuit and battery power supply are contained in the 2¼ × 2¼ × 5-inch aluminum box (Bud CU-3004) so the instrument is completely independent of the a.c. line. The dial is white cardboard with an inked-on calibration; the hairline indicator is on a Lucite disk cemented to the tuning knob. The d.c. meter is a miniature type, but the box is large enough to take a standard 2-inch instrument. The control on the near edge is R_2, for setting the d.c. meter reading to a suitable on-scale value.

coupling the oscillator frequency may be "pulled" by the circuit being checked, in which case different readings will be obtained when resonance is approached from the high side as compared with approaching from the low side.

Transistor "Grid-Dip" Oscillator

The transistor oscillator is particularly convenient in the applications for which the grid-dip meter is useful, since it lends itself to very compact construction with freedom from dependence on the a.c. line for power. The principal drawback at the present time is that there are no low-cost transistors that will oscillate well in the v.h.f. range. However, it is possible to build an oscillator that will operate at least through the ordinary communication frequencies, as shown by Figs. 21-19 to 21-21, inclusive.

The oscillator circuit in Fig. 21-20 is basically of the Colpitts type. Since there is no d.c. current in the transistor oscillator that compares with grid current in the tube oscillator, an equivalent effect is obtained by using CR_1 to rectify some of the r.f. energy, and then measuring the rectified current. To enable the use of a relatively inexpensive d.c. instrument, a second transistor is used as a d.c. amplifier following the rectifier. Omitting Q_2 would require M_1 to be a sensitive microammeter, since the power in the r.f. oscillator is extremely low. R_2 provides a means for setting the meter reading to the desired point on the scale.

The optimum value of bias resistor, R_1, varies with frequency, so the proper resistor is mounted in the coil form for each range. Any convenient pin arrangement can be used for the coil and resistor terminals. Mount the coils near the open ends of the forms so they can be tightly coupled to the circuit being checked. The resistors should be placed near the bottom so they will be as far as possible from the coils.

The instrument is used in the same way as a tube grid-dip meter in checking unknown circuits, and may be calibrated by the same method.

● AUDIO-FREQUENCY OSCILLATORS

A useful accessory for testing audio-frequency

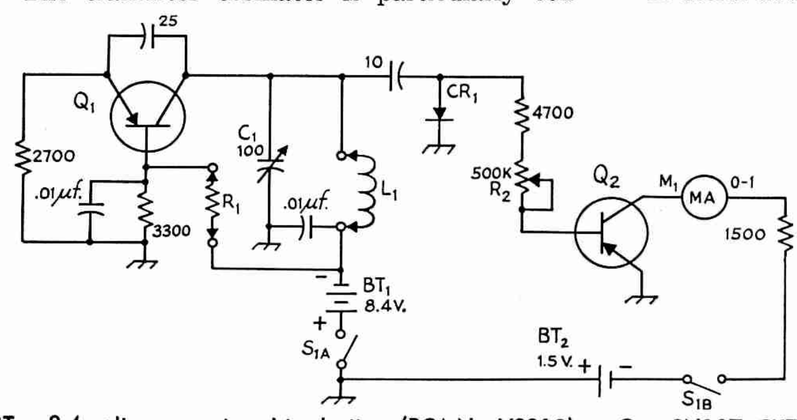


Fig. 21-20—Circuit of the transistorized grid-dip meter. Capacitances are in μμf. except where specified otherwise; fixed resistors are ½ watt. Fixed capacitors are ceramic.

BT_1—8.4-volt mercury transistor battery (RCA No. VS312).
BT_2—1.5-volt mercury cell (RCA VS 313).
C_1—100-μμf. midget variable (Hammerlund MAPC-100-B).
CR_1—1N34 or equiv.
L_1—3-5 Mc.: 72 turns No. 28 enam., ½-inch diam., 1 inch long, close-wound.
5-10 Mc.: 43 turns*
10-17 Mc.: 17 turns*
17-30 Mc.: 7 turns*
28-40 Mc.: 3 turns*
M_1—0-1 milliammeter.
Q_1—2N247.
Q_2—2N107, CK722, or 2N222.
R_1—3-5 Mc.: 39,000 ohms**.
5-10 Mc.: 10,000 ohms**.
10-17 Mc.: 4700 ohms**.
17-30 Mc.: 4700 ohms**.
28-40 Mc.: 10,000 ohms**.
R_2—0.5-megohm control.
S_1—D.p.s.t. toggle mounted on R_2.
* No. 24 wire, ½-inch diameter, 32 turns per inch (B & W 3004 Miniductor), mounted inside ¾-inch diameter polystyrene coil form (Amphenol 24-5H).
** Mounted in coil form with coil of same range.

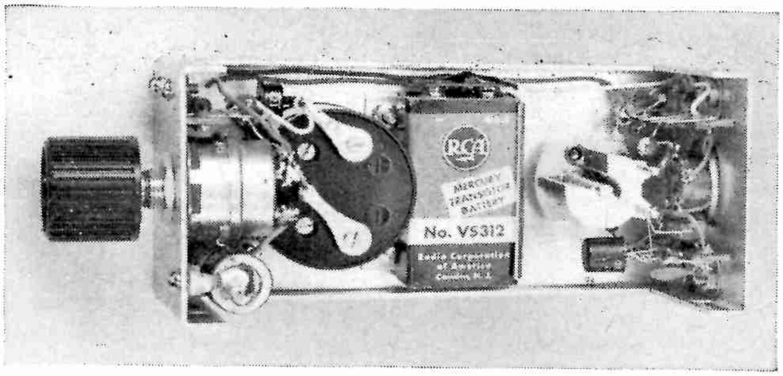


Fig. 21-21—Inside the case of the transistor oscillator. All components are mounted on the flanged section of the two-piece box. The oscillator is at the right in this view, with connections anchored to tie points placed on either side of the coil socket. Q_1 is visible just below the tuning capacitor. CR_1 is mounted on the tie-point strip above the coil socket. The d.c. amplifier circuit is to the left of the mercury battery; the 1.5-volt cell is mounted beside the variable resistor, using a lug soldered to the + terminal for support.

amplifiers and modulators is an audio-frequency signal generator or oscillator. Checks for distortion, gain, and the troubles that occur in such amplifiers do not require elaborate equipment; the principal requirement is a source of one or more audio tones having a good sine wave form, at a voltage level adjustable from a few volts down to a few millivolts so the oscillator can be substituted for the type of microphone to be used.

An easily constructed oscillator of this type is shown in Figs. 21-22 to 21-24, inclusive. Three audio frequencies are available, approximately 200, 900 and 2500 cycles. These three frequencies are sufficient for testing the frequency response of an amplifier over the range needed for voice communication.

The circuit uses a double triode as a cathode-coupled oscillator, the second section of the tube providing the feedback necessary for oscillation through the common cathode connection. The 3-watt lamp in this feedback loop acts as a variable resistance to control the oscillation amplitude and thus maintain the operating conditions at the point where the best wave form is generated. This operating point is set by the "oscillation control," R_1. The frequency is determined by the resistance and capacitance in

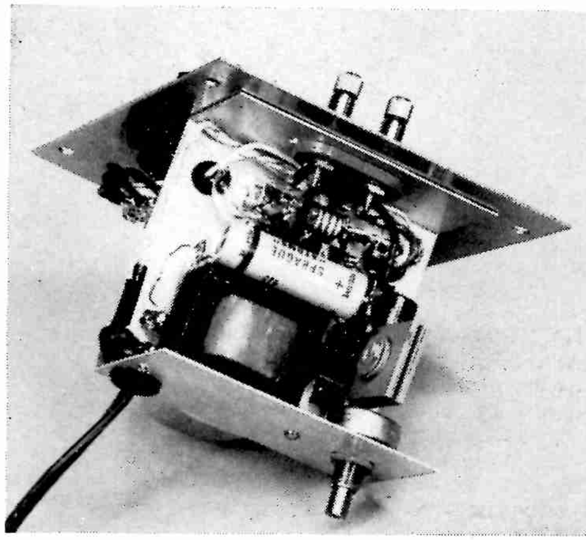


Fig. 21-22—Bottom view of the audio oscillator, showing the power-supply components and amplitude-control lamp, I_1. The lamp is mounted by wires soldered to its base. The selenium rectifier is supported by a tie-point strip. Placement of resistors, which are hidden by the other components, is not critical. The unit fits in a 4 × 5 × 6 inch box.

CR_1—20-ma. selenium rectifier.
I_1—3-watt, 115-volt lamp (G.E. 3S6).
L—8 henrys, 40 ma. (Thordarson 20C52).
R_1, R_2—Volume controls.
S_1—2-pole 5-position (3 used) rotary switch.
S_2—D.p.d.t. toggle.
S_3—S.p.s.t. toggle (mounted on R_1).
T_1—Power transformer, 150 volts, 25 ma.; 6.3 volts 0.5 amp. (Merit P-3046).

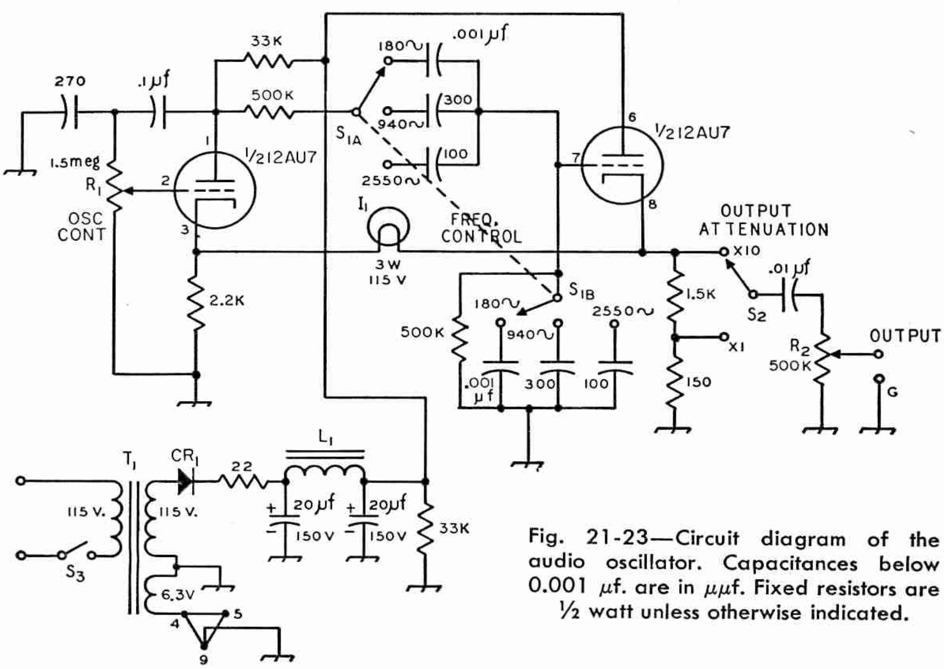


Fig. 21-23—Circuit diagram of the audio oscillator. Capacitances below 0.001 µf. are in µµf. Fixed resistors are ½ watt unless otherwise indicated.

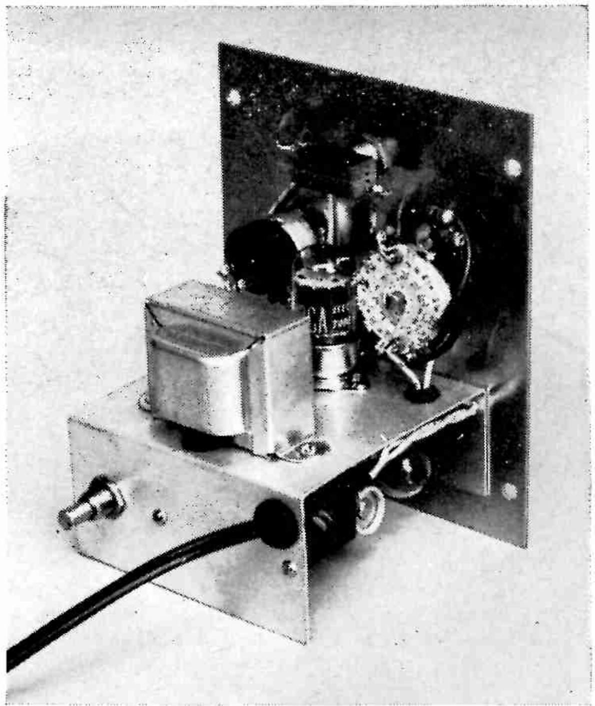


Fig. 21-24—Inside view of the audio oscillator. The a.c. switch. S_3, is mounted on the output control at the left on the panel. The ceramic capacitors in the frequency-determining circuits are mounted on the rotary switch, S_1, at the right. S_2 is above the tube, and T_1 is on the near edge of the chassis, which is a U-shaped piece of aluminum 3½ inches deep with 1½ inch lips. R_1 is mounted on the near lip at the left.

the coupling circuit between the first-section plate and second-section grid. Various values of capacitance can be selected by means of S_1 to set the frequency. The actual frequencies measured in the unit shown in the photographs are given on the diagram. They may be either increased or decreased by using smaller or larger capacitances, respectively.

Output is taken from the cathode of the second triode section. Either the full output, 1.5 volts, or approximately one-tenth of it can be selected by S_2. On either of these two ranges smooth control of output is provided by R_2.

The built-in power supply uses a small transformer and a selenium rectifier to develop approximately 150 volts. Hum is reduced to a negligible level by the filter consisting of the 8-henry choke and 20-μf. capacitors.

An oscilloscope is useful for preliminary checking of the oscillator since it will show wave form. R_1 should be set at the point that will ensure oscillation on all three frequencies when switching from one to the other.

NOISE GENERATORS

A noise generator is a device for creating a controllable amount of radio-frequency noise ("hiss"-type noise) evenly distributed throughout the frequency spectrum of interest. The simplest type of noise generator is a diode, either vacuum-tube or crystal, with direct current flowing through it. The current is also made to flow through a load resistance which in general is chosen to equal the characteristic impedance of the transmission line to be connected to the receiver's input terminals. The resistance then substitutes for the line, and the amount of r.f. noise fed to the input terminals of the receiver is controlled by controlling the d.c. through the diode.

The usefulness of the noise generator in amateur work lies in the fact that it provides a means for adjusting the "front-end" circuits of a receiver for optimum signal-to-noise ratio (see sections on receiver design). Although it can be built at little expense, it is actually more effective for this purpose than costly laboratory-type signal generators. A simple circuit using a crystal diode is shown in Fig. 21-25. Fig. 21-26 illustrates the construction, the principal requirement being that R_2 should be mounted right on the terminals of the coaxial fitting and that lead lengths should be as short as possible in the circuit formed by C_1, CR_1 and R_2. If these lead lengths are negligible the instrument should give uniform performance up to at least 150 Mc. R_2 should match the particular line and input impedance for which the receiver is designed.

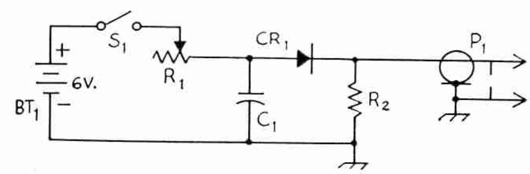


Fig. 21-25—Circuit of a simple crystal-diode noise generator.

BT_1—Dry-cell battery, any convenient type.
C_1—500-$\mu\mu$f. ceramic, disk or tubular.
CR_1—Silicon diode, 1N21 or 1N23 (do not use ordinary germanium diodes).
P_1—Coaxial fitting, cable type.
R_1—50,000-ohm control, counterclockwise logarithmic taper.
R_2—51 or 75 ohms, ½-watt composition.
S_1—S.p.s.t. toggle (may be mounted on R_1).

To use the generator, screw the coaxial fitting on the receiver's input fitting, open S_1, and measure the noise output of the receiver using an a.c. vacuum-tube voltmeter or similar a.f. voltage indicator. Make sure that the receiver's r.f. and audio gain controls are set well within the linear range, and do not use a.v.c. Then turn on the noise generator and set R_1 for an appreciable increase in output, say twice the original noise voltage, and note the dial setting. Receiver front-end adjustments may then be made with the object of attaining the same noise increase with the lowest possible direct current through the diode — that is, with the largest possible resistance at R_1.

The instrument may be used for comparing different receivers or different front-end arrangements, since this type of measurement is independent of receiver bandwidth (which has a marked effect on the actual signal-to-noise

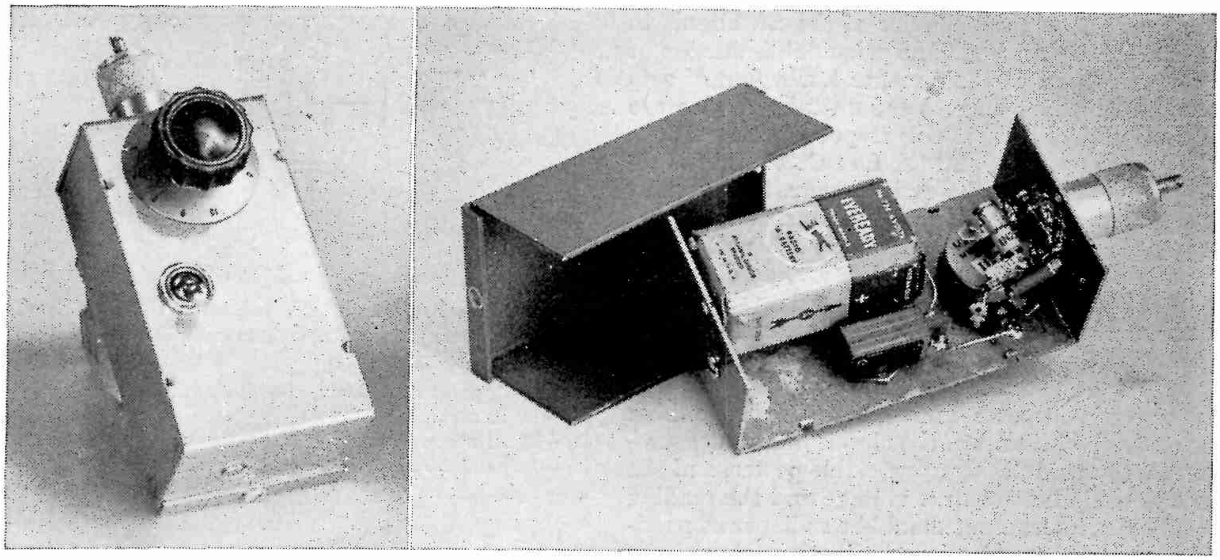


Fig. 21-26—Crystal-diode noise generator mounted in a 1⅝ × 2⅛ × 4-inch box. Most of the space is occupied by the miniature 6-volt dry-cell battery. The coaxial fitting (PL-259) can be mounted to the box by cutting a hole in a small square sheet-copper plate to make a snug fit over the end of the body of the connector and then soldering it in place. Holes can be drilled in the plate for mounting screws. The diode can be mounted in improvised clips, the larger being a small-size grid-grip and the smaller a miniature socket contact.

ratio). For consistent measurements the battery voltage should be checked to make sure that it does not change with the setting of R_1.

(Further information on noise generators, with additional references, may be found in *QST* for July, 1953.)

R.F. Measurements

● R.F. CURRENT

R.f. current-measuring devices use a **thermocouple** in conjunction with an ordinary d.c. instrument. The thermocouple is made of two dissimilar metals which, when heated, generate a small d.c. voltage. The thermocouple is heated by a resistance wire through which the r.f. current flows, and since the d.c. voltage developed is proportional to the heating, which in turn is proportional to the power used by the heating element, the deflections of the d.c. instrument are proportional to power rather than to current. This causes the calibrated scale to be compressed at the low-current end and spread out at the high-current end. The useful range of such an instrument is about 3 or 4 to 1; that is, an r.f. ammeter having a full-scale reading of 1 ampere can be read with satisfactory accuracy down to about 0.3 ampere, one having a full scale of 5 amperes can be read down to about 1.5 amperes, and so on. No single instrument can be made to handle a wide range of currents. Neither can the r.f. ammeter be shunted satisfactorily, as can be done with d.c. instruments, because even a very small amount of reactance in the shunt will cause the readings to be highly dependent on frequency.

Fig. 21-27 shows a convenient way of using an r.f. ammeter for measuring current in a coaxial line. The instrument is simply mounted in a metal box with a short lead from each terminal to a coaxial fitting. The shunt capacitance of an ammeter mounted in this way has only a negligible effect on accuracy at frequencies as high as 30 Mc. if the instrument has a bakelite case. Metal-cased meters should be mounted on a bakelite panel which in turn can be mounted behind a cut-out that clears the meter case by ¼ inch or so.

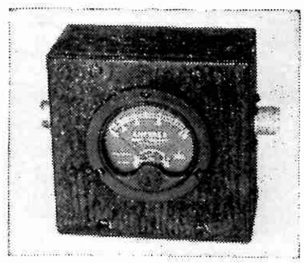


Fig. 21-27—R.f. ammeter mounted for connecting into a coaxial line for measuring power. A "2-inch" instrument will fit into a 2 × 4 × 4 metal box.

● R.F. VOLTAGE

An **r.f. voltmeter** is a rectifier-type instrument in which the r.f. is converted to d.c., which is then measured with a d.c. instrument. The best type of rectifier for most applications is a crystal diode, such as the 1N34 and similar types, because its capacitance is so low as to have little effect on the behavior of the r.f. circuit to which it is connected. The principal limitation of these rectifiers is their rather low value of safe inverse peak voltage. Vacuum-tube diodes are considerably better in this respect, but their size, shunt capacitance, and the fact that power is required for heating the cathode constitute serious disadvantages in many applications.

One of the principal uses for such voltmeters is as null indicators in r.f. bridges, as described later in this chapter. Another useful application is in measurement of the voltage between the conductors of a coaxial line, to show when a transmitter is adjusted for optimum output. In either case the voltmeter impedance should be high compared with that of the circuit under measurement, to avoid taking appreciable power, and the relationship between r.f. voltage and the reading of the d.c. instrument should be as linear as possible — that is, the d.c. indication should be directly proportional to the r.f. voltage at all points of the scale.

All rectifiers show a variation in resistance with applied voltage, the resistance being highest when the applied voltage is small. These variations can be fairly well "swamped out" by using a high value of resistance in the d.c. circuit of the rectifier. A resistance of at least 10,000 ohms is necessary for reasonably good linearity with a 0–1 milliammeter. High resistance in the d.c. circuit also raises the impedance of the r.f. voltmeter and reduces its power consumption.

The basic voltmeter circuit is shown in Fig. 21-28. It is simply a half-wave rectifier with a meter and a resistor, R_1, for improving the linearity. The time constant of C_1R_1 should be large compared with the period of the lowest radio frequency to be measured — a condition that can easily be met if R_1 is at least 10,000 ohms and C_1 is 0.001 μf. or more — so C_1 will stay charged near the peak value of the r.f. voltage. The radio-frequency choke may be omitted if there is a low-resistance d.c. path through the circuit being measured. C_2 provides additional r.f. filtering for the d.c. circuit.

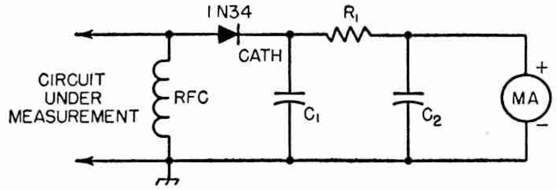


Fig. 21-28—R.f. voltmeter circuit using a crystal rectifier and d.c. microammeter or 0–1 milliammeter.

The simple circuit of Fig. 21-28 is useful for voltages up to about 20 volts, a limitation imposed by the inverse-peak voltage ratings of crystal diodes. A dual range voltmeter circuit, 0-20 and 0-100 volts, is shown in Fig. 21-29. A voltage divider, R_1R_2, is used for the higher range. An instrument using this circuit is shown in Fig. 21-30. It is designed for connection into a coaxial line. The principal constructional precautions are to keep leads short, and to mount

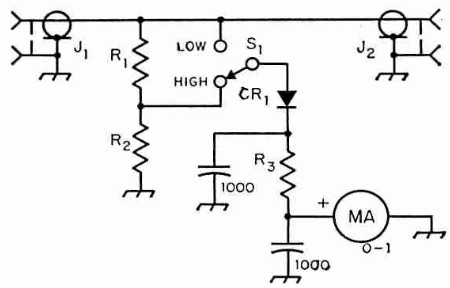


Fig. 21-29—Dual-range r.f. voltmeter circuit. Capacitances are in $\mu\mu$f.; capacitors are disk ceramic.

CR1—1N34 or equivalent.
J1, J2—Coaxial connectors, chassis-mounting type.
R1—1000 ohms, 1 watt.
R2—3300 ohms, 2 watts.
R3—App. 22,000 ohms (see text), ½ watt.
S1—S.p.d.t. rotary switch (Centralab 1460).

the components in such a way as to minimize stray coupling between them and to keep them fairly well separated from metal surfaces.

For accurate calibration (the power method described below may be used) R_3 should be adjusted, by selection of resistors or using two in series to obtain the desired value, so that the meter reads full scale, with S_1 set for the low range, with 20 volts r.m.s. on the line. A frequency in the vicinity of 14 Mc. should be used. Then, with S_1 set for the high range, various resistors should be tried at R_1 or R_2 until with the same voltage the meter reads 20 per cent of full scale. The resistance variations usually will be within the range of 10 per cent tolerance resistors of the values specified. The readings at various other voltages should be observed in order to check the linearity of the scale.

Calibration

Calibration is not necessary for purely comparative measurements. A calibration in actual voltage requires a known resistive load and an r.f. ammeter. The setup is the same as for r.f. power measurement as described later, and the

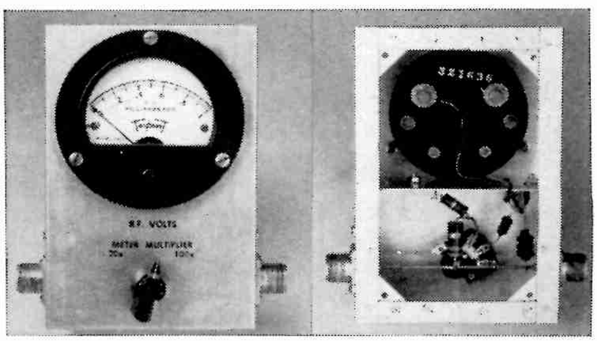


Fig. 21-30—Dual-range r.f. voltmeter for use in coaxial line, using a 0-1 d.c. milliammeter. The voltage-divider resistors, R_1 and R_2 (Fig. 21-29) are at the center in the lower compartment. The bypass capacitors and R_3 are mounted on a tie-point strip at the right. The unit is built in a 4 × 6 × 2 inch aluminum chassis, with an aluminum partition connecting the two sides of the box to form a shielded space. A bottom plate, not shown, is used to complete the shielding.

voltage calibration is obtained by calculation from the known power and known load resistance, using Ohm's Law: $E = \sqrt{PR}$. As many points as possible should be obtained, by varying the power output of the transmitter, so that the linearity of the voltmeter can be checked.

R.F. POWER

Measurement of r.f. power requires a resistive load of known value and either an r.f. ammeter or a calibrated r.f. voltmeter. The power is then either I^2R or E^2/R, where R is the load resistance in ohms.

The simplest method of obtaining a load of known resistance is to use an antenna system with coax-coupled matching circuit of the type described in the chapter on transmission lines. When the circuit is adjusted, by means of an s.w.r. bridge, to bring the s.w.r. down to 1 to 1 the load is resistive and of the value for which the bridge was designed (52 or 75 ohms).

The r.f. ammeter should be inserted in the line in place of the s.w.r. bridge after the matching has been completed, and the transmitter then adjusted — without touching the matching circuit — for maximum current. A 0–1 ammeter is useful for measuring the approximate range 5–50 watts in 52-ohm line, or 7.5–75 watts in 75-ohm line; a 0–3 instrument can be used for 13–450 watts in 52-ohm line and 20–675 watts in 75-ohm line. The accuracy is usually greatest in the upper half of the scale.

An r.f. voltmeter of the type described in the preceding section also can be used for power measurement in a similar setup. It has the advantage that, because its scale is substantially linear, a much wider range of powers can be measured with a single instrument.

INDUCTANCE AND CAPACITANCE

The ability to measure inductance and capacitance saves time that might otherwise be spent in cut-and-try. A convenient instrument for this purpose is the grid-dip oscillator, described earlier in this chapter.

For measuring inductance, use is made of a capacitance of known value as shown at A in Fig. 21-31. With the unknown coil connected to the standard capacitor, couple the grid-dip meter to the coil and adjust the oscillator frequency for the grid-current dip, using the loosest coupling that gives a detectable indication. The inductance is then given by the formula

$$L_{\mu h.} = \frac{25{,}330}{C_{\mu\mu f.}\, f^2_{Mc.}}$$

The reverse procedure is used for measuring capacitance — that is, a coil of known inductance is used as a standard as shown at B. The unknown capacitance is

$$C_{\mu\mu f.} = \frac{25{,}330}{L_{\mu h.} f^2_{Mc.}}$$

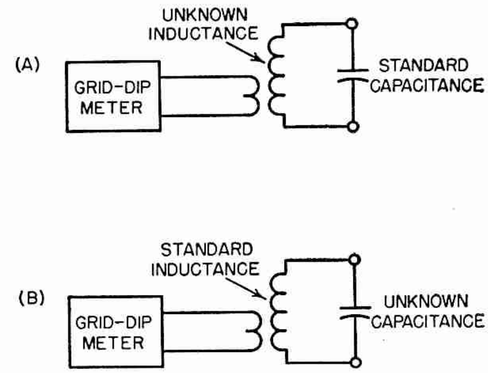


Fig. 21-31—Setups for measuring inductance and capacitance with the grid-dip meter.

The accuracy of this method depends on the accuracy of the grid-dip meter calibration and the accuracy with which the standard values of L and C are known. Postage-stamp silver-mica capacitors make satisfactory capacitance standards, since their rated tolerance is ±5 per cent. Equally good inductance standards can be made from commercial machine-wound coil material.

A single pair of standards will serve for measuring the L and C values commonly used in amateur equipment. A good choice is 100 $\mu\mu$f. for the capacitor and 5 μh. for the coil. Based on these values the chart of Fig. 21-33 will give the unknown directly in terms of the resonant frequency registered by the grid-dip meter. In measuring the frequency the coupling between the grid-dip meter and resonant circuit should be kept at the smallest value that gives a definite indication.

A correction should be applied to measurements of very small values of L and C to include the effects of the shunt capacitance of the mounting for the coil, and for the inductance of the leads to the capacitor. These amount to approximately 1 $\mu\mu$f. and 0.03 μh., respectively, with the method of mounting shown in Fig. 21-32.

Coefficient of Coupling

The same equipment can be used for measurement of the coefficient of coupling between two

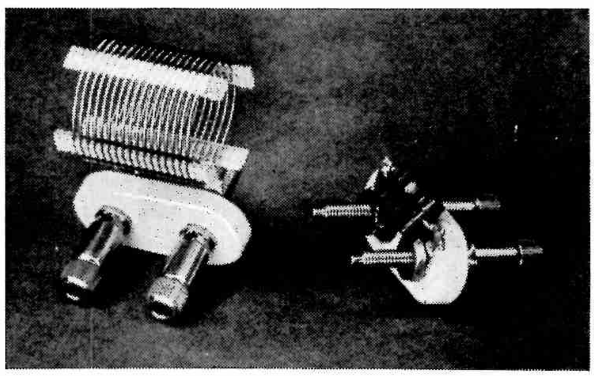


Fig. 21-32—A convenient mounting, using binding-post plates, for L and C standards made from commercially-available parts. The capacitor is a 100-$\mu\mu$f. silver mica unit, mounted so the lead length is as nearly zero as possible. The inductance standard, 5 μh., is 17 turns of No. 3015 B & W Miniductor, 1-inch diameter, 16 turns per inch.

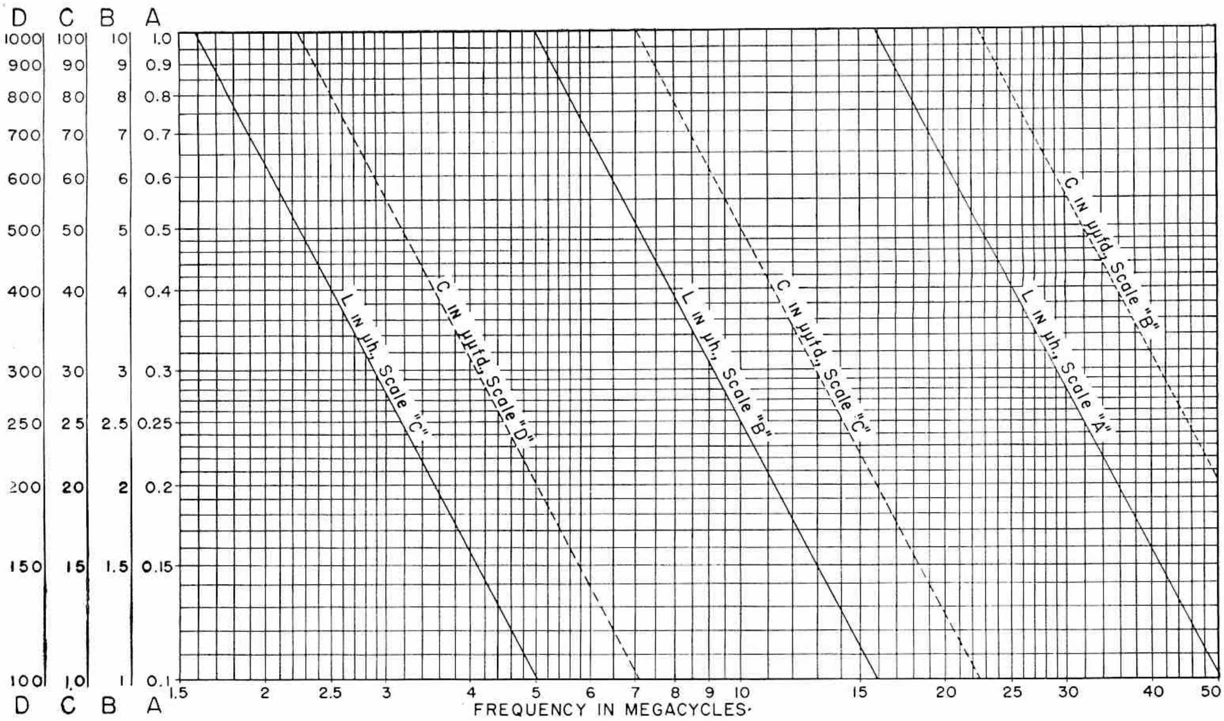


Fig. 21-33—Chart for determining unknown values of L and C in the range 0.1 to 100 µh. and 2 to 1000 µµf., using standards of 100 µµf. and 5 µh.

coils. This simply requires two measurements of inductance (of *one* of the coils) with the coupled coil first open-circuited and then short-circuited. Connect the 100-µµf. standard capacitor to one coil and measure the inductance with the terminals of the second coil open. Then short the terminals of the second coil and again measure the inductance of the first. The coefficient of coupling is given by

$$k = \sqrt{1 - \frac{L_2}{L_1}}$$

where k = coefficient of coupling
L_1 = inductance of first coil with terminals of second coil open
L_2 = inductance of first coil with terminals of second coil shorted.

R.F. RESISTANCE

Aside from the bridge methods used in transmission-line work, described later, there is relatively little need for measurement of r.f. resistance in amateur practice. Also, measurement of resistance by fundamental methods is not practicable with simple equipment. Where such measurements are made, they are usually based on known characteristics of available resistors used as standards.

Most types of resistors have so much inherent reactance and skin effect that they do not act like "pure" resistance at radio frequencies, but instead their effective resistance and impedance vary with frequency. This is especially true of wire-wound resistors. Composition (carbon) resistors of 25 ohms or more as a rule have negligible inductance for frequencies up to 100 Mc. or so. The skin effect also is small, but the shunt capacitance cannot be neglected in the higher values of these resistors, since it reduces their impedance and makes it reactive. However, for most purposes the capacitive effects can be considered to be negligible in composition resistors of values up to 1000 ohms, for frequencies up to 50 to 100 Mc., and the r.f. resistance of such units is practically the same as their d.c. resistance. Hence they can be considered to be practically pure resistance in such applications as r.f. bridges, etc., provided they are mounted in such a way as to avoid magnetic coupling to other circuit components, and are not so close to grounded metal parts as to give an appreciable increase in shunt capacitance.

Antenna and Transmission-Line Measurements

Two principal types of measurements are made on antenna systems: (1) the standing-wave ratio on the transmission line, as a means for determining whether or not the antenna is properly matched to the line (alternatively, the input resistance of the line or antenna may be measured); (2) the comparative radiation field strength in the vicinity of the antenna, as a means for checking the directivity of a beam antenna and as an aid in adjustment of element tuning and phasing. Both types of measurements can be made with rather simple equipment.

FIELD-STRENGTH MEASUREMENTS

The radiation intensity from an antenna is measured with a device that is essentially a very simple receiver equipped with an indicator to give a visual representation of the comparative signal strength. Such a **field-strength meter** is used with a "pick-up antenna" which should always have the same polarization as the antenna being checked — e.g., the pick-up antenna should be horizontal if the transmitting antenna is horizontal. Care should be taken to prevent stray pickup by the field-strength meter itself or by any transmission line that may connect it to the pick-up antenna.

Field-strength measurements preferably should be made at a distance of several wavelengths from the transmitting antenna being tested. Measurements made within a wavelength of the antenna may be misleading, because of the possibility that the measuring equipment may be responding to the combined induction and radiation fields of the antenna, rather than to the radiation field alone. Also, if the pick-up antenna has dimensions comparable with those of the antenna under test it is likely that the coupling between the two antennas will be great enough to cause the pick-up antenna to tend to become part of the radiating system and thus result in misleading field-strength readings.

A desirable form of pick-up antenna is a dipole installed at the same height as the antenna being tested, with low-impedance line such as 75-ohm Twin-Lead connected at the center to transfer the r.f. signal to the field-strength meter. The length of the dipole need only be great enough to give adequate meter readings. A half-wave dipole will give high sensitivity, but such length will not be needed unless the distance is several wavelengths and a relatively insensitive meter is used.

Field-Strength Meters

The crystal-detector wavemeter described earlier in this chapter may be used as a field-strength meter. It may be coupled to the transmission line from the pick-up antenna through the coaxial-cable jack, J_1.

The indications with a crystal wavemeter connected as shown in Fig. 21-10 will tend to be "square law" — that is, the meter reading will be proportional to the square of the r.f. voltage. This exaggerates the effect of relatively small adjustments to the antenna system and gives a false impression of the improvement secured. The meter reading can be made more linear by connecting a fairly large resistance in series with the milliammeter (or microammeter). About 10,000 ohms is required for good linearity. This considerably reduces the sensitivity of the meter, but the lower sensitivity can be compensated for by making the pick-up antenna sufficiently large.

Transistorized Wavemeter and Field-Strength Meter

A sensitive field-strength meter can be made by using a transistor as a d.c. amplifier following the crystal rectifier of a wavemeter. A circuit of this type is shown in Fig. 21-34. Depending on the characteristics of the particular transistor used, the amplification of current may be 10 or more times, so that a 0–1 milliampere d.c. instrument becomes the equivalent of a sensitive microammeter.

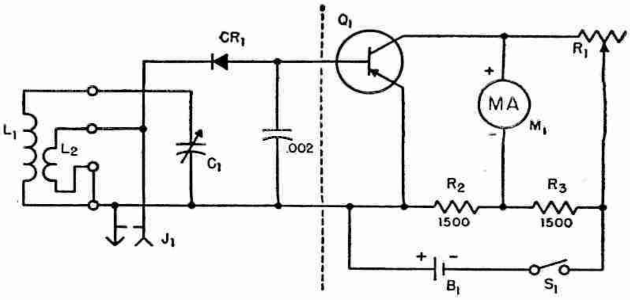


Fig. 21-34—Transistor d.c. amplifier applied to the wavemeter of Fig. 21-10 to increase sensitivity. Components not listed below are the same as in Fig. 21-10.

B_1—Small flashlight cell.
M_1—0-1 d.c. milliammeter (see text).
Q_1—2N107, CK722, etc.
R_1—10,000-ohm control.
R_2, R_3—1500 ohms, ½ watt.
S_1—S.p.s.t. toggle (on-off switch).

The circuit to the left of the dashed line in Fig. 21-34 is the same as the wavemeter circuit of Fig. 21-10, and the transistor amplifier can easily be accommodated in the case shown in Figs. 21-11 and 21-12.

The transistor is connected in the common-emitter circuit with the rectified d.c. from the crystal diode flowing in the base-emitter circuit. Since there is a small residual current in the collector circuit with no current flowing in the base-emitter circuit, the d.c. meter is connected in a bridge arrangement so the residual current can be balanced out. This is accomplished, in the absence of any signal input to the transistor base, by adjusting R_1 so that the voltage drop across it is equal to the voltage drop from collector to emitter in the transistor. R_2 and R_3, being of the same resistance, have equal voltage drops across them and so there is no difference of potential across the meter terminals until the collector current increases because of current flow in the base-emitter circuit.

The collector current in a circuit of this type is not strictly proportional to the base current, particularly for low values of base current. The meter readings are not directly proportional to the field strength, therefore, but tend toward "square law" response just as in the case of a simple diode with little or no resistance in its d.c. circuit. For this reason the d.c. meter, M_1, should not have too-high sensitivity if reasonably linear response is desired. A 0-1 milliammeter will be satisfactory.

The zero balance should be checked at intervals while the instrument is in use, since the residual current of the transistor is sensitive to temperature changes.

IMPEDANCE AND STANDING-WAVE RATIO

Adjustment of antenna matching systems requires some means either of measuring the input impedance of the antenna or transmission line, or measuring the standing-wave ratio. "Bridge" methods are suitable for either measurement.

There are many varieties of bridge circuits, the two shown in Fig. 21-35 being among the most popular for amateur purposes. The simple

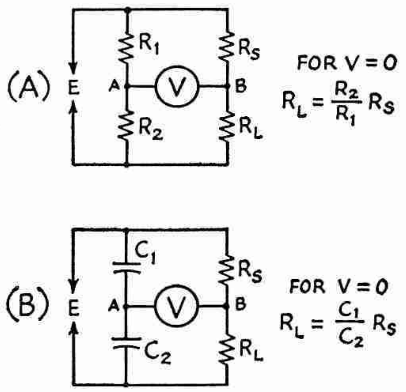


Fig. 21-35—Basic bridge circuits. (A) Resistance bridge; (B) resistance-capacitance bridge. The latter circuit is used in the "Micromatch," with R_S a very low resistance (1 ohm or less) and the ratio C_1/C_2 adjusted accordingly for a desired line impedance.

resistance bridge of Fig. 21-35A consists essentially of two voltage dividers in parallel across a source of voltage. When the voltage drop across R_1 equals that across R_S the drops across R_2 and R_L are likewise equal and there is no difference of potential between points *A* and *B*. Hence the voltmeter reading is zero and the bridge is said to be "balanced." If the drops across R_1 and R_S are not equal, points *A* and *B* are at different potentials and the voltmeter will read the difference. The operation of the circuit of Fig. 21-35B is similar, except that one of the voltage dividers is capacitive instead of resistive.

Because of the characteristics of practical components at radio frequencies, the circuit of Fig. 21-35A is best suited to applications where the ratio R_1/R_2 is fixed; this type of bridge is particularly well suited to measurement of standing-wave ratio. The circuit of Fig. 21-35B is well adapted to applications where a variable voltage divider is essential (since C_1 and C_2 may readily be made variable) as in measurement of unknown values of R_L.

S.W.R. Bridge

In the circuit of Fig. 21-35A, if R_1 and R_2 are made equal, the bridge will be balanced when $R_L = R_S$. This is true whether R_L is an actual resistor or the input resistance of a perfectly matched transmission line, provided R_S is chosen to equal the characteristic impedance of the line. Even if the line is not properly matched, the bridge will still be balanced for power traveling *outward* on the line, since outward-going power sees only the Z_0 of the line until it reaches the load. However, power reflected back from the load does not "see" a bridge circuit and the reflected voltage registers on the voltmeter. From the known relationship between the outgoing or "forward" voltage and the reflected voltage, the s.w.r. is easily calculated:

$$S.W.R. = \frac{V_o + V_r}{V_o - V_r}$$

where V_0 is the forward voltage and V_r is the reflected voltage. The forward voltage is equal to $E/2$ since R_S and R_L (the Z_0 of the line) are equal. It may be measured either by disconnecting R_L or shorting it.

Measuring Voltages

For the s.w.r. formula above to apply with reasonable accuracy (particularly at high standing-wave ratios) the current taken by the voltmeter must be inappreciable compared with the currents through the bridge "arms." The voltmeter used in bridge circuits employs a crystal diode rectifier (see discussion earlier in this chapter) and in order to meet the above requirement — as well as to have linear response, which is equally necessary for calibration purposes — should use a resistance of at least 10,000 ohms in series with the milliammeter or microammeter.

Since the voltage applied to the line is measured by shorting or disconnecting R_L (that is, the line input terminals), while the reflected voltage is measured with R_L connected, the load on the source of voltage *E* is different in the two measurements. If the regulation of the voltage source is not perfect, the voltage *E* will not remain the same under these two conditions. This can lead to large errors. Such errors can be avoided by using a second voltmeter to maintain a check on the voltage applied to the bridge, readjusting the

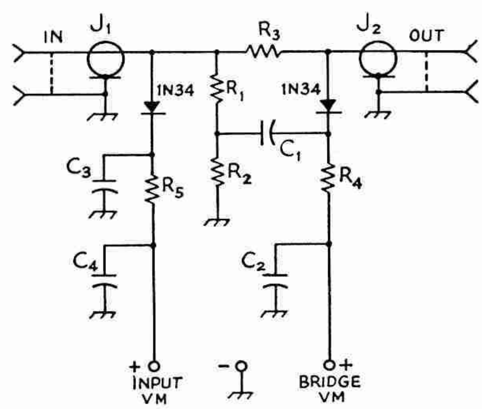


Fig. 21-36—Bridge circuit for s.w.r. measurements. This circuit is intended for use with a d.c. voltmeter, range 5 to 10 volts, having a resistance of 10,000 ohms per volt or greater.

C_1, C_2, C_3, C_4—0.005- or 0.01-μf. disk ceramic.
R_1, R_2—47-ohm composition, ½ or 1 watt.
R_3—52- or 75-ohm (depending on line impedance) composition, ½ or 1 watt; precision type preferred.
R_4, R_5—10,000 ohms, ½ watt.
J_1, J_2—Coaxial connectors.
Meter connects to either "input" or "bridge" position as required.

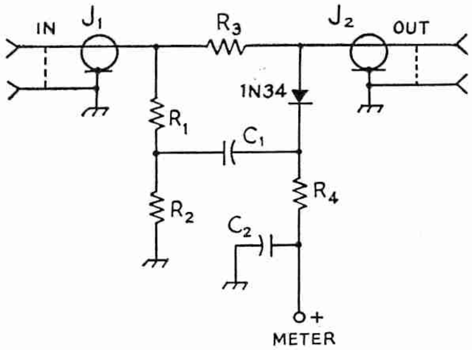


Fig. 21-37—A simple bridge circuit useful for impedance-matching in coaxial lines.

C_1, C_2—0.005- or 0.01-μf. disk ceramic.
R_1, R_2—47-ohm composition, ½ watt.
R_3—52- or 75-ohm (depending on line impedance) composition, ½ watt; precision type preferred.
R_4—1000-ohm composition, ½ watt.
J_1, J_2—Coaxial connector.
The meter may be a 0-1 milliammeter or d.c. voltmeter of any type having a sensitivity of 1000 ohm per volt or greater, and a full-scale range of 5 to 10 volts. Negative side of meter connects to ground.

coupling to the voltage source to maintain constant applied voltage during the two measurements. Since the "input" voltmeter is simply used as a reference, its linearity is not important, nor does its reading have to bear any definite relationship to that of the "bridge" voltmeter, except that its range has to be at least twice that of the latter.

A practical circuit incorporating these features is given in Fig. 21-36.

If the bridge is to be used merely for antenna adjustment, where the object is to secure the lowest possible s.w.r. rather than to measure the s.w.r. accurately, the voltmeter requirements are not stringent. In this case the object is to get as close to a "null" or balance (that is, zero reading) as possible. At or near exact balance the voltmeter impedance is not important. Neither is it necessary to maintain constant input voltage to the bridge. This simplifies the bridge circuit considerably, Fig. 21-37 being a practical example. The construction of a bridge of this type suitable for antenna and transmission line adjustments is shown in Fig. 21-38.

Bridge Construction

A principal point in the construction of an s.w.r. bridge is to avoid coupling between the resistors forming the bridge arms, and between the arms and the voltmeter circuit. This can be done by keeping the resistance arms separated and at right angles to each other, and by placing the crystal and its connecting leads so that the loop so formed is not in inductive relationship with any loops formed by the bridge arms. Shielding between the bridge arms and the crystal circuit is helpful in reducing such couplings, although it is not always necessary. The two resistors forming the "ratio arms," R_1 and R_2, should have identical relationships with metal parts, to keep the shunt capacitances equal, and also should have the same lead lengths so the inductances will balance. Leads should be kept as short as possible.

Testing and Calibration

In a bridge intended for s.w.r. measurement (Fig. 21-35) rather than simple matching, the first check is to apply just enough r.f. voltage, at the highest frequency to be used, so that the bridge voltmeter reads full scale with the load terminals open. Observe the input voltage, then short-circuit the load terminals and readjust the input to the same voltage. The bridge voltmeter should again register full scale. If it does not, the ratio arms, R_1 and R_2, probably are not exactly equal. These two resistors should be carefully matched, although their actual value is not critical. If a similar test at a low frequency shows better balance, the probable cause is stray inductance or capacitance in one arm not balanced by equal strays in the other.

After the "short" and "open" readings have been equalized, the bridge should be checked for null balance with a "dummy" resistance, equal to the line impedance, connected to the load terminals. It is convenient to mount a half- or 1-watt resistor of the proper value in a coax connector, keeping it centered in the connector and using the minimum lead length. The bridge voltmeter should read zero at all frequencies. A reading above zero that remains constant at all frequencies indicates that the "dummy" resistor is

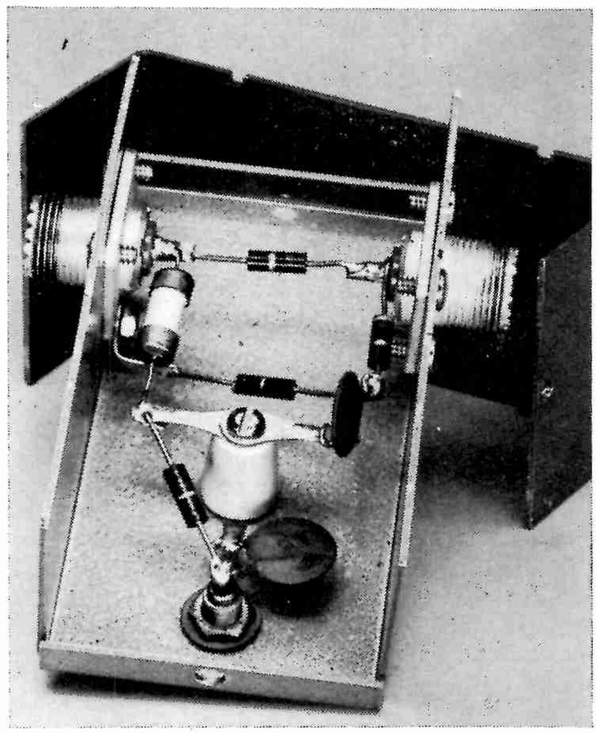


Fig. 21-38—An inexpensive bridge for matching adjustments using the circuit of Fig. 21-37. It is built in a 1⅝ × 2⅛ × 4-inch "Channel-lock" box. The standard resistor, R_3, bridges the two coax connectors. A pin jack is provided for connection to the d.c. meter, 0-1 ma. or 0-500 μa.; the meter negative can be connected to the case or to one of the coax fittings.

not matched to R_3, while readings that vary with frequency indicate stray reactive effects or stray coupling between parts of the bridge.

When the operation is satisfactory on the two points just described, the null should be checked with the dummy resistor connected to the bridge through several different lengths of transmission line, to ensure that R_3 actually matches the line impedance. If the null is not complete in this test both the dummy resistor and R_3 will have to be adjusted until a good match is obtained. With care, composition resistors can be filed down to raise the resistance, so it is best to start with resistors somewhat low in value. With each change in R_3, adjust the dummy resistor to give a good null when connected directly to the bridge, then try it at the end of several different lengths of line, continuing until the null is satisfactory under all conditions of line length and frequency.

With a high-impedance voltmeter, the s.w.r. readings will closely approximate the theoretical curve of Fig 21-39. The calibration can be checked by using composition resistors as loads.

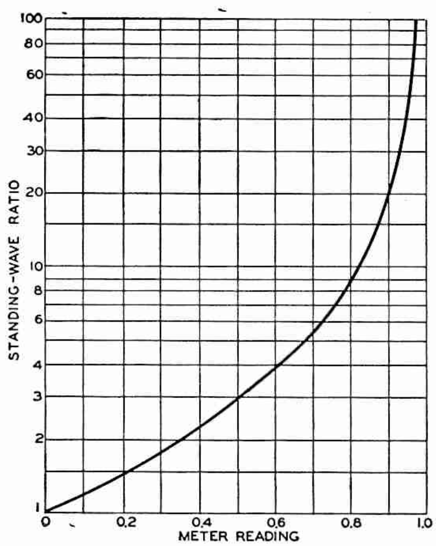


Fig. 21-39—Standing-wave ratio in terms of meter reading (relative to full scale) after setting forward voltage to full scale.

Adjust the transmitter coupling so that the bridge voltmeter reads full scale with the output terminals open, and then check the input voltage. Connect various values of resistance across the output terminals, making sure that the input voltage is readjusted to be the same in each case, and note the reading with the meter in the bridge position. This check should be made at a low frequency such as 3.5 Mc. in order to minimize the effect of reactance in the resistors. The s.w.r. is given by

$$S.W.R. = \frac{R_L}{R_0} \text{ or } \frac{R_0}{R_L}$$

where R_0 is the line impedance for which the bridge has been adjusted to null, and R_L is the resistance used as a load. Use the formula that places the larger of the two resistances in the numerator. If the readings do not correspond exactly for the same s.w.r. when appropriate resistors above and below the line impedance for which the bridge is designed are used, a possible reason is that the current taken by the voltmeter is affecting the measurements.

Using the Bridge

The operating procedure is the same whether the bridge is used for matching or for s.w.r. measurement. Apply power with the load terminals either open or shorted, and adjust the input until the bridge voltmeter reads full scale. Because the bridge operates a very low power level it may be necessary to couple it to a low-power driver stage rather than to the final amplifier. Alternatively, the plate voltage and excitation for the final amplifier may be reduced to the point where the power output is of the order of a few watts. Then connect the load and observe the voltmeter reading. For matching, adjust the matching network until the best possible null is obtained. For s.w.r. measurement, note the r.f. input voltage to the bridge after adjusting for full-scale with the load terminals open or shorted, then connect the load and readjust the transmitter for the same input voltage. The bridge voltmeter then indicates the standing-wave ratio as given by Fig. 21-39.

Antenna systems are in general resonant systems and thus exhibit a purely resistive impedance at only one frequency or over a small band of frequencies. In making bridge measurements, this will cause errors if the r.f. energy used to operate the bridge is not free from harmonics and other spurious components, such as frequencies lower than the desired operating frequency that may be fed through the final amplifier from a frequency-doubler stage. When a good null cannot be secured in, for example, the course of adjusting a matching section for 1-to-1 s.w.r., a check should be made to ensure that only the desired measurement frequency is present. An indicating-type absorption frequency meter coupled to the load usually will show whether energy on undesired frequencies is present in significant amounts. If so, additional selectivity must be used between the source of power and the measuring circuit.

Bridge for Monitoring S.W.R.

The low power level at which resistance-type bridges must operate is a disadvantage when the bridge is used as an operating adjunct — e.g., for the adjustment of matching circuits when changing bands, or for readjustment of such circuits within a band. For this purpose a bridge is needed that will carry the full power output of the transmitter without absorbing an appreciable fraction of it.

The "Monimatch" shown in Figs. 21-40 to 21-43, inclusive, is such a device. It makes use of the combined effects of inductive and capacitive coupling between the center conductor of a coaxial line and a length of wire parallel to it. When the coupled wire is properly terminated in a resistance, the voltage induced in it by power travelling along the line in one direction will be balanced out in the crystal-rectifier r.f. voltmeter

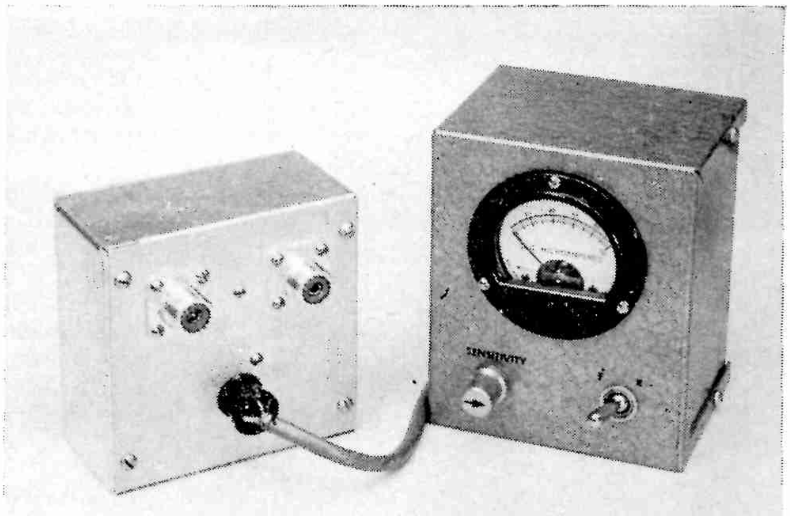


Fig. 21-40—Monimatch and indicator unit. The bridge is contained in the 2 × 4 × 4-inch aluminum box at the left. The indicator unit, made separate from the bridge in case the latter has to be installed in a spot where the meter would not be readily visible, is in a 3 × 4 × 5-inch box. Any convenient length of three-conductor cable (preferably shielded) can be used to connect the two.

circuit, but power travelling along the line in the opposite direction will cause a voltmeter indication. If the bridge is adjusted to match the Z_0 of the coaxial line being used, the voltmeter will respond only to the reflected voltage, just as in the case of the resistance-type bridges. The power consumed in the bridge is below one watt, even at the maximum power permitted amateur transmitters.

The circuit of Fig. 21-41 has two such bridge circuits so either the incident or reflected voltage can be measured.

The sensitivity of this type of bridge is proportional to frequency, so higher power is required for a given voltmeter deflection at low than at high frequencies. Typical values of "forward" rectified current (with R_1, Fig. 21-42, at zero resistance) are as follows, with a bridge adjusted for a characteristic impedance of 52 ohms:

Band	*10 Watts R.F.*	*50 Watts R.F.*
3.5 Mc.	70 μa.	250 μa.
7 Mc.	200 μa.	1 ma.
14 Mc.	750 μa.	Over 1 ma.
21–28 Mc.	Over 1 ma.	Over 1 ma.

A current of 1 ma. on 3.5 Mc. can be obtained with a power level of somewhat over 200 watts. These currents depend somewhat on the internal resistance of the d.c. instrument.

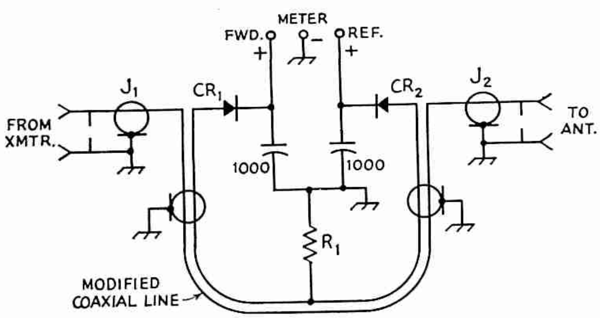


Fig. 21-41—Circuit of the Monimatch. The bridge element is a 24-inch length of coaxial cable modified as described in the text. Capacitors are disk ceramic; capacitances in μμf.

CR_1, CR_2—General-purpose germanium diodes (1N34A, etc.)

J_1, J_2—Coaxial fittings, chassis-mounting type.

R_1—Approximately 35 ohms for 52-ohm line; see text.

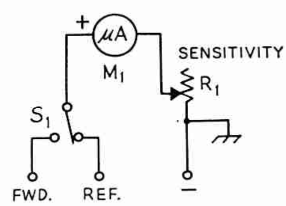


Fig. 21-42—Indicator-unit circuit. For low power and low frequencies, M_1 should be a 0-100 microammeter. A 0-1 milliammeter will suffice in other cases.

R_1—25,000-ohm control.

S_1—S.p.d.t. toggle.

The sensitivity also increases with an increase in cable length, but the cable should not be much longer than about 1/20 wavelength, to avoid standing-wave effects in the pick-up circuit. The length given in Fig. 21-41 is suitable for frequencies up to about 50 Mc. For higher frequencies the length should be decreased in proportion to the wavelength. This reduces the sensitivity considerably at the lower frequencies, so it is advisable to make separate units for v.h.f. and the frequencies below 30 Mc.

The additional conductor in the bridge shown in the photographs is a length of No. 30 enameled wire. To insert it under the cable shield, first loosen the braid by bunching it from the ends toward the center. Punch a small hole about ½ inch from each end of the braid and insert the end of the wire through one hole, then work it under the braid until it can be pulled out through the other hole. Next, smooth out the braid to its original length, being careful not to apply so much pressure that the enamel on the wire is scratched. Then open a small hole in the braid at the exact center of the length and fish enough of the No. 30 wire through to make the connection for R_1, again being careful about scraping the enamel off. Check with an ohmmeter to make sure the wire and braid are not short circuited. Then wrap the ends of the braid with

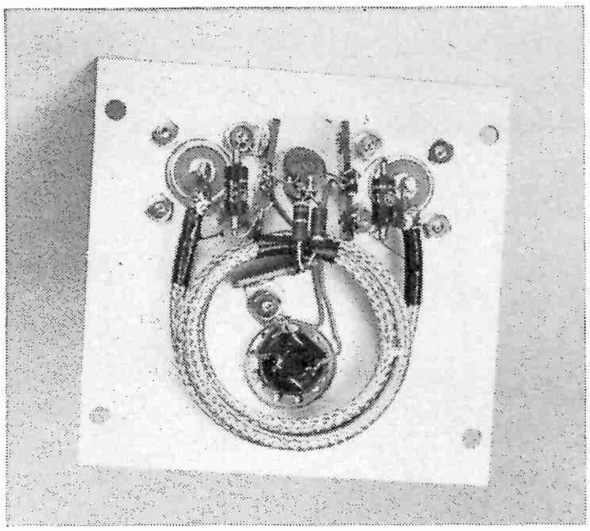


Fig. 21-43—Constructional details of the Monimatch (Fig. 21-40). This unit uses RG-58/U (52-ohm) cable, formed into several circular turns so the center where the tap for R_1 is taken off will be close to the input and output connectors. The crystal diodes are mounted on tie points alongside the coax fittings so leads are kept as short as possible. The terminating resistor R_1 consists of two resistors (47 and 150 ohms) in parallel to give a resistance of approximately 35 ohms. The socket for d.c. connections to the indicator unit is an Amphenol 71-4S (71-3S can be substituted). Outside braid of the cable is spot soldered between adjacent turns in several places for mechanical support and to ensure good grounding.

a turn or two of bare wire to prevent fraying and apply a drop or two of solder. The completed assembly may then be wound in a circle or other form that will bring the center connection near the two ends, and finally installed as shown in Fig. 21-43.

With heavier cable than the RG-58/U used in the unit shown it will probably be necessary to use a larger box. RG-58/U is rated for 430 watts of r.f. up to 30 Mc. and, RG-59/U for 680 watts. For higher powers RG-8/U or RG-11/U should be used. An example of construction using heavier cable is shown in the section on transmission lines. Aside from power, the type of cable should be chosen to match the characteristic impedance of the line with which the Monimatch is to be used.

A dummy antenna of the same resistance as the Z_0 of the line should be used to adjust R_1 (Fig. 21-41). A suitable dummy may be made by connecting four 220-ohm 1-watt composition resistors in parallel for 52-ohm line (or four 300-ohm resistors for 75-ohm line). Make the connecting leads as short as possible. The transmitter may be used as a source of power if its output can be reduced to about 4 watts, or a 40-watt lamp may be connected in series in the line from the transmitter to the bridge if the transmitter power cannot be reduced below 50 watts. With power applied (preferably at 28 Mc.) through J_1 and the dummy connected to J_2, try values for R_1 until the meter reading is zero with S_1 in the "reflected" position. It is best to start with the resistance a little high (a few trials will show which way to go) and then try various values of resistance in parallel until a good null reading is secured. The final value should lie between the limits of 25 and 100 ohms. Finally, reverse the transmitter and load connections, when a good null should be obtained with the switch in the "forward" position. The "forward" and "reflected" readings should be substantially identical both ways if the construction is symmetrical.

With S_1 in the "forward" position the meter gives a relative indication of power output, and thus is useful for transmitter tuning. With S_1 in the "reflected" position the meter reading will be zero when the line is properly matched.

Impedance Bridge

The bridge shown in Figs. 21-44 to 21-46, inclusive, uses the basic circuit of Fig. 21-35B and incorporates a "differential" capacitor to obtain an adjustable ratio. When a resistive load of unknown value is connected in place of R_L, the C_1/C_2 ratio may be varied to attain a balance, as indicated by a null reading. The capacitor settings can be calibrated in terms of resistance at R_L, so the unknown value can be read off the calibration.

The differential capacitor consists of two identical capacitors on the same shaft, arranged so that when the shaft is rotated to increase the capacitance of one unit, the capacitance of the other decreases. The practical circuit of the bridge is given in Fig. 21-45. Satisfactory operation hinges on observing the same constructional precautions as in the case of the s.w.r. bridge. Although a high-impedance voltmeter is not

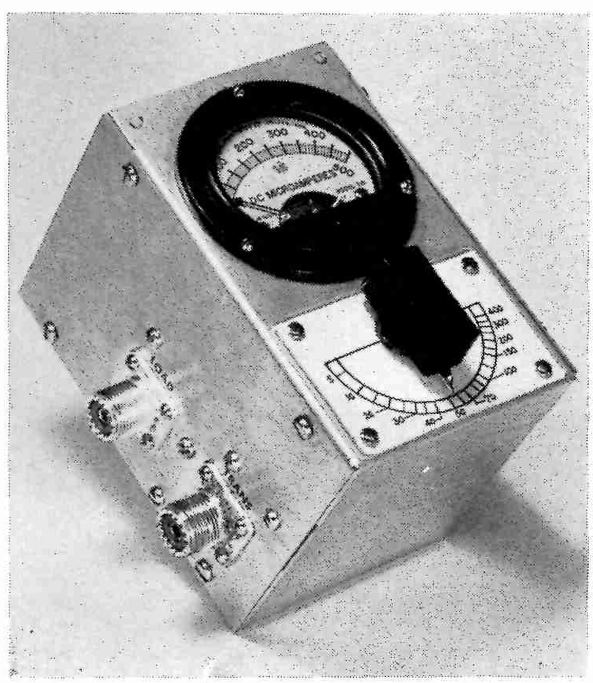


Fig. 21-44—An *RC* bridge for measuring unknown values of impedance. The bridge operates at an r.f. input voltage level of about 5 volts. The aluminum box is 4 by 5 by 6 inches.

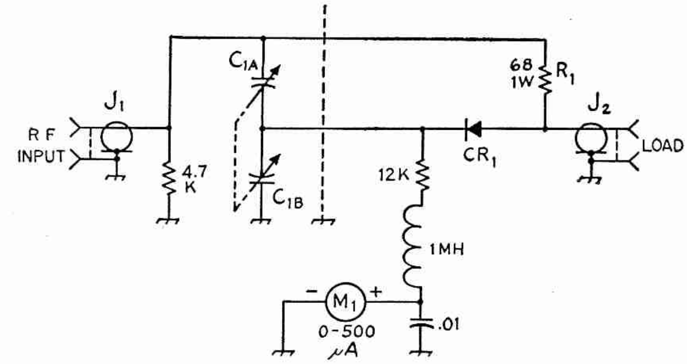


Fig. 21-45—Circuit of the impedance bridge. Resistors are composition, ½ watt except as noted. Fixed capacitors are ceramic.

C_1—Differential capacitor, 11-161 μμf. per section (Millen 28801).

CR_1—Germanium diode (1N34, 1N48, etc.).

J_1, J_2—Coaxial connectors, chassis type.

M_1—0-500 microammeter.

essential, since the bridge is always adjusted for a null, the use of such a voltmeter is advisable because its better linearity makes the actual null settings more accurately observable.

With the circuit arrangement and capacitor shown, the useful range of the bridge is from about 5 ohms to 400 ohms. The calibration is such that the percentage accuracy of reading is approximately constant at all parts of the scale. The midscale value is in the range 50–75 ohms, to correspond to the Z_0 of coaxial cable. The reliable frequency range of the bridge includes all amateur bands from 3.5 to 54 Mc.

Checking and Calibration

A bridge constructed as shown in the photographs should show a complete null at all frequencies within the range mentioned above when a 50-ohm "dummy" load of the type described earlier in connection with the s.w.r. bridge is connected to the load terminals. The bridge may be calibrated by using a number of ½-watt 5% tolerance composition resistors of different values in the 5–400 ohm range as loads, in each case balancing the bridge by adjusting C_1 for a null reading on the meter. The leads between the test resistor and J_2 should be as short as possible, and the calibration preferably should be done in the 3.5-Mc. band where stray inductance and capacitance will have the least effect.

Using the Bridge

Strictly speaking, a simple bridge can measure only purely resistive impedances. When the load is a pure resistance, the bridge can be balanced to a good null (meter reading zero). If the load has a reactance component the null will not be complete; the higher the ratio of reactance to resistance in the load the poorer the null reading. The operation of the bridge is such that when an exact null cannot be secured, the readings approximate the resistive component of the load for very low values of impedance, and approximate the total impedance at very high values of impedance. In the mid-range the approximation to either is poor, for loads having considerable reactance.

In using the bridge for adjustment of matching networks C_1 is set to the desired value (usually the Z_0 of the coaxial line) and the matching network is then adjusted for the best possible null.

PARALLEL-CONDUCTOR LINES

Bridge measurements made directly on parallel-conductor lines are frequently subject to considerable error because of "antenna" currents flowing on such lines. These currents, which are either induced on the line by the field around the antenna or coupled into the line from the transmitter by stray capacitance, are in the same phase in both line wires and hence do not balance out like the true transmission-line currents. They will nevertheless actuate the bridge voltmeter, causing an indication that has no relationship to the standing-wave ratio.

S.W.R. Measurements

The effect of "antenna" currents on s.w.r.

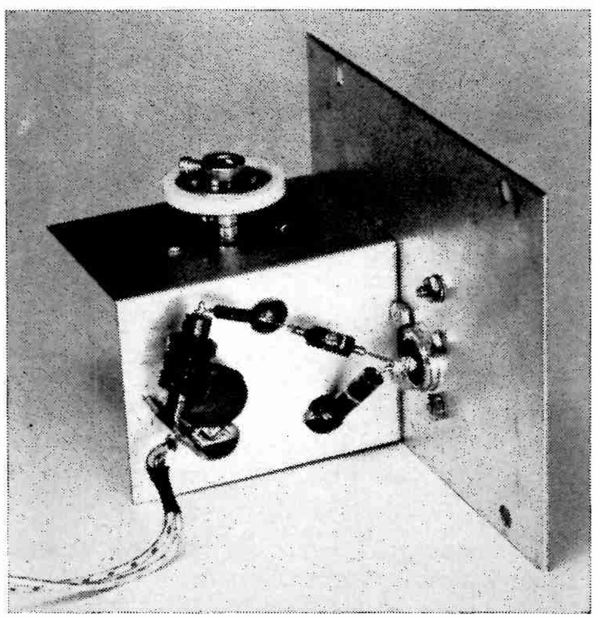


Fig. 21-46—All components except the meter are mounted on one of the removable sides of the box. The variable capacitor is mounted on an L-shaped piece of aluminum (with half-inch lips on the inner edge for bolting to the box side) 2 inches wide, 2¼ inches high and 2¾ inches deep, to shield the capacitor from the other components. The terminals project through holes as shown, with associated components mounted directly on them and the load connector, J_2. Since the rotor of C_1 must not be grounded, the capacitor is operated by an extension shaft and insulated coupling.

The lead from J_1 to C_{1A} should go directly from the input connector to the capacitor terminal (lower right) to which the 68-ohm resistor is attached. The 4700-ohm resistor is soldered across J_1.

measurements can be largely overcome by using a coaxial bridge and coupling it to the parallel-conductor line through a properly designed impedance-matching circuit. A suitable circuit is given in Fig. 21-47. An antenna coupler can be used for the purpose. In the balanced tank circuit the "antenna" or parallel components on the line tend to balance out and so are not passed on to the s.w.r. bridge. It is essential that L_1 be coupled to a "cold" point on L_2 to minimize capacitive coupling, and also desirable that the center of L_2 be grounded to the chassis on which the circuit is mounted. Values should be such that L_2C_2 can be tuned to the operating frequency and that L_1 provides sufficient coupling, as described in the transmission-line chapter. The measurement procedure is as follows:

Connect a noninductive (½- or 1-watt carbon) resistor, having the same value as the characteristic impedance of the parallel-conductor line, to the "line" terminals. Apply r.f. to the bridge, adjust the taps on L_2 (keeping them equidistant

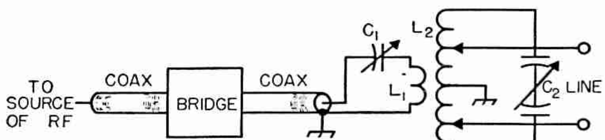


Fig. 21-47—Circuit for using coaxial s.w.r. bridge for measurements on parallel-conductor lines. Values of circuit components are idential with those used for the similar "antenna-coupler" circuit discussed in the chapter on transmission lines.

from the center), while varying the capacitance of C_1 and C_2, until the bridge shows a null. After the null is obtained, do not touch any of the circuit adjustments. Next, short-circuit the "line" terminals and adjust the r.f. input until the bridge voltmeter reads full scale. Remove the short-circuit and test resistor, and connect the regular transmission line. The bridge will then indicate the standing-wave ratio on the line.

The circuit requires rematching, with the test resistor, whenever the frequency is changed appreciably. It can, however, be used over a portion of an amateur band without readjustment, with negligible error.

Impedance Measurements

Measurements on parallel-conductor lines and other balanced loads can be made with the impedance bridge previously described by using a balun of the type shown schematically in Fig. 21-48. This is

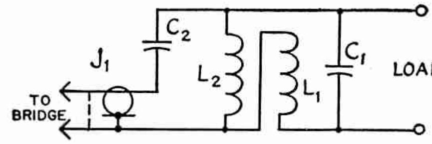


Fig. 21-48—Tuned balun for coupling between balanced and unbalanced lines. L_1 and L_2 should be built as a bifilar winding to get as tight coupling as possible between them. Typical constants are as follows:

Freq., Mc.	L_1, L_2	C_1	C_3
28	3 turns each on 2-inch form, equally spaced over 7/16 inch, total.	4 μμf.	420 μμf.
14	Same as 28 Mc.	39 μμf.	0.0015 μf.
7	8 turns of 150-ohm Twin-Lead, no spacing between turns, on 2¾-inch dia. form.	None	0.001 μf.
3.5	Same as 7 Mc.	62 μμf.	0.0045 μf.

Capacitors in unit shown in Fig. 21-49 are NPO disk ceramic. Units may be paralleled to obtain proper capacitance.

an autotransformer having a 2-to-1 turns ratio and thus provides a 4-to-1 step-down in impedance from a balanced load to the output circuit of the bridge, one side of which is grounded. L_1 and L_2 must be as tightly coupled as possible, and so should be constructed as a bifilar winding. The circuit is resonated to the operating frequency by C_1, and C_2 serves to tune out any residual reactance that may be present because the coupling between the two coils is not quite perfect.

Fig. 21-49 shows one method of constructing such a balun. The two interwound coils are made as nearly identical as possible, the "finish" end of the first being connected to the "start" end of the second through a short lead running under the winding inside the form. The center of this lead is tapped to give the connection to the shell side of the coax connector. C_1 should be chosen to resonate the circuit at the center of the band for which the balun is designed with J_1 open, and C_2 should resonate the circuit to the same frequency with both J_1 and the "load" terminals shorted. The frequency checks may be made with a grid-dip meter. (For further details, see *QST* for August, 1955.)

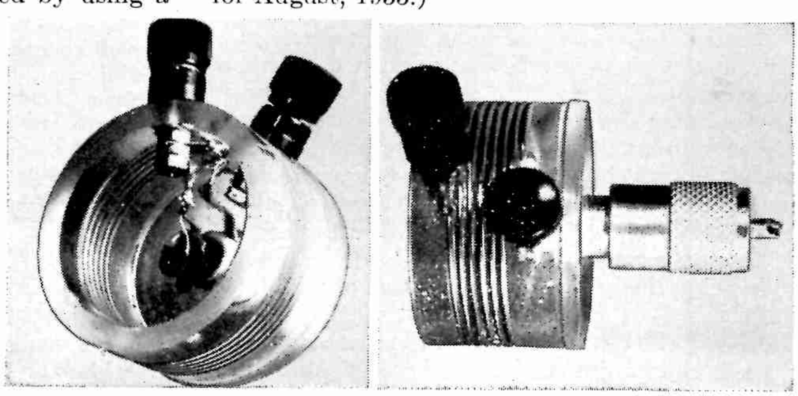


Fig. 21-49—Balun construction (W2ZE). 150-ohm Twin-Lead may be used for the bifilar winding in place of the ordinary wire shown. Symmetrical construction with tight coupling between the two coils is essential to good performance.

With the balun in use the bridge is operated in the same way as previously described, except that all impedance readings must be multiplied by 4. The balun also may be used for s.w.r. measurements on 300-ohm line in conjunction with a resistance bridge designed for 75-ohm coaxial line.

The "Twin-Lamp"

A simple and inexpensive standing-wave indicator for 300-ohm line is shown in Fig. 21-50. It consists only of two flashlight lamps and a short piece of 300-ohm line. When laid flat against the line to be checked, the coupling is such that outgoing power on the line causes the lamp nearest to the transmitter to light, while reflected power lights the lamp nearest the load. The power input to the line should be adjusted to make the lamp nearest the transmitter light to full brilliance. If the line is properly matched and the reflected power is very low, the lamp toward the antenna will be dark. If the s.w.r. is high, the two lamps will glow with practically equal brilliance.

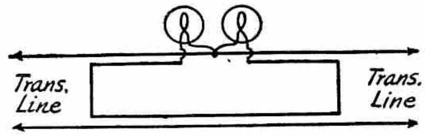


Fig. 21-51—Wiring diagram of the "twin-lamp" standing-wave indicator.

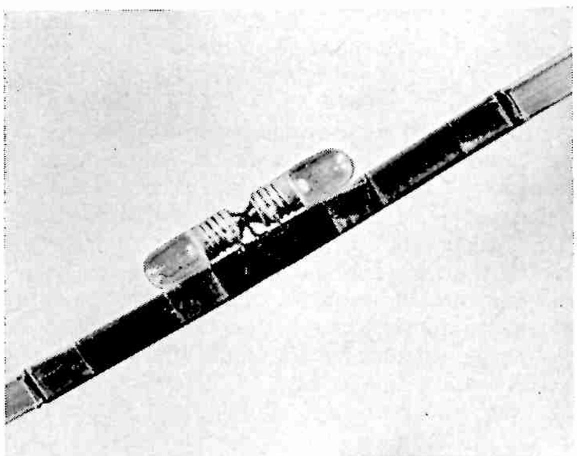


Fig. 21-50—The "twin-lamp" standing-wave indicator mounted on 300-ohm Twin-Lead. Scotch tape is used for fastening.

The length of the piece of 300-ohm line needed in the twin-lamp will depend on the transmitter power and the operating frequency. A few inches will suffice with high power at high frequencies, while a foot or two may be needed with low power and at low frequencies.

In constructing the twin-lamp, cut one wire in the exact center of the piece and peel the ends back on either side just far enough to provide leads to the flashlight lamps. Remove about ¼ inch of insulation from one wire of the main transmission line at some convenient point. Use the lowest-current flashlight bulbs or dial lamps available. Solder the tips of the bulbs together and connect them to the bare point in the transmission line, then solder the ends of the cut portion of the short piece to the shells of the bulbs. Figs. 21-50 and -51 should make the construction clear.

The twin-lamp will respond to "antenna" currents on the transmission line in much the same way as the bridge circuits discussed earlier. There is therefore always a possibility of error in its indications, unless it has been determined by other means that "antenna" currents are inconsequential compared with the true transmission-line current.

The Oscilloscope

The **cathode-ray oscilloscope** gives a visual representation of signals at both audio and radio frequencies and can therefore be used for many types of measurements that are not possible with instruments of the types discussed earlier in this chapter. In amateur work, one of the principal uses of the scope is for displaying an amplitude-modulated signal so a phone transmitter can be adjusted for proper modulation and continuously monitored to keep the modulation percentage within proper limits. For this purpose a very simple circuit will suffice, and a typical circuit is described later in this section.

The versatility of the scope can be greatly increased by adding amplifiers and linear deflection circuits, but the design and adjustment of such circuits tends to be complicated if optimum performance is to be secured, and is somewhat outside the field of this section. Special components are generally required. Oscilloscope kits for home assembly are available from a number of suppliers, and since their cost compares very favorably with that of a home-built instrument of comparable design, they are recommended for serious consideration by those who have need for or are interested in the wide range of measurements that is possible with a fully equipped scope.

● CATHODE-RAY TUBES

The heart of the oscilloscope is the **cathode-ray tube,** a vacuum tube in which the electrons emitted from a hot cathode are first accelerated to give them considerable velocity, then formed into a beam, and finally allowed to strike a special translucent screen which *fluoresces,* or gives off light at the point where the beam strikes. A beam of moving electrons can be moved laterally, or **deflected,** by electric or magnetic fields, and since its weight and inertia are negligibly small, it can be made to follow instantly the variations in periodically changing fields at both audio and radio frequencies.

The electrode arrangement that forms the electrons into a beam is called the **electron gun.**

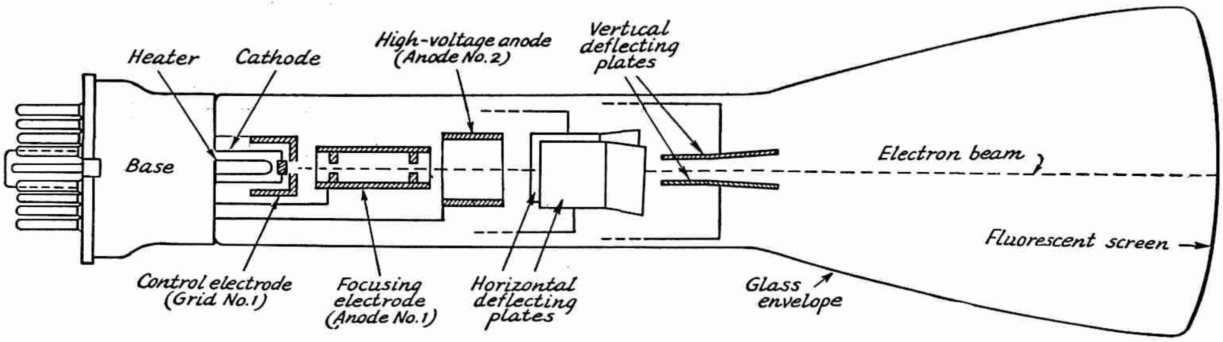


Fig. 21-52—Typical construction for a cathode-ray tube of the electrostatic-deflection type.

In the simple tube structure shown in Fig. 21-52, the gun consists of the cathode, grid, and anodes Nos. 1 and 2. The intensity of the electron beam is regulated by the grid in the same way as in an ordinary tube. Anode No. 1 is operated at a positive potential with respect to the cathode, thus accelerating the electrons that pass through the grid, and is provided with small apertures through which the electron stream passes. On emerging from the apertures the electrons are traveling in practically parallel straight-line paths. The electrostatic fields set up by the potentials on anode No. 1 and anode No. 2 form an **electron lens** system which makes the electron paths converge or focus to a point at the fluorescent screen. The potential on anode No. 2 is usually fixed, while that on anode No. 1 is varied to bring the beam into focus. Anode No. 1 is, therefore, called the **focusing electrode.**

Electrostatic deflection, the type generally used in the smaller tubes, is produced by **deflecting plates.** Two sets of plates are placed at right angles to each other, as indicated in Fig. 21-52. The fields are created by applying suitable voltages between the two plates of each pair. Usually one plate of each pair is connected to anode No. 2, to establish the polarities of the vertical and horizontal fields with respect to the beam and to each other.

Formation of Patterns

When periodically-varying voltages are applied to the two sets of deflecting plates, the path traced by the fluorescent spot forms a **pattern** that is stationary so long as the amplitude and phase relationships of the voltages remain unchanged. Fig. 21-53 shows how one such pattern is formed. The horizontal sweep voltage is assumed to have the "sawtooth" waveshape indicated. With no voltage applied to the vertical plates the trace simply sweeps from left to right across the screen along the horizontal axis $X-X'$ until the instant H is reached, when it reverses direction and snaps back to the starting point. The sine-wave voltage applied to the vertical plates similarly would trace a line along the axis $Y-Y'$ in the absence of any deflecting voltage on the horizontal plates. However, when both voltages are present the position of the spot at any instant depends upon the voltages on both sets of plates at that instant. Thus at time B the horizontal voltage has moved the spot a short distance to the right and the vertical voltage has similarly moved it upward, so that it reaches the actual position B' on the screen. The resulting trace is easily followed from the other indicated positions, which are taken at equal time intervals.

Types of Sweeps

A sawtooth sweep-voltage wave shape, such as is shown in Fig. 21-53, is called a **linear sweep,** because the deflection in the horizontal direction is directly proportional to time. If the sweep were perfect the **fly-back** time, or time taken for the spot to return from the end (H) to the beginning (I or A) of the horizontal trace, would be zero, so that the line HI would be perpendicular to the axis $Y-Y'$. Although the fly-back time cannot be made zero in practicable sweep-voltage generators it can be made quite small in comparison to the time of the desired trace AH, at least at most frequencies within the audio range. The line $H'I'$ is called the **return trace**; with a linear sweep it is less brilliant than the pattern, because the spot is moving much more rapidly during the fly-back time than during the time of the main trace.

The linear sweep shows the shape of the wave

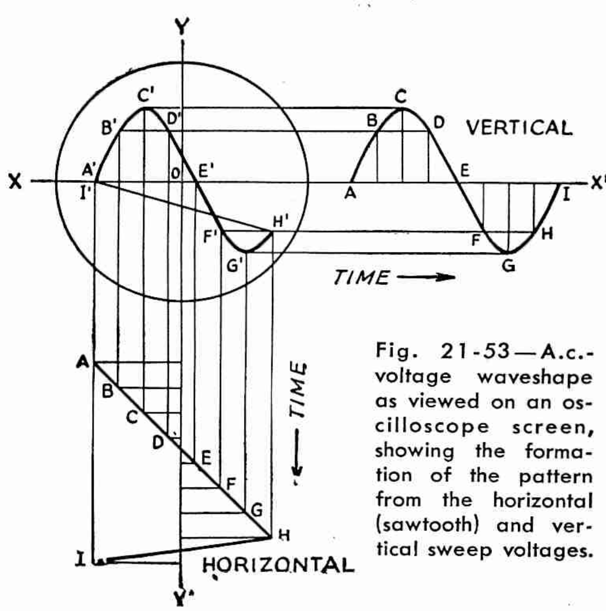


Fig. 21-53—A.c.-voltage waveshape as viewed on an oscilloscope screen, showing the formation of the pattern from the horizontal (sawtooth) and vertical sweep voltages.

in the same way that it is usually represented graphically. If the period of the a.c. voltage applied to the vertical plates is considerably less than the time taken to sweep horizontally across the screen, several cycles of the vertical or "signal" voltage will appear in the pattern.

For many amateur purposes a satisfactory horizontal sweep is simply a 60-cycle voltage of adjustable amplitude. In modulation monitoring (described in the chapter on amplitude modulation) audio-frequency voltage can be taken from the modulator to supply the horizontal sweep. For examination of audio-frequency wave forms, the linear sweep is essential. Its frequency should be adjustable over the entire range of audio frequencies to be inspected on the oscilloscope.

Lissajous Figures

When sinusoidal a.c. voltages are applied to the two sets of deflecting plates in the oscilloscope the resultant pattern depends on the relative amplitudes, frequencies and phase of the two voltages. If the ratio between the two frequencies is constant and can be expressed in integers a stationary pattern will be produced. This makes it possible to use the oscilloscope for determining an unknown frequency, provided a variable frequency standard is available, or for determining calibration points for a variable-frequency oscillator if a few known frequencies are available for comparison.

The stationary patterns obtained in this way are called **Lissajous figures.** Examples of some of the simpler Lissajous figures are given in Fig. 21-54. The frequency ratio is found by counting the number of loops along two adjacent edges. Thus in the third figure from the top there are three loops along a horizontal edge and only one along the vertical, so the ratio of the vertical frequency to the horizontal frequency is 3 to 1. Similarly, in the fifth figure from the top there are four loops along the horizontal edge and three along the vertical edge, giving a ratio of 4 to 3. Assuming that the known frequency is applied to the horizontal plates, the unknown frequency is

$$f_2 = \frac{n_2}{n_1} f_1$$

where f_1 = known frequency applied to horizontal plates,

f_2 = unknown frequency applied to vertical plates,

n_1 = number of loops along a vertical edge, and

n_2 = number of loops along a horizontal edge.

An important application of Lissajous figures is in the calibration of audio-frequency signal generators. For very low frequencies the 60-cycle power-line frequency is held accurately enough to be used as a standard in most localities. The medium audio-frequency range can be covered by comparison with the 440- and 600-cycle modulation on the WWV transmissions. An oscilloscope having both horizontal and vertical

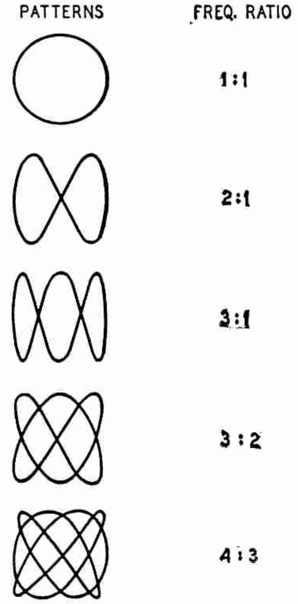


Fig. 21-54—Lissajous figures and corresponding frequency ratios for a 90-degree phase relationship between the voltages applied to the two sets of deflecting plates.

amplifiers is desirable, since it is convenient to have a means for adjusting the voltages applied to the deflection plates to secure a suitable pattern size. It is possible to calibrate over a 10-to-1 range, both upwards and downwards, from each of the latter frequencies and thus cover the audio range useful for voice communication.

Basic Oscilloscope Circuit

The essential oscilloscope circuit is shown in

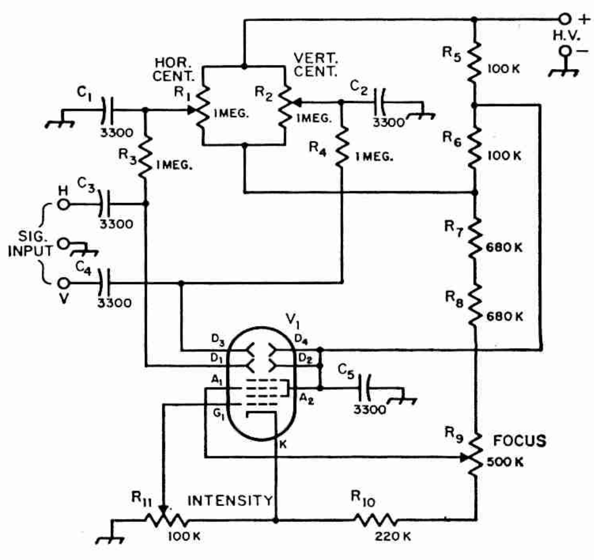


Fig. 21-55—Oscilloscope circuit for modulation monitoring. Constants are for 1500- to 2500-volt h.v. supply. For 1000-1500 volts, omit R_8 and connect the bottom end of R_7 to the top end of R_9.

C_1-C_5, inc.—3000-volt disk ceramic.

R_1, R_2, R_9, R_{11}—Volume-control type, linear taper.

R_3, R_4, R_5 R_6, R_{10}—½ watt.

R_7, R_8—1 watt.

V_1—Electrostatic-deflection cathode-ray tube, 2- to 5-inch. See tube tables for base connections and heater ratings of type chosen.

Fig. 21-55. The minimum requirements are supplying the various electrode potentials, plus controls for focusing and centering the spot on the face of the tube and adjusting the spot intensity. The circuit of Fig. 21-55 can be used with electrostatic-deflection tubes from two to five inches in face diameter, with voltages up to 2500. This includes practically all the types popular for small oscilloscopes.

The circuit has provision for introducing signal voltages to the two sets of deflecting plates. Either set of deflecting electrodes (D_1D_2, or D_3D_4) may be used for either horizontal or vertical deflection, depending on how the tube is mounted.

The high voltage may be taken from a transmitter power supply if desired. The current is only a milliampere or so. The voltage preferably should be constant, such as is obtained from a supply having a constant load — e.g., the supply for the Class C amplifier in an a.m. transmitter.

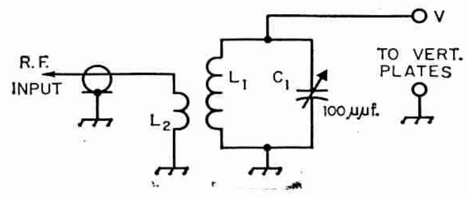
In the circuit of Fig. 21-55 the centering controls are at the full supply voltage above ground and therefore should be carefully insulated by being mounted on bakelite or similar material rather than directly on a metal panel or chassis. Insulated couplings or extension shafts should be used. The focussing control is also several hundred volts above ground and should be similarly insulated.

The tube should be protected from stray magnetic fields, either by enclosing it in an iron or steel box or by using one of the special c.r. tube shields available. If the heater transformer (or other transformer) is mounted in the same cabinet, care must be used to place it so the stray field around it does not deflect the spot. The spot cannot be focussed to a fine point when influenced by a transformer field.

Modulation Monitoring

The addition of Fig. 21–56 to the basic circuit of Fig. 21-55 provides all that is necessary for modulation checking. The r.f. from the transmitter is applied to the vertical plates through a tuned circuit L_1C_1 and link L_2. When adjusted to the transmitter operating frequency the tuned circuit furnishes ample deflection voltage even from a low-power transmitter, and C_1 can be used to control the pattern height.

Deflection voltage for the horizontal plates can be taken from the modulation transformer secondary of an a.m. transmitter, or 60-cycle deflection can be used to give a wave-envelope type pattern. In either case a maximum of about 200 volts r.m.s. will give full-width deflection. This voltage is almost independent of the size of c.r. tube used. Methods of using such a scope for modulation checking are described in the chapter on amplitude modulation.



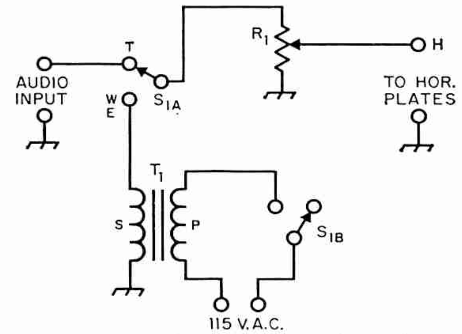


Fig. 21-56—Circuits for supplying r.f., audio, and a.c. voltages to oscilloscope deflection plates for modulation monitoring.

C_1—100-μμf. variable, receiving type.
L_1—1.75 Mc.: 30 enam. close-wound on 1-inch form, coil length ¾ inch.
3.5-8 Mc.: 30 turns No. 22 enam., close-wound on 1-inch form.
13-30 Mc.; 7 turns No. 22, spread to ¾ inch length on 1-inch form.
L_2—2 or more turns, as required for sufficient coupling, at cold end of L_1.
R_1—Volume control, 0.25 megohm or more.
S_1—D.p.d.t. switch.
T_1—Interstage audio transformer, any type. Use secondary-to-primary turns ratio of 1-to-1 to 2-to-1.

Frequency Limitations of Oscilloscopes

Most commercial or kitted oscilloscopes include vacuum-tube amplifiers between the input terminals and the deflection plates, to increase the sensitivity and usefulness of the instrument. Depending upon the construction of the amplifiers, their useful frequency range may be only as high as several hundred kc., although more expensive instruments will include amplifiers that work in the megacycle range. The operator should acquaint himself with the frequency limitations of the 'scope through study of the specifications, since attempts to pass, e.g., a 450-kc. i.f. signal through an amplifier that cuts off at 100 kc. are doomed to failure. No such frequency limits apply when the connection is made directly to the deflection plates, and consequently r.f. at 20 to 30 Mc. can be applied by the method shown in Fig. 21-56. A practical limitation will be found when r.f. from the vertical plates is (stray) capacitively coupled to the horizontal-deflection plates; this will show as a thickening of the trace. In some instances it can be reduced by r.f. bypassing of the horizontal deflection plates.

Assembling a Station

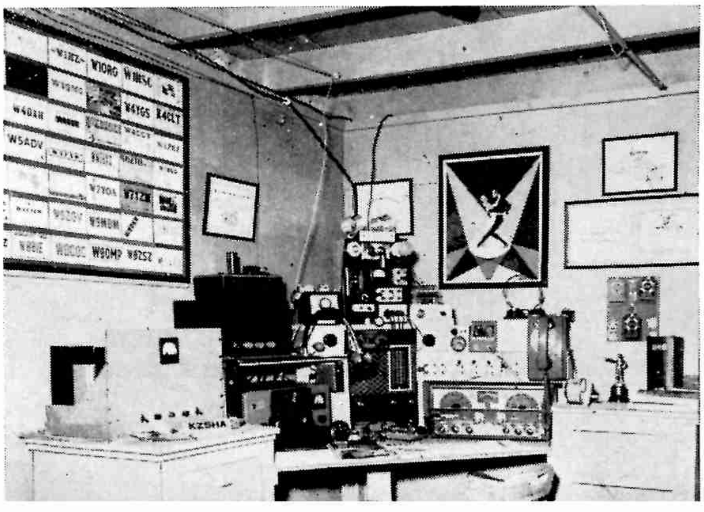
The actual location inside the house of the "shack" — the room where the transmitter and receiver are located — depends, of course, on the free space available for amateur activities. Fortunate indeed is the amateur with a separate room that he can reserve for his hobby, or the few who can have a special small building separate from the main house. However, most amateurs must share a room with other domestic activities, and amateur stations will be found tucked away in a corner of the living room, a bedroom, a large closet, or even under the kitchen stove! A spot in the cellar or the attic can almost be classed as a separate room, although it may lack the "finish" of a normal room.

Regardless of the location of the station, however, it should be designed for maximum operating convenience and safety. It is foolish to have the station arranged so that the throwing of several switches is required to go from "receive" to "transmit," just as it is silly to have the equipment arranged so that the operator is in an uncomfortable and cramped position during his operating hours. The reason for building the station as safe as possible is obvious, if you are interested in spending a number of years with your hobby!

CONVENIENCE

The first consideration in any amateur station is the operating position, which includes the operator's table and chair and the pieces of equipment that are in constant use (the receiver, send-receive switch, and key or microphone). The table should be as large as possible, to allow sufficient room for the receiver or receivers, frequency-measuring equipment, monitoring equipment, control switches, and keys and microphones, with enough space left over for the logbook, a pad and pencil, and perhaps a *large* ash tray. Suitable space should be included for radiogram blanks and a call book, if these accessories are in frequent use. If the table is small, or the number of pieces of equipment is large, it is often necessary to build a shelf or rack for the auxiliary equipment, or to mount it in some less convenient location in or under the table. If one has the facilities, a semicircular "console" can be built of wood, or a simpler solution is to use two small wooden cabinets to support a table top of wood or Masonite. A flush-type door will make an excellent table top. Home-built tables or consoles can be finished in any of the available oil stains, varnishes, paints or lacquers. Many operators use a large piece of plate glass over part of their table, since it furnishes a good writing surface and can cover miscellaneous charts and tables, prefix lists, operating aids, calendar, and similar accessories.

If the major interests never require frequent band changing, or frequency changing within a band, the transmitter can be located some distance from the operator, in a location where the meters can be observed from time to time (and the color of the tube plates noted!). If frequent band or frequency changes are a part



Here's one way to build a console. Use a 4-foot × 4-foot × ½-inch piece of plywood for a center section, and a couple of 3-drawer chests for the end sections. This gives plenty of operating space in a small area. (W5KSE, El Paso, Texas) of the usual operating procedure, the transmitter should be mounted close to the operator, either along one side or above the receiver, so that the controls are easily accessible without the need for leaving the operating position.

A compromise arrangement would place the v.f.o. or crystal-switched oscillator at the operating position and the transmitter in some convenient location not adjacent to the operator. Since it is usually possible to operate over a portion of a band without retuning the transmitter stages, an operating position of this type is an advantage over one in which the operator must leave his position to make a change in frequency.

Controls

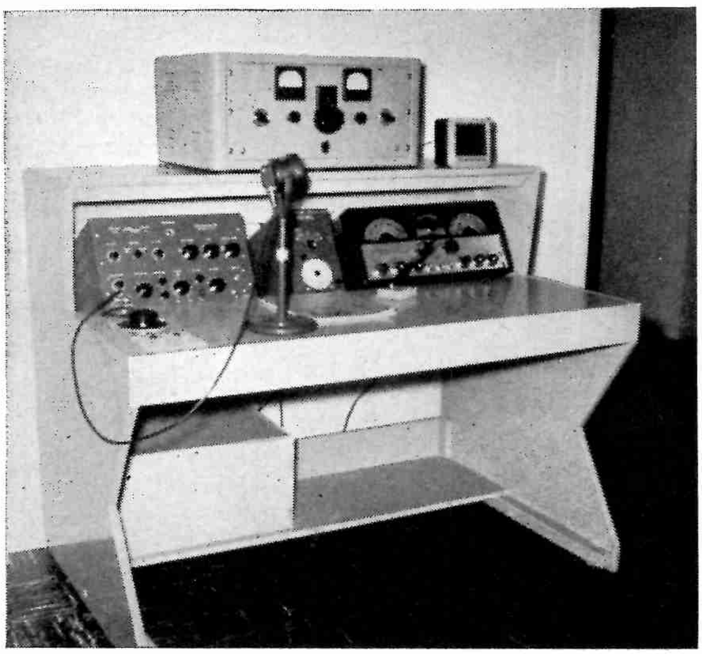
The operator has an excellent chance to exercise his ingenuity in the location of the operating controls. The most important controls in the station are the receiver tuning dial and the send-receive switch. The receiver tuning dial should be located four to eight inches above the operating table, and if this requires mounting the receiver off the table, a small shelf or bracket will do the trick. With the single exception of the amateur whose work is almost entirely in traffic or rag-chew nets, which require little or no attention to the receiver, it will be found that the operator's hand is on the receiver tuning dial most of the time. If the tuning knob is too high or too low, the hand gets cramped after an extended period of operating, hence the importance of a properly located receiver. The majority of c.w. operators tune with the left hand, preferring to leave the right hand free for copying messages and handling the key, and so the receiver should be mounted where the knob can be reached by the left hand. Phone operators aren't tied down this way, and tune the communications receiver with the hand that is more convenient.

The hand key should be fastened securely to the table, in a line just outside the right shoulder and far enough back from the front edge of the table so that the elbow can rest on the table. A good location for the semiautomatic or "bug" key is right next to the handkey, although some operators prefer to mount the automatic key in front of them on the left, so that the right forearm rests on the table parallel to the front edge.

The best location for the microphone is directly in front of the operator, so that he doesn't have to shout across the table into it, or run up the speech-amplifier gain so high that all manner of external sounds are picked up. If the microphone is supported by a boom or by a flexible "goose neck," it can be placed in front of the operator without its base taking up valuable table space.

In any amateur station worthy of the name, it should be necessary to throw no more than one switch to go from the "receive" to the "transmit" condition. In phone stations, this switch should be located where it can be easily reached by the hand that isn't on the receiver. In the case of c.w. operation, this switch is most conveniently located to the right or left of the key, although some operators prefer to have it mounted on the left-hand side of the operating position and work it with the left hand while the right hand is on the key. Either location is satisfactory, of course, and the choice depends upon personal preference. Some operators use a foot-controlled switch, which is a convenience but doesn't allow too much freedom of position during long operating periods.

If the microphone is hand-held during phone operation, a "push-to-talk" switch on the microphone is convenient, but hand-held



Here's a console that was designed with operating convenience in mind. W7EBG built it almost entirely out of ¾″ plywood, with strips of 2 × 2 along the bottom edges for caster supports. It is assembled with bolts so that it can be readily dismantled for shipping. Over-all dimensions are 48″ wide, 40½″ high, with the horizontal desk top 16″ wide and the sloping portion 15″ wide.

microphones tie up the use of one hand and are not too desirable, although they are widely used in mobile and portable work.

The location of other switches, such as those used to control power supplies, filaments, phone/c.w. change-over and the like, is of no particular importance, and they can be located on the unit with which they are associated. This is not strictly true in the case of the phone/c.w. DX man, who sometimes has need to change in a hurry from c.w. to phone. In this case, the change-over switch should be at the operating table, although the actual change-over should be done by a relay controlled by the switch.

If a rotary beam is used the control of the beam should be convenient to the operator. The direction indicator, however, can be located anywhere within sight of the operator, and does not have to be located on the operating table unless it is included with the control.

Frequency Spotting

In a station where a v.f.o. is used, or where a number of crystals are available, the operator should be able to turn on only the oscillator of his transmitter, so that he can spot accurately his location in the band with respect to other stations. This allows him to see if he has anything like a clear channel, or to see what his frequency is with respect to another station. Such a provision can be part of the "send-receive" switch. Switches are available with a center "off" position, a "hold" position on one side, for turning on the oscillator only, and a "lock" position on the other side for turning on the transmitter and antenna relays. If oscillator keying is used, the key serves the same purpose, provided a "send-receive" switch is available to turn off the high-voltage supplies and prevent a signal going out on the air during adjustment of the oscillator frequency.

For phone operation, the telegraph key or an auxiliary switch can control the transmitter oscillator, and the "send-receive" switch can then be wired into the control system so as to control the oscillator as well as the other circuits.

Comfort

Of prime importance is the comfort of the operator. If you find yourself getting tired after a short period of operating, examine your station to find what causes the fatigue. It may be that the chair is too soft or hasn't a straight back or is the wrong height for you. The key or receiver may be located so that you assume an uncomfortable position while using them. If you get sleepy fast, the ventilation may be at fault. (Or you may need sleep!)

● POWER CONNECTIONS AND CONTROL

Following a few simple rules in wiring your power supplies and control circuits will make it an easy job to change units in the station. If the station is planned in this way from the start, or if the rules are recalled when you are rebuilding, you will find it a simple matter to revise your station from time to time without a major rewiring job.

It is neater and safer to run a single pair of wires from the outlet over to the operating table or some central point, rather than to use a number of adapters at the wall outlet.

Interconnections

The wiring of any station will entail two or three common circuits, as shown in Fig. 22-3. The circuit for the receiver, monitoring equipment and the like, assuming it to be taken from a wall outlet, should be run from the wall to an inconspicuous point on the operating table, where it terminates in a multiple outlet large enough to handle the required number of plugs. A single switch between the wall outlet and the receptacle will then turn on all of this equipment at one time.

The second common circuit in the station is that supplying voltage to rectifier- and transmitter-tube filaments, bias supplies, and anything else that is not switched on and off during transmit and receive periods. The coil power for control relays should also be obtained from this circuit. The power for this circuit can come from a wall outlet or from the transmitter line, if a special one is used.

The third circuit is the one that furnishes power to the plate-supply transformers for the r.f. stages and for the modulator. (See section on Power Supplies for high-power considerations.) When it is opened, the transmitter is disabled except for the filaments, and the transmitter should be safe to work on. However, one always feels safer when working on the transmitter if he has turned off every power source.

With these three circuits established, it becomes a simple matter to arrange the station for different conditions and with new units. Anything on the operating table that runs all the time ties into the first circuit. Any new power supply or r.f. unit gets its filament power from the second circuit. Since the third circuit is controlled by the send-receive switch (or relay), any power-supply primary that is to be switched on and off for send and receive connects to circuit C.

Break-In and Push-To-Talk

In c.w. operation, "break-in" is any system that allows the transmitting operator to hear the other station's signal during the "key-up" periods between characters and letters. This allows the sending station to be "broken" by the receiving station at any time, to shorten calls, ask for "fills" in messages, and speed up operation in general. With present techniques, it requires the use of a separate receiving antenna or a "t.r. box" and, with high power, some means for protecting the receiver from the transmitter when the key is "down." Several methods, applicable to high-power stations, are described in Chapter Eight. If the transmitter is low-powered (50 watts or so), no special equipment is required except the separate receiving antenna and a receiver that "recovers" fast. Where break-in operation is used, there should be a switch on the operating table to turn off the plate supplies when adjusting the oscillator to a new frequency, although during all break-in work this switch will be closed.

"Push-to-talk" is an expression derived from the "push" switch on some microphones, and it means a phone station with a single control for all change-over functions. Strictly speaking, it should apply only to a station where this single send-receive switch must be held in place during transmission periods, but any fast-acting switch will give practically the same effect. A control switch with a center "off" position, and one "hold" and one "lock" position, will give more flexibility than a straight "push" switch. The one switch must control the transmitter power supplies, the receiver "on-off" circuit and, if one is used, the antenna change-over relay. The receiver control is necessary to disable its output during transmit periods, to avoid acoustic feedback.

Switches and Relays

It is dangerous to use an overloaded switch in the power circuits. After it has been used for some time, it may fail, leaving the power on the circuit even after the switch is thrown to the "off" position. For this reason, large switches, or relays with adequate ratings, should be used to control the plate power. Relays are rated by coil voltages (for their control circuits) and by their contact current and voltage ratings. Any switch or relay for the power-control circuits of an amateur station should be conservatively rated; overloading a switch or relay is very poor economy. Switches rated at 20 amperes at 125 volts will handle the switching of circuits at the kilowatt level, but the small toggle switches rated 3 amperes at 125 volts should be used only in circuits up to about 150 watts.

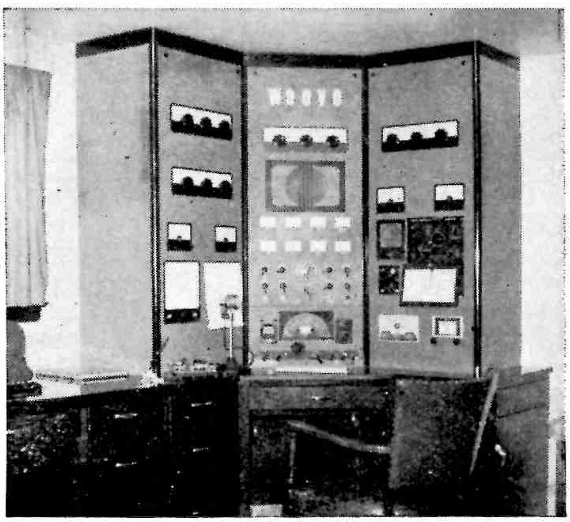
When relays are used, the send-receive switch closes the circuit to their coils, thus closing the relay contacts. The relay contacts are in the power circuit being controlled, and thus the switch handles only the relay-coil current. As a consequence, this switch can have a low current rating.

SAFETY

Of prime importance in the layout of the station is the personal safety of the operator and of visitors, invited or otherwise, during normal operating practice. If there are small children in the house, every step must be taken to prevent their accidental contact with power leads of any voltage. A locked room is a fine idea, if it is possible, otherwise housing the transmitter and power supplies in metal cabinets is an excellent, although expensive, solution. Lacking a metal cabinet, a wooden cabinet or a wooden framework covered with wire screen is the next-best solution. Many stations have the power supplies housed in metal cabinets in the operating room or in a closet or basement, and this cabinet or entry is kept locked — with the key out of reach of everyone but the operator. The power leads are run through conduit to the transmitter, using ignition cable for the high-voltage leads. If the power supplies and transmitter are in the same cabinet, a lock-type main switch for the incoming line power is a good precaution.

A simple substitute for a lock-type main switch is an ordinary line plug with a short connecting wire between the two pins. By wiring a female receptacle in series with the main power line in the transmitter, the shorting plug will act as the main safety lock. When the plug is removed and hidden, it will be impossible to energize the transmitter, and a stranger or child isn't likely to spot or suspect the open receptacle.

An essential adjunct to any station is a **shorting stick** for discharging any high voltage to ground before any work is done in the transmitter. Even if interlocks and power-supply bleeders are used, the failure of one or more of these components may leave the transmitter in a dangerous condi-



This neat "built-in" installation features separate finals and exciters for each band, along with room for receiver, frequency meter, oscilloscope, Q multiplier and v.h.f. converter. All units are mounted on the three large panels; the panels are hinged at the bottom so that they can be lowered for service work on the individual units. A common power supply is used, and band-changing consists of turning on the filaments in the desired r.f. section. (W9OVO, Sturgeon Bay, Wisc.)

tion. The shorting stick is made by mounting a small metal hook, of wire or rod, on one end of a dry stick or bakelite rod. A piece of ignition cable or other well-insulated wire is then run from the hook on the stick to the chassis or common ground of the transmitter, and the stick is hung alongside the transmitter. Whenever the power is turned off in the transmitter to permit work on the rig, the shorting stick is first used to touch the several high-voltage leads (plate r.f. choke, filter capacitor, tube plate connection, etc.) to insure that there is no high voltage at any of these points. This simple device has saved many a life. Use it!

Fusing

A minor hazard in the amateur station is the possibility of fire through the failure of a component. If the failure is complete and the component is large, the house fuses will generally blow. However, it is unwise and inconvenient to depend upon the house fuses to protect the lines running to the radio equipment, and every power supply should have its primary circuit individually fused, at about 150 to 200 per cent of the maximum rating of the supply. Circuit breakers can be used instead of fuses if desired.

Wiring

Control-circuit wires running between the operating position and a transmitter in another part of the room should be hidden, if possible. This can be done by running the wires under the floor or behind the base molding, bringing the wires out to terminal boxes or regular wall fixtures. Such construction, however, is generally only possible in elaborate installations, and the average amateur must content himself with trying to make the wires as inconspicuous as possible. If several pairs of leads must be run from the operating table to the transmitter, as is generally the case, a single piece of rubber- or vinyl-covered multiconductor cable will always look neater than several pieces of rubber-covered lamp cord, and it is much easier to sweep around or dust.

The antenna wires always present a problem, unless coaxial-line feed is used. Open-wire line from the point of entry of the antenna line should always be arranged neatly, and it is generally best to support it at several points. Many operators prefer to mount any antenna-tuning assemblies right at the point of entry of the feedline, together with an antenna changeover relay (if one is used), and then the link from the tuning assembly to the transmitter can be made of inconspicuous coaxial line. If the transmitter is mounted near the point of entry of the line, it simplifies the problem of "What to do with the feeders?"

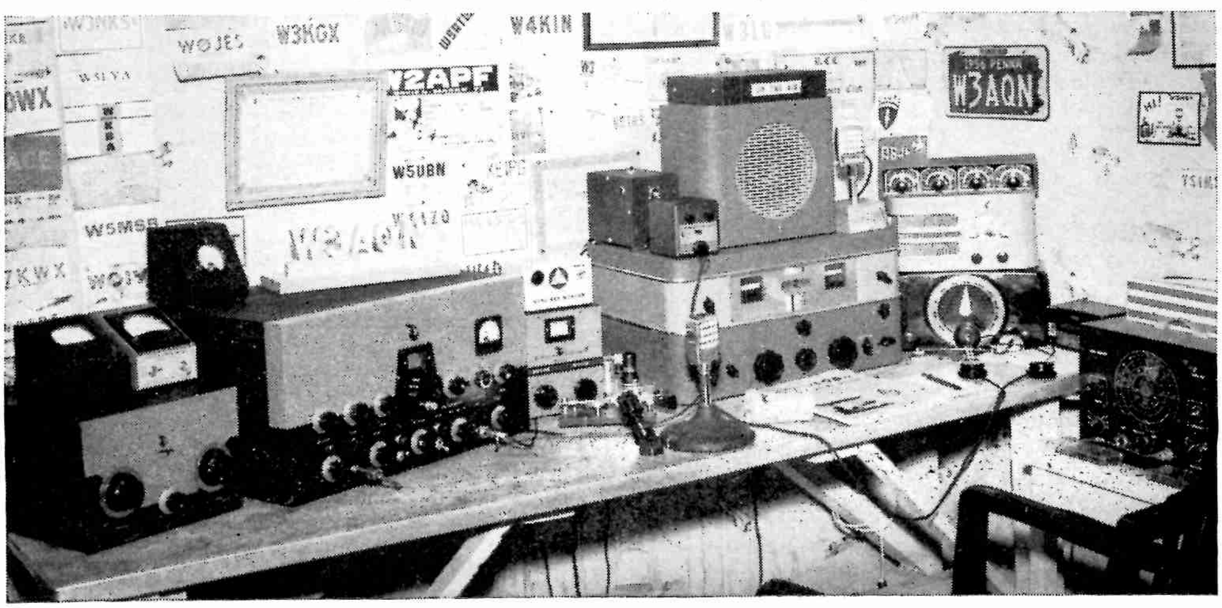
Lightning Protection

The antenna system usually associated with amateur radio equipment is most vulnerable to lightning due to its height and length. To validate one's insurance, the antenna installation must comply with the National Board of Fire Underwriters Electrical Code which says:

> *Lightning Arresters — Transmitting Stations.* Except where protected by a continuous metallic shield (coax) which is permanently and effectively grounded, or the antenna is permanently and effectively grounded, each conductor of a lead-in for outdoor antenna shall be provided with a lightning arrester or other suitable means which will drain static charges from the antenna system.

If coaxial line is used, compliance with the above is readily achieved by grounding the shield of the coax at the point where it is nearest to the ground outside the house. Use a heavy wire — the aluminum wire sold for grounding TV antennas is good. If the cable can be run underground, a grounding stake should be located at the point where the cable enters the ground, at the an-

A neat operating bench can be built from wood and covered with linoleum. There is enough room on the table shown here to house the transmitter, receiver, and numerous adjuncts and accessories. Interconnecting wiring is run behind the units or underneath the table. (W3AQN, York, Pa.)



tenna end. The grounding stake, to be effective in soils of average conductivity, should be not less than 10 feet long and, if possible, plated with a metal that will not corrode in the local soil. Making connection to the outside of the outer conductor of the coaxial line will normally have no effect on the s.w.r. in the line, and consequently it can be done at any point or points.

Open-wire or Twin-Lead transmission lines can be protected by installing a spark gap such as the one sketched in Fig. 22-1. The center contact should be grounded with a No. 4 or larger wire. The gaps can be made from ⅛ × ½-inch flat brass rod shaped as shown, and the gaps should be set sufficiently far apart to prevent flash-over during normal operation of the transmitter. Depending upon the power of the transmitter and the s.w.r. pattern on the line, the gap may run anything from 1/32 to 3/16 inch. It may spark intermittently when a thunderstorm is building up or is in the general area.

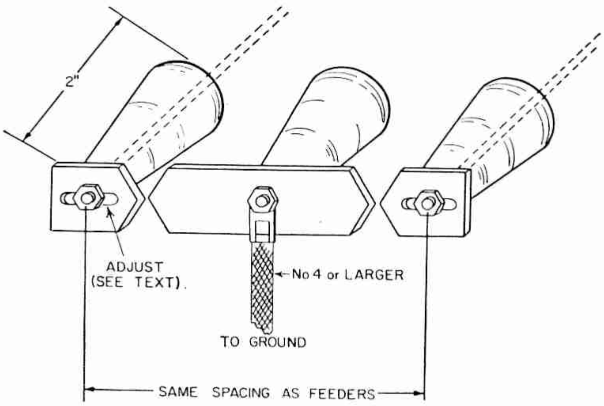


Fig. 22-1—A simple lightning arrester made from three stand-off or feed-through insulators and sections of brass or copper strap. It should be installed in the open-wire or Twin-Lead line at the point where it is nearest the ground outside the house. The heavy ground lead should be as short and direct as possible.

Rotary beams using a T or gamma match and with each element connected to the boom will usually be grounded through the supporting metal tower. If the antenna is mounted on a wooden pole or on the top of the house, a No. 4 or larger wire should be connected from the beam to the ground by the shortest and most direct route possible, using insulators where the wire comes close to the building. From a lightning-protection standpoint, it is desirable to run the coaxial and control lines from a beam down a metal tower and underground to the shack. If the tower is well grounded and the antenna is higher than any surrounding objects, the combination will serve well as a lightning rod.

The sole purpose of lightning rods or grounded roofs is to protect a building in case a lightning stroke occurs; there is no accepted evidence that any form of protection can prevent a stroke.*

Experiments have indicated that a high vertical conductor will generally divert to itself direct hits that might otherwise fall within a cone-shaped space of which the apex is the top of the conductor and the base a circle of radius approximately two times the height of the conductor. Thus a radio mast may afford some protection to low adjacent structures, but only when low-impedance grounds are provided.

Underwriters' Code

The National Electrical Safety Code, Pamphlet 70, Standard of the National Board of Fire Underwriters, deals with electric wiring and apparatus. The Code was set up to protect persons and buildings from the electrical hazards arising from the use of electricity, radio, etc. Article 810 is entitled "Radio Equipment." The scope of this article, section 8101, says, "The article applies to radio and television receiving equipment and to amateur radio transmitting equipment, but not to the equipment used in carrier-current operation."

The Board of Fire Underwriters sets up the code as a minimum standard for good practice. Most cities adopt the code, or parts of it, either entirely or with certain amendments which may apply to that particular city. It is up to the city to enforce these rules. When a violation is reported, periodic checks are made by an inspector until a correction is made and to insure

* See "Code for Protection Against Lightning," *National Bureau of Standards Handbook 46*, for sale by the Superintendent of Documents, Washington 25, D. C.

In this station arrangement, eight small panels near the front of the table carry the auxiliary gear. From left to right: (1) loud speaker with selector switch to receivers or monitor; (2) conelrad receiver and automatic transmitter disabler; (3) Monimatch; (4) antenna selector switch; (5) intercom to other rooms in house; (6) station control switch; (7) beam rotator control; (8) transmission timer and monitor. All eight accessory units are completely enclosed in perforated aluminum and are plug in. (K9HGJ, Milwaukee, Wisc.)

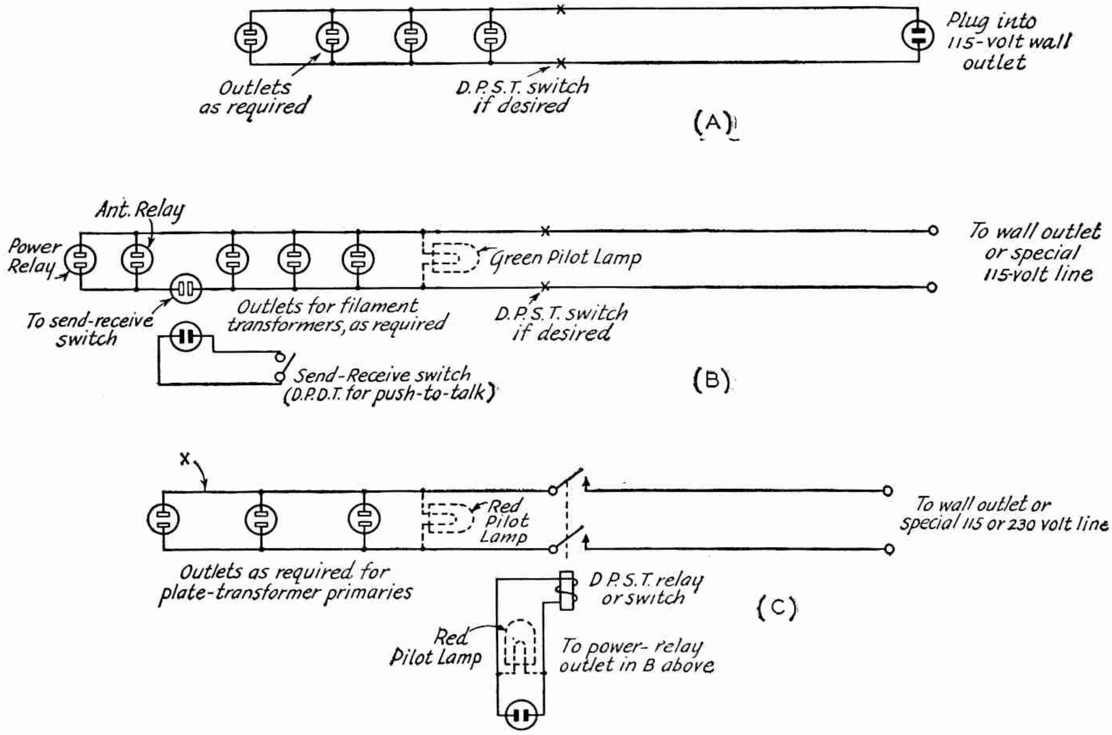


Fig. 22-2—Power circuits for a high-power station. A shows the outlets for the receiver, monitoring equipment, speech amplifier and the like. The outlets should be mounted inconspicuously on the operating table. B shows the transmitter filament circuits and control-relay circuits, if the latter are used. C shows the plate-transformer primary circuits, controlled by the power relay. Where 230- and 115-volt primaries are controlled simultaneously, point "X" should connect to the "neutral" or common. A heavy-duty switch can be used instead of the relay, in which case the antenna relay would be connected in circuit C. If 115-volt pilot lamps are used, they can be connected as shown. Lower-voltage lamps must be connected across suitable windings on transformers. With "push-to-talk" operation, the "send-receive" switch can be a d.p.d.t. affair, with the second pole controlling the "on-off" circuit of the receiver.

against future recurrence. The National Electric Code is only a minimum standard, and compliance with its rules will assure less operating failures and hazards, and greater safety.

The pamphlet is available by writing the National Board of Fire Underwriters at 85 John Street, New York 38, N. Y. Ask for No. 70.

Parts of the Underwriters' Code deal with power wiring and, in addition to the requirement of the use of Underwriters Laboratory approved materials and fittings, have the following to say of direct interest to amateurs:

"All switches shall indicate clearly whether they are open or closed.

"All (switch) handles throughout a system . . . shall have uniform open and closed positions.

". . . supply circuits shall not be designed to use the grounds normally as the sole conductor for *any part* of the circuit."

The latter means that wire conductor should be used for all parts of the power circuit. Dependence should not be placed on water pipes, etc., as one side of a circuit.

BCI and TVI

Every amateur has the obligation to make sure that the operation of his station does not, because of any shortcomings in equipment, cause interference with other radio services. It is unfortunately true that much of the interference that amateurs cause to broadcast and television reception is directly the fault of BC and TV receiver construction. Nevertheless, the amateur can and should help to alleviate interference even though the responsibility for it does not lie with him.

Successful handling of interference cases requires winning the listener's cooperation. Here are a few pointers on how to go about it.

Clean House First

The first step obviously is to make sure that the transmitter has no radiations outside the bands assigned for amateur use. The best check on this is your own a.m. or TV receiver. It is always convincing if you can demonstrate that you do not interfere with reception in your own home.

Don't Hide Your Identity

Whenever you make equipment changes — or shift to a hitherto unused band or type of emission — that might be expected to change the interference situation, check with your neighbors. If no one is experiencing interference, so much the better; it does no harm to keep the neighborhood aware of the fact that you are operating without bothering anyone.

Should you change location, announce your presence and conduct occasional tests on the air, requesting anyone whose reception is being spoiled to let you know about it so steps may be taken to eliminate the trouble.

Act Promptly

The average person will tolerate a limited amount of interference, but the sooner you take steps to eliminate it, the more agreeable the listener will be; the longer he has to wait for you, the less willing he will be to cooperate.

Present Your Story Tactfully

When you interfere, it is natural for the complainant to assume that your transmitter is at fault. If you are certain that the trouble is not in your transmitter, explain to the listener that the reason lies in the receiver design, and that some modifications may have to be made in the receiver if he is to expect interference-free reception.

Arrange for Tests

Most listeners are not very competent observers of the various aspects of interference. If at all possible, enlist the help of another amateur and have him operate your transmitter while you see for yourself what happens at the affected receiver.

In General

In this "public relations" phase of the problem a great deal depends on your own attitude. Most people will be willing to meet you half way, particularly when the interference is not of long standing, if you as a person make a good impression. Your personal appearance is important. So is what you say about the receiver — no one takes kindly to hearing his possessions derided. If you discuss your interference problems on the air, do it in a constructive way — one calculated to increase listener cooperation, not destroy it.

Interference With Standard Broadcasting

Interference with a.m. broadcasting usually falls into one or more rather well-defined categories. An understanding of the general types of interference will avoid much cut-and-try in finding a cure.

Transmitter Defects

Out-of-band radiation is something that must be cured at the transmitter. Parasitic oscillations are a frequently unsuspected source of such radiations, and no transmitter can be considered satisfactory until it has been thoroughly checked for both low- and high-frequency parasitics. Very often parasitics show up only as transients, causing key clicks in c.w. transmitters and "splashes" or "burps" on modulation peaks in a.m. transmitters. Methods for detecting and eliminating parasitics are discussed in the transmitter chapter.

In c.w. transmitters the sharp make and break that occurs with unfiltered keying causes transients that, in theory, contain frequency components through the entire radio spectrum. Practically, they are often strong enough in the immediate vicinity of the transmitter to cause serious interference to broadcast reception. Key clicks can be eliminated by the methods detailed in the chapter on keying.

A distinction must be made between clicks generated in the transmitter itself and those set up by the mere opening and closing of the key contacts when current is flowing. The latter are of the same nature as the clicks heard in a receiver when a wall switch is thrown to turn a light on or off, and may be more troublesome nearby than the clicks that actually go out on the signal. A filter for eliminating them usually has to be installed as close as possible to the key contacts.

Overmodulation in a.m. phone transmitters generates transients similar to key clicks. It can be prevented either by using automatic systems for limiting the modulation to 100 per cent, or by continuously monitoring the modulation. Methods for both are described in the chapter on amplitude modulation.

BCI is frequently made worse by radiation from the power wiring or the r.f. transmission line. This is because the signal causing the interference, in such cases, is radiated from wiring that is nearer the broadcast receiver than the antenna itself. Much depends on the method used to couple the transmitter to the antenna, a subject that is discussed in the chapters on transmission lines and antennas. If it is at all possible the antenna itself should be placed so that it is not in close proximity to house wiring, telephone and power lines, and similar conductors.

Image and Oscillator-Harmonic Responses

Most present-day broadcast receivers use a built-in loop antenna as the grid circuit for the mixer stage. The selectivity is not especially high at the signal frequency. Furthermore, an appreciable amount of signal pick-up usually occurs on the a.c. line to which the receiver is connected, the signal so picked up being fed to the mixer grid by stray means.

As a result, strong signals from nearby transmitters, even though the transmitting frequency is far removed from the broadcast band, can force themselves to the mixer grid. They will normally be eliminated by the i.f. selectivity, except in cases where the transmitter frequency is the image of the broadcast signal to which the receiver is tuned, or when the transmitter frequency is so related to a harmonic of the broadcast receiver's local oscillator as to produce a beat at the intermediate frequency.

These image and oscillator-harmonic responses tune in and out on the broadcast receiver dial just like a broadcast signal, except that in the case of harmonic response the tuning rate is more rapid. Since most receivers use an intermediate frequency in the neighborhood of 455 kc., the interference is a true image only when the amateur transmitting frequency is in the 1800-kc. band. Oscillator-harmonic responses occur from 3.5- and 7-Mc. transmissions, and sometimes even from higher frequencies.

Since images and harmonic responses occur at definite frequencies on the receiver dial, it is possible to choose operating frequencies that will avoid putting such a response on top of the broadcast stations that are favored in the vicinity. While your signal may still be heard when the receiver is tuned off the local stations, it will at least not interfere with program reception.

There is little that can be done to most receivers to cure interference of this type except to reduce the amount of signal getting into the set through the a.c. line. A line filter such as is shown in Fig. 23-1 often will help accomplish this. The values used for the coils and capacitors are in general not critical. The effectiveness of the filter may depend considerably on the ground connection used, and it is advisable to use a short ground lead to a cold-water pipe if at all possible. The line cord from the set should be bunched up, to minimize the possibility of pick-up on the cord. It may be necessary to install the filter inside the receiver, so that the filter is connected between the line cord and the set wiring, in order to get satisfactory operation.

Cross-Modulation

With phone transmitters, there are occasionally cases where the voice is heard whenever the broadcast receiver is tuned to a BC station, but there is no interference when tuning between stations. This is cross-modulation, a result of rectification in one of the early stages of the receiver. Receivers that are susceptible to this trouble usually also get a similar type of interference from regular broadcasting if there is a strong local BC station and the receiver is tuned to some *other* station.

The remedy for cross-modulation in the receiver is the same as for images and oscillator-harmonic response—reduce the strength of the amateur signal at the receiver by means of a line filter.

The trouble is not always in the receiver, since cross modulation can occur in any nearby rectifying circuit — such as a poor contact in water or steam piping, gutter pipes, and other conductors in the strong field of the transmitting antenna — external to both receiver and transmitter. Locating the cause may be difficult, and is best attempted with a battery-operated portable broadcast receiver used as a "probe" to find the spot where the interference is most intense. When such a spot is located, inspection of the metal structures in the vicinity should indicate the cause. The remedy is to make a good electrical bond between the two conductors having the poor contact.

Audio-Circuit Rectification

The most frequent cause of interference from operation at 21 Mc. and higher frequencies is rectification of a signal that by some means gets into the audio system of the receiver. In the milder cases an amplitude-modulated signal will be heard with reasonably good quality, but is not tunable — that is, it is present no matter what the frequency to which the receiver dial is set. An unmodulated carrier may have no observable effect in such cases beyond causing a little hum. However, if the signal is very strong there will be a reduction of the audio output level of the receiver whenever the carrier is thrown on. This causes an annoying "jumping" of the program when the interfering signal is keyed. With phone transmission the change in audio level is not so objectionable because it occurs at less frequent intervals. Rectification ordinarily gives no audio output from a frequency-modulated signal, so the interference can be made almost unnoticeable if f.m. or p.m. is used instead of a.m.

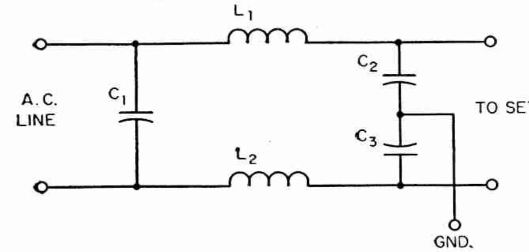


Fig. 23-1—"Brute-force" a.c. line filter for receivers. The values of C_1, C_2 and C_3 are not generally critical; capacitances from 0.001 to 0.01 μf. can be used. L_1 and L_2 can be a 2-inch winding of No. 18 enameled wire on a half-inch diameter form. In making up such a unit for use external to the receiver, make sure that there are no exposed conductors to offer a shock hazard.

Interference of this type usually results from a signal on the power line being coupled by some means into the audio circuits, although the pick-up also may occur on the set wiring itself. A "brute-force" line filter as described above may or may not be completely effective, but in any event is the simplest thing to try. If it does not do the job, some modification of the receiver will be necessary. This usually takes the form of a simple filter connected in the grid circuit of the tube in which the rectification is occurring. Usually it will be the first audio amplifier, which in most receivers is a diode-triode type tube.

Filter circuits that have proved to be effective are shown in Fig. 23-2. In A, the value of the grid leak in the combined detector/first audio tube is reduced to 2 to 3 megohms and the grid is by-passed to chassis by a 250-$\mu\mu$f. mica or ceramic capacitor. A somewhat similar method that does not require changing the grid resistor is shown at B. In C, a 75,000-ohm (value not critical) resistor is connected between the grid pin on the tube socket and all other grid connections. In combination with the input capacitance of the tube this forms a low-pass filter to prevent r.f. from reaching the grid. In some cases, simply bypassing the heater of the detector/first audio tube to chassis with a 0.001-μf. or larger capacitor will suffice. In all cases, check to see that the a.c. line is bypassed to chassis; if it is not, install by-pass capacitors (0.001 to 0.01 μf.).

Handling BCI Cases

Assuming that your transmitter has been checked and found to be free from spurious radiations, get another amateur to operate your station, if possible, while you make the actual check on the interference yourself. The following procedure should be used.

Tune the receiver through the broadcast band, to see whether the interference tunes like a regular BC station. If so, image or oscillator-harmonic response is the cause. If there is interference only when a BC station is tuned in, but not between stations, the cause is cross modulation. If the interference is heard at all settings of the tuning dial, the trouble is pickup in the audio circuits. In the latter case, the receiver's volume control may or may not affect the strength of the interference, depending on the means by which your signal is being rectified.

Having identified the cause, explain it to the set owner. It is a good idea to have a line filter with you, equipped with enough cord to replace the set's line cord, so it can be tried then and there. If it does not eliminate the interference, explain to the set owner that there is nothing further that can be done without modifying the receiver. Recommend that the work be done by a competent service technician, and offer to advise the service man on the cause and remedy. Don't offer to work on the set yourself, but if you are asked to do so use your own judgment about complying; set owners sometimes complain about the over-all performance of the receiver afterward, often without justification. If you work on it, take it to your station so the effect of the changes you make can be observed, and return the receiver promptly when you have finished.

MISCELLANEOUS TYPES OF INTERFERENCE

The operation of amateur phone transmitters occasionally results in interference on telephone lines and in audio amplifiers used in public-address work and for home music reproduction. The cause is rectification of the signal in an audio circuit.

Telephone Interference

Telephone interference can be cured by connecting a bypass capacitor (about 0.001 μf.) across the microphone unit in the telephone handset. The telephone companies have capacitors for this purpose. When such a case occurs, get in touch with the repair department of the phone company, giving all the particulars. Do not attempt to work on the telephone yourself.

Hi-Fi and P. A. Systems

In interference to public-address and "hi-fi" installations the principal sources of signal pick-up are the a.c. line or a line from the power amplifier to a speaker. All amplifier units should be bonded together and connected to a good ground such as a cold-water pipe. Make sure that the a.c. line is

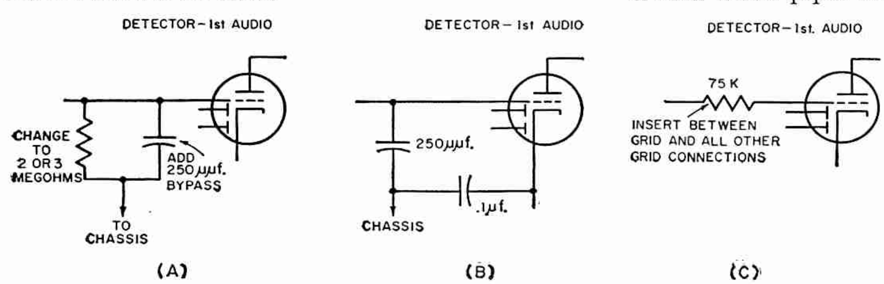


Fig. 23-2—Methods of eliminating r.f. from the grid of a combined detector/first-audio stage. At A, the value of the grid leak is reduced to 2 or 3 megohms, and a bypass capacitor is added. At B, both grid and cathode are bypassed.

bypassed to chassis in each unit with capacitors of about 0.01 μf. at the point where the line enters the chassis. The speaker line similarly should be bypassed to the amplifier chassis with about 0.001 μf.

If these measures do not suffice, the shielding on the amplifiers may be inadequate. A shield cover and bottom pan should be installed in such cases.

The spot in the system where the rectification is occurring often can be localized by seeing if the interference is affected by the volume control setting; if not, the cause is in a stage following the volume control.

Television Interference *(See also Chap. 17)*

Interference with the reception of television signals usually presents a more difficult problem than interference with a.m. broadcasting. In BCI cases the interference almost always can be attributed to deficient selectivity or spurious responses in the BC receiver. While similar deficiencies exist in many television receivers, it is also true that amateur transmitters generate harmonics that fall inside many or all television channels. These spurious radiations cause interference that ordinarily cannot be eliminated by anything that may be done at the receiver, so must be prevented at the transmitter itself.

The over-all situation is further complicated by the fact that television broadcasting is in three distinct bands, two in the v.h.f. region and one in the u.h.f.

V.H.F. Television

For the amateur who does most of his transmitting on frequencies below 30 Mc. the TV band of principal interest is the low v.h.f. band between 54 and 88 Mc. If harmonic radiation can be reduced to the point where no interference is caused to Channels 2 to 6, inclusive, it is almost certain that any harmonic troubles with channels above 174 Mc. will disappear also.

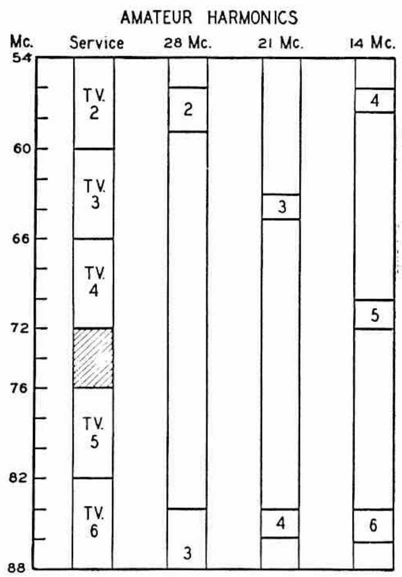
The relationship between the v.h.f. television channels and harmonics of amateur bands from 14 through 28 Mc. is shown in Fig. 23-3. Harmonics of the 7- and 3.5-Mc. bands are not shown because they fall in every television channel. However, the harmonics above 54 Mc. from these bands are of such high order that they are usually rather low in amplitude, although they may be strong enough to interfere if the television receiver is quite close to the amateur transmitter. Low-order harmonics — up to about the sixth — are usua ly the most difficult to eliminate.

Of the amateur v.h.f. bands, only 50 Mc. will have harmonics falling in a v.h.f. television channel (channels 11, 12 and 13). However, a transmitter for any amateur v.h.f. band may cause interference if it has multiplier stages either operating in or having harmonics in one or more of the v.h.f. TV channels. The r.f. energy on such frequencies can be radiated directly from the transmitting circuits or coupled by stray means to the transmitting antenna.

Frequency Effects

The degree to which transmitter harmonics or other undesired radiation actually in the TV channel must be suppressed depends principally on two factors, the strength of the TV signal on the channel or channels affected, and the relationship between the frequency of the spurious radiation and the frequencies of the TV picture and sound carriers within the channel. If the TV signal is very strong, interference can be eliminated by comparatively simple methods. However, if the TV signal is very weak, as in "fringe" areas where the received picture is visibly degraded by the appearance of set noise or "snow" on the screen, it may be necessary to go to extreme measures.

In either case the intensity of the interference depends very greatly on the exact frequency of the interfering signal. Fig. 23-4 shows the placement of the picture and sound carriers in the standard TV channel. In Channel 2, for example, the picture carrier frequency is $54 + 1.25 = 55.25$ Mc. and the sound carrier frequency is



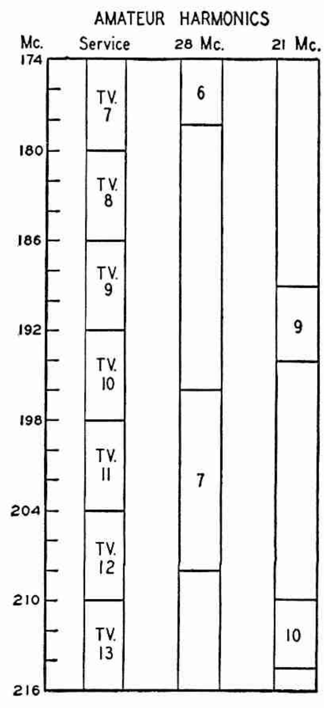


Fig. 23-3—Relationship of amateur-band harmonics to v.h.f. TV channels. Harmonic interference from transmitters operating below 30 Mc. is most likely to be serious in the low-channel group (54 to 88 Mc.).

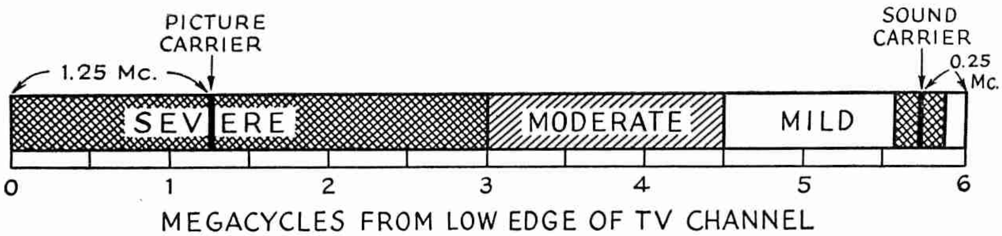


Fig. 23-4—Location of picture and sound carriers in a monochrome television channel, and relative intensity of interference as the location of the interfering signal within the channel is varied without changing its strength. The three regions are not actually sharply defined as shown in this drawing, but merge into one another gradually.

60 — 0.25 = 59.75 Mc. The second harmonic of 28,010 kc. (56,020 kc. or 56.02 Mc.) falls 56.02 — 54 = 2.02 Mc. above the low edge of the channel and is in the region marked "Severe" in Fig. 23-4. On the other hand, the second harmonic of 29,500 kc. (59,000 kc. or 59 Mc.) is 59 — 54 = 5 Mc. from the low edge of the channel and falls in the region marked "Mild." Interference at this frequency has to be about 100 times as strong as at 56,020 kc. to cause effects of equal intensity. Thus an operating frequency that puts a harmonic near the picture carrier requires about 40 db. more harmonic suppression in order to avoid interference, as compared with an operating frequency that puts the harmonic near the upper edge of the channel.

For a region of 100 kc. or so either side of the sound carrier there is another "Severe" region where a spurious radiation will interfere with reception of the sound program, and this region also should be avoided. In general, a signal of intensity equal to that of the picture carrier will not cause noticeable interference if its frequency is in the "Mild" region shown in Fig. 23-4, but the same intensity in the "Severe" region will utterly destroy the picture.

Interference Patterns

The visible effects of interference vary with the type and intensity of the interference. Complete "blackout," where the picture and sound disappear completely, leaving the screen dark, occurs only when the transmitter and receiver are quite close together. Strong interference ordinarily causes the picture to be broken up, leaving a jumble of light and dark lines, or turns the picture "negative" — the normally white parts of the picture turn black and the normally black parts turn white. "Cross-hatching" — diagonal bars or lines in the picture — accompanies the latter, usually, and also represents the most common type of less-severe interference. The bars are the result of the beat between the harmonic frequency and the picture carrier frequency. They are broad and relatively few in number if the beat frequency is comparatively low — near the picture carrier — and are numerous and very fine if the beat frequency is very high — toward the upper end of the channel. Typical cross-hatching is shown in Fig. 23-5. If the frequency falls in the "Mild" region in Fig. 23-4 the cross-hatching may be so fine as to be visible only on close inspection of the picture, in which case it may simply cause the apparent brightness of the screen to change when the transmitter carrier is thrown on and off.

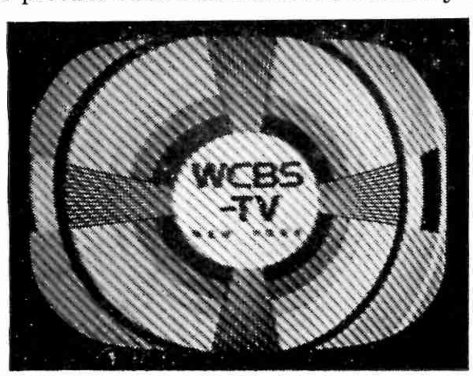


Fig. 23-5—"Cross-hatching," caused by the beat between the picture carrier and an interfering signal inside the TV channel.

Whether or not cross-hatching is visible, an amplitude-modulated transmitter may cause "sound bars" in the picture. These look about as shown in Fig. 23-6. They result from the variations in the intensity of the interfering signal when modulated. Under most circumstances modulation bars will not occur if the amateur transmitter is frequency- or phase-modulated. With these types of modulation the cross-hatching will "wiggle" from side to side with the modulation.

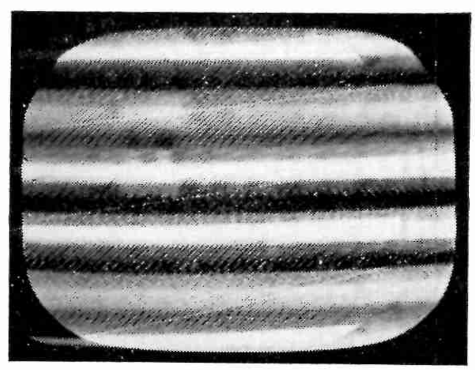


Fig. 23-6—"Sound bars" or "modulation bars" accompanying amplitude modulation of an interfering signal. In this case the interfering carrier is strong enough to destroy the picture, but in mild cases the picture is visible through the horizontal bars. Sound bars may accompany modulation even though the unmodulated carrier gives no visible cross-hatching.

Except in the more severe cases, there is seldom any effect on the sound reception when interference shows in the picture, unless the frequency is quite close to the sound carrier. In the latter event the sound may be interfered with even though the picture is clean.

Reference to Fig. 23-3 will show whether or not harmonics of the frequency in use will fall in any television channels that can be received in the locality. It should be kept in mind that not only harmonics of the final frequency may interfere, but also harmonics of any frequencies that may be present in buffer or frequency-multiplier stages. In the case of 144-Mc. transmitters, frequency-multiplying combinations that require a doubler or tripler stage to operate on a frequency actually in a low-band v.h.f. channel in use in the locality should be avoided.

Harmonic Suppression

Effective harmonic suppression has three separate phases:

1) Reducing the amplitude of harmonics generated in the transmitter. This is a matter of circuit design and operating conditions.

2) Preventing stray radiation from the transmitter and from associated wiring. This requires adequate shielding and filtering of all circuits and leads from which radiation can take place.

3) Preventing harmonics from being fed into the antenna.

It is impossible to build a transmitter that will not generate *some* harmonics, but it is obviously advantageous to reduce their strength, by circuit design and choice of operating conditions, by as large a factor as possible before attempting to prevent them from being radiated. Harmonic radiation from the transmitter itself or from its associated wiring obviously will cause interference just as readily as radiation from the antenna, so measures taken to prevent harmonics from reaching the antenna will not reduce TVI if the transmitter itself is radiating harmonics. But once it has been found that the transmitter itself is free from harmonic radiation, devices for preventing harmonics from reaching the antenna can be expected to produce results.

REDUCING HARMONIC GENERATION

Since reasonably efficient operation of r.f. power amplifiers always is accompanied by harmonic generation, good judgment calls for operating all frequency-multiplier stages at a very low power level — plate voltages not exceeding 250 or 300. When the final output frequency is reached, it is desirable to use as few stages as possible in building up to the final output power level, and to use tubes that require a minimum of driving power.

Circuit Design and Layout

Harmonic currents of considerable amplitude flow in both the grid and plate circuits of r.f. power amplifiers, but they will do relatively little harm if they can be effectively bypassed to the cathode of the tube. Fig. 23-7 shows the paths followed by harmonic currents in an amplifier circuit; because of the high reactance of the tank coil there is little harmonic current in it, so the harmonic currents simply flow through the tank capacitor, the plate (or grid) blocking capacitor, and the tube capacitances. The lengths of the leads forming these paths is of great importance, since the inductance in this circuit will resonate with the tube capacitance at some frequency in the v.h.f. range (the tank and blocking capacitances usually are so large compared with the tube capacitance that they have little effect on the resonant frequency). If such a resonance happens to occur at or near the same frequency as one of the transmitter harmonics, the effect is just the same as though a harmonic tank circuit had been deliberately introduced; the harmonic at that frequency will be tremendously increased in amplitude.

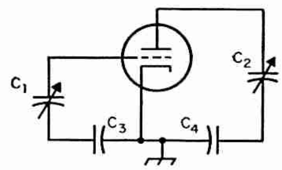


Fig. 23-7—A v.h.f. resonant circuit is formed by the tube capacitance and the leads through the tank and blocking capacitors. Regular tank coils are not shown, since they have little effect on such resonances. C_1 is the grid tuning capacitor and C_2 is the plate tuning capacitor. C_3 and C_4 are the grid and plate blocking or bypass capacitors, respectively.

Such resonances are unavoidable, but by keeping the path from plate to cathode and from grid to cathode as short as is physically possible, the resonant frequency usually can be raised above 100 Mc. in amplifiers of medium power. This puts it between the two groups of television channels.

It is easier to place grid-circuit v.h.f. resonances where they will do no harm when the amplifier is link-coupled to the driver stage, since this generally permits shorter leads and more favorable conditions for bypassing the harmonics than is the case with capacitive coupling. Link coupling also reduces the coupling between the driver and amplifier at harmonic frequencies, thus preventing driver harmonics from being amplified.

The inductance of leads from the tube to the tank capacitor can be reduced not only by shortening but by using flat strip instead of wire conductors. It is also better to use the chassis as the return from the blocking capacitor or tuned circuit to cathode, since a chassis path will have less inductance than almost any other form of connection.

The v.h.f. resonance points in amplifier tank circuits can be found by coupling a grid-dip meter covering the 50–250 Mc. range to the grid and plate leads. If a resonance is found in or near a TV channel, methods such as those described above should be used to move it well out of the TV range. The grid-dip meter also should be used to check for v.h.f. resonances in the tank coils, because coils made for 14 Mc. and below usually will show such resonances. In making the check, disconnect the coil entirely from the transmitter and move the grid-dip meter coil along it while exploring for a dip in the 54–88 Mc. band. If a resonance falls in a TV channel that is in use in the locality, changing the number of turns will move it to a less-troublesome frequency.

Operating Conditions

Grid bias and grid current have an important effect on the harmonic content of the r.f. currents in both the grid and plate circuits. In general, harmonic output increases as the grid bias and grid current are increased, but this is not necessarily true of a *particular* harmonic. The third and higher harmonics, especially, will go through fluctuations in amplitude as the grid current is increased, and sometimes a rather high value of grid current will minimize one harmonic as compared with a low value. This characteristic can be used to advantage where a particular harmonic is causing interference, remembering that the operating conditions that minimize one harmonic may greatly increase another.

For equal operating conditions, there is little or no difference between single-ended and push-pull amplifiers in respect to harmonic generation. Push-pull amplifiers are frequently trouble-makers on even harmonics because with such amplifiers the even-harmonic voltages are in phase at the ends of the tank circuit and hence appear with equal amplitude across the whole tank coil, if the center of the coil is not grounded. Under such circumstances the even harmonics can be coupled to the output circuit through stray capacitance between the tank and coupling coils. This does not occur in a single-ended amplifier having an inductively coupled tank, if the coupling coil is placed at the cold end, or with a pi-network tank.

Harmonic Traps

If a harmonic in only one TV channel is particularly bothersome — frequently the case when the transmitter operates on 28 Mc. — a trap tuned to the harmonic frequency may be installed in the plate lead as shown in Fig. 23-8. At the harmonic frequency the trap represents a very high impedance and hence reduces the amplitude of the harmonic current flowing through the tank circuit. In the push-pull circuit both traps have the same constants. The L/C ratio is not critical but a high-C circuit usually will have least effect on the performance of the plate circuit at the normal operating frequency.

Since there is a considerable harmonic voltage across the trap, radiation may occur from the trap unless the transmitter is well shielded. Traps should be placed so that there is no coupling between them and the amplifier tank circuit.

A trap is a highly selective device and so is useful only over a small range of frequencies. A second- or third-harmonic trap on a 28-Mc. tank circuit usually will not be effective over more than 50 kc. or so at the fundamental frequency, depending on how serious the interference is without the trap. Because they are critical of adjustment, it is better to prevent TVI by other means, if possible, and use traps only as a last resort.

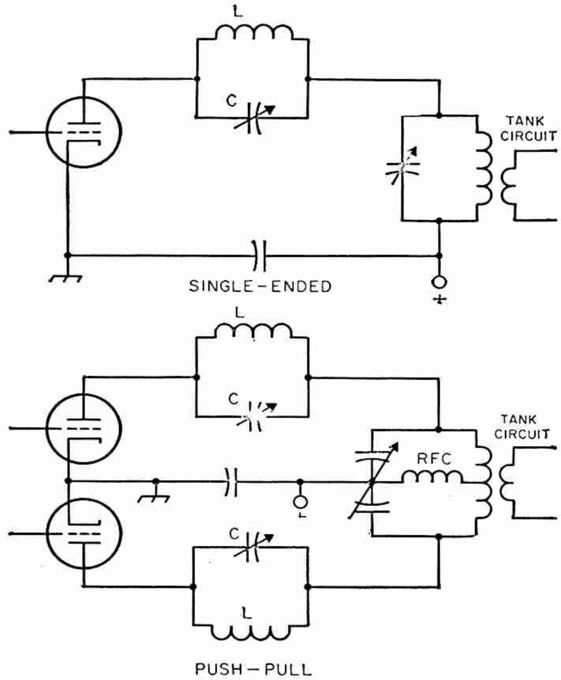


Fig. 23-8—Harmonic traps in an amplifier plate circuit. *L* and C should resonate at the frequency of the harmonic to be suppressed. C may be a 25- to 50-$\mu\mu$f. midget, and *L* usually consists of 3 to 6 turns about ½ inch in diameter for Channels 2 through 6. The inductance should be adjusted so that the trap resonates at about half capacitance of C before being installed in the transmitter. The frequency may be checked with a grid-dip meter. When in place, the trap should be adjusted for minimum interference to the TV picture.

PREVENTING RADIATION FROM THE TRANSMITTER

The extent to which interference will be caused by direct radiation of spurious signals depends on the operating frequency, the transmitter power level, the strength of the television signal, and the distance between the transmitter and TV receiver. Transmitter radiation can be a very serious problem if the TV signal is weak, if the TV receiver and amateur transmitter are close together, and if the transmitter is operated with high power.

Shielding

Direct radiation from the transmitter circuits and components can be prevented by proper shielding. To be effective, a shield must completely enclose the circuits and parts and must have no openings that will permit r.f. energy to escape. Unfortunately, ordinary metal boxes and cabinets do not provide good shielding, since such openings as louvers, lids, and holes for running in connections allow far too much leakage.

A primary requisite for good shielding is that all joints must make a good electrical connection along their entire length. A small slit or crack will let out a surprising amount of r.f. energy; so will ventilating louvers and large holes such as those used for mounting meters. On the other hand, small holes do not impair the shielding very greatly, and a limited number of ventilating holes may be used if they are small — not over ¼ inch in diameter. Also, wire screen makes quite effective shielding if the wires make good electrical connection at each crossover. Perforated aluminum such as the "do-it-yourself" sold at hardware stores also is good, although not very strong mechanically. If perforated material is used, choose the variety with the smallest openings. The leakage through large openings can be very much reduced by covering such openings with screening or perforated aluminum, well bonded to all edges of the opening.

The intensity of r.f. fields about coils, capacitors, tubes and wiring decreases very rapidly with distance, so shielding is more effective, from a practical standpoint, if the components and wiring are not too close to it. It is advisable to have a separation of several inches, if possible, between "hot" points in the circuit and the nearest shielding.

For a given thickness of metal, the greater the conductivity the better the shielding. Copper is best, with aluminum, brass and steel following in that order. However, if the thickness is adequate for structural purposes (over 0.02 inch) and the shield and a "hot" point in the circuit are not in close proximity, any of these metals will be satisfactory. Greater separation should be used with steel shielding than with the other materials not only because it is considerably poorer as a shield but also because it will cause greater losses in near-by circuits than would copper or aluminum at the same distance. Wire screen or perforated metal used as a shield should also be kept at some distance from high-voltage or high-current r.f. points, since there is considerably more leakage through the mesh than through solid metal.

Where two pieces of metal join, as in forming a corner, they should overlap at least a half inch and be fastened together firmly with screws or bolts spaced at close-enough intervals to maintain firm contact all along the joint. The contact surfaces should be clean before joining, and should be checked occasionally — especially steel, which is almost certain to rust after a period of time.

The leakage through a given size of aperture in shielding increases with frequency, so such points as good continuous contact, screening of large holes, and so on, become even more important when the radiation to be suppressed is in the high band — 174–216 Mc. Hence 50- and 144-Mc. transmitters, which in general will have frequency-multiplier harmonics of relatively high intensity in this region, require special attention in this respect if the possibility of interfering with a channel received locally exists.

Lead Treatment

Even very good shielding can be made completely useless when connections are run to external power supplies and other equipment from the circuits inside the shield. Every such conductor leaving the shielding forms a path for the escape of r.f., which is then radiated by the connecting wires. Hence a step that is essential in every case is to prevent harmonic currents from flowing on the leads leaving the shielded enclosure.

Harmonic currents always flow on the d.c. or a.c. leads connecting to the tube circuits. A very effective means of preventing such currents from being coupled into other wiring, and one that provides desirable bypassing as well, is to use shielded wire for all such leads, maintaining the shielding from the point where the lead connects to the tube or r.f. circuit right through to the point where it leaves the chassis. The shield braid should be grounded to the chassis at both ends and at frequent intervals along the path.

Good bypassing of shielded leads also is essential. Bearing in mind that the shield braid about the conductor confines the harmonic currents to the *inside* of the shielded wire, the object of bypassing is to prevent their escape. Figs. 23-9 and 23-10 show the proper way to bypass. The small-type 0.001-μf. ceramic disk capacitor, when mounted on the end of the shielded wire as shown in Fig. 23-9, actually forms a series-resonant circuit in the 54–88-Mc. range and thus represents practically a short-circuit for low-band TV harmonics. The exposed wire to the connection terminal should be kept as short as is physically possible, to prevent any possible harmonic pick-up exterior to the shielded wiring. Disk capacitors of this capacitance are available in several voltage ratings up to 3000 volts. For higher voltages, the maximum capacitance available is approximately 500 μμf., which is large enough for good bypassing of harmonics. Alternatively, mica capacitors may be used as shown in Fig. 23-10, mounting the capacitor flat against the chassis and grounding the end of the shield braid directly to chassis, keeping the exposed part as short as possible. Either 0.001-μf. or 470-μμf. (500 μμf.) capacitors should be used. The larger capacitance is series-resonant in Channel 2 and the smaller in Channel 6.

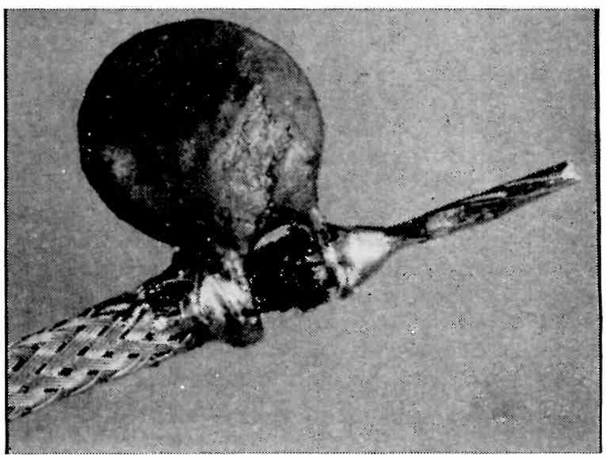


Fig. 23-9—Proper method of bypassing the end of a shielded lead using disk ceramic capacitor. The 0.001-μf. size should be used for 1600 volts or less; 500 μμf. at higher voltages. The leads are wrapped around the inner and outer conductors and soldered, so that the lead length is negligible. This photograph is about four times actual size.

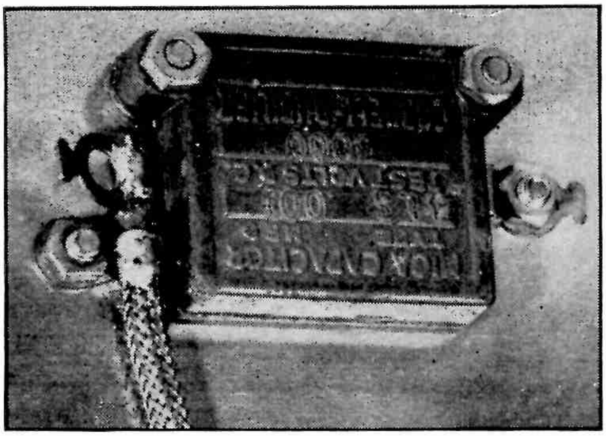


Fig. 23-10—Bypassing with a mica capacitor the end of a high-voltage lead. The end of the shield braid is soldered to a lug fastened to the chassis directly underneath. The other terminal of the capacitor is similarly bolted directly to the chassis. When the bypass is used at a terminal connection block the "hot" lead should be soldered directly to the terminal, if possible, but in any event connected to it by a very short lead.

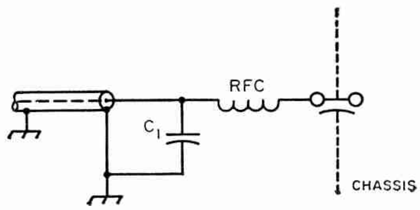
These bypasses are essential at the connection-block terminals, and desirable at the tube ends of the leads also. Installed as shown with shielded wiring, they have been found to be so effective that there is usually no need for further harmonic filtering. However, if a test shows that additional filtering is required, the arrangement shown in Fig. 23-11 may be used. Such an r.f. filter should be installed at the tube end of the shielded lead, and if more than one circuit is filtered care should be taken to keep the r.f. chokes separated from each other and so oriented as to minimize coupling between them. This is necessary for preventing harmonics present in one circuit from being coupled into another.

In difficult cases involving Channels 7 to 13 — i.e., close proximity between the transmitter and receiver, and a weak TV signal — additional lead-filtering measures may be needed to prevent radiation of interfering signals by 50- and 144-Mc. transmitters. A recommended method is shown in Fig. 23-12. It uses a shielded lead bypassed with a ceramic disk as described above, with the addition of a low-inductance feed-through type capacitor and a small r.f. choke, the capacitor being used as a terminal for the external connection. For voltages above 400, a capacitor of compact construction (as indicated in the caption) should be used, mounted so that there is a very minimum of exposed lead, inside the chassis, from the capacitor to the connection terminal.

As an alternative to the series-resonant bypassing described above, feed-through type capacitors such as the Sprague "Hypass" type may be used as terminals for external connections. The ideal method of installation is to mount them so they protrude through the chassis, with thorough bonding to the chassis all around the hole in which the capacitor is mounted. The principle is illustrated in Fig. 23-13.

Meters that are mounted in an r.f. unit should be enclosed in shielding covers, the connections being made with shielded wire with each lead bypassed as described above. The shield braid should be grounded to the panel or chassis immediately outside the meter shield, as indicated in Fig. 23-14. A bypass may also be connected across the meter terminals, principally to prevent any fundamental current that may be present from flowing through the meter itself. As an alternative to individual meter shielding the meters may be mounted entirely behind the panel, and the panel holes needed for observation may be covered with wire screen that is carefully bonded to the panel all around the hole.

Care should be used in the selection of shielded wire for transmitter use. Not only should the insulation be conservatively rated for the d.c. voltage in use, but the insulation should be of material that will not easily deteriorate in soldering. The r.f. characteristics of the wire are not especially important, except that the attenuation of harmonics in the wire itself will be greater if the



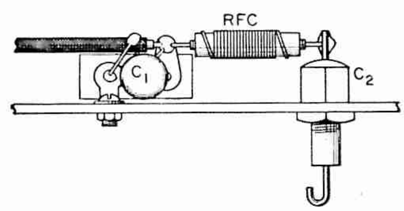


Fig. 23-12—Additional lead filtering for harmonics or other spurious frequencies in the high v.h.f. TV band (174-216 Mc.).

C_1—0.001-μf. disk ceramic.

C_2—0.001-μf. feed-through bypass (Erie Style 326). (For 500-2000-volt lead, substitute Plasticon Glass mike, LSG-251, for C_2.)

RFC—14 inches No. 26 enamel close-wound on 3/16-inch diam. form or resistor.

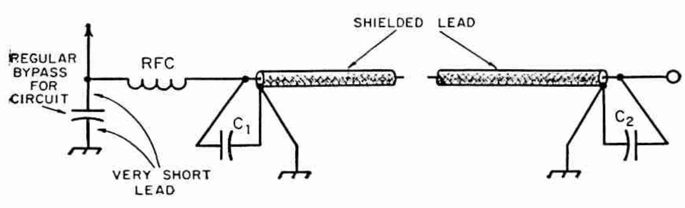


Fig. 23-11—Additional r.f. filtering of supply leads may be required in regions where the TV signal is very weak. The r.f. choke should be physically small, and may consist of a 1-inch winding of No. 26 enameled wire on a 1/4-inch form, close-wound. Manufactured single-layer chokes having an inductance of a few microhenrys also may be used.

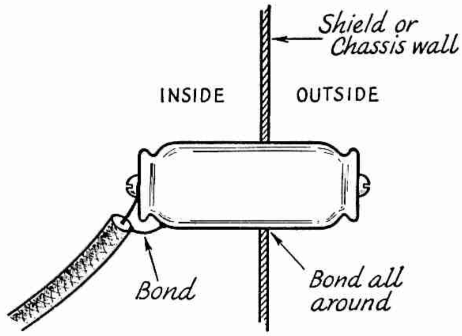


Fig. 23-13—The best method of using the "Hypass" type feed-through capacitor. Capacitances of 0.01 to 0.1 μf. are satisfactory. Capacitors of this type are useful for high-current circuits, such as filament and 115-volt leads, as a substitute for the r.f. choke shown in Fig. 23-11, in cases where additional lead filtering is needed.

insulating material has high losses at radio frequencies: in other words, wire intended for use at d.c. and low frequencies is preferable to cables designed expressly for carrying r.f. The attenuation also will increase with the length of the wire; in general, it is better to make the leads as long as circumstances permit rather than to follow the more usual practice of using no more lead than is actually necessary. Where wires cross or run parallel, the shields should be spot-soldered together and connected to the chassis. For high voltages, automobile ignition cable covered with shielding braid is recommended.

Proper shielding of the transmitter requires that the r.f. circuits be shielded entirely from the external connecting leads. A situation such as is shown in Fig. 23-15, where the leads in the r.f. chassis have been shielded and properly filtered but the chassis is mounted in a large shield, simply invites the harmonic currents to travel over the chassis and on out over the leads *outside* the chassis. The shielding about the r.f. circuits should make complete contact with the chassis on which the parts are mounted.

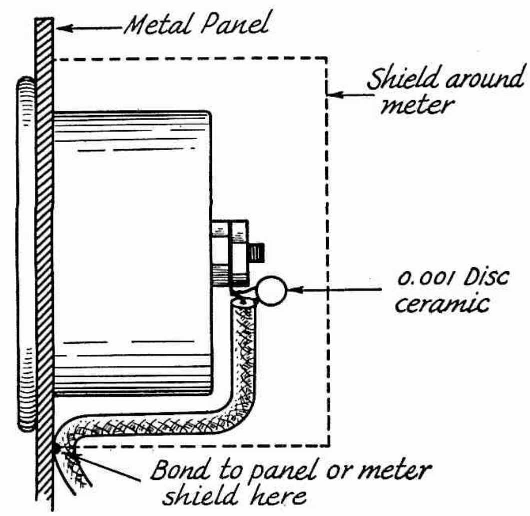


Fig. 23-14—Meter shielding and bypassing. It is essential to shield the meter mounting hole since the meter will carry r.f. through it to be radiated. Suitable shields can be made from 2½- or 3-inch diameter metal cans or small metal chassis boxes.

Checking Transmitter Radiation

A check for transmitter radiation always should be made before attempting to use low-pass filters or other devices for preventing harmonics from reaching the antenna system. The only really satisfactory indicating instrument is a television receiver. In regions where the TV signal is strong an indicating wavemeter such as one having a crystal or tube detector may be useful; if it is possible to get any indication at all from harmonics either on supply leads or around the transmitter itself, the harmonics are probably strong enough to cause interference. However, the absence of any such indication does not mean that harmonic interference will not be caused. If the techniques of shielding and lead filtering described in the preceding section are followed, the harmonic intensity on any external leads should be far below what any such instruments can detect.

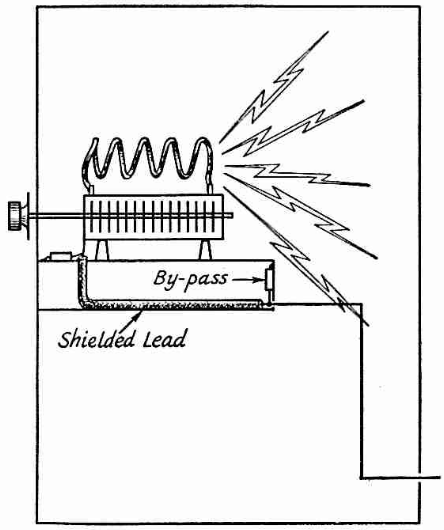


Fig. 23-15—A metal cabinet can be an adequate shield, but there will still be radiation if the leads inside can pick up r.f. from the transmitting circuits.

Radiation checks should be made with the transmitter delivering full power into a dummy antenna, such as an incandescent lamp of suitable power rating, preferably installed inside the shielded enclosure. If the dummy must be external, it is desirable to connect it through a coax-matching circuit such as is shown in Fig. 23-16. Shielding the dummy antenna circuit is also desirable, although it is not always necessary.

Make the radiation test on all frequencies that are to be used in transmitting, and note whether or not interference patterns show in the received picture. (These tests must be made while a TV signal is being received, since the beat patterns will not be formed if the TV picture carrier is not present.) If interference exists, its source can be detected by grasping the various external leads (by the insulation, not the live wire!) or bringing the hand near meter faces, louvers, and other possible points where harmonic energy might escape

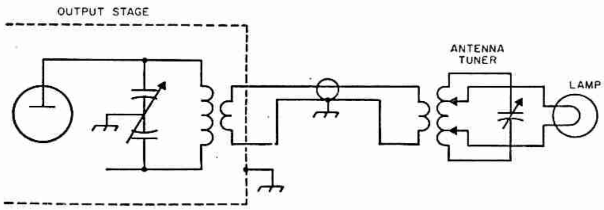


Fig. 23-16—Dummy-antenna circuit for checking harmonic radiation from the transmitter and leads. The matching circuit helps prevent harmonics in the output of the transmitter from flowing back over the transmitter itself, which may occur if the lamp load is simply connected to the output coil of the final amplifier. See transmission-line chapter for details of the matching circuit. Tuning must be adjusted by cut-and-try, as the bridge method described in the transmission-line chapter will not work with lamp loads because of the change in resistance when the lamps are hot.

from the transmitter. If any of these tests cause a *change* — not necessarily an *increase* — in the intensity of the interference, the presence of harmonics at that point is indicated. The location of such "hot" spots usually will point the way to the remedy. If the TV receiver and the transmitter can be operated side-by-side, a length of wire connected to one antenna terminal on the receiver can be used as a probe to go over the transmitter enclosure and external leads. This device will very quickly expose the spots from which serious leakage is taking place.

As a final test, connect the transmitting antenna or its transmission line terminals to the outside of the transmitter shielding. Interference created when this test is applied indicates that weak currents are on the outside of the shield and can be conducted to the antenna when the normal antenna connections are used. Currents of this nature represent interference that can be conducted *over* low-pass filters, etc., and which therefore cannot be eliminated by such filters.

PREVENTING HARMONICS FROM REACHING THE ANTENNA

The third and last step in reducing harmonic TVI is to keep the spurious energy generated in or passed through the final stage from traveling over the transmission line to the antenna. It is seldom worthwhile even to attempt this until the radiation from the transmitter and its connecting leads has been reduced to the point where, with the transmitter delivering full power into a dummy antenna, it has been determined by actual testing with a television receiver that the radiation is below the level that can cause interference. If the dummy antenna test shows enough radiation to be seen in a TV picture, it is a practical certainty that harmonics will be coupled to the antenna system no matter what preventive measures are taken.

In inductively coupled output systems, some harmonic energy will be transferred from the final amplifier through the mutual inductance between the tank coil and the output coupling coil. Harmonics of the output frequency transferred in this way can be greatly reduced by providing sufficient selectivity between the final tank and the transmission line. A good deal of selectivity, amounting to 20 to 30 db. reduction of the second harmonic and much higher reduction of higher-order harmonics, is furnished by a matching circuit of the type shown in Fig. 23-16 and described in the chapter on transmission lines. An "antenna coupler" is therefore a worthwhile addition to the transmitter.

In 50- and 144-Mc. transmitters, particularly, harmonics not directly associated with the output frequency — such as those generated in low-frequency early stages of the transmitter — may get coupled to the antenna by stray means. For example, a 144-Mc. transmitter might have an oscillator or frequency multiplier at 48 Mc., followed by a tripler to 144 Mc. Some of the 48-Mc. energy will appear in the plate circuit of the tripler, and if passed on to the grid of the final amplifier will appear as a 48-Mc. modulation on the 144-Mc. signal. This will cause a spurious signal at 192 Mc., which is in the high TV band, and the selectivity of the tank circuits may not be sufficient to prevent its being coupled to the antenna. Spurious signals of this type can be reduced by using link coupling between the driver stage and final amplifier (and between earlier stages as well) in addition to the suppression afforded by using an antenna coupler.

Capacitive Coupling

The upper drawing in Fig. 23-17 shows a parallel-conductor link as it might be used to couple into a parallel-conductor line through a matching circuit. Inasmuch as a coil is a sizable metallic object, there is capacitance between the final tank coil and its associated link coil, and between the matching-circuit coil and its link. Energy coupled through these capacitances travels over the link circuit and the transmission line as though these were merely single conductors. The tuned circuits simply act as masses of metal and offer no selectivity at all for capacitively-coupled energy. Although the actual capacitances are small, they offer a good coupling medium for frequencies in the v.h.f. range.

Capacitive coupling can be reduced by coupling

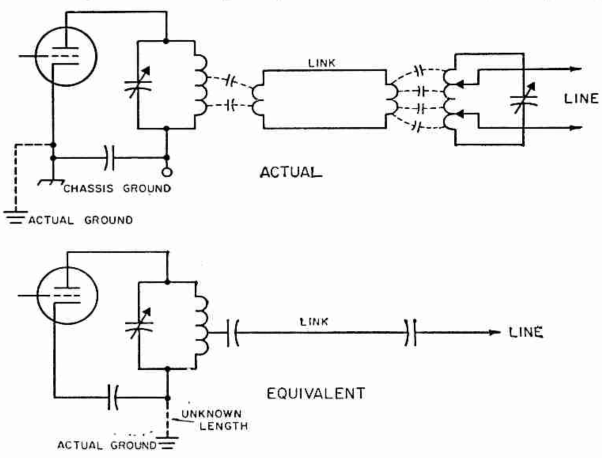


Fig. 23-17—The stray capacitive coupling between coils in the upper circuit leads to the equivalent circuit shown below, for v.h.f. harmonics.

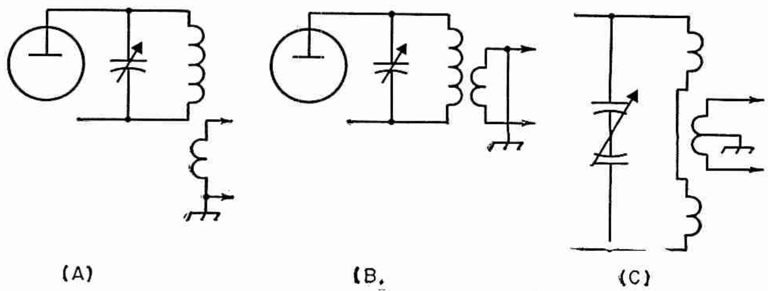


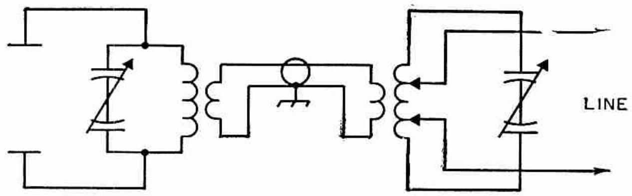
Fig. 23-18—Methods of coupling and grounding link circuits to reduce capacitive coupling between the tank and link coils. Where the link is wound over one end of the tank coil the side toward the hot end of the tank should be grounded, as shown at B.

to a "cold" point on the tank coil — the end connected to ground or cathode in a single-ended stage. In push-pull circuits having a split-stator capacitor with the rotor grounded for r.f., all parts of the tank coil are "hot" at even harmonics, but the center of the coil is "cold" at the fundamental and odd harmonics. If the center of the tank coil, rather than the rotor of the tank capacitor, is grounded through a bypass capacitor the center of the coil is "cold" at all frequencies, but this arrangement is not very desirable because it causes the harmonic currents to flow through the coil rather than the tank capacitor and this increases the harmonic transfer by pure inductive coupling.

With either single-ended or balanced tank circuits the coupling coil should be grounded to the chassis by a short, direct connection as shown in Fig. 23-18. If the coil feeds a balanced line or link, it is preferable to ground its center, but if it feeds a coax line or link one side may be grounded. Coaxial output is much preferable to balanced output, because the harmonics have to stay *inside* a properly installed coax system and tend to be attenuated by the cable before reaching the antenna coupler.

At high frequencies — and possibly as low as 14 Mc. — capacitive coupling can be greatly reduced by using a shielded coupling coil as shown in Fig. 23-19. The inner conductor of a length of coaxial cable is used to form a one-turn coupling coil. The outer conductor serves as an open-circuited shield around the turn, the shield being grounded to the chassis. The shielding has no effect on the inductive coupling. Because this construction is suitable only for one turn, the coil is not well adapted for use on the lower frequencies where many turns are required for good coupling. Shielded coupling coils having a larger number of turns are available commercially. A shielded coil is particularly useful with push-pull amplifiers when the suppression of even harmonics is important.

A shielded coupling coil or coaxial output will not prevent stray capacitive coupling to the antenna if harmonic currents can flow over the *outside* of the coax line. In Fig. 23-20, the arrangement at either A or C will allow r.f. to flow over the outside of the cable to the antenna system. The proper way to use coaxial cable is to shield the transmitter completely, as shown at B, and make sure that the outer conductor of the cable is a continuation of the transmitter shielding. This prevents r.f. inside the transmitter from getting out by any path except the *inside* of the cable. Harmonics flowing *through* a coax line can be stopped from reaching the antenna system by an



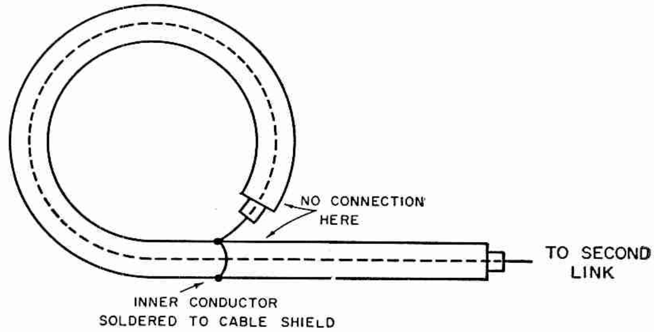


Fig. 23-19—Shielded coupling coil constructed from coaxial cable. The smaller sizes of cable such as RG-59/U are most convenient when the coil diameter is 3 inches or less, because of greater flexibility. For larger coils RG-8/U or RG-11/U can be used.

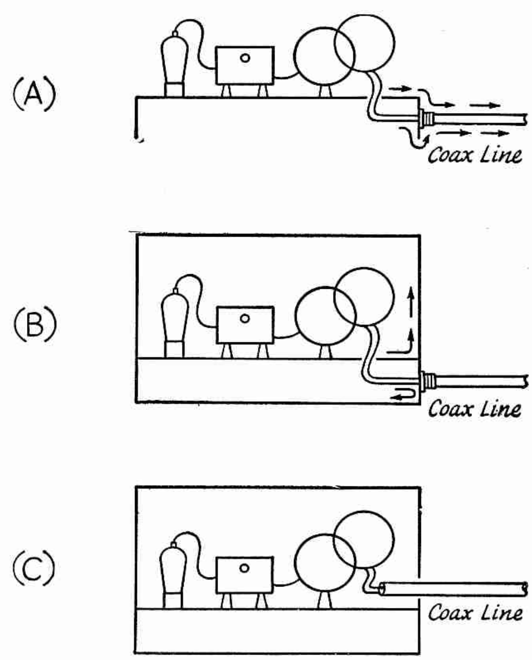


Fig. 23-20—Right (B) and wrong (A and C) ways to connect a coaxial line to the transmitter. In A or C, harmonic energy coupled by stray capacitance to the outside of the cable will flow without hindrance to the antenna system. In B the energy cannot leave the shield and can flow out only through, not over, the cable.

antenna coupler or by a low-pass filter installed in the line.

Low-Pass Filters

A low-pass filter properly installed in a coaxial line, feeding either a matching circuit (antenna coupler) or feeding the antenna directly, will provide very great attenuation of harmonics. When the main transmission line is of the parallel-conductor type, the coax-coupled matching-circuit arrangement is highly recommended as a means for using a coax low-pass filter.

A properly designed low-pass filter will not introduce appreciable power loss at the fundamental frequency if the coaxial line in which it is inserted is terminated so that the s.w.r. is low. (The s.w.r. can easily be measured by means of a simple bridge as described in the chapters on measurements and transmission lines.) Such a filter has the property of passing without loss all frequencies below its "cut-off" frequency, but simultaneously has large attenuation for all frequencies above the cut-off frequency.

Low-pass filters of simple and inexpensive construction for use with transmitters operating below 30 Mc. are shown in Figs. 23-21 and 23-23. The former is designed to use mica capacitors of readily available capacitance values, for compactness and low cost. Both use the same circuit, Fig. 23-22, the only difference being in the *L* and *C* values. Technically, they are three-section filters having two full constant-*k* sections and two *m*-derived terminating half-sections, and their attenuation in the 54–88-Mc. range varies from over 50 to nearly 70 db., depending on the frequency and the particular set of values used. Above 174 Mc. the theoretical attenuation is better than 85 db., but will depend somewhat on internal resonant conditions associated principally with the lead lengths to the capacitors. These leads should be kept as short as is physically possible.

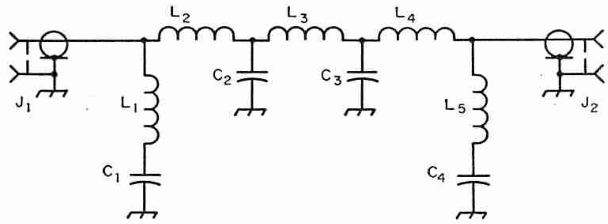


Fig. 23-22—Low-pass filter circuit for attenuating harmonics in the TV bands. J_1 and J_2 are chassis-type coaxial connectors. In the table below the letters refer to the following:

A—Using 100- and 70-μμf. 500-volt silver mica capacitors in parallel for C_2 and C_3.

B—Using 70- and 50-μμf. silver mica capacitors in parallel for C_2 and C_3.

C—Using 100- and 50-μμf. mica capacitors, 1200-volt (case-style CM-45) in parallel for C_2 and C_3.

D and E—Using variable air capacitors, 500- to 1000-volt rating, adjusted to values given (see measurements chapter for data on measuring capacitance).

	A	B	C	D	E	
Z_0	52	75	52	52	75	ohms
f_c	36	35.5	41	40	40	Mc.
f_∞	44.4	47	54	50	50	Mc.
f_1	25.5	25.2	29	28.3	28.3	Mc.
f_2	32.5	31.8	37.5	36.1	36.1	Mc.
C_1, C_4	50	40	50	46	32	μμf.
C_2, C_3	170	120	150	154	106	μμf.
L_1, L_5	5½	6	4	5	6½	turns*
L_2, L_4	8	11[1]	7	7	9½	turns*
L_3	9	13	8	8½	11½	turns*

*No. 12 or No. 14 wire, ½-inch inside diameter, 8 turns per inch.

[1] A 9-turn coil with closer turn spacing to give the same inductance is shown in Fig. 23-21.

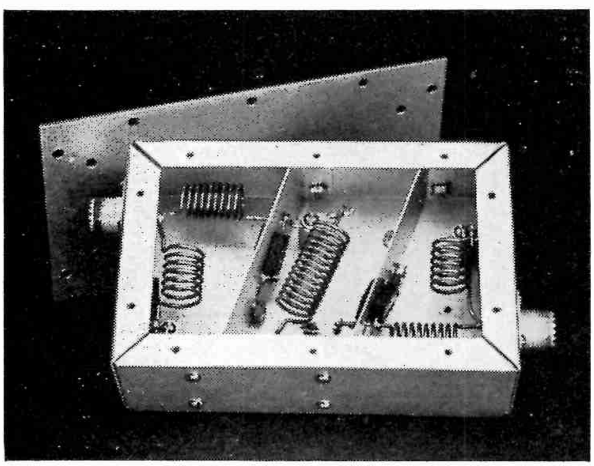


Fig. 23-21—An inexpensive low-pass filter using silver-mica postage-stamp capacitors. The box is a 2 by 4 by 6 aluminum chassis. Aluminum shields, bent and folded at the sides and bottom for fastening to the chassis, form shields between the filter sections. The diagonal arrangement of the shields provides extra room for the coils and makes it easier to fit the shields in the box, since bending to exact dimensions is not essential. The bottom plate, made from sheet aluminum, extends a half inch beyond the ends of the chassis and is provided with mounting holes in the extensions. It is held on the chassis with sheet-metal screws.

The power that filters using mica capacitors can handle safely is determined by the voltage and current limitations of the capacitors. The power capacity is least at the highest frequency. The unit using postage-stamp silver mica capacitors is capable of handling approximately 50 watts in the 28-Mc. band, when working into a properly-matched line, but is good for about 150 watts at 21 Mc. and 300 watts at 14 Mc. and lower frequencies. A filter with larger mica capacitors (case type CM-45) will carry about 250 watts safely at 28 Mc., this rating increasing to 500 watts at 21 Mc. and a kilowatt at 14 Mc. and lower. If there is an appreciable mismatch between the filter and the line into which it works, these ratings will be considerably decreased, so in order to avoid capacitor failure it is highly essential that the line on the output side of the filter be carefully matched by its load. This can be done with an s.w.r. bridge,

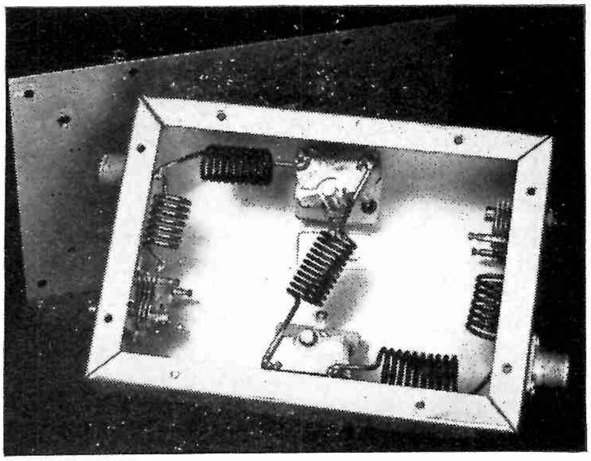


Fig. 23-23—Low-pass filter using variable air capacitors. The box is a 2 by 5 by 7 aluminum chassis, fitted with a bottom plate of similar construction to the one used in Fig. 23-21.

and the matching is easy to control if the line from the filter terminates in a matching circuit of the type described in the chapter on transmission lines.

The power capacity of these filters can be increased considerably by substituting r.f. type fixed capacitors (such as the Centralab 850 series) or variable air capacitors, in which event the power capability will be such as to handle the maximum amateur power on any band. The construction can be modified to accommodate variable air capacitors as shown in Fig. 23-23.

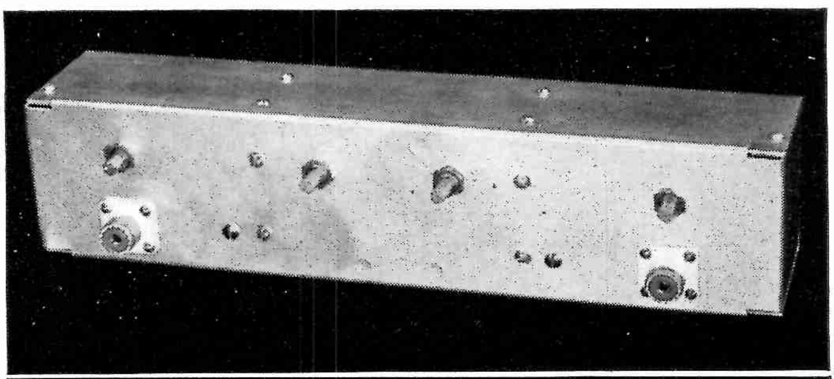
Using fixed capacitors of standard tolerances, there should be little difficulty in getting proper filter operation. A grid-dip meter with an accurate calibration should be used for adjustment of the coils. First, wire up the filter without L_2 and L_4. Short-circuit J_1 at its inside end with a screwdriver or similar conductor, couple the grid-dip meter to L_1 and adjust the inductance of L_1, by varying the turn spacing, until the circuit resonates at f_∞ as given in the table. Do the same thing at the other end of the filter with L_5. Then couple the meter to the circuit formed by L_3, C_2 and C_3, and adjust L_3 to resonate at the frequency f_1 as given by the table. Then remove L_3, install L_2 and L_4 and adjust L_2 to make the circuit formed by L_1, L_2, C_1 and C_2 (without the short across J_1) resonate at f_2 as given in the table. Do the same with L_4 for the circuit formed by L_4, L_5, C_3 and C_4. Then replace L_3 and check with the grid-dip meter at any coil in the filter; a distinct resonance should be found at or very close to the cut-off frequency, f_c. The filter is then ready for use.

The filter constants suggested at D and E in Fig. 23-22 are based on the optimum design for good impedance characteristics — that is, with $m = 0.6$ in the end sections — and a cut-off frequency below the standard i.f. for television receivers (sound carrier at 41.25 Mc.; picture carrier at 45.75 Mc.). This is to avoid possible harmonic interference from 21 Mc. and below to the receiver's intermediate amplifier. The other designs similarly cut off at 41 Mc. or below, but m in these cases is necessarily based on the capacitances available in standard fixed capacitors.

Filters for 50- and 144-Mc. Transmitters

Since a low-pass filter must have a cut-off frequency above the frequency on which the transmitter operates, a filter for a v.h.f. transmitter cannot be designed for attenuation in all television channels. This is no handicap for v.h.f. work but means that the filter will not be effective when used with lower-frequency transmitters, unless it happens that no TV channels in use in the locality fall inside the pass band of the filter.

Fig. 23-24 shows a filter for 52-ohm coax suitable for a 50-Mc. transmitter of any power up to the authorized limit. The circuit diagram is given in Fig. 23-25. If the values of inductance and capacitance can be measured (see chapter on measurements) the components can be preset and assembled without further adjustment. Alternatively, the grid-dip meter method described earlier may be used. The resonant frequencies are:



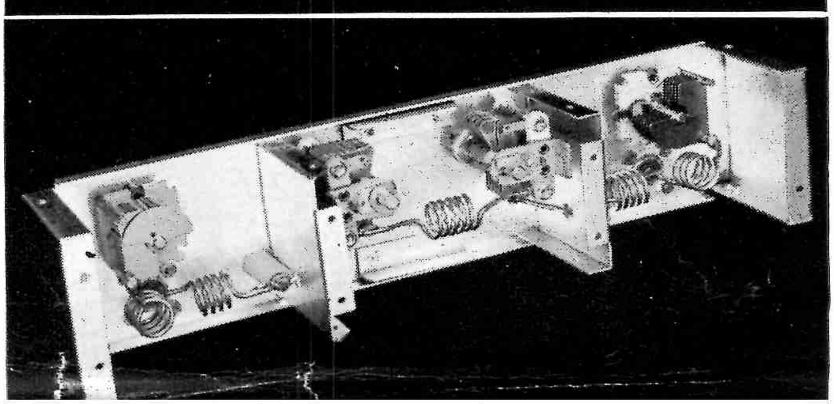


Fig. 23-24 — Low-pass filter fo use with 50-Mc. transmitters and 52-ohm line. It uses variable air capacitors adjusted to the proper capacitance values and is suited to powers up to a kilowatt.

L_1C_1 (J_1 shorted, L_3 disconnected) / L_5C_4 (J_3 shorted, L_4 disconnected)	81.5 Mc.
$L_3C_2C_3$ (L_2 and L_4 disconnected)	46 Mc.
$L_1L_2C_1C_2$ (L_3 disconnected) / $L_4L_5C_3C_4$ (L_3 disconnected)	58.5 Mc.

The cut-off frequency is approximately 65 Mc.

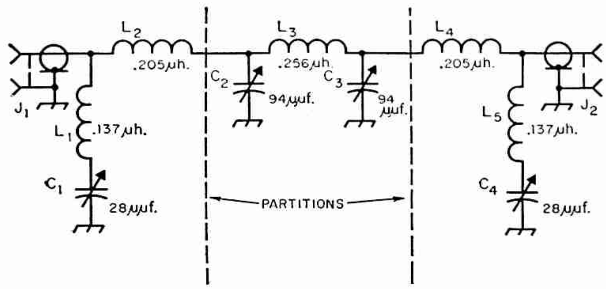


Fig. 23-25—Circuit diagram of the low-pass filters for 50- and 144-Mc. transmitters. Values on the drawing are for the 50-Mc. filter. Partitions are not used in the 144-Mc. unit.

C_1, C_4—50 Mc.; 50-μμf. variable, shaft-mounted, set to middle of tuning range (Johnson 50L15). 144 Mc.: 11-μμfd. ceramic (10-μμf. usable).
C_2, C_3—50 Mc.: 100-μμf. variable, shaft-mounted set with rotor ¼ inch out of stator (Bud MC-905). 144 Mc.: 38-μμf. stand-off bypass (Erie Style 721A).
50-Mc. coil data:
L_1, L_5—3½ turns ⅝ inch long. Top leads ¾ inch, bottom leads ¼ inch long.
L_2, L_4—4½ turns ⅝ inch long. Leads ½ inch long each end.
L_3—5½ turns ⅞ inch long. Leads 1 inch long each. All 50-Mc. coils No. 12 tinned, ½-inch diam., coil length measured between right-angle bends where leads begin.
144-Mc. coil data:
L_1, L_5—3 turns ¼ inch long. Leads ¼ inch long each end.
L_2, L_4—2 turns ⅛ inch long. Leads 1 inch long each end.
L_3—5 turns ¾ inch long. Leads ⅝ inch long each end. All 144-Mc. coils No. 18 tinned, ¼-inch diam., lengths measured as for 50-Mc. coils.
J_1, J_2—Coaxial fitting.

The case for the 50-Mc. filter is a standard aluminum slip-cover type box measuring 3⅛ by 13 by 2⅝ inches. The two end capacitors, C_1 and C_4, are mounted with their two stator posts toward the ends of the filter. The two larger units are mounted in the center compartment with their rotor shafts toward the middle. The top leads from coils L_1 and L_5 are wrapped around the stator terminals of C_1 and C_4, and the bottom leads fit directly into the coaxial input and output fittings. The outer ends of coils L_2 and L_4 are soldered to the coaxial fitting terminals, and their inner ends are soldered to lugs supported on one-inch ceramic stand-off insulators. Leads from the stand-offs go through holes in the partitions to the bottom stator lugs on C_2 and C_3. L_3 is soldered to the two upper lugs on these two capacitors, thus completing the filter circuit. Lead lengths for the coils given in the parts list are the total lengths to be left when the winding is completed, including the portions that will be used in soldering operations.

This filter will give high attenuation in Channels 4–6 and all the high-band channels, and thus will take care of most of the spurious signals generated in a 50-Mc. transmitter.

A filter for low-power 144-Mc. transmitters is shown in Fig. 23-26. It is designed for maximum attenuation in the 190–215 Mc. region to suppress the spurious radiations in that range that frequently occur with 144-Mc. transmitters, but also has good attenuation for all frequencies above 170 Mc. Optimum capacitance values are given in Fig. 23-25. If possible, several units of the nearest standard values available should be measured and those having values closest to the optimum used. The inductance values are too small to be measured with sufficient accuracy, so the filter should be adjusted as follows:

First, mount L_1 and C_1, short J_1 temporarily at its inner terminals, and adjust L_1 until the combination resonates at 200 Mc. as shown by a grid-dip meter. Next, remove the short from J_1 and connect L_2 and C_2, adjusting L_2 until the circuit formed by $L_1L_2C_1C_2$ resonates at 144 Mc. Then disconnect L_2 and mount L_3 between C_2 and C_3. Adjust L_3 until the circuit $L_3C_2C_3$ resonates at 112 Mc. Next, disconnect L_3 and follow a similar procedure starting from the other end with L_5 and C_4. Finally, reconnect all coils and a check at any point in the filter should show resonance at 160 Mc., the approximate cut-off frequency.

The case for the 144-Mc. filter is made from flashing copper and is 1¼ inches square by 7⅛ inches long. The main portion of the case is cut from a single piece with the end tabs folded down and soldered to the sides. Flanges are folded over at the bottom, and a cover is made to slip over these.

Filter Installation

In order to give the harmonic attenuation of

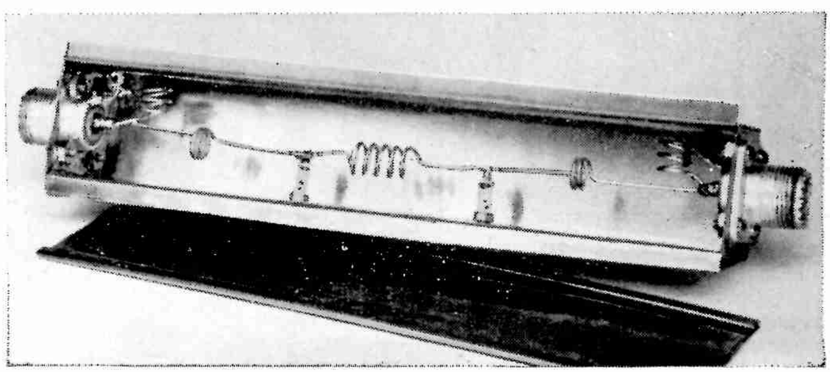


Fig. 23-26—A 52-ohm low-pass filter for 144-Mc. transmitters.

which it is capable, a low-pass filter must be installed in such a way that *all* the output of the transmitter flows through it. If harmonic currents are permitted to flow on the outside of the connecting coaxial cables, they will simply flow over the filter and on up to the antenna, and the filter does not have an opportunity to stop them. That is why it is so important to reduce the radiation from the transmitter and its leads to negligible proportions.

Fig. 23-27 shows the proper way to install a filter between a shielded transmitter and a matching circuit. Note that the coax, together with the shields about the transmitter and filter, forms a continuous shield to keep all the r.f. inside. It is thus forced to flow through the filter and the harmonics are attenuated. If there is no harmonic energy left after passing through the filter, shielding from that point on is not necessary; consequently, the matching circuit or antenna coupler does not need to be shielded. However, the antenna-coupler chassis arrangement shown in Fig. 23-27 is desirable because it will tend to prevent fundamental-frequency energy from flowing from the matching circuit back over the transmitter; this helps eliminate feed-back troubles in audio systems.

If the antenna is driven through coaxial line the matching circuit shown in Fig. 23-27 may be omitted. In that case the line goes directly from the filter to the antenna.

When a filter does not seem to give the harmonic attenuation of which it should be capable, the probable reason is that harmonics are bypassing it because of improper installation and inadequate transmitter shielding, including lead filtering. However, occasionally there are cases where the circuits formed by the cables and the apparatus to which they connect become resonant at a harmonic frequency. This greatly increases the harmonic output at that frequency. Such troubles can be completely overcome by substituting a slightly different cable length. The most critical length is that connecting the transmitter to the filter. Checking with a grid-dip meter at the final amplifier output coil usually will show whether an unfavorable resonance of this type exists.

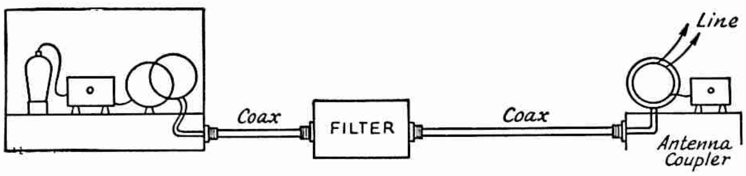


Fig. 23-27—The proper method of installing a low-pass filter between the transmitter and antenna coupler or matching circuit. If the antenna is fed through coax the matching circuit may be omitted but the same construction should be used between the transmitter and filter. The filter should be thoroughly shielded.

● SUMMARY

The methods of harmonic elimination outlined in this chapter have been proved beyond doubt to be effective even under highly unfavorable conditions. It must be emphasized once more, however, that the problem must be solved one step at a time, and the procedure must be in logical order. It cannot be done properly without two items of simple equipment: a grid-dip meter and wavemeter covering the TV bands, and a dummy antenna.

The proper procedure may be summarized as follows:

1) Take a critical look at the transmitter on the basis of the design considerations outlined under "Reducing Harmonic Generation".

2) Check all circuits, particularly those connected with the final amplifier, with the grid-dip meter to determine whether there are any resonances in the TV bands. If so, rearrange the circuits so the resonances are moved out of the critical frequency region.

3) Connect the transmitter to the dummy antenna and check with the wavemeter for the presence of harmonics on leads and around the transmitter enclosure. Seal off the weak spots in the shielding and filter the leads until the wavemeter shows no indication at any harmonic frequency.

4) At this stage, check for interference with a TV receiver. If there is interference, determine the cause by the methods described previously and apply the recommended remedies until the interference disappears.

5) When the transmitter is completely clean on the dummy antenna, connect it to the regular antenna and check for interference on the TV receiver. If the interference is not bad, an antenna coupler or matching circuit installed as previously described should clear it up. Alternatively, a low-pass filter may be used. If neither the antenna coupler nor filter makes any difference in the interference, the evidence is strong that the interference, at least in part, is being caused by receiver overloading because of the strong fundamental-frequency field about the TV antenna and receiver. (See later section for identification of fundamental-frequency interference.) A coupler and/or filter, installed as described above, will invariably make a difference in the intensity of the interference if the interference is caused by transmitter harmonics alone.

6) If there is still interference after installing the coupler and/or filter, and the evidence shows that it is probably caused by a harmonic, more attenuation is needed. A more elaborate filter may be necessary. However, it is well at this stage to assume that part of the interference may be caused by receiver overloading, and take steps to alleviate such a condition before trying highly-elaborate filters, traps, etc., on the transmitter.

● HARMONICS BY RECTIFICATION

Even though the transmitter is completely free from harmonic output it is still possible for interference to occur because of harmonics generated outside the transmitter. These result from rectification of fundamental-frequency currents induced in conductors in the vicinity of the transmitting antenna. Rectification can take place at any point where two conductors are in poor electrical contact, a condition that frequently exists in plumbing, downspouting, BX cables crossing each other, and numerous other places in the ordinary residence. It also can occur in any exposed vacuum tubes in the station, in power supplies, speech equipment, etc., that may not be enclosed in the shielding about the r.f. circuits. Poor joints anywhere in the antenna system are especially bad, and rectification also may take place in the contacts of antenna change-over relays. Another common cause is overloading the front end of the communications receiver when it is used with a separate antenna (which will radiate the harmonics generated in the first tube) for break-in.

Rectification of this sort will not only cause harmonic interference but also is frequently responsible for cross-modulation effects. It can be detected in greater or less degree in most locations, but fortunately the harmonics thus generated are not usually of high amplitude. However, they can cause considerable interference in the immediate vicinity in fringe areas, especially when operation is in the 28-Mc. band. The amplitude decreases rapidly with the order of the harmonic, the second and third being the worst. It is ordinarily found that even in cases where destructive interference results from 28-Mc. operation the interference is comparatively mild from 14 Mc., and is negligible at still lower frequencies.

Nothing can be done at either the transmitter or receiver when rectification occurs. The remedy is to find the source and eliminate the poor contact either by separating the conductors or bonding them together. A crystal wavemeter (tuned to the fundamental frequency) is useful for hunting the source, by showing which conductors are carrying r.f. and, comparatively, how much.

Interference of this kind is frequently intermittent since the rectification efficiency will vary with vibration, the weather, and so on. The possibility of corroded contacts in the TV receiving antenna should not be overlooked, especially if it has been up a year or more.

● TV RECEIVER DEFICIENCIES

Front-End Overloading

When a television receiver is quite close to the transmitter, the intense r.f. signal from the transmitter's fundamental may overload one or more of the receiver circuits to produce spurious responses that cause interference.

If the overload is moderate, the interference is of the same nature as harmonic interference; it is caused by harmonics generated in the early stages of the receiver and, since it occurs only on channels harmonically related to the transmitting frequency, is difficult to distinguish from harmonics actually radiated by the transmitter. In such cases additional harmonic suppression at the transmitter will do no good, but any means taken at the receiver to reduce the strength of the amateur signal reaching the first tube will effect an improvement. With very severe overloading, interference also will occur on channels *not* harmonically related to the transmitting frequency, so such cases are easily identified.

Cross-Modulation

Under some circumstances overloading will result in cross-modulation or mixing of the amateur signal with that from a local f.m. or TV station. For example, a 14-Mc. signal can mix with a 92-Mc. f.m. station to produce a beat at 78 Mc. and cause interference in Channel 5, or with a TV station on Channel 5 to cause interference in Channel 3. Neither of the channels interfered with is in harmonic relationship to 14 Mc. Both signals have to be on the air for the interference to occur, and eliminating either at the TV receiver will eliminate the interference.

There are many combinations of this type, depending on the band in use and the local frequency assignments to f.m. and TV stations. The interfering frequency is equal to the amateur fundamental frequency either added to or subtracted from the frequency of some local station, and when interference occurs in a TV channel that is not harmonically related to the amateur transmitting frequency the possibilities in such frequency combinations should be investigated.

I. F. Interference

Some TV receivers do not have sufficient selectivity to prevent strong signals in the intermediate-frequency range from forcing their way through the front end and getting into the i.f. amplifier. The once-standard intermediate frequency of, roughly, 21 to 27 Mc., is subject to interference from the fundamental-frequency output of transmitters operating in the 21-Mc. band. Transmitters on 28 Mc. sometimes will cause this type of interference as well.

A form of i.f. interference peculiar to 50-Mc. operation near the low edge of the band occurs with some receivers having the standard "41-Mc." i.f., which has the sound carrier at 41.25 Mc. and the picture carrier at 45.75 Mc. A 50-Mc. signal that forces its way into the i.f. system of the receiver will beat with the i.f. picture carrier to give a spurious signal on or near the i.f. sound carrier, even though the interfering signal is not actually in the nominal passband of the i.f. amplifier.

There is a type of i.f. interference unique to the 144-Mc. band in localities where certain u.h.f. TV channels are in operation, affecting only those TV receivers in which double-conversion type plug-in u.h.f. tuning strips are used. The design of these strips involves a first intermediate frequency that varies with the TV channel to be received and, depending on the particular strip design, this first i.f. may be in or close to the 144-Mc. amateur band. Since there is comparatively little selectivity in the TV signal-frequency circuits ahead of the first i.f., a signal from a 144-Mc. transmitter will "ride into" the i.f., even when the receiver is at a considerable distance from the transmitter. The channels that can be affected by this type of i.f. interference are:

Receivers with 21-Mc. second i.f.	*Receivers with 41-Mc. second i.f.*
Channels 14–18, inc.	Channels 20–25, inc.
Channels 41–48, inc.	Channels 51–58, inc.
Channels 69–77, inc.	Channels 82 and 83.

If the receiver is not close to the transmitter, a trap of the type shown in Fig. 23-30 will be effective. However, if the separation is small the 144-Mc. signal will be picked up directly on the receiver circuits and the best solution is to readjust the strip oscillator so that the first i.f. is moved to a frequency not in the vicinity of the 144-Mc. band. This has to be done by a competent technician.

I.f. interference is easily identified since it occurs on all channels — although sometimes the intensity varies from channel to channel — and the cross-hatch pattern it causes will rotate when the receiver's fine-tuning control is varied. When the interference is caused by a harmonic, overloading, or cross modulation, the structure of the interference pattern does not change (its intensity may change) as the fine-tuning control is varied.

High-Pass Filters

In all the above cases the interference can be eliminated if the fundamental signal strength can be reduced to a level that the receiver can handle. To accomplish this with signals on bands below 30 Mc., the most satisfactory device is a high-pass filter having a cut-off frequency between 30 and 54 Mc., installed at the tuner input terminals of the receiver. Circuits that have proved effective are shown in Figs. 23-28 and 23-29. Fig. 23-29 has one more section than the filters of Fig. 23-28 and as a consequence has somewhat better cut-off characteristics. All the circuits given are designed to have little or no effect on

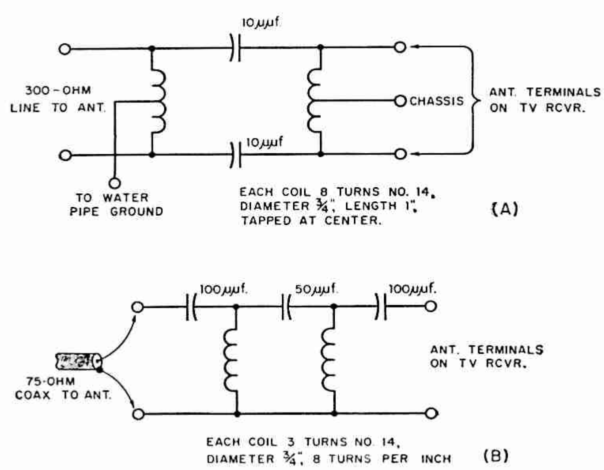


Fig. 23-28—High-pass filters for installation at the TV receiver antenna terminals. A—balanced filter for 300-ohm line, B—for 75-ohm coaxial line. *Important:* Do not use a direct ground on the chassis of a transformerless receiver. Ground through a 0.001-μf. mica capacitor.

the TV signals but will attenuate all signals lower in frequency than about 40 Mc. These filters preferably should be constructed in some sort of shielding container, although shielding is not always necessary. The dashed lines in Fig. 23-29 show how individual filter coils can be shielded from each other. The capacitors can be tubular ceramic units centered in holes in the partitions that separate the coils.

Simple high-pass filters cannot always be applied successfully in the case of 50-Mc. transmissions, because they do not have sufficiently-sharp cut-off characteristics to give both good attenuation at 50–54 Mc. and no attenuation above 54 Mc. A more elaborate design capable of giving the required sharp cut-off has been described (Ladd, "50-Mc. TVI — Its Causes and Cures," *QST*, June and July, 1954). This article also contains

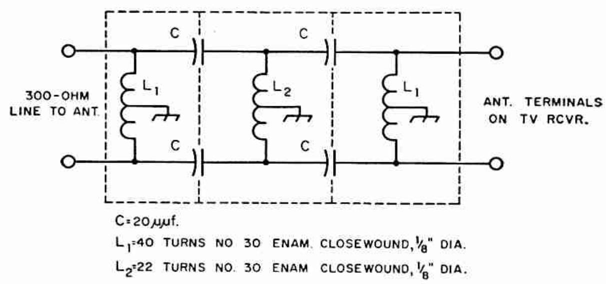


Fig. 23-29—Another type of high-pass filter for 300-ohm line. The coils may be wound on ⅛-inch diameter plastic knitting needles. *Important:* Do not use a direct ground on the chassis of a transformerless receiver. Ground through a 0.001-μf. mica capacitor.

other information useful in coping with the TVI problems peculiar to 50-Mc. operation. As an alternative to such a filter, a high-*Q* wave trap tuned to the transmitting frequency may be used, suffering only the disadvantage that it is quite selective and therefore will protect a receiver from overloading over only a small range of transmitting frequencies in the 50-Mc. band. A trap of this type using quarter-wave sections of Twin-Lead is shown in Fig. 23-30. These "suck-out" traps, while absorbing energy at the frequency to which they are tuned, do not affect the receiver operation otherwise. The assembly should be slid along the TV antenna lead-in until the most effective position is found, and then fastened securely in place with Scotch Tape. An insulated tuning tool should be used for adjustment of the trimmer capacitor, since it is at a "hot" point and will show considerable body-capacitance effect.

High-pass filters are available commercially at moderate prices. In this connection, it should be understood by all parties concerned that while an amateur is responsible for *harmonic* radiation from his transmitter, it is no part of his responsibility to pay for or install filters, wave traps, etc. that may be required at the receiver to prevent interference caused by his *fundamental* frequency. The set owner should be advised to get in touch with the organization from which he purchased the receiver or which services it, to make arrangements for proper installation. Proper in-

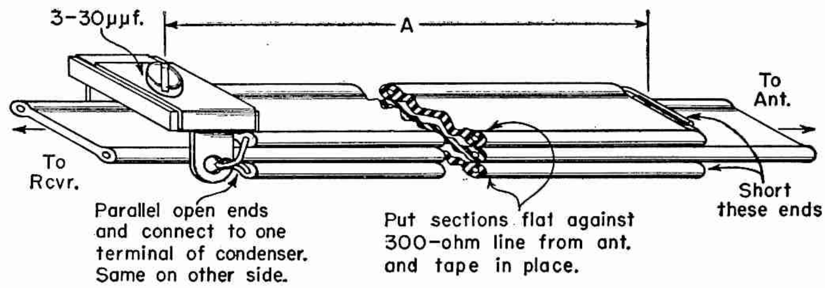


Fig. 23-30—Absorption-type wave trap using sections of 300-ohm line tuned to have an electrical length of ¼ wavelength at the transmitter frequency. Approximate physical lengths (dimension A) are 40 inches for 50 Mc. and 11 inches for 144 Mc., allowing for the loading effect of the capacitance at the open end. Two traps are used in parallel, one on each side of the line to the receiver.

stallation usually requires that the filter be installed right at the input terminals of the r.f. tuner of the TV set and not merely at the external antenna terminals, which may be at a considerable distance from the tuner. The question of cost is one to be settled between the set owner and the organization with which he deals.

Some of the larger manufacturers of TV receivers have instituted arrangements for cooperating with the set dealer in installing high-pass filters at no cost to the receiver owner. FCC-sponsored TVI Committees, now operating in many cities, have all the information necessary for effectuating such arrangements. To find out whether such a committee is functioning in your community, write to the FCC field office having jurisdiction over your location. A list of the field offices is contained in *The Radio Amateur's License Manual*, published by ARRL.

If the fundamental signal is getting into the receiver by way of the line cord a line filter such as that shown in Fig. 23-1 may help. To be most effective it should be installed inside the receiver chassis at the point where the cord enters, making the ground connections directly to chassis at this point. It may not be so helpful if placed between the line plug and the wall socket unless the r.f. is actually picked up on the house wiring rather than on the line cord itself.

Antenna Installation

Usually, the transmission line between the TV receiver and the actual TV antenna will pick up a great deal more energy from a nearby transmitter than the television receiving antenna itself. The currents induced on the TV transmission line in this case are of the "parallel" type, where the phase of the current is the same in both conductors. The line simply acts like two wires connected together to operate as one. If the receiver's antenna input circuit were perfectly balanced it would reject these "parallel" or "unbalance" signals and respond only to the true transmission-line ("push-pull") currents; that is, only signals picked up on the actual antenna would cause a receiver response. However, no receiver is perfect in this respect, and many TV receivers will respond strongly to such parallel currents. The result is that the signals from a nearby amateur transmitter are much more intense at the first stage in the TV receiver than they would be if the receiver response were confined entirely to energy picked up on the TV antenna alone. This situation can be improved by using shielded transmission line — coax or, in the balanced form, "twinax" — for the receiving installation. For best results the line should terminate in a coax fitting on the receiver chassis, but if this is not possible the shield should be grounded to the chassis right at the antenna terminals.

The use of shielded transmission line for the receiver also will be helpful in reducing response to harmonics actually being radiated from the transmitter or transmitting antenna. In most receiving installations the transmission line is very much longer than the antenna itself, and is consequently far more exposed to the harmonic fields from the transmitter. Much of the harmonic pickup, therefore, is on the receiving transmission line when the transmitter and receiver are quite close together. Shielded line, plus relocation of either the transmitting or receiving antenna to take advantage of directive effects, often will result in reducing overloading, as well as harmonic pickup, to a level that does not interfere with reception.

U.H.F. TELEVISION

Harmonic TVI in the u.h.f. TV band is far less troublesome than in the v.h.f. band. Harmonics from transmitters operating below 30 Mc. are of such high order that they would normally be expected to be quite weak; in addition, the components, circuit conditions and construction of low-frequency transmitters are such as to tend to prevent very strong harmonics from being generated in this region. However, this is not true of amateur v.h.f. transmitters, particularly those working in the 144-Mc. and higher bands. Here the problem is quite similar to that of the low v.h.f. TV band with respect to transmitters operating below 30 Mc.

There is one highly favorable factor in u.h.f. TV that does not exist in the most of the v.h.f. TV band: If harmonics are radiated, it is possible to move the transmitter frequency sufficiently (within the amateur band being used) to avoid interfering with a channel that may be in use in the locality. By restricting operation to a portion of the amateur band that will not result in harmonic interference, it is possible to avoid the necessity for taking extraordinary precautions to prevent harmonic radiation.

The frequency assignment for u.h.f. television consists of seventy 6-megacycle channels (Nos. 14 to 83, inclusive) beginning at 470 Mc. and ending at 890 Mc. The harmonics from amateur bands above 50 Mc. span the u.h.f. channels as shown in Table 23-I. Since the assignment plan

TABLE 23-I

Harmonic Relationship—Amateur V.H.F. Bands and U.H.F. TV Channels

Amateur Band	*Harmonic*	*Fundamental Freq. Range*	*U.H.F. TV Channel Affected*	*Amateur Band*	*Harmonic*	*Fundamental Freq. Range*	*U.H.F. TV Channel Affected*
144 Mc.	4th	144.0–144.5	31	*220 Mc.*	3rd	220–220.67	45
		144.5–146.0	32			220.67–222.67	46
		146.0–147.5	33			222.67–224.67	47
		147.5–148.0	34			224.67–225	48
					4th	220–221	82
	5th	144.0–144.4	55			221–222.5	83
		144.4–145.6	56				
		145.6–146.8	57	*420 Mc*	2nd	420–421	75
		146.8–148	58			421–424	76
						424–427	77
	6th	144–144.33	79			427–430	78
		144.33–145.33	80			430–433	79
		145.33–147.33	81			433–436	80
		147.33–148	82			436–439	81
						439–442	82
						442–448	83

calls for a minimum separation of six channels between any two stations in one locality, there is ample opportunity to choose a fundamental frequency that will move a harmonic out of range of a local TV frequency.

COLOR TELEVISION

The color TV signal includes a subcarrier spaced 3.58 megacycles from the regular picture carrier (or 4.83 Mc. from the low edge of the channel) for transmitting the color information. Harmonics which fall in the color subcarrier region can be expected to cause break-up of color in the received picture. This modifies the chart of Fig. 23-3 to introduce another "severe" region centering around 4.8 Mc. measured from the low-frequency edge of the channel. Hence with color television reception there is less opportunity to avoid harmonic interference by choice of operating frequency. In other respects the problem of eliminating interference is the same as with black-and-white television.

INTERFERENCE FROM TV RECEIVERS

The TV picture tube is swept horizontally by the electron beam 15,750 times per second, using a wave shape that has very high harmonic content. The harmonics are of appreciable amplitude even at frequencies as high as 30 Mc., and when radiated from the receiver can cause considerable interference to reception in the amateur bands. While measures to suppress radiation of this nature are required by FCC in currently manufactured receivers, many older sets have had no such treatment. The interference takes the form of rather unstable, a.c.-modulated signals spaced at intervals of 15.75 kc.

Studies have shown that the radiation takes place principally in three ways, in order of their importance: (1) from the a.c. line, through stray coupling to the sweep circuits; (2) from the antenna system, through similar coupling; (3) directly from the picture tube and sweep-circuit wiring. Line radiation often can be reduced by bypassing the a.c. line cord to the chassis at the point of entry, although this is not completely effective in all cases since the coupling may take place outside the chassis beyond the point where the by passing is done. Radiation from the antenna is usually suppressed by installing a high-pass filter on the receiver. The direct radiation requires shielding of high-potential leads and, in some receivers, additional bypassing in the sweep circuit; in severe cases, it may be necessary to line the cabinet with screening or similar shielding material.

Incidental radiation of this type from TV and broadcast receivers, when of sufficient intensity to cause serious interference to other radio services (such as amateur), is covered by Part 15 of the FCC rules. When such interference is caused, the user of the receiver is obligated to take steps to eliminate it. The owner of an offending receiver should be advised to contact the source from which the receiver was purchased for appropriate modification of the receiving installation. TV receiver dealers can obtain the necessary information from the set manufacturer.

It is usually possible to reduce interference very considerably, without modifying the TV receiver, simply by having a good amateur-band receiving installation. The principles are the same as those used in reducing "hash" and other noise — use a good antenna, such as the transmitting antenna, for reception; install it as far as possible from a.c. circuits; use a good feeder system such as a properly balanced two-wire line or coax with the outer conductor grounded; use coax input to the receiver, with a matching circuit if necessary; and check the receiver to make sure that it does not pick up signals or noise with the antenna disconnected. These measures not only reduce interference from sweep radiation and a.c. line noise, but also build up the strength of the desired signal, so that the overall improvement in signal-to-interference ratio is very much worth-while.

Operating a Station

The enjoyment of our hobby comes mostly from the operation of our station once we have finished its construction. Upon the *station* and its *operation* depend the communication records that are made. The standing of individuals as amateurs and respect for the capabilities of the whole institution of amateur radio depend to a considerable extent on the practical communications established by amateurs, the aggregate of all our station efforts.

An operator with a slow, steady, clean-cut method of sending has a big advantage over the poor operator. The technique of speaking in connected thoughts and phrases is equally important for the voice operator. Good sending is partly a matter of practice but patience and judgment are just as important qualities of an operator as a good "fist."

Operating knowledge embracing standard procedures, development of skill in employing c.w. to expand the station range and operating effectiveness at minimum power levels and some net know-how are all essentials in achieving a triumphant amateur experience with top station records, personal results, and demonstrations of what our stations can do in practical communications.

OPERATING COURTESY AND TOLERANCE

Normal operating interests in amateur radio vary considerably. Some prefer to rag-chew, others handle traffic, others work DX, others concentrate on working certain areas, countries or states and still others get on for an occasional contact only to check a new transmitter or antenna.

Interference is one of the things we amateurs have to live with. However, we can conduct our operating in a way designed to alleviate it as much as possible. *Before putting the transmitter on the air, listen on your own frequency.* If you hear stations engaged in communication on that frequency, stand by until you are sure no interference will be caused by your operations, or *shift to another frequency.* No amateur or any group of amateurs has any *exclusive* claim to any frequency in any band. We must work together, each respecting the rights of others. Remember, those other chaps can cause you as much interference as you cause them, sometimes more!

In this chapter we'll recount some fundamentals of operating success, cover major procedures for successful general work and include proper forms to use in message handling and other fields. Note also the sections on special activities, awards and organization. These permit us all to develop through our organization more success together than we could ever attain by separate uncoordinated efforts that overlook the precepts established through operating experience.

C.W. PROCEDURE

The best operators, *both* those using voice and c.w., observe certain operating procedures regarded as "standard practice."

1) *Calls.* Calling stations may call efficiently by transmitting the call signal of the station called three times, the letters DE, followed by one's own station call sent three times. (Short calls with frequent "breaks" to listen have proved to be the best method.) Repeating the call of the station called four or five times and signing not more than two or three times has proved excellent practice, thus: WØBY WØBY WØBY WØBY WØBY DE W1AW W1AW $\overline{\text{AR}}$.

CQ. The general-inquiry call (CQ) should be sent not more than five times without interspersing one's station identification. The length of repeated calls is carefully limited in intelligent amateur operating. (CQ is not to be used when testing or when the sender is not expecting or looking for an answer. Never send a CQ "blind." Always be sure to listen on the transmitting frequency first.)

The directional CQ: To reduce the number of useless answers and lessen QRM, every CQ call should be made informative when possible.

> *Examples:* A United States station looking for any Hawaiian amateur calls: CQ KH6 CQ KH6 CQ KH6 DE W4IA W4IA W4IA K. A Western station with traffic for the East Coast when looking for an intermediate relay station calls: CQ EAST CQ EAST CQ EAST DE W5IGW W5IGW W5IGW K. A station with messages for points in Massachusetts calls: CQ MASS CQ MASS CQ MASS DE W7CZY W7CZY W7CZY K.

Hams who do not raise stations readily may find that their sending is poor, their calls ill-timed or judgment in error. When conditions are right to bring in signals from the desired locality, you can call them. Reasonably short calls, with appropriate and brief breaks to listen, will raise stations with minimum time and trouble.

2) *Answering a Call:* Call three times (or less); send DE; sign three times (or less); after contact is established decrease the use of the call signals of both stations to *once or twice.* When a station receives a call but does not receive the call letters of the station calling, QRZ? may be used. It means "By whom am I being called?" QRZ should not be used in place of CQ.

3) *Ending Signals and Sign-Off:* The proper use of $\overline{AR}$, K, $\overline{KN}$, $\overline{SK}$ and CL ending signals is as follows:

$\overline{AR}$ — End of transmission. Recommended after call to a specific station before contact has been established.

> *Example:* W6ABC W6ABC W6ABC W6ABC W6ABC DE W9LMN W9LMN $\overline{AR}$. Also at the end of transmission of a radiogram, immediately following the signature, preceding identification.

K — Go ahead (any station). Recommended after CQ and at the end of each transmission during QSO when there is no objection to others breaking in.

> *Example:* CQ CQ CQ DE W1ABC W1ABC K or W9XYZ DE W1ABC K.

$\overline{KN}$ — Go ahead (specific station), all others keep out. Recommended at the end of each transmission during a QSO, or after a call, when calls from other stations are not desired and will not be answered.

> *Example:* W4FGH DE XU6GRL $\overline{KN}$.

$\overline{SK}$ — End of QSO. Recommended before signing *last* transmission at end of a QSO.

> *Example:* .... $\overline{SK}$ W8LMN DE W5BCD.

CL — I am closing station. Recommended when a station is going off the air, to indicate that it will not listen for any further calls.

> *Example:* .... $\overline{SK}$ W7HIJ DE W2JKL CL.

4) *Testing.* When it is necessary for a station to make test signals they must not continue for more than 10 seconds and must be composed of a series of VVV followed by the call sign of the station emitting the test signals. *Always listen first* to find a clear spot if possible, to avoid causing unwarranted QRM of a QSO in progress.

5) *Receipting* for conversation or traffic: Never receipt for a transmission until it has been entirely received. "R" means "transmission received as sent." Use R *only* when *all* is received correctly.

6) *Repeats.* When most of a transmission is lost, a call should be followed by correct abbreviations to ask for repeats. When a few words on the end of a transmission are lost, the *last word received correctly* is given after ?AA, meaning "all after." When a few words at the beginning of a transmission are lost, ?AB for "all before" a stated word should be used. The quickest way to ask for a fill in the middle of a transmission is to send the last word received correctly, a question mark, then the next word received correctly. Another way is to send "?BN [word] and [word]."

Do not send words twice (QSZ) unless it is requested. Send single. Do not fall into the bad habit of sending double *without a request* from fellows you work. Don't say "QRM" or "QRN" when you mean "QRS." Don't CQ unless there is definite reason for so doing. When sending CQ, use judgment.

General Practices

When a station has receiving trouble, the operator asks the transmitting station to "QSV." The letter "R" is often used in place of a decimal point (e.g., "3R5 Mc.") or the colon in time designation (e.g., "2R30 PM"). A long dash is sometimes sent for "zero."

The law concerning superfluous signals should be noted. If you *must* test, disconnect the antenna system and use an equivalent "dummy" antenna. Send your call frequently when operating. Pick a time for adjusting the station apparatus when few stations will be bothered.

The up-to-date amateur station uses "break-in." For best results send at a medium speed. Send evenly with proper spacing. The standard-type telegraph key is best for all-round use. Regular daily practice periods, two or three periods a day, are best to acquire real familiarity and proficiency with code.

No excuse can be made for "garbled" copy. Operators should copy what is sent and refuse to acknowledge a whole transmission until every word has been received correctly. *Good operators do not guess.* "Swing" in a fist is *not* the mark of a good operator. Unusual words are sent twice, the word repeated following the transmission of "?". If not *sure*, a good operator systematically asks for a fill or repeat. Sign your call frequently, interspersed with calls, and at the end of all transmissions.

On Good Sending

Assuming that an operator has learned sending properly, and comes up with a precision "fist" — not fast, but clean, steady, making well-formed rhythmical characters and spacing beautiful to listen to — he then becomes subject to outside pressures to his own possible detriment in everyday operating. He will want to "speed it up" because the operator at the other end is going faster, and so he begins, unconsciously, to run his words together or develops a "swing."

Perhaps one of the easiest ways to get into bad habits is to do too much playing around with special keys. Too many operators spend only enough time with a straight key to acquire "passable" sending, then subject their newly-developed "fists" to the entirely different movements of bugs, side-swipers, electronic keys, or what-have-you. All too often, this results in the ruination of what may have become a very good "fist."

Think about your sending a little. Are you satisfied with it? You should not be — ever. Nobody's sending is perfect, and therefore *every* operator should continually strive for improvement. Do you ever run letters together — like Q for MA, or P for AN — especially when you are in a hurry? Practically everybody does at one time or another. Do you have a "swing"? Any recognizable "swing" is a deviation from perfection. Strive to send like tape sending; copy a W1AW Bulletin and try to send it with the same spacing using a local oscillator on a subsequent transmission.

Check your spacing in characters, between characters and between words occasionally by making a recording of your fist on an inked tape recorder. This will show up your faults as nothing else will. Practice the correction of faults.

USING A BREAK-IN SYSTEM

Break-in avoids unnecessarily long calls, prevents QRM, gives more communication per hour of operating. Brief calls with frequent short pauses for reply can approach (but not equal) break-in efficiency.

A separate receiving antenna facilitates break-in operation. It is only necessary with break-in to pause just a moment with the key up (or to cut the carrier momentarily and pause in a phone conversation) to listen for the other station. The click when the carrier is cut off is as effective as the word "break."

C.w. telegraphy break-in is usually simple to arrange. With break-in, ideas and messages to be transmitted can be pulled right through the holes in the QRM. Snappy, efficient amateur work with break-in usually requires a separate receiving antenna and arrangement of the transmitter and receiver to eliminate the necessity for throwing switches between transmissions.

In calling, the transmitting operator sends the letters "BK" at intervals during his call so that stations hearing the call may know that break-in is in use and take advantage of the fact. *He pauses at intervals* during his call, to listen for a moment for a reply. If the station being called does not answer, the call can be continued.

With a tap of the key, the man on the receiving end can interrupt (if a word is missed). The other operator is constantly monitoring, awaiting just such directions. It is not necessary that *you* have perfect facilities to take advantage of break-in when the stations you work are break-in-equipped. After any invitation to *break* is given (and at each pause) press your key — and contact can start *immediately*.

VOICE OPERATING

The use of proper procedure to get best results is just as important as in using code. In telegraphy words must be spelled out letter by letter. It is therefore but natural that abbreviations and shortcuts should have come into widespread use. In voice work, however, abbreviations are not necessary, and should have less importance in our operating procedure.

Voice-Operating Hints

1) Listen before calling.
2) Make short calls with breaks to listen. Avoid long CQs; do not answer any.
3) Use push-to-talk or voice control. Give essential data concisely in first transmission.
4) Make reports honest. Use definitions of strength and readability for reference. Make your reports informative and useful. Honest reports and *full* word description of signals save amateur operators from FCC trouble.
5) Limit transmission length. Two minutes or less will convey much information. When three or more stations converse in round tables, brevity is essential.
6) Display sportsmanship and courtesy. Bands are congested . . . make transmissions meaningful . . . give others a break.
7) Check transmitter adjustment . . . avoid a.m. overmodulation and splatter. On s.s.b. check carrier balance carefully. Do not radiate when moving v.f.o. frequency or checking n.f.m. swing. Use receiver b.f.o. to check stability of signal. Complete testing before busy hours!

The letter "K" has been agreed to in telegraphic practice so that the operator will not have to pound out the separate letters that spell the words "go ahead." The voice operator can *say* the words "go ahead" or "over," or "come in please."

One laughs on c.w. by spelling out HI. On phone *use* a laugh when one is called for. Be natural as you would with your family and friends.

The matter of reporting *readability* and *strength* is as important to phone operators as to those using code. With telegraph nomenclature, it is necessary to spell out words to describe signals or use abbreviated signal reports. But on voice, we have the ability to "say it with words." "Readability four, Strength eight" is the best way to give a quantitative report. Reporting can be done so much more meaningfully with ordinary words: "You are weak but you are in the clear and I can understand you, so go ahead," or "Your signal is strong but you are buried under local interference." Why not say it with words?

Voice Equivalents to Code Procedure

Voice	*Code*	*Meaning*
Go ahead; over	K	Self-explanatory
Wait; stand by	$\overline{AS}$	Self-explanatory
Received	R	Receipt for a correctly-transcribed message or for "solid" transmission with no missing portions

Phone-Operating Practice

Efficient voice communication, like good c.w. communication, demands good operating. Adherence to certain points "on getting results" will go a long way toward improving our phone-band operating conditions.

Use push-to-talk technique. Where possible arrange on-off switches, controls or voice-controlled break-in for fast back-and-forth exchanges that emulate the practicality of the wire telephone.

This will help reduce the length of transmissions and keep brother amateurs from calling you a "monologuist" — a guy who likes to hear himself talk!

Listen with care. Keep noise and "backgrounds" out of your operating room to facilitate good listening. It is natural to answer the strongest signal, but take time to listen and give some consideration to the *best* signals, regardless of strength. Every amateur cannot run a kilowatt, but there is no reason why every amateur cannot have a signal of good quality, and utilize uniform operating practices to aid in the understandability and ease of his own communications.

Interpose your call regularly and at frequent intervals. Three short calls are better than one long one. In calling CQ, one's call should certainly appear at least once for every five or six CQs. Calls with frequent breaks to listen will save time and be most productive of results. In identifying, always transmit your *own* call *last. Don't* say "This is W1ABC standing by for W2DEF"; say "W2DEF, this is W1ABC, over." FCC regulations show the call of the transmitting station sent *last.*

Include country prefix before call. It is not correct to say "9RRX, this is 1BDI." Correct and legal use is "W9RRX, this is W1BDI." FCC regulations require proper use of calls; stations have been cited for failure to comply with this requirement.

Monitor your own frequency. This helps in timing calls and transmissions. Transmit when there is a chance of being copied successfully — not when you are merely "more QRM." Timing transmissions is an art to cultivate.

Keep modulation constant. By turning the gain "wide open" you are subjecting anyone listening to the diversion of whatever noises are present in or near your operating room, to say nothing of the possibility of feedback, echo due to poor acoustics, and modulation excesses due to sudden loud noises. Speak near the microphone, and don't let your gaze wander all over the station causing sharply-varying input to your speech amplifier; at the same time, keep far enough from the microphone so your signal is not modulated by your breathing. Change distance or gain only as necessary to insure uniform transmitter performance without overmodulation, splatter or distortion.

Make connected thoughts and phrases. Don't mix disconnected subjects. Ask questions consistently. Pause and get answers.

Have a pad of paper handy. It is convenient and desirable to jot down questions as they come in the course of discussion in order not to miss any. It will help you to make intelligent to-the-point replies.

Steer clear of inanities and soap-opera stuff. Our amateur radio and also our personal reputation as serious communications workers depend on us.

Avoid repetition. Don't repeat back what the other fellow has just said. Too often we hear a conversation like this: "Okay on your new antenna there, okay on the trouble you're having with your receiver, okay on the company who just came in with some ice cream, okay . . . [etc.]." Just *say* you received everything O.K. Don't try to prove it.

Use phonetics only as required. When clarifying genuinely doubtful expressions and in getting your call identified positively we suggest use of the ARRL Phonetic List. Limit such use to really-necessary clarification.

The speed of radiotelephone transmission (with perfect accuracy) depends almost entirely upon the skill of the two operators involved. One must learn to speak at a rate allowing perfect understanding as well as permitting the receiving operator to copy down the message text, if that is necessary. Because of the similarity of many English speech sounds, the use of alphabetical word lists has been found necessary. All voice-operated stations should use a *standard* list as needed to identify call signals or unfamiliar expressions.

ARRL Word List for Radiotelephony

ADAM	JOHN	SUSAN
BAKER	KING	THOMAS
CHARLIE	LEWIS	UNION
DAVID	MARY	VICTOR
EDWARD	NANCY	WILLIAM
FRANK	OTTO	X-RAY
GEORGE	PETER	YOUNG
HENRY	QUEEN	ZEBRA
IDA	ROBERT	

Example: W1AW . . . W 1 ADAM WILLIAM . . . W1AW

Round Tables. The round table has many advantages if run properly. It clears frequencies of interference, especially if all stations involved are on the same frequency, while the enjoyment value remains the same, if not greater. By use of push-to-talk, the conversation can be kept lively and interesting, giving each station operator ample opportunity to participate without waiting overlong for his turn.

Round tables can become very unpopular if they are not conducted properly. The monologuist, off on a long spiel about nothing in particular, cannot be interrupted; *make your transmissions short and to the point.* "Butting in" is discourteous and unsportsmanlike; *don't enter a round table, or any contact between two other amateurs, unless you are invited.* It is bad enough trying to copy through prevailing interference without the added difficulty of poor voice quality; *check your transmitter adjustments frequently.* In general, follow the precepts as hereinbefore outlined for the most enjoyment in round tables as well as any other form of radiotelephone communication.

● WORKING DX

Most amateurs at one time or another make "working DX" a major aim. As in every other phase of amateur work, there are right and wrong ways to go about getting best results in working foreign stations, and it is the intention of this section to outline a few of them.

The ham who has trouble raising DX stations readily may find that poor transmitter efficiency is not the reason. He may find that his sending is poor, or his calls ill-timed, or his judgment in error. When conditions are right to bring in the DX, and the receiver sensitive enough to bring in several stations from the desired locality, the way to work DX is to use the appropriate frequency and timing and *call these stations*, as against the common practice of calling "CQ DX."

The call CQ DX means slightly different things to amateurs in different bands:

a) On v.h.f., CQ DX is a general call ordinarily used only when the band is open, under favorable "skip" conditions. For v.h.f. work such a call is used for looking for new states and countries, also for distances beyond the customary "line-of-sight" range on most v.h.f. bands.

b) CQ DX on our 7-, 14-, 21- and 28-Mc. bands may be taken to mean "General call to any foreign station." The term "foreign station" usually refers to any station in a foreign continent. (*Experienced* amateurs in the U. S. A. and Canada do *not* use this call, but *answer* such calls made by foreign stations.)

c) CQ DX used on 3.5 Mc. under winter-night conditions may be used in this same manner. At other times, under average 3.5-Mc. propagation conditions, the call may be used in domestic work when looking for new states or countries in one's own continent, usually applying to stations located over 1000 miles distant from you.

The way to work DX is not to use a CQ call at *all* (in our continent). Instead, use your best tuning skill — and listen — and listen — and *listen. You have to hear them before you can work them.* Hear the desired stations first; time your calls well. Use your utmost skill. A sensitive receiver is often more important than the power input in working foreign stations. If you can hear stations in a particular country or area, chances are that you will be able to work someone there.

"---DO A LOT OF SNOOPING"

DX OPERATING CODE
(For W/VE Amateurs)

Some amateurs interested in DX work have caused considerable confusion and QRM in their efforts to work DX stations. The points below, if observed by all W/VE amateurs, will go a long way toward making DX more enjoyable for everybody.

1. Call DX only after he calls CQ, QRZ?, signs $\overline{SK}$, or phone equivalents thereof.

2. Do *not* call a DX station:
   - a. On the frequency of the station he is working until you are *sure* the QSO is over. This is indicated by the ending signal $\overline{SK}$ on c.w. and any indication that the operator is listening, on phone.
   - b. Because you hear someone else calling him.
   - c. When he signs $\overline{KN}$, $\overline{AR}$, CL, or 'phone equivalents.
   - d. Exactly on his frequency.
   - e. After he calls a directional CQ, unless of course you are in the right direction or area.

3. Keep within frequency-band limits. Some DX stations operate outside. Perhaps they can get away with it, but you cannot.

4. Observe calling instructions of DX stations. "10U" means call ten kc. *up* from his frequency, "15D" means 15 kc. *down*, etc.

5. Give honest reports. Many foreign stations *depend* on W and VE reports for adjustment of station and equipment.

6. Keep your signal clean. Key clicks, chirps, hum or splatter give you a bad reputation and may get you a citation from FCC.

7. *Listen* for and *call* station you want. Calling CQ DX is not the best assurance that the *rare* DX will reply.

8. When there are several W or VE stations waiting to work a DX station, avoid asking him to "listen for a friend." Let your friend take his chances with the rest. Also avoid engaging DX stations in rag-chews against their wishes.

One of the most effective ways to work DX is to know the operating habits of the DX stations sought. Doing too much transmitting on the DX bands is not the way to do this. Again, *listening* is effective. Once you know the operating habits of the DX station you are after you will know when and where to call, and when to remain silent waiting your chance.

Some DX stations indicate where they will tune for replies by use of "10U" or "15D." (See point 4 of the DX Operating Code.) In voice work the overseas operator may say "listening on 14,225 kc." or "tuning upward from 28,500 kc." Many a DX station will not reply to a call on his exact frequency.

ARRL has recommended some operating procedures to DX stations aimed at controlling some of the thoughtless operating practices sometimes used by W/VE amateurs. A copy of these recommendations (Operating Aid No. 5) can be obtained free of charge from ARRL Headquarters.

In any band, particularly at line-of-sight frequencies, when directional antennas are used, the directional CQ such as CQ W5, CQ north, etc., is the preferable type of call. Mature amateurs agree that CQ DX is a wishful rather than a practical type of call for most stations in the North Americas looking for foreign contacts. Ordinarily, it is a cause of unnecessary QRM.

Conditions in the transmission medium make all field strengths from a given region more nearly equal at a distance, irrespective of power used. In general, the higher the frequency band, the less important power considerations become. This accounts in part for the relative popularity of the 14-, 21- and 28-Mc. bands among amateurs who like to work DX.

DATE TIME	STATION CALLED	CALLED BY	HIS FREQ. OR DIAL	HIS SIGNALS RST	MY SIGNALS RST	FREQ. MC.	EMISSION TYPE	POWER INPUT WATTS	TIME OF ENDING QSO	OTHER DATA
11-16-53										
6:15PM	WØTQD	×	3.65	589	569X	3.5	A1	250	6:43	Tfc – rec'd 6, sent 10
7:20	CQ	×				7				
7:21	×	W4TWI	7.16	369	579				7:32	Vy heavy QRM on me
9:25	W8UKS	×	3.83	59	47	3.9	A3	100	10:05	Sam
11-18-53										
7:05AM	VK4EL	×	14.03			14	A1	250		Answered a W6
7:09	ZL2ACV	×	14.07	339	559X				7:20	
7:21	×	KA2KW	14.07	469X	349				7:33	First KA
7:36	CQ	×								
7:37	×	W6TI	14.01	589	589C				8:12	

KEEP AN ACCURATE AND COMPLETE STATION LOG AT ALL TIMES! F.C.C. REQUIRES IT.

A page from the official ARRL log is shown above, answering every Government requirement in respect to station records. Bound logs made up in accord with the above form can be obtained from Headquarters for a nominal sum or you can prepare your own, in which case we offer this form as a suggestion. The ARRL log has a special wire binding and lies perfectly flat on the table.

● KEEPING AN AMATEUR STATION LOG

The FCC requires every amateur to keep a complete station operating record. It may also contain records of experimental tests and adjustment data. A stenographer's notebook can be ruled with vertical lines in any form to suit the user. The Federal Communications Commission requirements are that a log be maintained that shows (1) the date and time of *each* transmission, (2) *all calls* and transmissions made (whether two-way contacts resulted or not), (3) the input power to the last stage of the transmitter, (4) the frequency band used, (5) the time of *ending* each QSO and the operator's identifying signature for responsibility for each session of operating. Messages may be written in the log or separate records kept — but record must be retained for one year as required by the FCC. For the convenience of amateur station operators ARRL stocks both logbooks and message blanks, and if one uses the official log he is sure to comply fully with the Government requirements if the precautions and suggestions included in the log are followed.

Message Handling

Amateur operators in the United States and a few other countries enjoy a privilege not available to amateurs in most countries — that of handling third-party message traffic. In the early history of amateur radio in this country, some amateurs who were among the first to take advantage of this privilege formed an extensive relay organization which became known as the American Radio Relay League.

Thus, amateur message-handling has had a long and honorable history and, like most services, has gone through many periods of development and change. Those amateurs who handled traffic in 1914 would hardly recognize it the way some of us do it today, just as equipment in those days was far different from that in use now. Progress has been made and new methods have been developed in step with advancement in communication techniques of all kinds. Amateurs who handled a lot of traffic found that organized operating schedules were more effective than random relays, and as techniques advanced and messages increased in number, trunk lines were organized, spot frequencies began to be used, and there sprang into existence a number of traffic nets in which many stations operated on the same frequency to effect wider coverage in less time with fewer relays; but the old methods are still available to the amateur who handles only an occasional message.

Although message handling is as old an art as is amateur radio itself, there are many amateurs who do not know how to handle a message and have never done so. As each amateur grows older and gains experience in the amateur service, there is bound to come a time when he will be called upon to handle a written message, during a communications emergency, in casual contact with one of his many acquaintances on the air, or as a result of a request from a non-amateur friend. Regardless of the occasion, if it comes to you, you will want to rise to it! Considerable embarrassment is likely to be experienced by the amateur who finds he not only does not know the form in which the message should be prepared, but does not know what to do with the message once it has been filed or received in his station.

Traffic work need not be a complicated or time-consuming activity for the casual or occasional message-handler. Amateurs may participate in traffic work to whatever extent they wish, from an occasional message now and then to becoming a part of organized traffic systems.

This chapter explains some principles so the reader may know where to find out more about the subject and may exercise the message-handling privilege to best effect as the spirit and opportunity arise.

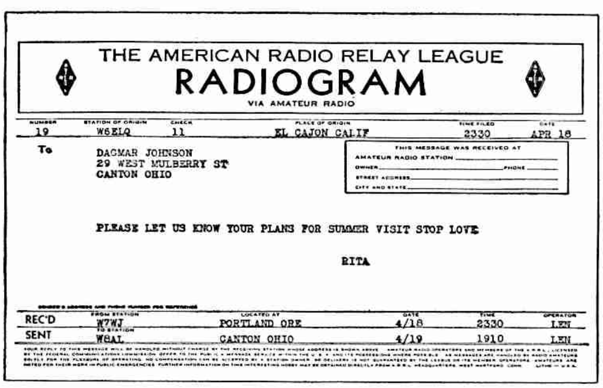
Responsibility

Amateurs who originate messages for transmission or who receive messages for relay or delivery should first consider that in doing so they are accepting the responsibility of clearing the message from their station on its way to its destination in the shortest possible time. Forty-eight hours after filing or receipt is the generally-accepted rule among traffic-handling amateurs, but it is obvious that if every amateur who relayed the message allowed it to remain in his station this long it might be a long time reaching its destination. Traffic should be relayed or delivered as quickly as possible.

Message Form

Once this responsibility is realized and accepted, handling the message becomes a matter of following generally-accepted standards of form and transmission. For this purpose, each message is divided into four parts: the preamble, the address, the text and the signature. Some of these parts themselves are subdivided. It is necessary in preparing the message for transmission and in actually transmitting it to know not only what each part is and what it is for, but to know in what *order* it should be transmitted, and to know the various procedure signals used with it when sent by c.w. If you are going to send a message, you may as well send it right.

Standardization is important! There is a great deal of room for expressing originality and individuality in amateur radio, but there are also times and places where such expression can only cause confusion and inefficiency. Recognizing the need for standardization in message form and message transmitting procedures, ARRL has long since recommended such standards, and most traffic-interested amateurs have followed them. In general, these recommendations, and the various changes they have undergone from year to year, have been at the request of amateurs participating in this activity, and they are completely outlined and explained in *Operating an Amateur Radio Station*, a copy of which is available upon request or by use of the coupon at the end of this chapter.


THE AMERICAN RADIO RELAY LEAGUE
RADIOGRAM
VIA AMATEUR RADIO

NUMBER	STATION OF ORIGIN	CHECK	PLACE OF ORIGIN	TIME FILED	DATE
19	W6ELQ	11	EL CAJON CALIF	2330	APR 18

To
DAGMAR JOHNSON
29 WEST MULBERRY ST
CANTON OHIO

THIS MESSAGE WAS RECEIVED AT
AMATEUR RADIO STATION
OWNER PHONE
STREET ADDRESS
CITY AND STATE

PLEASE LET US KNOW YOUR PLANS FOR SUMMER VISIT STOP LOVE

RITA

	FROM STATION / TO STATION	LOCATED AT	DATE	TIME	OPERATOR
REC'D	W7WJ	PORTLAND ORE	4/18	2330	LEN
SENT	W8AL	CANTON OHIO	4/19	1910	LEN

Here is an example of a plain-language message in correct ARRL form. The preamble is always sent as shown: number, station of origin, check, place of origin, time filed, date.

Clearing a Message

Amateurs not experienced in message handling should depend on the experienced message-handler to get a message through, if it is important; but the average amateur can enjoy operating with a message to be handled either through a local traffic net or by free-lancing. The latter may be accomplished by careful listening for an amateur station at desired points. directional CQs, use of the National Calling and Emergency frequencies, or by making and keeping a schedule with another amateur for regular work between specified points. He may well aim at learning and enjoying through doing. The joy and accomplishment in thus developing one's operating skill to top perfection has a reward all its own.

The best way to clear a message is to put it into one of the many organized traffic networks, or to give it to a station who can do so. There are many amateurs who make the handling of traffic their principal operating activity, and many more still who participate in this activity to a greater or lesser extent. The result is a system of traffic nets which spreads to all corners of the United States and covers most U. S. possessions and Canada. Once a message gets into one of these nets, regardless of the net's size or coverage, it is systematically routed toward its destination in the shortest possible time.

If you decide to "take the bull by the horns" and put the message into a traffic net yourself (and more power to you if you do!), you will need to know something about how traffic nets operate, and the special Q signals and procedure they use to dispatch all traffic with a maximum of efficiency. Reference to net lists in *QST* (usually in the November and January issues) will give you the frequency and operating time of the net in your section, or of other nets into which your message can go. Listening for a few minutes at the time and frequency indicated should acquaint you with enough fundamentals to enable you to report into the net and indicate your traffic. From that time on you follow the instructions of the net control station, who will tell you when and to whom (and on what frequency, if different from the net frequency) to send your message. Since most nets use the special "QN" signals, it is usually very helpful to have a list of these before you (list available from ARRL Hq., Operating Aid No. 9).

Network Operation

About this time, you may find that you are enjoying this type of operating activity and want to know more about it and increase your proficiency. Many amateurs are happily "addicted" to traffic handling after only one or two brief exposures to it. Much traffic is at present being conducted by c.w., since this mode of communication seems to be popular for record purposes — but this does not mean that high code speed is a necessary prerequisite to working in traffic networks. There are many nets organized specifically for the slow-speed amateur, and most of the so-called "fast" nets are usually glad to slow down to accommodate slower operators, especially those nets at state or section level.

The significant facet of net operation, however, is that code speed alone does *not* make for efficiency — sometimes quite the contrary! A high-speed operator who does not know net procedure can "foul up" a net much more completely and more quickly than can a slow operator. It is a proven fact that a bunch of high-speed operators who are not "savvy" in net operation cannot accomplish as much during a specified period as an equal number of slow operators who *know* net procedure. Don't let low code speed deter you from getting into traffic work. Given a little time, your speed will reach the point where you can compete with the best of them. Concentrate first on learning net procedure, for most traffic nowadays is handled on nets.

Much traffic is also handled on phone. This mode is exceptionally well suited to short-range traffic work and requires knowledge of phonetics and procedure peculiar to voice operation. Procedure is of paramount importance on phone, since the public may be listening. The major problem, of course, is QRM.

Teamwork is the theme of net operation. The net which functions most efficiently is the net in which all participants are thoroughly familiar with the procedure used, and in which operators refrain from transmitting except at the direction of the net control station, and do not occupy time with extraneous comments, even the exchange of pleasantries. There is a time and place for everything. When a net is in session it should concentrate on handling traffic until all traffic is cleared. Before or after the net is the time for rag-chewing and discussion. Some details of net operation are included in *Operating an Amateur Radio Station*, mentioned earlier, but the whole story cannot be told. There is no substitute for actual participation.

The National Traffic System

To facilitate and speed the movement of message traffic, there is in existence an integrated national system by means of which originated traffic will normally reach its destination area the same day the message is originated. This system uses the local section net as a basis. Each section net sends a representative to a "regional" net (normally covering a call area) and each "regional" net sends a representative to an "area" net (normally covering a time zone). After the area net has cleared all its traffic, its members then go back to their respective regional nets, where they clear traffic to the various section net representatives. By means of connecting schedules between the area nets, traffic can flow both ways so that traffic originated on the West Coast reaches the East Coast with a maximum of dispatch, and vice versa. In general local section nets function at 1900, regional nets at 1945, area nets at 2030 and the same or different regional personnel again at 2130. Some section nets conduct a late session at 2200 to effect traffic delivery the same night. Local standard time is referred to in each case.

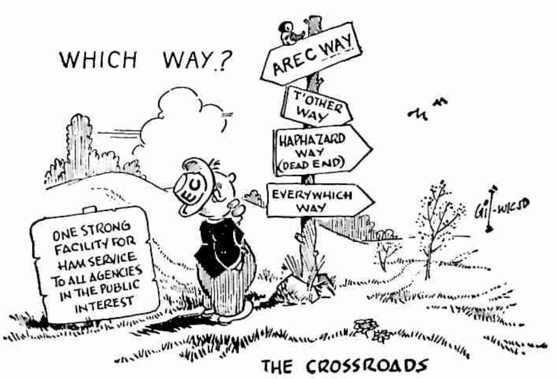
The NTS plan somewhat spreads traffic opportunity so that casual traffic may be reported into nets for efficient handling one or two nights per week, early or late; or the ardent traffic man can operate in *both* early and late groups and in between to roll up impressive totals and speed traffic reliably to its destination. Old-time traffic men who prefer a high degree of organization and teamwork have returned to the traffic game as a result of the new system. Beginners have shown more interest in becoming part of a system nationwide in scope, in which *anyone* can participate. The National Traffic System has vast and intriguing possibilities as an amateur service. It is open to any amateur who wishes to participate.

The above is but the briefest résumé of what is of necessity a rather complicated arrangement of nets and schedules. Complete details of the System and its operation are available to anyone interested. Just drop a line to ARRL Headquarters.

Emergency Communication

One of the most important ways in which the amateur serves the public, thus making his existence a national asset, is by his preparation for and his participation in communications emergencies. Every amateur, regardless of the extent of his normal operating activities, should give some thought to the possibility of his being the only means of communication should his community be cut off from the outside world. It has happened many times, often in the most unlikely places; it has happened without warning, finding some amateurs totally unprepared; it can happen to *you*. Are you ready?

There are two principal ways in which any amateur can prepare himself for such an eventuality. One is to provide himself with equipment capable of operating on any type of emergency power (i.e., either a.c. or d.c.), and equip-



ment which can readily be transported to the scene of disaster. Mobile equipment is especially desirable in most emergency situations.

Such equipment, regardless of how elaborate or how modern, is of little use, however, if it is not used properly and at the right times; and so another way for an amateur to prepare himself for emergencies, by no means less important than the first, is to *learn to operate efficiently*. There are many amateurs who feel that they know how to operate efficiently but who find themselves considerably handicapped at the crucial time by not knowing proper procedure, by being unable, due to years of casual amateur operation, to adapt themselves to snappy, abbreviated transmissions, and by being unfamiliar with message form and routing procedures. It is dangerous to overrate your ability in this respect; it is far better to assume that you have much to learn.

In general it can be said that there is more emergency equipment available than there are operators who know properly how to operate during emergency conditions, for such conditions require clipped, terse procedure with complete break-in on c.w. and fast push-to-talk on phone. The casual rag-chewing aspect of amateur radio, however enjoyable and worth-while in its place, must be forgotten at such times in favor of the business at hand. There is only one way to gain experience in this type of operation, and that is by practicing it. During an emergency is no time for practice; it should be done beforehand, as often as possible, on a regular basis.

This leads up to the necessity for emergency organization and preparedness. ARRL has long recognized this necessity and has provided for it. The Section Communications Manager (whose address appears on page 6 of every issue of *QST*) is empowered to appoint certain qualified amateurs in his section for the purpose of coordinating emergency communication organization and preparedness in specified areas or communities. This appointee is known as an Emergency Coordinator for the city or town. One is specified for each community. For coordination and promotion at section level a Section Emergency Coordinator arranges for and recommends the appointments of various Emergency Coordinators at activity points throughout the section. Emergency Coordinators organize amateurs in their communities according to local needs for emergency communication facilities.

The community amateurs taking part in the local organization are members of the Amateur Radio Emergency Corps (AREC). *All* amateurs are invited to register in the AREC, whether they are able to play an active part in their local organization or only a supporting role. Application blanks are available from your EC, SEC, SCM or direct from ARRL Headquarters. In the event that inquiry reveals no Emergency Coordinator appointed for your community, your SCM would welcome a recommendation either from yourself or from a radio club of which you are a member. By holding an amateur operator license, you have the responsibility both to your community and to amateur radio to uphold the traditions of the service.

Among the League's publications is a booklet entitled *Emergency Communications*. This booklet, while small in size, contains a wealth of information on AREC organization and functions and is invaluable to any amateur participating in emergency or civil defense work. It is free to AREC members and should be in every ama-

Before Emergency

PREPARE yourself by providing a transmitter-receiver setup together with an emergency power source upon which you can depend.

TEST both the dependability of your emergency equipment and your own operating ability in the annual ARRL Simulated Emergency Test and the several annual on-the-air contests, especially Field Day.

REGISTER your facilities and your availability with your local ARRL Emergency Coordinator. If your community has no EC, contact your local civic and relief agencies and explain to them what the Amateur Service offers the community in time of disaster.

In Emergency

LISTEN before you transmit. Never violate this principle.

REPORT at once to your Emergency Coordinator so that he will have up-to-the-minute data on the facilities available to him. Work with local civic and relief agencies as the EC suggests, offer these agencies your services directly in the absence of an EC.

RESTRICT all on-the-air work in accordance with FCC regulations, Sec. 12.156, whenever FCC "declares" a state of communications emergency.

QRRR is the official ARRL "land SOS," a distress call for emergency only. It is for use *only* by a station seeking assistance.

RESPECT the fact that the success of the amateur effort in emergency depends largely on circuit discipline. The established Net Control Station should be the supreme authority for priority and traffic routing.

COOPERATE with those we serve. Be ready to help, but stay off the air unless there is a specific job to be done that you can handle more efficiently than any other station.

COPY all bulletins from W1AW. During time of emergency special bulletins will keep you posted on the latest developments.

After Emergency

REPORT to ARRL Headquarters as soon as possible and as fully as possible so that the Amateur Service can receive full credit. Amateur Radio has won glowing public tribute in many major disasters since 1919. Maintain this record.

teur's shack. Drop a line to the ARRL Communications Department if you want a copy, or use the coupon at the end of this chapter.

The Radio Amateur Civil Emergency Service

In order to be prepared for any eventuality, FCC and the Office of Civil and Defense Mobilization (OCDM), in collaboration with ARRL, have promulgated the Radio Amateur Civil Emergency Service. RACES is a temporary amateur service, intended primarily to serve civil defense and to continue operation during any extreme national emergency, such as war. It shares certain segments of frequencies with the regular Amateur Service on a nonexclusive basis. Its regulations have been made a sub-part of the familiar amateur regulations; that is, the original regulations have become sub-part A, the RACES regulations being added as sub-part B. Copies of both parts are included in the latest edition of the ARRL *License Manual*.

If *every* amateur participated, we would still be far short of the total operating personnel required properly to implement RACES. As the service which bears the responsibility for the successful implementation of this important function, we face not only the task of installing (and in some cases building) the necessary equipment, but also of the training of thousands of additional people. This can and should be a function of the local unit of the Amateur Radio Emergency Corps under its EC and his assistants, working in close collaboration with the local civil defense organization.

The first step in organizing RACES locally is the appointment of a Radio Officer by the local civil defense director, possibly on the recommendation of his communications officer. A complete and detailed communications plan must be approved successively by local, state and OCDM regional directors, by the OCDM National office, and by FCC. Once this has been accomplished, applications for station authorizations under this plan can be submitted direct to FCC. *QST* will carry further information from time to time, and ARRL will keep its field officials fully informed by bulletins as the situation requires. A complete bibliography of *QST* articles dealing with the subject of civil defense and RACES is available upon request from the ARRL Communications Department.

In the event of war, civil defense will place great reliance on RACES for radio communications. RACES is an Amateur Service. Its implementation is logically a function of the Amateur Radio Emergency Corps — an *additional* function in peacetime, but probably an exclusive function in wartime. Therefore, your best opportunity to be of service will be to register with your local EC, and to participate *actively* in the local AREC/RACES program.

ARRL Operating Organization

Amateur operation must have point and constructive purpose to win public respect. Each individual amateur is the ambassador of the entire fraternity in his public relations and attitude toward his hobby. ARRL field organization adds point and purpose to amateur operating.

The Communications Department of the League is concerned with the practical operation of stations in all branches of amateur activity. Appointments or awards are available for rag-chewer, traffic enthusiast, phone operator, DX man and experimenter.

There are seventy-three ARRL Sections in the League's field organization, which embraces the United States, Canada and certain other territory. Operating affairs in each Section are supervised by a Section Communications Manager elected by members in that section for a two-year term of office. Organization appointments are made by the section managers, elected as provided in the Rules and Regulations of the Communications Department, which accompany the League's By-Laws and Articles of Association. Section Communications Managers' addresses for all sections are given in full in each issue of *QST*. SCMs welcome monthly activity reports from all amateur stations in their jurisdiction.

Whether your activity embraces phone or telegraphy, or both, there is a place for you in League organization.

● LEADERSHIP POSTS

To advance each type of station work and group interest in amateur radio, and to develop practical communications plans with the greatest success, appointments of leaders and organizers in particular single-interest fields are made by SCMs. Each leadership post is important. Each provides activities and assistance for appointee groups and individual members along the lines of natural interest. Some posts further the general ability of amateurs to communicate efficiently at all times, by pointing activity toward networks and round tables, others are aimed specifically at establishment of provisions for organizing the amateur service as a stand-by communications group to serve the public in disaster, civil defense need or emergency of any sort. The SCM appoints the following in accordance with section needs and individual qualifications:

PAM — Phone Activities Manager. Organizes activities for OPSs and voice operators in his section. Promotes phone nets and recruits OPSs.

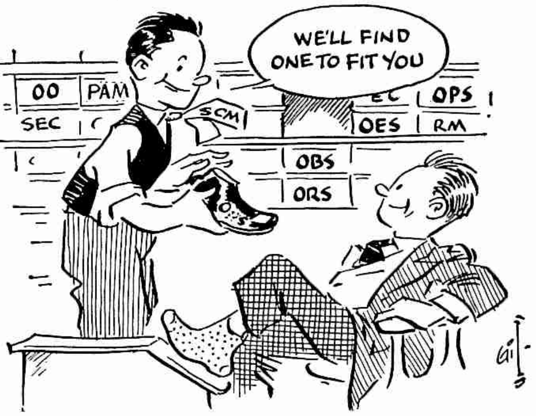
RM — Route Manager. Organizes and coordinates c.w. traffic activities. Supervises and promotes nets and recruits ORSs.

SEC — Section Emergency Coordinator. Promotes and administers section emergency radio organization.

EC — Emergency Coordinator. Organizes amateurs of a community or other local area for emergency radio service; maintains liaison with officials and agencies served; also with other local communication facilities. Sponsors tests, recruits for AREC and encourages alignment with RACES.

STATION APPOINTMENTS

ARRL's field organization has a place for every active amateur who has a station. The Communications Department organization exists to increase individual enjoyment and station effectiveness in amateur radio work, and we extend a cordial invitation to every amateur to participate fully in the activities and to apply to the SCM for one of the following station appointments. ARRL membership and the General Class license or VE equivalent is prerequisite to appointments, except OES is available to Novice/ Technician grades.



OPS Official Phone Station. Sets high voice operating standards and procedures, furthers phone nets and traffic.

ORS Official Relay Station. Traffic service, operates c.w. nets; noted for 15 w.p.m. and procedure ability.

OBS Official Bulletin Station. Transmits ARRL and FCC bulletin information to amateurs.

OES Official Experimental Station. Collects and reports v.h.f.-u.h.f.-s.h.f. propagation data, may engage in facsimile, TT, TV, work on 50 Mc. and/or above. Takes part as feasible in v.h.f. traffic work, reports same, supports v.h.f. nets, observes procedure standards.

OO Official Observer. Sends cooperative notices to amateurs to assist in frequency observance, insures high-quality signals, and prevents FCC trouble.

Emblem Colors

Members wear the ARRL emblem with black-enamel background. A red background for an emblem will indicate that the wearer is SCM. SECs, ECs, RMs, and PAMs may wear the emblem with green background. Observers and all *station* appointees are entitled to wear blue emblems.

SECTION NETS

Amateurs can add much experience and pleasure to their own amateur lives, and substance and accomplishment to the credit of all of amateur radio, when organized into effective interconnection of cities and towns.

The successful operation of a net depends a lot on the Net Control Station. This station should be chosen carefully and be one that will not hesitate to enforce each and every net rule and set the example in his own operation.

A progressive net grows, obtaining new members both directly and through other net members. Bulletins may be issued at intervals to keep in direct contact with the members regarding *general net activity,* to keep tab on net procedure, make suggestions for improvement, keep track of active members and weed out inactive ones.

A National Traffic System is sponsored by ARRL to facilitate the over-all expeditious relay and delivery of message traffic. The system recognizes the need for handling traffic beyond the section-level networks that have the popular support of both phone and c.w. groups (OPS and ORS) throughout the League's field organization. Area and regional provisions for NTS are furthered by Headquarters correspondence. The ARRL Net Directory, revised in December each year, includes the frequencies and times of operation of the hundreds of different nets operating on amateur band frequencies.

Radio Club Affiliation

ARRL is pleased to grant affiliation to any amateur society having (1) at least 51% of the voting club membership as full members of the League, and (2) at least 51% of members government-licensed radio amateurs. In high school radio clubs *bearing the school name,* the first above requirement is modified to require one full member of ARRL in the club. Where a society has common aims and wishes to add strength to that of other club groups and strengthen amateur radio by affiliation with the national amateur organization, a request addressed to the Communications Manager will bring the necessary forms and information to initiate the application for affiliation. Such clubs receive field-organization bulletins and special information at intervals for posting on club bulletin boards or for relay to their memberships. A travel plan providing communications, technical and secretarial contact from the Headquarters is worked out seasonally to give maximum benefits to as many as possible of the several hundred active *affiliated* radio clubs. Papers on club work, suggestions for organizing, for constitutions, for radio courses of study, etc., are available on request.

Club Training Aids

One section of the ARRL Communications Department handles the Training Aids Program. This program is a service to ARRL affiliated clubs. Material is aimed at education, training and entertainment of club members. Interesting quiz material is available.

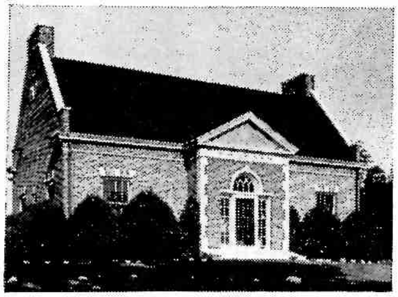
Training Aids include such items as motion-picture films, film strips, slides, audio tapes and lecture outlines. Bookings are limited to ARRL-affiliated clubs, since the visual aids listings are not sufficiently extensive to permit such services to other groups.

All Training Aids materials are loaned free (except for shipping charges) to ARRL affiliated clubs. Numerous groups use this ARRL service to good advantage. If your club is affiliated but has not yet taken advantage of this service, you are missing a good chance to add the available features to your meeting programs and general club activities. Watch club bulletins and *QST* or write the ARRL Communications Department for TA-21 and TA-32.

Operating Activities and Awards

● W1AW

The Maxim Memorial Station, W1AW, is dedicated to fraternity and service. Operated by the League headquarters, W1AW is located about four miles south of the Headquarters offices on a seven-acre site. The station is on the air daily, except holidays, and available time is divided between different bands and modes.



Telegraph and phone transmitters are provided for all bands from 1.8 to 144 Mc. The normal frequencies in each band for c.w. and voice transmissions are as follows: 1820, 3555, 3945, 7080, 7255, 14,100, 14,280, 21,075, 21,330, 28,080, 29,000, 50,900 and 145,600 kc. Operating-visiting hours and the station schedule are listed every other month in *QST*.

Operation is roughly proportional to amateur interest in different bands and modes, with one kw. except on 160 and v.h.f. bands. W1AW's daily bulletins and code practice aim to give operational help to the largest number.

All amateurs are invited to visit W1AW, as well as to work the station from their own shacks. The station was established to be a living memorial to Hiram Percy Maxim and to carry on the work and traditions of amateur radio.

● OPERATING ACTIVITIES

Within the ARRL field organization there are several special activities. First week ends of each month are often occasions for ARRL officials, officers and directors to get together over the air from their own stations. This activity is known to the gang as the LO (League officials) party. For all appointees, quarterly CD parties are scheduled additionally to develop operating ability and a spirit of fraternalism.

In addition to those for appointees and officials, ARRL sponsors various other activities open to all amateurs. The DX-minded amateur may participate in the Annual ARRL International DX Competition during February and March. This popular contest may bring you the thrill of working new countries and building up your DXCC totals; certificate awards are offered to top scorers in each country and ARRL section (see page 6 of any *QST*) and to club leaders. Then there is the ever-popular Sweepstakes in November. Of domestic scope, the SS affords the opportunity to work new states for that WAS award. A Novice activity is planned annually. The interests of v.h.f. enthusiasts are also provided for in contests held in January, June and September of each year. Where enough logs (three) are received to constitute minimum "competition" a certificate in spot activities, such as the "SS" and v.h.f. party, is awarded the leading newcomer for his work considered only in competition with other newcomers.

As in all our operating, the idea of having a good time is combined in the Annual Field Day with the more serious thought of preparing ourselves to render public service in times of emergency. A premium is placed on the use of equipment without connection to commercial power sources. Clubs and individual groups always enjoy themselves in the "FD," and learn much about the requirements for operating under knockabout conditions afield.

ARRL contest activities are diversified to appeal to all operating interests, and will be found announced in detail in issues of *QST* preceding the different events.

● AWARDS

The League-sponsored operating activities heretofore mentioned have useful objectives and provide much enjoyment for members of the fraternity. Achievement in amateur radio is recognized by various certificates offered through the League and detailed below.

WAS Award

WAS means "Worked All States." This award is available regardless of affiliation or nonaffiliation with any organization. Here are the simple rules to follow in going after your WAS:

1) Two-way communication must be established on the amateur bands with each of the states; any and all amateur

bands may be used. A card from the District of Columbia may be submitted in lieu of one from Maryland.

2) Contacts with all states must be made from the same location. Within a given community one location may be defined as from places no two of which are more than 25 miles apart.

3) Contacts may be made over any period of years, provided only that all contacts are from the same location, and except that only contacts with Alaska dated January 3, 1959 or later count, and only contacts with Hawaii dated August 21, 1959 or later count.

4) QSL cards, or other written communications from stations worked confirming the necessary two-way contacts, must be submitted by the applicant to ARRL headquarters.

5) Sufficient postage must be sent with the confirmations to finance their return. No correspondence will be returned unless sufficient postage is furnished.

6) The WAS award is available to all amateurs. It is required that the confirmations submitted be placed *alphabetically in order by states.*

7) Address all applications and confirmations to the Communications Department, ARRL, 38 La Salle Road, West Hartford, Conn.

DX Century Club Award

Here are the rules under which the DX Century Club Award will be issued to amateurs who have worked and confirmed contact with 100 countries in the postwar period.

1) The DX Century Club Award Certificate for confirmed contacts with 100 or more countries is available to all amateurs everywhere in the world.

2) Confirmations must be submitted direct to ARRL headquarters for all countries claimed. Claims for a total of 100 countries must be included with first application. Confirmation from foreign contest logs may be requested in the case of the ARRL International DX Competition only, subject to the following conditions:

a) Sufficient confirmations of other types must be submitted so that these, plus the DX Contest confirmations, will total 100. In every case, Contest confirmations must not be requested for any countries from which the applicant has regular confirmations. That is, contest confirmations will be granted only in the case of countries from which applicants have no regular confirmations.

b) Look up the contest results as published in *QST* to see if your man is listed in the foreign scores. If he isn't, he did not send in a log and no confirmation is possible.

c) Give year of contest, date and time of QSO.

d) In future DX Contests do not request confirmations until after the final results have been published, usually in one of the early fall issues. Requests before this time must be ignored.

3) The ARRL Countries List, printed periodically in *QST*, will be used in determining what constitutes a "country." This chapter contains the Postwar Countries List.

4) Confirmations must be accompanied by a list of claimed countries and stations to aid in checking and for future reference.

5) Confirmations from additional countries may be submitted for credit each time ten additional confirmations are available. Endorsements for affixing to certificates and showing the new confirmed total (110, 120, 130, etc.) will be awarded as additional credits are granted. ARRL DX Competition logs from foreign stations may be utilized for these endorsements, subject to conditions stated under (2).

6) All contacts must be made with amateur stations working in the authorized amateur bands or with other stations licensed to work amateurs.

7) In cases of countries where amateurs are licensed in the normal manner, credit may be claimed only for stations using regular government-assigned call letters. No credit may be claimed for contacts with stations in any countries in which amateurs have been temporarily closed down by special government edict where amateur licenses were formerly issued in the normal manner.

8) All stations contacted must be "land stations" . . . contacts with ships, anchored or otherwise, and aircraft, cannot be counted.

9) All stations must be contacted from the same call area, where such areas exist, or from the same country in cases where there are no call areas. One exception is allowed to this rule: where a station is moved from one call area to another, or from one country to another, all contacts must be made from within a radius of 150 miles of the initial location.

10) Contacts may be made over any period of years from November 15, 1945, provided only that all contacts be made under the provisions of Rule 9, and by the same station licensee; contacts may have been made under different call letters in the same area (or country), if the licensee for all was the same.

11) Any altered or forged confirmations submitted for CC credit will result in disqualification of the applicant. The eligibility of any DXCC applicant who was ever barred from DXCC to reapply, and the conditions for such application, shall be determined by the Awards Committee. Any holder of the Century Club Award submitting forged or altered confirmations must forfeit his right to be considered for further endorsements.

12) Operating ethics: Fair play and good sportsmanship in operating are required of all amateurs working toward the DX Century Club Award. In the event of specific objections relative to continued poor operating ethics an individual may be disqualified from the DXCC by action of the ARRL Awards Committee.

13) Sufficient postage for the return of confirmations must be forwarded with the application. In order to insure the safe return of large batches of confirmations, it is suggested that enough postage be sent to make possible their return by first-class mail, registered.

14) Decisions of the ARRL Awards Committee regarding interpretation of the rules as here printed or later amended shall be final.

15) Address all applications and confirmations to the Communications Department, ARRL, 38 La Salle Road, West Hartford 7, Conn.

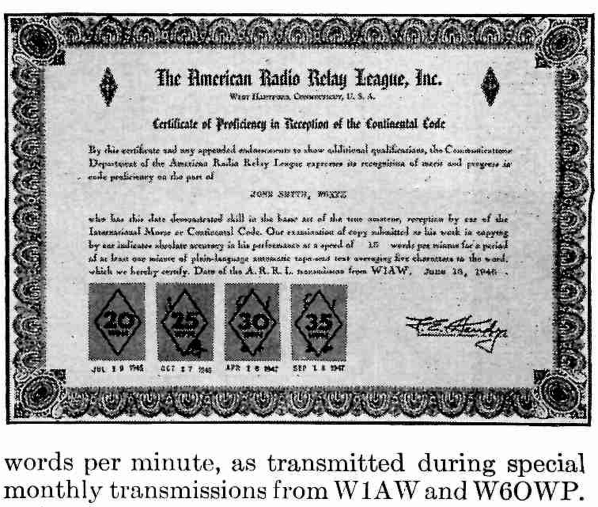
WAC Award

The WAC award, Worked All Continents, is issued by the International Amateur Radio Union (IARU) upon proof of contact with each of the six continents. Amateurs in the U.S.A., Possessions and Canada should apply for the award through ARRL, headquarters society of the IARU. Those elsewhere must submit direct to their own IARU member-society. Residents of countries not represented in the Union may apply directly to ARRL for the award. Two basic types of WAC certificates are issued. One contains no endorsements and is awarded for c.w., or a combination of c.w. and phone contacts; the other is awarded when all work is done on phone. There is a special endorsement to the phone WAC when all of the confirmations submitted clearly indicate that the work was done on two-way s.s.b. The *only* special band endorsements are for 3.5 and 50 Mc.

Code Proficiency Award

Many hams can follow the general idea of a contact "by ear" but when pressed to "write it down" they "muff" the copy. The Code Proficiency Award permits each amateur to prove himself as a proficient operator, and sets up a system of awards for step-by-step gains in copying proficiency. It enables every amateur to check his code proficiency, to better that proficiency, and to receive a certification of his receiving speed.

This program is a whale of a lot of fun. The League will give a certificate to any licensed radio amateur who demonstrates that he can copy perfectly, for at least one minute, plain-language Continental code at 10, 15, 20, 25, 30 or 35


The American Radio Relay League, Inc.
West Hartford, Connecticut, U. S. A.

Certificate of Proficiency in Reception of the Continental Code

By this certificate and any appended endorsements to show additional qualifications, the Communications Department of the American Radio Relay League expresses its recognition of merit and progress in code proficiency on the part of

JOHN SMITH, W9XYZ

who has this date demonstrated skill in the basic art of the true amateur, reception by ear of the International Morse or Continental Code. Our examination of copy submitted as his work in copying by ear indicates absolute accuracy in his performance at a speed of 15 words per minute for a period of at least one minute of plain-language automatic tape-sent text averaging five characters to the word, which we hereby certify. Date of the A. R. R. L. transmission from W1AW, June 18, 1946.

20 | 25 | 30 | 35

JUL 19 1946 | OCT 17 1946 | APR 18 1947 | SEP 18 1947

words per minute, as transmitted during special monthly transmissions from W1AW and W6OWP.

As part of the ARRL Code Proficiency program W1AW transmits plain-language practice material each evening at speeds from 5 to 35 w.p.m. All amateurs are invited to use these transmissions to increase their code-copying ability. Non-amateurs are invited to utilize the lower speeds, 5, 7½ and 10 w.p.m., which are transmitted for the benefit of persons studying the code in preparation for the amateur license examination. Refer to any issue of *QST* for details of the practice schedule.

Rag Chewers Club

The Rag Chewers Club is designed to encourage friendly contacts and discourage the "hello-good-by" type of QSO. It furthers fraternalism through amateur radio. Membership certificates are awarded.

How To Get in: (1) Chew the rag with a member of the club for at least a solid half hour. This does not mean a half hour spent in trying to get a message over through bad QRM or QRN, but a solid half hour of conversation or message handling. (2) Report the conversation by card to The Rag Chewers Club, ARRL, Communications Department, West Hartford, Conn., and ask the member station you talk with to do the same. When *both reports* are received you will be sent a membership certificate entitling you to all the privileges of a Rag Chewer.

How To Stay in: (1) Be a conversationalist on the air instead of one of those tongue-tied infants who don't know any words except "cuagn" or "cul," or "QRU" or "nil." Talk to the fellows you work with and get to know them. (2) Operate your station in accordance with the radio laws and ARRL practice. (3) Observe rules of courtesy on the air. (4) Sign "RCC" after each call so that others may know you can talk as well as call.

A-1 Operator Club

The A-1 Operator Club should include in its ranks every good operator. To become a member, one must be nominated by at least two operators who already belong. General keying or voice technique, procedure, copying ability, judgment and courtesy all count in rating candidates under the club rules detailed at length in *Operating an Amateur Radio Station.* Aim to make yourself a fine operator, and one of these days you may be pleasantly surprised by an invitation to belong to the A-1 Operator Club, which carries a worth-while certificate in its own right.

Brass Pounders League

Every individual reporting more than a specified minimum in official monthly traffic totals is given an honor place in the *QST* listing known as the Brass Pounders League and a certificate to recognize his performance is furnished by the SCM. In addition, a *BPL Traffic Award* (medallion) is given to individual amateurs working at their own stations after the third time they "make BPL" provided it is duly reported to the SCM and recorded in *QST*.

The value to amateurs in operator training, and the utility of amateur message handling to the members of the fraternity itself as well as to the general public, make message-handling work of prime importance to the fraternity. Fun, enjoyment, and the feeling of having done something really worth while for one's fellows is accentuated by pride in message files, records, and letters from those served.

Old Timers Club

The Old Timers Club is open to anyone who holds an amateur call at the present time, and who held an amateur license (operator or station) 20-or-more years ago. Lapses in activity during the intervening years are permitted.

If you can qualify as an "Old Timer," send an outline of your ham career. Indicate the date of your first amateur license and your present call. If eligible for the OTC, you will be added to the roster and will receive a membership certificate.

● INVITATION

Amateur radio is capable of giving enjoyment, self-training, social and organization benefits in proportion to what the individual amateur puts into his hobby. All amateurs are invited to become ARRL members, to work toward awards, and to accept the challenge and invitation offered in field-organization appointments. Drop a line to ARRL Headquarters for the booklet *Operating an Amateur Radio Station*, which has detailed information on the field-organization appointments and awards. Accept today the invitation to take full part in all League activities and organization work.

CONELRAD COMPLIANCE

The FCC rules for the Amateur Service concerned with requirements in the event of enemy attack are contained in the ARRL *License Manual* as part of the amateur regulations, Sections 12.190 through 12.196. These are the rules for *con*trol of *el*ectromagnetic *rad*iation, conelrad, to minimize radio navigational aids to an enemy. Read and follow these rules. They concern you.

Amateurs are required to *shut down* when a Conelrad Radio Alert is indicated. FCC requires monitoring, by some means, of a broadcast station while you operate. By use of proper equipment, each amateur can make his conelrad compliance routine and almost automatic. You will find descriptions of such devices, most of them quite simple, in this *Handbook* and in *QST*.

Operating Abbreviations and Prefixes

● Q SIGNALS

Given below are a number of Q signals whose meanings most often need to be expressed with brevity and clearness in amateur work. (Q abbreviations take the form of questions only when each is sent followed by a question mark.)

QRG Will you tell me my exact frequency (or that of.......)? Your exact frequency (or that of......) is......kc.

QRH Does my frequency vary? Your frequency varies.

QRI How is the tone of my transmission? The tone of your transmission is..... (1. Good; 2. Variable; 3. Bad).

QRK What is the readability of my signals (or those of......)? The readability of your signals (or those of.....) is..... (1. Unreadable; 2. Readable now and then; 3. Readable but with difficulty; 4. Readable; 5. Perfectly readable).

QRL Are you busy? I am busy (or I am busy with ......). Please do not interfere.

QRM Are you being interfered with? I am interfered with.

QRN Are you troubled by static? I am being troubled by static.

QRO Must I increase power? Increase power.

QRP Must I decrease power? Decrease power.

QRQ Shall I send faster? Send faster (......words per min.).

QRS Shall I send more slowly? Send more slowly (.... w.p.m.).

QRT Shall I stop sending? Stop sending.

QRU Have you anything for me? I have nothing for you.

QRV Are you ready? I am ready.

QRW Shall I tell.....that you are calling him on .....kc.? Please inform.....that I am calling him on.....kc.

QRX When will you call me again? I will call you again at......hours (on........kc.).

QRZ Who is calling me? You are being called by..... (on......kc.).

QSA What is the strength of my signals (or those of ......)? The strength of your signals (or those of.....) is....... (1. Scarcely perceptible; 2. Weak; 3. Fairly good; 4. Good; 5. Very good).

QSB Are my signals fading? Your signals are fading.

QSD Is my keying defective? Your keying is defective.

QSG Shall I send.....messages at a time? Send..... messages at a time.

QSL Can you acknowledge receipt? I am acknowledging receipt.

QSM Shall I repeat the last message which I sent you, or some previous message? Repeat the last message which you sent me [or message(s) number(s).....].

QSO Can you communicate with....direct or by relay? I can communicate with.....direct (or by relay through.....).

QSP Will you relay to.....? I will relay to....

QSV Shall I send a series of Vs on this frequency (or ....kc.)? Send a series of Vs on this frequency (or.....kc.).

QSW Will you send on this frequency (or on....kc.)? I am going to send on this frequency (or on .....kc.).

QSX Will you listen to.....on.....kc.? I am listening to......on.....kc.

QSY Shall I change to transmission on another frequency? Change to transmission on another frequency (or on....kc.).

QSZ Shall I send each word or group more than once? Send each word or group twice (or....times).

QTA Shall I cancel message number....as if it had not been sent? Cancel message number.....as if it had not been sent.

QTB Do you agree with my counting of words? I do not agree with your counting of words; I will repeat the first letter or digit of each word or group.

QTC How many messages have you to send? I have.... messages for you (or for.....).

QTH What is your location? My location is.....

QTR What is the exact time? The time is......

Special abbreviations adopted by ARRL:

QST General call preceding a message addressed to all amateurs and ARRL members. This is in effect "CQ ARRL."

QRRR Official ARRL "land SOS." A distress call for emergency use only by a station in an emergency situation.

THE R-S-T SYSTEM

READABILITY

1 — Unreadable.
2 — Barely readable, occasional words distinguishable.
3 — Readable with considerable difficulty.
4 — Readable with practically no difficulty.
5 — Perfectly readable.

SIGNAL STRENGTH

1 — Faint signals, barely perceptible.
2 — Very weak signals.
3 — Weak signals.
4 — Fair signals.
5 — Fairly good signals.
6 — Good signals.
7 — Moderately strong signals.
8 — Strong signals.
9 — Extremely strong signals.

TONE

1 — Extremely rough hissing note.
2 — Very rough a.c. note, no trace of musicality.
3 — Rough low-pitched a.c. note, slightly musical.
4 — Rather rough a.c. note, moderately musical.
5 — Musically-modulated note.
6 — Modulated note, slight trace of whistle.
7 — Near d.c. note, smooth ripple.
8 — Good d.c. note, just a trace of ripple.
9 — Purest d.c. note.

If the signal has the characteristic steadiness of crystal control, add the letter X to the RST report. If there is a chirp, the letter C may be added to so indicate. Similarly for a click, add K. The above reporting system is used on both c.w. and voice, leaving out the "tone" report on voice.

A.R.R.L. COUNTRIES LIST • *Official List for ARRL Postwar DXCC*

AC3	Sikkim
AC4	Tibet
AC5	Bhutan
AP2	Pakistan
BV, (C3)	Formosa
BY, (C)	China
C9	Manchuria
CE	Chile
CE9, KC4, LU-Z, VKØ, VP8, ZL5, etc.	Antarctica
CE9	(See VP8)
CEØA —	Easter Island
CEØZ	Juan Fernandez Archipelago
CM, CO	Cuba
CN2	Tangier
CN8, CN9	Morocco
CP	Bolivia
CR4	Cape Verde Islands
CR5	Portuguese Guinea
CR5	Principe, Sao Thome
CR6	Angola
CR7	Mozambique
CR8	Goa (Portuguese India)
CR9	Macao
CR1Ø	Portuguese Timor
CT1	Portugal
CT2	Azores
CT3	Madeira Islands
CX	Uruguay
DJ, DL, DM	Germany
DU	Philippine Islands
EA	Spain
EA6	Balearic Islands
EA8	Canary Islands
EA9	Ifni
EA9	Rio de Oro
EA9	Spanish Morocco
EAØ	Spanish Guinea
EI	Republic of Ireland
EL	Liberia
EQ	Iran
ET2	Eritrea
ET3	Ethiopia
F	France
FA	Algeria
FB8	Amsterdam & St. Paul Islands
FB8	Comoro Islands
FB8	Kerguelen Islands
FB8	Madagascar
FB8	Tromelin Island
FC (unofficial)	Corsica
FD	Togo
FE8	French Cameroons
FF8	French West Africa
FG7	Guadeloupe
FI8	French Indo-China
FK8	New Caledonia
FL8	French Somaliland
FM7	Martinique
FN	French India
FO8	Clipperton Island
FO8	French Oceania
FP8	St. Pierre & Miquelon Islands
FQ8	French Equatorial Africa
FR7	Reunion Island
FS7	Saint Martin
FU8, YJ1	New Hebrides
FW8	Wallis & Futuna Islands
FY7	French Guiana & Inini
G	England
GC	Channel Islands
GD	Isle of Man
GI	Northern Ireland
GM	Scotland
GW	Wales
HA	Hungary
HB	Switzerland
HC	Ecuador
HC8	Galapagos Islands
HE	Liechtenstein
HH	Haiti
HI	Dominican Republic
HK	Colombia
HKØ	Archipelago of San Andres and Providencia
HL	Korea
HP	Panama
HR	Honduras
HS	Thailand
HV	Vatican City
HZ	Saudi Arabia
I1, IT1	Italy
I1	Trieste
I5	Italian Somaliland
IS1	Sardinia
JA, KA	Japan
JT1	Mongolia
JY	Jordan
JZØ	Netherlands New Guinea
K, W	United States of America
KA	(See JA)
KAØ, KG6I	Bonin & Volcano Islands
KB6	Baker, Howland & American Phoenix Islands
KC4	(See CE9)
KC4	Navassa Island
KC6	Eastern Caroline Islands
KG1	(See OX)
KG4	Guantanamo Bay
KG6	Mariana Islands
KG6I —	(See KAØ)
KH6	Hawaiian Islands
KJ6	Johnston Island
KL7	Alaska
KM6	Midway Islands
KP4	Puerto Rico
KP6	Palmyra Group, Jarvis Island
KR6	Ryukyu Islands
KS4B	Serrana Bank & Roncador Cay
KS4	Swan Island
KS6	American Samoa
KV4	Virgin Islands
KW6	Wake Island
KX6	Marshall Islands
KZ5	Canal Zone
LA	Jan Mayen
LA	Norway
LA	Svalbard
LU	Argentina
LU-Z	(See CE9, VP8)
LX	Luxembourg
LZ	Bulgaria
M1	San Marino
MP4	Bahrein Island
MP4	Qatar
MP4	Trucial Oman
OA	Peru
OD5	Lebanon
OE	Austria
OH	Finland
OHØ	Aland Islands
OK	Czechoslovakia
ON4	Belgium
OQ5, Ø	Belgian Congo
OX, KG1	Greenland
OY	Faeroes
OZ	Denmark
PAØ, PI1	Netherlands
PJ	Netherlands West Indies
PJ2M—	Sint Maarten
PK1, 2, 3	Java
PK4	Sumatra
PK5	Netherlands Borneo
PK6	Celebes & Molucca Islands
PX	Andorra
PY	Brazil
PYØ	Fernando de Naronha
PYØ	Trinidade & Martin Vaz Islands
PZ1	Netherlands Guiana
SL, SM	Sweden
SP	Poland
ST2	Sudan
SU	Egypt
SV	Crete
SV	Dodecanese
SV	Greece
TA	Turkey
TF	Iceland
TG	Guatemala
TI	Costa Rica
TI9	Cocos Island
UA1, 2, 3, 4, 6	European Russian Socialist Federated Soviet Republic
UA1	Franz Josef Land
UA9, Ø	Asiatic Russian S.F.S.R.
UAØ	Wrangel Island
UB5	Ukraine
UC2	White Russian S.S.R.
UD6	Azerbaijan
UF6	Georgia
UG6	Armenia
UH8	Turkoman
UI8	Uzbek
UJ8	Tadzhik
UL7	Kazakh
UM8	Kirghiz
UN1	Karelo-Finnish Republic
UO5	Moldavia
UP2	Lithuania
UQ2	Latvia
UR2	Estonia
VE, VO	Canada
VK	Australia (including Tasmania)
VK	Lord Howe Island
VK9, ZC3	Christmas Island
VK9	Cocos Islands
VK9	Nauru Island
VK9	Norfolk Island
VK9	Papua Territory
VK9	Territory of New Guinea
VKØ	(See CE9)
VKØ	Heard Island
VKØ	Macquarie Island
VO	(See VE)
VP1	British Honduras
VP2	Anguilla
VP2	Antigua, Barbuda
VP2	British Virgin Islands
VP2	Dominica
VP2	Granada & Dependencies
VP2	Montserrat
VP2	St. Kitts, Nevis
VP2	St. Lucia
VP2	St. Vincent & Dependencies
VP4	Trinidad & Tobago
VP5	Jamaica (including Cayman Isls.)
VP5	Turks & Caicos Islands
VP6	Barbados
VP7	Bahama Islands
VP8	(See CE9)
VP8	Falkland Islands
VP8, LU-Z	South Georgia
VP8, LU-Z	South Orkney Islands
VP8, LU-Z	South Sandwich Islands
VP, LU-Z, CE9	South Shetland Islands
VP9	Bermuda Islands
VQ1	Zanzibar
VQ2	Northern Rhodesia
VQ3	Tanganyika Territory
VQ4	Kenya
VQ5	Uganda
VQ6	British Somaliland
VQ8	Chagos Islands
VQ8	Mauritius
VQ8	Rodriguez Island
VQ9	Seychelles
VR1	British Phoenix Islands
VR1	Gilbert & Ellice Islands & Ocean Island
VR2	Fiji Islands
VR3	Fanning & Christmas Islands
VR4	Solomon Islands
VR5	Tonga Islands
VR6	Pitcairn Island
VS1	Singapore
VS2	(See 9M2)
VS4	Sarawak
VS5	Brunei
VS6	Hong Kong
VS9	Aden & Socotra
VS9	Maldive Islands
VS9	Sultanate of Oman
VU2	India
VU4	Laccadive Islands
VU5	Andaman and Nicobar Islands
W	(See K)
XE, XF	Mexico
XE4	Revilla Gigedo
XV5	(See 3W8)
XW8	Laos
XZ2	Burma
YA	Afghanistan
YI	Iraq
YJ	(See FU8)
YK	Syria
YN, YNØ	Nicaragua
YO	Roumania
YS	Salvador
YU	Yugoslavia
YV	Venezuela
YVØ	Aves Island
ZA	Albania
ZB1	Malta
ZB2	Gibraltar
ZC3	(See VK9)
ZC4	Cyprus
ZC5	British North Borneo
ZC6, 4X4	Palestine
ZD1	Sierra Leone
ZD2	Nigeria
ZD3	Gambia
ZD4	(See 9G1)
ZD4	Gold Coast, Togoland
ZD6	Nyasaland
ZD7	St. Helena
ZD8	Ascension Island
ZD9	Tristan da Cunha & Gough Islands
ZE	Southern Rhodesia
ZK1	Cook Islands
ZK1	Manihiki Islands
ZK2	Niue
ZL	Chatham Islands
ZL	Kermadec Islands
ZL	New Zealand
ZL5	(See CE9)
ZM6	British Samoa
ZM7	Tokelau (Union) Islands
ZP	Paraguay
ZS1, 2, 4, 5, 6	Union of South Africa
ZS2	Prince Edward & Marion Islands
ZS3	Southwest Africa
ZS7	Swaziland
ZS8	Basutoland
ZS9	Bechuanaland
3A	Monaco
3V8	Tunisia
3W8, XV5	Vietnam
4S7	Ceylon
4W1	Yemen
4X4	Israel
5A	Libya
7G1 (unofficial)	Rep. of Guinea
9G1, ZD4	Ghana
9K2	Kuwait
9M2	Malaya
9N1	Nepal
9S4	Saar
	Aldabra Islands

INTERNATIONAL PREFIXES

AAA-ALZ	United States of America
AMA-AOZ	Spain
APA-ASZ	Pakistan
ATA-AWZ	India
AXA-AXZ	Commonwealth of Australia
AYA-AZZ	Argentine Republic
BAA-BZZ	China
CAA-CEZ	Chile
CFA-CKZ	Canada
CLA-CMZ	Cuba
CNA-CNZ	Morocco
COA-COZ	Cuba
CPA-CPZ	Bolivia
CQA-CRZ	Portuguese Overseas Provinces
CSA-CUZ	Portugal
CVA-CXZ	Uruguay
CYA-CZZ	Canada
DAA-DMZ	Germany
DNA-DQZ	Belgian Congo
DRA-DTZ	Bielorussian Soviet Socialist Republic
DUA-DZZ	Republic of the Philippines
EAA-EHZ	Spain
EIA-EJZ	Ireland
EKA-EKZ	Union of Soviet Socialist Republics
ELA-ELZ	Liberia
EMA-EOZ	Union of Soviet Socialist Republics
EPA-EQZ	Iran
ERA-ERZ	Union of Soviet Socialist Republics
ESA-ESZ	Estonia
ETA-ETZ	Ethiopia
EUA-EZZ	Union of Soviet Socialist Republics
FAA-FZZ	France and Colonies and Protectorates
GAA-GZZ	Great Britain
HAA-HAZ	Hungarian People's Republic
HBA-HBZ	Switzerland
HCA-HDZ	Ecuador
HEA-HEZ	Switzerland
HFA-HFZ	People's Republic of Poland
HGA-HGZ	Hungarian People's Republic
HHA-HHZ	Republic of Haiti
HIA-HIZ	Dominican Republic
HJA-HKZ	Republic of Colombia
HLA-HMZ	Korea
HNA-HNZ	Iraq
HOA-HPZ	Republic of Panama
HQA-HRZ	Republic of Honduras
HSA-HSZ	Thailand
HTA-HTZ	Nicaragua
HUA-HUZ	Republic of El Salvador
HVA-HVZ	Vatican City State
HWA-HYZ	France and Colonies and Protectorates
HZA-HZZ	Saudi Arabia
IAA-IZZ	Italy and Colonies
JAA-JSZ	Japan
JTA-JVZ	Mongolian People's Republic
JWA-JXZ	Norway
JYA-JYZ	Jordan
JZA-JZZ	Netherlands New Guinea
KAA-KZZ	United States of America
LAA-LNZ	Norway
LOA-LWZ	Argentine Republic
LXA-LXZ	Luxembourg
LYA-LYZ	Lithuania
LZA-LZZ	Reople's Republic of Bulgaria
MAA-MZZ	Great Britain
NAA-NZZ	United States of America
OAA-OCZ	Peru
ODA-ODZ	Lebanon
OEA-OEZ	Austria
OFA-OJZ	Finland
OKA-OMZ	Czechoslovakia
ONA-OTZ	Belgium and Colonies
OUA-OZZ	Denmark
PAA-PIZ	Netherlands
PJA-PJZ	Netherlands Antilles
PKA-POZ	Republic of Indonesia
PPA-PYZ	Brazil
PZA-PZZ	Surinam
QAA-QZZ	(Service abbreviations)
RAA-RZZ	Union of Soviet Socialist Republics
SAA-SMZ	Sweden
SNA-SRZ	People's Republic of Poland
SSA-SSM	Egypt
SSN-STZ	Sudan
SUA-SUZ	Egypt
SVA-SZZ	Greece
TAA-TCZ	Turkey
TDA-TDZ	Guatemala
TEA-TEZ	Costa Rica
TFA-TFZ	Iceland
TGA-TGZ	Guatemala
THA-THZ	France and Colonies and Protectorates
TIA-TIZ	Costa Rica
TJA-TZZ	France and Colonies and Protectorates
UAA-UQZ	Union of Soviet Socialist Republics
URA-UTZ	Ukrainian Soviet Socialist Republic
UUA-UZZ	Union of Soviet Socialist Republics
VAA-VGZ	Canada
VHA-VNZ	Commonwealth of Australia
VOA-VOZ	Canada
VPA-VSZ	British Colonies and Protectorates
VTA-VWZ	India
VXA-VYZ	Canada
VZA-VZZ	Commonwealth of Australia
WAA-WZZ	United States of America
XAA-XIZ	Mexico
XJA-XOZ	Canada
XPA-XPZ	Denmark
XQA-XRZ	Chile
XSA-XSZ	China
XTA-XTZ	France and Colonies and Protectorates
XUA-XUZ	Cambodia
XVA-XVZ	Viet-Nam
XWA-XWZ	Laos
XXA-XXZ	Portuguese Overseas Provinces
XYA-XZZ	Burma
YAA-YAZ	Afghanistan
YBA-YHZ	Republic of Indonesia
YIA-YIZ	Iraq
YJA-YJZ	New Hebrides
YKA-YKZ	Syrian Republic
YLA-YLZ	Latvia
YMA-YMZ	Turkey
YNA-YNZ	Nicaragua
YOA-YRZ	Roumanian People's Republic
YSA-YSZ	Republic of El Salvador
YTA-YUZ	Yugosalvia
YVA-YYZ	Venezuela
YZA-YZZ	Yugoslavia
ZAA-ZAZ	Albania
ZBA-ZJZ	British Colonies and Protectorates
ZKA-ZMZ	New Zealand
ZNA-ZOZ	British Colonies and Protectorates
ZPA-ZPZ	Paraguay
ZQA-ZQZ	British Colonies and Protectorates
ZRA-ZUZ	Union of South Africa
ZVA-ZZZ	Brazil
2AA-2ZZ	Great Britain
3AA-3AZ	Monaco
3BA-3FZ	Canada
3GA-3GZ	Chile
3HA-3UZ	China
3VA-3VZ	Tunisia
3WA-3WZ	Viet-Nam
3YA-3YZ	Norway
3ZA-3ZZ	People's Republic of Poland
4AA-4CZ	Mexico
4DA-4IZ	Republic of the Philippines
4JA-4LZ	Union of Soviet Socialist Republics
4MA-4MZ	Venezuela
4NA-4OZ	Yugoslavia
4PA-4SZ	Ceylon
4TA-4TZ	Peru
4UA-4UZ	United Nations
4VA-4VZ	Republic of Haiti
4WA-4WZ	Yemen
4XA-4XZ	State of Israel
4YA-4YZ	International Civil Aviation Organization
5AA-5AZ	Libya
5CA-5CZ	Morocco
5LA-5LZ	Liberia
5PA-5QZ	Denmark
9AA-9AZ	San Marino
9KA-9KZ	Kuwait
9NA-9NZ	Nepal
9SA-9SZ	Saar

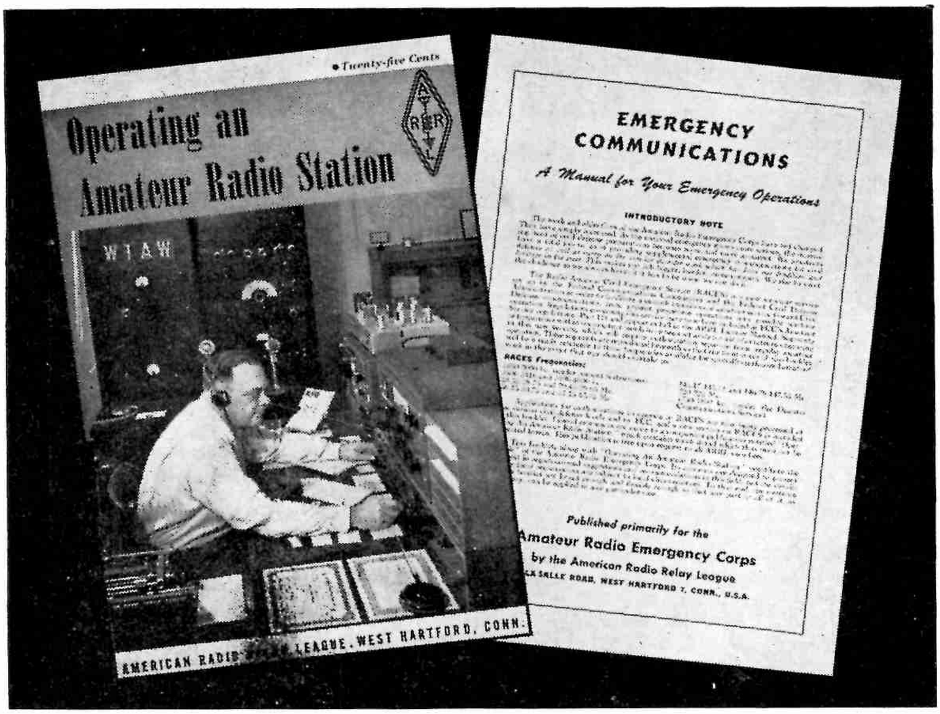
ABBREVIATIONS FOR C.W. WORK

Abbreviations help to cut down unnecessary transmission. However, make it a rule not to abbreviate unnecessarily when working an operator of unknown experience.

AA	All after
AB	All before
ABT	About
ADR	Address
AGN	Again
ANT	Antenna
BCI	Broadcast interference
BCL	Broadcast listener
BK	Break; break me; break in
BN	All between; been
B4	Before
C	Yes
CFM	Confirm; I confirm
CK	Check
CL	I am closing my station; call
CLD-CLG	Called; calling
CUD	Could
CUL	See you later
CUM	Come
CW	Continuous wave
DLD-DLVD	Delivered
DX	Distance
ECO	Electron-coupled oscillator
FB	Fine business; excellent
GA	Go ahead (or resume sending)
GB	Good-by
GBA	Give better address
GE	Good evening
GG	Going
GM	Good morning
GN	Good night
GND	Ground
GUD	Good
HI	The telegraphic laugh; high
HR	Here; hear
HV	Have
HW	How
LID	A poor operator
MILS	Milliamperes
MSG	Message; prefix to radiogram
N	No
ND	Nothing doing
NIL	Nothing; I have nothing for you
NR	Number
NW	Now; I resume transmission
OB	Old boy
OM	Old man
OP-OPR	Operator
OSC	Oscillator
OT	Old timer; old top
PBL	Preamble
PSE-PLS	Please
PWR	Power
PX	Press
R	Received as transmitted; are
RAC	Rectified alternating current
RCD	Received
REF	Refer to; referring to; reference
RPT	Repeat; I repeat
SED	Said
SEZ	Says
SIG	Signature; signal
SINE	Operator's personal initials or nickname
SKED	Schedule
SRI	Sorry
SVC	Service; prefix to service message
TFC	Traffic
TMW	Tomorrow
TNX-TKS	Thanks
TT	That
TU	Thank you
TVI	Television interference
TVL	Television listener
TXT	Text
UR-URS	Your; you're; yours
VFO	Variable-frequency oscillator
VY	Very
WA	Word after
WB	Word before
WD-WDS	Word; words
WKD-WKG	Worked; working
WL	Well; will
WUD	Would
WX	Weather
XMTR	Transmitter
XTAL	Crystal
YF (XYL)	Wife
YL	Young lady
73	Best regards
88	Love and kisses

W/K CALL AREAS BY STATES

Alabama	4
Alaska	KL7
Arizona	7
Arkansas	5
California	6
Colorado	Ø
Connecticut	1
Delaware	3
Florida	4
Georgia	4
Hawaii	KH6
Idaho	7
Illinois	9
Indiana	9
Iowa	Ø
Kansas	Ø
Kentucky	4
Louisiana	5
Maine	1
Maryland (and District of Columbia)	3
Massachusetts	1
Michigan	8
Minnesota	Ø
Mississippi	5
Missouri	Ø
Montana	7
Nebraska	Ø
Nevada	7
New Hampshire	1
New Jersey	2
New Mexico	5
New York	2
North Carolina	4
North Dakota	Ø
Ohio	8
Oklahoma	5
Oregon	7
Pennsylvania	3
Rhode Island	1
South Carolina	4
South Dakota	Ø
Tennessee	4
Texas	5
Utah	7
Vermont	1
Virginia	4
Washington	7
West Virginia	8
Wisconsin	9
Wyoming	7



▶ *Operating an Amateur Radio Station* covers the details of practical amateur operating. In it you will find information on Operating Practices, Emergency Communication, ARRL Operating Activities and Awards, the ARRL Field Organization, Handling Messages, Network Organization, "Q" Signals and Abbreviations used in amateur operating, important extracts from the FCC Regulations, and other helpful material. It's a handy reference that will serve to answer many of the questions concerning operating that arise during your activities on the air.

▶ *Emergency Communications* is the "bible" of the Amateur Radio Emergency Corps. Within its eight pages are contained the fundamentals of emergency communication which every amateur interested in public service work should know, including a complete diagrammatical plan adaptable for use in any community, explanation of the role of the American Red Cross and FCC's regulations concerning amateur operation in emergencies. The Radio Amateur Civil Emergency Service (RACES) comes in for special consideration, including a table of RACES frequencies on the front cover.

The two publications described above may be obtained without charge by any *Handbook* reader. Either or both will be sent upon request.

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Vacuum Tubes and Semiconductors

For the convenience of the designer, the receiving-type tubes listed in this chapter are grouped by filament voltages and construction types (glass, metal, miniature, etc.). For example, all miniature tubes are listed in Table I, all metal tubes are in Table II, and so on.

Transmitting tubes are divided into triodes and tetrodes-pentodes, then listed according to rated plate dissipation. This permits direct comparison of ratings of tubes in the same power classification.

For quick reference, all tubes are listed in numerical-alphabetical order in the index. Types having no table reference are either obsolete or of little use in amateur equipment. Base diagrams for these tubes are listed, however.

Tube Ratings

Vacuum tubes are designed to be operated within definite maximum (and minimum) ratings. These ratings are the maximum safe operating voltages and currents for the electrodes, based on inherent limiting factors such as permissible cathode temperature, emission, and power dissipation in electrodes.

In the transmitting-tube tables, maximum ratings for electrode voltage, current and dissipation are given separately from the typical operating conditions for the recommended classes of operation. In the receiving-tube tables, because of space limitations, ratings and operating data are combined. Where only one set of operating conditions appears, the positive electrode voltages shown (plate, screen, etc.) are, in general, also the maximum rated voltages.

For certain air-cooled transmitting tubes, there are two sets of maximum values, one designated as CCS (Continuous Commercial Service) ratings, the other ICAS (Intermittent Commercial and Amateur Service) ratings. Continuous Commercial Service is defined as that type of service in which long tube life and reliability of performance under continuous operating conditions are the prime consideration. Intermittent Commercial and Amateur Service is defined to include the many applications where the transmitter design factors of minimum size, light weight, and maximum power output are more important than long tube life. ICAS ratings are considerably higher than CCS ratings. They permit the handling of greater power, and although such use involves some sacrifice in tube life, the period over which tubes give satisfactory performance in intermittent service can be extremely long.

The plate dissipation values given for transmitting tubes should not be exceeded during normal operation. In plate modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is approximately 66 percent of the value listed and will rise to the maximum value under 100-per-cent sinusoidal modulation.

Typical Operating Conditions

The typical operating conditions given for transmitting tubes represent, in general, maximum ICAS ratings where such ratings have been given by the manufacturer. They do not represent the *only* possible method of operation of a particular tube type. Other values of plate voltage, plate current, grid bias, etc., may be used so long as the maximum ratings for a particular voltage or current are not exceeded.

Equivalent Tubes

The equivalent tubes listed in Table VIII are used occasionally in amateur service. In addition to the types listed, other equivalents are available for special purposes such as series-heater string operation in TV receivers. These types require unusual values of heater voltage (3.15, 4.2, etc.), and have controlled warm-up time characteristics to minimize voltage unbalance during starting. Except for heater design, these types correspond electrically and mechanically to 6-volt prototypes.

INDEX TO TUBE TABLES

CHAPTER 25

INDEX TO VACUUM-TUBE TYPES

Base-diagram section pages V5-V14. Classified data pages V15-V32.

Type	Page	Base
6K7	V19	7R
6K8	V19	8K
6L4	V21	7BR
6L5G	—	6Q
6L6	V22	7AC
6L6GA	V22	7S
6L6GB	V19	7S
6L6GX	—	7S
6L7	V19	7T
6M5	—	9N
6M6G	—	7S
6M7G	—	7R
6M8GT	—	8AU
6N4	—	7CA
6N5	—	6R
6N6G	—	7AU
6N7	V19	8B
6N7	V25	8B
6N8	—	9T
6P5GT	—	6Q
6P7G	—	7U
6P8G	—	8K
6Q4	—	9S
6Q5G	—	6Q
6Q6G	—	6Y
6Q7	V19	7V
6R4	—	9R
6R6G	—	6AW
6R7	V19	7V
6R8	V17	9E
6S4	V22	9AC
6S4A	V17	9AC
6S6GT	—	5AK
6S7	V19	7R
6S8GT	V20	8CB
6SA7GT	V19	8R
6SB7Y	V19	8R
6SC7	V19	8S
6SD7GT	V20	8N
6SE7GT	—	8N
6SF5	V19	6AB
6SF7	V19	7AZ
6SG7	V19	8BK
6SH7	V19	8BK
6SH7L	—	8BK
6SJ7	V19	8N
6SJ7Y	V19	8N
6SK7	V19	8N
6SL7GT	V20	8BD
6SN7GT	V22	8BD
6SN7GTA	V22	8BD
6SN7GTB	V20	8BD
6SQ7GT	V19	8Q
6SR7	V19	8Q
6SS7	V19	8N
6ST7	—	8Q
6SU7GTY	V22	8BD
6SV7	—	7AZ
6SZ7	—	8Q
6T4	V17	7DK
6T5	—	6R
6T6GM	—	6Z
6T7	—	7V
6T8	V22	9E
6T8A	V17	9E
6U3	—	9BM
6U4GT	V24	4CG
6U5	—	6R
6U6GT	V20	7S
6U7G	—	7R
6U8	V22	9AE
6U8A	V17	9AE
6V3	—	9BD
6V3A	—	9BD
6V4	V24	9M
6V5GT	V20	6AO
6V6	V22	7AC
6V6GTA	V19	7S
6V7G	—	7V
6V8	V17	9AH
6W4GT	—	4CG
6W5G	—	6S
6W6GT	V20	7S
6W7G	—	7R
6X4/6063	V24	7CF
6X5GT	V24	6S
6X6G	—	7AL
6X8	—	9AK
6X8A	V17	9AK
6Y3G	—	4AC
6Y5	—	6J
6Y6G	V22	7S
6Y6GA	V20	7S
6Y6GT	V22	7S
6Y7G	—	8B
6Z3	V24	4G
6Z4	V24	5D
6Z5	—	6K
6Z7G	—	8B
6ZY5G	—	6S
7A4	V22	5AS
7A5	—	6AA
7A6	V22	7AJ
7A7	V22	8V
7A8	V20	8U
7AB7	—	8BO
7AD7	—	8V
7AF7	—	8AC
7AG7	—	8V
7AH7	V20	8V
7AJ7	—	8V
7AK7	V20	8V
7B4	V22	5AC
7B5	V22	6AE
7B6	V22	8W
7B7	V20	8V
7B8	V22	8X
7C4	—	4AH
7C5	V22	6AA
7C6	—	8W
7C7	V20	8V
7D7	—	8AR
7E5	V21	8BN
7E6	—	8W

Type	Page	Base
7E7	V20	8AE
7EP4	V30	11N
7EV6	V22	7AC
7F7	V22	8AC
7F8	V20	8BW
7G7	—	8V
7G8	—	8BV
7GP4	V30	14G
7H7	V22	8V
7J7	—	8BL
7JP1-4-7	V30	14R
7K7	V20	8BF
7L7	—	8V
7N7	V22	8AC
7Q7	V22	8AL
7R7	—	8AE
7S7	—	8BL
7T7	—	8V
7V7	—	8V
7VP1	V30	14R
7W7	—	8BJ
7X6	—	7AJ
7X7	—	8BZ
7Y4	—	5AB
7Z4	—	5AB
8BP4	—	14G
9BM5	—	7BZ
9BW6	—	9AM
9NP1	—	6BN
10	—	4D
10EB8	V22	9DX
10GP4	—	14G
10HP4	—	14G
10Y	V25	4D
11/12	—	4F
12A4	V17	9AG
12A5	—	7F
12A6	V21	7S
12A7	—	7K
12A8GT	V22	8A
12AB5	V17	9EU
12AC6	V17	7BK
12AD6	V17	7CH
12AD7	V17	9A
12AE6A	V17	7BT
12AE7	V17	9A
12AF6	V17	7BK
12AG6	—	7CH
12AH7GT	V21	8BE
12AH8	—	9BP
12AJ6	V17	7BT
12AL5	V22	6BT
12AL8	V17	9GS
12AQ5	V17	7BZ
12AT6	V22	7BT
12AT7	V17	9A
12AU6	V22	7BK
12AU7A	V25	9A
12AU7A	V17	9A
12AV5GA	V22	6CK
12AV6	V22	7BT
12AV7	V17	9A
12AW6	V17	7CM
12AW7	—	7CM
12AX4GT	—	4CG
12AX4GTA	—	4CG
12AX7	V17	9A
12AY7	V17	9A
12AZ7A	V17	9A
12B4	V22	9AG
12B4A	V17	9AG
12B6M	—	6Y
12B7	—	8V
12B7ML	—	8V
12B8GT	—	8T
12BA6	V22	7BK
12BA7	V22	8CT
12BD6	V22	7BK
12BE6	V22	7CH
12BF6	V22	7BT
12BH7	—	9A
12BH7A	V17	9A
12BK5	V22	9BQ
12BK6	V22	7BT
12BL6	V17	7BK
12BN6	V22	7DF
12BQ6GA	V22	6AM
12BQ6GT	V22	6AM
12BQ6GTB	V22	6AM
12BR7A	V17	9CF
12BT6	V22	7BT
12BU6	V22	7BT
12BW4	V22	9DJ
12BV7	V17	9BF
12BY7	V22	9BF
12BY7A	V17	9BF
12BZ6	V22	7CM
12BZ7	V17	9A
12C5	V22	7CV
12C8	V22	8E
12CA5	V22	7CV
12CM6	V22	9CK
12CN5	V17	7CV
12CR6	V22	7EA
12CS5	V22	9CK
12CS6	V22	7CH
12CT8	—	9DA
12CU5	V22	7CV
12CU6	V22	6AM
12CX6	V17	7BK
12DB5	V22	9GR
12DE8	V17	Fig. 81
12DF5	V24	9BS
12DF7	V22	9A
12DK7	V17	9HZ
12DL8	V17	9HR
12DQ6A	V22	6AM
12DQ7	V18	9BF
12DS7A	V18	9JU
12DT5	V22	9HN
12DT7	V18	9A
12DT8	V22	9DE
12DU7	V18	9JX

Type	Page	Base
12DV7	V18	9JY
12DV8	V18	9HR
12DW5	V22	9CK
12DW8	V18	9JC
12DY8	V18	9JD
12DZ6	V18	7BK
12E5GT	—	6Q
12EA6	V18	7BK
12EC8	V18	9FA
12ED5	V18	7CV
12EF6	V22	7S
12EG6	V18	7CH
12EK6	V18	7BK
12EL6	V18	7FB
12EM6	V18	9HV
12EN6	V21	7S
12F5GT	—	5M
12F8	V18	9FH
12FK6	V18	7BT
12FM6	V18	7BT
12FP7	—	14E
12FT6	V18	7BT
12G4	V22	6BG
12G7G	—	7V
12G8	—	9CZ
12GP7	—	14S
12H4	V18	7DW
12H6	V22	7Q
12HP7	—	11J
12J5GT	V22	6Q
12J7GT	V22	7R
12J8	V18	9GC
12K5	V18	7EK
12K7GT	V22	7R
12K8	V22	8K
12L6GT	V21	7S
12L8GT	—	8BU
12Q7GT	—	7V
12R5	V18	7CV
12S8GT	V22	8CB
12SA7	V22	8R
12SC7	V22	8S
12SF5	V22	6AB
12SF7	V22	7AZ
12SG7	V22	8BK
12SH7	V22	8BK
12SJ7	V22	8N
12SK7	V22	8N
12SL7GT	V22	8BD
12SN7GT	V22	8BD
12SN7GTA	V22	8BD
12SQ7	V22	8Q
12SR7	V22	8Q
12SW7	—	8Q
12SX7	—	8BD
12SY7	V21	8R
12U7	V18	9A
12V6GT	—	7S
12W6GT	V22	7S
12X4	V24	5BS
12Z3	—	4G
12Z5	—	7L
14A4	—	5AC
14A5	—	6AA
14A7	V22	8V
14AF7	V22	8AC
14AP1-4	—	12A
14B6	V22	8W
14B8	—	8X
14C5	—	6AA
14C7	—	8V
14E6	—	8W
14E7	—	8AE
14F7	V22	8AC
14F8	—	8BW
14H7	—	8V
14J7	—	8BL
14N7	V22	8AC
14Q7	V22	8AL
14R7	—	8AE
14S7	—	8BL
14V7	—	8V
14W7	—	8BJ
14X7	—	8BZ
14Y4	—	5AB
14Z3	—	4G
15	—	5F
15A6	—	9AR
15E	V25	Fig. 51
16A5	—	9BL
17	—	3G
17Z3	—	9CB
18	—	6B
18FW6	V18	7CC
18FX6	V18	7CH
18FY6	V18	7BT
19	—	6C
19CL8A	V22	9FX
19X3	—	9BM
19Y3	—	9BM
20	—	4D
20AP1-4	—	12A
20J8GM	—	8H
21A6	—	9AS
21A7	—	8AR
21EX6	V21	5BT
22	—	4K
24-A	—	5E
24-G	V25	2D
24XH	V30	Fig. 1
25A6	—	7S
25A7GT	—	8F
25AC5GT	—	6Q
25AV5GA	—	6CK
25AV5GT	—	6CK
25AX4GT	—	4CG
25B5	—	6D
25B6G	—	7S
25B8GT	—	8T
25BK5	—	9BQ
25BQ6GA	V22	6AM
25BQ6GT	V22	6AM
25BQ6GTB	V22	6AM

Type	Page	Base
25C5	V22	7CV
25C6G	—	7AC
25C6GA	V22	7S
25CA5	V22	7CV
25CD6G	V22	5BT
25CD6GA	V22	5BT
25CD6GB	V22	5BT
25CU6	V22	6AM
25D8GT	—	8AF
25DN6	V22	5BT
25DQ6	—	6AM
25EC6	V22	5BT
25EH5	V22	7CV
25F5	V18	7CV
25L6GT	V22	7S
25N6G	—	7W
25S	—	6M
25SA7GT	V22	8AD
25T	V25	3G
25W4GT	—	4CG
25W6GT	V22	7S
25X6GT	—	7Q
25Y4GT	—	5AA
25Y5	—	6E
25Z3	V24	4G
25Z4	—	5AA
25Z5	V24	6E
25Z6	V24	7Q
26	—	4D
26A6	—	7BK
26A7GT	—	8BU
26BK6	—	7BT
26C6	—	7BT
26CG6	—	7BK
26D6	—	7CH
26Z5W	—	9BS
27	—	5A
28Z5	—	5AB
30	—	4D
31	—	4D
32	—	4K
32ET5	V18	7CV
32L7GT	—	8Z
33	—	5K
34	—	4M
35/51	—	5E
35A5	V21	6AA
35B5	V18	7BZ
35C5	V22	7CV
35L6GT	V22	7S
35T	V25	3G
35TG	V25	2D
35W4	V24	5BQ
35Y4	—	5AL
35Z3	—	4Z
35Z4GT	V24	5AA
35Z5G	V24	6AD
35Z6G	—	7Q
36	—	5E
36AM3	V24	5BQ
37	—	5A
38	—	5F
39/44	—	5F
40	—	4D
40Z5GT	—	6AD
41	V22	6B
42	V22	6B
43	—	6B
45	—	4D
45Z3	—	5AM
45Z5GT	—	6AD
46	—	5C
47	—	5B
48	—	6A
49	—	5C
50	—	4D
50A5	V22	6AA
50AX6G	—	7Q
50B5	V18	7BZ
50BK5	V22	9BQ
50C5	V22	7CV
50C6G	V22	7S
50C6GA	V21	7S
50DC4	V24	5BQ
50L6GT	V22	7S
50T	—	2D
50X6	—	7AJ
50Y6GT	V24	7Q
50Y7GT	—	8AN
50Z6G	V24	7Q
50Z7G	—	8AN
51	—	5E
52	—	5C
53	—	7B
53A	—	Fig. 53
55	—	6G
56	—	5A
56AS	—	5A
57	—	6F
57AS	—	6F
58	—	6F
58AS	—	6F
59	—	7A
70A7GT	—	8AB
70L7GT	—	8AA
71-A	—	4D
72	—	4P
73	—	4Y
75	V22	6G
75TH	V26	2D
75TL	V26	2D
76	—	5A
77	—	6F
78	V22	6F
79	—	6H
80	V24	4C
81	—	4B
82	—	4C
83	V24	4C
83-V	V24	4AD
84/6Z4	V24	5D
85	—	6G
85AS	—	6G

Type	Page	Base
89	—	6F
90C1	V23	5BO
99	—	4D
100TH	V26	2D
100TL	V26	2D
111H	—	2D
112-A	—	4D
117L7GT	V24	8AO
117M7GT	V24	8AO
117N7GT	V21	8AV
117N7GT	V24	8AV
117P7GT	V24	8AV
117Z3	V24	4CB
117Z4GT	—	5AA
117Z6GT	—	7Q
128AS	—	5A
150T	—	2N
152TH	V26	4BC
152TL	V27	4BC
182-B	—	4D
183	—	4D
203-A	—	4E
203-H	—	3N
204-A	—	Fig. 39
205-D	—	4D
211	V26	4E
212-E	—	Fig. 43
217-A	—	4AT
217-C	—	4AT
227-A	—	Fig. 53
241-B	—	Fig. 44
242-A	—	4E
242-B	—	4E
242-C	—	4E
249-B	—	Fig. 29
250TH	V27	2N
250TL	V27	2N
254	V26	2N
254-A	—	Fig. 57
254-B	—	Fig. 57
261-A	—	4E
270-A	—	Fig. 39
276-A	—	4E
282-A	—	Fig. 57
284-B	—	3N
284-D	—	4E
295-A	—	4E
300T	—	2N
303-A	—	4E
304-A	—	Fig. 39
304-B	—	2D
304TH	V27	4BC
304TL	V27	4BC
305-A	—	Fig. 59
306-A	—	Fig. 63
307-A	—	Fig. 61
308-B	—	Fig. 43
310	—	4D
311	V26	4E
311CH	—	Fig. 32
312-A	—	Fig. 68
312-E	—	Fig. 44
316-A	V25	—
327-A	—	Fig. 50
327-B	—	Fig. 50
342-B	—	4E
356-A	—	Fig. 55
361-A	—	4E
376-A	—	4E
417-A	V22	9V
482-B	—	4D
483	—	4D
485	—	5A
527	—	Fig. 53
559	—	Fig. 10
575-A	—	4AT
592	V27	Fig. 28
705-A	—	Fig. 45
717-A	—	8BK
756	—	4D
800	—	2D
801A/801	V25	4D
802	—	6BM
803	V29	5J
804	—	Fig. 61
805	V26	3N
806	V27	2N
807	V28	5AW
807W	V28	5AW
808	—	2D
809	V25	3G
810	V27	2N
811	V26	3G
811A	V26	3G
812	V26	3G
812A	V26	3G
812H	—	3G
813	V29	5BA
814	V28	Fig. 64
815	V28	8BY
816	V24	4P
822	—	3N
822S	—	2N
826	V26	7BO
828	V29	5J
829	—	7BP
829A	—	7BP
829B	V28	7BP
830	—	4D
830B	V26	3G
831	—	Fig. 40
832	—	7BP
832A	V28	7BP
833A	V27	Fig. 41
834	—	2D
835	—	4E
836	V24	4P
837	V28	6BM
838	—	4E
840	—	5J
841	—	4D
841A	—	3G
841SW	—	3G

SEMICONDUCTORS

VACUUM-TUBE BASE DIAGRAMS

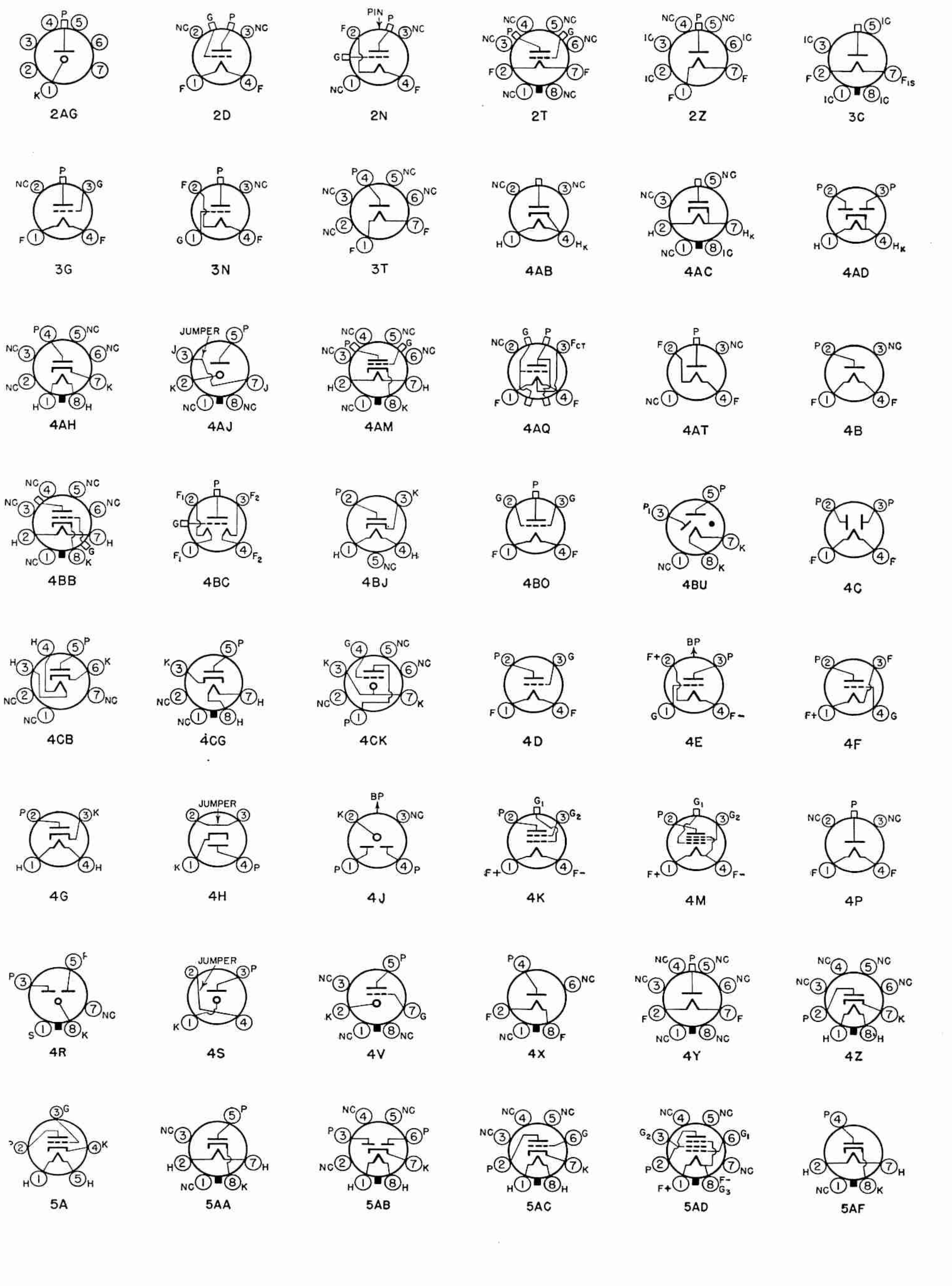
Socket connections correspond to the base designations given in the column headed "Base" in the classified tube-data tables. Bottom views are shown throughout. Terminal designations are as follows:

A = Anode	D = Deflecting Plate	IS = Internal Shield	RC = Ray-Control Electrode
B = Beam	F = Filament	K = Cathode	Ref = Reflector
BP = Bayonet Pin	FE = Focus Elect.	NC = No Connection	S = Shell
BS = Base Sleeve	G = Grid	P = Plate (Anode)	TA = Target
C = Ext. Coating	H = Heater	P_1 = Starter-Anode	U = Unit
CL = Collector	IC = Internal Con.	P_{BF} = Beam Plates	• = Gas-Type Tube

Alphabetical subscripts D, P, T and HX indicate, respectively, diode unit, pentode unit, triode unit or hexode unit in multi-unit types. Subscript CT indicates filament or heater tap.

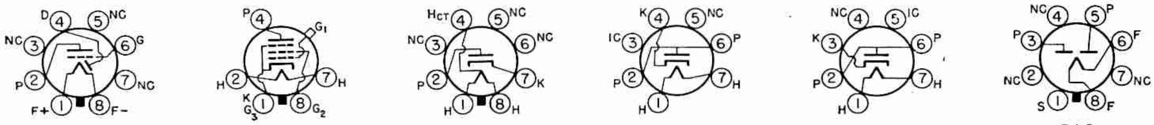
Generally when the No. 1 pin of a metal-type tube in Table II, with the exception of all triodes, is shown connected to the shell, the No. 1 pin in the glass (G or GT) equivalent is connected to an internal shield.

E.I.A. (R.E.T.M.A.) TUBE BASE DIAGRAMS

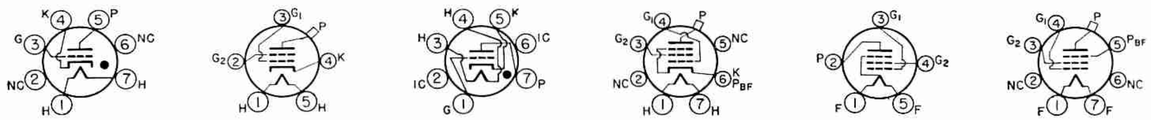


TUBE BASE DIAGRAMS

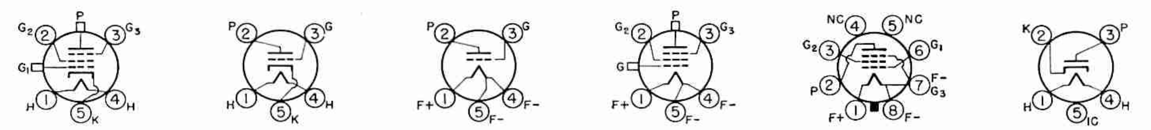
Bottom views are shown. Terminal designations on sockets are given on page V5.



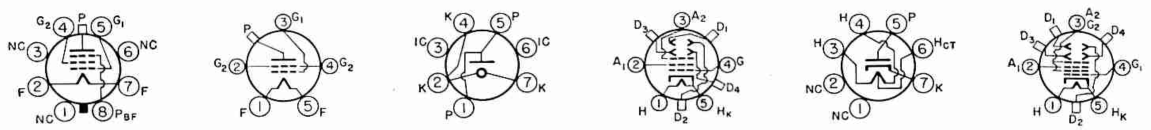
5AG 5AK 5AL 5AM 5AP 5AQ



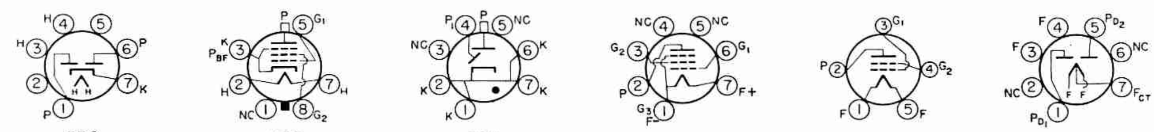
5AS 5AW 5AY 5AZ 5B 5BA



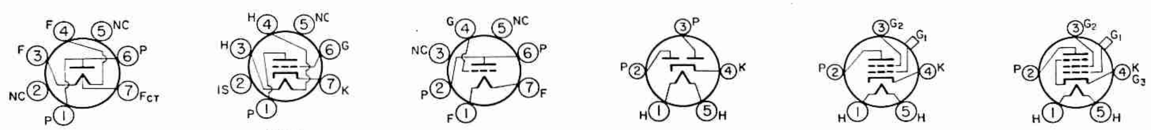
5BB 5BC 5BD 5BE 5BF 5BG



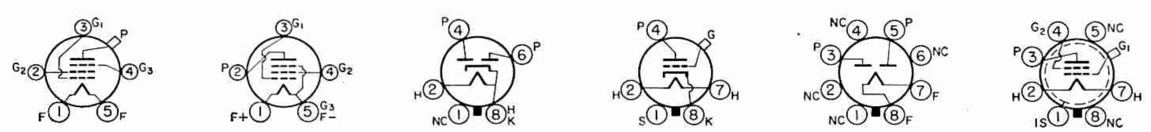
5BJ 5BK 5BO 5BP 5BQ 5BR



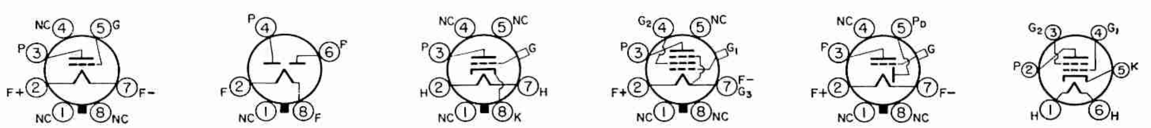
5BS 5BT 5BU 5BZ 5C 5CA



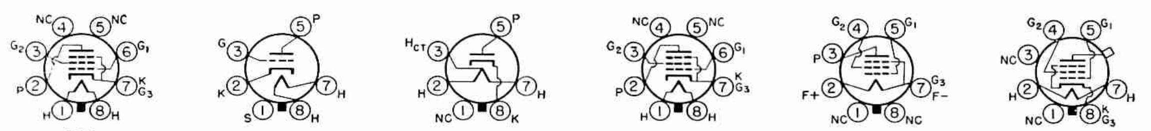
5CB 5CE 5CF 5D 5E 5F



5J 5K 5L 5M 5Q 5R



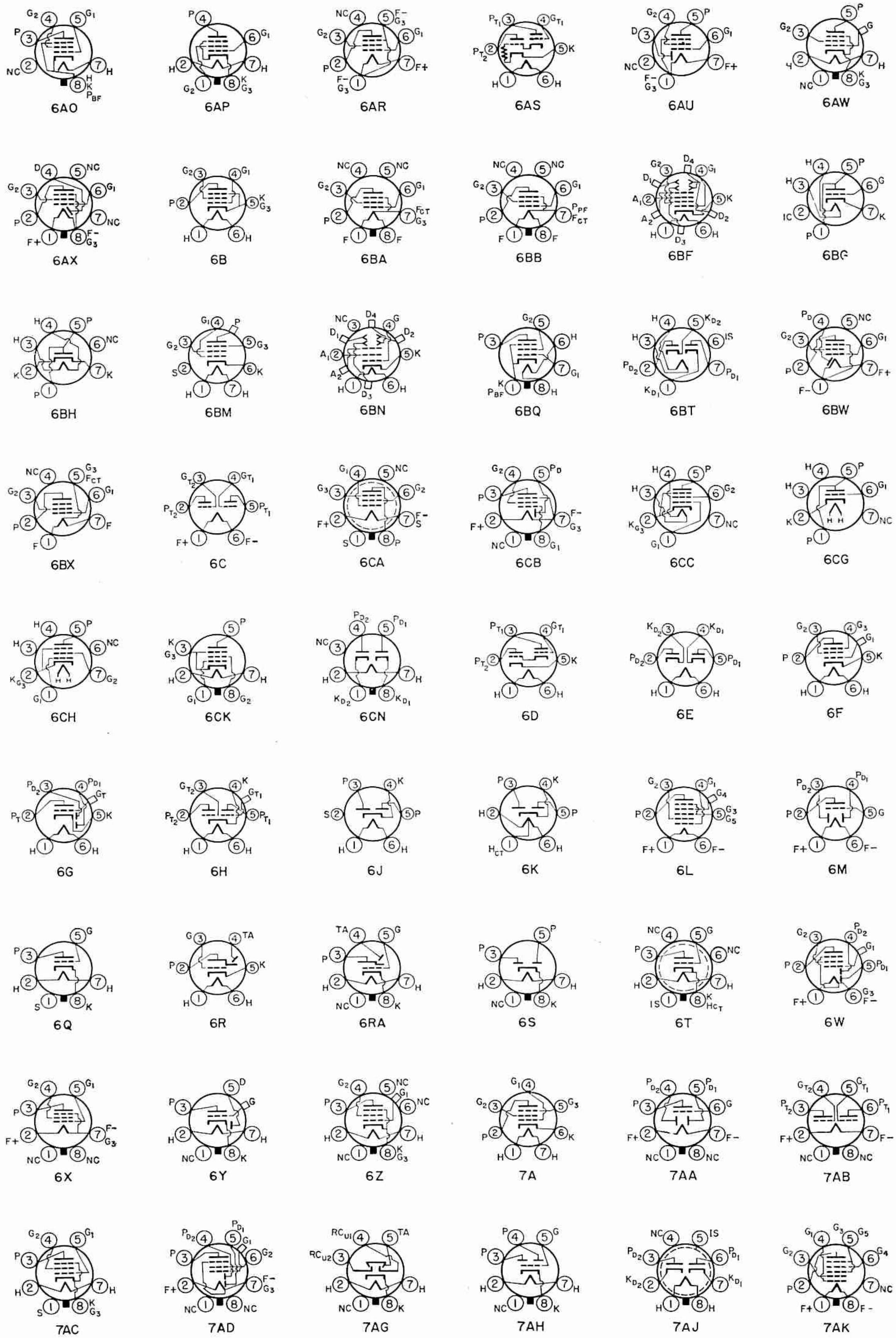
5S 5T 5U 5Y 5Z 6A



6AA 6AB 6AD 6AE 6AF 6AM

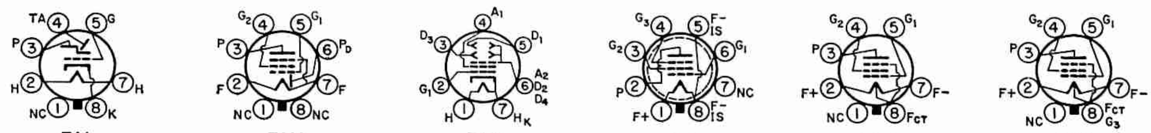
TUBE BASE DIAGRAMS

Bottom views are shown. Terminal designations on sockets are given on page V5.

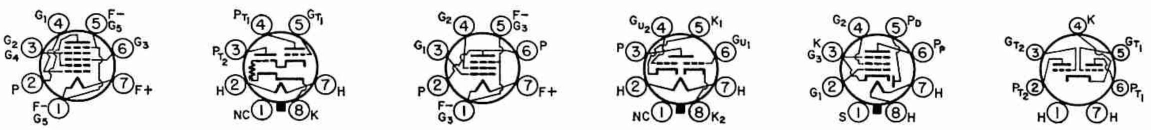


TUBE BASE DIAGRAMS

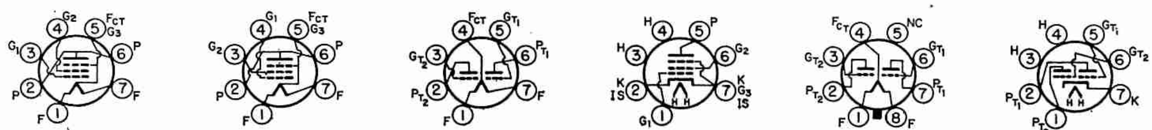
Bottom views are shown. Terminal designations on sockets are given on page V5.



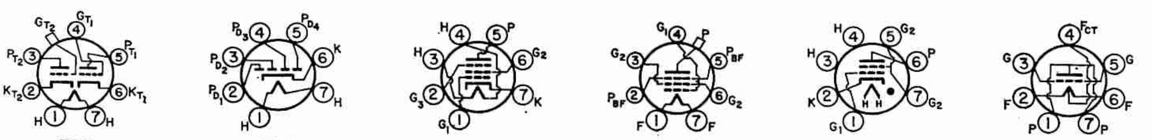
7AL 7AM 7AN 7AO 7AP 7AQ



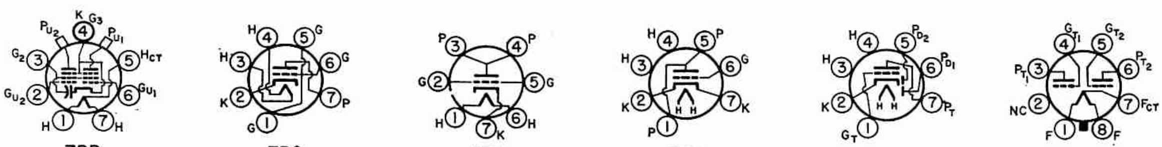
7AT 7AU 7AV 7AX 7AZ 7B



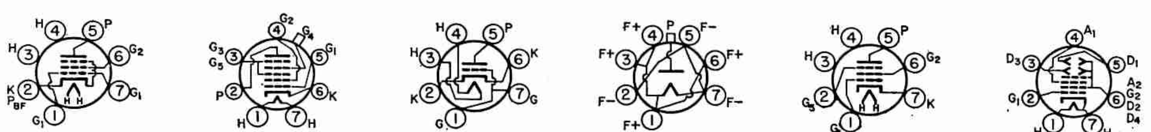
7BA 7BB 7BC 7BD 7BE 7BF



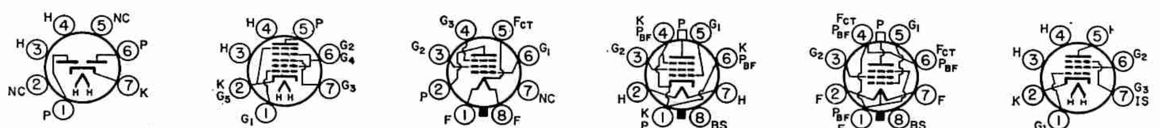
7BH 7BJ 7BK 7BM 7BN 7BO



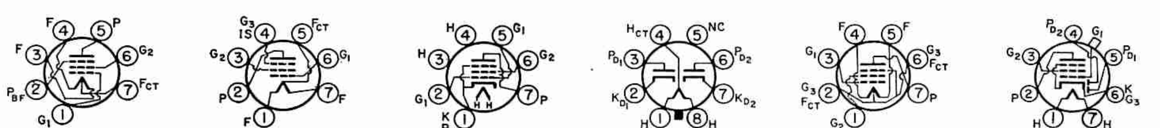
7BP 7BQ 7BR 7BS 7BT 7BW



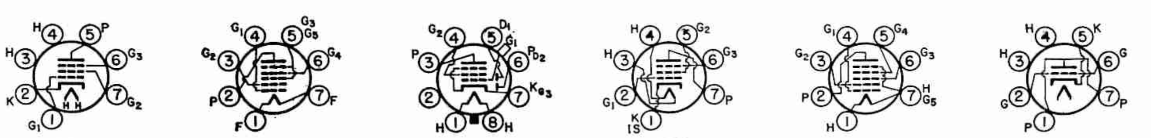
7BZ 7C 7CA 7CB 7CC 7CE



7CF 7CH 7CJ 7CK 7CL 7CM



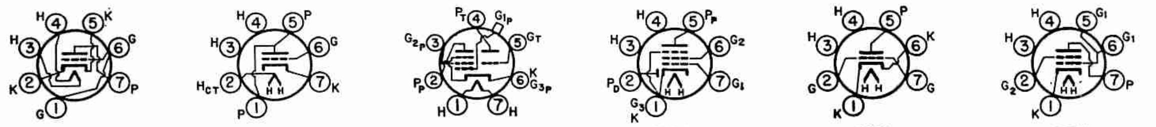
7CQ 7CU 7CV 7CX 7CY 7D



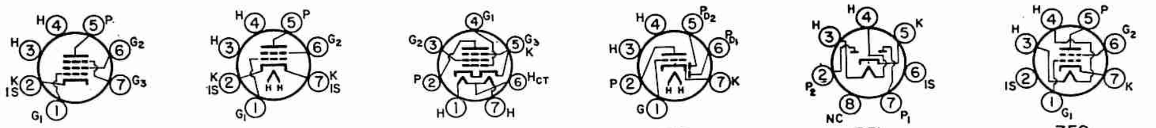
7DB 7DC 7DE 7DF 7DH 7DK

TUBE BASE DIAGRAMS

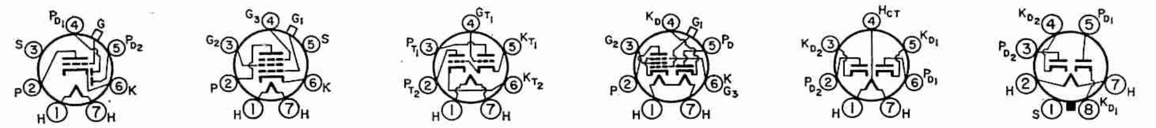
Bottom views are shown. Terminal designations on sockets are given on page V5.



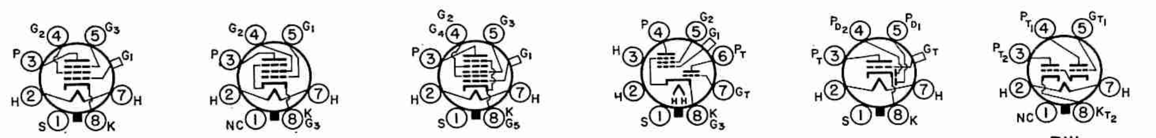
7DT 7DW 7E 7EA 7EG 7EK



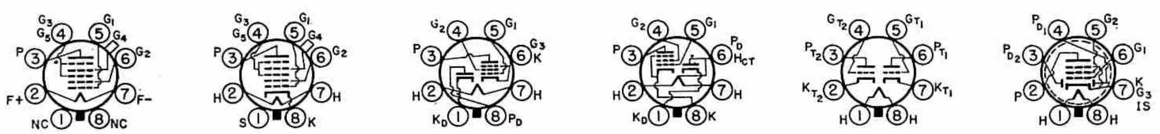
7EN 7EW 7F 7FB 7FL 7FQ



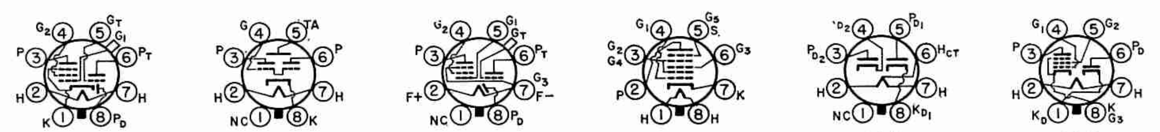
7G 7H 7J 7K 7L 7Q



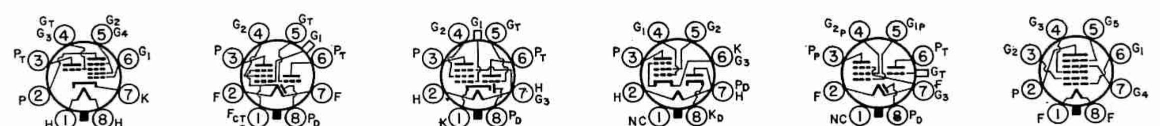
7R 7S 7T 7U 7V 7W



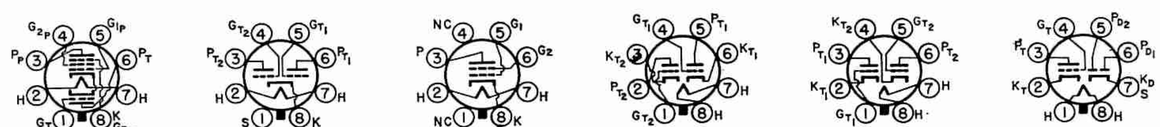
7Z 8A 8AA 8AB 8AC 8AE



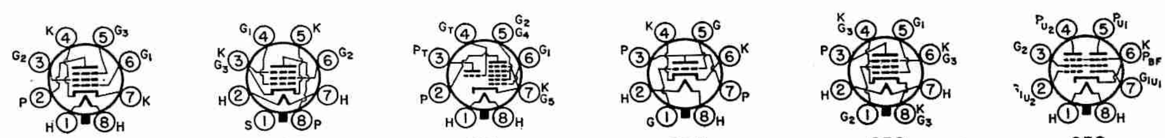
8AF 8AG 8AJ 8AL 8AN 8AO



8AR 8AS 8AU 8AV 8AW 8AX



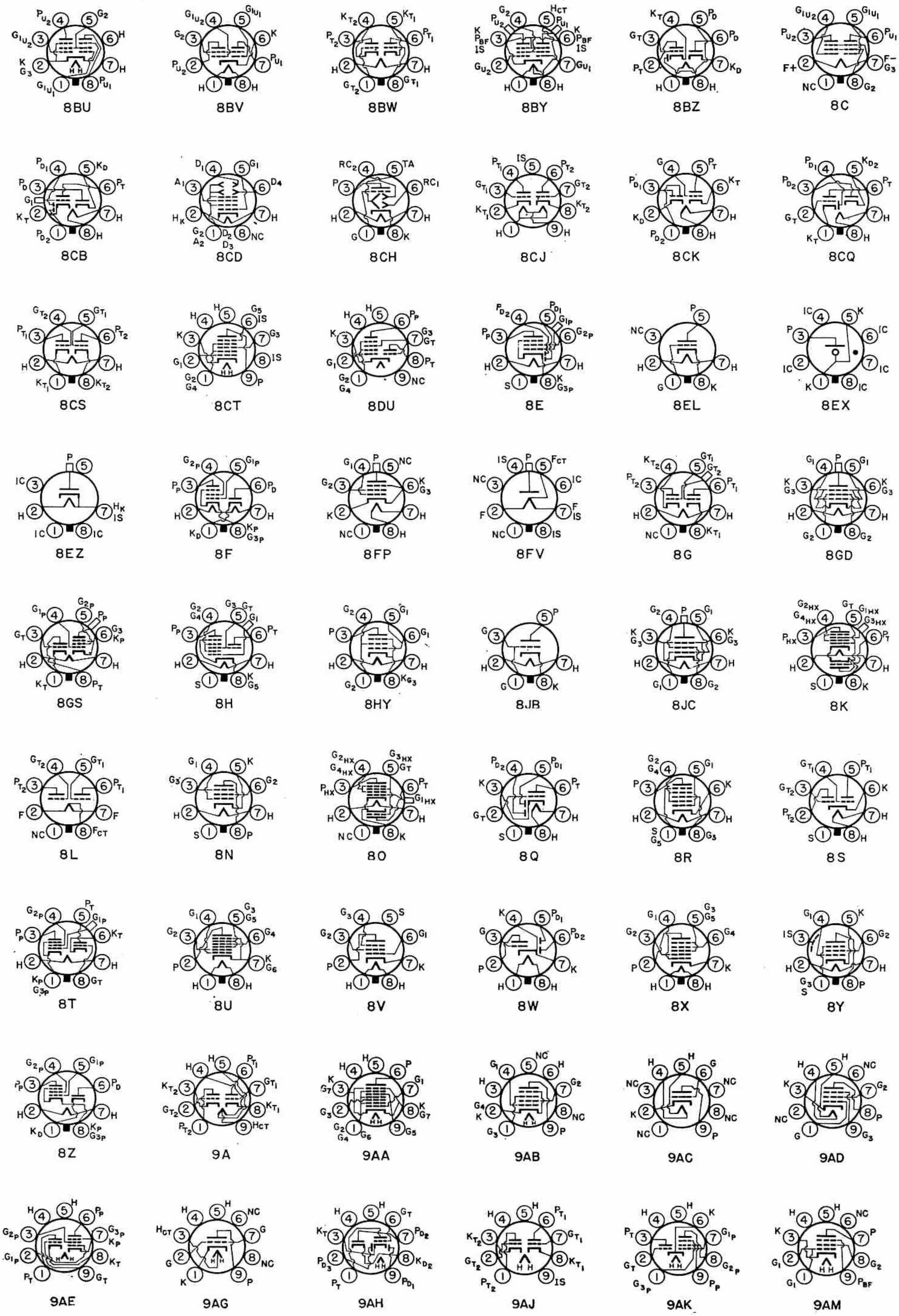
8AY 8B 8BA 8BD 8BE 8BF



8BJ 8BK 8BL 8BN 8BO 8BS

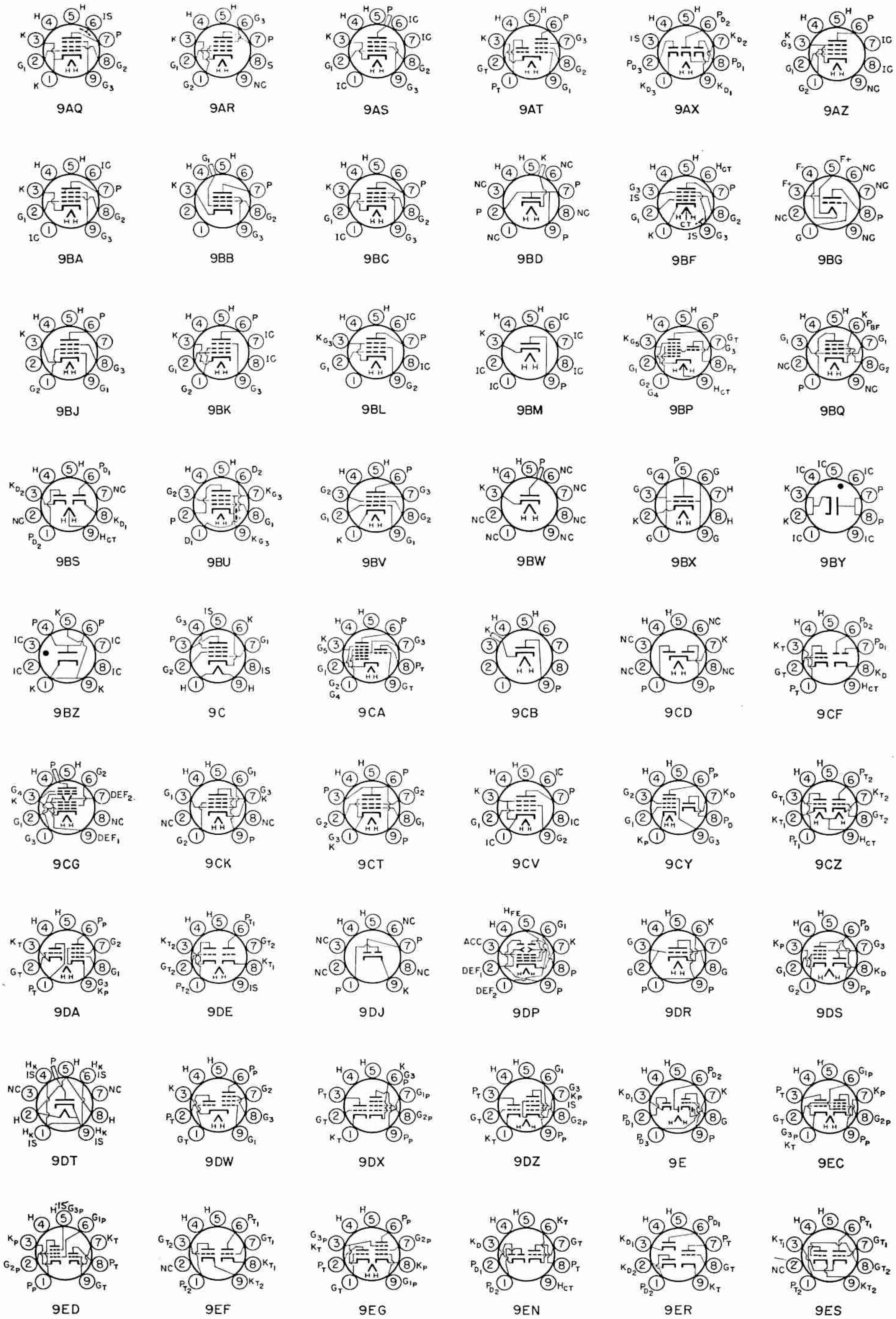
TUBE BASE DIAGRAMS

Bottom views are shown. Terminal designations on sockets are given on page V5.



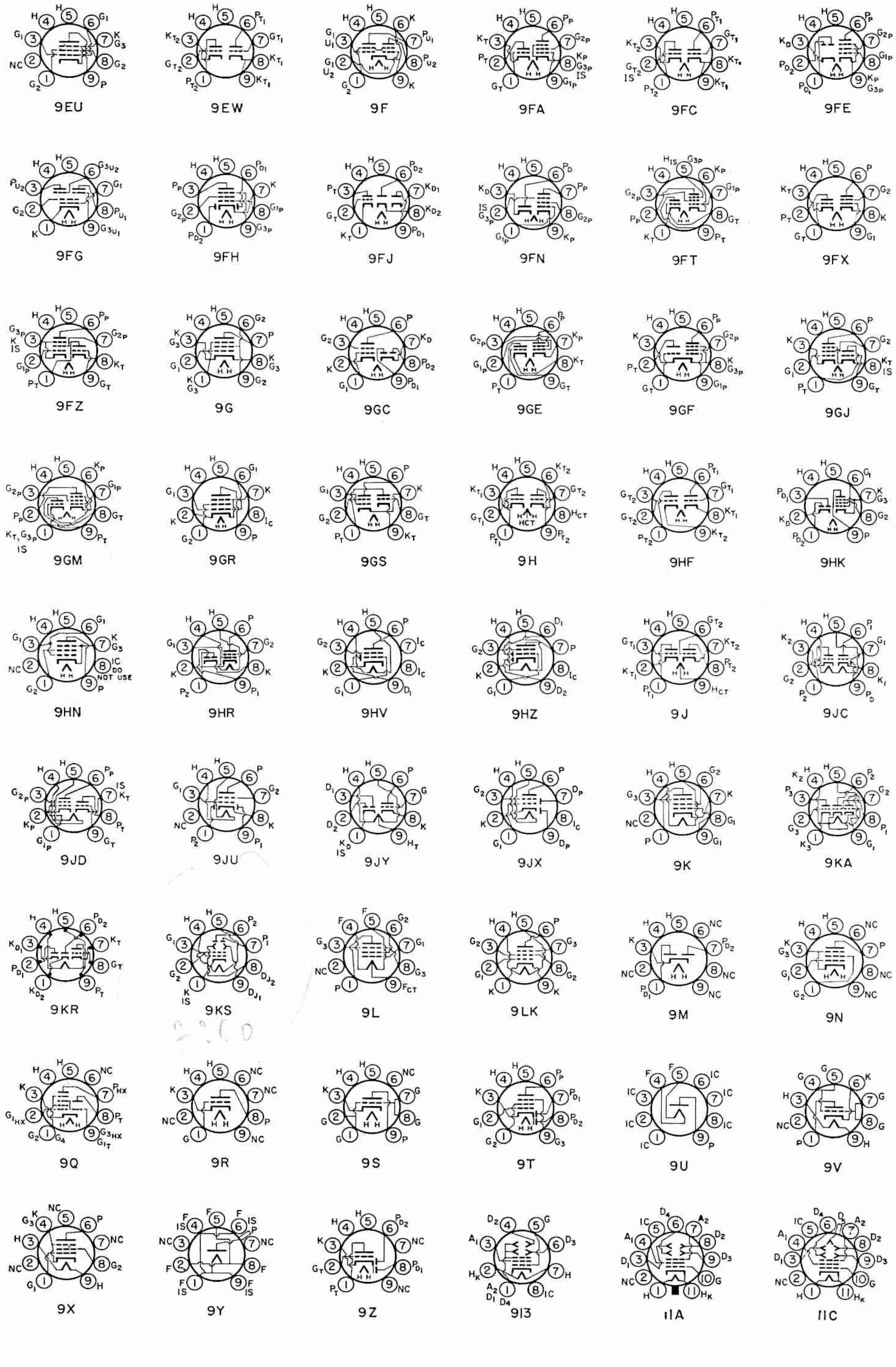
TUBE BASE DIAGRAMS

Bottom views are shown. Terminal designations on sockets are given on page V5.



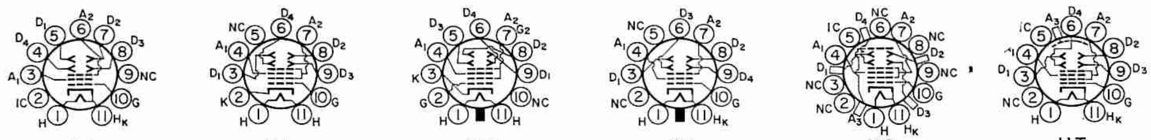
TUBE BASE DIAGRAMS

Bottom views are shown. Terminal designations on sockets are given on page V5.

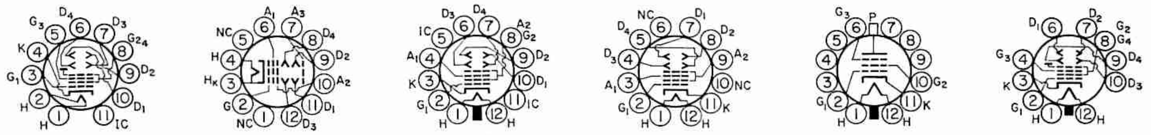


TUBE BASE DIAGRAMS

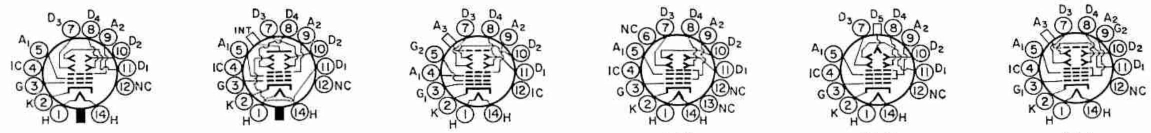
Bottom views are shown. Terminal designations on sockets are given on page V5.



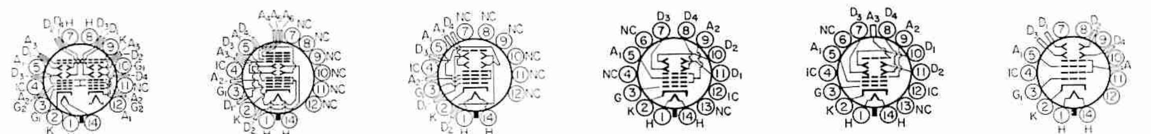
11J 11L 11M 11N 11S 11T



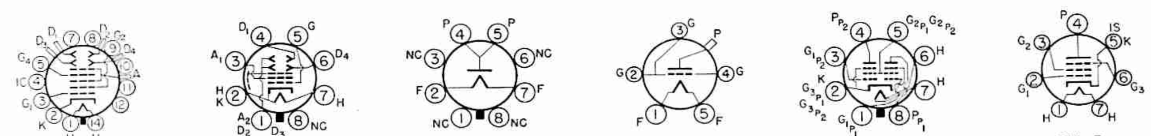
11V 12A 12E 12F 12J 12T



14A 14B 14E 14G 14H 14J



14K 14P 14Q 14R 14S 14U



14V FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5

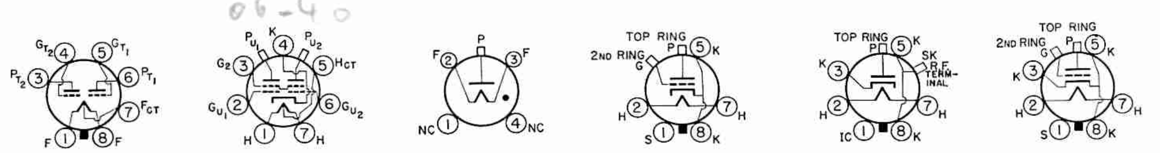


FIG. 6 FIG. 7 FIG. 8 FIG. 9 FIG. 10 FIG. 11

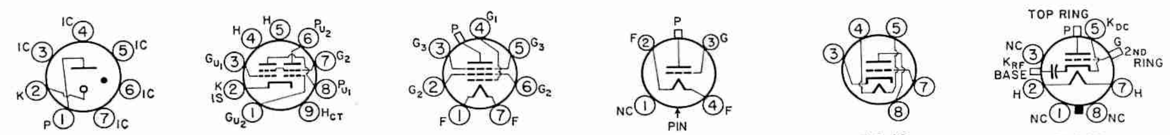


FIG. 12 FIG. 13 FIG. 14 FIG. 15 FIG. 16 FIG. 17

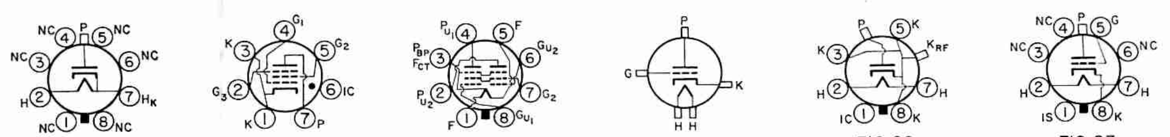


FIG. 18 FIG. 19 FIG. 20 FIG. 21 FIG. 22 FIG. 23

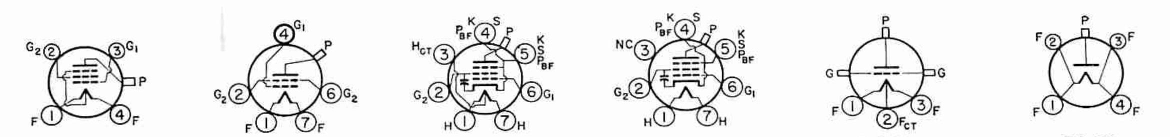


FIG. 24 FIG. 25 FIG. 26 FIG. 27 FIG. 28 FIG. 29

TUBE BASE DIAGRAMS

Bottom views are shown. Terminal designations on sockets are given on page V5.

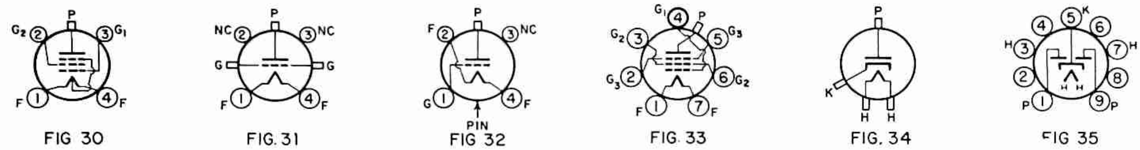


FIG 30 FIG. 31 FIG 32 FIG. 33 FIG. 34 FIG 35

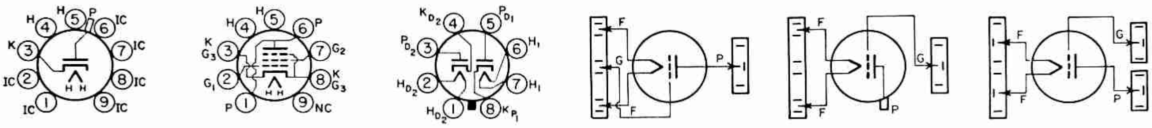


FIG. 36 FIG. 37 FIG. 38 FIG. 39 FIG. 40 FIG. 41

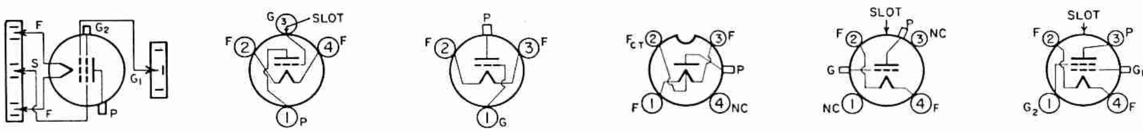


FIG. 42 FIG 43 FIG 44 FIG 45 FIG 46 FIG. 47

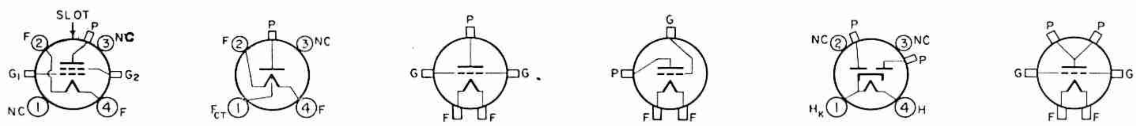


FIG 48 FIG 49 FIG. 50 FIG. 51 FIG 52 FIG 53

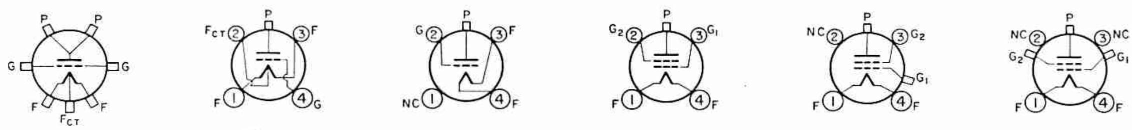


FIG 54 FIG. 55 FIG 56 FIG. 57 FIG. 58 FIG 59

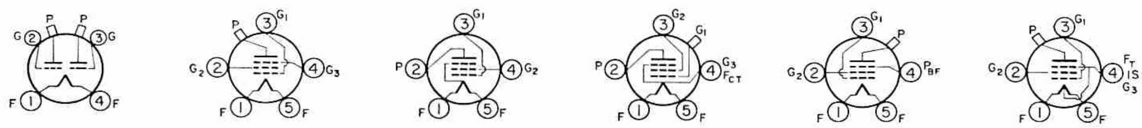


FIG. 60 FIG. 61 FIG 62 FIG. 63 FIG. 64 FIG 65

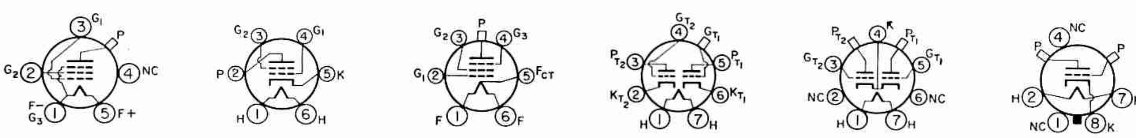


FIG. 66 FIG. 67 FIG. 68 FIG. 69 FIG 70 FIG. 71

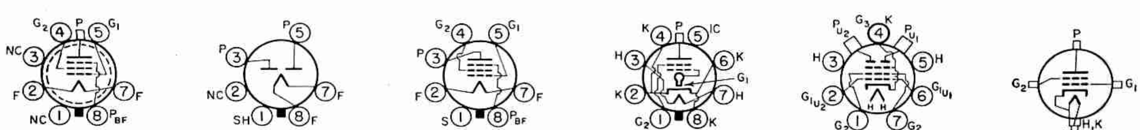


FIG 72 FIG. 73 FIG. 74 FIG. 75 FIG. 76 FIG. 77

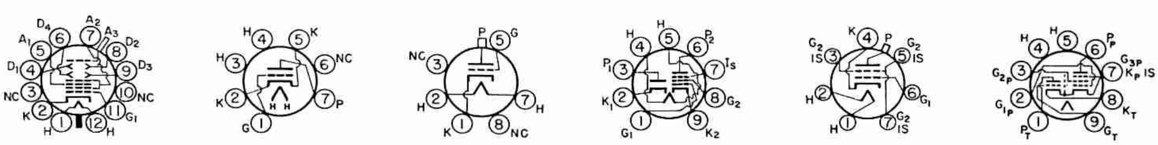


FIG. 78 FIG 79 FIG. 80 FIG 81 FIG. 82 FIG 83

TABLE I—MINIATURE RECEIVING TUBES

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances μμf. C_{in}	C_{out}	C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[11]	Amp. Factor[4]	Load Res. Ohms	Watts Output
.3	H.f. Diode	5AP	1.4	0.15	—	—	—	Max. a.c. voltage per plate —117. Max. output current —0.5 ma.									
.F4	Sharp Cut-off Pent.	6AR	1.4	0.025	3.8	7.6	0.009	90	0	90	0.55	1.8	1.8 meg.	1050	—	—	—
N5	Diode—Remote Cut-off Pent.	6BW	1.4	0.05	—	—	—	67.5	0	67.5	0.55	2.1	600K	630	—	—	—
4	Sharp Cut-off Pent.	6AR	1.4	0.05	3.6	7.5	0.008	90	0	90	2.0	4.5	350K	1025	—	—	—
5	Pentagrid Conv.	7DC	1.4	0.05	7.5	12	0.3	90	0	45	0.6	0.5	650K	300	—	—	—
5	Pentagrid Conv.	7AT	1.4	0.05	7.0	12	0.3	90	0	67.5	3.5	1.5	400K	280	Grid No. 1 100K		
4	Pentagrid Pwr. Amp.	7AV	1.4	0.1	—	—	—	90	−7.0	67.5	1.4	7.4	100K	1575	—	8K	0.270
5	Diode—Pentode A1 Amp.	6AU	1.4	0.05	—	—	—	67.5	0	67.5	0.4	1.6	600K	625	—	—	—
	R.f. Amp.							90	0	90	Screen Resistor 3 meg., grid 10 meg.					1 meg.	0.050
4	Variable-μ Pent.	6AR	1.4	0.05	3.6	7.5	0.01	90	0	67.5	1.4	3.5	500K	900	—	—	—
4	Sharp Cut-off Pent.	6AR	1.4	0.05	3.6	7.5	0.01	90	0	90	0.5	1.6	1 meg.	900	—	—	—
5	Diode Pentode	6BW	1.4	0.05	—	—	—	67.5	0	67.5	0.4	1.6	600K	625	—	—	—
30	Beam Pwr. Pent. A1 Amp.	7CQ	6.0	0.65	9.5	6.6	0.2	250	450*	250	3.3/7.4	44[2]	63K	3700	40[5]	4.5K	4.5
	A1 Amp.[3]							250	225*	250	6.6/14.8	88[2]	—	—	80[5]	9K[6]	9
	AB1 Amp.[3]							250	−25	250	3/13.5	82[2]	—	—	48[5]	8K[6]	12.5
	AB2 Amp.[3]							250	−30	250	4/20	120[2]	—	—	40[5]	3.8[6]	17
A5‡	Sharp Cut-off Pent.	7EW	2.4	0.60	3.8	2.3	0.06	250	−1	150	—	10	150K	8000	—	—	—
N5‡	Dual Diode	7FL	2.1	0.45	—	—	—	Max. a.c. voltage per plate—200 Max. output current—5.0 ma.									
4	Pwr. Amp. Pent.	7BB	1.4	0.2	4.8	4.2	0.34	135	−7.5	90	2.6	14.9[2]	90K	1900	—	8K	0.6
			2.8	0.1				150	−8.4	90	2.2	14.1[2]	100K				0.7
5	H.f. Dual Triode[10]	7BC	1.4	0.22	0.9	1.0	3.2	90	−2.5	—	—	3.7	8.3K	1800	15	—	—
			2.8	0.11													
K6‡	Sharp Cut-off Pent.	7CM	3.15	0.6	6.3	1.9	0.02	300	−6.5	150	3.8	12	—	9800	—	—	—
4	Pwr. Amp. Pent.	7BA	1.4	0.1	5.5	3.8	0.2	90	−4.5	90	2.1	9.5	100K	2150	—	10K	0.27
			2.8	0.05							1.7	7.7	120K	2000		10K	0.24
4	Pwr. Amp. Pent.	7BA	1.4	0.1	—	—	—	90	−7	67.5	1.4	7.4	100K	1575	—	8K	0.27
			2.8	0.05							1.1	6.1		1425			0.235
N6‡	Sharp Cut-off Pent.	7CM	4.2	0.6	10	2.4	0.04	300	−3.5	180	3.2	11	—	1400	—	—	—
B4	U.h.f. Triode	5CE	6.3	0.15	2.2	0.5	1.5	250	200*	—	—	10	10.9K	5500	60	—	—
D8	Dual Diode—Pent.	9T	6.3	0.3	4.0	4.6	0.002	250	−2	85	2.3	6.7	1 meg	1100	—	—	—
F4A	U.h.f.—Triode A1 Amp.	7DK	6.3	0.225	2.2	0.45	1.9	80	150*	—	—	16	2.27K	6600	15	—	—
	Osc. 950 Mc.							100	10KΩ	—	0.4[9]	22	—	—	—	—	—
G5	Sharp Cut-off Pent.	7BD	6.3	0.3	6.5	1.8	0.03	250	180*	150	2.0	6.5	800K	5000	—	—	—
								100	180*	100	1.4	4.5	600K	4550	—	—	—
H6	Sharp Cut-off Pent. Pent. Amp.	7BK	6.3	0.45	10	2.0	0.03	300	160*	150	2.5	10	500K	9600	—	—	—
	Triode Amp.							150	160*	—	—	12.5	3.6K	11K	40	—	—
J4	U.h.f. Triode	9BX	6.3	0.225	4.4	0.18	2.4	125	68*	—	—	16	4.2K	10K	42	—	—
K5	Sharp Cut-off Pent.	7BD	6.3	0.175	4.0	2.8	0.02	180	200*	120	2.4	7.7	690K	5100	—	—	—
								150	330*	140	2.2	7	420K	4300	—	—	—
								120	200*	120	2.5	7.5	340K	5000	—	—	—
K6	Pwr. Amp. Pent.	7BK	6.3	0.15	3.6	4.2	0.12	180	−9	180	2.5	15	200K	2300	—	10K	1.1
L5	Dual Diode[10]	6BT	6.3	0.3	—	—	—	Max. r.m.s. voltage —117. Max. d.c. output current —9 ma.[1]									
M4	U.h.f. Triode	9BX	6.3	0.225	4.4	0.16	2.4	150	100*	—	—	7.5	10K	9000	90	—	—
M8A‡	Diode—Sharp Cut-off Pent.	9CY	6.3	0.45	6.0	2.6	0.015	200	120*	150	2.7	11.5	600K	7000	—	—	—
N4	U.h.f. Triode	7DK	6.3	0.225	2.8	0.28	1.7	200	100*	—	—	13	—	10K	70	—	—
N5	Beam Pwr. Pent.	7BD	6.3	0.45	9.0	4.8	0.075	120	120*	120	12	35	12.5K	8000	—	2.5K	1.3
N8A‡	Medium-μ Triode	9DA	6.3	0.45	2.0	2.7	1.5	200	−6	—	—	13	5.75K	3300	—	—	—
	Sharp Cut-off Pent.				7.0	2.3	0.04	200	180*	150	2.8	9.5	30K	6200	—	—	—
Q5A‡	Beam Pwr. Pent.	7BZ	6.3	0.45	8.3	8.2	0.35	180	−8.5	180	3/4	30[2]	58K	3700	29[5]	5.5K	2.0
								250	−12.5	250	4.5/7	47[2]	52K	4100	45[5]	5K	4.5
Q6	Dual Diode—High-μ Triode	7BT	6.3	0.15	1.7	1.5	1.8	100	−1	—	—	0.8	61K	1150	70	—	—
								250	−3	—	—	1	58K	1200	70	—	—
R5	Pwr. Amp. Pent.	6CC	6.3	0.4	—	—	—	250	−16.5	250	5.7/10	35[2]	65K	2400	34[5]	7K	3.2
								250	−18	250	5.5/10	33[2]	68K	2300	32[5]	7.6K	3.4
R8	Sheet Beam	9DP	6.3	0.3	—	—	—	TV Color Ckts.—Synchronous Detector—Burst Gate									
S5	Beam Pwr. Amp.	7CV	6.3	0.8	12	6.2	0.6	150	−8.5	110	2/6.5	36[2]	—	5600	35[5]	4.5K	2.2
S6	Sharp Cut-off Pent.	7CM	6.3	0.175	4	3	0.2	120	−2	120	3.5	5.2	110K	3200	—	—	—
S8	Diode—Sharp Cut-off Pent.	9DS	6.3	0.45	7	2.2	0.04	200	180*	150	3	9.5	300K	6200	—	—	—
T6	Duplex Diode—High-μ Triode	7BT	6.3	0.3	2.3	1.1	2.1	250	−3	—	—	1	58K	1200	70	—	—
T8A‡	Medium-μ Triode	9DW	6.3	0.45	2	0.5	1.5	100	100*	—	—	8.5	6.9K	5800	40	—	—
	Sharp Cut-off Pent.				4.5	0.9	0.025	250	200*	150	1.6	7.7	750K	4600	—	—	—
U6A‡	Sharp Cut-off Pent.	7BK	6.3	0.3	5.5	5	0.0035	250	68*	150	4.3	10.6	1 meg.	5200	—	—	—
U8A‡	Medium-μ Triode	9DX	6.3	0.6	2.6	0.34	2.2	150	150*	—	—	9	8.2K	4900	40	—	—
	Sharp Cut-off Pent.				7.5	3.4	0.06	200	82*	125	3.4	15	150K	7000	—	—	—
V6	Dual Diode—High-μ Triode	7BT	6.3	0.3	2.2	0.8	2.0	250	−2	—	—	1.2	62.5K	1600	100	—	—
W8A‡	High-μ Triode	9DX	6.3	0.6	3.2	0.32	2.2	200	−2	—	—	4	17.5K	4000	70	—	—
	Sharp Cut-off Pent.				11	2.8	0.036	200	180*	150	3.5	13	400K	9000	—	—	—
X8	Medium-μ Triode	9AE	6.3	0.45	2.5	1	1.8	150	56*	—	—	18	5K	8500	40	—	—
	Sharp Cut-off Pent.				5	3.5	0.006	250	120*	110	3.5	10	400K	4800	—	—	—
Z8	Medium-μ Triode	9ED	6.3	0.45	2	1.7	1.7	200	−6	—	—	13	5.75K	3300	19	—	—
	Semiremote Cut-off Pent.				6.5	2.2	0.02	200	180*	150	3	9.5	300K	6000	—	—	—
A6	Remote Cut-off Pent.	7BK	6.3	0.3	5.5	5	0.0035	250	68*	100	4.2	11	1 meg.	4400	—	—	—
A7	Pentagrid Conv.	8CT	6.3	0.3	Osc. 20KΩ			250	−1	100	10	3.8	1 meg.	950	—	—	—
A8A‡	Medium-μ Triode	9DX	6.3	0.6	2.5	0.7	2.2	200	−8	—	—	8	6.7K	2700	18	—	—
	Sharp Cut-off Pent.				11	2.8	0.036	200	180*	150	3.5	13	400K	9000	—	—	—
C4	U.h.f. Medium-μ Triode	9DR	6.3	0.225	2.9	0.26	1.6	150	100*	—	—	14.5	4.8K	10K	48	—	—
C5	Sharp Cut-off Pent.	7BD	6.3	0.3	6.5	1.8	0.03	250	180*	150	2.1	7.5	800K	5700	—	—	—
C7	Triple Diode	9AX	6.3	0.45				Max. diode current per plate = 12 Ma. Max. htr.-cath. volts = 200									
C8	Medium-μ Dual Triode[10]	9AJ	6.3	0.4	2.5	1.3	1.4	150	220*	—	—	10	—	6200	35	—	—
D6	Remote Cut-off Pent.	7BK	6.3	0.3	4.3	5.0	0.005	100	−1	100	5	13	150K	2550	—	—	—
								250	−3	100	3	9	800K	2000	—	—	—

TABLE I—MINIATURE RECEIVING TUBES—*Continued*

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances μμf. C_{in}	C_{out}	C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[11]	Amp. Factor[4]	Load Res. Ohms	Watts Output
6BE6	Pentagrid Conv.	7CH	6.3	0.3	Osc. 20KΩ			250	−1.5	100	6.8	2.9	1 meg.	475	—	—	—
6BE8A‡	Medium-μ Triode	9EG	6.3	0.45	2.8	1.5	1.8	150	56*	—	—	18	5K	8500	40	—	—
	Sharp Cut-off Pent.				4.4	2.6	0.04	250	68*	110	3.5	10	400K	5200	—	—	—
6BF5	Beam Pwr. Amp.	7BZ	6.3	1.2	14	6	0.65	110	−7.5	110	4/10.5	39[2]	12K	7500	36[5]	2.5K	1.9
6BF6	Dual Diode—Medium-μ Triode	7BT	6.3	0.3	1.8	0.8	2	250	−9	—	—	9.5	8.5K	1900	16	10K	0.3
6BH5	Remote Cut-off Pent.	9AZ	6.3	0.2	4.9	5.5	0.002	250	−2.5	100	1.7	6.0	1.1 meg.	2200	—	—	—
6BH6	Sharp Cut-off Pent.	7CM	6.3	0.15	5.4	4.4	0.0035	250	−1	150	2.9	7.4	1.4 meg.	4600	—	—	—
6BH8‡	Medium-μ Triode	9DX	6.3	0.6	2.6	0.38	2.4	150	−5	—	—	9.5	5.15K	3300	17	—	—
	Sharp Cut-off Pent.				7	2.4	0.046	200	82*	125	3.4	15	150K	7000	—	—	—
6BJ6A	Remote Cut-off Pent.	7CM	6.3	0.15	4.5	5.5	0.0035	250	−1	100	3.3	9.2	1.3 meg.	3800	—	—	—
6BJ7	Triple Diode	9AX	6.3	0.45	Max. peak inverse plate voltage = 330 V. Max. d.c. plate current each diode = 1.0 Ma.												
6BJ8‡	Dual Diode—Medium-μ Triode	9ER	6.3	0.6	2.8	0.38	2.6	250	−9	—	—	8	7.15K	2800	20	—	—
6BK5	Beam Pwr. Pent.	9BQ	6.3	1.2	13	5	0.6	250	−5	250	3.5/10	37[2]	100K	8500	35[5]	6.5K	3.5
6BK6	Dual Diode—High-μ Triode	7BT	6.3	0.3	—	—	—	250	−2	—	—	1.2	62.5K	1600	100	—	—
6BK7B	Medium-μ Dual Triode[10]	9AJ	6.3	0.4	3	1	1.8	150	56*	—	—	18	4.6K	9300	43	—	—
6BL8	Triode	Fig. 83	6.3	.43	2.5	1.8	1.5	250	−1.3	—	—	14	—	5000	20	—	—
	Pentode				5.2	3.4	.025	250	−1.3	175	2.8	10	400K	6200	47	—	—
6BN4	Medium-μ Triode	7EG	6.3	0.2	3.2	1.4	1.2	150	220*	—	—	9	6.3K	6800	43	—	—
6BN6	Gated-Beam Pent.	7DF	6.3	0.3	4.2	3.3	0.004	80	−1.3	60	5	0.23	—	—	—	68K	—
6BN8‡	Dual Diode—High-μ Triode	9ER	6.3	0.6	3.6	0.25	2.5	250	−3	—	—	1.6	28K	2500	70	—	—
6BQ5	Pwr. Amp. Pent.	9CV	6.3	0.76	10.8	6.5	0.5	300	−7.3	200	10.8	49.5[2]	38K	—	—	5.2K	17
6BQ7A	Medium-μ Dual Triode[10]	9AJ	6.3	0.4	2.85	1.35	1.15	150	220*	—	—	9	6.1K	6400	39	—	—
6BR8A‡	Medium-μ Triode	9FA	6.3	0.45	2.5	0.4	1.8	150	56*	—	—	18	5K	8500	40	—	—
	Sharp Cut-off Pent.				5	2.6	0.015	250	68*	110	3.5	10	400K	5200	—	—	—
6BS8	Low-Noise Dual Triode[10]	9AJ	6.3	0.4	2.6	1.35	1.15	150	220*	—	—	10	5K	7200	36	—	—
6BT6	Dual Diode—High-μ Triode	7BT	6.3	0.3	—	—	—	250	−3	—	—	1	58K	1200	70	—	—
6BT8	Dual Diode—Pent.	9FE	6.3	0.45	7	2.3	0.04	200	180*	150	2.8	9.5	300K	6200	—	—	—
6BU6	Dual Diode—Low-μ Triode	7BT	6.3	0.3	—	—	—	250	−9	—	—	9.5	8.5K	1900	16	10K	0.3
6BU8	Dual Pent.[10]	9FG	6.3	0.3	6	3[1]	—	100[1]	—	67.5	3.3	2.2	—	—	—	—	—
6BV8‡	Dual Diode—Medium-μ Triode	9FJ	6.3	0.6	3.6	0.4	2	200	330*	—	—	11	5.9K	5600	33	—	—
6BW8	Dual Diode—Pent.	9HK	6.3	0.45	4.8	2.6	0.02	250	68*	110	3.5	10	250K	5200	—	—	—
6BX8	Dual Triode [10]	9AJ	6.3	0.4	—	—	1.4	65	−1	—	—	9	—	6700	25	—	—
6BY6	Pentagrid Amp.	7CH	6.3	0.3	5.4	7.6	0.08	250	−2.5	100	9	6.5	E_{c3} = −2.5 V.		1900	—	—
6BY8‡	Diode—Sharp Cut-off Pent.	9FN	6.3	0.6	5.5	5	0.0035	250	68*	150	4.3	10.6	1 meg.	5200	—	—	—
6BZ6	Semiremote Cut-off Pent.	7CM	6.3	0.3	7.5	1.8	0.02	200	180*	150	2.6	11	600K	6100	—	—	—
6BZ7	Medium-μ Dual Triode[10]	9AJ	6.3	0.4	2.5	1.35	1.15	150	220*	—	—	10	5.6K	6800	38	—	—
6BZ8	Dual Triode [10]	9AJ	6.3	0.4	—	—	—	125	100*	—	—	10[1]	5.6K	8000	45	—	—
6C4	Medium-μ Triode	6BG	6.3	0.15	1.8	1.3	1.6	250	−8.5	—	—	10.5	7.7K	2200	17	—	—
6CA5	Beam Pent.	7CV	6.3	1.2	15	9	0.5	125	−4.5	125	4/11	36[2]	15K	9200	37[5]	4.5K	1.5
6CB6A‡	Sharp Cut-off Pent.	7CM	6.3	0.3	6.5	1.9	0.02	200	180*	150	2.8	9.5	600K	6200	—	—	—
6CE5‡	R.f. Pent.	7BD	6.3	0.3	6.5	1.9	0.03	200	180*	150	2.8	9.5	600K	6200	—	—	—
6CF6	Sharp Cut-off Pent.	7CM	6.3	0.3	6.3	1.9	0.02	200	180*	150	2.8	9.5	600K	6200	—	—	—
6CG6	Semiremote Cut-off Pent.	7BK	6.3	0.3	5	5	0.008	250	−8	150	2.3	9	720K	2000	—	—	—
6CG7‡	Medium-μ Dual Triode[10]	9AJ	6.3	0.6	2.3	2.2	4	250	−8	—	—	9	7.7K	2600	20	—	—
6CG8A‡	Medium-μ Triode	9GF	6.3	0.45	2.6	0.05	1.5	100	100*	—	—	8.5	6.9K	5800	40	—	—
	Sharp Cut-off Pent.				4.8	0.9	0.03	250	200*	150	1.6	7.7	750K	4600	—	—	—
6CH8	Medium-μ Triode	9FT	6.3	0.45	1.9	1.6	1.6	200	−6	—	—	13	5.75K	3300	19	—	—
	Sharp Cut-off Pent.				7	2.25	0.025	200	180*	150	2.8	9.5	300K	6200	—	—	—
6CL6	Pwr. Amp. Pent.	9BV	6.3	0.65	11	5.5	0.12	250	−3	150	7/7.2	31[2]	150K	11K	30[5]	7500	2.8
6CL8A‡	Medium-μ Triode	9FX	6.3	.45	2.7	0.4	1.8	300	—	—	—	15	5K	8000	40	—	—
	Sharp Cut-off Tetrode				5	2.4	.02	300	−1	300	4	12	100K	6400	—	—	—
6CM6	Beam Pwr. Amp.	9CK	6.3	0.45	8	8.5	0.7	315	−13	225	2.2/6	35[2]	80K	3750	34[5]	8.5K	5.5
6CM7‡	Medium-μ Dual Triode — Triode No. 1	9ES	6.3	0.6	2	0.5	3.8	200	−7	—	—	5	11K	2000	20	—	—
	Triode No. 2				3.5	0.4	3	250	−8	—	—	10	4.1K	4400	18	—	—
6CM8‡	High-μ Triode	9FZ	6.3	0.45	1.6	0.22	1.9	250	−2	—	—	1.8	50K	2000	100	—	—
	Sharp Cut-off Pent.				6	2.6	0.02	200	180*	150	2.8	9.5	300K	6200	—	—	—
6CN7‡	Dual Diode—High-μ Triode	9EN	6.3	0.3	1.5	0.5	1.8	100	−1	—	—	0.8	54K	1300	70	—	—
			3.15	0.6				250	−3	—	—	1	58K	1200	70	—	—
6CQ8‡	Medium-μ Triode	9GE	6.3	0.45	2.7	0.4	1.8	125	56*	—	—	15	5K	8000	40	—	—
	Sharp Cut-off Tetrode				5	2.5	0.019	125	−1	125	4.2	12	140K	5800	—	—	—
6CR6	Diode—Remote Cut-off Pent.	7EA	6.3	0.3	—	—	—	250	−2	100	3	9.5	200K	1950	—	—	—
6CR8‡	Triode	9GJ	6.3	0.45	2	1.4	1.6	125	−2	—	—	12	5.5K	4000	22	—	—
	Pentode				6	2.8	0.018	125	56*	125	3	13	300K	7700	—	—	—
6CS5	Beam Pwr. Pent.	9CK	6.3	1.2	15	9	0.5	200	180*	125	2.2	47[2]	28K	8000	—	4K	3.8
6CS6	Pentagrid Amp.	7CH	6.3	0.3	5.5	7.5	0.05	100	−1	30	1.1	0.75	1 meg.	950	E_{c3} = 0 V.		—
6CS7‡	Medium-μ Dual Triode — Triode No. 1	9EF	6.3	0.6	1.8	0.5	2.6	250	−8.5	—	—	10.5	7.7K	2200	17	—	—
	Triode No. 2				3.0	0.5	2.6	250	−10.5	—	—	19	3.45K	4500	15.5	—	—
6CU5	Beam Pwr. Pent.	7CV	6.3	1.2	13.2	8.6	0.7	120	−8	110	4/8.5	50[2]	10K	7500	—	2.5K	2.3
6CX8	Medium-μ Triode	9DX	6.3	0.75	2.2	0.38	4.4	150	150*	—	—	9.2	8.7K	4600	40	—	—
	Sharp Cut-off Pent.				9	4.4	0.06	200	68*	125	5.2	24	70K	10K	—	—	—
6CY5	Sharp Cut-off Tetrode	7EW	6.3	0.2	4.5	3	0.03	125	−7	80	1.5	10	100K	8000	—	—	—
6CY7	Dissimilar—Dual Triode	9EF	6.3	0.75	1.5[7]	0.3[7]	1.8[7]	250[7]	−3[7]	—	—	1.2[7]	52K[7]	1300[7]	68[7]	—	—
					5[8]	1[8]	4.4[8]	150[8]	620*[8]	—	—	30[8]	920[8]	5400[8]	5[8]	—	—
6CZ5‡	Beam Pwr. Amp. — A_1 Amp.	9HN	6.3	0.45	8	8.5	0.7	250	−14	250	4.6/8	48[2]	73K	4800	46[5]	5K	5.4
	AB_1 Amp.[3]							350	−23.5	280	3/13	103[2]	—	—	46[5]	7.5K[6]	1.5
6DB5	Beam Pwr. Amp.	9GR	6.3	1.2	15	9	0.5	200	180*	125	2.2/8.5	46/47	28K	8000	—	4K	3.8
6DB6	Sharp Cut-off Pent.	7CM	6.3	0.3	6	5	0.0035	150	−1	150	6.6	5.8	50K	2050	E_{c3} = −3 V.		—
6DC6	Semiremote Cut-off Pent.	7CM	6.3	0.3	6.5	2	0.02	200	180*	150	3	9	500K	5500	—	—	—
6DE6	Sharp Cut-off Pent.	7CM	6.3	0.3	6.3	1.9	0.02	200	180*	150	2.8	9.5	600K	6200	—	—	—
6DE7	Dissimilar—Dual Triode	9HF	6.3	0.9	2.2[7]	0.52[7]	4[7]	250[7]	−11[7]	—	—	5.5[7]	8.75K[7]	2000[7]	17.5[7]	—	—
					5.5[8]	1[8]	8.5[8]	150[8]	−17.5[8]	—	—	35[8]	925[8]	6500[8]	6[8]	—	—
6DK6	Sharp Cut-off Pent.	7CM	6.3	0.3	6.3	1.9	.02	300	−6.5	150	3.8	12	—	9800	—	—	—
6DR7	Dissimilar — Dual Triode	9HF	6.3	0.9	2.2	0.34	4.5	330	−3	—	—	1.4	—	1600	68[7]	—	—
					5.5	1.0	8.5	275	−17.5	—	—	35	—	6500	6[8]	—	—

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances μμf. C_{in}	C_{out}	C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[11]	Amp. Factor[4]	Load Res. Ohms	Watts Output
6DS5	Beam Pwr. Amp.	7BZ	6.3	0.8	9.5	6.3	0.19	250	−8.5	200	3/10	32[2]	28K	5800	32[5]	8K	3.8
								250	270*	200	3/9	25[2]	28K	5800	27[5]	8K	3.6
6DT5	Pwr. Amp. Pent.	9CV	6.3	0.76	10.8	6.5	0.5	300	−7.3	200	10.8	49.5[2]	38K	—	—	5.2K	17
6DT6	Sharp Cut-off Pent.	7EN	6.3	0.3	5.8	—	0.02	150	560*	100	2.1	1.1	150K	615	—	—	—
6DT8	High-μ Dual Triode[10]	9DE	6.3	0.3	2.7	1.6	1.6	250	200*	—	—	10	10.9K	5500	60	—	—
6DW5	Beam Pwr. Amp.	9CK	6.3	1.2	14	9	0.5	200	−22.5	150	2	55	15K	5500	—	—	—
6EA8‡	Triode	9AE	6.3	.45	3	.3	1.7	330	−12	—	—	18	5K	8500	40	—	—
	Sharp Cut-off Pent.				5	2.6	.02	330	−9	330	4	12	80K	6400	—	—	—
6EB8	High-μ Triode	9DX	6.3	.75	2.4	.36	4.4	330	−5	—	—	2	37K	2700	100	—	—
	Sharp Cut-off Pent.				11	4.2	0.1	330	−9	—	7	25	75K	12.5K	—	—	—
6EH5	Power Pentode	7CV	6.3	1.2	17	9	.65	135	0	117	14.5	42	11K	14.6K	—	3K	1.4
6ES8	Dual Triode	9DE	6.3	.365	3.4	1.7	1.9	130	−1.2	—	—	15	—	12.5K	34	—	—
6EV5	Sharp Cut-off Tet.	7EW	6.3	0.2	4.5	2.9	0.035	250	−1	80	0.9	11.5	150K	8800	—	—	—
6EZ8	Triple Triode — Triode No. 1	9KA	6.3	.45	2.6	1.4	1.5	330	−4	—	—	4.2	13.6K	4200	57	—	—
	Triple Triode — Triode No. 2 & 3					1.2											
6FM8	Duplex Diode	9KR	6.3	.45	2.4	—	—	Max. a.c. voltage = 200. Max. d.c. output current = 5 ma.									
					2.2	—	—										
	Triode				1.5	.16	1.8	330	−3	—	—	1	58K	1200	70	—	—
6FV6	Sharp Cut-off Tetrode	7FQ	6.3	.2	4.5	3	.03	125	−1	80	1.5	10	100K	8000	—	—	—
6FV8	Triode	9FA	6.3	.45	2.8	1.5	1.8	330	−1	—	—	14	5K	8K	40	—	—
	Pentode				5	2	.02	330	−1	125	4	12	200K	6.5K	—	—	—
6J4	Grounded-Grid Triode	7BQ	6.3	0.4	7.5	3.9	0.12	150	100*	—	—	15	4.5K	12K	55	—	—
6J6A‡	Medium-μ Dual Triode — A1 Amp.[10]	7BF	6.3	0.45	2.2	0.4	1.6	100	50*	—	—	8.5	7.1K	5300	38	—	—
	Medium-μ Dual Triode — Mixer							150	810*	—	—	4.8	10.2K	1900	Osc. peak voltage = 3 V.		
6R8	Triple Diode-Triode	9E	6.3	0.45	1.5	1.1	2.4	250	−9	—	—	9.5	8.5K	1900	16	10K	0.3
6S4A	Medium-μ Triode	9AC	6.3	0.6	4.2	0.9	2.6	250	−8	—	—	26	3.6K	4500	16	—	—
6T4	U.h.f. Triode	7DK	6.3	0.225	2.6	0.25	1.7	80	150*	—	—	18	1.86K	7000	13	—	—
6T8A‡	Triple Diode-High-μ Triode	9E	6.3	0.45	1.6	1	2.2	100	−1	—	—	0.8	54K	1300	70	—	—
								250	−3	—	—	1	58K	1200	70	—	—
6U8A‡	Medium-μ Triode	9AE	6.3	0.45	2.5	0.4	1.8	150	56*	—	—	18	5K	8500	40	—	—
	Sharp Cut-off Pent.				5	2.6	0.01	250	68*	110	3.5	10	400K	5200	—	—	—
6V8	Triple Diode—Triode	9AH	6.3	0.45	—	—	—	100	−1	—	—	0.8	54K	1300	70	—	—
								250	−3	—	—	1	58K	1200	70	—	—
6X8A‡	Medium-μ Triode	9AK	6.3	0.45	2.0	0.5	1.4	100	100*	—	—	8.5	6.9K	—	40	—	—
	Sharp Cut-off Pent.				4.3	0.7	0.09	250	200*	150	1.6	7.7	750K	—	—	—	—
12A4	Medium-μ Triode	9AG	12.6	0.3	4.9	0.9	5.6	250	−9	—	—	23	2.5K	8000	20	—	—
			6.3	0.6				250	−12.5	—	—	4.4	—	—	—	—	—
12AB5	Beam Pwr. Amp. — A1 Amp.	9EU	12.6	0.2	8	8.5	0.7	250	−12.5	250	4.5/7	47[2]	50K	4100	45[5]	5K	4.5
	Beam Pwr. Amp. — AB1 Amp.[3]							250	−15	250	5/13	79[2]	60K[1]	3750	70[5]	10K[6]	10
12AC6	Remote Cut-off Pent.	7BK	12.6	0.15	4.3	5	0.005	12.6	0	12.6	0.2	0.55	500K	730	—	—	—
12AD6	Pentagrid Conv.	7CH	12.6	0.15	8	8	0.3	12.6	0	12.6	1.5	0.45	1 meg.	260	Grid No. 1 Res. 33K		
12AD7	Dual High-μ Triode[10]	9A	12.6	0.225	1.6[7]	0.5[7]	1.8[7]	250	−2	—	—	1.25	62.5K	1600	100	—	—
			6.3	0.45	1.6[8]	0.45[8]	1.8[8]										
12AE6A	Dual Diode—Medium-μ Triode	7BT	12.6	0.15	1.8	1.1	2	12.6	0	—	—	0.75	15K	1000	15	—	—
12AE7	Low-μ Dissimiliar Double Triode	9A	12.6	.45	4.7	.75	3.9	16	—	—	—	1.9	31.5K	4000	13	—	—
					4.2	.85	3.4	16	—	—	—	7.5	985	6500	6.4	—	—
12AF6	R.f. Pent.	7BK	12.6	0.15	5.5	4.8	0.006	12.6	0	12.6	0.35	0.75	300K	1150	—	—	—
12AJ6	Dual Diode—High-μ Triode	7BT	12.6	0.15	2.2	0.8	2	12.6	0	—	—	0.75	45K	1200	55	—	—
12AL8	Medium-μ Triode	9GS	12.6	0.45	1.5	0.3	12	12.6	−0.9	—	—	0.25	27K	550	15	—	—
	Tetrode				8	1.1	0.7	12.6	−0.8	12.6**	50**	25	1K	8000	—	—	—
12AQ5	Beam Pwr. Amp. — A1 Amp.	7BZ	12.6	0.225	8.3	8.2	0.35	250	−12.5	250	4.5/7	47[2]	52K	4100	45[5]	5K	4.5
	Beam Pwr. Amp. — AB1 Amp.[3]							250	−15	250	5/13	79[2]	60K[1]	3750[1]	70[5]	10K[6]	10
12AT7	High-μ Dual Triode[10]	9A	12.6	0.15	2.2[7]	0.5[7]	1.5[7]	100	270*	—	—	3.7	15K	4000	60	—	—
			6.3	0.3	2.2[8]	0.4[8]	1.5[8]	250	200*	—	—	10	10.9K	5500	60	—	—
12AU7A	Medium-μ Dual Triode[10]	9A	12.6	0.15	1.6[7]	0.5[7]	1.5[7]	100	0	—	—	11.8	6.25K	3100	19.5	—	—
			6.3	0.3	1.6[8]	0.35[8]	1.5[8]	250	−8.5	—	—	10.5	7.7K	2200	17	—	—
12AV7	Medium-μ Dual Triode[10]	9A	12.6	0.225	3.1[7]	0.5[7]	1.9[7]	100	120*	—	—	9	6.1K	6100	37	—	—
			6.3	0.45	3.1[8]	0.4[8]	1.9[8]	150	56*	—	—	18	4.8K	8500	41	—	—
12AW6	Sharp Cut-off Pent.	7CM	12.6	0.15	6.5	1.5	0.025	250	200*	150	2	7	800K	5000	42	—	—
12AX7	High-μ Dual Triode — A1 Amp.[10]	9A	12.6	0.15	1.6[7]	0.46[7]	1.7[7]	250	−2	—	—	1.2	62.5K	1600	100	—	—
	High-μ Dual Triode — Class B		6.3	0.3	1.6[8]	0.34[8]	1.7[8]	300	0	—	—	40[2]	—	—	14[5]	16K[6]	7.5
12AY7	Medium-μ Dual Triode[10] — A1 Amp.	9A	12.6	0.15	1.3	0.6	1.3	250	−4	—	—	3	—	1750	40	—	—
	Medium-μ Dual Triode[10] — Low-Level Amp.		6.3	0.3				150	2700*	Plate resistor = 20K. Grid resistor = 0.1 meg. V. G. = 12.5							
12AZ7A‡	High-μ Dual Triode[10]	9A	12.6	0.225	3.1[7]	0.5[7]	1.9[7]	100	270*	—	—	3.7	15K	4000	60	—	—
			6.3	0.45	3.1[8]	0.4[8]	1.9[8]	250	200*	—	—	10	10.9K	5500	60	—	—
12B4A‡	Low-μ Triode	9AG	12.6	0.3	5	1.5	4.8	150	−17.5	—	—	34	1.03K	6300	6.5	—	—
			6.3	0.6													
12BH7A‡	Medium-μ Dual Triode[10]	9A	12.6	0.3	3.2[7]	0.5[7]	2.6[7]	250	−10.5	—	—	11.5	5.3K	3100	16.5	—	—
			6.3	0.6	3.2[8]	0.4[8]	2.6[8]										
12BL6	Sharp Cut-off Pent.	7BK	12.6	0.15	5.5	4.8	0.006	12.6	−0.65	12.6	0.0005	1.35	500K	1350	—	—	—
12BR7A‡	Dual Diode—Medium-μ Triode	9CF	12.6	0.225	2.8	1	1.9	100	270*	—	—	3.7	15K	4000	60	—	—
			6.3	0.45				250	200*	—	—	10	10.9K	5500	60	—	—
12BV7	Sharp Cut-off Pent.	9BF	12.6	0.3	11	3	0.055	250	68*	150	6	25	90K	12K	1100	—	—
			6.3	0.6													
12BY7A‡	Sharp Cut-off Pent.	9BF	12.6	0.3	11.1	3	0.055	250	68*	150	6	25	90K	12K	1200	—	—
			6.3	0.6													
12BZ7	High-μ Dual Triode[10]	9A	12.6	0.3	6.5[7]	0.7[7]	2.5[7]	250	−2	—	—	2.5	31.8K	3200	100	—	—
			6.3	0.6	6.5[8]	0.55[8]	2.5[8]										
12CN5	Pentode	7CV	12.6	0.45	—	—	0.25	12.6	0	12.6	0.35	4.5	40K	3800	—	—	—
12CX6	Sharp Cut-off Pent.	7BK	12.6	0.15	7.6	6.2	0.05	12.6	0	12.6	1.4	3	40K	3100	—	—	—
12DE8	Diode—Remote Cut-off Pent.	Fig. 81	12.6	0.2	5.5	5.7	0.006	12.6	−0.8	12.6	0.5	1.3	300K	1500	—	—	—
12DK7	Dual Diode—Tetrode	9HZ	12.6	0.5	—	—	—	12.6	0	12.6	1	6	4K	5000	—	3.5K	0.01
12DL8	Dual Diode—Tetrode	9HR	12.6	0.55	12	1.3	—	12.6	−0.5	12.6**	75**	40	480	15K	7.2	—	—

TABLE I—MINIATURE RECEIVING TUBES—*Continued*

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances μμf. C_{in}	Capacitances μμf. C_{out}	Capacitances μμf. C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[11]	Amp. Factor[4]	Load Res. Ohms	Watts Output
12DQ7	Beam Pwr. Pent.	9BF	12.6	.3	10	3.8	0.1	330	—	180	5.6	26	53K	10.5K	—	—	—
			6.3	.6													
12DS7A	Dual Diode	9JU	12.6	.4	Max. a.c. voltage = 16. Max. d.c. output current = 5 ma.												
	Pwr. Tetrode				—	—	—	16	—	16	75	40	480	15K	7.2	800	.04
12DT7	High-μ Dual Triode	9A	12.6	.15	1.6	.46	1.7	300	−2	—	—	1.2	62.5K	1600	100	—	—
			6.3	.3	1.6	.34	1.7										
12DU7	Dual Diode	9JX	12.6	.275	Max. average diode current = 1.0 ma.												
	Tetrode				11	3.6	.6	16	—	16	1.5	12	6K	6200	—	2.7K	.025
12DV7	Dual Diode	9JY	12.6	.15	Max. average diode current = 1.0 ma.												
	Triode				1.3	.38	1.6	16	—	—	—	0.4	19K	750	14	—	—
12DV8	Dual Diode—Tetrode	9HR	12.6	0.375	9.0	1.0	12	12.6	18*	—	—	6.8[2]	—	—	7.6	1250	.005
12DW8	Diode	9JC	12.6	.45	1.6[7]	.7	1.8	16	0	—	—	1.9[7]	—	2700	9.5	—	—
	Dissimiliar Dual Triode				4.4[8]	.7	3.2					7.5[8]	—	6500	6.4	—	—
12DY8	Sharp Cut-off Triode	9JD	12.6	.35	2	2	1.5	16	0	—	—	1.2	10K	2000	20	—	—
	Tetrode				11	3	.74	16	—	12.6	2	14	5K	6000	—	—	—
12DZ6	Pwr. Amp. Pent.	7BK	12.6	0.175	12.5	8.5	.25	12.6	—	12.6	2.2	4.5[2]	25K	3800	—	—	—
12EA6	R.F. Pent.	7BK	12.6	0.175	11	4	.04	12.6	−3.4	12.6	1.4	3.2[2]	32K	3800	—	—	—
12EC8	Medium-μ Triode	9FA	12.6	0.225	2.6	0.4	1.7	16	−2.2	—	—	2.4	6K	4700	25	—	—
	Pent.				4.6	2.6	.02	16	−1.6	12.6	—	.66	750K	2000	—	—	—
12ED5‡	Pwr. Amp. Pent.	7CV	12.6	.45	14	8.5	.26	150	−4.5	150	11	36[2]	14K	8500	—	—	1.5
12EG6	Dual Control Heptode	7CH	12.6	.15	—	—	—	30	—	12.6	2.4	.4	150K	800	—	—	—
12EK6	R.F. Pent.	7BK	12.6	.2	10	5.5	.032	12.6	−4.0	12.6	2	4.4	40K	4200	—	—	—
12EL6	Dual Diode—High-μ Triode	7FB	12.6	0.15	2.2	1	1.8	12.6	0	—	—	0.75	45K	1200	55	—	—
12EM6	Diode—Tetrode	9HV	12.6	0.5	—	—	—	12.6	0	12.6	1	6	4K	5000	—	—	—
12F8	Dual Diode—Remote Cut-off Pent.	9FH	12.6	0.15	4.5	3	0.06	12.6	0	12.6	0.38	1	333K	1000	—	—	—
12FK6	Dual Diode—Low-μ Triode	7BT	12.6	0.15	1.8	.7	1.6	16	0	—	—	1.3	6.2K	1200	7.4	—	—
12FM6	Dual Diode—Med.-μ Triode	7BT	12.6	0.15	2.7	1.7	1.7	30	0	—	—	1.8	5.6K	2400	13.5	—	—
12FT6	Dual Diode—Triode	7BT	12.6	0.15	1.8	1.1	2.0	30	0	—	—	2	7.6K	1900	15	—	—
12H4	General Purpose Triode	7DW	12.6	0.15	2.4	0.9	3.4	90	0	—	—	10	—	3000	20	—	—
			6.3	0.3				250	−8	—	—	9	—	2600	20	—	—
12J8	Dual Diode—Tetrode	9GC	12.6	0.325	10.5	4.4	0.7	12.6	0	12.6	1.5	12[5]	6K	5500	—	2.7K	0.02
12K5	Tetrode (Pwr. Amp. Driver)	7EK	12.6	0.45	—	—	—	12.6	−2	12.6**	85**	8	800	7000	5.6	800	0.035
12R5‡	Beam Pwr. Pent.	7CV	12.6	0.6	13	9	0.55	110	−8.5	110	3.3	40	13K	7000	—	—	—
12U7	Dual Medium-μ Triode[10]	9A	12.6	0.15	1.6[7,8]	0.4[7]	1.5[7,8]	12.6	0	—	—	1	12.5K	1600	20	—	—
18FW6	Remote Cut-off Pent.	7CC	18	0.1	5.5	5	.0035	150	—	100	4.4	11	250K	4400	—	—	—
18FX6	Dual Control Heptode	7CH	18	0.1	—	—	—	150	—	—	—	2.3	400K	—	—	—	—
18FY6	High-μ Triode—Diode	7BT	18	0.1	2.4	.22	1.8	150	−1	—	—	.6	77K	1300	100	—	—
25F5	Beam Pwr. Pent.	7CV	25	0.15	12	6	0.57	110	−7.5	110	3/7	36/37	16K	5800	—	2.5K	1.2
32ET5	Beam Pwr. Pent.	7CV	32	0.1	12	6	.6	150	−7.5	130	—	—	21.5K	5500	—	2.8K	1.2
35B5	Beam Pwr. Amp.	7BZ	35	0.15	11	6.5	0.4	110	−7.5	110	3/7	41[2]	—	5800	40[5]	2.5K	1.5
50B5	Beam Pwr. Amp.	7BZ	50	0.15	13	6.5	0.5	110	−7.5	110	4/8.5	50[2]	14K	7500	49[5]	2.5K	1.9
5686	Beam Pwr. Pent.	9G	6.3	0.35	6.4	8.5	0.11	250	−12.5	250	3[5]	27[5]	45K	3100	—	9K	2.7
5687	Medium-μ Dual Triode[10]	9H	12.6	0.45	4[7]	0.6[7]	4[7]	120	−2	—	—	36	1.7K	11K	18.5	—	—
			6.3	0.9	4[8]	0.5[8]	4[8]	250	−12.5	—	—	12.5	3K	5500	16.5	—	—
5722	Noise Generating Diode	5CB	6.3	1.5	—	2.2	—	200	—	—	—	35	—	—	—	—	—
5842/417A	High-μ Triode	9V	6.3	0.3	9.0	1.8	0.55	150	62*	—	—	26	1.8K	24K	43	—	—
5879	Sharp Cut-off Pent.	9AD	6.3	0.15	2.7	2.4	0.15	250	−3	100	0.4	1.8	2 meg.	1000	—	—	—
6386	Medium-μ Dual Triode[10]	8CJ	6.3	0.35	2	1.1	1.2	100	200*	—	—	9.6	4.25K	4000	17	—	—
6887	Dual Diode	6BT	6.3	0.2	Max. peak inverse plate voltage = 360 V. Max. d.c. plate current each diode = 10 ma.												
6973	Pwr. Pentode	9EU	6.3	.45	6	6	.4	440	−15	330	—	—	73K	4800	—	—	—
7258	Sharp Cut-off	9DA	12.6	.195	7	2.4	.4	330	—	125	3.8	12	170K	7800	—	—	—
	Med.-μ Triode				2	.26	1.5	330	−3	—	—	15	4.7K	4500	21	—	—
9001	Sharp Cut-off Pent.	7BD	6.3	0.15	3.6	3	0.01	250	−3	100	0.7	2	1 meg.	1400	—	—	—
9002	U.h.f. Triode	7BS	6.3	0.15	1.2	1.1	1.4	250	−7	—	—	6.3	11.4K	2200	25	—	—
9003	Remote Cut-off Pent.	7BD	6.3	0.15	3.4	3	0.1	250	−3	100	2.7	6.7	700K	1800	—	—	—
9006	U.h.f. Diode	6BH	6.3	0.15	Max. a.c. voltage = 270. Max. d.c. output current = 5 ma.												

‡ Controlled heater warm-up characteristic.
Ω Oscillator gridleak or screen-dropping resistor ohms.
* Cathode resistor ohms.
** Space-charge grid.

[1] Per Plate.
[2] Maximum-signal current for full-power output.
[3] Values are for two tubes in push-pull.
[4] Unless otherwise noted.
[5] No signal plate ma.
[6] Effective plate-to-plate.
[7] Triode No. 1.
[8] Triode No. 2.
[9] Oscillator grid current ma.
[10] Values for each section.
[11] Micromhos.
[12] Through 33K.

TABLE II—METAL RECEIVING TUBES

Characteristics given in this table apply to all tubes having type numbers shown, including metal tubes, glass tubes with "G" suffix, and bantam tubes with "GT" suffix. For "G" and "GT" tubes not listed (not having metal counterparts), see Tables III, V, VI and VIII.

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances μμf. C_{in}	C_{out}	C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[12]	Amp. Factor[13]	Load Res. Ohms	Watts Output
A8	Pentagrid Conv.	8A	6.3	0.3	—	—	—	250	−3	100	2.7	3.5	360K	550	—	—	—
								E_{bb} (Osc.) 250 V. through 20K. Grid resistor (Osc.) 50K. I_b=4 ma. I_{g1}=0.4 ma.									
AB7 853	Remote Cut-off Pent.	8N	6.3	0.45	8	5	0.15	300	−3	200	3.2	12.5	700K	5000	—	—	—
								300	−3	30K[8]	3.2	12.5	700K	5000	—	—	—
AC7 852	Sharp Cut-off Pent.	8N	6.3	0.45	11	5	0.15	300	160*	150	2.5	10	1 meg.	9000	—	—	—
								300	160*	60K[8]	2.5	10	1 meg.	9000	—	—	—
AG7	Pwr. Amp. Pent.	8Y	6.3	0.65	13	7.5	0.06	300	−3	150	7/9	30/31	130K	11K	—	10K	3
B8	Dual-Diode—Pent.	8E	6.3	0.3	6	9	0.005	250	−3	125	2.3	10	600K	1325	—	—	—
C5	Medium-μ Triode — A_1 Amp.	6Q	6.3	0.3	3	11	2	250	−8	—	—	8	10K	2000	20	—	—
	Biased Detector							250	−17	Plate current adjusted to 0.2 ma. with no signal.							
F5	High-μ Triode	5M	6.3	0.3	5.5	4	2.4	250	−2	—	—	0.9	66K	1500	100	—	—
F6	Pwr. Amp. Pent. — A_1 Amp.[1, 5]	7S	6.3	0.7	6.5	13	0.2	250	−20	20[10]	—	31/34	2.6K	2600	6.8	4K	0.85
	AB_2 Amp.[1, 6]							350	730*	132[11]	—	50/60	—	—	—	10K[7]	9
								350	−38	123[11]	—	48/92	—	—	—	6K[7]	13
	A_1 Amp.[5]							250	−16.5	250	6/11	34/36	80K	2500	—	7K	3.2
								285	−20	285	7/13	38/40	78K	2500	—	7K	4.8
	AB_2 Amp.[6]							375	−26	250	5/20	34/82	—	—	82[11]	10K[7]	18.5
								375	340*	250	8/18	54/77	—	—	94[11]	10K[7]	19
H6	Dual Diode	7Q	6.3	0.3	—	—	—	Max. a.c. voltage per plate=150 r.m.s. Max. output current 8.0 ma. d.c.									
J5	Medium-μ Triode	6Q	6.3	0.3	3.4	3.6	3.4	250	−8	—	—	9	7.7K	2600	20	—	—
J7	Sharp Cut-off Pent. — A_1 Amp.	7R	6.3	0.3	7	12	0.005	250	−3	100	0.5	2	1 meg.	1225	—	—	—
	Biased Detector							250	10K*	100	Zero signal cathode current=0.43 ma.					0.5 meg.	
K7	Variable-μ Pent. — R.f. Amp.	7R	6.3	0.3	7	12	0.005	250	−3	125	2.6	10.5	600K	1650	990	—	—
	Mixer							250	−10	100				Osc. peak volts=7			
K8	Triode—Hexode Conv. — Hexode	8K	6.3	0.3	—	—	—	250	−3	100	6	2.5	600K	350	—	—	—
	Triode							100	50K[8]	—	—	3.8	I_{g1} (Osc.)=0.15 ma.				
L6-GB[2]	Beam Pwr. Amp. — A_1 Amp.[1, 5]	7AC	6.3	0.9	11.5	9.5	0.9	250	−20	20[10]	—	40/44	1.7K	4700	8	5K	1.4
	A_1 Amp.[5] Self Bias							250	167*	250	5.4/7.2	75/78	—	—	14[10]	2.5K	6.5
								300	218*	200	3/4.6	51/55	—	—	12.7[10]	4.5K	6.5
	A_1 Amp.[5] Fixed Bias							250	−14	250	5/7.3	72/79	22.5K	6000	14[10]	2.5K	6.5
								350	−18	250	2.5/7	54/66	33K	5200	18[10]	4.2K	10.8
	A_1 Amp.[6] Self Bias							250	125*	250	10/15	120/130	—	—	35.6[11]	5K[7]	13.8
								270	125*	270	11/17	134/145	—	—	28.2[11]	5K[7]	18.5
	A_1 Amp.[6] Fixed Bias							250	−16	250	10/16	120/140	24.5[5]	5500[5]	32[11]	5K[7]	14.5
								270	−17.5	270	11/17	134/155	23.5[5]	5700[5]	35[11]	5K[7]	17.5
	AB_1 Amp.[6] Self Bias							360	270*	270	5/17	88/100	—	—	40.6[11]	9K[7]	24.5
	AB_1 Amp.[6] Fixed Bias							360	−22.5	270	5/11	88/140	—	—	45[11]	3.8K[7]	18
								360	−22.5	270	5/15	88/132	—	—	45[11]	6.6K[7]	26.5
	AB_2 Amp.[6] Fixed Bias							360	−18	225	3.5/11	78/142	—	—	52[11]	6K[7]	31
								360	−22.5	270	5/16	88/205	—	—	72[11]	3.8K[7]	47
L7	Pentagrid—Mixer Amp. — A^1 Amp.	7T	6.3	0.3	—	—	—	250	−3	100	6.5	5.3	600K	1100	−3[14]	—	—
	Mixer							250	−6	150	9.2	3.3	1 meg.	350	−15[14]	—	—
N7	Class-B Twin Triode — B Amp.[9]	8B	6.3	0.8	—	—	—	300	0	—	—	35/70	—	—	82[11]	8K[7]	10
	A_1 Amp.[15]							250	−5	—	—	6	11.3K	3100	—	—	—
Q7	Dual Diode—High-μ Triode	7V[2]	6.3	0.3	5	3.8	1.4	250	−3	—	—	1	58K	1200	70	—	—
R7	Dual Diode—Triode	7V[2]	6.3	0.3	4.8	3.8	2.4	250	−9	—	—	9.5	8.5K	1900	16	10K	0.28
S7	Remote Cut-off Pent.	7R[2]	6.3	0.15	6.5	10.5	0.005	250	−3	100	2	8.5	1 meg.	1750	—	—	—
SA7GT	Pentagrid Conv.	8R[2]	6.3	0.3	9.5	12	0.13	250	0[3]	100	8	3.4	800K	Grid No. 1 resistor 20K.			
SB7Y	Pentagrid Conv.	8R	6.3	0.3	9.6	9.2	0.13	100	−1	100	10.2	3.6	50K	900	—	—	—
								250	−1	100	10	3.8	1 meg.	950	—	—	—
								250	22K[8]	12K[8]	12/13	6.8/6.5	Osc. Section in 88–108 Mc. Service.				
SC7	High-μ Dual Triode[5]	8S	6.3	0.3	2	3	2	250	−2	—	—	2	53K	1325	70	—	—
SF5	High-μ Triode	6AB[2]	6.3	0.3	4	3.6	2.4	250	−2	—	—	0.9	66K	1500	100	—	—
SF7	Diode—Variable-μ Pent.	7AZ	6.3	0.3	5.5	6	0.004	250	−1	100	3.3	12.4	700K	2050	—	—	—
SG7	H.f. Amp. Pent.	8BK	6.3	0.3	8.5	7	0.003	250	−2.5	150	3.4	9.2	1 meg.	4000	—	—	—
SH7	H.f. Amp. Pent.	8BK	6.3	0.3	8.5	7	0.003	250	−1	150	4.1	10.8	900K	4900	—	—	—
SJ7[4]	Sharp Cut-off Pent.	8N	6.3	0.3	6	7	0.005	250	−3	100	0.8	3	1 meg.	1650	—	—	—
SK7	Variable-μ Pent.	8N	6.3	0.3	6	7	0.003	250	−3	100	2.6	9.2	800K	2000	—	—	—
SQ7GT	Dual Diode—High-μ Triode	8Q	6.3	0.3	3.2	3	1.6	250	−2	—	—	0.9	91K	1100	100	—	—
SR7	Dual Diode—Triode	8Q	6.3	0.3	3.6	2.8	2.4	250	−9	—	—	9.5	8.5K	1900	16	—	—
SS7	Variable-μ Pent.	8N	6.3	0.15	5.5	7	0.004	250	−3	100	2	9	1 meg.	1850	—	—	—
V6	Beam Pwr. Amp. — A_1 Amp.[5]	7AC	6.3	0.45	10	11	0.3	180	−8.5	180	3/4	29/30	50K	3700	8.5[10]	5.5K	2
								250	−12.5	250	4.5/7	45/47	50K	4100	12.5[10]	5K	4.5
								315	−13	225	2.2/6	34/35	80K	3750	13[10]	8.5K	5.5
	AB_1 Amp.[6]							250	−15	250	5/13	70/79	60K	3750	30[11]	10K[7]	10
								285	−19	285	4/13.5	70/92	70K	3600	38[11]	8K[7]	14
612	Pentagrid Amp.	7T	6.3	0.3	7.5	11	0.001	250	−3	100	6.5	5.3	600K	1100	−3[14]	—	—
620	Sharp Cut-off Pent.	7R	6.3	0.3	7	12	0.005	250	−3	100	0.5	2	1 meg.	1225	—	—	—
621	Pwr. Amp. Pent. — A_1 Amp.[1, 6]	7S	6.3	0.7	7.5	11.5	0.2	330	500*	—	—	55/59	—	—	54[11]	5K[7]	2
	A_1 Amp.[6]							300	−30	300	6.5/13	38/69	—	—	60[11]	4K[7]	5
622	Beam Pwr. Amp.[6]	7AC	6.3	0.9	10	12	0.4	300	−20	250	4/10.5	86/125	—	—	40[11]	4K[7]	10
693	Sharp Cut-off Pent.	8N	6.3	0.3	5.3	6.2	0.005	250	−3	100	0.85	3	1 meg.	1650	—	—	—

* Cathode resistor-ohms.
1 Screen tied to plate.
2 No connection to Pin No. 1 for 6L6G, 6Q7G, 6R7GT/G, 6S7G, 6SA7GT/G and 6SF5-GT.
3 Grid bias=2 volts if separate oscillator excitation is used.
4 Also type 6SJ7Y.
5 Values are for single tube or section.
6 Values are for two tubes in push-pull.
7 Plate-to-plate value.
8 Osc. grid leak—Scrn. res.
9 Values for two units.
10 Peak a.f. grid voltage.
11 Peak a.f. G-G voltage.
12 Micromhos.
13 Unless otherwise noted.
14 G_3 voltage.
15 Units connected in parallel.

TABLE III—6.3-VOLT GLASS TUBES WITH OCTAL BASES

(For "G" and "GT"-type tubes not listed here, see equivalent type in Tables II and VIII; characteristics and connections will be similar)

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances μμf. C_{in}	Capacitances μμf. C_{out}	Capacitances μμf. C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[10]	Amp. Factor	Load Res. Ohms	Watts Output
6AC5GT	Triode Pwr. Amp. AB Amp.[4]	6Q	6.3	0.4	—	—	—	250	0	—	—	5[6]	36.7K	3400	125	10K[5]	8
6AD7G	Triode— Pwr. Amp. Pent. — Triode	8AY	6.3	0.85	—	—	—	250	−25	—	—	4	19K	325	6	—	—
	— Pent.							250	−16.5	250	6.5/10.5	34/36	80K	2500	—	7K	3.2
6AH4GT	Medium-μ Triode	8EL	6.3	0.75	7	1.7	4.4	250	−23	—	—	30	1.78K	4500	8	—	—
6AL7GT	Electron-Ray Indicator	8CH	6.3	0.15	—	—	—	Outer edge of any of the three illuminated areas displaced 1/16 in. min. outward with +5 volts to its electrode. Similar inward disp. with −5 volts. No pattern with −6 volts grid.									
6AQ7GT	Dual Diode—High-μ Triode	8CK	6.3	0.3	2.8	3.2	3	250	−2	—	—	2.3	44K	1600	70	—	—
6AR6	Beam Pent.	6BQ	6.3	1.2	11	7	0.55	250	−22.5	250	5	77	21K	5400	—	—	—
6AR7GT	Dual Diode—Remote Pent.	7DE	6.3	0.3	5.5	7.5	0.003	250	−2	100	1.8	7	1.2meg.	2500	—	—	—
6AS7G	Low-μ Twin Triode—D.C. Amp.[1]	8BD	6.3	2.5	6.5	2.2	7.5	135	250*	—	—	125	0.28K	7000	2	—	—
6AU5GT	Beam Pwr. Amp.[8]	6CK	6.3	1.25	11.3	7	0.5	115	−20	175	6.8	60	6K	5600	—	—	—
6AV5GA	Beam Pwr. Amp.[8]	6CK	6.3	1.2	14	7.0	0.5	250	−22.5	150	2.1	55	20K	5500	—	—	—
6BD5GT	Beam Pwr. Amp.[8]	6CK	6.3	0.9	—	—	—	310	−200[7]	310	—	90[9]	—	—	—	—	—
6BG6GA	Beam Pwr. Amp.[8]	5BT	6.3	0.9	11	6	0.8	250	−15	250	4	75	25K	6000	—	—	—
6BL7GTA	Medium-μ Dual Triode[1]	8BD	6.3	1.5	4.4	0.9	6.0	250	−9	—	—	40	2150	7000	15	—	—
6BQ6GTB 6CU6	Beam Pwr. Amp.[8]	6AM	6.3	1.2	15	7	0.6	250	−22.5	150	2.1	57	14.5K	5900	—	—	—
6BX7GT	Dual Triode[1]	8BD	6.3	1.5	5	3.4	4.2	250	390*	—	—	42	1.3K	7600	10	—	—
6CB5A	Beam pwr. Amp.[8]	8GD	6.3	2.5	22	10	0.4	175	−30	175	6	90	5K	8800	—	—	—
6CD6GA	Beam Pwr. Amp.[8]	5BT	6.3	2.5	24	9.5	0.8	175	−30	175	5.5	75	7.2K	7700	—	—	—
6CK4	Low-μ Triode	8JB	6.3	1.25	8.0	1.8	6.5	550	−26	—	—	55	1.0K	6500	6.7	—	—
6CL5	Beam Pwr. Amp.[8]	8GD	6.3	2.5	20	11.5	0.7	175	−40	175	7	90	6K	6500	—	—	—
6CU6	Beam Pwr. Amp.[8]	6AM	6.3	1.2	15	7	0.55	250	−22.5	150	2.1	55	20K	5500	—	—	—
6DG6GT	Beam Pwr. Amp.	7S	6.3	1.2	—	—	—	200	180*	125	8.5[7]	47[7]	28K	8000	—	4K	3.8
6DN6	Beam Pwr. Pent.[8]	5BT	6.3	2.5	22	11.5	0.8	125	−18	125	6.3	70	4K	9000	—	—	—
6DN7	Dissimilar Dual Triode	8BD	6.3	0.9	2.2	0.7	4.0	350	−8	—	—	8	9K	2500	22	—	—
					4.6	1.0	5.5	550	−9.5	—	—	68	2K	7700	15	—	—
6DQ5	Beam Pwr. Amp.[8]	8JC	6.3	2.5	23	11	0.5	175	−25	125	5	110	5.5K	10.5K	—	—	—
6DQ6B	Beam Pwr. Amp.[8]	6AM	6.3	1.2	15	7	0.55	250	−22.5	150	2.4	75	20K	6600	—	—	—
6EA7	Dissimiliar— Dual Triode	8BD	6.3	1.05	2.2	0.6	4	350	−3	—	—	1.5	34K	1900	65	—	—
					6	1.3	8	550	−25	—	—	95	770	6500	5	—	—
6EF6	Beam Pwr. Amp.[11]	7S	6.3	0.9	11.5	9	0.8	250	−18	250	2	50	—	5000	—	—	—
6EY6	Beam Pwr. Pent.	7AC	6.3	0.68	8.5	7	.7	350	−17.5	300	3	44	60K	4.4K	—	—	—
6EZ5	Beam Pwr. Pent.	7AC	6.3	0.8	9	7	.6	350	−20	300	3.5	43	50K	4.1K	—	—	—
6FH6	Beam Pwr. Pent.	6AM	6.3	1.2	33	8	.4	770	−22.5	220	1.7	75	12K	6K	—	—	—
6G6G	Beam Pwr. Amp. A_1 Amp.	7S	6.3	0.15	5.5	7	0.5	180	−9	180	2.5[6]	15[6]	175K	2300	—	10K	1.1
	A_1 Amp.[2]							180	−12	—	—	11	4.75K	2000	9.5	12K	0.25
6K6GT	Pwr. Amp. Pent.	7S	6.3	0.4	5.5	6	0.5	315	−21	250	4/9	25/28	110K	2100	—	9K	4.5
6S8GT	Triple-Diode—Triode	8CB	6.3	0.3	1.2	5	2	250	−2	—	—	—	91K	1100	100	—	—
6SD7GT	Semi-Remote Pent.	8N	6.3	0.3	9	7.5	0.0035	250	−2	125	3	9.5	700K	4250	—	—	—
6SL7GT	High-μ Dual Triode[1]	8BD	6.3	0.3	3.4	3.8	2.8	250	−2	—	—	2.3	44K	1600	70	—	—
6SN7GTB	Medium-μ Dual Triode[1]	8BD	6.3	0.6	3	1.2	4	250	−8	—	—	9	7.7K	2600	20	—	—
6U6GT	Beam Pwr. Amp.	7S	6.3	0.75	—	—	—	200	−14	135	3/13	55/62	20K	6200	—	3K	5.5
6W6GT	Beam Pwr. Amp.	7S	6.3	1.2	15	9	0.5	200	180*	125	2/8.5	46/47	28K	8000	—	4K	3.8
6Y6GA	Beam Pwr. Amp.	7S	6.3	1.25	15	1	0.7	200	−14	135	2.2/9	61/66	18.3K	7100	—	2.6K	6
1635	High-μ Dual Triode	8B	6.3	0.6	—	—	—	300	0	—	—	6.6/54	—	—	—	12K[5]	10.4
7027	Beam Pwr. Amp.	8HY	6.3	0.9	10	7.5	1.5	450	−30	350	19.2	194	—	6000	—	6K[5]	50

* Cathode resistor-ohms.
[1] Per section.
[2] Screen tied to plate.
[3] Values are for single tube.
[4] Values are for two tubes in push-pull.
[5] Plate-to-plate value.
[6] No signal current.
[7] Max. value.
[8] Horz. Deflection Amp.
[9] Cathode current.
[10] Micromhos.
[11] Vert. Deflection Amp.

TABLE IV—6.3-VOLT LOCK-IN-BASE TUBES

For other lock-in-base types see Tables V, VI, and VII

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances μμf. C_{in}	Capacitances μμf. C_{out}	Capacitances μμf. C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[3]	Amp. Factor	Load Res. Ohms	Watts Output
7A8	Octode Conv.	8U	6.3	0.15	7.5	9	0.15	250	−3	100	3.2	3	50K	Anode grid 250 Volts max.[1]			
7AH7	Remote Cut-off Pent.	8V	6.3	0.15	7	6.5	0.005	250	250*	250	1.9	6.8	1 meg.	3300	—	—	—
7AK7	Sharp Cut-off Pent.	8V	6.3	0.8	12	9.5	0.7	150	0	90	21	41	11.5K	5500	—	—	—
7B7	Remote Cut-off Pent.	8V	6.3	0.15	5	6	0.007	250	−3	100	1.7	8.5	750K	1750	—	—	—
7C7	Sharp Cut-off Pent.	8V	6.3	0.15	5.5	6.5	0.007	250	−3	100	0.5	2	2 meg.	1300	—	—	—
7E7	Dual Diode—Pent.	8AE	6.3	0.3	4.6	5.5	0.005	250	330*	100	1.6	7.5	700K	1300	—	—	—
7F8	Medium-μ Dual Triode[2]	8BW	6.3	0.3	2.8	1.4	1.2	250	500*	—	—	6	14.5K	3300	48	—	—
7K7	Dual Diode—High-μ Tri.	8BF	6.3	0.3	2.4	2	1.7	250	−2	—	—	2.3	44K	1600	70	—	—

* Cathode resistor-ohms.
[1] Through 20K resistor.
[2] Each section.
[3] Micromhos.

TABLE V—1.5-VOLT FILAMENT BATTERY TUBES

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances $\mu\mu$f. C_{in}	C_{out}	C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[2]	Amp. Factor	Load Res. Ohms	Watts Output
A7GT	Pentagrid Conv.	7Z	1.4	0.05	7	10	0.5	90	0	45	0.7	0.6	600K	E_{bb} Anode-grid = 90 Volts.			
H5GT	Diode High-μ Triode	5Z	1.4	0.05	1.1	4.6	1	90	0	—	—	0.15	240K	275	65	—	—
LN5	Sharp Cut-off Pent.	7AO	1.4	0.05	3	8	0.007	90	0	90	0.35	1.6	1.1 meg.	800	—	—	—
N5GT	R.f. Pentode	5Y	1.4	0.05	3	10	0.007	90	0	90	0.3	1.2	1.5 meg.	750	—	—	—
E6	Sharp Cut-off Pent.	7CJ	2.8[1]	0.05	5.5	8	0.007	90	0	90	1.2	2.9	325K	1700	—	—	—

[1] Center-tap filament permits 1.4 volt operation.

[2] Micromhos.

TABLE VI—HIGH-VOLTAGE HEATER TUBES

See also Table VIII.

Type	Name	Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances $\mu\mu$f. C_{in}	C_{out}	C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[2]	Amp. Factor	Load Res. Ohms	Watts Output
2A6	Beam Pwr. Amp.	7S	12.6	0.15	8	9	0.3	250	−12.5	250	3.5/5.5	30/32	70K	3000	—	7.5K	3.4
2AH7GT	Medium-μ Dual Triode[1]	8BE	12.6	0.15	3.2	3	3	180	−6.5	—	—	7.6	8.4K	1900	16	—	—
2EN6‡	Beam Pwr. Amp.	7S	12.6	0.6	14	8	0.65	200	−9.5	110	2.2	50	28K	8000	—	—	—
2L6GT‡	Beam Pwr. Pent.	7S	12.6	0.6	15	10	0.6	110	−7.5	110	4/10	49/50	13K	8000	—	2K	2.1
								200	180*	125	2.2/8.5	46/47	28K	8000	—	4K	3.8
2SY7	Heptode Conv.	8R	12.6	0.15	Osc.-Grid leak 20K.			250	−2	8.5	3.5	—	1 meg.	450	—	—	—
1EX6	Beam Pwr. Pent.	5BT	21.5	0.6	22	8.5	1.1	—	−30	195	.3	67	8.5K	7700	—	—	—
5A5	Beam Pwr. Amp.	6AA	35	0.15	—	—	—	110	−7.5	110	3/7	40/41	16K	5800	—	2.5K	1.5
0C6GA	Beam Pwr. Amp.	7S	50	0.15	—	—	—	200	−14	135	2.2/9	61/66	18.3K	7100	—	2.6K	6
17N7GT	Rect.—Beam Pwr. Amp.	8AV	117	0.09	Rect. same as 117L7GT			100	−6	100	5	51	16K	7000	—	3K	1.2
824	Beam Pwr. Pent.	7S	25	0.3	—	—	—	135	−22	135	2.5/14.5	61/69	15K	5000	—	1.7K	4.3
082	Low-μ Dual Triode[1]	8BD	26.5	0.6	6	2.2	8	135	250*	—	—	125	0.28K	7000	2	—	—

* Cathode resistor-ohms.

‡ Controlled heater warm-up characteristic.

[1] Each section.

[2] Micromhos.

TABLE VII—SPECIAL RECEIVING TUBES

Type	Name		Base	Fil. or Heater V.	Fil. or Heater Amp.	Capacitances $\mu\mu$f. C_{in}	C_{out}	C_{gp}	Plate Supply V.	Grid Bias	Screen Volts	Screen Ma.	Plate Ma.	Plate Res. Ohms	Transconductance[2]	Amp. Factor	Load Res. Ohms	Watts Output
Q5GT	Beam Pwr. Amp.		7AP	2.8[1]	0.05	8	6.5	0.6	90	−4.5	90	1.3	9.5	90K	2200	—	8K	0.27
F4	Acorn Triode		7BR	6.3	0.225	2	0.6	1.9	80	150*	—	—	13	2.9K	5800	17	—	—
L4	Acorn Triode		7BR	6.3	0.225	1.8	0.5	1.6	80	150*	—	—	9.5	4.4K	6400	28	—	—
E5/1201	H.f. Triode		8BN	6.3	0.15	3.6	2.8	1.5	180	−3	—	—	5.5	12K	3000	36	—	—
54	Detector Amp.—Pentode (Acorn)	A_1 Amp.	5BB	6.3	0.15	3.4	3	0.007	250	−3	100	0.7	2	1 meg.	1400	—	—	—
		Detector							250	−6	100	I_b adjusted to 0.1 ma. with no signal.					250K	—
55	Medium-μ Triode (Acorn)		5BC	6.3	0.15	1	0.6	1.4	250	−7	—	—	6.3	11.4K	2200	25	—	—
									90	−2.5	—	—	2.5	14.7K	1700	25	—	—
56	Remote Cut-off Pent. (Acorn)	A_1 Amp.	5BB	6.3	0.15	3.4	3	0.007	250	−3	100	2.7	6.7	700K	1800	—	—	—
		Mixer							250	−10	100	Oscillator peak volts −7 min.					—	—
58-A	Medium-μ Triode (Acorn)		5BD	1.25	0.1	0.6	0.8	2.6	135	−7.5	—	—	3	10K	1200	12	—	—
59	Sharp Cut-off Pent. (Acorn)		5BE	1.25	0.05	1.8	2.5	0.015	135	−3	67.5	0.4	1.7	800K	600	—	—	—
509	Amplifier Pentode		5B	1.1	0.25	7	7	1	135	−1.5	67.5	0.65	2.5	400K	725	—	—	—
173	U.h.f. "Pencil" Diode		Fig. 34	6.3	0.135	Plate to K = 1.1			Peak inverse—375 Volts. Peak I_p—50 Ma. Max. d.c. output—5.5 ma.									—
77	Ceramic U.h.f. Triode		—	6.3	0.24	1.9	0.01	1.0	250	−5	—	—	6.4	8.9K	9000	—	—	—
004	U.h.f. Diode (Acorn)		4BJ	6.3	0.15	Plate to K = 1.3			Max. a.c. voltage—117. Max. d.c. output current—5 ma.									
005	U.h.f. Diode (Acorn)		5BG	3.6	0.165	Plate to K = 0.8			Max. a.c. voltage—117. Max. d.c. output current—1 ma.									

* Cathode resistor-ohms.

[1] Center-tap filament permits 1.4-volt operation.

[2] Micromhos.

TABLE VIII—EQUIVALENT TUBES

The equivalent tubes listed in this table are, in general, designed for industrial, military and other special-purpose applications. These tubes are generally not directly interchangeable because of mechanical and/or electrical differences involving basing, heater characteristics, maximum ratings, interelectrode capacitances, etc.

Type	Equivalent and Table		Base	E_f[1]	I_f[2]	Type	Equivalent and Table		Base	E_f[1]	I_f[2]
(3	1J3	X	3C	1.25	0.2	5FV8	6FV8	I	9FA	4.7	0.6
.H4	1H5GT	V	5AG	1.4	0.05	5V4G	5V4GA	X	5L	5.0	3.0
C39WA	2C39	XI	—	5.8	1.03	6A6	6N7	II	7B	6.3	0.8
EA5	2EA5	I	7EW	2.9	0.45	6A7	6A8	II	7C	6.3	0.3
.F4[3]	3Q5GT	VII	6BB	2.8	0.05	6AE8	6K8	II	8DU	6.3	0.3
V4[3]	3Q4	I	6BX	2.8	0.05	6AM8	6AM8A‡	I	9CY	6.3	0.45
DK6	3DK6	I	7CM	4.2	0.45	6AN8	6AN8A‡	I	9DA	6.3	0.45
EA8	6EA8	I	9AE	4.7	0.6	6AQ5	6AQ5A‡	I	7BZ	6.3	0.45

TABLE VIII—EQUIVALENT TUBES—*Continued*

Type	Equivalent and Table		Base	E_f[1]	I_f[2]
6AS7GA	6AS7G	III	**8BD**	6.3	2.5
6AT8	6AT8A‡	I	**9DW**	6.3	1.8
6AU6	6AU6A‡	I	**7BK**	6.3	0.3
6AU7‡	12AU7A	I	**9A**	3.15	0.6
6AX7‡[3]	12AX7	I	**9A**	6.3	0.3
6BE8	6BE8A‡	I	**9EG**	6.3	0.45
6BQ6GA/GTA	6BQ6GTB	III	**6AM**	6.3	1.2
6BR8	6BR8A‡	I	**9FA**	6.3	0.45
6C6	6J7	II	**6F**	6.3	0.3
6CB6	6CB6A‡	I	**7CM**	6.3	0.3
6CD6G	6CD6GA	III	**5BT**	6.3	2.5
6CG8	6CG8A‡	I	**9GF**	6.3	0.45
6CL8	6CL8A‡	I	**9FX**	6.3	0.45
6CS8‡	6CR8	I	**9FZ**	6.3	0.45
6CU8	6AN8	I	**9GM**	6.3	0.45
6EW6	4EW6	I	**7CM**	6.3	0.4
6J6	6J6A‡	I	**7BF**	6.3	0.45
6L6GA	6L6GB	II	**7S**	6.3	0.9
6S4	6S4A	I	**9AC**	6.3	0.6
6SN7GTA	6SN7GTB	III	**8BD**	6.3	0.6
6SU7GTY	6SL7GT	III	**8BD**	6.3	0.3
6T8	6T8A‡	I	**9E**	6.3	0.45
6U8	6U8A‡	I	**9AE**	6.3	0.45
6V6	6V6GTA	II	**7S**	6.3	0.45
6Y6G	6Y6GA	III	**7S**	6.3	1.25
6Y6GT	6Y6GA	III	**7S**	6.3	1.25
7A4	6J5	II	**5AS**	6.3	0.3
7A6	6H6	II	**7AJ**	6.3	0.15
7A7	6SK7	II	**8V**	6.3	0.3
7B4	6SF5	II	**5AC**	6.3	0.3
7B5	6K6GT	III	**6AE**	6.3	0.4
7B6	6SQ7	II	**8W**	6.3	0.3
7B8	6A8	II	**8X**	6.3	0.3
7C5	6V6	II	**6AA**	6.3	0.45
7EY6‡	6EY6	III	**7AC**	7.2	0.6
7F7	6SL7GT	III	**8AC**	6.3	0.3
7H7	6SG7	II	**8V**	6.3	0.3
7N7	6SN7GT	III	**8AC**	6.3	0.6
7Q7	6SA7	II	**8AL**	6.3	0.3
10EB8‡	6EB8	I	**9DX**	10.5	0.45
12A8GT	6A8	II	**8A**	12.6	0.15
12AL5	6AL5	I	**6BT**	12.6	0.15
12AT6	6AT6	I	**7BT**	12.6	0.15
12AU6	6AU6A	I	**7BK**	12.6	0.15
12AV5GA‡	6AV5GT	III	**6CK**	12.6	0.6
12AV6	6AV6	I	**7BT**	12.6	0.15
12B4	12B4A‡[3]	I	**9AG**	12.6	0.3
12BA6	6BA6	I	**7BK**	12.6	0.15
12BA7	6BA7	I	**8CT**	12.6	0.15
12BD6	6BD6	I	**7BK**	12.6	0.15
12BE6	6BE6	I	**7CH**	12.6	0.15
12BF6	6BF6	I	**7BT**	12.6	0.15
12BK5‡	6BK5	I	**9BQ**	12.6	0.6
12BK6	6BK6	I	**7BT**	12.6	0.15
12BN6	6BN6	I	**7DE**	12.6	0.15
12BQ6GA‡	6BQ6GTB	III	**6AM**	12.6	0.6
12BQ6GT‡	6BQ6GTB	III	**6AM**	12.6	0.6
12BQ6GTB‡	6BQ6GTB	III	**6AM**	12.6	0.6
12BT6	6BT6	I	**7BT**	12.6	0.15
12BU6	6BU6	I	**7BT**	12.6	0.15
12BW4	6BW4	X	**9DJ**	12.6	0.45
12BY7	12BY7A‡[3]	I	**9BF**	12.6	0.3
12BZ6‡	6BZ6	I	**7CM**	12.6	0.15
12C5‡	50B5	I	**7CV**	12.6	0.6
12C8	6B8	II	**8E**	12.6	0.15
12CA5‡	6CA5	I	**7CV**	12.6	0.6
12CM6	6CM6	I	**9CK**	12.6	0.225
12CR6	6CR6	I	**7EA**	12.6	0.15
12CS5‡	6CS5	I	**9CK**	12.6	0.6
12CS6	6CS6	I	**7CH**	12.6	0.15
12CU5‡	6CU5	I	**7CV**	12.6	0.6
12CU6	6CU6	III	**6AM**	12.6	0.6
12DB5‡	6DB5	I	**9GR**	12.6	0.6
12DF7[3]	12AX7	I	**9A**	12.6	0.15
12DQ6A‡	6DQ6B	III	**6AM**	12.6	0.6
12DT5	6DT5	I	**9HN**	12.6	0.6
12DT8	6DT8	I	**9DE**	12.6	0.15
12DW5‡	6DW5	I	**9CK**	12.6	0.6
12EF6‡	6EF6	III	**7S**	12.6	0.45
12G4	6J5	II	**6BG**	12.6	0.15
12H6	6H6	II	**7Q**	12.6	0.15
12J5GT	6J5	II	**6Q**	12.6	0.15
12J7GT	6J7	II	**7R**	12.6	0.15
12K7GT	6K7	II	**7R**	12.6	0.15
12K8	6K8	II	**8K**	12.6	0.15
12S8GT	6S8GT	III	**8CB**	12.6	0.15
12SA7	6SA7	II	**8R**	12.6	0.15
12SC7	6SC7	II	**8S**	12.6	0.15
12SF5	6SF5	II	**6AB**	12.6	0.15
12SF7	6SF7	II	**7AZ**	12.6	0.15
12SG7	6SG7	II	**8BK**	12.6	0.15
12SH7	6SH7	II	**8BK**	12.6	0.15
12SJ7	6SJ7	II	**8N**	12.6	0.15
12SK7	6SK7	II	**8N**	12.6	0.15
12SL7GT	6SL7GT	III	**8BD**	12.6	0.15
12SN7GT	6SN7GTB	III	**8BD**	12.6	0.3
12SN7GTA	6SN7GTB	III	**8BD**	12.6	0.3
12SQ7	6SQ7	II	**8Q**	12.6	0.15
12SR7	6SR7	II	**8Q**	12.6	0.15
12W6GT‡	6W6GT	III	**7S**	12.6	0.6
14A7	6SK7	II	**8V**	12.6	0.15
14AF7	7AF7	IV	**8AC**	12.6	0.15
14B6	6SQ7	II	**8W**	12.6	0.15
14F7	6SL7GT	III	**8AC**	12.6	0.15
14N7	6SN7GTB	III	**8AC**	12.6	0.6
14Q7	6SA7	II	**8AL**	12.6	0.15
19CL8A	6CL8A	I	**9FX**	18.9	0.15
25BQ6GA	6BQ6GTB	III	**6AM**	25	0.3
25BQ6GT	6BQ6GTB	III	**6AM**	25	0.3
25BQ6GTB‡	6BQ6GTB	III	**6AM**	25	0.3
25C5	50C5	VIII	**7CV**	25	0.3
25C6GA	50C6GA	VIII	**7S**	25	0.3
25CA5	6CA5	I	**7CV**	25	0.3
25CD6G	6CD6GA	III	**5BT**	25	0.6
25CD6GA‡	6CD6GA	III	**5BT**	25	0.6
25CD6GB‡	6CD6GA	III	**5BT**	25	0.6
25CU6	6CU6	III	**6AM**	25	0.3
25DN6‡	6DN6	III	**5BT**	25	0.6
25EC6‡	25CD6GB	VIII	**5BT**	25	0.6
25EH5	6EH5	I	**7CV**	25	0.3
25L6GT	12L6GT	VI	**7S**	25	0.3
25SA7GT	6SA7GT	II	**8AD**	—	—
25W6GT	6W6GT	III	**7S**	25	0.3
35C5	35B5	I	**7CV**	35	0.15
35L6GT	35B5	I	**7S**	35	0.15
41	6K6GT	III	**6B**	6.3	0.4
42	6F6	II	**6B**	6.3	0.7
50A5	12L6GT	VI	**6AA**	50	0.15
50BK5	6BK5	I	**9BQ**	50	0.15
50C5	50B5	I	**7CV**	50	0.15
50C6GA	50C6G	VI	**7S**	50	0.15
50L6GT	12L6GT	VI	**7AC**	50	0.15
75	6SQ7	II	**6G**	6.3	0.3
78	6K7	II	**6F**	6.3	0.3
417A	5842	I	**9V**	6.3	0.3
1221	6J7	II	**6F**	6.3	0.3
1223	6J7	II	**7R**	6.3	0.3
1631	6L6GB	II	**7AC**	12.6	0.45
1632	12L6GT	VI	**7S**	12.6	0.6
1634	6SC7	II	**8S**	12.6	0.15
5591	6AK5	I	**7BD**	6.3	0.15
5654	6AK5	I	**7BD**	6.3	0.175
5670	2C51	I	**8CJ**	6.3	0.35
5679	6H6	II	**7CX**	6.3	0.15
5691	6SL7GT	III	**8BD**	6.3	0.6
5692	6SN7GT	III	**8BD**	6.3	0.6
5725	6AS6	I	**7CM**	6.3	0.175
5726	6AL5	I	**6BT**	6.3	0.3
5749	6BA6	I	**7BK**	6.3	0.3
5750	6BE6	I	**7CH**	6.3	0.3
5751[3]	12AX7	I	**9A**	12.6	0.175
5814A[3]	12SN7GT	VIII	**9A**	12.6	0.175
5871	6V6GTA	II	**7AC**	6.3	0.9
5881	6L6GB	II	**7AC**	6.3	0.9
5910	1U4	I	**6AR**	1.4	0.05
5915	6BY6	I	**7CH**	6.3	0.3
5963[3]	12AU7A	I	**9A**	12.6	0.15
5964	6J6A	I	**7BF**	6.3	0.45
5965[3]	12AV7	I	**9A**	12.6	0.225
6046	12L6GT	VI	**7AC**	25	0.3
6057[3]	12AX7	I	**9A**	12.6	0.15
6058	6AL5	I	**6BT**	6.3	0.3
6059	6J7	II	**9BC**	6.3	0.15
6060[3]	12AT7	I	**9A**	12.6	0.15
6061	6V6GTA	I	**9AM**	6.3	0.45
6064	6AM6	I	**7DB**	6.3	0.3
6065	6BH6	I	**7DB**	6.3	0.2
6066	6AT6	I	**7BT**	6.3	0.3

TABLE VIII—EQUIVALENT TUBES—*Continued*

Type	Equivalent and Table		Base	E_f[1]	I_f[2]	Type	Equivalent and Table		Base	E_f[1]	I_f[2]
0673[3]	12AU7A	I	**9A**	12.6	0.15	**6678**	6U8A‡	I	**9AE**	6.3	0.45
080	6AS7G	III	**8BD**	6.3	2.5	**6679[3]**	12AT7	I	**9A**	12.6	0.15
101	6J6A	I	**7BF**	6.3	0.45	**6680[3]**	12AU7A	I	**9A**	12.6	0.15
132	6CH6	I	**9BA**	6.3	0.75	**6681[3]**	12AX7	I	**9A**	12.6	0.15
136	6AU6A	I	**7BK**	6.3	0.3	**6829[3]**	5965	VIII	**9A**	12.6	0.225
2013	12AT7	I	**9A**	12.6	0.15	**6897**	2C39	XI	——	6.3	1.05
265	6BH6	I	**7CM**	6.3	0.175	**7000**	6J7	II	**7R**	6.3	0.3
350[3]	12BH7A	I	**9CZ**	12.6	0.3	**7025[3]**	12AX7	VII	**9A**	12.6	0.15
485	6AH6	I	**7BK**	6.3	0.45	**7137**	6J4	I	**7BQ**	6.3	0.4
660	6BA6	I	**7CC**	6.3	0.3	**7700**	6J7	II	**6F**	6.3	0.3
661	6BH6	I	**7CM**	6.3	0.15	**EEC81[3]**	12AT7	I	**9A**	12.6	0.15
662	6BJ6A	I	**7CM**	6.3	0.15	**EEC82[3]**	12AU7A	I	**9A**	12.6	0.15
663	6AL5	I	**6BT**	6.3	0.3	**EEC83[3]**	12AX7	I	**9A**	12.6	0.15
669	6AQ5A	I	**7BZ**	6.3	0.45	**KT-66[4]**	6L6GB	II	**7AC**	6.3	1.27
677	6CL6	I	**9BV**	6.3	0.65	**XXD**	7AF7	IV	**8AC**	12.6	0.15

‡ Controlled heater warm-up characteristics.
1 Filament or heater voltage.
2 Filament or heater current.
3 Heater center-tapped for operation at half voltage shown.
4 British version of 6L6.

TABLE IX—CONTROL AND REGULATOR TUBES

Type	Name	Base	Cathode	Fil. or Heater		Peak Anode Voltage	Max. Anode Ma.	Minimum Supply Voltage	Oper-ating Voltage	Oper-ating Ma.	Grid Resistor	Tube Voltage Drop
				Volts	Amp.							
A2 **073**	Voltage Regulator	**5BO**	Cold	——	——	——	——	185	150	5–30	——	——
A3/VR75	Voltage Regulator	**4AJ**	Cold	——	——	——	——	105	75	5–40	——	——
A4G **267**	Gas Triode Starter-Anode Type	**4V** **4V**	Cold	——	——	With 105–120-volt a.c. anode supply, peak starter-anode a.c. voltage is 70 peak r.f. voltage 55. Peak d.c. ma = 100. Average d.c. ma = 25.						
A5	Gas Pentode	**Fig. 19**	Cold	——	——	Plate —750 V., Screen —90 V., Grid +3 V., Pulse —85 V.						
32 **074**	Voltage Regulator	**5BO**	Cold	——	——	——	——	133	108	5–30	——	——
33/VR90	Voltage Regulator	**4AJ**	Cold	——	——	——	——	125	90	5–40	——	——
C2	Voltage Regulator	**5BO**	Cold	——	——	——	——	105	75	5–30	——	——
C3/VR105	Voltage Regulator	**4AJ**	Cold	——	——	——	——	135	105	5–40	——	——
D3/VR150	Voltage Regulator	**4AJ**	Cold	——	——	——	——	185	150	5–40	——	——
021	Grid-Controlled Rectifier Relay Tube	**7BN**	Htr.	6.3	0.6	650	500	——	650	100	0.1–10[4]	8
						400	——	——	——	——	1.0[4]	——
04	Control Tube	**5AY**	Htr.	6.3	0.25	Ep = 350; Grid volts = −50; Avg. Ma. = 25; Peak Ma. = 100; Voltage drop = 16.						
0C1	Voltage Regulator	**5BO**	Cold	——	——	——	——	125	90	1–40	——	——
34	Gas Triode Grid Type	**6Q**	Htr.	6.3	0.6	300	300	——	——	2	25000	——
						350	300	——	——	75	25000	——
57	Grid-Controlled Rectifier	**3G**	Fil.	2.5	5.0	2500	500	−5[2]	——	——	——	10–24
91	Voltage Regulator	——	——	——	——	——	——	87	55–60	2.0	——	——
265	Voltage Regulator	**4AJ**	Cold	——	——	——	——	130	90	5–30	——	——
266	Voltage Regulator	**4AJ**	Cold	——	——	——	——	——	70	5–40	——	——
267	Relay Tube	**4V**	Cold	——	——		Characteristics same as OA4G					
050	Grid-Controlled Rectifier	**8BA**	Htr.	6.3	0.6	650	500	——	——	100	0.1–10[4]	8
551	Voltage Regulator	**5BO**	Cold	——	——	115	——	115	87	1.5–3.5	——	——
562	Thyratron—Fuse	**Fig. 79**	Htr.	6.3	1.5	200[3]	I_k to fuse—150 Amp., 60 cycle, half-wave					50 V.
596	Relay Service	**7BN**	Htr.	6.3	0.15	500[3]	100 ma. peak current; 25-ma. average.					
727	Gas Thyratron	**7BN**	Htr.	6.3	0.6	650	——	——	——	——	——	——
823	Relay or Trigger	**4CK**	Cold	——	——	Max. peak inv. volts = 200; Peak Ma. = 100; Avg. Ma. = 25.						
390	Shunt Regulator	**12J**	Htr.	6.3	0.6	E_{G1} = −60 volts; E_{G2} = 200 volts; E_{G3} = 5500 volts. E_P = 30000 volts; I_{G2} = 0 Ma.; I_P Max. = 0.5 Ma.						
962	Voltage Regulator	**2AG**	Cold	——	——	——	——	730	700	5/55[5]	——	——
998	Series Regulator	**8BD**	Htr.	6.3	2.4	250	125	——	110	100	350[6]	——
308	Voltage Regulator	**8EX**	Cold	——	——	——	3.5	115	87	——	——	——
354	Voltage Regulator	**Fig. 12**	Cold	——	——	——	——	180	150	5–15	——	——
Y21	Grid-Controlled Rectifier	——	Fil.	2.5	10.0	——	——	——	3000	500	——	——
X61	Radio-Controlled Relay	——[1]	Fil.	1.4	0.05	45	1.5	30	——	0.5–1.5	3[4]	30

1 No base. Tinned wire leads.
2 At 1000 anode volts.
3 Peak inverse voltage.
4 Megohms.
5 Values in μ amperes.
6 Cathode resistor-ohms.

TABLE X—RECTIFIERS—RECEIVING AND TRANSMITTING

See Also Table IX—Control and Regulator Tubes

Type	Name	Base	Cathode	Fil. or Heater Volts	Fil. or Heater Amp.	Max. A.C. Voltage Per Plate	D.C. Output Current Ma.	Max. Inverse Peak Voltage	Peak Plate Current Ma.	Type
1G3-GT/ 1B3-GT	Half-Wave Rectifier	3C	Fil.	1.25	0.2	—	1.0	33000	30	HV
1K3/1J3	Half-Wave Rectifier	3C	Fil.	1.25	0.2	—	0.5	26000	50	HV
1V2	Half-Wave Rectifier	9U	Fil.	0.625	0.3	—	0.5	7500	10	HV
2B25	Half-Wave Rectifier	3T	Fil.	1.4	0.11	1000	1.5	—	9	HV
2X2-A	Half-Wave Rectifier	4AB	Htr.	2.5	1.75	4500	7.5	—	—	HV
2Y2	Half-Wave Rectifier	4AB	Fil.	2.5	1.75	4400	5.0	—	—	HV
2Z2/G84	Half-Wave Rectifier	4B	Fil.	2.5	1.5	350	50	—	—	HV
3B24	Half-Wave Rectifier	Fig. 49	Fil.	5.0	3.0	—	60	20000	300	HV
				2.5[5]	3.0	—	30	20000	150	
3B28	Half-Wave Rectifier	4P	Fil.	2.5	5.0	—	250	10000	1000	HV
5AU4	Full-Wave Rectifier	5T	Fil.	5.0	4.5	300[3]	350[3]	1400	1075	HV
						400[3]	325[3]			
						500[4]	325[4]			
5AW4	Full-Wave Rectifier	5T	Fil.	5.0	4.0	450[3]	250[3]	1550	750	HV
						550[4]	250[4]			
5R4GY 5R4GYA	Full-Wave Rectifier	5T	Fil.	5.0	2.0	900[3]	150[3]	2800	650	HV
						950[4]	175[4]			
5T4	Full-Wave Rectifier	5T	Fil.	5.0	2.0	450	250	1250	800	HV
5U4G	Full-Wave Rectifier	5T	Fil.	5.0	3.0	Same as Type 5Z3				HV
5U4GA	Full-Wave Rectifier	5T	Fil.	5.0	3.0	300[3]	275[3]	1550	900	HV
						450[3]	250[3]			
						550[4]	250[4]			
5U4GB 5AS4A	Full-Wave Rectifier	5T	Fil.	5.0	3.0	300[3]	300[3]	1550	1000	HV
						450[3]	275[3]			
						550[4]	275[4]			
5V3	Full-Wave Rectifier	5T	Htr.	5.0	3.8	425[3] 500[4]	350	1400	1200	HV
5V4GA	Full-Wave Rectifier	5L	Htr.	5.0	2.0	375[3]	175	1400	525	HV
5W4GT	Full-Wave Rectifier	5T	Fil.	5.0	1.5	350	110	1000	—	HV
5X4G	Full-Wave Rectifier	5Q	Fil.	5.0	3.0	Same as Type 5Z3				HV
5Y3-G-GT	Full-Wave Rectifier	5T	Fil.	5.0	2.0	Same as Type 80				HV
5Y4-G-GT	Full-Wave Rectifier	5Q	Fil.	5.0	2.0	Same as Type 80				HV
5Z3	Full-Wave Rectifier	4C	Fil.	5.0	3.0	500	250	1400	—	HV
5Z4	Full-Wave Rectifier	5L	Htr.	5.0	2.0	400[4]	125	1100	—	HV
6AV4	Full-Wave Rectifier	5BS	Htr.	6.3	0.95	—	90	1250	250	HV
6AX5GT	Full-Wave Rectifier	6S	Htr.	6.3	1.2	450	125	1250	375	HV
6BW4	Full-Wave Rectifier	9DJ	Htr.	6.3	0.9	450	100	1275	350	HV
6BX4	Full-Wave Rectifier	5BS	Htr.	6.3	0.6	—	90	1350	270	HV
6BY5G	Full-Wave Rectifier	6CN	Htr.	6.3	1.6	375[3]	175	1400	525	HV
6CA4	Full-Wave Rectifier	9M	Htr.	6.3	1.0	350[3]	150	1000	450	HV
6DA4	Half-Wave Diode	4CG	Htr.	6.3	1.2	—	155	4400	900	HV
6U4GT	Half-Wave Rectifier	4CG	Htr.	6.3	1.2	—	138	1375	660	HV
6V4	Full-Wave Rectifier	9M	Htr.	6.3	0.6	350	90	—	—	HV
6X4/6063 6X5GT	Full-Wave Rectifier	7CF 6S	Htr.	6.3	0.6	325[3] 450[4]	70	1250	210	HV
6Z3	Half-Wave Rectifier	4G	Fil.	6.3	0.3	350	50	—	—	HV
12DF5	Full-Wave Rectifier	9BS	Htr.	6.3	0.9	450	100	1275	350	HV
				12.6	0.45					
12X4	Full-Wave Rectifier	5BS	Htr.	12.6	0.3	650[3]	70	1250	210	HV
						900[4]	70	1250	210	
25Z3	Half-Wave Rectifier	4G	Htr.	25	0.3	250	50	—	—	HV
25Z5	Rectifier-Doubler	6E	Htr.	25	0.3	125	100	—	500	HV
25Z6	Rectifier-Doubler	7Q	Htr.	25	0.3	125	100	—	500	HV
35W4	Half-Wave Rectifier	5BQ	Htr.	35[1]	0.15	125	60	330	600	HV
35Z4GT	Half-Wave Rectifier	5AA	Htr.	35	0.15	250	100	700	600	HV
35Z5G	Half-Wave Rectifier	6AD	Htr.	35[1]	0.15	125	60	—	—	HV
36AM3	Half-Wave Rectifier	5BQ	Htr.	36	0.1	117	75	365	530	HV
50DC4	Half-Wave Rectifier	5BQ	Htr.	50	0.15	117	100	330	720	HV
50Y6GT	Full-Wave Rectifier	7Q	Htr.	50	0.15	125	85	—	—	HV
50Z6G	Voltage Doubler	7Q	Htr.	50	0.3	125	150	—	—	HV
80	Full-Wave Rectifier	4C	Fil.	5.0	2.0	350[3]	125	1400	375	HV
						500[4]	125			
83	Full-Wave Rectifier	4C	Fil.	5.0	3.0	500	250	1400	800	MV
83-V	Full-Wave Rectifier	4AD	Htr.	5.0	2.0	400	200	1100	—	HV
84/6Z4	Full-Wave Rectifier	5D	Htr.	6.3	0.5	350	60	1000	—	HV
117L7GT/[6] 117M7GT	Rectifier-Tetrode	8AO	Htr.	117	0.09	117	75	—	—	HV
117N7GT	Rectifier-Tetrode	8AV	Htr.	117	0.09	117	75	350	450	HV
117P7GT[6]	Rectifier-Tetrode	8AV	Htr.	117	0.09	117	75	350	450	HV
117Z3	Half-Wave Rectifier	4CB	Htr.	117	0.04	117	90	330	—	HV
816	Half-Wave Rectifier	4P	Fil.	2.5	2.0	2200	125	7500	500	MV
836	Half-Wave Rectifier	4P	Htr.	2.5	5.0	—	—	5000	1000	HV
866-A-AX	Half-Wave Rectifier	4P	Fil.	2.5	5.0	3500	250	10000	1000	MV
866B	Half-Wave Rectifier	4P	Fil.	5.0	5.0	—	—	8500	1000	MV
866 Jr.	Half-Wave Rectifier	4B	Fil.	2.5	2.5	1250	250[2]	—	—	MV
872A/872	Half-Wave Rectifier	4AT	Fil.	5.0	7.5	—	1250	10000	5000	MV

[1] Tapped for pilot lamps.
[2] Per pair with choke input.
[3] Capacitor input.
[4] Choke input.
[5] Using only one-half of filament.
[6] Obsolete.

TABLE XI—TRIODE TRANSMITTING TUBES

Type	Maximum Ratings: Plate Dissipation Watts	Plate Voltage	Plate Current Ma.	D.C. Grid Current Ma.	Freq. Mc. Full Ratings	Amplification Factor	Cathode: Volts	Amperes	Capacitances: C_{in} $\mu\mu f.$	C_{gp} $\mu\mu f.$	C_{out} $\mu\mu f.$	Base	Typical Operation: Class of Service[1]	Plate Voltage	Grid Voltage	Plate Current Ma.	D.C. Grid Current Ma.	Approx. Driving Power Watts	P-to-P Load Ohms	Approx. Output Power Watts
8-A	0.6	135	7	1.0	500	12	1.25	0.1	0.6	2.6	0.8	5BD	C·T·O	135	−20	7	1.0	0.035	—	0.6
6A‡[2]	1.5	300	30	16	250	32	6.3	0.45	2.2	1.6	0.4	7BF	C·T	150	−10	30	16	0.35	—	3.5
02	1.6	250	8	2.0	250	25	6.3	0.15	1.2	1.4	1.1	7BS	C·T·O	180	−35	7	1.5	—	—	0.5
5	1.6	180	8	2.0	250	25	6.3	0.15	1.0	1.4	0.6	5BC	C·T·O	180	−35	7	1.5	—	—	0.5
'114B	1.8	180	12	3.0	300	13	1.4	0.155	1.0	1.3	1.0	2T	C·T·O	180	−30	12	2.0	0.2	—	1.4[3]
													C·P	180	−35	12	2.5	0.3	—	1.4[3]
4	2.0	150	20	8.0	500	17	6.3	0.225	2.0	1.9	0.6	7BR	C·T·O	150	−15 550* 2000[4]	20	7.5	0.2	—	1.8
AU7A[2]	2.75[6]	350	12[6]	3.5[6]	54	18	6.3	0.3	1.5	1.5	0.5	9A	C·T·O	350	−100	24	7	—	—	6.0
26	3.0	150	30	10	400	24	6.3	0.2	2.2	1.3	0.38	Fig. 16	C·T·O	135	1300[4]	20	9.5	—	—	1.25
'615 '-E1148	3.5	300	20	4.0	300	20	6.3	0.175	1.4	1.6	1.2	Fig. 71	C·T·O	300	−35	20	2.0	0.4	—	4.0[3]
													C·P	300	−35	20	3.0	0.8	—	3.5[3]
4	5.0	350	25	8.0	54	18	6.3	0.15	1.8	1.6	1.3	6BG	C·T·O	300	−27	25	7.0	0.35	—	5.5
36	5	1500[5]	—	—	1200	25	6.3	0.4	1.4	2.4	0.36	Fig. 21	C·T·O[10]	1000[5]	0	900[5]	—	—	—	200[5]
37	5	350	—	—	3300	25	6.3	0.4	1.4	1.85	0.02	Fig. 21	C·T·O[12]	150	3000[4]	15	3.6	—	—	0.5
64	5	1500[5]	11.5	—	3300	25	6.3	0.4	1.4	1.85	0.02	Fig. 21	C·T·O[16]	1000[5]	0	1300[5]	—	—	—	200[5]
75	5	165	30	8	3000	20	6.3	0.135	2.3	1.3	0.09	Fig. 21	G·G·O	120	−8	25	4	—	—	0.05
I7[2]	5.5[6]	350	30[6]	5.0[6]	10	35	6.3	0.8	—	—	—	8B	C·T·O[11]	350	−100	60	10	—	—	14.5
40	6.5	500	25	—	500	36	6.3	0.75	2.1	1.3	0.05	Fig. 11	C·T·O	250	−5	20	0.3	—	—	0.075
93	8.0	400	40	13	1000	27	6.0	0.33	2.5	1.75	0.07	Fig. 21	C·T	350	−33	35	13	2.4	—	6.5
													C·P	300	−45	30	12	2.0	—	6.5
.-6442	8.0	350	35	15	2500	47	6.3	0.9	5.0	2.3	0.03	—	C·T	350	−50	35	15	—	—	—
													C·P	275	−50	35	15	—	—	—
34/ :34[2]	10	300	80	20	250	13	6.3	0.8	3.4	2.4	0.5	Fig. 70	C·T·O	300	−36	80	20	1.8	—	16
43	12	500	40	—	1250	48	6.3	0.9	2.9	1.7	0.05	Fig. 11	C·T·O	470	—	38[7]	—	—	—	9[7]
63	13	400	55	25	500	27	6.3	0.28	2.9	1.7	0.08	—	C·T	350	−58	40	15	3	—	10
													C·P	320	−52	35	12	2.4	—	8
64	13	400	50	25	500	40	6.3	0.28	2.95	1.75	0.07	—	C·T	350	−45	40	15	3	—	8
Y	15	450	65	15	8	8.0	7.5	1.25	4.1	7.0	3.0	4D	C·T·O	450	−100	65	15	3.2	—	19
													C·P	350	−100	50	12	2.2	—	12
'75A	15	450	90	25	175	9.6	6.3	2.6	1.8	2.6	1.0	2T	C·T	450	−140	90	20	5.2	—	26
													C·P	400	−140	90	20	5.2	—	21
1-A/801	20	600	70	15	60	8.0	7.5	1.25	4.5	6.0	1.5	4D	C·T	600	−150	65	15	4.0	—	25
													C·P	500	−190	55	15	4.5	—	18
													B[7]	600	−75	130	320[9]	3.0[8]	10K	45
0	20	750	85	25	60	20	7.5	1.75	4.9	5.1	0.7	3G	C·T	750	−85	85	18	3.6	—	44
													C·P	750	−140	70	15	3.6	—	38
20	20	750	85	30	60	62	7.5	1.75	5.3	5.0	0.6	3G	C·T	750	−40	85	28	3.75	—	44
													C·P	750	−100	70	23	4.8	—	38
													B[7]	800	0	40/136	160[9]	1.8[8]	12K	70
E[18]	20	—	—	—	600	25	5.5	4.2	1.4	1.15	0.3	Fig. 51	C·T·O	2000	−130	63	18	4.0	—	100
T 25A3	25	2000	75	25	60	24	6.3	3.0	2.7	1.5		3G		1500	−95	67	13	2.2	—	75
														1000	−70	72	9	1.3	—	47
													B[7]	2000	−80	16/80	270[9]	0.7[8]	55.5K	110
28[18]	25	2000	75	25	100	23	6.3	3.0	2.1	1.8	0.1	Fig. 31	C·T·O	2000	−170	63	17	4.5	—	100
34[18]					60				2.5	1.7	0.4	3G		1500	−110	67	15	3.1	—	75
25D3					150				2.0	1.6	0.2	2D		1000	−80	72	15	2.6	—	47
G									1.7	1.5	0.3		B[7]	2000	−85	16/80	290[9]	1.1[8]	55.5K	110
24	25	2000	75	7[13]	60	24	6.3	3.0	1.7	1.6	0.2	2D	C·T	2000	−130	63	18	4	—	100
	17	1600	60										C·P	1600	−170	53	11	3.1	—	68
	25	2000	75										AB_2[7]	1250	−42	24/130	270[9]	3.4[8]	21.4K	112
:24	25	2000	75	30	60	25	6.3	3.0	2.5	1.7	0.4	3G	C·T	2000	−140	56	18	4.0	—	90
													C·P	1500	−145	50	25	5.5	—	60
25	30	1000	65	—	500	18	6.3	1.92	2.7	2.8	0.35	4AQ	G·M·A	1000	−135	50	4	3.5	—	20
	20		65	20									C·P	800	−105	40	10.5	1.4	—	22
	30		80	20									C·T	1000	−90	50	14	1.6	—	35
'31Z[2] '1231Z[2]	30	500	150	30	60	45	6.3	3.5	5.0	5.5	1.9	Fig. 60	C·T	500	−45	150	25	2.5	—	56
							12.6	1.7					C·P	400	−100	150	30	3.5	—	45
6A -191	30	450	80	12	500	6.5	2.0	3.65	1.2	1.6	0.8	—	C·T	450	—	80	12	—	—	7.5
													C·P	400	—	80	12	—	—	6.5
9	30	1000	125	—	60	50	6.3	2.5	5.7	6.7	0.9	3G	C·T	1000	−75	100	25	3.8	—	75
													C·P	750	−60	100	32	4.3	—	55
													B[7]	1000	−9	40/200	155[9]	2.7[8]	11.6K	145
23	30	1000	100	25	60	20	6.3	2.5	5.7	6.7	0.9	3G	C·T·O	1000	−90	100	20	3.1	—	75
													C·P	750	−125	100	20	4.0	—	55
													B[7]	1000	−40	30/200	230[9]	4.2[8]	12K	145
12 .-8012-A	40	1000	80	20	500	18	6.3	2.0	2.7	2.8	0.35	Fig. 54	C·T·O	1000	−90	50	14	1.6	—	35
									2.7	2.5	0.4		C·P	800	−105	40	10.5	1.4	—	22
													G·M·A	1000	−135	50	4.0	3.5	—	20
0	40	1500	150	40	60	25	7.5	2.5	4.5	4.8	0.8	3G	C·T·O	1500	−140	150	28	9.0	—	158
													C·P	1250	−115	115	20	5.25	—	104
40	40	1500	150	45	60	62	7.5	2.5	4.8	5.0	0.8	3G	C·T·O	1500	−90	150	38	10	—	165
													C·P	1250	−100	125	30	7.5	—	116
													B[7]	1500	−9	250[8]	285[9]	6.0[8]	12K	250
50A4 T	50	2000	150	50	100	39	5.0	4.0	4.1	1.8	0.3	3G	C·T	2000	−135	125	45	13	—	200
50D4 TG									2.5		0.4	2D	C·P	1500	−150	90	40	11	—	105
													B[7]	2000	−40	4/167	255[9]	4.0[8]	27.5K	235

1 See page V27 for Key to Class-of-Service abbreviations.

TABLE XI—TRIODE TRANSMITTING TUBES—*Continued*

Type	Maximum Ratings: Plate Dissipation Watts	Plate Voltage	Plate Current Ma.	D.C. Grid Current Ma.	Freq. Mc. Full Ratings	Amplification Factor	Cathode: Volts	Amperes	Capacitances: C_{in} μμf.	C_{gp} μμf.	C_{out} μμf.	Base	Typical Operation: Class of Service[1]	Plate Voltage	Grid Voltage	Plate Current Ma.	D.C. Grid Current Ma.	Approx. Driving Power Watts	P-to-P Load Ohms	Approx. Output Power Watts
HK54	50	3000	150	30	100	27	5.0	5.0	1.9	1.9	0.2	2D	C·T	3000	−290	100	25	10	—	250
													C·P	2500	−250	100	20	8.0	—	210
													B[7]	2500	−85	20/150	360[9]	5.0	40K	275
T55	55	1500	150	40	60	20	7.5	3.0	5.0	3.9	1.2	3G	C·T	1500	−170	150	18	6.0	—	170
													C·P	1500	−195	125	15	5.0	—	145
811	55	1500	150	50	60	160	6.3	4.0	5.5	5.5	0.6	3G	C·T	1500	−113	150	35	8.0	—	170
													C·P	1250	−125	125	50	11	—	120
													B[7]	1500	−9	20/200	150[9]	3.0[8]	17.6K	220
812	55	1500	150	35	60	29	6.3	4.0	5.3	5.3	0.8	3G	C·T	1500	−175	150	25	6.5	—	170
													C·P	1250	−125	125	25	6.0	—	120
													B[7]	1500	−45	50/200	232[9]	4.7[8]	18K	220
826	55	1000	140	40	250	31	7.5	4.0	3.0	2.9	1.1	7BO	C·T·O	1000	−70	130	35	5.8	—	90
													C·P	1000	−160	95	40	11.5	—	70
													G·M·A	1000	−125	65	9.5	8.2	—	25
830B 930B	60	1000	150	30	15	25	10	2.0	5.0	11	1.8	3G	C·T·O	1000	−110	140	30	7.0	—	90
													C·P	800	−150	95	20	5.0	—	50
													B[7]	1000	−35	20/280	270[9]	6.0[8]	7.6K	175
811-A[19]	65	1500	175	50	60	160	6.3	4.0	5.9	5.6	0.7	3G	C·T	1500	−70	173	40	7.1	—	200
													C·P	1250	−120	140	45	10.0	—	135
													B[7]	1500	−4.5	32/313	170[9]	4.4[8]	12.4K	340
812-A	65	1500	175	35	60	29	6.3	4.0	5.4	5.5	0.77	3G	C·T	1500	−120	173	30	6.5	—	190
													C·P	1250	−115	140	35	7.6	—	130
													B[7]	1500	−48	28/310	270[9]	5.0	13.2K	340
5514	65	1500	175	60	60	145	7.5	3.0	7.8	7.9	1.0	4BO	C·T	1500	−106	175	60	12	—	200
													C·P	1250	−84	142	60	10	—	135
													B[7]	1500	−4.5	350[8]	88[8]	6.5[8]	10.5K	400
3-75A3 75TH	75	3000	225	40	40	20	5.0	6.25	2.7	2.3	0.3	2D	C·T	2000	−200	150	32	10	—	225
													C·P	2000	−300	110	15	6	—	170
													B[7]	2000	−90	50/225	350[9]	3[8]	19.3K	300
3-75A2 75TL	75	3000	225	35	40	12	5.0	6.25	2.6	2.4	0.4	2D	C·T	2000	−300	150	21	8	—	225
													C·P	2000	−500	130	20	14	—	210
													AB_2[7]	2000	−190	50/250	600[9]	5[8]	18K	350
8005	85	1500	200	45	60	20	10	3.25	6.4	5.0	1.0	3G	C·T	1500	−130	200	32	7.5	—	220
													C·P	1250	−195	190	28	9.0	—	170
													B[7]	1500	−70	40/310	310[9]	4.0	10K	300
V-70-D	85	1750	200	45	30	—	7.5	3.25	4.5	4.5	1.7	3G	C·T	1750	−100	170	19	3.9	—	225
														1500	−90	165	19	3.9	—	195
													C·P	1500	−90	165	19	3.7	—	185
														1250	−72	127	16	2.6	—	122
3-100A4 100TH	100	3000	225	60	40	40	5.0	6.3	2.9	2.0	0.4	2D	C·T	3000	−200	165	51	18	—	400
													C·P							
													B[7]	3000	−65	40/215	335[9]	5.0[8]	31K	650
3-100A2 100TL	100	3000	225	50	40	14	5.0	6.3	2.3	2.0	0.4	2D	C·T	3000	−400	165	30	20	—	400
													C·P							
													G·M·A	3000	−560	60	2.0	7.0	—	90
													B[7]	3000	−185	40/215	640[9]	6.0[8]	30K	450
VT127A	100	3000	—	—	150	15.5	5.0	10.4	2.7	2.3	0.35	Fig. 53	C·T	2000	−340	210	67	25	—	315
													B[7]	1500	−125	242	44	7.3	3K	200
211 311	100	1250	175	50	15	12	10	3.25	6.0	14.5	5.5	4E	C·T	1250	−225	150	18	7.0	—	130
									6.0	9.25	5.0		C·P	1000	−260	150	35	14	—	100
													B[7]	1250	−100	20/320	410[9]	8.0[8]	9K	260
254	100	4000	225	60	—	25	5.0	7.5	2.5	2.7	0.4	2N	C·T	3000	−245	165	40	18	—	400
													C·P	2500	−360	168	40	23	—	335
													B[7]	2500	−80	40/240	460[9]	25	25.2K	420
8003	100	1500	250	50	30	12	10	3.25	5.8	11.7	3.4	3N	C·T·O	1350	−180	245	35	11	—	250
													C·P	1100	−260	200	40	15	—	167
													B[7]	1350	−100	40/490	480[9]	10.5[8]	6K	460
3CX100A5[15]	100	1000	125[14]	50	2500	100	6.0	1.05	7.0	2.15	0.035	—	G·G·A	800	−20	80	30	6	—	27
	70	600	100[14]										C·P	600	−15	75	40	6	—	18
3X100A11 2C39	100	1000	60	40	500	100	6.3	1.1	6.5	1.95	0.03	—	G·I·C	600	−35	60	40	5.0	—	20
GL2C39A[15]	100	1000	125[14]	50	500	100	6.3	1.0	6.5	1.9	0.035	—	C·T·O	900	−40	90	30	—	—	40
GL2C39B[15]	70								7.0	1.9	0.035		C·P	600	−150	100[14]	50	—	—	—
3C22	125	1000	150	70	500	40	6.3	2.0	4.9	2.4	0.05	Fig. 17	C·T·O	1000	−200	150	70	—	—	65
GL146	125	1500	200	60	15	75	10	3.25	7.2	9.2	3.9	Fig. 56	C·T·O	1250	−150	180	30	—	—	150
													C·P	1000	−200	160	40	—	—	100
													B[7]	1250	0	34/320	—	—	8.4K	250
GL152	125	1500	200	60	15	25	10	3.25	7.0	8.8	4.0	Fig. 56	C·T·O	1250	−150	180	30	—	—	150
													C·P	1000	−200	160	30	—	—	100
													B[7]	1250	−40	16/320	—	—	8.4K	250
805	125	1500	210	70	30	40–60	10	3.25	8.5	6.5	10.5	3N	C·T	1500	−105	200	40	8.5	—	215
													C·P	1250	−160	160	60	16	—	140
													B[7]	1500	−16	84/400	280[9]	7.0[8]	8.2K	370
AX9900/ 5866[15]	135	2500	200	40	150	25	6.3	5.4	5.8	5.5	0.1	Fig. 3	C·T	2500	−200	200	40	16	—	390
													C·P	2000	−225	127	40	16	—	204
													B[7]	2500	−90	80/330	350[9]	14[8]	15.68K	560
3-150A3 152TH	150	3000	450	85	40	20	5.0	12.5	5.7	4.8	0.4	4BC	C·T	3000	−300	250	70	27	—	600
							10	6.25					C·P	2500	−350	200	30	15	—	400
													B[7]	2500	−125	40/340	390[9]	16[8]	17K	600

[1] See page V27 for Key to Class-of-Service abbreviations.

TABLE XI—TRIODE TRANSMITTING TUBES—*Continued*

Type	Maximum Ratings: Plate Dissipation Watts	Plate Voltage	Plate Current Ma.	D.C. Grid Current Ma.	Freq. Mc. Full Ratings	Amplification Factor	Cathode: Volts	Amperes	Capacitances: C_{in} μμf.	C_{gp} μμf.	C_{out} μμf.	Base	Typical Operation: Class of Service[1]	Plate Voltage	Grid Voltage	Plate Current Ma.	D.C. Grid Current Ma.	Approx. Driving Power Watts	P-to-P Load Ohms	Approx. Output Power Watts
-150A2 52TL	150	3000	450	75	40	12	5	12.5	4.5	4.4	0.7	4BC	C·T	3000	−400	250	40	20	—	600
							10	6.25					B[7]	3000	−260	65/335	675[9]	3[8]	20.4K	700
IF201A	150	2500	200	50	30	18	10–11	4.0	8.8	7.0	1.2	Fig. 15	C·T	2500	−300	200	18	8	—	380
													C·P	2000	−350	160	20	9	—	250
													B[7]	2500	−130	60/360	460[9]	8[8]	16K	600
;L-5C24	160	1750	107	—	—	8	10	5.2	5.6	8.8	3.3	Fig. 15	A1	1500	−155	107	—	—	8.2K[5]	55
													AB1	1750	−200	320[8]	390[9]	—	8K	240
10	175	2500	300	75	30	36	10	4.5	8.7	4.8	12	2N	C·T	2500	−180	300	60	19	—	575
													C·P	2000	−350	250	70	35	—	380
													G·M·A	2250	−140	100	2.0	4	—	75
													B[7]	2250	−60	70/450	380[9]	13[8]	11.6K	725
000	175	2500	300	45	30	16.5	10	4.5	5.0	6.4	3.3	2N	C·T·O	2500	−240	300	40	18	—	575
													C·P	2000	−370	250	37	20	—	380
													G·M·A	2250	−265	100	0	2.5	—	75
													B[7]	2250	−130	65/450	560[9]	7.9[8]	12K	725
200	200	2500	350	80	30	16	10	5.75	9.5	7.9	1.6	2N	C·T	2500	−280	350	54	25	—	685
													C·P	2000	−260	300	54	23	—	460
92/[15] -200A3	200	3500	250	25[13]	150	25	10	5.0	3.6	3.3	0.29	Fig. 28	C·T	3500	−270	228	30	15	—	600
	130	2600	200	25[13]									C·P	2500	−300	200	35	19	—	375
	200	3500	250	25[13]									B[7]	2000	−50	120/500	520[9]	20[8]	8.5K	600
C34 F300	200	3000	275	60	60	23	11–12	4.0	6.0	6.5	1.4	2N	C·T	3000	−400	250	28	16	—	600
					20								C·P	2000	−300	250	36	17	—	385
													B[7]	3000	−115	60/360	450[9]	13[8]	20K	780
-300	200	3000	300	—	—	23	11	6.0	6.0	7.0	1.4	—	C·T	3000	−400	250	28	20	—	600
													C·P	2000	−300	250	36	17	—	385
													B[7]	2500	−100	60/450	—	7.5[8]	—	750
06	225	3300	300	50	30	12.6	5.0	10	6.1	4.2	1.1	2N	C·T	3300	−600	300	40	34	—	780
													C·P	3000	−670	195	27	24	—	460
													B[7]	3300	−240	80/475	930[9]	35[8]	16K	1120
-250A4 50TH	250	4000	350	40[13]	40	37	5.0	10.5	4.6	2.9	0.5	2N	C·T·O	2000	−100	357	94	29	—	464
														3000	−150	333	90	32	—	750
													C·P	2000	−160	250	60	22	—	335
														2500	−180	225	45	17	—	400
														3000	−200	200	38	14	—	435
													AB2[7]	1500	0	220/700	460[9]	46[8]	4.2K	630
-250A2 50TL	250	4000	350	35[13]	40	14	5.0	10.5	3.7	3.0	0.7	2N	C·T·O	2000	−200	350	45	22	—	455
														3000	−350	335	45	29	—	750
													C·P	2000	−520	250	29	24	—	335
														2500	−520	225	20	16	—	400
														3000	−520	200	14	11	—	435
													AB2[7]	1500	−40	200/700	780[9]	38[8]	3.8K	580
867 .X-9901	250	3000	400	80	100	25	5.0	14.1	7.7	5.9	0.18	Fig. 3	C·T	3000	−250	363	69	27	—	840
													C·P	2500	−300	250	70	28	—	482
													B[7]	3000	−110	570[8]	465[9]	32	14.2K	1280
L-6569[19]	250	4000	300	120	30	45	5.0	14.5	7.6	3.7	0.1	Fig. 3	G·G·A	2500	−70	300	85	75[20]	—	555
														3000	−95	300	110	85[20]	—	710
														3500	−110	285	90	85[20]	—	805
														4000	−120	250	50	70[20]	—	820
-300A3 04TH	300	3000	900	60[13]	40	20	5.0	25	13.5	10.2	0.7	4BC	C·T·O	1500	−125	665	115	25	—	700
														2000	−200	600	125	39	—	900
													C·P	1500	−200	420	55	18	—	500
							10	12.5						2000	−300	440	60	26	—	680
														2500	−350	400	60	29	—	800
													AB2[7]	1500	−65	1065[8]	330[9]	25[8]	2.84K	1000
-300A2 04TL[19]	300	3000	900	50[13]	40	12	5.0	25	12.1	8.6	0.8	4BC	C·T·O	1500	−250	665	90	33	—	700
														2000	−300	600	85	36	—	900
													C·P	2000	−500	250	30	18	—	410
														2000	−500	500	75	52	—	810
														2500	−525	200	18	11	—	425
														2500	−550	400	50	36	—	830
							10	12.5					AB1[7]	1500	−118	270/572	236[9]	0	2.54K	256
														2500	−230	160/483	460[9]	0	8.5K	610
													AB2[7]	1500	−118	1140[8]	490[9]	39[8]	2.75K	1100
33A	350	3300	500	100	30	35	10	10	12.3	6.3	8.5	Fig. 41	C·T·O	2250	−125	445	85	23	—	780
														3000	−160	335	70	20	—	800
	450[15]	4000[15]			20[15]								C·P	2500	−300	335	75	30	—	635
														3000	−240	335	70	26	—	800
													B[7]	3000	−70	100/750	400[9]	20[8]	9.5K	1650
L-6580[19]	400	4000[15]	350	120	—	45	5.0	14.5	7.6	3.9	0.1	5BK	G·G·A	4000	−110	350	92	105[20]	—	1080
														2500	−70	350	95	85	—	660

Cathode resistor in ohms.

KEY TO CLASS-OF-SERVICE ABBREVIATIONS
- A1 = Class-A1 a.f. modulator.
- AB1 = Class-AB1 push-pull a.f. modulator.
- AB2 = Class-AB2 push-pull a.f. modulator.
- B = Class-B push-pull a.f. modulator.
- C·M = Frequency multiplier.
- C·P = Class-C plate-modulated telephone.
- C·T = Class-C telegraph.
- C·T·O = Class-C amplifier-osc.
- G·G·A = Grounded-grid class-C amp.
- G·G·O = Grounded-grid osc.
- G·I·C = Grid-isolation circuit.
- G·M·A = Grid-modulated amp.

2 Twin triode. Values, except interelectrode capacitances, are for both sections in push-pull.
3 Output at 112 Mc.
4 Grid leak resistor in ohms.
5 Peak valves.
6 Per section.
7 Values are for two tubes in push-pull.
8 Max. signal value.
9 Peak a.f. grid-to-grid volts.
10 Plate-pulsed 1000-Mc. osc.
11 Class-B data in Table II.
12 1000-Mc. c.w. osc.
13 Max. grid aissipation in watts.
14 Max. cathode current in ma.
15 Forced-air cooling required.
16 Plate-pulsed 3300-Mc. osc.
17 1900-Mc. c.w. osc.
18 No Class-B data available.
19 Linear-amplifier tube-operation data for single sideband in Table 11-1.
20 Includes bias loss, grid dissipation, and feed-through power.

TABLE XII—TETRODE AND PENTODE TRANSMITTING TUBES

Type	Maximum Ratings: Plate Dissipation Watts	Plate Voltage	Screen Dissipation Watts	Screen Voltage	Freq. Mc. Full Ratings	Cathode: Volts	Amperes	Capacitances: C_{in} μμf.	C_{gp} μμf.	C_{out} μμf.	Base	Typical Operation: Class of Service[14]	Plate Voltage	Screen Voltage	Suppressor Voltage	Grid Voltage	Plate Current Ma.	Screen Current Ma.	Grid Current Ma.	Approx. Driving Power Watts	P-to-P Load Ohms	Approx. Output Power Watts
6939[3]	7.5	275	3	200	500	6.3	0.75	6.6	0.15	1.55	Fig. 13	C·T	200	200	—	−20	60	13	2	1.0	—	7.5
						12.6	0.375					C·P	180	180	—	−20	55	11.5	1.7	1.0	—	6
												C·M	200	190	—	68K[1]	46	10	2.2	0.9	—	—
RK25	10	500	8	250	—	2.5	2	10	0.2	10	6BM	C·T	500	200	45	−90	55	38	4	0.5	—	22
						6.3	0.9					C·P	400	150	0	−90	43	30	6	0.8	—	13.5
2E30	10	250	2.5	250	160	6	0.7	10	0.5	4.5	7CQ	C·T	250	200	—	−50	50	10	2.5	0.2	—	7.5
												AB$_2$[6]	250	250	—	−30	40/120	4/20	2.3[7]	0.2	3.8K	17
837	12	500	8	300	20	12.6	0.7	16	0.2	10	6BM	C·T	500	200	40	−70	80	15	4	0.4	—	28
												C·P	400	140	40	−40	45	20	5	0.3	—	11
7551 / 7558	12	300	2	250	175	12.6	0.38	10	0.15	5.5	9LK	C·T	300	250	—	−55	80	5.1	1.6	1.5	—	10
						6.3	0.8					C·P	250	250	—	−75	70	3.0	2.3	1.0	—	7.5
5763 / 6417	13.5	350	2	250	50	6.0	0.75	9.5	0.3	4.5	9K	C.T.	350	250	—	−28.5	48.5	6.2	1.6	0.1	—	12
						12.6	0.375					C·P	300	250	—	−42.5	50	6	2.4	0.15	—	10
												C·M[2]	300	250	—	−75	40	4	1	0.6	—	2.1
												C·M[4]	300	235	—	−100	35	5	1	0.6	—	1.3
2E24	13.5	600	2.5	200	125	6.3[5]	0.65	8.5	0.11	6.5	7CL	C·P	500	180	—	−45	54	8	2.5	0.16	—	18
												C·T	600	195	—	−50	66	10	3	0.21	—	27
2E26[13] / 6893	13.5	600	2.5	200	125	6.3	0.8	12.5	0.2	7	7CK	C·T	600	185	—	−45	66	10	3	0.17	—	27
						12.6	0.4					C·P	500	180	—	−50	54	9	2.5	0.15	—	18
												AB$_2$[6]	500	125	—	−15	22/150	32[7]	—	0.36[7]	8K	54
6360[3]	14	300	2	200	200	6.3	0.82	6.2	0.1	2.6	Fig. 13	C·T	300	200	—	−45	100	3	3	0.2	—	18.5
						12.6	0.41					C·P	200	100	—	15K[1]	86	3.1	3.3	0.2	—	9.8
												C·M[11]	300	150	—	−100	65	3.5	3.8	0.45	—	4.8
												AB$_2$	300	200	—	−21.5	30/100	1/11.4	64[8]	0.04	6.5K	17.5
2E25	15	450	4	250	125	6	0.8	8.5	0.15	6.7	5BJ	C·T·O	450	250	—	−45	75	15	3	0.4	—	24
												C·P	400	200	—	−45	60	12	3	0.4	—	16
												AB$_2$[6]	450	250	—	−30	44/150	10/40	3	0.9[7]	6K	40
832A[3]	15	750	5	250	200	6.3	1.6	8	0.07	3.8	7BP	C·T	750	200	—	−65	48	15	2.8	0.19	—	26
						12.6	0.8					C·P	600	200	—	−65	36	16	2.6	0.16	—	17
1619	15	400	3.5	300	45	2.5	2	10.5	0.35	12.5	Fig. 74	C·T	400	300	—	−55	75	10.5	5	0.36	—	19.5
												C·P	325	285	—	−50	62	7.5	2.8	0.18	—	13
												AB$_2$[6]	400	300	0	−16.5	75/150	6.5/11.5	—	0.4[7]	6K	36
5516	15	600	5	250	80	6	0.7	8.5	0.12	6.5	7CL	C·T	600	250	—	−60	75	15	5	0.5	—	32
												C·P	475	250	—	−90	63	10	4	0.5	—	22
												AB$_2$[6]	600	250	—	−25	36/140	1/24	4[7]	0.16	10.5K	67
6252/ AX9910[3]	20	750	4	300	300	6.3	1.3	6.5	—	2.5	Fig. 7	C·T	600	250	—	−60	140	14	4	2.0	—	—
						12.6	0.65					C·P	500	250	—	−80	100	12	3	4.0	—	—
												B	500	250	—	−26	25/73	0.7/16	52[8]	—	20K	23.5
1614	25	450	3.5	300	80	6.3	0.9	10	0.4	12.5	7AC	C·T	450	250	—	−45	100	8	2	0.15	—	31
												C·P	375	250	—	−50	93	7	2	0.15	—	24.5
												AB$_1$[6]	530	340	—	−36	60/160	20[7]	—	—	7.2K	50
815[3]	25	500	4	200	125	6.3	1.6	13.3	0.2	8.5	8BY	C·T·O	500	200	—	−45	150	17	2.5	0.13	—	56
						12.6	0.8					C·P	400	175	—	−45	150	15	3	0.16	—	45
												AB$_2$	500	125	—	−15	22/150	32[7]	—	0.36[7]	8K	54
1624	25	600	3.5	300	60	2.5	2	11	0.25	7.5	Fig. 66	C·T	600	300	—	−60	90	10	5	0.43	—	35
												C·P	500	275	—	−50	75	9	3.3	0.25	—	24
												AB$_2$[6]	600	300	—	−25	42/180	5/15	106[8]	1.2[7]	7.5K	72
6146[13]	25	750	3	250	60	6.3	1.25	13.5	0.22	8.5	7CK	C·T	500	170	—	−66	135	9	2.5	0.2	—	48
													750	160	—	−62	120	11	3.1	0.2	—	70
												C·T[12]	400	190	—	−54	150	10.4	2.2	3.0	—	35
6883						12.6	0.625					C·P	400	150	—	−87	112	7.8	3.4	0.4	—	32
													600	150	—	−87	112	7.8	3.4	0.4	—	52
												AB$_2$[6]	600	190	—	−48	28/270	1.2/20	2[7]	0.03	5K	113
6159						26.5	0.3						750	165	—	−46	22/240	0.3/20	2.6[7]	0.04	7.4K	131
												AB$_1$[6]	750	195	—	−50	23/220	1/26	100[8]	0	8K	120
6524[3] / 6850	25	600	—	300	100	6.3	1.25	7	0.11	3.4	Fig. 76	C·T	600	200	—	−44	120	8	3.7	0.2	—	56
						12.6	0.625					C·P	500	200	—	−61	100	7	2.5	0.2	—	40
												AB$_2$	500	200	—	−26	20/116	0.1/10	2.6	0.1	11.1K	40
807[13] / 807W / 5933	30	750	3.5	300	60	6.3	0.9	12	0.2	7	5AW	C·T	750	250	—	−45	100	6	3.5	0.22	—	50
												C·P	600	275	—	−90	100	6.5	4	0.4	—	42.5
												AB$_2$[6]	750	300	—	−32	60/240	5/10	92[8]	0.2[7]	6.95K	120
1625[13]						12.6	0.45				5AZ	B[10]	750	—	—	0	15/240	—	555[8]	5.3[7]	6.65K	120
2E22	30	750	10	250	—	6.3	1.5	13	0.2	8	5J	C·T·O	750	250	22.5	−60	100	16	6	0.55	—	53
AX-9903[3] / 5894	40	600	7	250	250	6.3	1.8	6.7	0.08	2.1	Fig. 7	C·T	600	250	—	−80	200	16	2	0.2	—	80
						12.6	0.9					C·P	600	250	—	−100	200	24	8	1.2	—	85
829B[3] / 3E29[3]	40	750	7	240	200	6.3	2.25	14.5	0.12	7	7BP	C·T	500	200	—	−45	240	32	12	0.7	—	83
						12.6	1.125					C·P	425	200	—	−60	212	35	11	0.8	—	63
												B	500	200	—	−18	27/230	—	56[8]	0.39	4.8K	76
HY1269	40	750	5	300	6	6.3	3.5	16	0.25	7.5	Fig. 65	C·T·O	750	300	—	−70	120	15	4	0.25	—	63
						12.6	1.75					C·P	600	250	—	−70	100	12.5	5	0.5	—	42
												AB$_2$[6]	600	300	—	−35	200[7]	—	—	0.3	—	80
3D24	45	2000	10	400	125	6.3	3	6.5	0.2	2.4	Fig. 75	C·T·O	2000	375	—	−300	90	20	10	4.0	—	140
													1500	375	—	−300	90	22	10	4.0	—	105
4D22	50	750	14	350	60	12.6 / 25.2	1.6 / 0.8	28	0.27	13	Fig. 26	C·T	750	300	—	−100	240	26	12	1.5	—	135
													600	300	—	−100	215	30	10	1.25	—	100
4D32						6.3	3.75				Fig. 27	C·P	600	—	—	−100	220	28	10	1.25	—	100
													550	—	—	−100	175	17	6	0.6	—	70
												AB$_2$[6]	600	250	—	−25	100/365	26[7]	70[8]	0.45[7]	3K	125
814	65	1500	10	300	30	10	3.25	13.5	0.1	13.5	Fig. 64	C·T	1500	300	—	−90	150	24	10	1.5	—	160
												C·P	1250	300	—	−150	145	20	10	3.2	—	130

[14] See page V29 for Key to Class-of-Service abbreviations.

Type	Maximum Ratings: Plate Dissipation Watts	Plate Voltage	Screen Dissipation Watts	Screen Voltage	Freq. Mc. Full Ratings	Cathode: Volts	Amperes	Capacitances: C_{in} μμf.	C_{gp} μμf.	C_{out} μμf.	Base	Typical Operation: Class of Service[14]	Plate Voltage	Screen Voltage	Suppressor Voltage	Grid Voltage	Plate Current Ma.	Screen Current Ma.	Grid Current Ma.	Approx. Driving Power Watts	P-to-P Load Ohms	Approx. Output Power Watts
4-65A[13]	65	3000	10	600	150	6	3.5	8	0.08	2.1	Fig. 25	C·T·O	1500	250	—	−85	150	40	18	3.2	—	165
													3000	250	—	−100	115	22	10	1.7	—	280
												C·P	1500	250	—	−125	120	40	16	3.5	—	140
													2500	250	—	−135	110	25	12	2.6	—	230
												AB_2[6]	1800	250	—	−50	50/250	30[7]	180[8]	2.6[7]	20K	270
4E27/ 8001	75	4000	30	750	75	5	7.5	12	0.06	6.5	7BM	C·T	2000	500	60	−200	150	11	6	1.4	—	230
												C·P	1800	400	60	−130	135	11	8	1.7	—	178
HK257 HK257B	75	4000	25	750	75[16]	5	7.5	13.8	0.04	6.7	7BM	C·T	2000	500	60	−200	150	11	6	1.4	—	230
												C·P	1800	400	60	−130	135	11	8	1.7	—	178
PL-6549	75	2000	10	600	175	6	3.5	7.5	0.09	3.4	Fig. 14	C·T	2000	400	70	−125	150	12	5	0.8	—	270
												C·P	2000	400	70	−140	125	15	4	0.7	—	200
												AB_2[6]	2000	400	70	−85	30/225	0.1/10	180[8]	0.05[7]	19K	325
828	80	2000	23	750	30	10	3.25	13.5	0.05	14.5	5J	C·T	1500	400	75	−100	180	28	12	2.2	—	200
												C·P	1250	400	75	−140	160	28	12	2.7	—	150
												AB_1[6]	2000	750	60	−120	50/270	2/60	240	0	18.5K	385
6816[9]	115	1000	4.5	300	400	6.3	2.1	14	0.085	0.015	Fig. 77	C·T·O	900	300	—	−30	170	1	10	3	—	80
												C·P	700	250	—	−50	130	10	10	3	—	45
6884						26.5	0.52					AB_1[6]	850	300	—	−15	80/200	0/20	30[8]	0	7K	80
												AB_2[6]	850	300	—	−15	80/355	0/25	46[8]	0.3	3.96K	140
813[13]	125	2500	20	800	30	10	5	16.3	0.25	14	5BA	C·T·O	1250	300	0	−75	180	35	12	1.7	—	170
													2250	400	0	−155	220	40	15	4	—	375
												C·P	1250	300	0	−160	150	35	13	2.9	—	140
													2000	350	0	−175	200	40	16	4.3	—	300
												AB_2[6]	2000	750	0	−90	40/315	1.5/58	230[8]	0.1[7]	16K	455
													2500	750	0	−95	35/360	1.2/55	235[8]	0.35[7]	17K	650
4-125A[13] 4D21 6155	125	3000	20	600	120	5	6.5	10.8	0.07	3.1	5BK	C·T·O	2000	350	—	−100	200	50	12	2.8	—	275
													3000	350	—	−150	167	30	9	2.5	—	375
												C·P	2000	350	—	−220	150	33	10	3.8	—	225
													2500	350	—	−210	152	30	9	3.3	—	300
												AB_2[6]	2500	350	—	−43	93/260	0/6	178[8]	1.0[7]	22K	400
												AB_1[6]	2500	600	—	−96	50/232	0.3/8.5	192[8]	0	20.3K	330
4E27A/ 5-125B	125	4000	20	750	75	5	7.5	10.5	0.08	4.7	7BM	C·T	3000	500	60	−200	167	5	6	1.6	—	375
													1000	750	0	−170	160	21	3	0.6	—	115
803	125	2000	30	600	20	10	5	17.5	0.15	29	5J	C·T	2000	500	40	−90	160	45	12	2	—	210
												C·P	1600	400	100	−80	150	45	25	5	—	155
7094	125	2000	20	400	60	6.3	3.2	9.0	0.5	1.8	Fig. 82	C·T	1500	400	—	−100	330	20	5	4	—	340
												C·P	1200	400	—	−130	275	20	5	5	—	240
												AB_1	2000	400	—	−65	60/400	—	120[8]	0	12K	560
4X150A	150[9]	1250	12	400	500	6	2.6	15.5	0.03	4.5	Fig. 75	C·T·O	1250	250	—	−90	200	20	10	0.8	—	195
												C·P	1000	250	—	−105	200	20	15	2	—	140
4X150G[15]						2.5	6.25	27	0.035	4.5	—	AB_2[6]	1250	300	—	−44	475[7]	0/65	100[8]	0.15[7]	5.6K	425
4-250A[13] 5D22 6156	250[9]	4000	35	600	110	5	14.5	12.7	0.12	4.5	5BK	C·T·O	2500	500	—	−150	300	60	9	1.7	—	575
													3000	500	—	−180	345	60	10	2.6	—	800
												C·P	2500	400	—	−200	200	30	9	2.2	—	375
													3000	400	—	−310	225	30	9	3.2	—	510
												AB_2[6]	2000	300	—	−48	510[7]	0/26	198[8]	5.5[7]	8K	650
												AB_1[6]	2500	600	—	−110	430[7]	0.3/13	180[8]	0	11.4K	625
4X250B	250[9]	2000	12	400	175	6	2.1	18.5	0.04	4.7	Fig. 75	C·T·O	2000	250	—	−90	250	25	27	2.8	—	410
												C·P	1500	250	—	−100	200	25	17	2.1	—	250
												AB_1[6]	2000	350	—	−50	500[7]	30[7]	100[8]	0	8.26K	650
7034/[9] 4X150A	250	2000	12	300	150	6	2.6	16	0.03	4.4	Fig. 75	C·T·O	2000	250	—	−88	250	24	8	2.5	—	370
												C·P	1600	250	—	−118	200	23	5	3	—	230
7035/[13] 4X150D	250	2000	12	400		26.5	0.58					AB_2[6]	2000	300	—	−50	100/500	0/36	106[8]	0.2	8.1K	630
												AB_1[6]	2000	300	—	−50	100/470	0/36	100[8]	0	8.76K	580
4CX-300A	300[9]	2000	12	400	500	6	2.75	29.5	0.04	4.8	—	C·T	2000	250	—	−90	250	25	27	2.8	—	410
												C·P	1500	250	—	−100	200	25	17	2.1	—	250
												AB_1[6]	2000	350	—	−50	500[7]	30[7]	100[8]	0	8.26K	650
4-400A	400[9]	4000	35	600	110	5	14.5	12.5	0.12	4.7	5BK	C·T·C·P	4000	300	—	−170	270	22.5	10	10	—	720
4-1000A	1000	6000	75	1000	—	7.5	21	27.2	.24	7.6	—	C·T	3000	500	—	−150	700	146	38	11	—	1430
												C·P	3000	500	—	−200	600	145	36	12	—	1390
												AB_2	4000	500	—	−60	300/1200	0/95	—	11	7K	3000
4CX1000A	1000	3000	12	350	—	6	12.5	35	.005	12	—	AB_1	2000	325	—	−55	500/2000	−4/60	—	—	2.8K	2160
													2500	325	—	−55	500/2000	−4/60	—	—	3.1K	2920
													3000	325	—	−55	500/1800	−4/60	—	—	3.85K	3360
PL-172	1000	3000	35	600	—	6	7.8	38	.09	18	—	C·T	2000	400	75	−150	725	44	22	4.1	—	1110
													2500	500	75	−175	960	64	31	6.8	—	1870
													3000	500	75	−175	900	56	24	4.8	—	2170
												AB_1	2000	500	75	−110	400/1600	20/90	210[8]	—	2.65K	1820
													2500	500	75	−110	440/1600	20/85	210[8]	—	3.5K	310
													3000	500	75	−115	440/1500	10/75	200[8]	—	4.6K	2680

1 Grid-resistor.
2 Doubler to 175 Mc.
3 Dual tube. Values for both sections, in push-pull. Interelectrode capacitances, however, are for each section.
4 Tripler to 175 Mc.
5 Filament limited to intermittent operation.
6 Values are for two tubes in push-pull.
7 Max.-signal value.
8 Peak grid-to-grid a.f. volts.
9 Forced-air cooling required.
10 Two tubes triode connected, G_2 to G_1 through 20K Ω. Input to G_2.
11 Tripler to 200 Mc.
12 Typical Operation at 175 Mc.
13 Linear-amplifier tube-operation data for single-sideband in Chap. 11.
14 KEY TO CLASS-OF-SERVICE ABBREVIATIONS
- AB_1 = Class-AB_1 push-pull a.f. modulator.
- AB_2 = AB_2 push-pull a.f. modulator.
- B = Class-B push-pull a.f. modulator.
- C·M = Frequency multiplier.
- C·P = Class-C plate-modulated telephone.
- C·T = Class-C telegraph.
- C·T·O = Class-C amplifier-osc.

15 No Class B data available.
16 HK257B 120 Mc. full rating.

TABLE XIII—ELECTROSTATIC CATHODE-RAY TUBES

Type[6]	Heater		Base	Anode No. 2 Voltage	Anode No. 1 Voltage[1]	Anode No. 3 Voltage	Cut-off Grid Voltage[2]	Deflection Avg. Volts DC/Inch	
	Volts	Amp.						D_1 D_2	D_3 D_4
1EP1-2-11	6.3	0.6	11V	1000	100/300	—	−14/−42	210/310	240/350
2AP1A	6.3	0.6	11L	1000	250	—	−30/−90	230	196
2BP1-11	6.3	0.6	12E	2000	300/560	—	−135	270	174
3ACP1-7-11	6.3	0.6	14J	2000	545	4000	−45/−75	180/220	133/163
3AP1-4—906-P1-4-5-11	2.5	2.1	7AN	1500	430	—	−25/−75	114	109
3AP1A			7CE						
3BP1-4-11	6.3	0.6	14A	2000	575	—	−30/−90	200	148
3BP1A			14G						
3CP1	6.3	0.6	11C	2000	575	—	−30/−90	124	165
3DP1A—3DP7	6.3	0.6	14H	2000	575	—	−30/−90	220	148
3EP1—1806-P1	6.3	0.6	11N	2000	575	—	−30/−90	221	165
3FP7	6.3	0.6	14B	2000	575	4000	−30/−90	250	180
3FP7A			14J						
3GP1-4-5-11	6.3	0.6	11A	1500	350	—	−25/−75	120	105
3GP1A—3GP4A	6.3	0.6	11N	1500	245/437	—	−25/−75	96/144	84/126
3JP1-2-4-7-11-12	6.3	0.6	14J	2000	400/690	4000	−30/−90	170/230	125/270
3JP1A-7A-11A	6.3	0.6	14J	2000	400/690	4000	−45/−75	180/220	133/163
3KP1-4-11	6.3	0.6	11M	2000	320/600	—	−0/−90	100/136	76/104
3MP1[3]	6.3	0.6	12F	2000	400/700	—	−126	230/290	220/280
3RP1—4-3RP1A	6.3	0.6	12E	2000	330/620	—	−135	146/198	104/140
3SP1-4-7	6.3	0.6	12E	2000	330/620	—	−28/−135	146/198	104/140
3UP1	6.3	0.6	12F	2000	320/620	—	−126	240/310	232/296
3WP1-2-11	6.3	0.6	12T	2000	330/620	—	−60/−100	83/101	57/70
5ABP1-7-11	6.3	0.6	14J	2000	400/690	4000	−52/−87	26/34	18/24
5ADP1-7-11	6.3	0.6	14J	1500	300/515	3000	−34/−56	40/50	30.5/37.5
5AJP1	6.3	0.6	Fig. 78	500	400/900	6000	−30/−60	230	230
5AMP1	6.3	0.6	14U	2500	0/300	—	−34/−56	40/50	20/25
5AP1—1805-P1	6.3	0.6	11A	1500	430	—	−31/−57	93	90
5AP4—1805-P4	6.3	0.6	11A	1500	430	—	−17.5/−57	93	90
5AQP1	6.3	0.6	14G	2500	0/300	—	−34/−56	40/50	31.5/38.5
5ATP1-2-7-11	6.3	0.6	14V	6000	0/700	—	−34/−56	94/116	34/42
5BP1—1802-P1-2-4-5-11	6.3	0.6	11A	2000	425	—	−20/−60	84	76
5BP1A	6.3	0.6	11N	2000	450	—	−20/−60	84	76
5BP7A	6.3	0.6	11N	2000	375/560	—	−20/−60	70/98	63/89
5CP1-2-4-5-7-11	6.3	0.6	14B	2000	575	4000	−30/−90	92	78
5CP1A			14J						
5CP1B-2B-7B-11B	6.3	0.6	14J	2000	400/690	4000	−45/−75	83/101	70/86
5CP7A—11A-12	6.3	0.6	14J	2000	575	4000	−30/−90	92	74
5GP1	6.3	0.6	11A	2000	425	—	−24/−56	36	72
5HP1-4	6.3	0.6	11A	2000	425	—	−20/−60	84.8	77
5HP1A	6.3	0.6	11N	2000	450	—	−20/−60	84	76
5JP1A—4A	6.3	0.6	11S	2000	333/630	4000	−45/−105	77/115	77/115
5LP1A—4A	6.3	0.6	11T	2000	376/633	4000	−30/−90	83/124	72/108
5MP1-4-5-11	2.5	2.1	7AN	1500	375	—	−15/−45	66	60
5NP1-4	6.3	0.6	11A	2000	450	—	−20/−60	84	76
5RP1A-4A	6.3	0.6	14P	2000	362/695	20000	−30/−90	140/210	131/197
5SP1-4	6.3	0.6	14K	2000	363/695	4000	−30/−90	74/110	62/94
5UP1-7-11	6.3	0.6	12E	2000	340/360	—	−90	56/77	46/62
5VP7	6.3	0.6	11N	2000	315/562	—	−20/−60	70/98	63/89
5XP1	6.3	0.6	14P	2000	362/695	20000	−30/−90	140/210	46/68
5XP1A-2A-11A	6.3	0.6	14P	2000	362/695	12000	−45/−75	130/159	42/52
5YP1	6.3	0.6	14Q	2000	541/1040	6000	−45/−135	108/162	36/54
7EP4	6.3	0.6	11N	3000	546/858	—	−43/−100	106/158	91/137
7GP4[3]	6.3	0.6	14G	3000	810/1200	—	−36/−84	93/123	75/102
7JP1-P4-P7	6.3	0.6	14R	6000	1620/2400	—	−72/−168	186/246	150/204
7VP1	6.3	0.6	14R	3000	800/1200	—	−84	93/123	75/102
24XH	6.3	0.6	Fig. 1	600	120	—	−60	0.14[5]	0.16[5]
902-A	6.3	0.6	8CD	600	150	—	−30/−90	139	117
905	2.5	2.1	5BP	2000	450	—	−17.5/−52.5	115	97
905-A			5BR						
907			5BP						
908-A	2.5	2.1	7CE	1500	430	—	−25/−75	114	109
913	6.3	0.6	913	500	1000	—	−20/−60	299	221
2002	6.3	0.6	Fig. 1	600	120	—	—	0.16[5]	0.17[5]
2005	2.5	0.6	Fig. 1[4]	2000	1000	200	−35	0.5[5]	0.56[5]

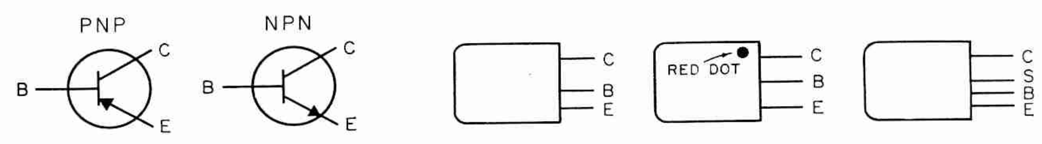
[1] Bogey value for focus. Voltage should be adjustable about value shown.
[2] Bias for visual extinction of undeflected spot. Voltage should be adjustable from 0 to the higher value shown.
[3] Discontinued.
[4] Cathode connected to Pin 7.
[5] In mm. /volt d.c.
[6] Phosphor characteristics (see next column).

Designation	Color and persistance	Application
P1	Green medium	Oscilloscope.
P2	Blue-green medium	Special oscilloscopes and radar.
P4	White medium	Television.
P5	Blue very short	Photographic recording of high speed traces.
P7	Blue-white short / Yellow long.	Radar indicators.
P11	Blue short	Oscilloscope.
P12	Orange long	Radar indicators.

TABLE XIV—TRANSISTORS

No.	Type	Maximum Ratings				Characteristics			Typical Operation Common Emitter Circuit					
			Collector		Emitter					Collector				
		Diss. Mw.	Ma.	Volts	Ma.	Noise Figure Db.	Input Res. Ohms[1]	Freq. Cutoff Mc.	Use	Ma.	Volts	Power Gain Db.	Output Load R. Ohms	Power Output Mw.
2N34	PNP	50	50	−25	10	18	1000	0.6	Audio[2]	−1.0	−6	40	30K	125
2N35	NPN	50	100	25	−10	16	1000	0.8	Audio[2]	1.0	6	40	30K	125
2N43	PNP	155	−50	−45	50	6	—	1.3	Audio	−1.0	−5	39	—	—
2N44	PNP	155	−50	−45	50	6	—	1.0	Audio	−1.0	−5	43	—	—
2N68	PNP	2500	−1500	−25	1500	—	—	0.4	Audio	−150.0	−12	23	100	600
2N78	NPN	75	20	15	−20	12	—	6.0	I.F.-R.F.	—	—	30	—	—
2N94	NPN	50	50	20	—	—	—	2.0	I.F.	0.5	6	24	100K	—
2N94A	NPN	50	50	20	—	15	—	5.0	I.F.-R.F.	0.5	6	30	100K	—
2N104	PNP	—	−50	−30	50	12	—	0.7	Audio	−1.0	−15	32	—	—
2N105	PNP	35	−15	−25	15	4.5	2300	0.014	Audio	−0.7	−4	42	20K	—
2N107	PNP	50	−10	−12	10	22	700	0.6	—	−1.0	−5	38	30K	—
2N109	PNP	50	−35	−12	35	—	750	—	Audio[2]	−35.0	−4.5	30	200	75
2N123	PNP	100	−150	−20	150	—	—	7.5	Switching	−5.0	−15	—	—	—
2N131A	PNP	100	−100	−30	—	22	—	0.8	Audio	−1.0	−6	—	—	—
2N132A	PNP	130	−10	−12	—	20	1000	1.2	Audio	−1.0	−6	42	30K	—
2N139	PNP	35	−15	−16	15	4.5	500	—	I.F.	−1.0	−9	30	30K	—
2N140	PNP	35	−15	−16	15	—	700	7.0	I.F.-R.F.	−0.4	−9	27	75K	—
2N155	PNP	8500	−3000	−30	—	—	20	0.3	Audio[2]	−360.0	−14	30	—	9[3]
2N167	NPN	65	75	30	—	—	—	8.0	I.F.-R.F.	—	—	—	—	—
2N169A	NPN	55	20	25	−20	—	500	5.0	I.F.-R.F.	1.0	5	27	15K	—
2N175	PNP	20	−2	−10	2	6	3570	—	Audio	−0.5	−4	43	—	—
2N218	PNP	35	−15	−16	15	4.5	500	—	I.F.	−1.0	−9	30	30K	—
2N219	PNP	35	−15	−16	15	—	700	7.0	I.F.-R.F.	−0.4	−9	27	75K	—
2N233	NPN	50	100	10	—	—	—	2.0	I.F.	—	—	21	—	—
2N247	PNP	35	−10	−35	10	8	—	30.0	R.F.	−1.0	−9	24	—	—
2N248	PNP	30	—	−25	—	—	—	50	R.F.	—	—	—	—	—
2N255	PNP	1500	−3000	−15	—	—	—	0.2	Audio[2]	−500.0	−6	27	—	5[3]
2N256	PNP	1500	−3000	−30	—	—	—	0.2	Audio[2]	−500.0	−12	27	—	10[3]
2N270	PNP	150	−75	−12	−75	—	—	—	Audio[2]	—	−12	32	—	500
2N274	PNP	35	−10	−35	10	8	—	30.0	R.F.	−1.0	−9	45	—	—
2N292	NPN	65	20	15	—	—	—	6.0	I.F.-R.F.	—	—	25	—	—
2N301	PNP	7500	−1000	−20	1000	—	—	—	Audio[2]	—	−14.4	30	—	12[3]
2N301A	PNP	7500	−1000	−30	1000	—	—	—	Audio[2]	—	−14.4	30	—	12[3]
2N306	NPN	50	—	20	—	—	—	0.6	Audio	—	—	—	—	—
2N307	PNP	10000	−1000	−35	—	—	—	0.3	Audio	—	—	30	—	—
2N331	PNP	200	−200	−30	200	9	—	1.0	Audio	−1.0	−6	44	—	—
2N351	PNP	10000	−3000	−40	3000	—	—	—	Audio[2]	−3000	−40	—	—	—
2N370	PNP	80	−10	−20	10	—	1750	30.0	R.F.	−1.0	−12	12.5	—	—
2N371	PNP	80	−10	−20	10	—	—	30.0	R.F.	−1.0	−12	—	—	—
2N372	PNP	80	−10	−20	10	—	100	30.0	Mixer	−1.0	−12	17	11K	—
2N374	PNP	80	−10	−25	10	—	2600	30.0	Conv.	−1.0	−12	40	—	—
2N376	PNP	10000	−3000	−30	3000	—	—	—	Audio[2]	−3000	−40	—	—	—
2N384	PNP	120	−10	−30	10	—	30	100.0	R.F.	−1.5	−12	15	—	—
2N411	PNP	80	−15	−13	15	—	700	10.0	I.F.-R.F.	−0.6	−9	32	—	—
2N412	PNP	80	−15	−13	15	—	700	10.0	I.F.-R.F.	−0.6	−9	32	—	—
2N428	PNP	150	−400	−30	400	—	—	17.0	R.F.	—	—	—	—	—
2N499	PNP	75	−50	−30	50	—	—	250.0	R.F.	—	—	—	—	—
2N544	PNP	80	−10	−18	10	—	2100	30.0	R.F.	1.0	−12	30	—	—
2N554	PNP	—	−3000	−30	3000	—	—	—	Audio	—	—	—	—	—
2N561	PNP	50000	−10000	−80	10000	—	—	—	Audio[2]	500	−28	35	150	10[3]
2N586	PNP	250	−250	−45	250	—	—	—	Switching	—	—	—	—	—
2N588	PNP	80	−50	−18	50	—	—	200.0	R.F.	—	—	—	—	—
2N677	PNP	50000	−15000	−50	—	—	—	—	Switching	—	—	60	—	—
2N1014	PNP	50000	−10000	−100	10000	—	—	—	Audio	—	—	—	—	—
2N1102	NPN	180	100	40	−100	—	500	—	Audio	—	—	—	—	—
2N1266	PNP	80	—	−10	—	—	—	—	I.F.	—	—	22	—	—
3N25	TET	25	−2	−15	2	—	—	200.0	R.F.	—	—	—	—	—
3N36	TET	30	30	7	—	—	—	50.0	R.F.	—	—	—	—	—
3N37	TET	30	20	7	—	—	—	90.0	R.F.	—	—	—	—	—
AO-1	SB	10	−5	−4.5	—	—	—	30.0	R.F.	—	—	—	—	—
CK722	PNP	180	−10	−22	10	25	800	—	—	−1.0	−6	39	20K	—
CK768	PNP	—	−5	−10	—	—	—	3.5	I.F.-R.F.	−1.0	−6	—	—	—
OC71	PNP	125	−10	−15	—	—	—	0.3	Audio	—	—	40	—	—
OC72	PNP	167	−125	−16	—	—	—	0.35	Audio	—	—	34	—	—
SB100	SB	10	−5	−4.5	—	—	—	30.0	R.F.	−0.5	−3	—	25K	—

1 Common emitter circuit
2 Two transistors in Class B
3 Power output watts



Code for identifying typical junction transistors. The leads are marked C-collector, B-base, E-emitter and S-interlead shield and metal case.

TABLE XV CRYSTAL DIODES

Type	Use	Max. Inverse Volts	Max. Average Ma.	Min. Forward Ma.[1]	Max. Reverse μ-Amp.
1N34	General Purpose	60	50	5.0	800 @ −50 V.
1N34A	General Purpose	75	50	5.0	500 @ −50 V.
1N35	General Purpose	50	22.5	7.5	100 @ −10 V.
1N38	General Purpose	100	50	3.0	625 @ −100 V.
1N38A	General Purpose	100	50	4.0	500 @ −100 V.
1N39A	General Purpose	225	40	4.0	600 @ −200 V.
1N48	General Purpose	85	50	4.0	833 @ −50 V.
1N52A	General Purpose	85	50	5.0	100 @ −50 V.
1N54A	Hi-Back Resistance	75	50	5.0	100 @ −50 V.
1N55A	General Purpose	170	50	4.0	500 @ −150 V.
1N56A	Hi-Conduction	50	60	15.0	300 @ −30 V.
1N58A	General Purpose	115	50	4.0	600 @ −100 V.
1N60	Vid. Detector	25	50	5.0	40 @ −20 V.
1N63	Hi-Back Resistance	125	50	4.0	50 @ −50 V.
1N64	Vid. Detector	20	50	0.1	25 @ −1.3 V.
1N65	General Purpose	85	50	2.5	200 @ −50 V.
1N66	General Purpose	60	50	5.0	800 @ −50 V.
1N67	Hi-Back Resistance	80	35	4.0	50 @ −50 V.
1N67A	Hi-Back Resistance	100	50	4.0	50 @ −50 V.
1N68	Hi-Back Resistance	100	35	3.0	625 @ −100 V.
1N68A	General Purpose	100	50	3.0	625 @ −100 V.
1N69A	General Purpose	75	40	5.0	500 @ −50 V.
1N70A	General Purpose	125	30	3.0	300 @ −50 V.
1N77A	Photo Diode	50 V., 20 MW			
1N81	General Purpose	50	30	3.0	10 @ −10 V.
1N82	Mixer	Max. Freq.—1000 Mc.	16 db. Noise Factor		
1N82A	Mixer	Max. Freq.—1000 Mc.	14 db. Noise Factor		
1N89	Restorer	80	30	3.5	100 @ −50 V.
1N90	General Purpose	75	30	5.0	750 @ −50 V.
1N91	Pwr. Rectifier	100	150	470 @ 0.5 V.	2700 @ −100 V.
1N95	General Purpose	60	250	10.0	500 @ −50 V.
1N96	General Purpose	60	250	20.0	500 @ −50 V.
1N97	General Purpose	80	250	10.0	100 @ −50 V.
1N98	Hi-Back Resistance	100	250	20.0	100 @ −50 V.
1N99	General Purpose	80	300	10.0	50 @ −50 V.
1N100	General Purpose	80	300	20.0	50 @ −50 V.
1N116	General Purpose	60	30	5.0	100 @ −50 V.
1N117	General Purpose	60	30	10.0	100 @ −50 V.
1N118	General Purpose	60	30	20.0	100 @ −50 V.
1N126A	General Purpose	75	30	5.0	850 @ −50 V.
1N127A	General Purpose	125	30	3.0	300 @ −50 V.
1N128	General Purpose	50	30	3.0	10 @ −10 V.
1N151	General Purpose	100	500	1570 @ 0.7 V.	2400 @ −100 V.
1N152	General Purpose	200	500	1570 @ 0.7 V.	1900 @ −200 V.
1N153	General Purpose	300	500	1570 @ 0.7 V.	1200 @ −300 V.
1N158	Pwr. Rectifier	380	500	—	—
1N191	Computer	90	30	5.0	25 @ −10 V.
1N192	Computer	70	30	5.0	50 @ −10 V.
1N198A	Hi-Temperature	100	30	4.0	250 @ −50 V. (75°C)
1N279	Hi-Conduction	35	—	100.0	200 @ −20 V.
1N283	Hi-Conduction	25	—	200.0	80 @ −10 V.
1N294	Switching	70	60	5.0	800 @ −50 V.
1N295	Vid. Detector	40	—	—	—
1N448	100-Volt Computer	120	—	25.0	100 @ −100 V.
1N634	60-Volt Very Low Z	120	—	50.0	115 @ −100 V.
1N636	General Purpose	75	—	2.5	20 @ −20 V.
HB1	Zener Diode	Zener Volts = 7.5			
HB2	Zener Diode	Zener Volts = 20			
HB3	Zener Diode	Zener Volts = 40			
HB4	Zener Diode	Zener Volts = 75			
HB5	Zener Diode	Zener Volts = 170			
HB6	Zener Diode	Zener Volts = 300			
M150	Silicon Power Rectifier	Max. Rms. Input: 130 V., Peak Inverse: 400 V., D.C. Current: 150 Ma.			
M500	Silicon Power Rectifier	Max. Rms. Input: 130 V., Peak Inverse: 400 V., D.C. Current: 500 Ma.			
V15	Capacitor Diode	Max. Oper. Voltage −25, Range: 6.5–39 μμf.			Q At 50 Mc. −18
V20	Capacitor Diode	Max. Oper. Voltage −20, Range: 10–50 μμf.			Q At 50 Mc. −18.7
V27	Capacitor Diode	Max. Oper. Voltage −20, Range: 14–70 μμf.			Q At 50 Mc. −15.7
V33	Capacitor Diode	Max. Oper. Voltage −20, Range: 17–85 μμf.			Q At 50 Mc. −14.6
V39	Capacitor Diode	Max. Oper. Voltage −20, Range: 20–100 μμf.			Q At 50 Mc. −15.1
V47	Capacitor Diode	Max. Oper. Voltage −20, Range: 24–120 μμf.			Q At 50 Mc. −15.4
V56	Capacitor Diode	Max. Oper. Voltage −50, Range: 32–145 μμf.			Q At 50 Mc. −13.5

[1] At +1 Volt

The Catalog Section

☆ ☆ ☆

In the following pages is a catalog file of products of the principal manufacturers and the principal distributors who serve the radio field: industrial, commercial, amateur. All firms whose advertising has been accepted for this section have met The American Radio Relay League's rigid standards for established integrity; their products and engineering methods have received the League's approval.

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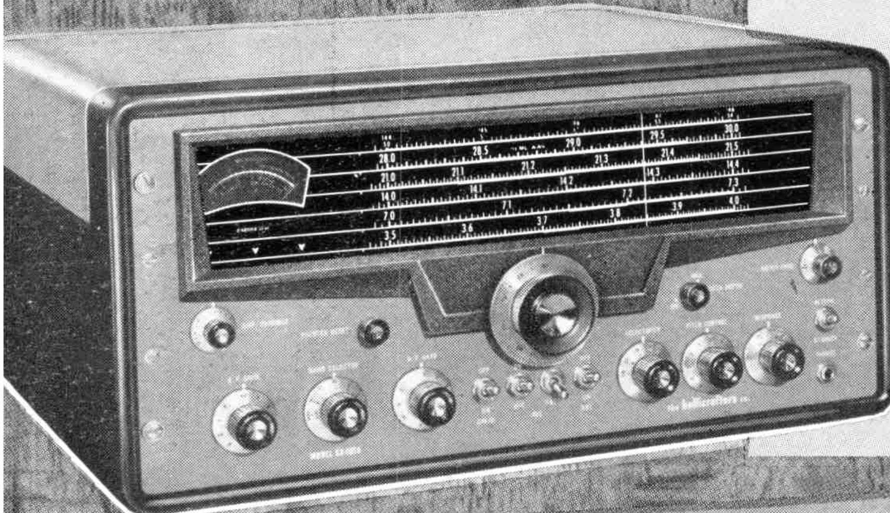
SX-101A Receiver



Heavyweight champion in stability, performance!

SX101A is setting new standards for dependability and ruggedness throughout the amateur world. It's *all* amateur; provides complete coverage, and every technical feature desired for years to come.

FREQUENCY COVERAGE: Band 1—30.5-34.5 Mc. Band 2—3.48-4.02 Mc. Band 3—6.99-7.31 Mc. Band 4—13.98-14.415 Mc. Band 5—20.99-21.52 Mc. Band 6—26.9-29.8 Mc. Band 7—10 Mc. WWV.

FEATURES: Complete coverage of five ham bands plus a 2 and 6 meter conv. band—80, 40, 20, 15, 10 meters. Large slide rule dial. Band-in-use scales individually illuminated. Illuminated S-

HT-32A
Transmitter

The new ideas in communications are born at . . .

effortless performance!

Beautifully engineered with extra-heavy-duty components, the HT-33A is *conservatively rated* at the maximum legal limit. You are guaranteed one of the big signals on the band, plus the effortless performance that means so much to efficiency and long life. (Conforms to F.C.D.A. specifications.)

FREQUENCY COVERAGE: Complete coverage of amateur bands; 80, 40, 20, 15, 10 meters.

FEATURES: Rated *conservatively* at the maximum legal input. Third and fifth order distortion products down in excess of 30 db. Built-in r.f. output meter greatly simplifies tune-up. All important circuits metered. Maximum harmonic suppression obtained through pi-network. Variable output loading. Protection of power supply assured by circuit breaker. HT-33A is a perfect match to Hallicrafters' famous HT-32 in size, appearance and drive requirements.

CIRCUIT DETAILS: This power amplifier utilizes a PL-172 high efficiency pentode operating in class AB1 or AB2. The tube is grid-driven across a non-inductive resistor, thus assuring the maximum stability under all possible conditions. Band switching is accomplished by one knob which selects the proper inductance value for each band. The output circuit is a pi-network with an adjustable output capacitor, so loads from 40 to 80 ohms may be accommodated. A d.c. milliameter may be switched to various circuits to measure the following: Cathode current, grid current, screen current, plate voltage, and r.f. voltage across the output line for tune-up.

TUBES: (1) PL-172 high power pentode; (2) 3B28 rectifiers; (4) OA2 screen regulators.

FRONT PANEL CONTROLS: Meter selector; Filament switch; High Voltage switch; Bias adjustment; Band switch; Plate tuning; Plate loading.

PHYSICAL DATA: Gray and black steel cabinet (matches HT-32) with brushed chrome knob trim. Size: 8¾″ x 19″ (relay rack panel). Shipping wt. approx. 130 lbs.

REAR CHASSIS: Co-ax input; co-ax output; filament and bias fuse; cutoff bias relay terminals; screen fuse; ground terminal.

meter. Dual scale S-meter. S-meter zero point independent of sensitivity control. S-meter functions with AVC off. Special 10 Mc. position for WWV. Dual conversion. Exclusive Hallicrafters' upper-lower sideband selection. Second conversion oscillators quartz crystal controlled. Tee-notch filter. Full gear drive from tuning knob to gang condensers—absolute reliability. 40:1 tuning knob ratio. Built-in precision 100 kc. evacuated marker crystal. Vernier pointer adjustment. Five steps of selectivity from 500 cycles to 5000 cycles. Precision temperature compensation plus Hallicrafters' exclusive production heat cycling for lowest drift. Direct coupled series noise limiter for improved noise reduction. Sensitivity—one microvolt or less on all amateur bands. 52 ohm antenna input. Antenna trimmer. Relay rack panel. Heaviest chassis in the industry—.089 cold rolled steel. Double spaced gang condenser. 13 tubes plus voltage regulator and rectifier. Powerline fuse.

FRONT PANEL CONTROLS: Main tuning knob with 0-100 logging dial. Pointer reset, antenna trimmer, tee-notch frequency, tee-notch depth, sensitivity, band selector, volume, selectivity, pitch (BFO), response — (upper-lower-sideband AM-CW). AVC on/off, AVC fast/slow, ANL on/off, Cal. on/off, Rec./standby.

TUBES AND FUNCTIONS: 6DC6, R.F. amplifier—6BY6, 1st converter—12 BY7A, high frequency oscillator—6BA6, 1650 kc. i.f. amplifier—12AT7, dual crystal controlled 2nd conversion oscillator—6BA6, 2nd converter—6DC6 51 kc. i.f. amplifier—6BJ7, AM detector, A.N.L., A.V.C.—6BY6 SSBCW detector—6SC7 1st audio amplifier & B.F.O.—6K6, audio power output — 6BA6, S-meter amplifier — 6AU6, 100 kc. crystal oscillator—OA2, voltage regulator—5Y3, rectifier.

PHYSICAL DATA: 20″ wide, 10½″ high and 16″ deep—Panel size 8¾″ x 19″—weight approximately 74 lbs. (Conforms to F.C.D.A. specifications.)

Acclaimed by the most critical!

Now proven superior — vastly superior — is Hallicrafters' exclusive 5.0 mc. quartz crystal filter system. First practical *high frequency* filter, provides unprecedented rejection of unwanted sideband—50 db. or more—and *world's cleanest signal.*
Another major advance: Bridged-Tee Modulator, temperature stabilized and compensated.

FEATURES: 5.0 mc. quartz crystal filter—rejection 50 db. or more. Bridged-tee modulator. C.T.O. direct reading in kilocycles to less than 300 cycles from reference point. 144 watts plate input (P.E.P. two-tone). Five band output (80, 40, 20, 15, 10 meters). All modes of transmission — CW, AM, S.S.B. Unwanted sideband down 50 db. or more. Distortion products down 30 db. or more. Carrier suppression down 50 db. or more. Both sidebands transmitted on A.M. Precision gear driven C.T.O. Exclusive Hallicrafters patented sideband selection. Logarithmic meter for accurately tuning and carrier level adjustment. Ideal CW keying and break-in operation, Push To Talk and full voice control system built in. Phone patch input provided. Keying circuit brought out for teletype keyer.

FRONT PANEL CONTROLS, FUNCTIONS AND CONNECTIONS: Operation—power off, standby, Mox., Cal., Vox.—P.T.T. Audio level 0-10 R.F. level 0-10. Final tuning 80, 40, 20, 15, 10 meters. Function—Upper sideband, lower sideband, DSB, CW. Meter compression. Calibration level 0-10. Driver tuning 0-5. Band selector—80, 40, 20, 15, 10 meters. High stability, gear driven V.F.O. with dial drag. Microphone con. Key jack. Headphone monitor jack.

TUBES AND FUNCTIONS: 2-6146 Power output amplifier. 6CB6 Variable frequency oscillator. 12BY7 R. F. driver. 6AH6 2nd Mixer. 6AH6 3rd Mixer. 6AB4 Crystal oscillator. 12AX7 Voice control. 12AT7 Voice control. 6AL5 Voice control. 12AX7 Audio Amp. 12AU7 Audio amp. and carrier Oscillator. 12AU7 Diode Modulator. 12AT7 Sideband selecting oscillator. 6AH6 1st Mixer. 6AH6 4.95 Mc. Amp. 6AU6 9.00 Mc. Amp. 5R4GY HV Rectifier. 5V4G LV Rectifier. OA2 Voltage Regulator.

REAR CHASSIS: Co-ax antenna connector. FSK jack A.C. accessory outlet. Line fuse. Control connector. AC power line cord. Cabinet 20″ wide, 10½″ high, and 17″ deep. Approximate shipping weight 86 lbs. (Conforms to F.C.D.A. specifications.)

hallicrafters

allicrafters brings you an entirely new class

The engineering team that developed the incomparable SX-101 and HT-32 now offers a precision rig that puts single sideband within reach of all

HT-37 Transmitter

The heart of the now-famous HT-32—*the needed, basic performance charactertistics*—is yours in this precision-engineered new AM/CW/SSB transmitter—and at a price we did not believe possible when we began designing it! Same power. Same rugged VFO construction, and identical VOX. You'll be amazed at the smooth, distinctive speech quality that's yours for the first time at moderate cost.

FEATURES: 144 watts plate input (P.E.P. two-tone); five band output (80, 40, 20, 15, 10 meters); all modes of transmission—CW, AM, S.S.B.; unwanted sideband down 40 db. at 1KC; distortion products down 30 db. or more; carrier suppression down 50 db.; modern styling; instant CW Cal. from any mode; both sidebands transmitted on AM; precision V.F.O.; rugged heavy duty deluxe chassis; 52 ohm pi network output for harmonic suppression; dual range meter for accurate tuning and carrier level adjustment; ideal CW keying; full voice control system built in.

FRONT PANEL CONTROLS, FUNCTIONS, CONNECTIONS: Operation—(power off, standby, mox, cal, vox); Audio gain; R.F. level; Final tuning; Function—(upper sideband, lower sideband, DSB, CW); carrier balance; Calibration level; Driver tuning; Band selector V.F.O.; Microphone connector; Key jack.

TUBES AND FUNCTIONS: (2)-6146 Power output amplifiers; 6CB6 Variable frequency oscillator; 12BY7 R.F. driver; 6AH6 1st Mixer; 6AH6 2nd Mixer; 6AB4 Crystal oscillator; 12AX7 Voice control; 12AT7 Voice control; 6AL5 Voice control; 12AX7 Audio Amplifier; 12AT7 Audio amp and carrier Oscillator; 12AT7 Audio Modulator; (2)-12AT7 Balanced Modulators; 5R4GY HV Rectifier; 5V4G LV Rectifier; OA2 Voltage Regulator.

REAR CHASSIS: Co-ax antenna connector; Line fuse; Control connector; AC power line cord.

PHYSICAL DATA: Matching unit for SX-111; cabinet is gray steel with brushed chrome trim and knobs. Size: 9″ high x 19¼″ wide x 15½″ deep. Shipping weight: approximately 80 lbs.

The new ideas in communications are born at . . .

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SX-111 Receiver

Here's the receiver you've been waiting for—a real thoroughbred that retains *the essential performance characteristics* of the renowned SX-101, but at a price that can put it in your shack tomorrow! Rugged . . . dependable . . . beautifully styled, the new SX-111 is outstanding evidence that Hallicrafters aim is always to bring you the finest equipment at the lowest possible price.

FREQUENCY COVERAGE: Complete coverage of 80, 40, 20, 15 and 10 meters in five separate bands. Sixth band is tunable to 10 Mc. for crystal calibrator calibration with WWV.

FEATURES: AM/CW/SSB reception. Dual conversion, Hallicrafter's exclusive selectable sideband operation. Crystal-controlled 2nd converter. Tee-notch filter. Calibrated S-meter. Vernier dial-pointer adjustment. Series noise limiter. Built-in crystal calibrator. Exceptional electrical and mechanical stability. Large slide-rule dial.

SENSITIVITY: One microvolt on all bands, with 5 steps of selectivity from 500 to 5,000 c.p.s.

TUNING MECHANISM: New friction-and-gear type with 48:1 tuning ration. Virtually eliminates backlash.

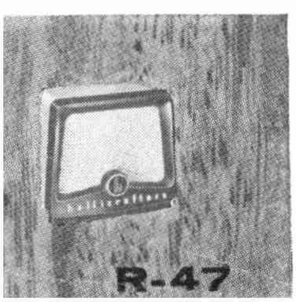
CONTROLS: Tuning; Pointer Reset; Antenna Trimmer; T-notch Frequency; RF Gain; Audio Gain; Band Selector; Function (off/on, standby, upper or lower sideband, calibrate); AVC off/on; BFO off/on; ANL off/on; Selectivity.

TUBES: 10 tubes plus voltage regulator and rectifier. 6DC6 RF Amplifier; 6BY6 1st converter; 6C4 Oscillator; 6BA6 2nd converter; 12AT7 Dual crystal second converters; 6CB6 1650 kc. i.f. amplifier; 6DC6 i.f. amplifier (50 kc.); 6BJ7 AVC-noise limiter-detector; 12AX7 1st audio and BFO; 6AQ5 Power output; 5Y3 rectifier; AO2 Voltage regulator.

POWER SUPPLY: 105-125 volts, 50-60 cycle AC.

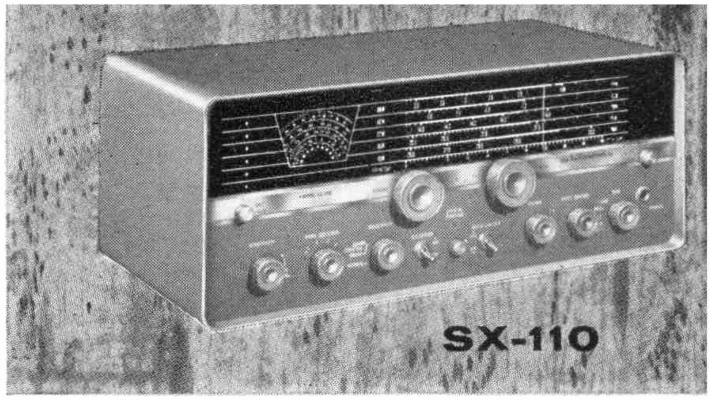
PHYSICAL DATA: Size: 18¾" wide x 10¼" deep x 8¾" high. Attractive gray steel cabinet with brushed chrome trim. Shipping wt. approximately 40 lbs.

Two outstanding speaker values



R-47 SPEAKER

Specially designed for voice and SSB. Flat response from 300 to 2850 c.p.s. Input impedance: 3.2 ohms. Size: 5½" x 5¼" x 3½". Wt. 2½ lb.



The last word in features and design!

SX-110 Receiver

Never before have so many outstanding, wanted features been incorporated in an all-purpose receiver—features developed originally for the highest-priced sets.

FREQUENCY COVERAGE: Broadcast Band 540-1680 kc plus three short wave bands covers 1680 kc—34 mc.

FEATURES: Slide rule bandspread dial calibrated for 80, 40, 20, 15 and 10 meter amateur bands and 11 meter citizens' band. Separate bandspread tuning condenser, crystal filter, antenna trimmer, "S" Meter, one r-f, two i-f stages.

INTERMEDIATE FREQUENCY: 455 kc.

TUNING ASSEMBLY AND DIAL DRIVE MECHANISM: Ganged, 3 section tuning capacitor assembly with electrical bandspread. Circular main tuning dial is calibrated in megacycles and has 0-100 logging scale.

AUDIO OUTPUT IMPEDANCE: 3.2 and 500 ohms.

TUBE COMPLEMENT: Seven tubes plus one rectifier: 6SG7, r-f amplifier—6SA7, converter—6SG7, 1st i-f amplifier—6SK7, 2nd i-f amplifier—6SC7, BFO and audio amplifier—6K6GT, Audio output—6H6, ANL-AVC-detector—6Y3GT, rectifier.

AUDIO POWER OUTPUT: 2 watts.

POWER SUPPLY: 105/125 V., 50/60 cycle AC.

PHYSICAL DATA: Gray steel cabinet with brushed chrome trim. Size 18¾" wide x 8" high x 10¼" deep. Shipping weight approximately 32 lbs.

S-108 Receiver

Same basic performance as SX-110 (above) less S-Meter, antenna trimmer and crystal filter, but includes a built-in speaker.

R-48 SPEAKER (See photo with HT-37 and SX-111). Latest design, eliptical assembly. 3.16 oz. Alnico V magnet. Fidelity switch for music or voice. 3.2 ohm input impedance. 6½" x 13¼" x 8¼".

SX-100 Most versatile receiver of all!

FREQUENCY COVERAGE: 540 kc—34 Mc. Band 1: 538 kc-1580 kc—Band 2: 1720 kc-4.9 Mc—Band 3: 4.6 Mc-13 Mc—Band 4: 12 Mc-34 Mc. Bandspread dial is calibrated for the 80, 40, 20, 15 and 10 meter amateur bands.

TYPE OF SIGNALS: AM—CW—SSB.

FEATURES: Selectable side band operation. "Tee-Notch" Filter—provides a stable non-regenerative system for the rejection of unwanted heterodyne. Also produces an effective steepening of the already excellent 500 Cycles i-f pass band and further increases the effectiveness of the advanced exalted carrier type reception. Notch depth control for maximum null adjustment. Antenna trimmer. Plug-in laboratory type evacuated 100 kc quartz crystal calibrator—included in price. Logging dials for both tuning controls. Full precision gear drive dial system. Second conversion oscillator crystal controlled—provides greater stability and additional temperature compensation of high frequency oscillator circuits. Phono jack. Socket for D.C. and remote control.

CONTROLS: Pitch control, reception, standby, phone jack, response control (upper and lower side band selector), antenna trimmer, notch depth, calibrator on/off, sensitivity, band selector, volume, tuning, AVC on/off noise limiter on/off, bandspread, selectivity.

INTERMEDIATE FREQUENCY: 1650 kc and 51 kc.

AUDIO OUTPUT IMPEDANCE: 3.2/500 ohms: **AUDIO POWER OUTPUT:** 1.5 watts with 10% or less distortion. **POWER SUPPLY:** 105/125 V., 50/60 cycle AC.

TUBE COMPLEMENT: 6CB6 R.F. amplifier; 6BY6, 1stconvertor;6AH6,H.F.oscillator; 6BA6, 2nd converter; 12AT7, Dual crystal second converters; (2) 6BA6, 51 kc and 1650 kc i-f amplifiers; 6BJ7, AVC-noise limiter; 6SC7, 1st audio and BFO; 6K6, Power output; 5Y3, Rectifier; OA2, Voltage regulator; 6C4, i-f amplifier—(51 kc); 6AU6, 100 kc XTAL marker.

PHYSICAL DATA: Gray black steel cabinet with brushed chrome knob trim, patterned silver back plate and red pointers. Piano hinge top. Size 18⅜" wide x 8½" high x 10⅝" deep. Shipping weight approximately 42 lbs. *(U.L. approved)*

Complete VHF Station

SR-34 Transmitter/Receiver

GENERAL DESCRIPTION: The SR-34 is designed for either AM or CW and combines complete functions of a two *and* six meter radio station. 115-V. A.C., 6-V. D.C., or 12V. D.C. Transistorized power supply. Meets F.C.D.A. matching-fund specifications.

The transmitter is crystal-controlled; up to four crystals may be switch-selected. A fifth position on this switch permits external V.F.O. operation.

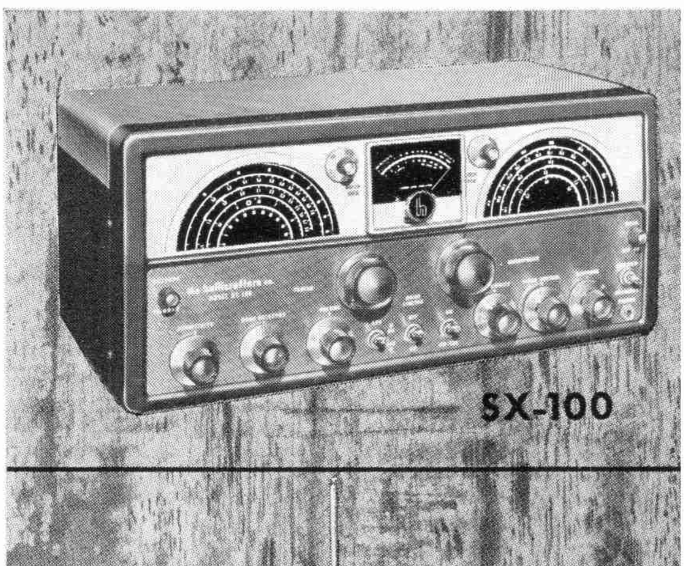
The receiver is a double conversion superheterodyne with a quartz crystal controlled second oscillator. Separate oscillator and R.F. sections for each band.

All receiver functions provided—S-meter, B.F.O., ANL, etc. Sensitivities average 1 microvolt on both bands.

FRONT PANEL CONTROLS: *Receiver:* Band Selector (48.9-54.1 mc., 143.9 to 148.1 mc.): Main Tuning; Sensitivity; Audio Volume; B.F.O. Pitch; Squelch Level; Headphone Jack; AVC On/Off; ANL On/Off; B.F.O. On/Off. *Transmitter:* Function Switch (P.A., Rec., Cal., AM, CW); Power On/Off; Band Switch; Crystal Selector and V.F.O.; Oscillator Tuning; Doubler Tuning; Tripler Tuning; Final Tuning; Final Loading; Meter Switch.

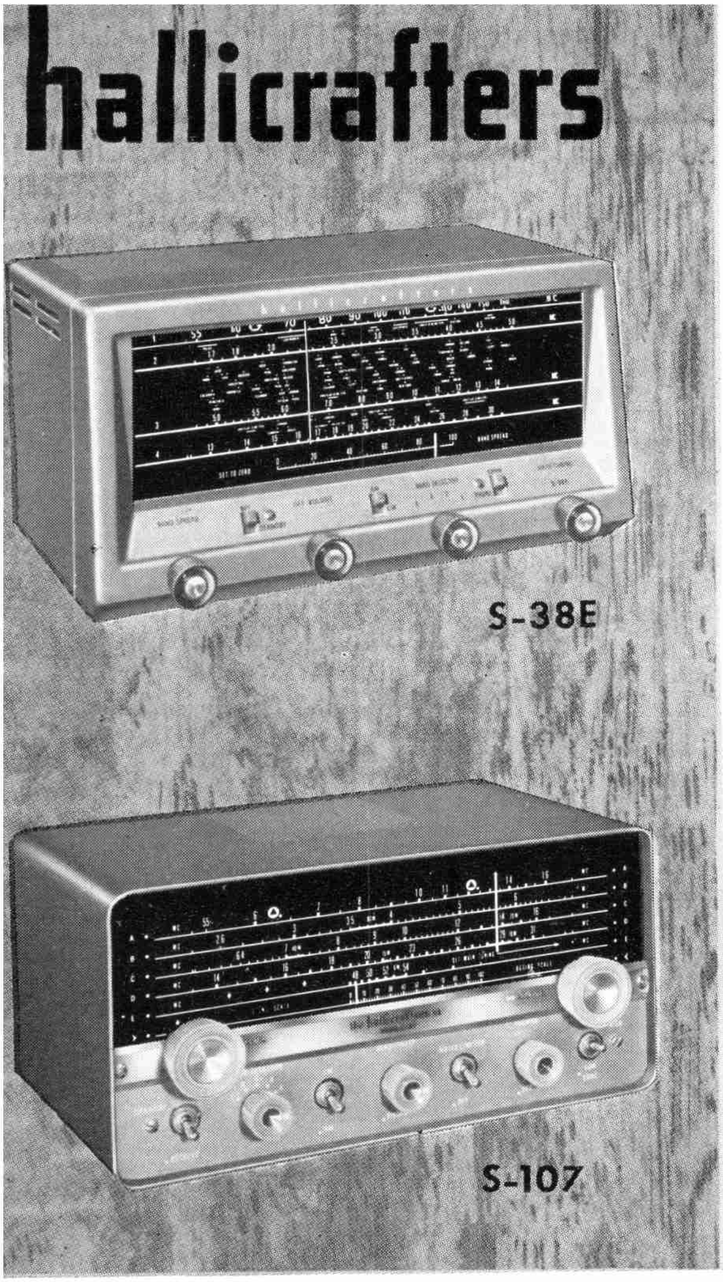
POWER OUTPUT: 5 to 8 watts AM or CW, 100% mod. negative peak clipping. *Rear Apron:* Speech input level control; key jack; P.A. speaker terminals; mic. selector (high Z or carbon); mic. input; A.C. and D.C. fuses; power plug.

Also available in A.C. only model.



SX-100

SR-34



World's most popular short wave receiver!

MODEL S-38E

Latest model of Hallicrafters' most popular of all short wave receivers! Beautiful new, modern cabinet styling, improved circuitry for superior performance and utmost dependability.

FREQUENCY COVERAGE: Standard broadcast from 540-1650 kc., plus three short wave bands from 1650 kc. through 32 mc. Intermediate freq.: 455 kc.

FEATURES: Two-section tuning gang with electrical bandspread; easy-to-read, slide-rule overseas dial; oscillator for code reception; built-in 5″ speaker, universal output for headset; rear switch for speaker or headset selection. *(U.L. approved)*

CONTROLS: Tuning dial. Separate electrical bandspread dial with 0-100 scale. Receive/standby switch. On/off/volume. AM, CW switch. Band selector.

POWER SUPPLY: 1 watt audio power output. 105/125 volts. 50-60 cycle AC/DC. Line cord (S7D 1566) for 220 volt AC/DC available.

TUBE COMPLEMENT. Four tubes plus one rectifier: 35W4 rectifier; 50C5 audio output; 12AU6 amplifier; 12BA6 IF amplifier and B.F.O.; 12BE6 converter.

AUDIO OUTPUT: Five inch PM speaker and universal output for headset.

EXTERNAL CONNECTIONS: Phone tip jacks and terminals for single wire or doublet antenna, switch for speaker or headphones on rear. External antenna provided.

PHYSICAL DATA: Available in gray steel cabinet with silver trim, or blond or mahogany finish with gold trim. Size 12⅞″ wide x 7″ high x 9¼″ deep. Shipping weight approximately 14 lbs.

New beauty . . . new standards of performance!

MODEL S-107

COVERAGE: Standard Broadcast from 540-1630 kc plus four short wave bands over 2.5-31 and 48-54.5 mc. Intermediate frequency; 455 kc. CONTROLS: Main tuning in mc. Separate electrical bandspread with 0-100 logging scale plus calibration for 48-54.5 mc band, receive/standby switch, band selector 540-1630 kc, 2.5-6.3 mc, 6.3-16 mc, 14-31 mc, and 48-54.5 mc, AM/CW switch, sensitivity/phono control, noise limiter switch, on/off/volume, two-position tone switch. BAND CHANGE MECHANISM: Five position rotary wafer switch. TUNING ASSEMBLY AND DIAL DRIVE MECHANISM: Separate 2-section tuning capacitator assemblies for main tuning and band spread tuning. Slide rule dial. Phonograph jack, headphone tip jacks. Bandspread tuning calibrated for 48-54.5 mc. ANTENNA INPUT IMPEDANCE: Balanced/unbalanced. 50-300 ohms. HEADPHONE OUTPUT IMPEDANCE: Universal impedance. AUDIO OUTPUT: Five inch PM speaker and universal impedance output for headset. TUBE COMPLEMENT: Seven tubes plus one rectifier: 6C4, Osc.–6BA6, Mixer–(2) 6BA6, i-f amplifier–6H6, Det., AVC and ANL–6SC7, BFO and AF amp.–6K6GT, Output–5Y3GT, rectifier. EXTERNAL CONNECTIONS: speaker/phones switch and terminals for doublet or single wire antenna on rear. AUDIO POWER OUTPUT: One watt. POWER SUPPLY: 105/125 V., 50/60 cycle. AC. PHYSICAL DATA: Sturdy gray hammertone steel cabinet with brushed chrome trim. Size 13⅜″ wide x 7″ high x 8⅞″ deep. Shipping weight approximately 18½ lbs. *(U.L. approved)*

The
hallicrafters
Company
4401 West Fifth Avenue, Chicago 24, Illinois

JAMES MILLEN
MALDEN · MASSACHUSETTS

ONE INCH INSTRUMENTATION OSCILLOSCOPE

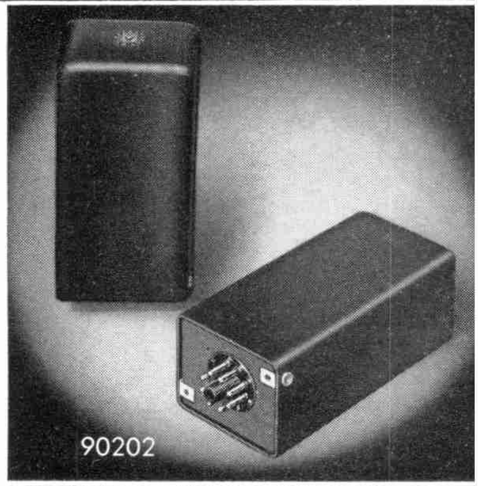
Miniaturized, packaged panel mounting cathode ray oscilloscope designed for use in instrumentation in place of the conventional "pointer type" moving coil meters uses the 1'' tube. Panel bezel matches in size and type the standard 2'' square meters. Magnitude, phase displacement, wave shape, etc. are constantly visible on scope

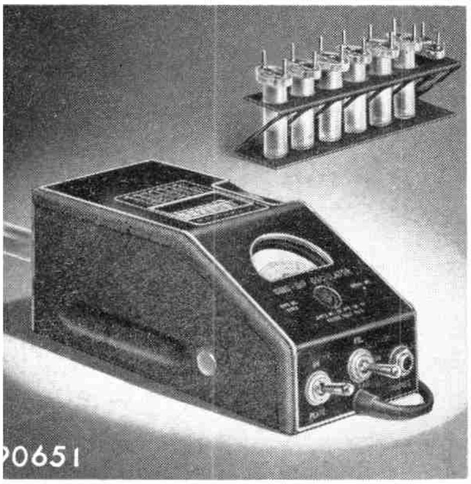
No. 90901, 1CP1, less tube............
No. 90911, 1EP1, less tube............

POWER SUPPLY FOR OSCILLOSCOPE

750 volts d.c. at 3 ma. and 6.3 volts a.c. at 600 ma. 117 volts 50–60 cycle input. Designed especially for use with No. 90901 and No. 90911 one inch instrumentation oscilloscopes. 4⅝ in. high x 1⅞ x 2⅛. Octal plug for input and output. Entire assembly including rectifier is encapsulated.

No. 90202 Power Supply (complete).....





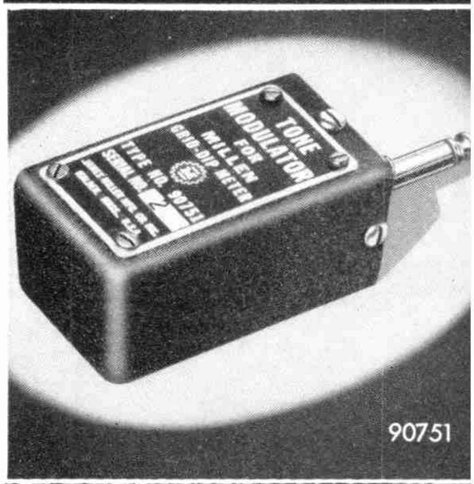
GRID DIP METER

The No. 90651 MILLEN GRID DIP METER is compact and completely self contained. The AC power supply is of the "transformer" type. The drum dial has seven calibrated uniform length scales from 1.7 MC to 300 MC with generous over laps plus an arbitrary scale for use with special application inductors. Internal terminal strip permits battery operation for antenna measurement.

No. 90651, with tube.................

Additional Inductors for Lower Frequencies

No. 46702—925 to 2000 KC..........
No. 46703—500 to 1050 KC..........
No. 46704—325 to 600 KC..........
No. 46705—220 to 350 KC..........

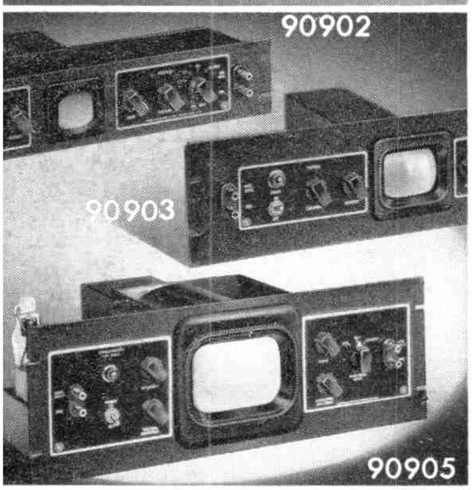


TONE MODULATOR

The No. 90751 Tone Modulator is a small package, containing a transistor audio oscillator and its mercury battery, which plugs into the 'phone jack of a Grid Dip Meter to modulate the signal at approximately 800 cycles for applications requiring a modulated signal.

Dimensions: only 2¾ x 1⁵⁄₁₆ x 1⁵⁄₁₆ in.

No. 90751, less battery...............



COMPACT OSCILLOSCOPES

The No. 90923 Oscilloscope is an extremely compact (3½ inch high) rack panel type, general purpose oscilloscope, utilizing the type 3XP1, 3XP2, 3XP7, or 3XP11, 3 inch by 1½ inch rectangular face cathode ray tube.

No. 90923, with tubes.................

The No. 90902, No. 90903 and No. 90905 Rack Panel Oscilloscopes, for two, three and five inch tubes, respectively, are inexpensive *basic units* comprising power supply, brilliancy and centering controls, safety features, magnetic shielding, switches, etc. As a transmitter monitor, no additional equipment or accessories are required. The well-known trapezoidal monitoring patterns are secured by feeding modulated carrier voltage from a pickup loop directly to vertical plates of the cathode ray tube and audio modulating voltage to horizontal plates. By the addition of such units as sweeps, pulse generators, amplifiers, servo sweeps, etc., all of which can be conveniently and neatly constructed on companion rack panels, the original basic 'scope unit may be expanded to serve any conceivable industrial or laboratory application.

No. 90902, less tubes.................
No. 90903, less tubes.................
No. 90905, less tubes.................

'SCOPE AMPLIFIER—SWEEP UNIT

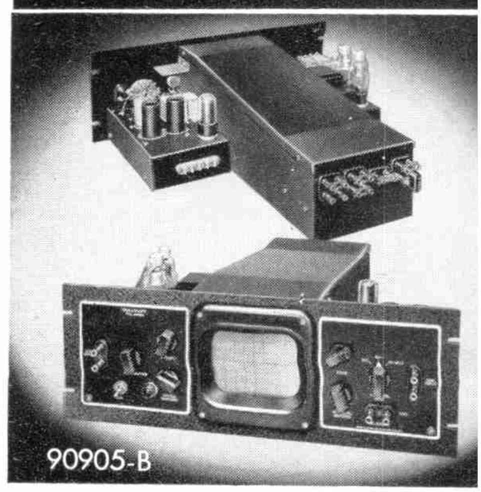
Vertical and horizontal amplifiers along with hard-tube, saw tooth sweep generator. Complete with power supply mounted on a standard 5¼'' rack panel.

No. 90921, with tubes................

FLAT FACE OSCILLOSCOPE

90905-B 5-inch Rack Mounting Basic Oscilloscope features include: balanced deflection, front panel input terminals, rear panel input terminals, astigmatism control, blanking input terminals, flat face precision tolerance Dumont 5ADP1 tube, 1800 or 2500 volts accelerating, good sensitivity, sharp focus, horizontal selector switch, 60 cycle sine wave sweep available, power supply available to operate external equipment, minimum control interaction, rugged construction, light filter. 7 x 19 in. panel.

No. 90905-B Oscilloscope, less tubes.....



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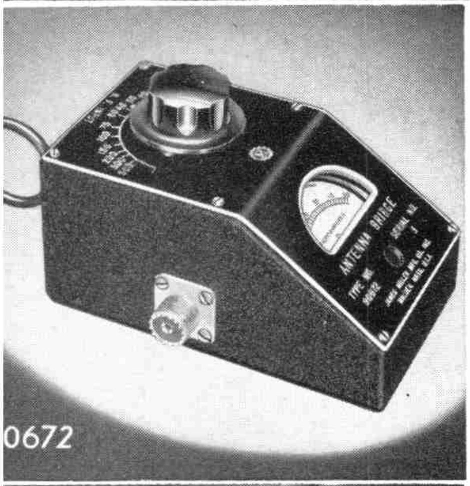
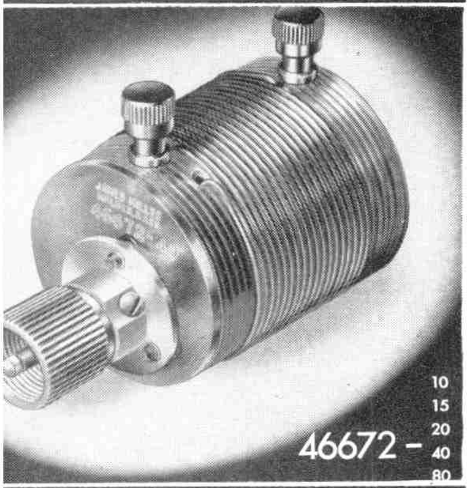




ANTENNA BRIDGE

The Millen 90672 Antenna Bridge is an accurate and sensitive bridge for measuring impedances in the range of 5 to 500 ohms (or 20 to 2000 ohms with balun) at radio frequencies up to 200 mc. The variable element is an especially designed differential variable capacitor capable of high accuracy and permanency of calibration. Readily driven by No. 90651 Grid Dipper.

No. 90672 . . . .

AUDIO CLIPPER

The No. 75016 Audio Clipper is a small plug-in symmetrical type clipper with self-contained mercury batteries. It may be used to clip noise for C-W reception as well as for A-M or SSB, or it may be used to clip a sine wave input to form a square wave output.

Dimensions: only 2¾ x 1 5/16 x 1 5/16 in.

No. 75016, less batteries. . . . .

BALUNS

The No. 46672 (1 for each amateur band) wound Balun is an accurate 2 to 1 turns ratio, high Q auto transformer with the residual reactances tuned out and with very tight coupling between the two halves of the total winding. The points of series and parallel resonance are selected so that each Balun provides an accurate 4 to 1 impedance ratio over the entire band of frequencies for which it was designed. Suitable for use with the No. 90672 Antenna Bridge or medium power transmitters.

No. 46672–80/40/20/15/10. . . . .

50 WATT EXCITER-TRANSMITTER

Modern design includes features and shielding for TVI reduction, bandswitching for 4–7–14–21–28 megacycle bands, circuit metering. Conservatively rated for use either as a transmitter or exciter for high power PA stages. 5763 oscillator-buffer-multiplier and 6146 power amplifier. Rack mounted.

No. 90801, less tubes. . . . .

VARIABLE FREQUENCY OSCILLATOR

The No. 90711 is a complete transmitter control unit with 6SK7 temperature-compensated, electron coupled oscillator of exceptional stability and low drift, a 6SK7 broad-band buffer or frequency doubler, a 6AG7 tuned amplifier which tracks with the oscillator tuning, and a regulated power supply. Output sufficient to drive a 6146 is available on 160, 80 and 40 meters and reduced output is available on 20 meters. Since the output is isolated from the oscillator by two stages, zero frequency shift occurs when the output load is varied from open circuit to short circuit. The entire unit is unusually solidly built so that no frequency shift occurs due to vibration. The keying is clean and free from annoying chirp, quick drift, jump, and similar difficulties often encountered in keying variable frequency oscillators.

No. 90711, with tubes. . . . .

HIGH VOLTAGE POWER SUPPLY

The No. 90281 high voltage power supply has a d.c. output of 700 volts with maximum current of 235 ma. In addition, a.c. filament power of 6.3 volts at 4 amperes is also available so that this power supply is an ideal unit for use with transmitters, such as the Millen No. 90801, as well as general laboratory purposes. The power supply uses two No. 816 rectifiers. The panel is standard 8¾'' x 19'' rack mounting.

No. 90281, less tubes. . . . .

HIGH FREQUENCY RF AMPLIFIER

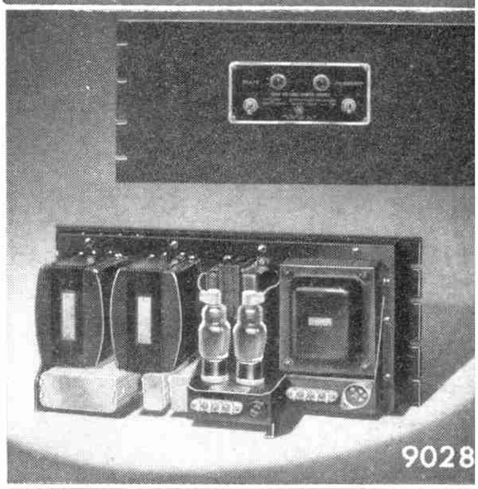
A physically small unit capable of a power output of 70 to 85 watts on 'Phone or 87 to 110 watts on C-W on 20, 15, 11, 10, 6 or 2 meter amateur bands. Provision is made for quick band shift by means of the No. 48000 series VHF plug-in coils. The No. 90811 unit uses either an 829-B or 3E29.

No. 90811 with 10 meter band coils, less tube. . . . .

RF POWER AMPLIFIER

This 500 watt amplifier may be used as the basis of a high power amateur transmitter. The No. 90881 RF power amplifier is wired for use with the popular "812A" type tubes. Other popular tubes may be used. The amplifier is of unusually sturdy mechanical construction, on a 10½'' relay rack panel. Plug-in inductors are furnished for operation on 10, 20, 40 or 80 meter amateur bands. The standard Millen No. 90801 exciter unit is an ideal driver for the No. 90881 RF power amplifier.

No. 90881, with one set of coils, but less tubes. . . . .



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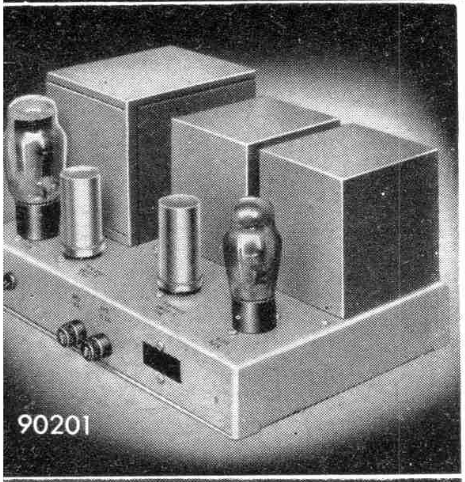
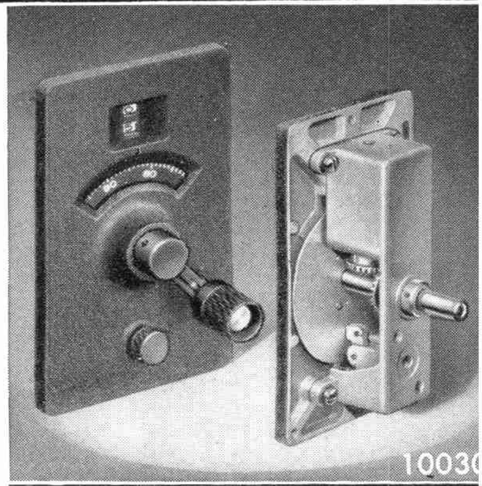


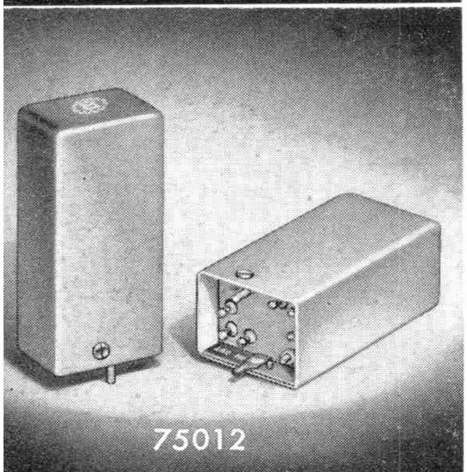


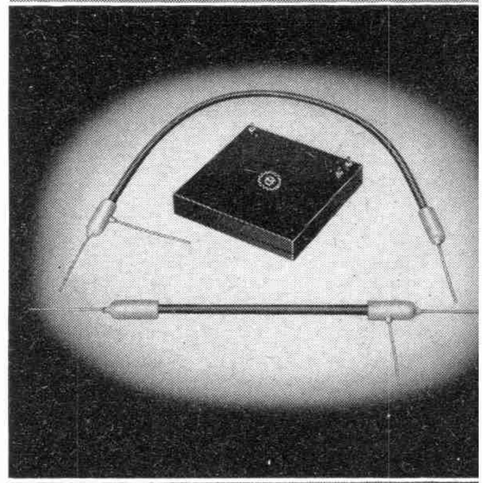
REGULATED POWER SUPPLY

A compact, uncased, regulated power supply, either for table use in the laboratory or for incorporation as an integral part of larger equipment. 250 v.d.c. unregulated at 115 ma. 105 v.d.c. regulated at 35 ma. Minus 105 v.d.c. regulated bias at 4 ma. 6.3 v. a.c. at 4.2 amps.
No. 90201, with tubes. . . . .

INSTRUMENT DIAL

The No. 10030 is an extremely sturdy instrument type indicator. Control shaft has 1 to 1 ratio. Veeder type counter is direct reading in 99 revolutions and vernier scale permits readings to 1 part in 100 of a single revolution. Has built-in dial lock and ¼″ drive shaft coupling. May be used with multi-revolution transmitter controls, etc., or through gear reduction mechanism for control of fractional revolution capacitors, etc., in receivers or laboratory instruments.
No. 10030. . . . .





PHASE-SHIFT NETWORK

A complete and laboratory aligned pair of phase-shift networks in a single compact 2″ x 1$\frac{7}{16}$″ x 4″ case with characteristics so as to provide a phase shift between the two networks of 90° ± 1.3° over a frequency range of 225 cycles to 2750 cycles. Well adapted for use in either single sideband transmitter or receiver. Possible to obtain a 40 db suppression of the unwanted sideband. The No. 75012 precision adjusted phase-shift network eliminates the necessity of complicated laboratory equipment for network adjustment
No. 75012. . . . .

DELAY LINES

No. 34751—Sealed flexible distributed constants line. Excellent rise time. 1350 ohms, 22 inches per microsecond or 550 ohms, 50 inches per mu.-sec. Delay cut to specifications.
No. 34700—Hermetically sealed encased line. Good rise time. 0–0.45 mu.-sec. 1350 ohm line or 0.22 mu.-sec. 500 ohm line in 1″ x 1″ x 5½″ in case. Also larger standard cases and cases made to order. Special impedances 400 to 2200 ohms.
No. 34600—Lumped delay line built to specifications. Delays 0.05 mu.-sec. to 250 mu.-sec. Impedance 50 ohms to 2000 ohms.

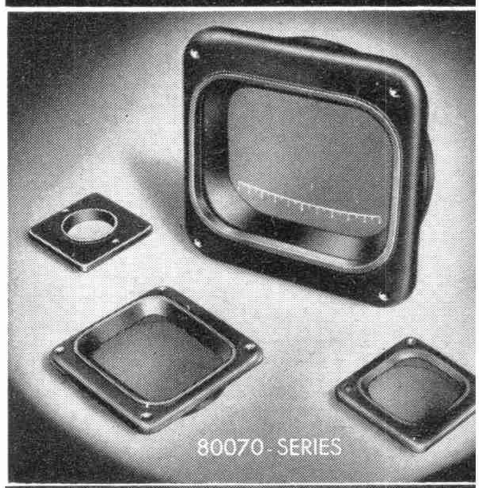
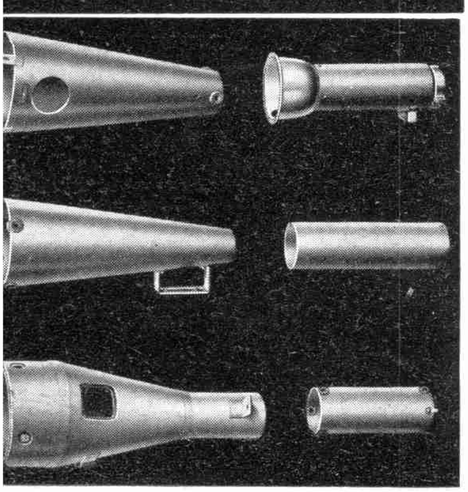


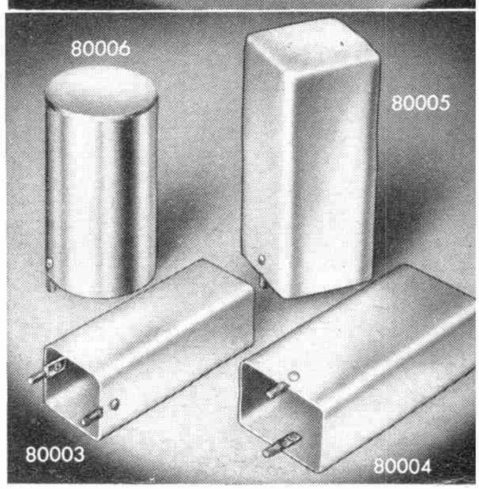
PHOTO MULTIPLIER SHIELDS MU-METAL

The photo multiplier tube operates most effectively when perfectly shielded. Careful study has proven that mu-metal provides superior shielding. Millen Mu-Metal shields are available from stock for the most popular tubes.
No. 80801B for the 1P21, 1P22, 1P28, 931A
No. 80802B for the 5819, 6217, 6292, 6342.
No. 80802C for the 6199, 6291, 6467. . . . .
No. 80802E for the 6810A, 6903. . . . .
No. 80802F for the 6372. . . . .
No. 80803J for the 6363, K1197. . . . .
No. 80805M for the 6364. . . . .

BEZELS FOR CATHODE RAY TUBES

Standard types are of satin finish black plastic. 5″ size has neoprene support cushion and green lucite filter. 3″ and 2″ sizes have integral cushioning.
No. 80075—5″. . . . .
No. 80073—3″. . . . .
No. 80072—2″. . . . .
No. 80071—1″. . . . .



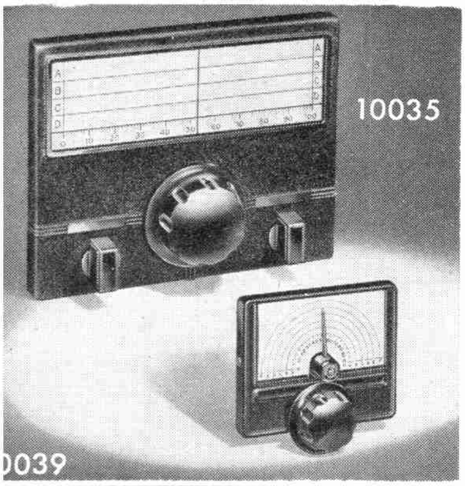


CATHODE RAY TUBE SHIELDS

For many years we have specialized in the design and manufacture of magnetic metal shields of nicoloi and mumetal for cathode ray tubes in our own complete equipment, as well as for applications of all other principal complete equipment manufacturers. Stock types as well as special designs to customers' specifications promptly available.
No. 80045—Nicoloi for 5BP1. . . . .
No. 80055—Nicoloi for 5CP1. . . . .
No. 80043—Nicoloi for 3″ tube. . . . .
No. 80042—Nicoloi for 2″ tube. . . . .

SHIELD CASES ALUMINUM

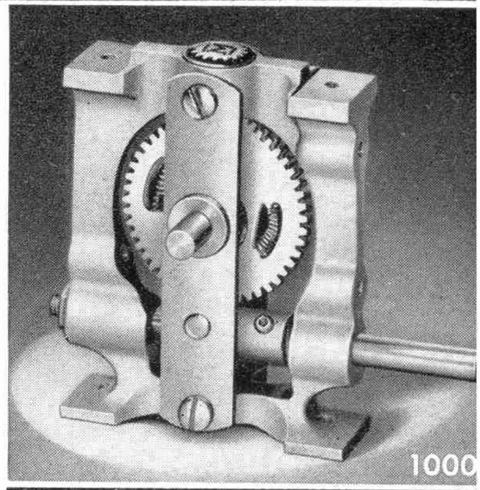
Effective RF shielding for coils and transformers can be provided by Millen Aluminum cans. Available in several sizes from stock.
No. 80003—1⅜″ x 1⅜″ x 4″. . . . .
No. 80004—1⅞″ x 1$\frac{7}{16}$″ x 4½″. . . . . . .
No. 80005—2″ x 2″ x 4⅞′. . . . .
No. 80006—2⅛″ round x 4″. . . . .
No. 80007—2¼″ round x 2⅜″ open ends



PANEL DIALS

The No. 10035 illuminated panel dial has 12 to 1 ratio; size, 8½″ x 6½″. Small No. 10039 has 8 to 1 ratio; size, 4″ x 3¼″. Both are of compact mechanical design, easy to mount and have totally self-contained mechanism, thus eliminating back of panel interference. Provision for mounting and marking auxiliary controls, such as switches, potentiometers, etc., provided on the No. 10035. Standard finish, either size, flat black art metal.

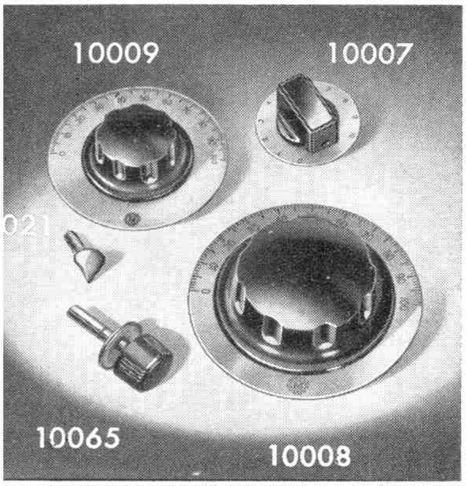
No. 10039 . . . .
No. 10035 . . . .



WORM DRIVE UNIT

Cast aluminum frame may be panel or base mounted. Spring loaded split gears to minimize back lash.
Standard ratio 16/1. Also in 48/1 on request

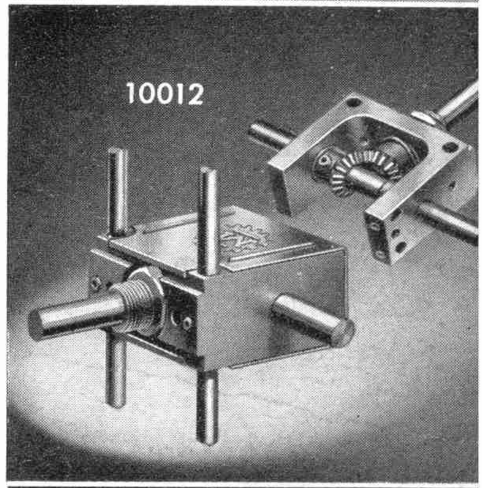
No. 10000—(state ratio) . . . .



DIALS AND KNOBS

Just a few of the many stock types of small dials and knobs are illustrated herewith. 10007 is 1⅝″ diameter, 10009 is 2¾″ and 10008 is 3½″

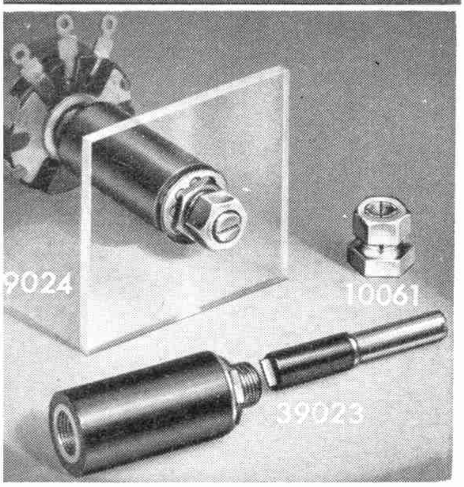
No. 10002 . . . .
No. 10007 . . . .
No. 10008 . . . .
No. 10009 . . . .
No. 10015 . . . .
No. 10018 . . . .
No. 10021 . . . .
No. 10065 . . . .



RIGHT ANGLE DRIVE

Extremely compact, with provisions for many methods of mounting. Ideal for operating potentiometers, switches, etc., that must be located, for short leads, in remote parts of chassis.

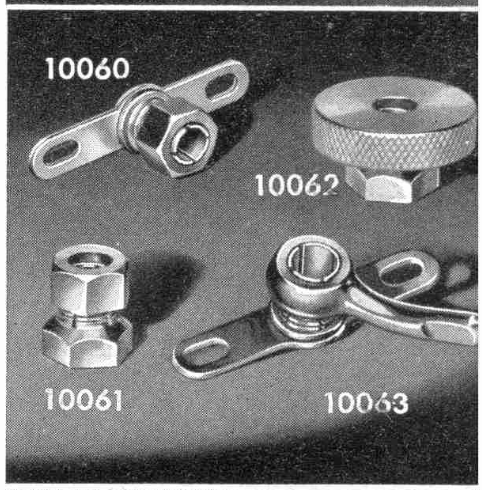
No. 10012 . . . .



HIGH VOLTAGE INSULATED SHAFT EXTENSION

No. 10061 shaft locks and the No. 39023 insulated high voltage potentiometer extension mountings are available as a single integrated unit—the No. 39024. The proper shaft length is independent of the panel thickness. The standard shaft has provision for screw driver adjustment. Special shaft arrangements are available for industrial applications. Extension shaft and insulated coupling are molded as a single unit to provide accuracy of alignment and ease of installation.

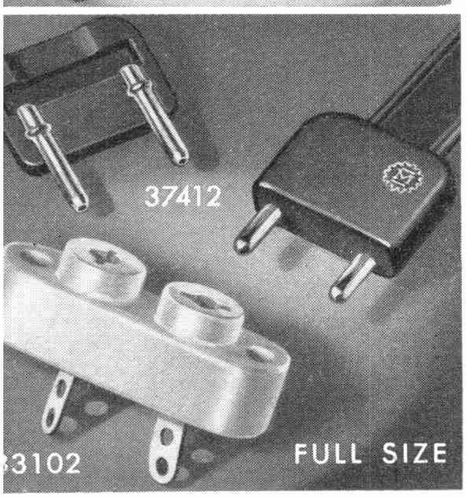
No. 39023, non locking type . . . .
No. 39024, locking type . . . .



SHAFT LOCKS

In addition to the original No. 10060 and No. 10061 "DESIGNED FOR APPLICATION" shaft locks, we can also furnish such variations as the No. 10062 and No. 10063 for easy thumb operation as illustrated above. The No. 10061 instantly converts any plain "¼ shaft" volume control, condenser, etc. from "plain" to "shaft locked" type. Easy to mount in place of regular mounting nut.

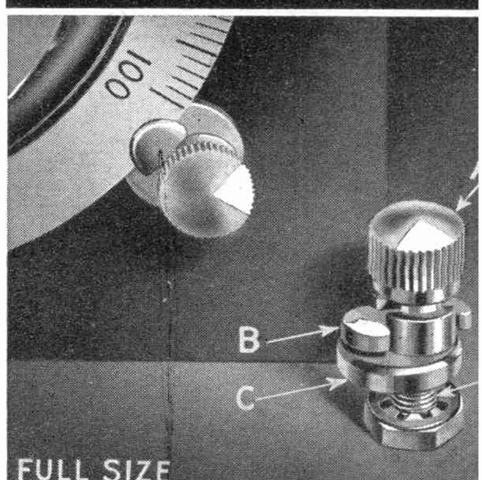
No. 10060 . . . .
No. 10061 . . . .
No. 10062 . . . .
No. 10063 . . . .



TRANSMISSION LINE PLUG

An inexpensive, compact, and efficient polystyrene unit for use with the 300 ohm ribbon type polyethylene transmission lines. Fits into standard Millen No. 33102 (crystal) socket. Pin spacing ½″, diameter .095″.

No. 37412 . . . .



DIAL LOCK

Compact, easy to mount, positive in action, does not alter dial setting in operation! Rotation of knob "A" depresses finger "B" and "C" without imparting any rotary motion to Dial. Single hole mounted.

No. 10050 . . . .

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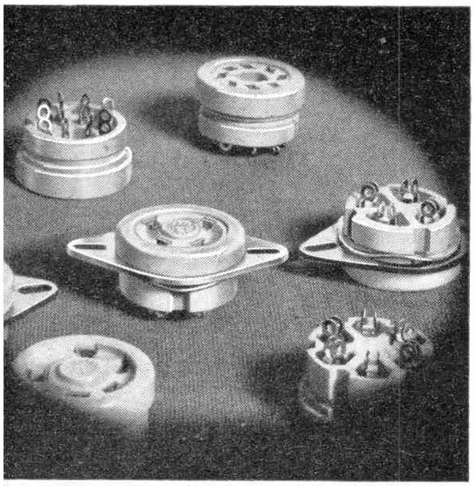
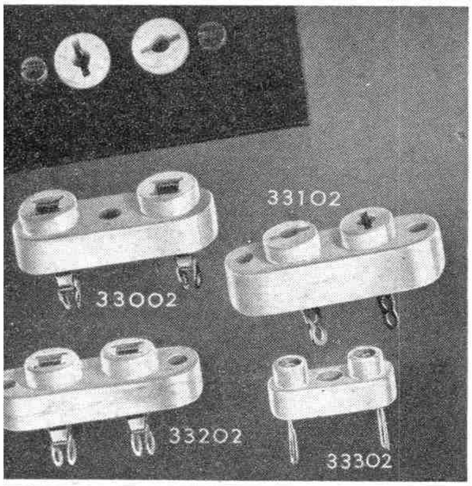
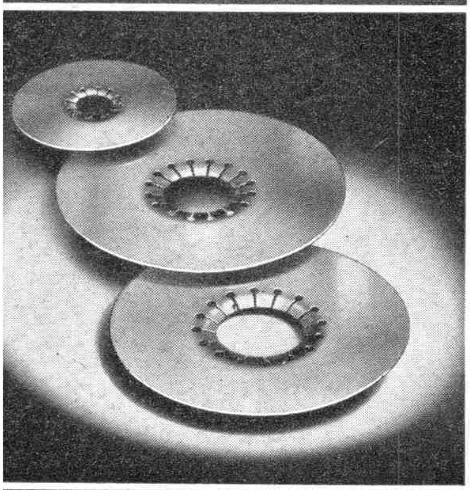
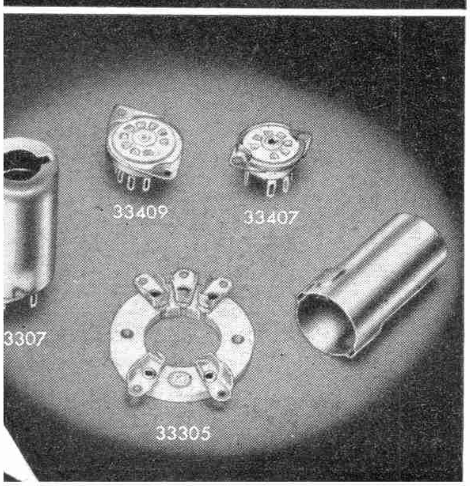








TUBE SOCKETS DESIGNED FOR APPLICATION

MODERN SOCKETS for MODERN TUBES! Long Flashover path to chassis permits use with transmitting tubes, 866 rectifiers, etc. Long leakage path between contacts. Contacts are type proven by hundreds of millions already in government, commercial and broadcast service, to be extremely dependable. Sockets may be mounted either with or without metal flange. Mounts in standard size chassis hole. All types have barrier between contacts and chassis. All but octal and crystal sockets also have barriers between individual contacts in addition.

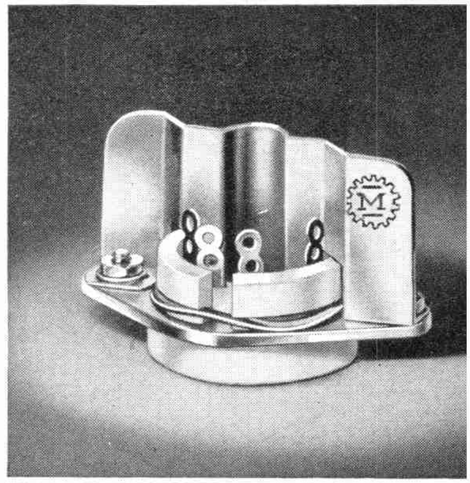
The No. 33888 shield is for use with the 33008 octal socket. By its use, the electrostatic isolation of the grid and plate circuits of single-ended metal tubes can be increased to secure greater stability and gain.

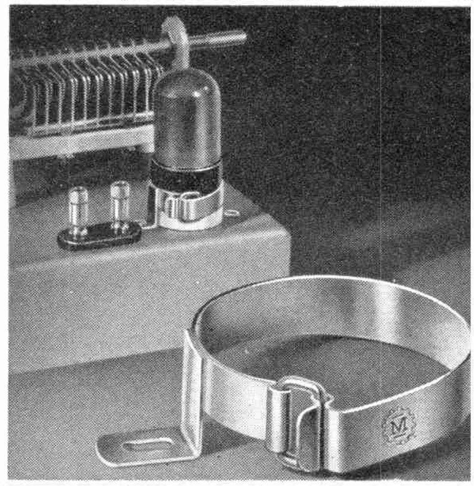
The 33087 tube clamp is easy to use, easy to install, effective in function. Available in special sizes for all types of tubes. Single hole mounting. Spring steel, cadmium plated.

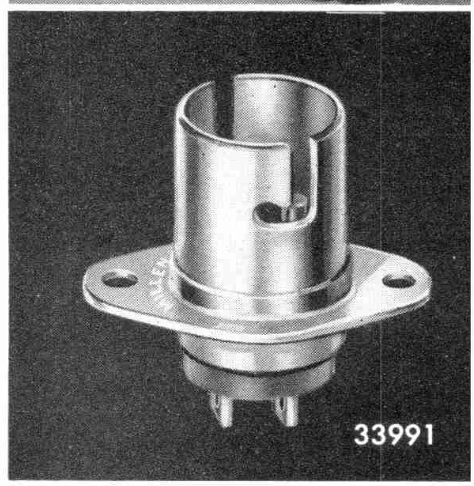
Cavity Socket Contact Discs, 33446 are for use with the "Lighthouse" ultra high frequency tube. This set consists of three different size unhardened beryllium copper multifinger contact discs. Heat treating instructions forwarded with each kit for hardening after spinning or forming to frequency requirements.

Voltage regulator dual contact bayonet socket, 33991 black phenolic insulation and 33992 with low loss mica filled phenolic insulation.

No. 33004—4 Pin Tube Socket.........
No. 33005—5 Pin Tube Socket.........
No. 33006—6 Pin Tube Socket.........
No. 33008—8 Pin Tube Socket.........
No. 33888—Shield for 33008.........
No. 33087—Tube Clamp.............
No. 33002—Crystal Socket ¾″ x .125″..
No. 33102—Crystal Socket .487″ x .095″
No. 33202—Crystal Socket ½″ x .125″..
No. 33302—Crystal Socket .487″ x .050″
No. 33446—Contact Discs.............
No. 33991—Socket for 991...........
No. 33992—Socket for 991...........
No. 33207—829 Socket..............
No. 33305—Acorn Socket............
No. 33307—Miniature Socket and Shield, ceramic.................
No. 33309—Noval Socket and Shield, ceramic...................
No. 33405—5 Pin Socket Eimac.........
No. 33407—Miniature Socket only, ceramic
No. 33409—Noval Socket only, ceramic..



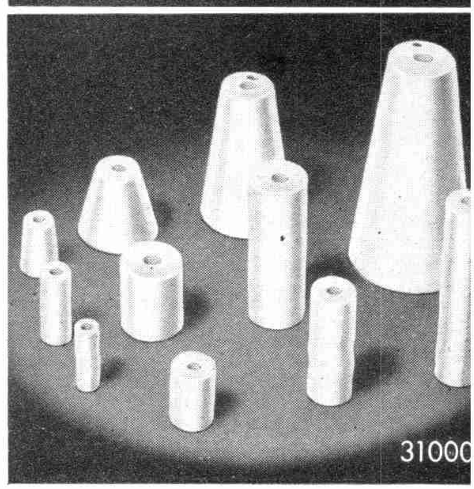


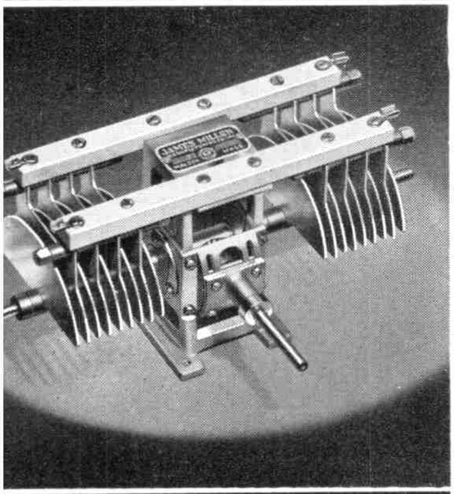


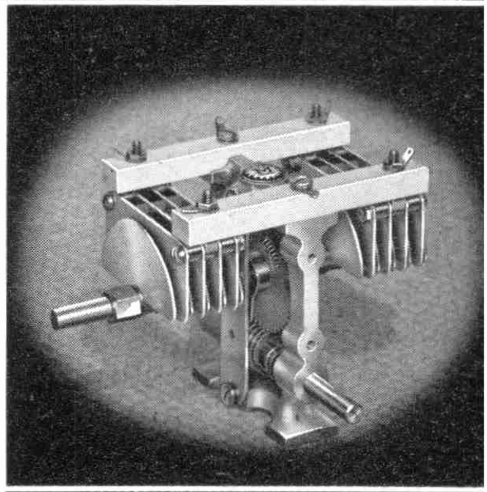
STAND-OFF INSULATORS

Steatite insulators are available in a variety of sizes—Listed below are some of the most popular.

No. 31001—Stand-off ½″ x 1″........
No. 31002—Stand-off ½″ x 2½″ ......
No. 31003—Stand-off ¾″ x 2″........
No. 31004—Stand-off ¾″ x 3½″.......
No. 31006—Stand-off 9/32″ x ⅞″........
No. 31007—Stand-off ⅜″ x 1″........
No. 31011—Cone ¾″ x ½″ (box of 5)..
No. 31012—Cone 1″ x 1″...........
No. 31013—Cone 1½″ x 1″..........
No. 31014—Cone 2″ x 1″...........
No. 31015—Cone 3″ x 1½″..........



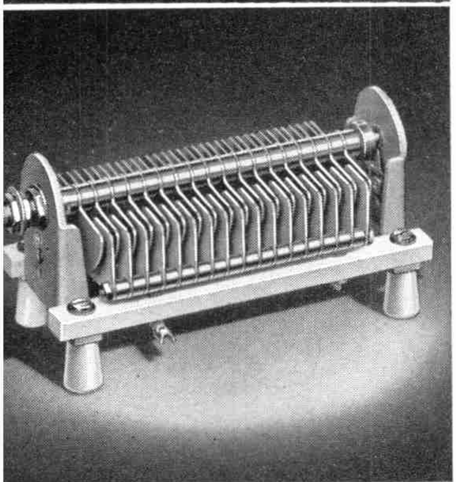


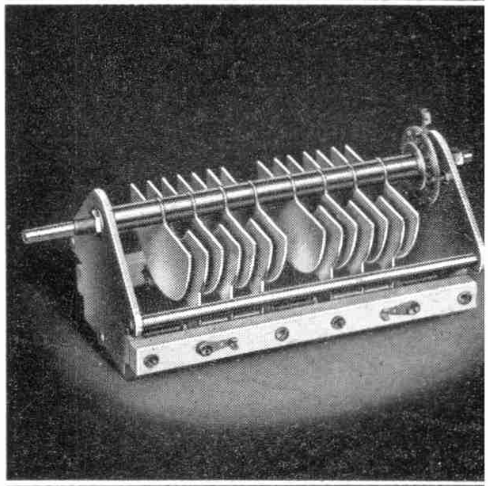


04000 and 11000 SERIES TRANSMITTING CONDENSERS

Another member of the "Designed for Application" series of transmitting variable air capacitors is the 04000 series with peak voltage ratings of 3000, 6000, and 9000 volts. Right angle drive, 1–1 ratio. Adjustable drive shaft angle for either vertical or sloping panels. Sturdy construction, thick, round-edged, polished aluminum plates with 1¾'' radius. Constant impedance, heavy current, multiple finger rotor contactor of new design. Available in all normal capacities.

The 11000 series has 16/1 ratio center drive and fixed angle drive shaft.

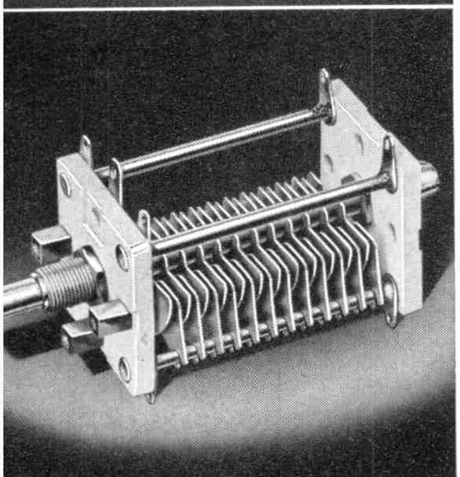


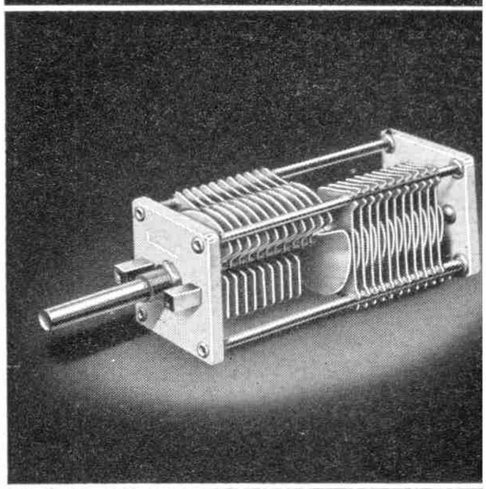


12000 and 16000 SERIES TRANSMITTING CONDENSERS

Rigid heavy channeled aluminum end plates. Isolantite insulation, polished or plain edges. One piece rotor contact spring and connection lug. Compact, easy to mount with connector lugs in convenient locations. Same plate sizes as 11000 series above.

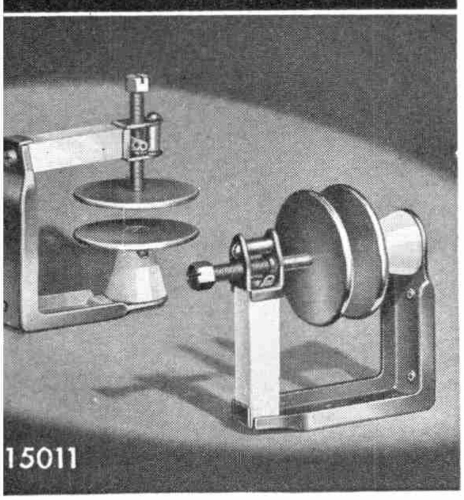
The 16000 series has same plate sizes as 04000 series. Also has constant impedance, heavy current, multiple finger rotor contactor of new design. Both 12000 and 16000 series available in single and double sections and many capacities and plate spacing

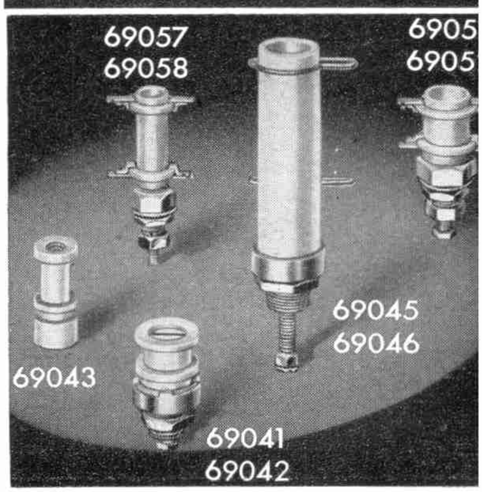




THE 28000–29000 SERIES VARIABLE AIR CAPACITORS

"Designed for Application," double bearings, steatite end plates, cadmium or silver plated brass plates. Single or double section .022'' or .066'' air gap. End plate size: 19/16'' x 11/16''. Rotor plate radius: ¾''. Shaft lock, rear shaft extension, special mounting brackets, etc., to meet your requirements. The 28000 series has semi-circular rotor plate shape. The 29000 series has approximately straight frequency line rotor plate shape. Prices quoted on request. Many stock sizes.





NEUTRALIZING CAPACITOR

Designed originally for use in our own No. 90881 Power Amplifier, the No. 15011 disc neutralizing capacitor has such unique features as rigid channel frame, horizontal or vertical mounting, fine thread over-size lead screw with stop to prevent shorting and rotor lock. Heavy rounded-edged polished aluminum plates are 2'' diameter. Glazed Steatite insulation.

No. 15011 ....

PERMEABILITY TUNED CERAMIC FORMS

In addition to the popular shielded plug-in permeability tuned forms, 74000 series, the 69040 series of ceramic permeability tuned unshielded forms are available as standard stock items. Winding diameters available from 3/16'' to ½'' and winding space from 11/32'' to 1½''.

No. 69041—(Copper Slug)..........
No. 69042—(Iron Core)............
No. 69043—(Copper Slug)..........
No. 69044—(Iron Core)............
No. 69045—(Copper Slug)..........
No. 69046—(Iron Core)............
No. 69047—(Copper Slug)..........
No. 69048—(Iron Core)............
No. 69051—(Copper Slug)..........
No. 69052—(Iron Core)............
No. 69054—(Iron Core)............
No. 69055—(Copper Slug)..........
No. 69056—(Iron Core)............
No. 69057—Copper Slug)..........
No. 69058—(Iron Core)............
No. 69061—(Copper Slug)..........
No. 69062—(Iron Core)............

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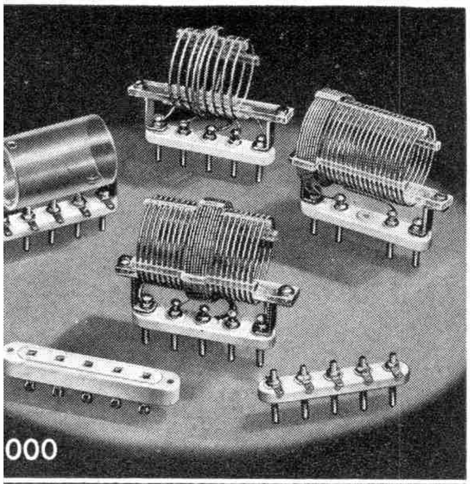
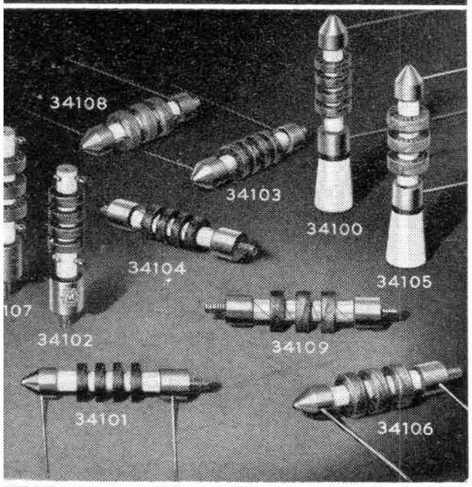
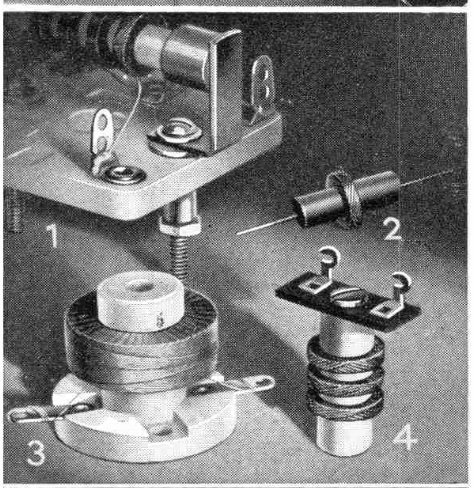
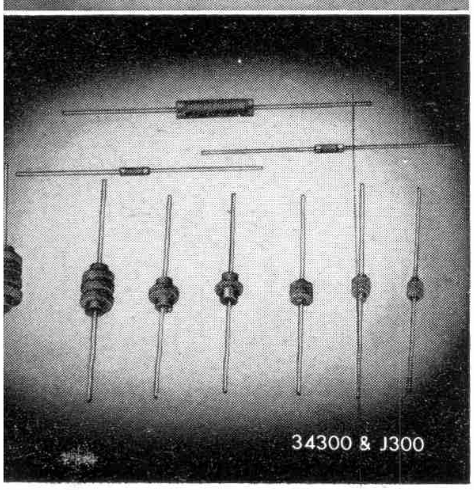








TRANSMITTING TANK COILS

A full line—all popular wattages for all bands. Send for special catalog sheet.

TUNABLE COIL FORM

Standard octal base of low loss mica-filled bakelite, polystyrene ½'' diameter coil form, heavy aluminum shield, iron tuning slug of high frequency type, suitable for use up to 35 mc. Adjusting screw protrudes through center hole of standard octal socket.

No. 74001, with iron core . . . .
No. 74002, less iron core . . . .

RF CHOKES

Many have copied, few have equalled, and none have surpassed the genuine original design Millen Designed for Application series of midget RF Chokes. The more popular styles now in constant production are illustrated herewith. Special styles and variations to meet unusual requirements quickly furnished.

Figures 1 and 4 illustrate special types of RF chokes available on order. The popular 34300 and 34200 series are shown in figures 2 and 3 respectively.

General Specifications: 2.5 mh, 250 ma for types 34100, 34101, 34102, 34103, 34104 and 1 mh, 300 ma for types 34105, 34106, 34107, 34108, 34109.

No. 34100 . . . .
No. 34101 . . . .
No. 34102 . . . .
No. 34103 . . . .
No. 34104 . . . .

MIDGET COIL FORMS

Made of low loss mica filled brown bakelite. Guide funnel makes for easy threading of leads through pins.

No. 45000 . . . .
No. 45004 . . . .
No. 45005 . . . .

OCTAL BASE AND SHIELD

Low loss phenolic base with octal socket plug and aluminum shield can 1 7/16 x 1 7/8 x 3 15/16.

No. 74400 . . . .

MINIATURE POWDERED IRON CORE RF INDUCTANCES

The No. J300—Miniature powdered iron core inductances. 0.107 in dia. x ⅜ in. long. Inductances from 3.3 microhenries to 2.5 millihenries ± 5%. EIA standard values plus 25, 50, 150, 250, 350, 500, and 2500 microhenries. Three layer solenoids from 39 to 350 microhenries. ¼ in. wide single pi from 360 to 2500 microhenries. Special coils on order.

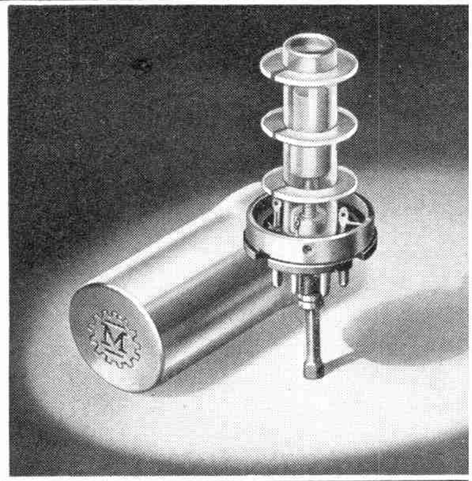
PHENOLIC FORM RF INDUCTANCES

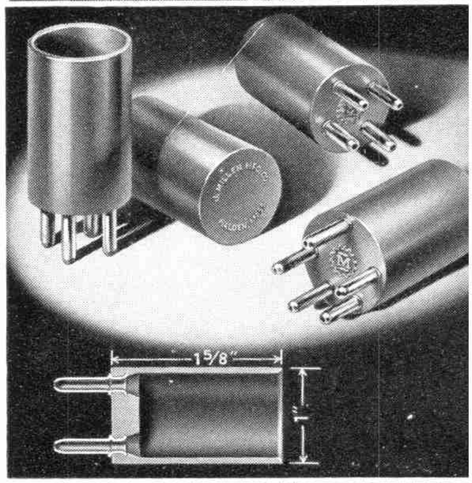
The No. 34300 Inductances—Phenolic coil form with axial leads. Inductances from 1 microhenry to 2.5 millihenries ± 5%. RETMA standard values plus 25, 50, 150, 250, 350, 500, and 2500 microhenries. Solenoids from 1 to 16 microhenries. Single pi from 18 to 300 microhenries. Multiple pi for higher inductances. Forms 7/32'' dia. x 7/16 in. long, 3/16'' x 5/8'', 1/4'' x 3/4'', and 1/4'' x 1''. Special coils on order.

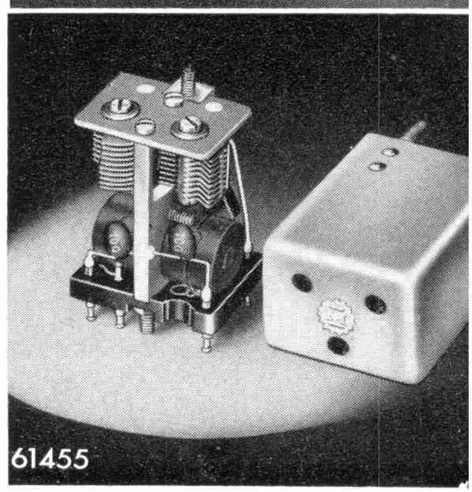
MINIATURE IF TRANSFORMERS

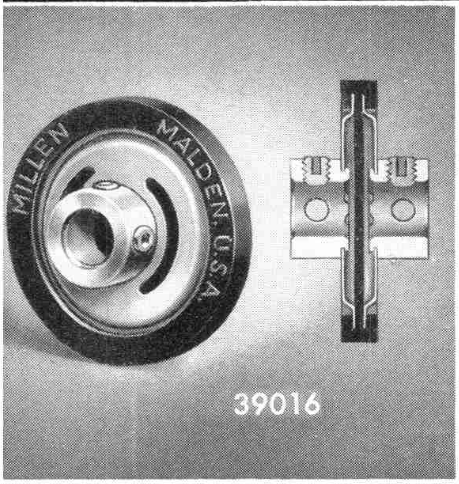
Extremely high Q—appro imately 200—Variable Coupling—(under, critical, and over) with all adjustments on top. Small size 1 1/16'' x 1 9/16'' x 1 7/8'' Molded terminal base. Air capacitor tuned. Coils completely enclosed in cup cores. T pped primary and secondary. Rugged construction. High electrical stability.

No. 61455, 455 kc. Universal Trans . . . . . .
No. 61453, 455 kc. BFO . . . .
No. 61160, 1600 kc. Universal Trans . . . . .
No. 61163, 1600 kc. BFO . . . .







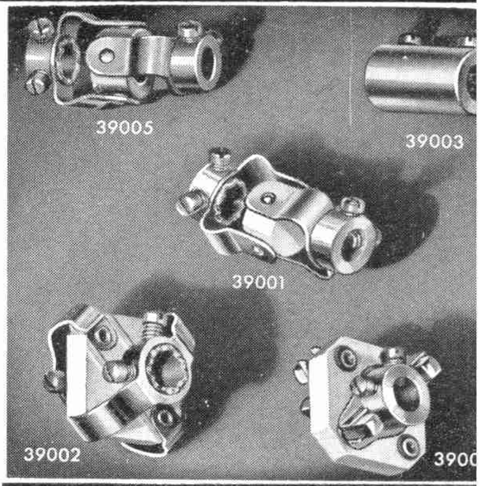


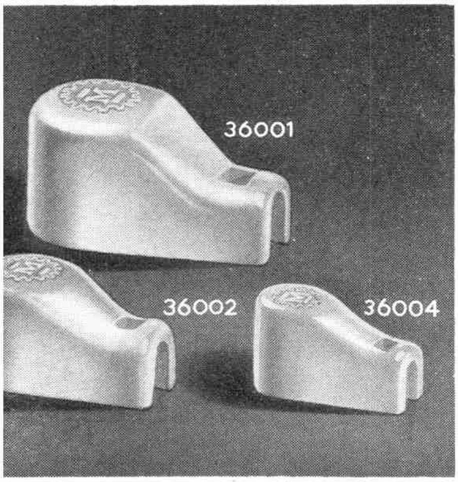
FLEXIBLE COUPLINGS

The No. 39000 series of Millen "Designed for Application" flexible coupling units include, in addition to improved versions of the conventional types, also such exclusive original designs as the No. 39001 insulated universal joint and the No. 39006 "slide-action" coupling (in both steatite and bakelite insulation).

The No. 39006 "slide-action" coupling permits longitudinal shaft motion, eccentric shaft motion and out-of-line operation, as well as angular drive without backlash.

The No. 39005 and 39005-B (high torque) are similar to the No. 39001, but are not insulated. The steatite insulated No. 39001 has a special anti-backlash pivot and socket grip feature. All of the above illustrated units are for ¼" shaft and are standard production type units. The No. 39016 incorporates features which have long been desired in a flexible coupling. No Back Lash—Higher Flexibility—Higher Breakdown Voltage—Smaller Diameter—Shorter Length—Higher Alignment Accuracy—Higher Resistance to Mechanical Shock—Solid Insulating Barrier Diaphragm—Molded as a Single Unit.





CERAMIC PLATE OR GRID CAPS

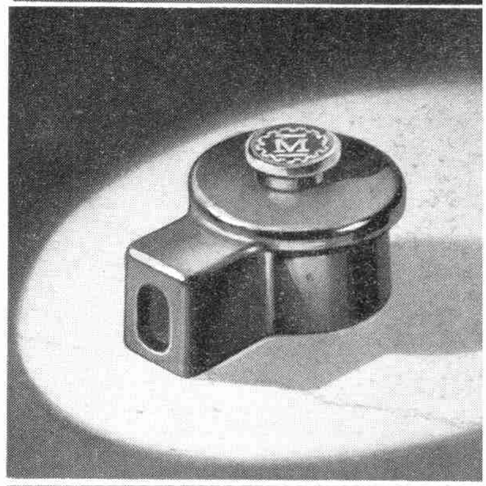
Soldering lug and contact one-piece. Lug ears annealed and solder dipped to facilitate each combination "mechanical plus soldered" connection of cable.

No. 36001—9/16"....................
No. 36002—3/8"....................
No. 36004—1/4"....................

SNAP LOCK PLATE CAP

For Mobile, Industrial and other applications where tighter than normal grip with multiple finger 360° low resistance contact is required. Contact self-locking when cap is pressed into position. Insulated snap button at top releases contact grip for easy removal without damage to tube.

No. 36011—9/16"....................
No. 36012—3/8"....................



SAFETY TERMINAL

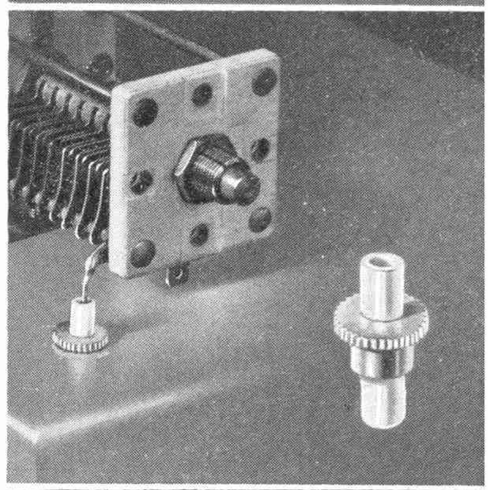
Combination high voltage terminal and thru-bushing. Tapered contact pin fits firmly into conical socket providing large area, low resistance connection. Pin is swivel mounted in cap to prevent twisting of lead wire.

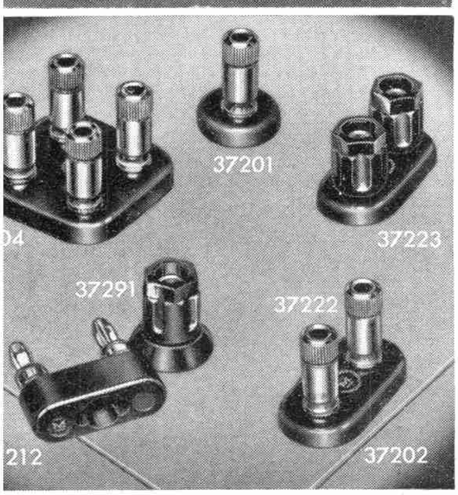
No. 37001, Black or Red..............
No. 37501, Low loss..................

THRU-BUSHING

Efficient, compact, easy to use and neat appearing. Fits ¼" hole in chassis. Held in place with a drop of solder or a "nick" from a crimping tool.

No. 32150........................





POSTS, PLATES, AND PLUGS

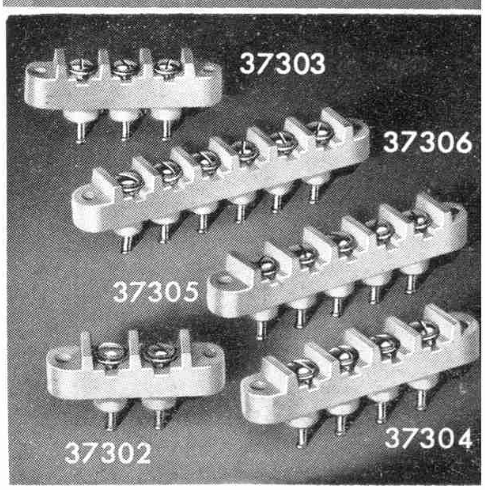
The No. 37200 series, including both insulated and non-insulated binding posts with associated plates and plugs, provide various combinations to meet most requirements. The posts have captive heads and keyed mounting.

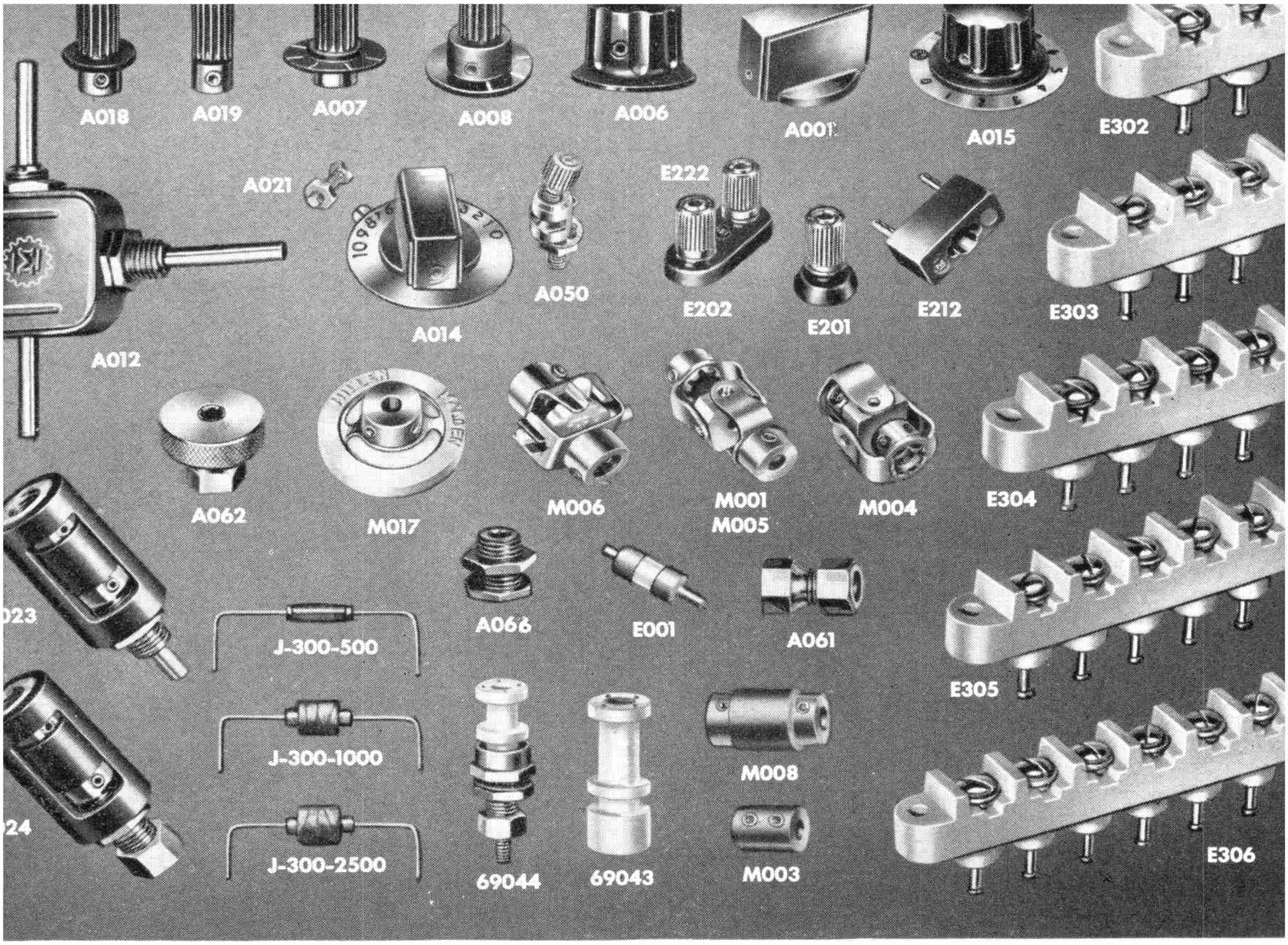
The No. 37291 and No. 37223 are standard in black or red with other colors on special order. No. 37201, No. 37202, and No. 37204 and No. 37222 are available in black, red, or low loss. The No. 37202 is also available in steatite.

No. 37201—Single plates, pr...........
No. 37291—Single plates (tapered), pr...
No. 37202—Dual plates, pr...........
No. 37204—Double dual plates, pr......
No. 37212—Dual plug...............
No. 37222—Non-insulated binding post, ea.
No. 37223—Insulated binding posts, ea...

STEATITE TERMINAL STRIPS

Terminal and lug are one piece. Lugs are turret type and are free floating so as not to strain L4 ceramic on wide temperature variations. Easy to mount with series of round holes. 1400 volt and 3500 volt series.



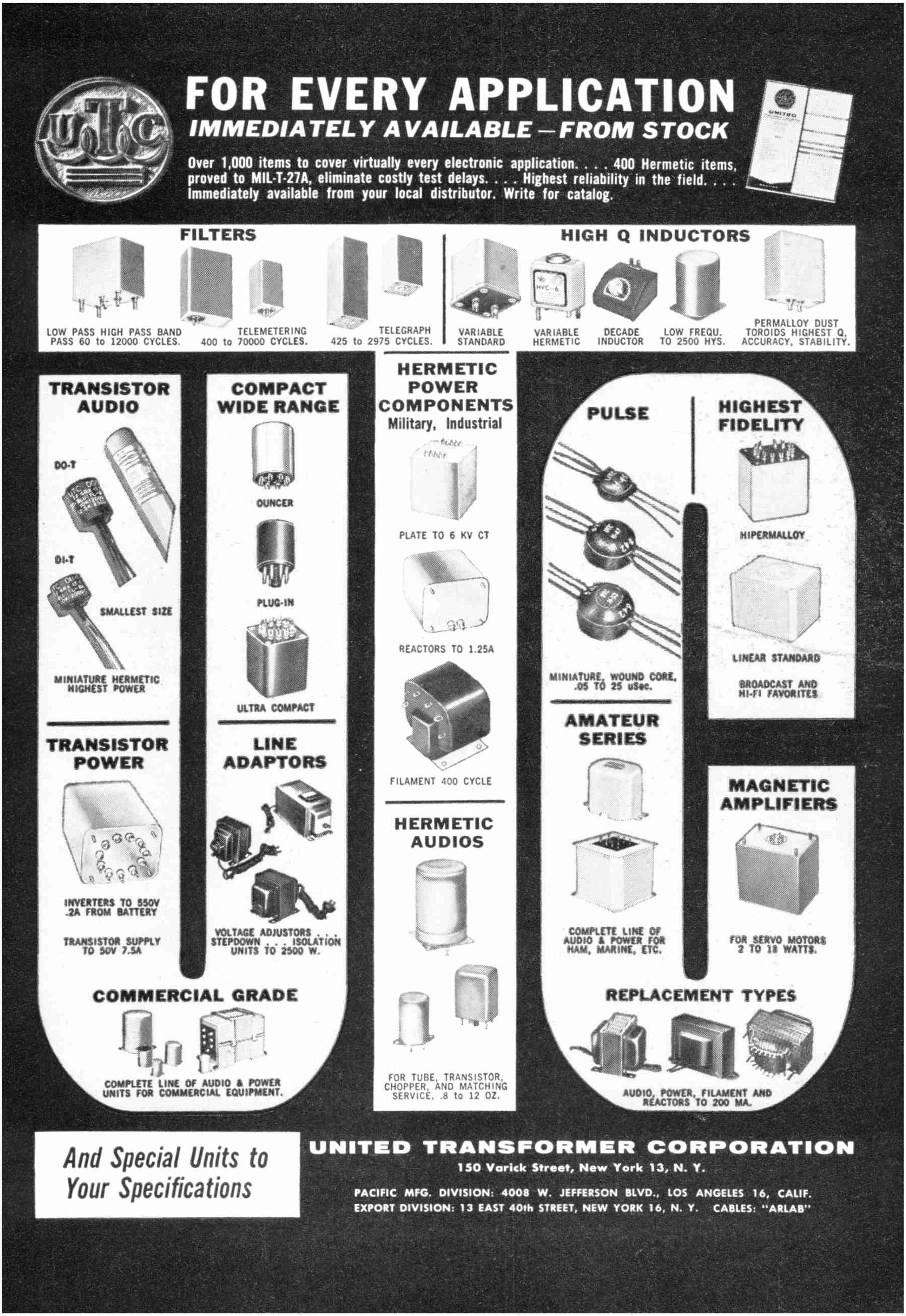


MINIATURIZED COMPONENTS

DESIGNED for APPLICATION miniaturized components developed for use in our own equipment such as the 90901 Oscilloscope, are now available for separate sale. Many of these parts are similar, in most details except size, to their equivalents in our standard component parts group. In certain devices where complete miniaturization is not paramount, a combination of standard and miniature components may possibly be used to advantage. For convenience, we have also listed on this page the extremely small sized coil forms from our standard catalog.

CODE	DESCRIPTION
A001	Bar knob for ⅛'' shaft. ½'' high by ¾'' long.
A006	Fluted black plastic knob with brass insert for ⅛'' shaft. ½'' high by ¾'' diameter.
A007	¼'' black plastic dial knob with brass insert for ⅛'' shaft. ⅝'' diameter dial. 5/16'' high.
A008	¼'' black plastic knob. Same as no. A007 except for style.
A012	Right angle drive for ⅛'' shafts. Single hole mounting.
A014	1'' bar dial for ⅛'' shaft. ½'' high. 180° or 280° dials for clockwise or counter-clockwise rotation.
A015	1'' fluted knob dial for ⅛'' shaft. ½'' high. Same dial plates as no. A014.
A017	1⅛'' diameter fluted black plastic knob for ⅛'' shaft.
A018	Knob, same as no. A007 except with ⅜'' diameter skirt.
A019	Knob, same as no. A007, but without dial.
A021	Miniature metal index for miniature dials.
A050	Miniature dial lock.
A061	Shaft lock for ⅛'' diameter shaft. ¼''-32 bushing. Nickel plated brass.
A062	Shaft lock with knurled locking nut.
A066	Shaft bearing for ⅛'' diameter shafts. Nickel plated brass Fits 17/64'' diameter hole.

CODE	DESCRIPTION
E001	Steatite ceramic standoff or tie-point. Integral mounting eyelet. 0.205'' overall diameter.
E201	Black or red plastic binding post plates for No. E222.
E202	Black or red plastic plates for two binding posts spaced ½''.
E212	Black or red plastic plug for two binding posts spaced ½''.
E222	Metal binding post with jack top.
E302A	to E306A Steatite ceramic terminal strips. 5/16'' wide. Terminals spaced ⅜'' on centers. Screw type or solder type thru-terminals.
J300–3.3	to J300–2500 Complete line of miniature inductances 3.3 to 2500 microhenries. ⅜'' long. Diameter 0.115'' to 0.297''.
M001	Insulated universal joint style flexible coupling for ⅛'' dia. shafts.
M003	Solid coupling for ⅛'' dia. shafts. Nickel plated brass.
M004	Universal joint style flexible coupling for ⅛'' diameter shafts. Inverted hubs for short length. Not insulated.
M005	Universal joint style flexible coupling for ⅛'' diameter shafts. External hub for maximum flexibility. Not insulated.
M006	Universal joint style flexible coupling for ⅛'' diameter shafts. Spring finger. Steatite ceramic insulation.
M008	Plastic insulated coupling with nickel plated brass inserts for ⅛'' diameter shafts.
M017	Plastic insulated flexible coupling for ⅛'' diameter shafts. 17/32'' long by 15/16'' diameter. Bronze yoke.
M023	Insulated shaft extension for ¼''-32 bushing and ⅛'' shaft For mounting sub-miniature potentiometer.
M024	Locking insulated shaft extension similar to no. M023.
69043	Steatite ceramic coil form. Adjustable core. Winding space ¼'' diameter by 13/32'' long. Mounting 4-40 hole.
69044	Steatite ceramic coil form. Adjustable core. Winding space 0.187'' diameter by 3/16'' long. No. 10-32 mounting.



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TELEGRAPH 425 to 2975 CYCLES.
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VARIABLE HERMETIC
DECADE INDUCTOR
LOW FREQU. TO 2500 HYS.
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TRANSISTOR AUDIO
DO-T
DI-T
SMALLEST SIZE
MINIATURE HERMETIC HIGHEST POWER
COMPACT WIDE RANGE
OUNCER
PLUG-IN
ULTRA COMPACT
HERMETIC POWER COMPONENTS
Military, Industrial
PLATE TO 6 KV CT
REACTORS TO 1.25A
FILAMENT 400 CYCLE
PULSE
MINIATURE, WOUND CORE, .05 TO 25 uSec.
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HIPERMALLOY
LINEAR STANDARD
BROADCAST AND HI-FI FAVORITES
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INVERTERS TO 550V .2A FROM BATTERY
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HERMETIC AUDIOS
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COMPLETE LINE OF AUDIO & POWER FOR HAM, MARINE, ETC.
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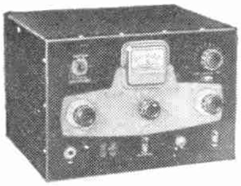


VIKING "ADVENTURER" 50 WATT TRANSMITTER—Used to earn first Novice WAC! (Worked All Continents.) Self-contained, effectively TVI suppressed, instant bandswitching 80, 40, 20, 15, and 10 meters. Operates by crystal or external VFO. An octal power receptacle located on the rear apron provides full 450 VDC at 150 ma. and 6.3 VAC at 2 amp. output of supply to power auxiliary equipment such as a VFO, signal monitor, or modulator for phone operation. This receptacle also permits using the full output of the supply to power other equipment when the transmitter is not operating. Wide range pi-network output handles virtually any antenna without separate antenna tuner. Break-in keying is clean and crisp. Designed for easy assembly. With tubes, less crystals and key. Dimensions: 10⅜" x 8⅛" x 7⅜". Shipping Weight: 19 lbs.

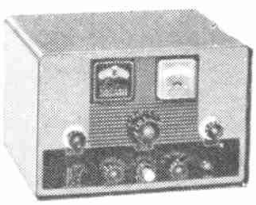
Cat. No. 240-181-1..Kit..............................Amateur Net $54.95

SPEECH AMPLIFIER/SCREEN MODULATOR—Designed to provide phone operation for the "Adventurer". High gain—use with either crystal or dynamic microphones. Simple installation—only minor wiring changes necessary in "Adventurer". With tubes.

Cat. No. 250-40..Kit..................................Amateur Net $12.25

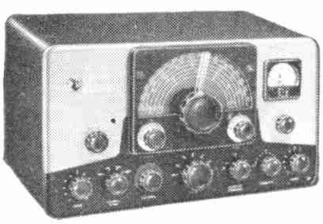
VIKING "NAVIGATOR" TRANSMITTER/EXCITER—This compact, flexible CW transmitter has enough RF power to excite most high powered final amplifiers on CW and AM. 40 watts—bandswitching 160 through 10 meters. Highly stable, built-in VFO is temperature compensated and voltage regulated—may also be operated crystal control. Timed sequence keying—effectively TVI suppressed. Pi-network antenna load matching from 40 to 600 ohms. With tubes, less crystals and key. Dimensions: 13¼" x 9⅛" x 10¹⁄₁₆". Shipping Weight: 27 lbs.

Cat. No. 240-126-1..Kit..............................Amateur Net $149.50
Cat. No. 240-126-2..Wired and tested.................Amateur Net $199.50



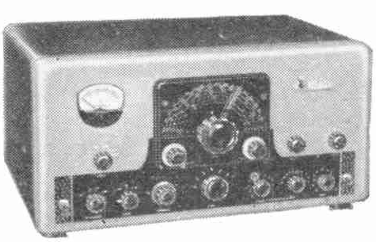
VIKING "CHALLENGER" TRANSMITTER—Ideal for fixed station, emergency, portable or field day use, the "Challenger" is a full size transmitter with three RF stages—designed for fast, easy tuning, excellent stability and plenty of reserve drive. 70 watts phone input 80 through 6 meters, 120 watts CW input 80 through 10 meters . . . 85 watts CW input on 6 meters! A single 6DQ6A buffer drives two husky 6DQ6A bridge neutralized tetrodes in the final amplifier. Hi "Q" wide range pi-network output—effectively TVI suppressed and filtered. For crystal or external VFO control. Excellent keying system. With tubes and built-in power supply.

Cat. No. 240-182-1..Kit..............................Amateur Net $114.75
Cat. No. 240-182-2..Wired and tested..................Amateur Net $154.75



VIKING "RANGER" TRANSMITTER—This outstanding amateur transmitter will also serve as an RF and audio exciter for high power equipment. As an exciter, it will drive any of the popular kilowatt level tubes. No internal changes necessary to switch from transmitter to exciter operation. Self-contained, 75 watts CW or 65 watts phone input . . . instant bandswitching 160, 80, 40, 20, 15, and 10 meters. Extremely stable, built-in VFO or crystal control—effectively TVI suppressed—high gain audio—timed sequence (break-in) keying—adjustable wave shaping. Pi-network antenna load matching from 50 to 500 ohms. Easily assembled—with tubes, less crystals, key and microphone. 15½" x 9⅝" x 14". Shipping Weight: 54 lbs.

Cat. No. 240-161-1..Kit..............................Amateur Net $229.50
Cat. No. 240-161-2..Wired and tested.................Amateur Net $329.50



VIKING "VALIANT" TRANSMITTER—Designed for outstanding flexibility and performance. 275 watts input on CW and SSB (P.E.P. with auxiliary SSB exciter), 200 watts AM. Instant bandswitching 160 through 10 meters—operates by built-in VFO or crystal control. Pi-network tank circuit will match antenna loads from 50 to 600 ohms—final tank coil is silver-plated. Other features: TVI suppressed—timed sequence (break-in) keying—high gain push-to-talk audio system—low level audio clipping—built-in low pass audio filter—self-contained power supplies. With tubes, less crystals, key, and microphone. Dimensions: 21" x 11⅝" x 16¼". Shipping Weight: 83 lbs.

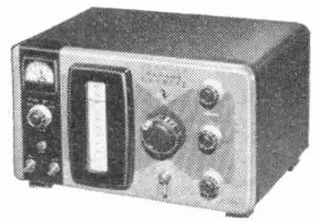
Cat. No. 240-104-1..Kit..............................Amateur Net $349.50
Cat. No. 240-104-2..Wired and tested.................Amateur Net $439.50

VIKING "FIVE HUNDRED" TRANSMITTER—Rated a full 600 watts CW . . . 500 watts phone and SSB. (P.E.P. with auxiliary SSB exciter.) All exciter stages ganged to VFO tuning. Two compact units: RF unit small enough to place on your operating desk beside receiver—power supply/modulator unit may be placed in any convenient location. Crystal or built-in VFO control—instant bandswitching 80 through 10 meters—TVI suppressed—high gain push-to-talk audio system—low level audio clipping. Pi-network output circuit with silver-plated final tank coil will load virtually any antenna system. With tubes, less crystals, key, and microphone. Dimensions: RF Unit—21" x 11⅝" x 16½". Power Supply—20⅜" x 15¾" x 10⅞". Total Shipping Weight: 200 lbs.

Cat. No. 240-500-1 . . Kit. . . . . Amateur Net $749.50
Cat. No. 240-500-2 . . Wired and tested. . . . . Amateur Net $949.50

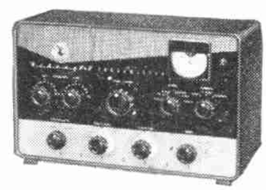
VIKING "THUNDERBOLT" AMPLIFIER—The hottest linear amplifier on the market—handles over 2000 watts P.E.P.* input SSB; 1000 watts CW; 800 watts AM linear; in a completely self-contained desk-top package. Continuous coverage 3.5 to 30 mcs.—instant bandswitching. May be driven by the Viking "Navigator", "Ranger", "Pacemaker", or other unit of comparable output. Drive requirements: approximately 10 watts in Class AB_2 linear, 20 watts Class C continuous wave. With tubes and built-in power supply. Dimensions: 21" x 11⅝" x 16 7/16". Shipping Weight: 140 lbs.

Cat. No. 240-353-1 . . Kit. . . . . Amateur Net $524.50
Cat. No. 240-353-2 . . Wired and tested. . . . . Amateur Net $589.50



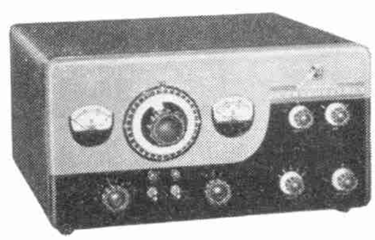
VIKING "COURIER" AMPLIFIER—Rated a solid one-half kilowatt P.E.P. input with auxiliary SSB exciter as a Class B linear amplifier; one-half kilowatt input CW or 200 watts in AM linear mode. Completely self-contained desk-top package—may be driven by the Viking "Navigator," "Ranger," "Pacemaker," or other unit of comparable output. Continuous coverage 3.5 to 30 mcs. Drive requirements: 5 to 35 watts depending upon mode and frequency desired. Pi-network output designed to match 40 to 600 ohm antenna loads. Fully TVI suppressed. Complete with tubes and built-in power supply. Dimensions: 15½" x 9⅝" x 14". Shipping Weight: 68 lbs.

Cat. No. 240-352-1 . . Kit. . . . . Amateur Net $244.50
Cat. No. 240-352-2 . . Wired and tested. . . . . Amateur Net $289.50



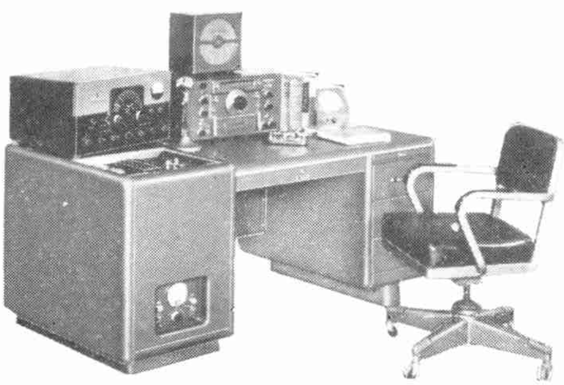
VIKING "6N2" TRANSMITTER—Instant bandswitching on 6 and 2 meters, this compact VHF transmitter is rated at 150 watts CW and 100 watts AM phone. Completely shielded and TVI suppressed, the "6N2" may be used with the Viking "Ranger," "Viking I," "Viking II," or similar power supply/modulator combinations capable of at least 6.3 VAC at 3.5 amp., 300 VDC at 70 ma., 300 to 750 VDC at 200 ma. and 30 or more watts audio. May be operated by built-in crystal control or external VFO with 8-9 mc. output. With tubes, less crystals, key, and microphone. Dimensions: 13⅛" x 8⅜" x 8½". Shipping Weight: 14 lbs.

Cat. No. 240-201-1 . . Kit. . . . . Amateur Net $129.50
Cat. No. 240-201-2 . . Wired and tested. . . . . Amateur Net $169.50



VIKING "6N2" THUNDERBOLT AMPLIFIER—Brand new . . . continuous bandswitched coverage on 6 and 2 meters. Rated at 1200 watts P.E.P.* input SSB and DSB, Class AB_1; 1000 watts CW input Class C; and 700 watts input AM linear, Class AB_1. Drive requirement approximately 5 watts in Class AB_1 linear or 6 watts Class C continuous wave. Effectively TVI suppressed and filtered—wide range pi network output. Outstanding efficiency—losses on 2 meters held to approximately 5%, instead of common 25% losses experienced in some other 2 meter circuitry, due to unique silver-plated anode and other external metal portions of the 7034 tubes; silver-plated inductors, capacitors, and switch. With tubes. Dimensions: 21" x 11⅝" x 16 7/16".
Shipping Weight: 140 lbs.

Cat. No. 240-362-1 . . Kit. . . . . Amateur Net $524.50
Cat. No. 240-362-2 . . Wired and tested. . . . . Amateur Net $589.50



VIKING "KILOWATT" AMPLIFIER—Brilliantly designed and engineered, the Viking "Kilowatt" is the only power amplifier available which will handle full 2000 watts SSB* input and 1000 watts CW and plate-modulated AM! Class "C" final amplifier operation provides plate circuit efficiencies in excess of 70%. Final amplifier utilizes two 4-400A tetrodes in parallel, bridge neutralized. Continuous coverage 3.5 to 30 mc. Excitation requirements: 30 watts RF and 10 watts audio for AM; 10 watts peak for SSB.

Cat. No. 240-1000. Wired and tested. . . . . Amateur Net $1595.00
Cat. No. 251-101-1 . . Matching accessory desk top, back and three drawer pedestal. . . . . FOB Corry, Pa. $132.00

**The FCC permits a maximum of one kilowatt average power input for the amateur service. In SSB operation under normal conditions this results in peak envelope power inputs of 2000 watts or more depending upon individual voice characteristics.*

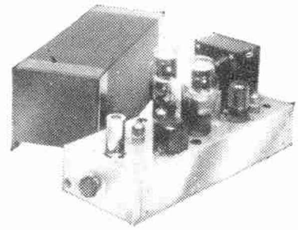
The E. F. Johnson Company reserves the right to change prices and specifications without notice and without incurring obligation.

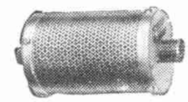
E. F. Johnson Company
120 SECOND AVENUE S. W. • WASECA, MINNESOTA

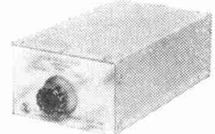
Your best buy!

Johnson Station Accessories

. . . For Outstanding PERFORMANCE!







VIKING AUDIO AMPLIFIER—A self-contained 10-watt speech amplifier complete with power supply. Speech clipping and filtering designed to raise average modulated carrier level . . . improves the performance and effectiveness of your AM transmitter. Inputs provided for microphone, or line. Complete with tubes. Dimensions: 13⅞" x 8" 5⅜". Shipping Weight: 22 lbs.

Cat. No. 250-33-1 . . Kit . . . . Amateur Net $73.50

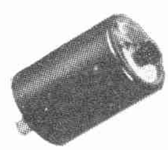
Cat. No. 250-33-2 . . Wired and tested . . . . Amateur Net $99.50

POWER REDUCER—Provides up to 20 watts continuous dissipation for 100-150 watt transmitters such as Johnson Viking, Collins 32V, or others, permitting them to serve as exciters for the Viking "Kilowatt". Completely shielded—equipped with SO-239 coaxial connectors. Dimensions: 3½" long x 2¼" diameter.

Cat. No. 250-29 . . . . Amateur Net $13.95

POWER DIVIDER—Provides up to 35 watts continuous dissipation. Designed to provide the proper output loading of the "Pacemaker" SSB Transmitter when used to drive the Viking Kilowatt Amplifier.

Cat. No. 250-34 . . . . Amateur Net $25.50



VIKING "6N2" VFO—Exceptionally stable and compact—designed to replace 8 to 9 mc. crystals in frequency multiplying 6 and 2 meter transmitters, including types using overtone oscillators. Temperature compensated and voltage regulated for minimum drift and high stability. Plexiglas dial calibrated from 144 to 148 mc., 50 to 51.5 mc., 51.5 to 53 mc. 10 to 1 vernier tuning. Complete with tubes and calibrated dial. Dimensions: 4" x 4½" x 5".

Cat. No. 240-133-1 . . Kit . . . . Amateur Net $34.95

Cat. No. 240-133-2 . . Wired and tested . . . . Amateur Net $54.95

VIKING "6N2" CONVERTER—This compact "6N2" Converter provides instant front panel switching from normal receiver operation to either 6 or 2 meters. Maximum sensitivity and low noise figure—excellent image and I. F. rejection due to double-tuned, overcoupled, interstage circuits on both 6 and 2 meters. With tubes. Dimensions: 2¾" x 5" x 12." Shipping Weight: 5 lbs. Available kit or wired in either 26 to 30 mcs., 28 to 30 mcs., 14 to 18 mcs., or 30.5 to 24.5 mcs. ranges. Specify range desired.

Kits . . . . Amateur Net $59.95

Wired Models . . . . Amateur Net $89.95

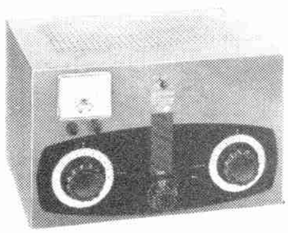
MOBILE VFO—Diminutive variable frequency oscillator designed specifically for mobile use. Rugged construction minimizes frequency shift due to road shock and vibration . . . small size permits steering post mounting. Temperature compensated and voltage regulated. Calibrated 75 through 10 meters . . . 3.75 to 4 mc. output for 75 meters and 7.05 to 7.45 for 40 to 10 meters. 10.5 mc. output also available for doubling to 15 meters. With tubes. Dimensions: 4" x 4¼" x 5".

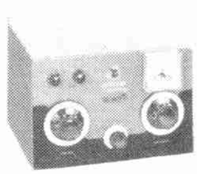
Cat. No. 240-152-1 . . Kit . . . . Amateur Net $33.95

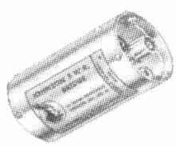
Cat. No. 240-152-2 . . Wired and tested . . . . Amateur Net $52.50

"WHIPLOAD-6"—Provides high efficiency base loading for mobile whips with instant bandswitch selection of 75, 40, 20, 15, 11, and 10 meters. On 75 meters a special capacitor with dial scale permits tuning entire band. Covers other bands without tuning. Air-wound coil provides extremely high "Q." Fibre-glass housing protects assembly. Mounts on standard mobile whip.

Cat. No. 250-26 . . Wired and tested . . . . Amateur Net $16.95







VIKING "MATCHBOXES" Provides completely integrated antenna matching and switching systems for kilowatt or 275-watt transmitters. Units complete with built-in directional coupler and indicator. Bandswitching 80, 40, 20, 15, and 10 meters. Quickly and easily match transmitter to balanced or unbalanced lines over a wide range of antenna impedances will tune out large amounts of capacitive or inductive reactance. No "plug-in" coils or "load-tapping" necessary.

275 WATT "MATCHBOX"

Cat. No.	Amateur Net
250-23-3 . . With built-in Directional Coupler & Indicator	$86.50
250-23 . . Less built-in Directional Coupler & Indicator	$54.95

KILOWATT "MATCHBOX"

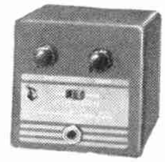
Cat. No.	Amateur Net
250-30-3 . . With built-in Directional Coupler & Indicator	$149.50
250-30 . . Less built-in Directional Coupler & Indicator	$124.50

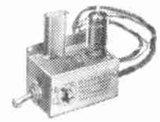
SWR BRIDGE—Measures standing wave ratios for effective use of a low pass filter and antenna coupler. 52 ohms impedance can be changed to 70 ohms or other value. SO-239 connectors and polarized meter jacks. Dimensions: 4 1/32" long x 2 5/16" diameter.

Cat. No. 250-24 . . Wired and tested . . . . Amateur Net $9.75

"SIGNAL SENTRY"—Monitors CW or phone signals on all frequencies to 50 mc. without tuning. Energized by transmitter RF. Mutes receiver audio for break-in. May be used as code practice oscillator with simple circuit modification. Requires 250 VDC at 5 ma.; and 6.3 VAC at .6 amp. from receiver or other source. With tubes. Dimensions: $3\frac{5}{8}$" x $3\frac{7}{8}$" x $3\frac{3}{4}$". Shipping Weight: 3 lbs.

Cat. No. 250-25 . . Wired and tested . . . . Amateur Net $22.00





CRYSTAL CALIBRATOR—Provides accurate 100 kc. check points to 55 mc. Requires 6.3 volts at .15 amps. and 150-300 volts at 2 ma. With tube, military-type crystal, power cable and extension leads. Dimensions: $1\frac{5}{8}$" x $2\frac{1}{2}$" x $1\frac{1}{2}$". (Over-all height to top of tube is $3\frac{3}{8}$".)

Cat. No. 250-28 . . Wired and tested . . . . Amateur Net $17.95

LOW PASS FILTER—Handles more than 1000 watts RF—provides 75 db or more attenuation above 54 mc. Insertion loss less than .25 db. Replaceable Teflon insulated fixed capacitors. SO-239 coaxial connectors. Wired and pre-tuned. Dimensions: 9" long x $2\frac{5}{16}$" diameter.

Cat. No. 250-20 . . Wired and pre-tuned 52 ohms . . . . Amateur Net $14.95

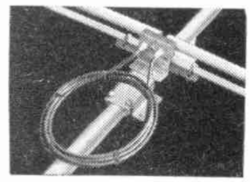
Cat. No. 250-35 . . Wired and pre-tuned 72 ohms . . . . Amateur Net $14.95

ATTENUATORS—These T-pad attenuators provide 6 db of attenuation with required power dissipation to enable various units to serve as exciters for the Viking "Thunderbolt" linear amplifier. Dial instantly cuts attenuator in or out of circuit. Dimensions: $4\frac{1}{2}$" x $3\frac{1}{8}$" x $9\frac{1}{8}$". Shipping Weight: 2 lbs.

For use with Viking "Ranger" of similar unit. Provision for 75 watt incandescent bulb so unit may be used with Viking II or similar transmitter/exciter.

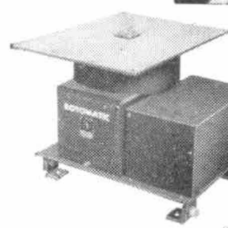
Cat. No. 250-42-1 . . . . Amateur Net $21.50

Cat. No. 250-42-3 For use with HT-32, or similar unit. . . . . **Amateur Net $21.50**



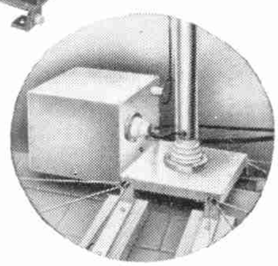
PRE-TUNED BEAMS—Rugged, semi-wide spaced pre-tuned beams with balun matching sections. For 20, 15 and 10 meters. Approximately 9.0 db gain over tuned dipole—greater than 27 db front-to-back ratio with low SWR. Pattern is uni-directional, beam width is 55°. No adjustments required. Boom assemblies are of 2" galvanized steel tubing, elements are aluminum alloy tubing. No loading devices needed for flutter dampening or corona discharge.

Cat. No. (With 3 elements, beam and balun)		Amateur Net
138-420-3	20 Meter Beam—20′ Boom. 84 lbs. Net Weight	$139.50
138-415-3	15 Meter Beam—13′7″ Boom. 53 lbs. Net Weight	110.00
138-410-3	10 Meter Beam—10′ Boom. 42 lbs. Net Weight	79.50



ROTOMATIC ROTATOR—Safely supports multiple arrays weighing up to several hundred pounds, even under heavy icing conditions or high wind loading. Rotates 1 RPM—over-all gear reduction 12,000 to 1. Rotator housing is cast aluminum, with 5/16" steel rotating table. Includes desk top control box for automatic and accurate antenna azimuth bearing.

Cat. No.		Amateur Net
138-116	With limit switches for 370° rotation—coaxial line	$354.00
138-108	Beam switching relay	$ 22.00
144-16	8 Conductor cable for rotator, per ft.	$ .26



"MATCHSTICK"—Fully automatic, pre-tuned multi-band vertical antenna system. Band-switching 80 through 10 meters. Remotely motor driven from operating position. Easily mounts on roof top or in limited space location. Low SWR (less than 2 to 1) all bands. Impedance: 52 ohms. Complete with 35′ mast, base, tuning network, relays, control box and 6 nylon guy ropes. Shipping Weight: 38 lbs.

Cat. No. 137-102 . . Pre-tuned . . . . Amateur Net $129.50

T-R SWITCH—Provides instantaneous high-efficiency electronic antenna switching. Excellent receiver isolation. Gain: 0 db at 30 mcs.; 6 db at 3.5 mcs. Rated at 4000 watts peak power. Instantaneous break-in on SSB, DSB, CW or AM. Will not affect transmission line SWR—provides an effective impedance match to most receivers through 3 to 30 mc. range. With tube, power supply, and provision for RF probe, etc. Dimensions: $4\frac{3}{16}$" x $4\frac{3}{8}$" x $5\frac{5}{16}$". Shipping Weight: 5 lbs.

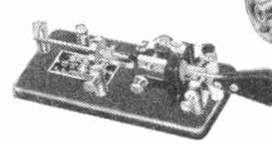
Cat. No. 250-39 . . Wired and tested . . . . Amateur Net $27.75

DIRECTIONAL COUPLER AND INDICATOR—Provides continuous reading of SWR and relative power in transmission line. Coupler may be permanently installed in 52 ohm coaxial line—handles maximum legal power as specified by FCC. Standard tip jacks permit use of commercial multimeter as indicating instrument—reference sheets showing curves supplied for popular multimeter basic ranges. Indicator is a 0-100 micro-ammeter calibrated in SWR and relative power. Monitors incident or reflected power quickly with flip of a switch. Coupler dimensions: $6\frac{1}{4}$" long x $2\frac{5}{16}$" diameter. Shipping Weight: 2 lbs. Indicator dimensions: 4" x $4\frac{3}{8}$" x $4\frac{1}{4}$". Shipping Weight: 4 lbs.

Cat. No. 250-37 . . Coupler, Wired and tested . . . . Amateur Net $11.75

Cat. No. 250-38 Indicator, Wired and tested . . . . Amateur Net $25.00

KEYS AND PRACTICE SETS—Johnson also manufactures a complete line of semi-automatic, high speed, standard, heavy duty and practice keys; code practice sets and buzzers. See your distributor for complete information.



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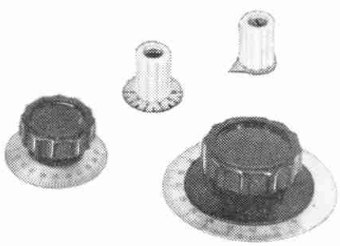
Your best buy!

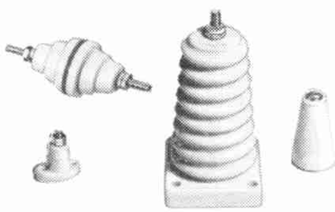
Johnson Components

...Tops for QUALITY!

The E. F. Johnson Company also manufactures a complete line of electronic components for those of you who prefer to design and build your own transmitting equipment and accessories. The complete line is covered in Catalog 978 . . . write for your free copy today!

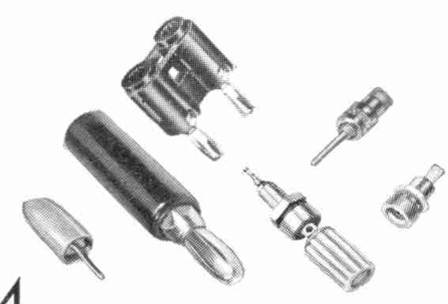


KNOBS AND DIALS—Includes a new group of molded nylon collet knobs available in 13 bright colors; and a distinctive line of matching knobs and dials suitable for use on the finest electronic and electrical equipment. Available with phenolic skirts, etched and anodized aluminum skirts with markings, or flat dial scores engraved and filled. Collet knobs are constructed of tough, shock-proof nylon—designed for use with ⅛″ shafts; standard phenolic knobs meet MIL-P-14 specifications, and are furnished with heavy brass inserts for ¼″ shafts.



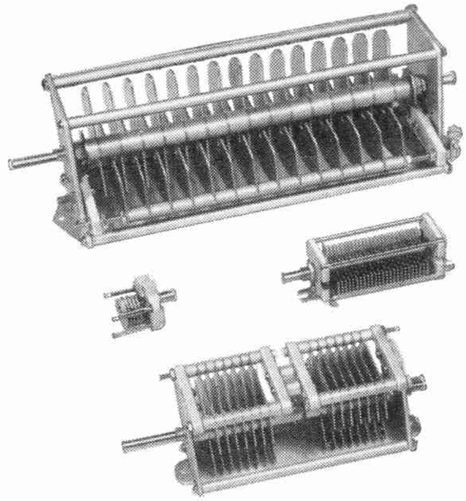
INSULATORS—High quality steatite and porcelain insulators. Heavily glazed surfaces and heavy nickel-plated brass hardware suitable for exposed application. May be supplied with screws and nuts or with jacks to accommodate standard banana plugs. Through-panel and stand-off types. Also antenna insulators, bushings, and feeder insulators.

PILOT LIGHTS—A complete selection of standardized pilot lights. Faceted jewel or wide-angle lucite lens types; enclosed or open body styles; standard bayonet, candelabra, or miniature screw types, and a wide variety of mounting brackets and assemblies. Jewels available in clear, red, green, amber, blue, and opal. All Johnson pilot lights are described in detail in Pilot Light Catalog 750a—send for your copy!



CONNECTORS—A complete line of new nylon connectors is available in addition to standard banana jacks and plugs. Nylon components include insulated solderless tip and banana plugs, tip and banana jacks, tip jack and sleeve assemblies, metal-clad tip jacks, and a 6-way binding post. In thirteen bright colors—nylon components are designed to operate through an extremely wide temperature range and high relative humidity conditions. (Voltage breakdown up to 11,000 volts.) Solderless nylon plugs are easy to assemble—both plugs and jacks require a minimum amount of mounting space.

VARIABLE CAPACITORS



TYPE "M"—These diminutive capacitors provide the perfect answer to problems encountered in the design of compact radio frequency equipment. Bridge-type stator terminal provides extremely low inductance path to both stator supports. Soldered bearing and heavily anchored stator supports insure extreme rigidity.

TYPE "S"—Midway between types "M" and "K" in size, design is compact and construction rugged. Equipped with DC-200 treated steatite end frame and nickel-plated brass plates—an excellent choice where higher capacity values than provided in "M" types is required in small space.

TYPES "C" AND "D"—Functional favorites built to exacting standards for medium power RF equipment. Dual types have centered rotor connection for balance. End frames tapped for panel mounting. Brackets furnished for chassis mounting.

TYPES "E" AND "F"—Rugged units provide a large amount of capacity per cubic inch and extremely low capacity to the chassis. Panel or chassis mounting.

TYPE "G"—Neutralizing capacitors for medium and low-powered stages constructed on the rotor-stator principle. Panel or chassis mounting.

TYPE "J"—Heavy-duty miniature type has wider spacing than most small air variables, yet occupies little more space. Useful for small space plate tank circuits and low power stages where standard miniatures have insufficient plate spacing.

TYPE "K"—Widely used for military and many commercial applications, the Johnson type "K" features DC-200 impregnated steatite end frames, slotted stator contacts, and extra-rigid soldered plate construction.

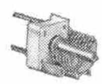
TYPE "L"—A superior quality general purpose capacitor embodying important advances in design and construction. The rotor bearing and stator support rods are actually soldered directly to the ceramic (steatite) end frames, making the capacitor virtually vibration-proof.

TYPE "N"—Extremely high voltage rating in proportion to size requiring a small mounting area. Constant voltage rating throughout full capacity range. These are of the aluminum cup and cylinder type of construction and are supported by a steatite frame with cast aluminum mounting bracket.

TYPE "R"—The rugged Johnson version of a popular standardized capacitor. Featuring extra heavy steatite stator support insulators and soldered .023″ thick brass plates; all metal parts heavily nickel-plated for corrosion-resistance.

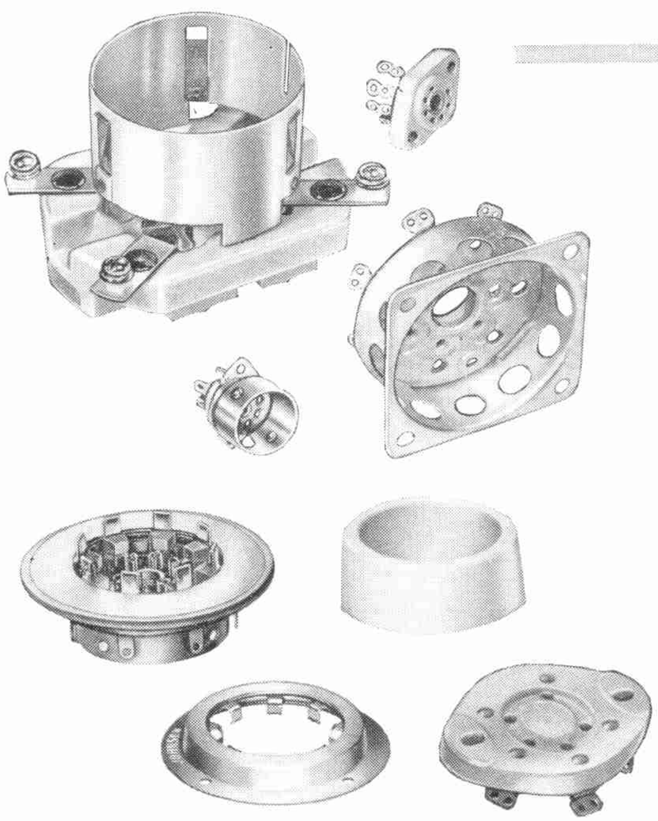
TYPE "U"—New design—rotor and stator are precision machined from one piece of solid brass, offering excellent uniformity and outstanding mechanical stability. Low cost due to automatic production techniques. High torque-to-mass ratio. Excellent, low temperature coefficient.

TYPE "U"



TYPE "T"

TYPE "T"—Tiny new sub-miniature air variable built to comply with MIL-C-92 specifications. Excellent mechanical stability, "Q" greater than 3000 at 1 Mc., and high torque-to-mass ratio. Available only in production quantities for commercial applications.



TUBE SOCKETS

Johnson steatite and porcelain tube sockets are available in three grades: Standard, Industrial, and Military. All are manufactured to rigidly controlled specifications, and all are made of only the highest quality materials.

Bayonet Types—include Medium, Jumbo, and Super Jumbo 4 pin models.

Steatite Wafer Types—available in 4, 5, 6, 7, and 8 pin standard sockets as well as Super Jumbo 4 pin, Giant 5 and 7 pin models and VHF transmitting Septar base types.

Miniature Types—are steatite insulated and available in Miniature 7 and 9 pin models. Matching miniature shields also available.

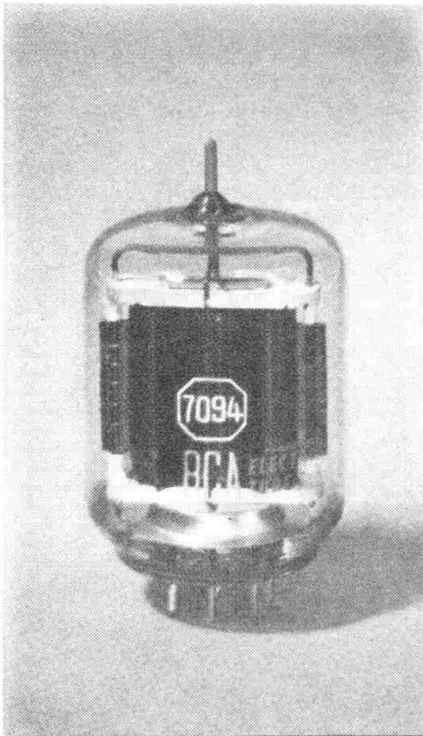
Special Purpose Types—include sockets for tubes such as the 204A and 849, the 833A, 304TL, 5D21, 705A, and other special types.

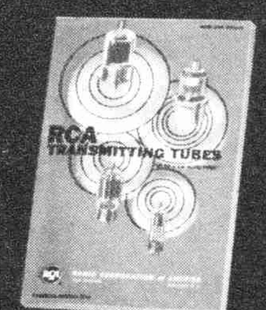
For High Power Transmitting Tubes—such as the 4X150A, 4X150D, 4X250B, 4CX250B, 4X250F, 7034, 7035. Available in several designs—with or without screen grid by-pass capacitor. Basic socket molded of low-dielectric loss-factor Kel-F plastic. Contacts are low-resistance silver-plated beryllium copper.

E. F. Johnson Company

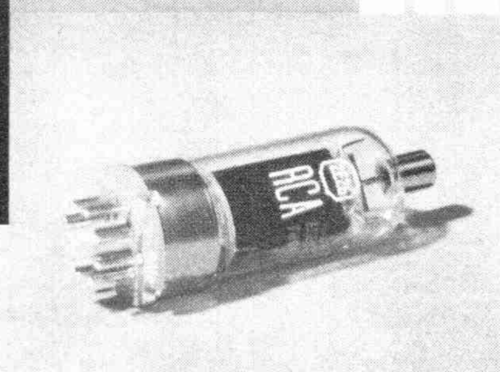
120 SECOND AVENUE S.W. - WASECA, MINNESOTA

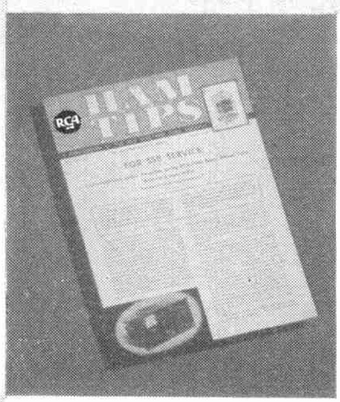
Typical RCA Beam Power Tubes for amateur service





RCA Transmitting Tube Manual TT-4 ...256 fact-filled pages covering 108 RCA power tube types and 13 RCA high-voltage rectifier types. Available at your RCA Industrial Tube Distributor. Or send $1.00 to RCA Commercial Eng., Sec. A-11-M, Harrison, N. J.





RCA HAM TIPS...Written by hams for hams. A regular publication carrying up-to-the-minute articles, and latest "tips" for the shack. Free from your RCA Industrial Tube Distributor.

Popular RCA "High-Perveance" Power Tubes for Transmitter Application

(listed according to power-input ratings)

RCA Type	Beam Power or Triode	Class of Service	Max. Plate Input Watts	Max. DC Plate Volts	Max. freq. For full Input (Mc)	Heater (H) or Filament (F) Volts
5763	Beam Power	CW AM	17 15	350 300	50	6.0 (H)
6417	Beam Power	Same as RCA-5763, except for heater voltage				12.6 (H)
2E26	Beam Power	CW SSB AM	40 37.5 27	600 500 500	125	6.3 (H)
2E24	Beam Power	Same as RCA-2E26, but has quick-heating *filament*				6.3 (F)
6893	Beam Power	Same as RCA-2E26, except for heater voltage				12.6 (H)
832-A*	Beam Power	CW AM	50** 36**	750 600	200	6.3▲ (H) 12.6● (H)
807	Beam Power	CW SSB AM	75 90 60	750 750 600	60	6.3 (H)
1625	Beam Power	Same as RCA-807, except for heater voltage and use of medium-7-pin base				12.6 (H)
6524*	Beam Power	CW SSB AM	85** 85** 55**	600 600 500	100	6.3 (H)
6850*	Beam Power	Same as RCA-6524, except for heater voltage				12.6 (H)
6146	Beam Power	CW SSB AM	90 85 67.5	750 750 600	60	6.3 (H)
6883	Beam Power	Same as RCA-6146, except for heater voltage				12.6 (H)
829-B*	Beam Power	CW SSB AM	120** 120** 90**	750 750 600	200	6.3▲ (H) 12.6● (H)
7270	Beam Power	CW SSB AM	315 250 210	1350 1350 1100	60	6.3 (H)
811-A	Triode	CW SSB AM	260 235 175	1500 1500 1250	30	6.3 (F)
812-A	Triode	CW AM	260 175	1500 1250	30	6.3 (F)
8005	Triode	CW AM	300 240	1500 1250	60	10 (F)
7034/ 4X150A	Beam Power	CW SSB AM	500 630 320	2000 2250 1600	150	6.0 (H)
7094	Beam Power	CW SSB AM	500 400 335	1500 2000 1200	60	6.3 (H)
813	Beam Power	CW SSB AM	500 450 400	2250 2500 2000	30	10 (F)
8000	Triode	CW SSB AM	750 510 500	2500 2750 2000	30	10 (F)
833-A	Triode	CW SSB AM	1000, *plus* 1000, *plus* 1000	3300 3300 3000	30	10 (F)

* Twin-Type ** Total for both units ▲ For parallel-heater connection ● For series-heater connection

Available in a choice of input power ratings *up to the legal limit*, RCA power tubes are the Amateur's answer for power reliability in virtually every rf and af power application you can name. And remember this: Many RCA power tubes for amateurs do not require expensive air-system sockets.

The quick-reference chart shown here will help you pick the popular RCA types you need—from more than 90 types of beam power tubes and triodes available for amateur transmitter application. Note that every type listed on this chart has "high-perveance" design...a development that enables you to get *the power you want at relatively low plate voltage*. And note this, too: Every type is conservatively rated to assure long hours of "solid" QSO's.

Whether you are planning high power or low power, CW or 'phone, AM or SSB—you'll get more watts for your "transmitter dollar" when you design, or when you "retube", with "RCA's".

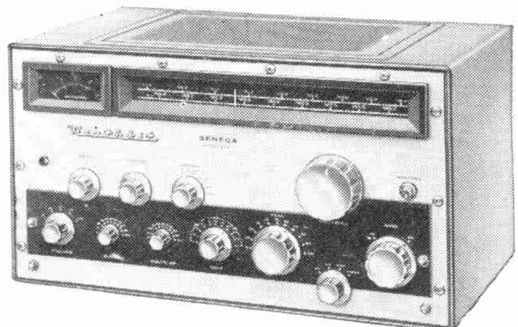
That's why RCA Power Tubes continue to be top choice among the leading transmitter designers. Your RCA Industrial Tube Distributor handles the complete line.

RADIO CORPORATION OF AMERICA

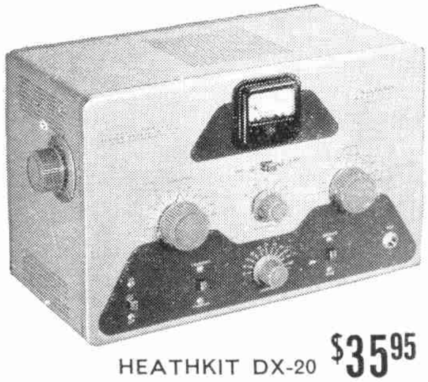
® ***Electron Tube Division*** ***Harrison, N. J.***

"SENECA" VHF HAM TRANSMITTER KIT

Beautifully styled and a top performer of highest quality throughout. The "Seneca" is a completely self-contained 6 and 2 meter transmitter featuring a built-in VFO for both 6 and 2 meters, and 4 switch-selected crystal positions, 2 power supplies, 5 radio frequency stages, and 2 dual-triode audio stages. Panel controls allow VFO or crystal control, phone or CW operation on both amateur bands. An auxiliary socket provides for receiver muting, remote operation of antenna relay and remote control of the transmitter such as with the Heathkit VX-1 Voice Control. Features up to 120 watts input on phone and 140 watts on CW in the 6 meter band. Ratings slightly reduced in the 2 meter band. Ideal for ham operators wishing to extend transmission into the VHF region. Shpg. Wt. 56 lbs.



HEATHKIT VHF-1 $159.95



HEATHKIT DX-20 $35.95

DX-20 CW TRANSMITTER KIT

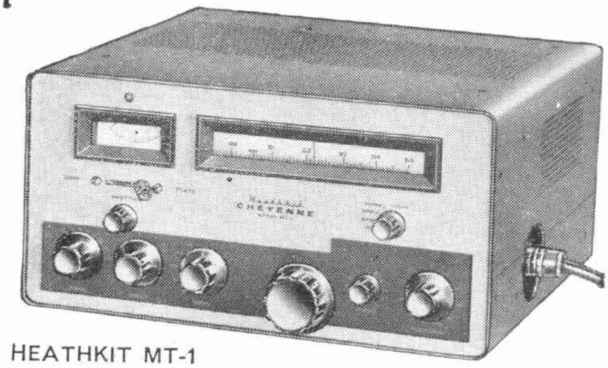
Designed exclusively for CW work, the DX-20 provides the novice as well as the advanced-class CW operator with a low cost transmitter featuring high operating efficiency. Single-knob bandswitching covers 80, 40, 20, 15 and 10 meters using crystals or an external VFO. Pi network output circuit matches antenna impedances between 50 and 1,000 ohms. Employs a single 6DQ6A tube in the final amplifier stage for plate power input of 50 watts. A 6CL6 serves as the crystal oscillator. The husky power supply uses a heavy duty 5U4GB rectifier and top-quality "potted" transformer for long service life. Easy-to-read panel meter indicates final grid or plate current selected by the panel switch. Complete RF shielding to minimize TVI interference. Easy-to-build with complete instructions provided. Shpg. Wt. 19 lbs.

HEATH COMPANY Benton Harbor, Michigan — a subsidiary of Daystrom, Inc.

Mobile Gear...for the Ham on the Go!

"CHEYENNE" MOBILE HAM TRANSMITTER KIT

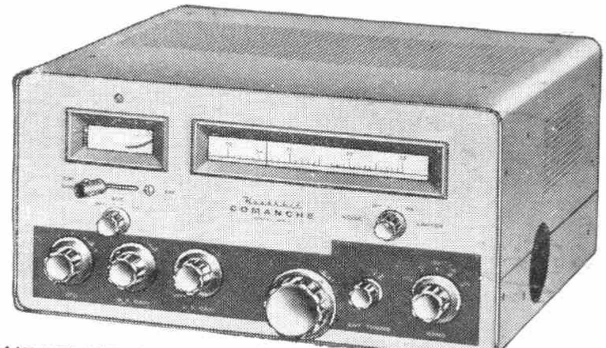
All the fun and excitement . . . plus the convenience of mobile operation are yours in the all-new Heathkit "Cheyenne" transmitter. The neat, compact, and efficient circuitry provides you with high power capability in mobile operation, with low battery drain using carrier controlled modulation. All necessary power is supplied by the model MP-1 described below. Covers 80, 40, 20, 15 and 10 meters with up to 90 watts input on phone. Features built-in VFO, modulator, 4 RF stages, with a 6146 final amplifier and pi network (coaxial) output coupling. High quality components are used for long service life and reliable operation, along with rugged chassis construction to withstand mobile vibrations and shock. Thoughtful circuit layout provides for ease of assembly with complete instructions and detailed pictorial diagrams to insure success. A spotting switch is also provided. A specially designed ceramic microphone is included to insure effective modulation with plenty of "punch". Plan now to enjoy the fun of mobile operation by building this superb transmitter. Shpg. Wt. 19 lbs.



HEATHKIT MT-1
$99.95

"COMANCHE" MOBILE HAM RECEIVER KIT

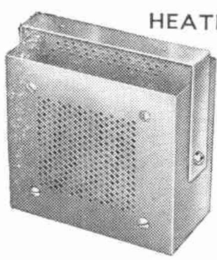
Everything you could ask for in modern design mobile gear is provided in the "Comanche" . . . handsome styling, rugged construction, top quality components . . . and, best of all, a price you can afford. The "Comanche" is an 8-tube superheterodyne ham band receiver operating AM, CW and SSB on the 80, 40, 20, 15 and 10 meter amateur bands. A 3 mc crystal lattice-type IF filter permits the receiver to use single conversion without image interference, and at the same time creates a steep sided 3 kc flat top IF bandpass characteristic comparable to mechanical type filters. The neat, compact and easy-to-assemble circuitry features outstanding sensitivity, stability and selectivity on all bands. Circuit includes an RF stage, converter, 2 IF stages, 2 detectors, noise limiter, 2 audio stages and a voltage regulator. Sensitivity is better than 1 microvolt on all bands and signal-to-noise ratio is better than 10 db down at 1 microvolt input. One of the finest investments you can make in mobile gear. Shpg. Wt. 19 lbs.



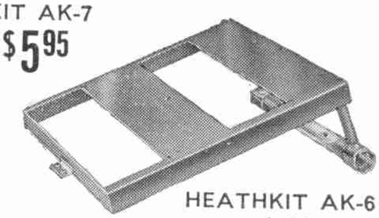
HEATHKIT MR-1
$119.95

MOBILE SPEAKER KIT

A matching companion speaker for the "Comanche" mobile receiver. Housed in a rugged steel case with brackets provided for easy installation on fire wall or under dashboard, etc. Uses 5 PM speaker with 8 ohm voice coil. Measures 5″ H. x 5″ W. x 2½″ D. Shpg. Wt. 4 lbs.



HEATHKIT AK-7
$5.95

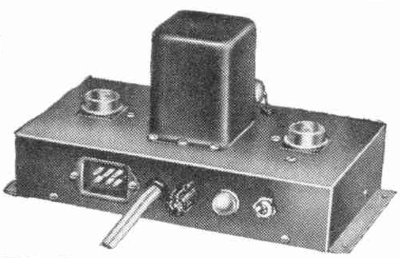


HEATHKIT AK-6
$4.95

MOBILE BASE MOUNT KIT

The AK-6 Base Mount is designed to hold both transmitter and receiver conveniently at driver's side. Universal mounting bracket has adjustable legs to fit most automobiles. Shpg. Wt. 5 lbs.

HEATHKIT MP-1
$44.95



MOBILE POWER SUPPLY KIT

This heavy duty transistor power supply furnishes all the power required to operate both the MT-1 Transmitter and MR-1 Receiver. It features two 2N442 transistors in a 400 cycle switching circuit, supplying a full 120 watts of DC power. Under intermittent operation it will deliver up to 150 watts. Kit contains everything required for complete installation, including 12′ of heavy battery cable, tap-in studs for battery posts, power plug and 15′ of connecting cable. Chassis size is 9$\frac{1}{16}$″ L. x 4¾″ W. x 2″ H. Operates from 12-14 volt battery source. Circuit convenience provided by self-contained relay which allows push-to-talk mobile operation. Shpg. Wt. 8 lbs.

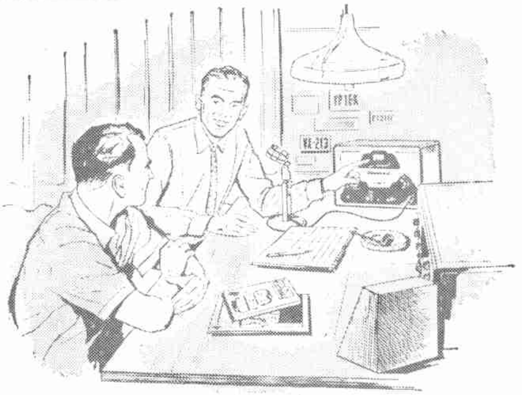
POWER METER KIT

This handy unit picks up energy from your mobile antenna and indicates when your transmitter is tuned for maximum output. A variable sensitivity control is provided. Features a strong magnet on a swivel-mount for holding it on a car dashboard or other suitable spot. Has its own antenna or may be connected to existing antenna. Sensitive 200 ua meter. Shpg. Wt. 2 lbs.

HEATHKIT PM-2
$12.95

COMPANION UNITS

HEATHKIT

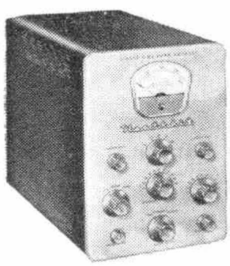


HEATHKIT TX-1 $234.95

"APACHE" HAM TRANSMITTER KIT

The many features and modern styling of the "Apache" will provide you with just about everything you could ask for in transmitting facilities. Emphasizing high quality the "Apache" operates with a 150 watt phone input and 180 watt CW input. In addition to CW and phone operation, built-in switch selected circuitry provides for single-sideband transmission using the SB-10 External adapter. The newly designed, compact and stable VFO provides low drift frequency control necessary for SSB transmission. A slide rule type illuminated rotating VFO dial with full gear drive vernier tuning provides ample bandspread and precise frequency settings. The bandswitch allows quick selection of the amateur bands on 80, 40, 20, 15 and 10 meters. This unit also has adjustable low-level speech clipping and a low distortion modulator stage employing two of the new 6CA7/EL34 tubes in push-pull class AB operation. Time sequence keying is provided for "chirpless" break-in CW operation. The final amplifier is completely shielded for TVI protection and neutralized for greater stability. A cooling fan is also provided. The formed one-piece cabinet with convenient access hatch provides accessibility to tubes and crystal sockets. Die-cast aluminum knobs and control panel escutcheons add to the attractive styling of the transmitter. Pi network output coupling matches antenna impedances between 50 and 72 ohms. A "spotting" push button enables the operator to "zero beat" an incoming frequency without putting the transmitter on the air. Equip your ham shack now for top transmitting enjoyment with this outstanding unit. Shpg. Wt. 110 lbs. Shipped motor freight unless otherwise specified.

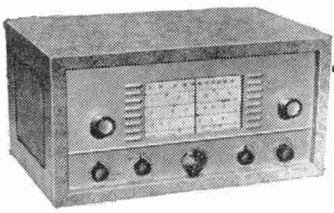
HEATHKIT SB-10 $89.95



SINGLE SIDEBAND ADAPTER KIT

Designed as a compatible plug-in adapter unit for the TX-1 "Apache" transmitter, this unit lets you operate on SSB at a minimum of cost, yet does not affect the normal AM and CW functions of the transmitter. By making a few simple circuit modifications, the DX-100 and DX-100-B transmitters can be used, utilizing all existing RF circuitry. Extremely easy to operate and tune, the adapter employs the phasing method for generating a single-sideband signal, thus allowing operation entirely on fundamental frequencies. The critical audio phase shift network is supplied completely preassembled and wired in a sealed plug-in unit. Produces either a USB, LSB or DSB signal, with or without carrier insertion. Covers 80, 40, 20, 15 and 10 meter bands. An easy-to-read panel meter indicates power output to aid in tuning. A built-in electronic voice control with anti-trip circuit is also provided. 10 watts PEP output. Unwanted sideband suppression is in excess of 30 db and carrier suppression is in excess of 40 db. An EL84/6BQ5 tube is used for linear RF output. Shpg. Wt. 12 lbs.

MODIFICATION KIT: Modifies DX-100 and DX-100-B for use with the SB-10 Adapter. Model MK-1. Shpg. Wt. 1 lb. $8.95.



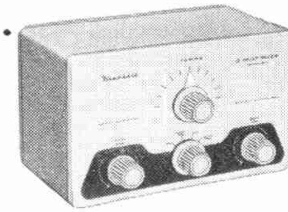
HEATHKIT AR-3 $29.95

(less cabinet)

ALL-BAND RECEIVER KIT

A fine receiver for the beginning ham or short wave listener, designed for high circuit efficiency and easy construction. Covers 550 kc to 30 mc in four bands clearly marked on a slide-rule dial. Transformer operated power supply. Features include: bandswitch, bandspread tuning, phone-standby-CW switch, phone jack, antenna trimmer, noise eliminator, RF gain control and AF control. Shpg. Wt. 12 lbs.

CABINET: Opt. extra. No. 91-15A. Shpg. Wt. 5 lbs. $4.95.



HEATHKIT QF-1 $9.95

"Q" MULTIPLIER KIT

Useful on crowded phone and CW bands, this kit adds selectivity and signal rejection to your receiver. Use it with any AM receiver having an IF frequency between 450 and 460 kc that is not AC-DC type. Provides an effective "Q" of approximately 4,000 for extremely sharp "peak" or "null". The QF-1 is powered from the receiver with which it is used. Shpg. Wt. 3 lbs.

OF DISTINCTIVE QUALITY

ACCESSORY SPEAKER KIT

Handsomely designed and color styled to match the "Mohawk" receiver this heavy duty 8" speaker with 4.7 ounce magnet provides excellent tone quality. Housed in attractive 3/8" plywood cabinet with perforated metal grille. Speaker impedance is 8 ohms. Shpg. Wt. 7 lbs.

HEATHKIT AK-5
$9.95

"MOHAWK" HAM RECEIVER KIT

HEATHKIT RX-1 **$274.95**

Styled to match the "Apache" transmitter the "Mohawk" ham band receiver provides all the functions required for clear, rock-steady reception. Designed especially for ham band operation this 15-tube receiver features double conversion with IF's at 1682 kc and 50 kc and covers all the amateur frequencies from 160 through 10 meters on 7 bands with an extra band calibrated to cover 6 and 2 meters using a converter. Specially designed for single sideband reception with crystal controlled oscillators for upper and lower sideband selection. A completely preassembled wired and aligned front end coil bandswitch assembly assures ease of construction and top performance of the finished unit. Other features include 5 selectivity positions from 5 kc to 500 CPS, bridge T-notch filter for excellent heterodyne rejection, and a built-in 100 kc crystal calibrator. The set provides a 10 db signal-to-noise ratio at less than 1 microvolt input. Each ham band is separately calibrated on a rotating slide rule dial to provide clear frequency settings with more than ample bandspread. Front panel features S-meter, separate RF, IF and AF gain controls, T-notch tuning, T-notch depth, ANL, AVC, BFO, Bandswitch tuning, antenna trimmer, calibrate set, calibrate on, CW-SSB-AM, receive-standby, upper-lower sideband, selectivity, phone jack and illuminated gear driven vernier slide rule tuning dial. Attractively styled with die-cast aluminum control knobs and escutcheons. No external alignment equipment is required for precise calibration of the "Mohawk". All adjustments are easily accomplished using the unique method described in the manual. An outstanding buy in a communications receiver. Shpg. Wt. 66 lbs. Shipped motor freight unless otherwise specified.

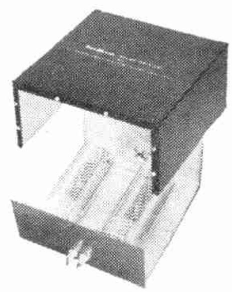
HEATHKIT AM-2
$15.95

REFLECTED POWER METER KIT

The AM-2 measures forward and reflected power or standing wave ratio. Handles a peak power of well over 1 kilowatt of energy and covers 160 through 6 meters. Input and output impedance provided for 50 or 75 ohm lines. No external power required for operation. Use it also to match impedances between exciters or RF sources and grounded grid amplifiers. Shpg. Wt. 3 lbs.

BALUN COIL KIT

Match unbalanced coaxial lines, found on most modern transmitters, to balanced lines of either 75 or 300 ohms impedance with this handy transmitter accessory. Capable of handling power input up to 200 watts, the B-1 may be used with transmitters and receivers covering 80 through 10 meters. No adjustment required. Shpg. Wt. 4 lbs.

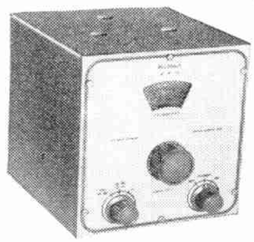


HEATHKIT B-1
$8.95

HEATHKIT VX-1
$23.95

ELECTRONIC VOICE CONTROL KIT

Eliminate hand switching with this convenient kit. Switch from receiver to transmitter by merely talking into your microphone. Sensitivity controls allow adjustment to all conditions. Power supply is built in and terminal strip on the rear of the chassis accommodates receiver and speaker connections and also a 117 volt antenna relay. Shpg. Wt. 5 lbs.

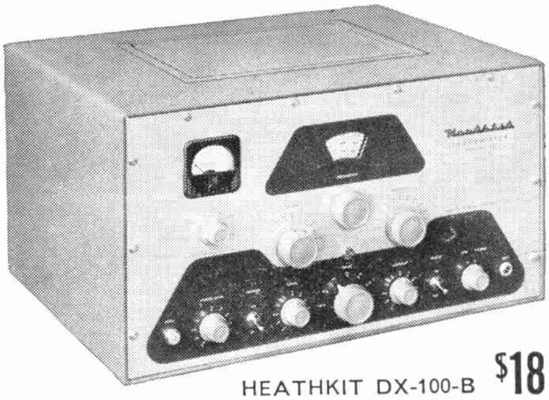


HEATHKIT VF-1
$19.50

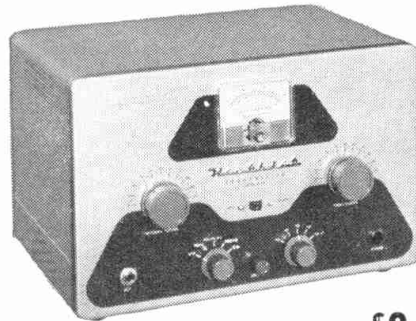
VFO KIT

Far below the cost of crystals to obtain the same frequency coverage this variable frequency oscillator covers 160, 80, 40, 20, 15 and 10 meters with three basic oscillator frequencies. Providing better than 10 volt average RF output on fundamentals, the VF-1 is capable of driving the most modern transmitters. Requires only 250 volts DC at 15 to 20 ma, and 6.3 VAC at 0.45 a. Illuminated dial reads direct. Shpg. Wt. 7 lbs.

Save 1/2 or more...with Heathkits



HEATHKIT DX-100-B $189^{50}



HEATHKIT DX-40 $64^{95}

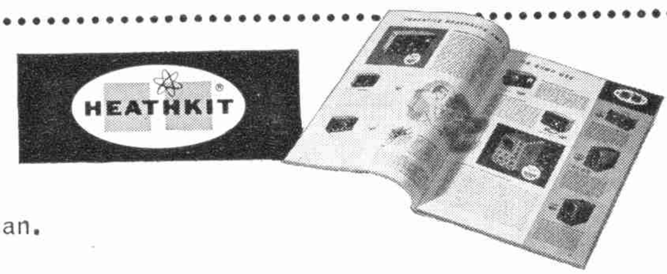
DX-100-B PHONE AND CW TRANSMITTER KIT

A long standing favorite in the Heathkit line, the DX-100-B combines modern styling and circuit ingenuity to bring you an exceptionally fine transmitter at an economical price. Panel controls allow VFO or crystal control, phone or CW operation on all amateur bands up to 30 mc. The rugged one-piece formed cabinet features a convenient top-access hatch for changing crystals and making other adjustments. The chassis is punched to accept sideband adapter modifications. Featured are a built-in VFO, modulator, and power supply, complete shielding to minimize TVI, and a pi network output coupling to match impedances from 50 to 72 ohms. RF output is in excess of 100 watts on phone and 120 watts on CW. Band coverage is from 160 through 10 meters. For operating convenience single-knob bandswitching and illuminated VFO dial on meter face are provided. A pair of 6146 tubes in parallel are employed in the output stage modulated by a pair of 1625's. Shpg. Wt. 107 lbs. Shipped motor freight unless otherwise specified.

DX-40 PHONE AND CW TRANSMITTER KIT

An outstanding buy in its power class the DX-40 provides both phone and CW operation on 80, 40, 20, 15 and 10 meters. A single 6146 tube is used in the final amplifier stage to provide full 75 watt plate power input on CW or controlled carrier modulation peaks up to 60 watts for phone operation. Modulator and power supplies are built in and single-knob bandswitching is combined with the pi network output circuit for complete operating convenience. Features a D'Arsonval movement panel meter. A line filter and liberal shielding provides for high stability and minimum TVI. Provision is made for three crystals easily accessible through a "trap door" in the back of the cabinet. A 4-position switch selects any of the three crystals or jack for external VFO. Power for the VFO is available on the rear apron of the chassis. Easy-to-follow step-by-step instructions let assembly proceed smoothly from start to finish even for an individual who has never built electronic equipment before. Shpg. Wt. 25 lbs.

Free Send now for latest Heathkit Catalog describing in detail over 100 easy-to-assemble kits for the Hi-Fi fan, radio ham, boat owner and technician.



HEATH COMPANY BENTON HARBOR 9, MICH.

pioneer in do-it-yourself electronics

a subsidiary of Daystrom, Inc.

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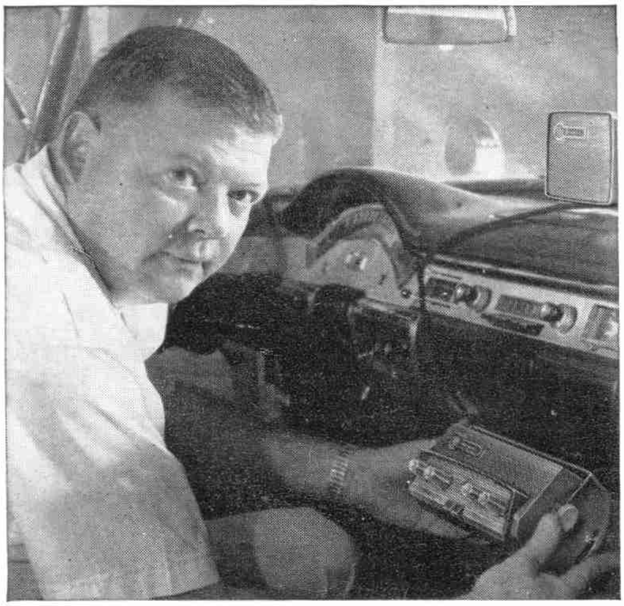
All prices and specifications subject to change without notice. Please include postage on orders to be shipped parcel post. 20% deposit is required on all C.O.D. orders. All prices are NET F.O.B. Benton Harbor, Mich., and apply to Continental U.S. and Possessions only.

QUANTITY	KIT NAME	MODEL NO.	PRICE



Dan Trueblood, W4ESB, of Goldsboro, N.C. is shown installing a customer's new General Electric Transistorized Progress Line mobile unit. A ham since 1935, Dan has been an authorized General Electric Service technician for two-way radio for five years. He currently operates single side band with a full kilowatt, when he's not busy selling, installing and maintaining G-E two-way radio.

Turn your skills into profit installing and maintaining G-E Two-Way Mobile Radio

Thousands of new mobile radio systems are being installed every year—for delivery services, salesmen, taxis, gas and electric utilities, industrial and construction vehicles, and many other uses. All these systems require *service* — service your unique background and knowledge can be easily adapted to provide.

Servicing two-way radio can be a full-time vocation, or a profitable sideline. Many highly successful General Electric mobile radio service stations were founded by licensed radio amateurs, and many now utilize the skills of hams such as yourself on a part-time basis as well as full-time. Working in an authorized G-E Service Station is also an ideal way in which to prepare for the second or first class Commercial Radio Operator's license, required for commercial mobile radio servicing.

G-E two-way radio equipment is designed and built with the serviceman in mind. General Electric's famous Progress Line, for example, features interchangeable rack-mounted transmitter, receiver and power supply for fast servicing. G.E.'s new line of transistorized portable and mobile equipment offers even greater service advantages.

Find out how you can become an authorized G-E serviceman. Write National Service Manager, General Electric Company, Communication Products Dept., Section 30, Mountain View Road, Lynchburg, Virginia.

Progress Is Our Most Important Product

GENERAL ELECTRIC


MS/AN CONNECTORS
Relied upon since 1939. Latest design advancement is new "Stub E" construction—shortest lightest "E."
MINNIE CONNECTORS
Complete new family of miniature "E's"—altitude-moisture resistant. Sizes 12 to 22—3 to 48 contacts.
RF CONNECTORS
All RF series available, including remarkable Subminax. New Quick-Crimp BNC's cut assembly time in half.
PRIN-CIR CONNECTORS
Receptacles, plugs and adapters with super-reliable gold-plated contacts. From 6 to 22 contacts.
RACK & PANEL CONNECTORS
Seven families available for every R & P application. Patented crimp Poke-Home contacts in 93 & 94 series.
COAXIAL CABLE
Most complete line anywhere of RG-/U polyethylene and Teflon coaxial cables. Miniatures also.
INDUSTRIAL ELECTRONIC COMPONENTS
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ALL STANDARD AMPHENOL COMPONENTS STOCKED IN DEPTH BY YOUR AUTHORIZED AMPHENOL DISTRIBUTOR...
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BROADVIEW, ILLINOIS

Collins mobile transceiver KWM-2

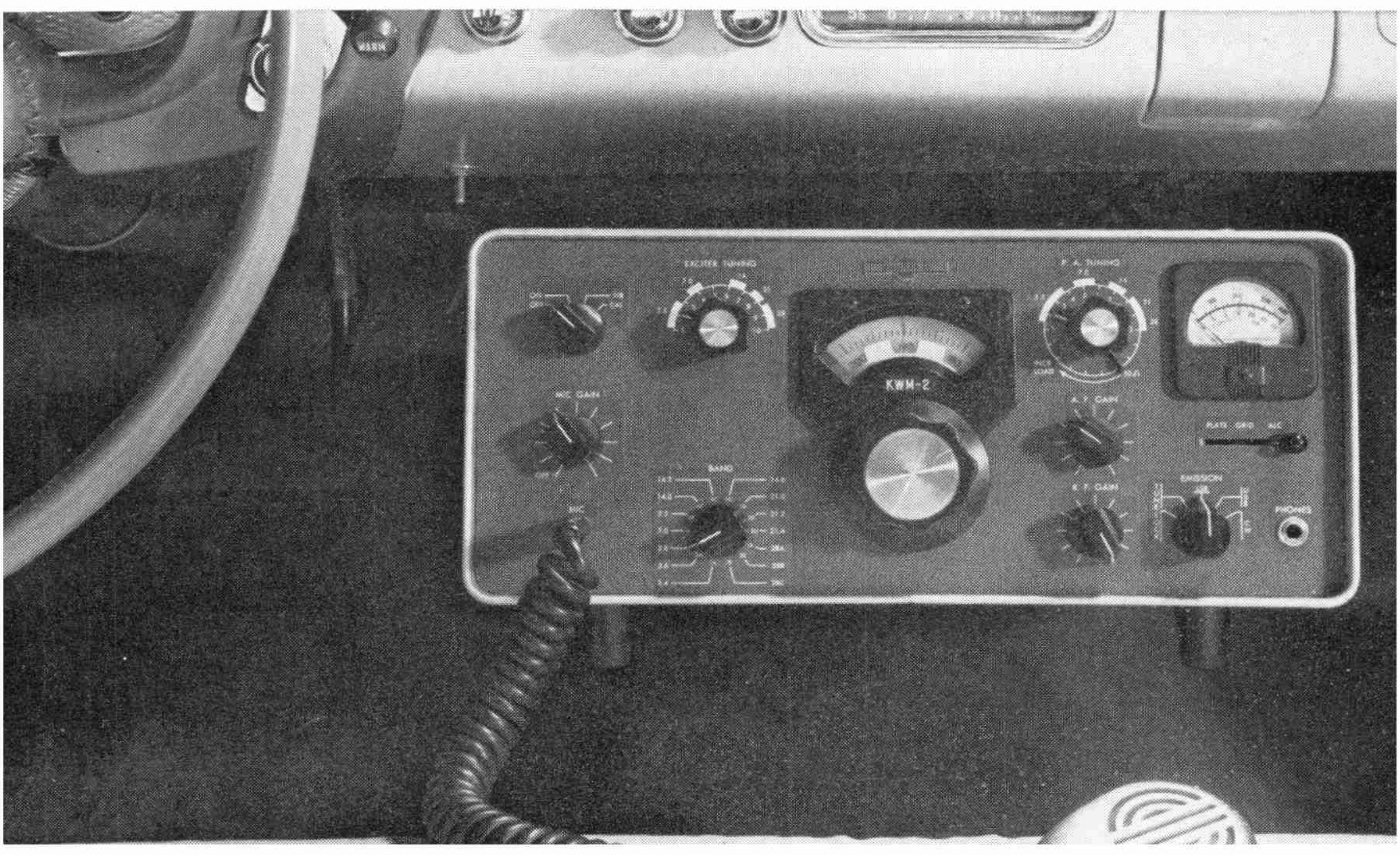
Another Collins creative design – the advanced amateur's 80-10 meter transceiver – system engineered for mobile and home operation.

Superior single sideband performance in a variety of installations is assured by the Collins KWM-2 Mobile Transceiver. Engineered for the amateur who desires an 80 through 10 meter mobile transceiver, the KWM-2 design incorporates time-proven and advanced communication concepts.

The Mobile Transceiver provides outstanding frequency stability on fourteen 200 kc bands from 3.4 mc to 30.0 mc. With 175 watts PEP input on SSB, or 160 watts on CW, the KWM-2 provides ample power for dependable amateur communication. Filter type SSB generation, Collins permeability-tuned variable oscillator, crystal-controlled HF double conversion oscillator, VOX and anti-trip circuits, and exclusive ALC and RF inverse feedback are among the features of the KWM-2. The Collins Mechanical Filter, RF amplifier, all tuned circuits, and severa tubes perform the dual role of transmitting and re ceiving. CW break-in and monitoring sidetone circuit are built-in, and all four plugs in the mobile moun connect the KWM-2 automatically. A connector or the rear provides for antenna selection or loadin coil selection for mobile operation.

The Collins KWM-2 Mobile Transceiver weighs 1 lbs. 3 oz. and measures 7¾" H (including legs) 14¾" W, and 13¼" D. Mounts, accessories, an power supplies are available for 12 v dc, and 115 ac operation.

See the KWM-2 now on display at your Collins Distributor. Ask for the colorful KWM-2 brochure with complete specifications.



Collins S/LINE

superiority in single sideband systems

'he S/Line is a complete station for the advanced mateur. The 32S-1 Transmitter and 75S-1 Receiver nay be operated separately or as a transceiver in vhich the receiver controls the transmitter frequency. 'he 312B-4 Speaker Console integrates the two units urther with over-all station control, and control of a irectional wattmeter for maximum output efficiency. 'or the amateur desiring the strongest signal, the 0S-1 Linear Amplifier provides maximum legal out- ut with greatly simplified operation.

32S-1 Transmitter

The 32S-1 is an SSB or CW transmitter with a nomi- ial output of 100 watts on all amateur bands be- ween 3.5 and 29.7 mc. Input power is 175 watts 'EP on SSB or 160 watts on CW.

The transmitter covers 3.5 to 30 mc except for the .0-6.5 mc range. Crystal sockets, crystals and band- witch position are provided for ten 200 kc bands, vith the standard amateur configuration equipped as ollows: 3.4-3.6, 3.6-3.8, 3.8-4.0; 7.0-7.2,7.2-7.4; 14.0- 4.2, 14.2-14.4; 21.0-21.2, 21.2-21.4, 21.4-21.6. Crystal ockets and bandswitch positions also are provided or three 200 kc bands between 28 and 29.7 mc. One of these sockets is equipped with a crystal for 28.5 to 28.7 mc. A fourteenth position, correspond- ng to the WWV position on the receiver, can be used 'or an additional 200 kc band in the 9.5-15.0 mc ange, if desired.

'eatures which have made Collins amateur SSB quipment famous are incorporated into the 32S-1, including Mechanical Filter-type sideband genera- tion; stable, permeability-tuned VFO; crystal-con- trolled HF oscillator; RF inverse feedback for better linearity; automatic load control for higher average talk power and protection against flattopping.

For ac operation, the 516F-2 Power Supply is used with the 32S-1; for 12 v dc operation, the 516E-1 used with the KWM-1 and KWM-2 may be used with minor modification.

Specifications

EMISSION: SSB — upper or lower sideband. CW— keyed tone.

POWER INPUT: 175 watts PEP on SSB. 160 watts on CW.

POWER OUTPUT: 100 watts PEP nominal (slightly lower on 10 meters) into 50 ohms.

OUTPUT IMPEDENCE: 50 ohms nominal with not more than approximately 2 to 1 SWR. Impedance match variable 25-100 ohms.

FREQUENCY STABILITY: After warm-up, over-all sta- bility due to temperature, humidity, pressure and voltage variation is 100 cps. Calibration accu- racy: 1 kc.

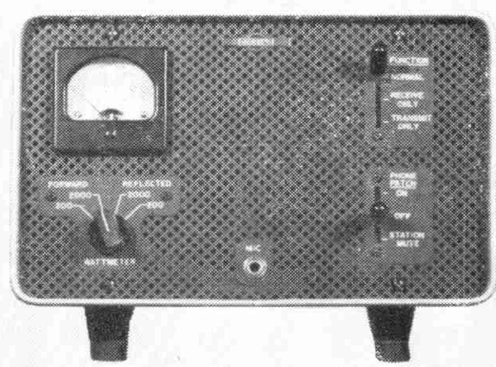
VISUAL DIAL ACCURACY: 200 cps on all bands.

ELECTRICAL DIAL ACCURACY: After calibration: 300 cps on all bands.

HARMONIC AND OTHER SPURIOUS RADIATION: Carrier suppression —40 db. Unwanted sideband —50 db. Oscillator feed-through and/or mixer products —50 db. Second harmonic —50 db. 3rd order distortion —30 db.

75S-1 Receiver

312B-4 Speaker Console



312B-4 Speaker Console

The 312B-4 (pictured between 75S-1 and 32S-1 below) houses a speaker, and RF directional wattmeter with 200 and 2000 watt scales, and switches for various station control functions.

75S-1 Receiver

The 75S-1 provides SSB, CW and AM reception on all amateur bands between 3.5 and 29.7 mc. It is capable of coverage of the entire HF spectrum between 3.5 and 30 mc by selection of the appropriate HF heterodyning crystals.

The standard amateur configuration includes crystal sockets, crystals and bandswitch positions for: 3.4-3.6, 3.6-3.8, 3.8-4.0; 7.0-7.2, 7.2-7.4; 14.0-14.2, 14.2-14.4; 21.0-21.2, 21.2-21.4, 21.4-21.6. Crystal sockets and bandswitch positions are also provided for three 200 kc bands between 28 and 29.7 mc, with one of the sockets equipped with a crystal for 28.5 to 28.7 mc. A crystal and bandswitch position is also provided for 14.8-15.0 mc for reception of WWV and WWVH for time and frequency calibration data.

The same standard of excellence and many of the design features of the 75A-4 are incorporated in the 75S-1. These include dual conversion with a crystal-controlled first heterodyning oscillator; bandpass first IF; stable, permeability-tuned VFO; RF amplifier designed to minimize cross modulation products; Mechanical Filter; excellent AVC characteristics; and both product and diode detector.

New features include the use of only 150 volts on vacuum tube plates, use of silicon diodes in lieu of conventional high vacuum rectifier; and choice of three degrees of selectivity (with optional CW filter).

A power connector at the rear of the 75S-1 chassis provides for disabling the internal ac power supply so that the 12 v dc power supply for the KWM-2 may power the receiver as well as the transmitter.

Specifications

VISUAL DIAL ACCURACY: 200 cps on all bands.

ELECTRICAL DIAL ACCURACY: (after calibration) 300 cps on all bands.

SENSITIVITY: The CW sensitivity is better than 1 microvolt (with a 50-ohm dummy antenna) for a 15 db signal-plus-noise-to-noise ratio.

SELECTIVITY: 2.1 kc Mechanical Filter for SSB; 0.5 kc Mechanical Filter (not supplied) for CW; 4.0 kc IF transformer passband for AM.

SPURIOUS RESPONSE: Image rejection is more than 50 db. Internal spurious signals below 1 microvolt equivalent antenna input.

30S-1 Linear Amplifier

The 30S-1 is a completely self-contained, single tube, grounded grid linear amplifier. Requiring 70 to 100 watts driving power (from the 32S-1 or KWM-2, for example), it provides the full legal power input for SSB (1 kw average) or 1 kw input for CW. The tube used is the Eimac 4CX1000A. The 30S-1 may be used on any frequency between 3.4 and 30 mc.

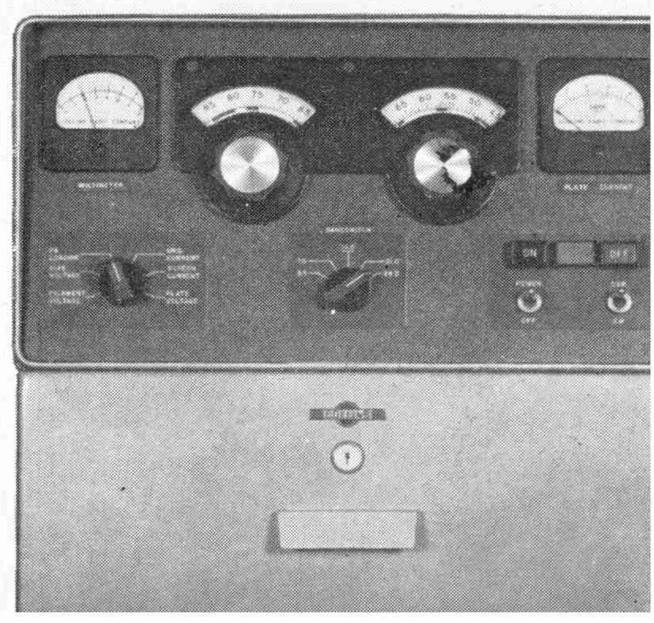
The 30S-1 may be loaded into an antenna without exceeding the legal dc input of 1 kw during tune-up. Front panel switching makes two different power levels immediately available for SSB operation: 100 watts from the exciter alone or the full 1 kw meter average input for SSB. The air blower for the 4CX1000A operates quietly — barely audible in a quiet room. The power supply for the 30S-1, which is housed in the lower portion of the cabinet, provides cathode bias voltage, screen voltage and 3000 volts for the 4CX1000A plate. Space is provided in this compartment for the 516F-2 Power Supply.

Extended Frequency Versions of the S/Line

The 32S-1 and 75S-1 are available in extended frequency versions, designated the 75S-2 and 32S-2. The two differ from the original only in that an additional crystal board has been added beneath the chassis. In this board is placed the standard complement of ham band crystals normally received with the equipment. The upper board is left empty so that the amateur may place whatever additional crystals he may desire up to a total of 14. A front panel switch is added to allow switching between the two crystal boards.

32S-1 Transmitter

30S-1 Linear Amplifier



Collins S/LINE accessories and KWM-2

02C-3 Directional Wattmeter– Measures for-ard and reflected power on 200 and 2000 watt scales. oupler unit mounts separate from indicator-con-ol box. Power loss and mismatch introduced by the nstrument are negligible.

312-1 Directional Coupler – The coupler unit rom the 302C-3 for amateurs who desire to utilize n optional meter and switch for a customized fixed nstallation or for a mobile installation.

51E Table Mounts – For mounting the S/Line nd KWM-2 on planes, boats, etc. May be fastened o any flat surface. Front clamps attach to the feet f the units for secure hold-down. 351E-1 for 32S-1, 5S-1; 351E-2 for 312B-4, 516F-2; 351E-3 for 312B-3, 51E-4 for KWM-2.

51D-2 Mobile Mount – Provides secure mount-ng for KWM-2 in most automobiles. Cantilever rms fold out of the way when KWM-2 is removed.

Mating plugs connect power, receive-transmit an-enna, noise blanker, antenna and antenna control as KWM-2 slides into place. Cables included.

12B-5 Speaker Console and External PTO– Used with KWM-2 in fixed station operation to provide separate receiving and transmitting control, and directional wattmeter.

399C-1 Speaker and External PTO–Contains speaker and external PTO for separate receiver and transmitter control of KWM-2.

136 Series Noise Blankers – Provide effective reduction of impulse-type noise, particularly ignition noise. 136A-1 for 75S-1; 136B-1 for KWM-1; 136B-2 for KWM-2; 136C-1 for 75A-4.

312B-3 Speaker – Contains a 5″ x 7″ speaker and connecting cable. Attractively styled to match receiver and transmitter.

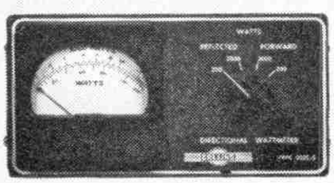
516F-2 AC Power Supply– Operates from 115 v ac, 50-60 cps. Provides all voltages for the 32S-1.

516E-1 Power Supply – Operates from 12 v dc. Provides all required voltages for the KWM-2 or 32S-1 and 75S-1 for mobile or portable operation. Transistorized for maximum efficiency and minimum maintenance. The 516E-2, a 28 v dc supply may also be used.

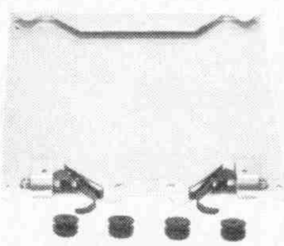
For addresses of Collins dealers or further information and complete specifications on the entire Collins S/Line and accessories, write to: Amateur Sales, Collins Radio Company, Cedar Rapids, Iowa.

COLLINS

OLLINS RADIO COMPANY • CEDAR RAPIDS, IOWA • DALLAS, TEXAS • BURBANK, CALIFORNIA

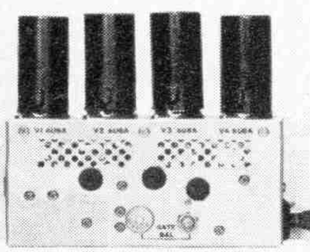


302C-3

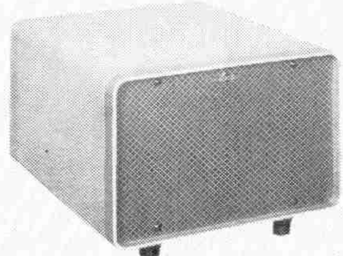


351E-1

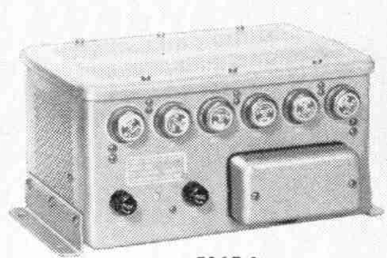
312B-5



136B-2



516F-2



516E-1

RHEOSTATS

RESISTORS

RELAYS
•
TAP SWITCHES

TANTALUM CAPACITORS

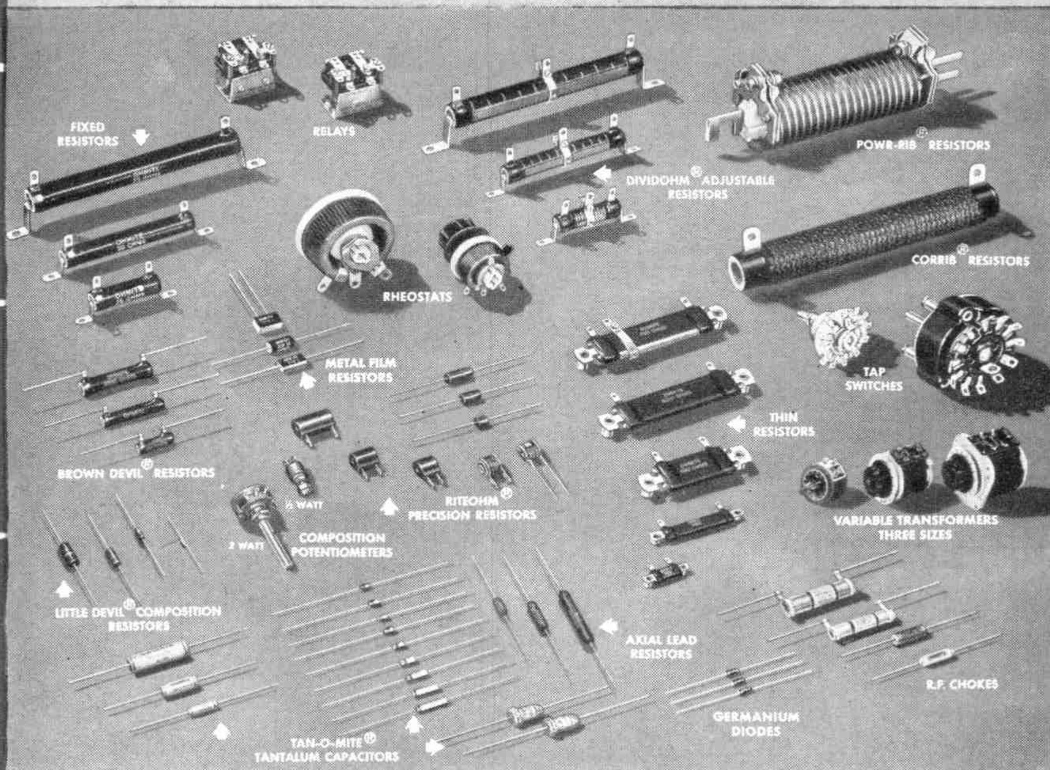
VARIABLE TRANSFORMERS

GERMANIUM DIODES

when you specify Ohmite components . . . you build reliability into your product

OHMITE®

INDUSTRY-PREFERRED COMPONENTS



RHEOSTATS—Insure permanently smooth, close control. All-ceramic, vitreous-enameled: 12½, 25, 50, 75, 100, 150, 225, 300, 500, 750, and 1000-watt sizes.

OHMITE RELAYS—Four stock models—DOS, DO, DOSY, and CRU, in 65 different types. At 115 VAC or 32 VDC, noninductive load, Models DOS and DOSY have a contact rating at 15 amp; Model DO, 10 amp; Model CRU, 5 amp. A wide range of coil operating voltages is available.

TANTALUM CAPACITORS—Units are available in three types: subminiature, insulated, wire-type, in eleven sizes. Three sizes of foil-type. New slug-type tantalum capacitors. All feature high performance in minimum space and a wide range of capacitance and voltage ratings.

Write for Stock Catalog

POWER RESISTORS—Wire-wound, vitreous-enameled resistors. Stock sizes: 25, 50, 100, 160, 200 watts; values 1 to 250,000 ohms. "Brown Devil" fixed resistors in 5, 10, and 20-watt sizes; values from 0.5 to 100,000 ohms. Adjustable power resistors; quickly adjustable to the value needed. Adjustable lugs can be attached for multitap resistors and voltage dividers. Sizes 10 to 200 watts, to 100,000 ohms.

R. F. CHOKES—Single-layer-wound on low power factor cores with moistureproof coating. Seven stock sizes, 3 to 520 mc. Two units rated 600 ma; others, 1000 ma.

BE RIGHT WITH

OHMITE®

TAP SWITCHES—Compact, high-current rotary selectors for a-c use. All-ceramic. Self-cleaning, silver-to-silver contacts. Rated at 10, 15, 25, 50, and 100 amperes.

PRECISION RESISTORS—Four types available: molded silicone-ceramic, vacuum-impregnated, encapsulated, or metal film. Tolerances to ± 0.1% in ⅛, ¼, ½, ¾, 1, and 2-watt sizes, from 0.1 to 2,000,000 ohms.

VARIABLE TRANSFORMERS—Model VT2, 1½ amp rating, output voltage, 0-120V—0-132V; Model VT4, 3½ amp rating, output voltage 0-120V—0-140V; Model VT8, 7½ amp rating, output voltage 0-120V—0-140V. Input voltage all models, 120V, 60 cycles. Thirty-five stock models, cased and uncased.

OHMITE MANUFACTURING COMPANY
3608 Howard Street, Skokie, Illinois

If it weren't for Amateur Radio 25 years ago, there'd be no Eimac tubes today...

enty-five years ago W6UF and W6CHE were unhappy with the way final amplifier tubes were perform-
g. They decided to do something about it. They founded a company, called their products Eimac tubes
d ran their first ad in QST, November, 1934.

hat has happened since is reviewed in part on these pages. At Eimac W6UF and W6CHE, and 120 other
ıateur radio operators are on-the-air getting just as much of a thrill out of their hobby today as they did
en and enjoying it much more.

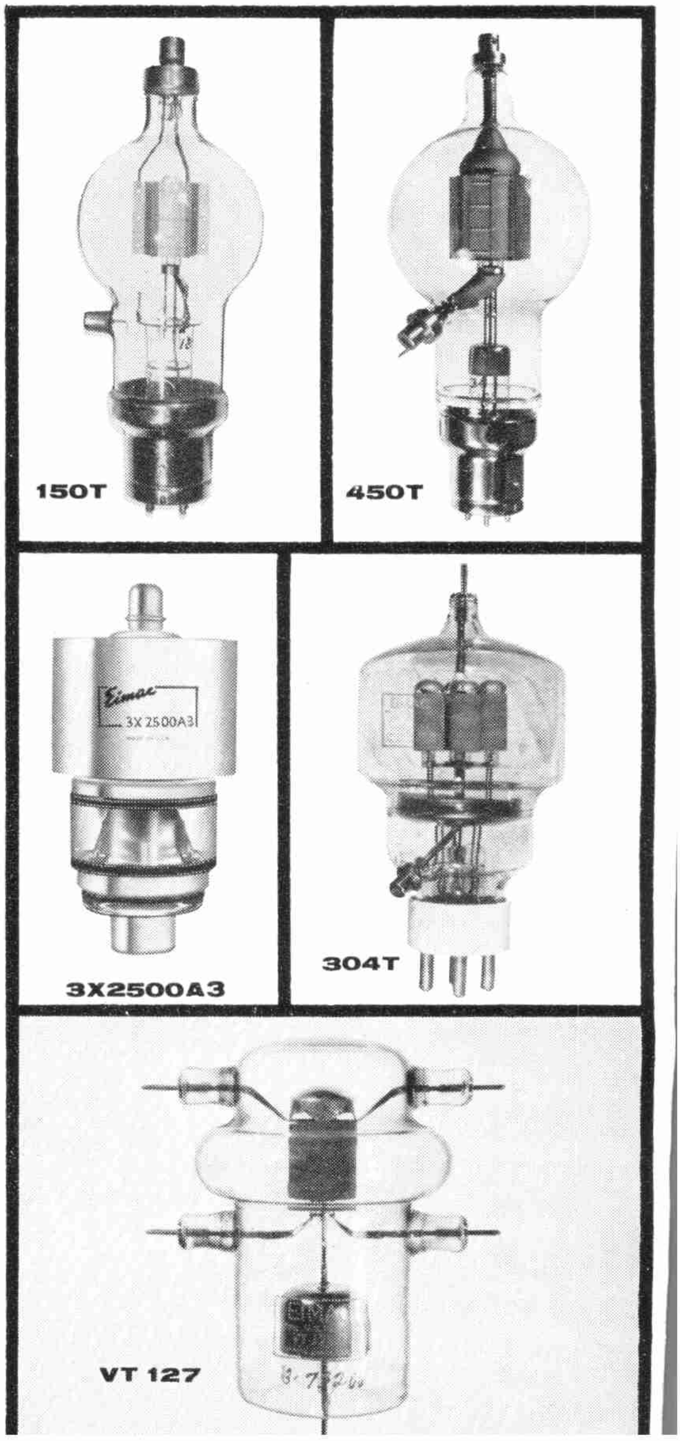
150T "The only tube the low power man can buy, yet still use effectively at higher power" was the case for the first Eimac tube, the 150T triode, in 1934. It was designed primarily for the amateur and established Eimac tube characteristics for the future—clean, hard vacuums, simplified design, lower driving power, high mutual conductance and superior overload capability.

450T Only two years later in 1936, the statement could proudly be made that "practically every major airline uses Eimac tubes." The 450T triode had captured the imagination and fulfilled the critical desires of aviation and was first choice in ground-to-air communications. It featured a new type thoriated tungsten filament by Eimac ending premature emission failures and guaranteed never to fail because of gas released internally. Later, in 1938, Eimac tubes went into TV service at Station KTSL.

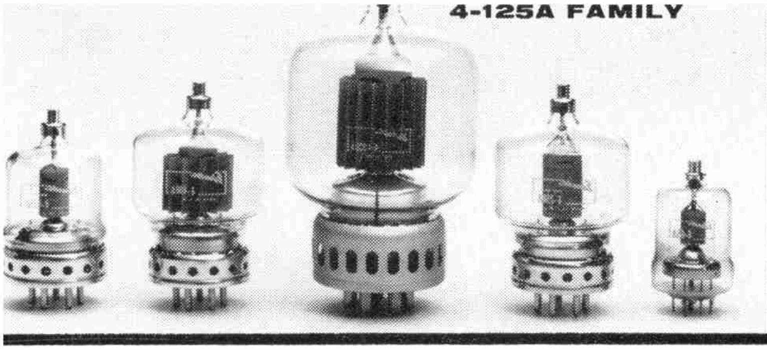
3X2500A3 FM and Eimac tubes were together from the start. By the time Major Armstrong had convinced the world that FM was a great advancement in broadcasting, Eimac tubes were in nearly every experimental FM broadcast station in the nation. The first tubes used were the internal anode triodes. In 1945 the external anode triode 3X2500A3 was introduced and subsequently used in the world's most powerful FM transmitter —50,000 watts.

304T In 1940 the Eimac multi-unit triodes made their debut to provide a high power, low voltage tube with uncommonly low internal resistance which would operate efficiently up to 200mc. In actual service the tubes operated with as much as 20,000 volts on the plate—10 times the rated voltage. The 304T, four triodes in one, was then and is now acclaimed as a top linear amplifier tube.

VT 127 The Navy held its first sea radar tests in 1939. Generating the power were Eimac 100T triodes. Two years later when World War II started, this equipment was the prototype of the first radar to see action in the Pacific. Airborne radar with its demands for smaller antenna meant higher frequency operation. The Eimac 15E met all requirements and made possible 26,000 radar sets used universally by the Navy. Said the Navy, "No other single type of airborne electronic equipment contributed as much." Many of the renowned VT series radar tubes were another Eimac contribution.



4-125A FAMILY



4X150A

4-125A FAMILY (5 TUBES) In 1945 Eimac led in power tetrode development with the introduction of the 4-125A as the first of its radial-beam family. These tubes set the standard for the tetrode art and are known for their low driving power requirements, low grid emission, low grid-plate capacitances, minimized neutralization requirements and dependable VHF performance.

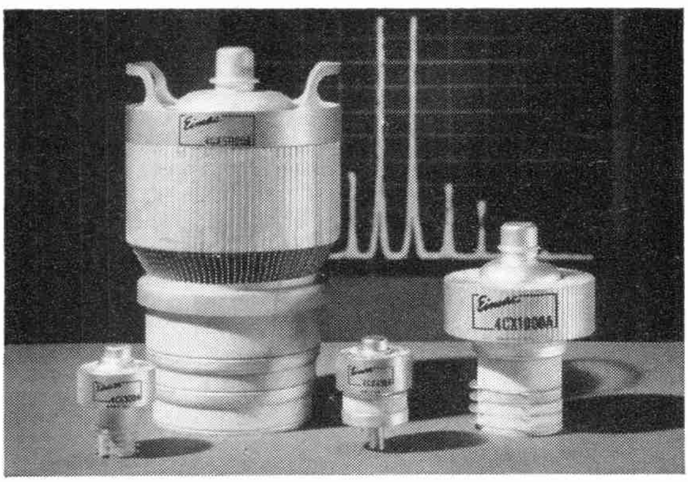
4X150A Radial-beam power tetrode advantages in the rugged, compact external anode package was introduced by Eimac in 1946 with the 4X500A followed closely by the incomparable 4X150A. This unique approach enabled smaller, high power, high frequency equipment and coaxial cavity circuits. The Eimac 4X150A has since become the most copied of transmitting tubes and father of the modern 4CX250B and 4CX300A.

AMPLIFIER KLYSTRON Despite its reputation in leading tetrode development and manufacture, Eimac saw the shortcomings of grid tubes for UHF, in 1948, and started a development program in amplifier klystrons. The result — Eimac external-cavity ceramic klystrons — the most extensively used tubes in tropospheric communications. From the initial Pole Vault system to White Alice and NATO, these klystrons are unrivaled.

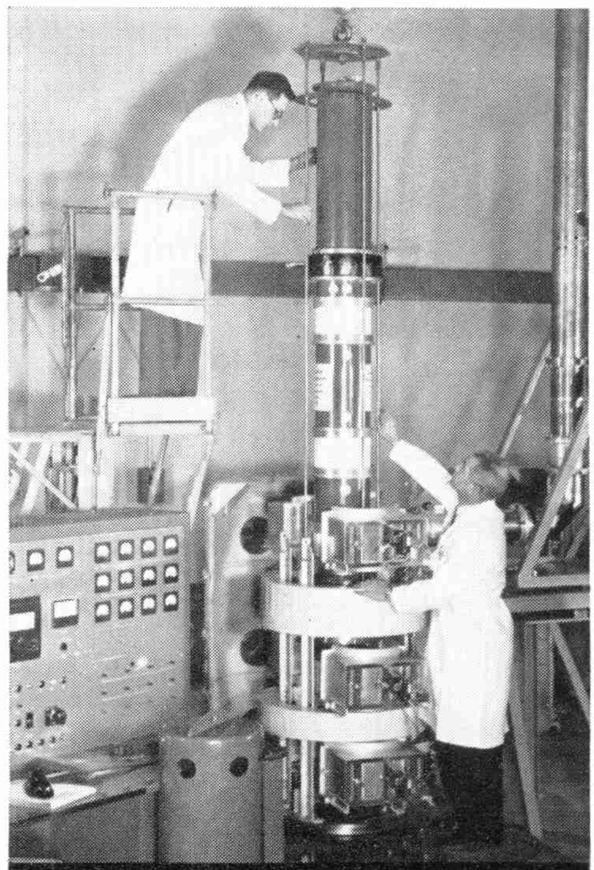
4CX300A, 4CX250B, 4CX1000A, 4CX5000A Ceramic is replacing glass in the Eimac tube line-up. Over 40 tube types now have the advantages of the ceramic envelope. Its ability to withstand thermal and physical shock has application benefits. Other extras are also built in, such as smaller size without power sacrifice, high temperature and precise tolerance processing.

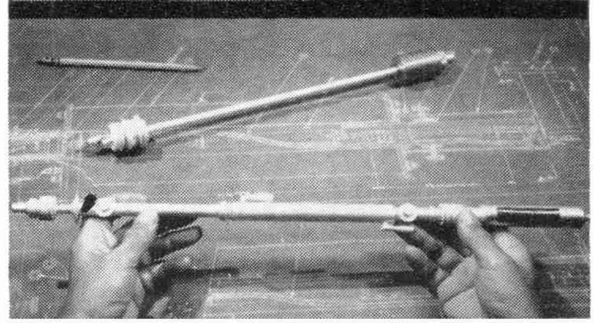
X626 Super power, 1.25 megawatts of long-pulse power, at UHF is now available with the Eimac X626. In Ballistic Missile detection and tracking, or interplanetary DX, (this tube holds the record to Venus and back — 56,000,000 miles), the X626 is now an important part of our space age.

TWT Now, microwave in the form of ceramic traveling wave tubes and reflex klystrons. Eimac is engaged in the development and manufacture of new electron devices to propagate the uncrowded spectrum at Super High Frequencies and above.



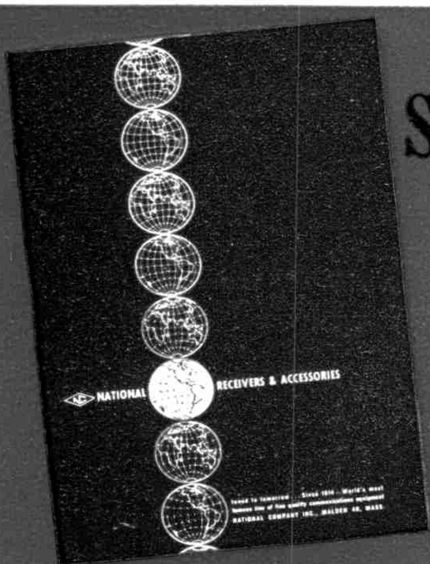
X626





TWT

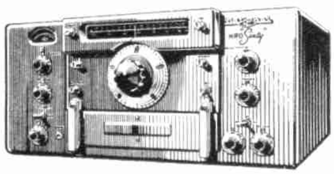
The dependable tubes of yesteryear have not been forgotten. They are constantly improved. Most of the oldtimers on review here are still available and many are replacements for originals that have finally given in after years and years of service.



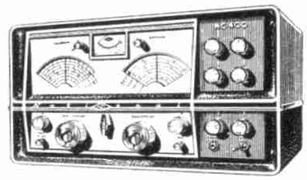
BURTON BROWNE/New York

Send for this FREE National Catalog for up-to-date information on America's finest receivers!

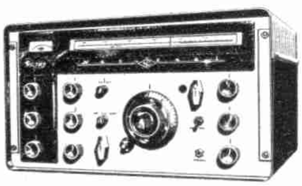
Gives Complete Specifications, Full List of Accessories, Latest Prices on these Famous NATIONAL RECEIVERS.



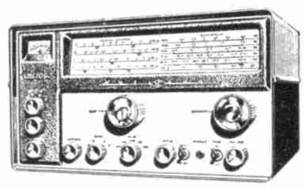
HRO-60
Features widest frequency coverage of any receiver available, 50 kc to 54 mc . . . the world's most famous receiver.



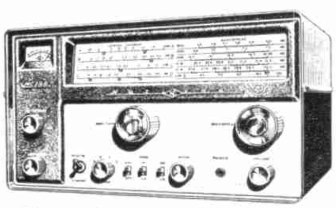
NC-400
National's newest general coverage receiver. Covers 540 kc to 31 mc in 7 bands. 18 tubes (including rectifier) AM-CW-SSB. May be used in fixed channel or diversity operation.



NC-303
National's newest "ham band only" receiver. 10 separate dial scales cover 160 to 1¼ meters. Dual conversion. New 5-position "IF SHIFT" provides optimum selectivity for a CW-PHONE-PHONE NET-VHF-Selectable SSB.

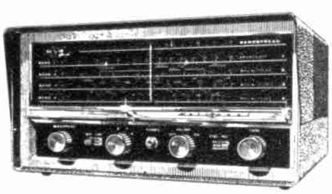


NC-109
One of America's lowest price SSB receivers! Covers 540 kc to 40 mc. National's exclusive "MICROTOME" filter provides 5 degrees of sharp selectivity for all modes of operation. VOICE—CW—SSB.



NC-188
Low-priced general coverage receiver. Covers 540 kc to 40 mc, and is directly calibrated for the 4 general coverage ranges and five bandspread ranges for 80-10 meter amateur bands.

NC-66
AC/DC-Battery Portable. Covers 150 kc to 23 mc in 5 bands. Exclusive RDF-66 Direction Finder Accessory provides accurate navigation for small boats.



NC-60
Special "A"
. . . First all-new, low-priced shortwave/standard broadcast receiver in over 10 years! Covers 540 kc to 31 mc in 4 bands. 110 volt AC/DC. Built-in speaker.

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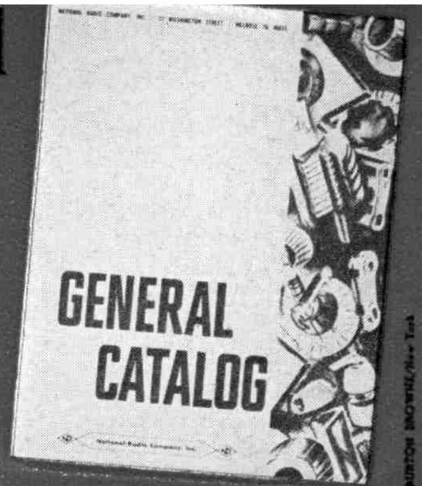
Send for this FREE National Catalog to meet your Component Requirements

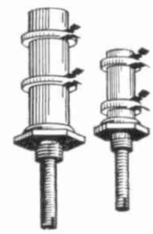
In addition to the components mentioned below, National Radio Co. also manufactures complete lines of capacitors, tanks, grid and plate caps, IF transformers, ceramic insulators, bushings, spreaders, couplings, terminal assemblies, and other electronic and electro-mechanical components. Write for components catalog covering your specific applications.



MIL-SPEC KNOBS

Type KMS. Complete line of standard plastic control knobs made in conformance with MS-91528. Four basic types (with or without skirts), three shaft sizes, gloss or matte finishes, or to your color specifications . . . in all Mil-Spec sizes.

UNIVERSAL CERAMIC COIL FORMS



For military and commercial applications. Available in five standard sizes with or without terminal collars. Terminal collars accept up to four terminals per collar. All materials are in accordance with applicable MIL-SPECS. Pre-assembled forms to your prints quoted upon request.

CHOKES

R-45 SERIES: Ferrite bead chokes for frequencies from 5 to 200 mc. R-40 SERIES: Ferrite-core chokes, extremely high Q for small size. Fungus-proof varnish impregnation per MIL-V137A. R-25 SERIES: MIL-inductance chokes for high frequency circuits. Inductance per MIL-C15305A, coil forms per MIL-P-14, impregnation per MIL-V-173A. R-33, R-50, R-60 SERIES: RF coils molded on phenolic forms per MIL-P-14.

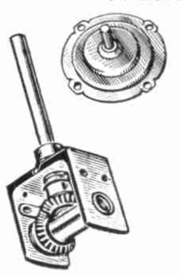
HR KNOBS

TYPE HRS: Molded Tenite knobs, grey, black or to specifications. TYPE HRT: Large deLuxe knobs designed for National's receivers, now available by popular request. TYPE HRB: Band switching knob or other applications where switch is turned to several index positions. TYPE HRM: Small brass knurled knobs. TYPE HRK: Fluted, large black Bakelite knobs. TYPE HRP: Chip resistant black Bakelite knob without pointer. TYPE HRP-P: Same as HRP but with pointer.

"FLUSH MOUNT" CAPTIVE NUTS

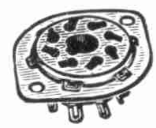
National Exclusive! Flush fit on both sides of aluminum sheet provides permanent tapped holes. Stainless steel 303 as per MIL-S-853A, passivated finish as per MIL-P12011. Additional types to meet MIL SPECS P-11268, E-5400, and E-16400. Captive studs also available.

PRECISION RIGHT ANGLE, VERNIER DRIVES

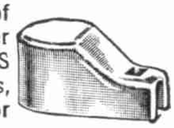


TYPE PRAD: Right angle drive remote operation of low torque units. TYPE RAD: Right angle drive for ganging capacitors, potentiometers or other parts in inaccessible locations. TYPE AN: Vernier mechanism for use with any 3/16" National knobs and others. TYPE AVD: Vernier mechanism similar to type AN except that the output shaft is non-insulated.

SOCKETS, CAPS, TERMINALS



TYPE CIR: Tube sockets of grade L-4 ceramic materials (JAN-1-10 spec.) in four models. TYPE CS: Crystal mounting sockets for crystal holders (JAN-1-10 spec.).
TYPES XM-10, XM-50: Heavy-duty, metal shell sockets for four-pin tubes. TYPES XLA-7: Low-loss socket for 6F4 and 950 series acorn tubes. TYPES SPP-3, SPP-9: Plate caps of grade L-4 steatite (JAN-1-10 spec.) with silver or tin plated beryllium copper grips. TYPES GG-8, 12, 24: Grid grips made in two types, three sizes, variety of materials . . . clip grip, or loop grip . . . other specifications also.



TERMINAL/ASSEMBLIES: TYPE FWC: Insulators molded of mica-filled Bakelite. TYPE FWE: Nickel plated brass jacks. TYPE FWA: Nickel plated brass binding posts. TYPE FWT: Plugs for stacking. TYPES FWH, FWJ: Terminal assemblies.

Specifications subject to change without notice.

Many National Radio Co. components are made to specifications . . .
For your SPECIAL design or development applications problems, write or call:

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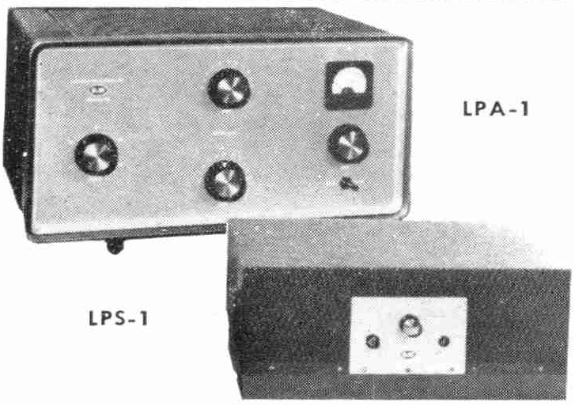
B & W PRESENTS 1960's TOP PRODUCTS IN QUALITY AND PERFORMANCE



LPA-1

LPS-1

Grounded Grid Linear Amplifier

New! Advanced design amplifier incorporating every element needed for fool-proof, reliable operation. This smartly-styled *full kilowatt* package of power takes up no more table space than a receiver. Can be driven by commercial and home-built exciters in the 100-watt output class. Includes R.F. section complete with tubes, blower, filament and bias supply and optional input matching unit. Pi-network output circuit for precise tuning and loading on 80-40-20-15-10 meters.

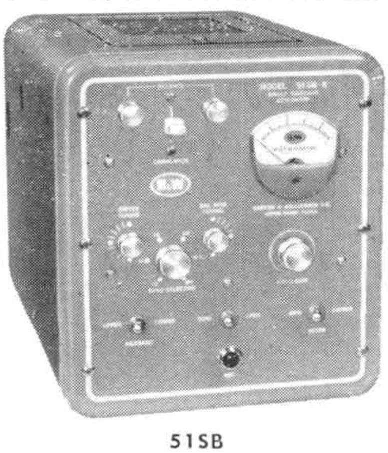
POWER SUPPLY UNIT LPS-1 — Designed as companion to the LPA-1 for side-by-side installation or remote location. Switching panel removable for remote control. Full wave single-phase bridge rectifier with four Type 816 mercury vapor tubes included. R.F. filtering. Heavy-duty transformer core stacks and superior high-voltage insulation for reliable, continuous operation at 1 KW.

MATCHING UNITS MODEL LPA-MU & MODEL LPA-MU-2 — Compact, pretuned bandswitching assembly for matching fixed-output type exciters to B&W amplifier, insures maximum input drive on all bands. Model LPA-MU is designed for the LPA-1 and is installed so that input matching to the final is accomplished automatically when amplifier is bandswitched. Model LPA-MU-2 is similar, but is designed for previous B&W amplifiers Models L-1000-A and L-1001-A. Assembled, ready for installation with instructions and fittings.

5100-B

Medium Powered Transmitter 5100-B

Completely self-contained including power supply and VFO. Bandswitching on the 80-40-20-15-10 meter bands. Peak envelope power 180 watts CW-SSB; 145 watts AM. Excellent SSB when used with the 51SB-B described below. Stable VFO accurately calibrated for all amateur bands including 10 meters. Bias system provides complete cutoff under key-up conditions. Excellent TVI suppression. Pi-network output. The 5100-B makes a superlatively well regulated driver for a grounded grid class "B" linear, with output to spare.



51SB

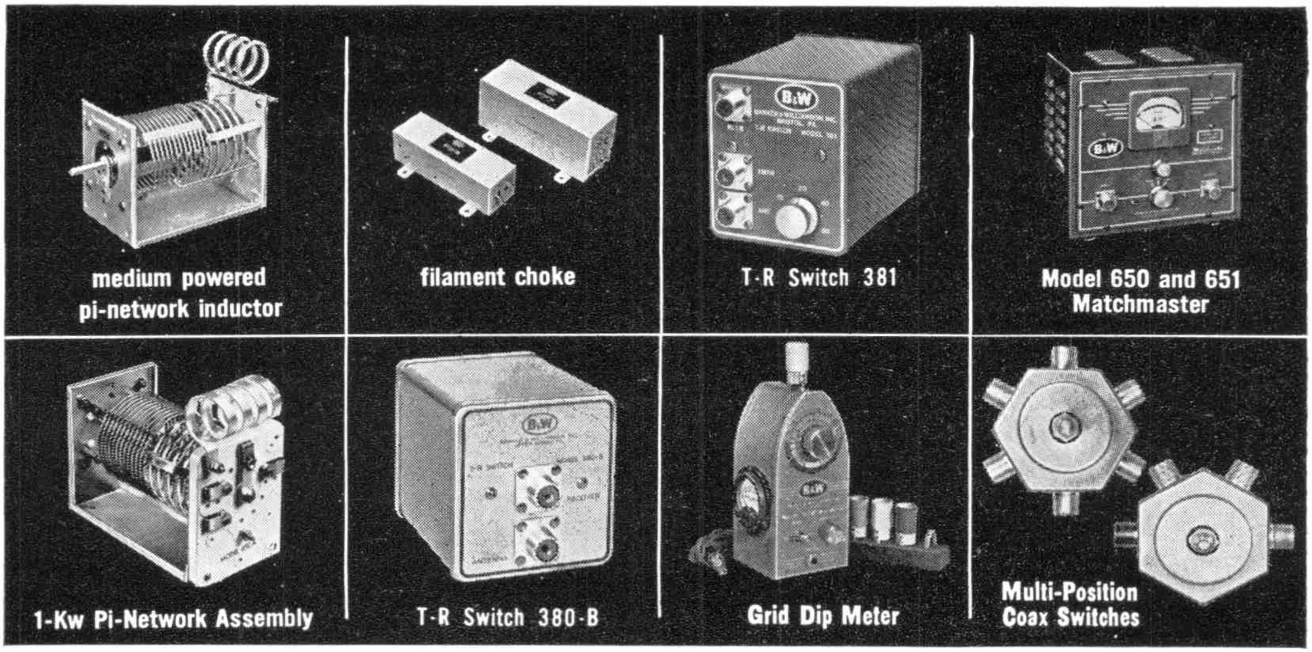
Single Sideband Generator 51SB

Excellent SSB with your present transmitter. Provides push-to-talk, speaker deactivating circuit, TVI suppression. Complete bandswitching on 80-40-20-15-10 meters. Utilizes frequency control method of your present rig. R-F portion has 90° phase shift network, double balanced modulator, and two class "A" R.F. voltage amplifiers. All operating controls on the front panel. Input impedance 50 ohms resistive; input voltage 1.5–2.0 RMS on all bands.

MODEL 51SB-B — For use with B&W 5100-B from which it derives all operating power.

B & W

BARKER & WILLIAMSON, INC.
Bristol, Pennsylvania



Pi-Network Inductor Assemblies

Integral bandswitched Pi-network inductors for single or parallel tube operation 80 through 10 meters. Give top efficiency in Class "C" or linear operation using triodes or tetrodes in conventional and grounded grid circuits. Ample current-carrying capacity and optimum "Q" over entire operating range. *Model 850A* — Conservatively rated at 1 KW on CW-SSB and AM with 100% modulation. Max. voltage: 4000 VDC on CW-SSB; 2500–3000 on AM with 100% modulation. *Model 851* — Medium powered with rating of 250 watts on AM phone and 500 watts on CW-SSB. Max. voltage: 2000 VDC on CW-SSB; 1250 VDC on AM phone.

Grid Dip Meter

A highly accurate, sensitive instrument. May be used as a grid-dip oscillator, signal generator, or absorption wavemeter. Five color-coded plug-in coils cover 1.75 to 260 mc. Color-coded dial easily read. Operates from 110 VAC. Easy to use in hard-to-get-at places. Model 600.

T-R Switches

Fully automatic electronic antenna switching from transmitter to receiver and vice versa. Ideal for fast break-in operation on SSB-AM-CW-DSB. Fail-safe design eliminates risk of transmitter damage if switch is not energized. Match 52-75 ohm coax lines. *Model 381* handles full legal power with wide safety margin. Selectable bandswitching, 80 through 10 meters, for high signal-to-noise ratio and minimum intermodulation effect from local broadcast and TVI. For commercial applications, Model 381 handles up to 5 KW SSB and CW under SWR conditions not exceeding 1.5 to 1 using 72 ohm coax line, and higher power with 52 ohm line. *Model 380-B* is designed for medium power applications. Has broadband circuitry which eliminates tuning and adjustment.

Multi-Position Coax Switches

For 75 or 52 ohm line. Instantly switches coax lines . . . no screwing or unscrewing coax connectors. Handles up to 1 KW modulated power. Max. cross-talk −45db at 30 mc. Model 550A 5-position switch. Model 551A 2-pole, 2-position switch.

Low Pass Filter

For Transmitters to 1KW. Minimum 85 db attenuation throughout TV bands. Uses exclusive B&W patented wave-guide design in novel multi-sectional construction giving greater attenuation in less space at lower cost. Model 425 for 52 ohms impedance. Model 426 for 75 ohms.

Matchmaster

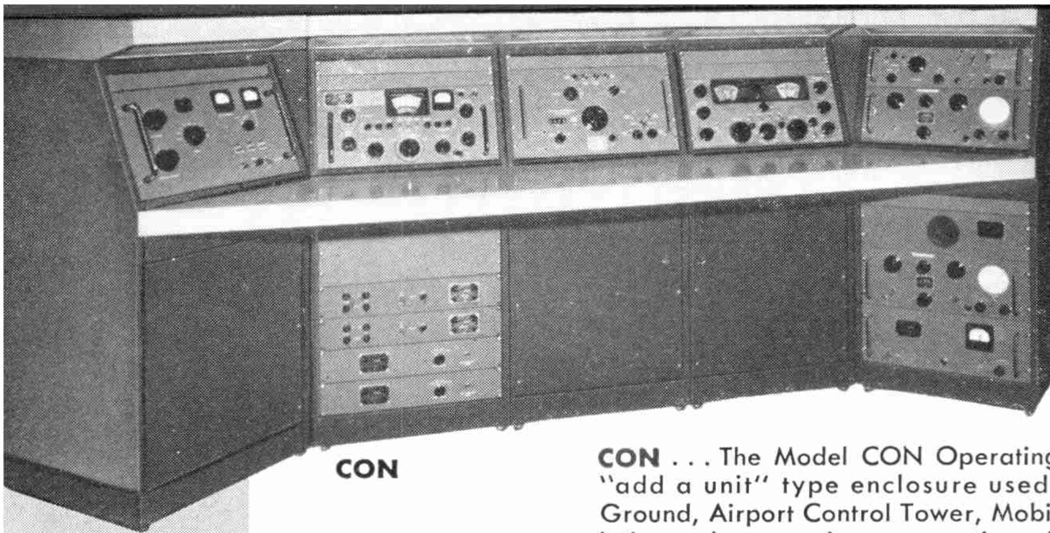
Self-contained in 6″ x 8″ x 8″ steel cabinet. Serves as dummy load for transmitter tests. SWR measurements throughout range of 500 kc to 30 mc. Direct-reading R.F. watt meter up to 125 watts, higher powers by sampling. Integral SWR bridge for matching antennas and other loads to transmitter. Model 650 for 52 ohm line, Model 651 for 75 ohms.

R. F. Filament Chokes

Used with standard filament transformers in grounded grid amplifier circuitry. Broadband design requires no tuning 80 through 10 meters. Packaged in steel case with mounting brackets. *Model FC-15* — For one or two tubes requiring not more than 15 amps fil. current. *Model FC-30* — For one or two tubes of up to 30 amps fil. current.

B & W

BARKER & WILLIAMSON, INC.
Bristol, Pennsylvania

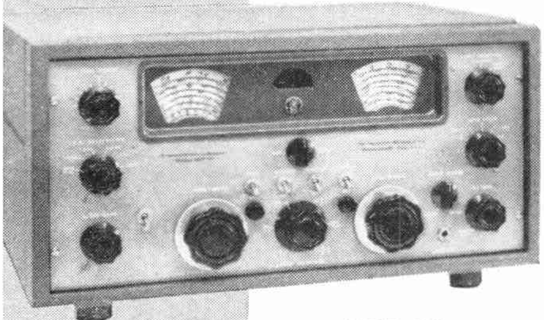


in

SSB • DSB

CON

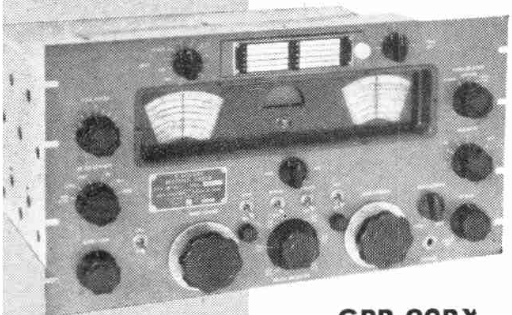
CON . . . The Model CON Operating Console is an unusual "add a unit" type enclosure used in Point to Point, Air-Ground, Airport Control Tower, Mobile and Shipboard installations where maximum operating efficiency and equipment flexibility is required. The units are made up of standard 19" assemblies which can be used to form straight line, "L", "U" and many other arrangements.......................... **Bulletin 211**



GPR-90

GPR-90 (R-825/URR) . . . a general purpose communications receiver of the double conversion superheterodyne type covering the frequency range of .51 to 31 mcs. Stable—selective—accurate—built-in crystal calibrator....... **Bulletin 179**

GPR-90RX (R-840/URR) . . . Provides the same high quality characteristics of the GPR-90 but also permits the use of 10 precisely adjustable crystal positions available from the front panel plus a rear deck input for an external high stability control oscillator or synthesizer........................ **Bulletin 205**



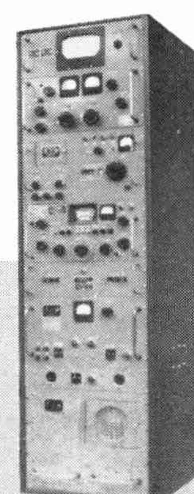
GPR-90RX

GSB . . . Single Sideband Adapter of the filter slicer type permitting accurate and simple tuning of SSB, AM, CW and MCW. Filter provides additional selectivity and pass-band tuning. Upper and lower sidebands are selected by a flip of a switch... **Bulletin 194**

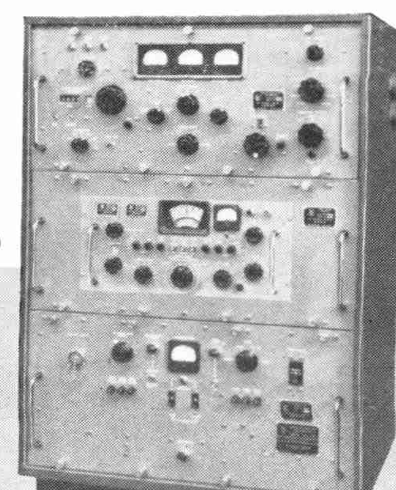
SBT-1K ( ) . . . Single Sideband Transmitter is a conservatively rated general purpose transmitter providing at least 1 KW PEP from 2—32 mcs.—SSB—ISB—DSB—CW—MCW—FS. Rugged, compact, serviceable, completely bandswitched—ideally suited for mobile, marine, fixed station operations. Four models available................................... **Bulletin 237**

GPT-750 ( ) 2 (AN/URT-17A) . . . is a fully bandswitched, continuously tunable (2-32MC) radio transmitter. The building block concept makes this transmitter versatile, easy to install, operate and maintain. Four models available. SSB, ISB, DSB, AM, CW, MCW, FAX, FS. The GPT-750 ( )2 is ideally suited for fixed station, mobile and shipboard operation.
Bulletin 227

GSB



SBT-1KA



GPT-750D

HF/LF communications

it's TMC

• ISB • CW • MCW • AM • FS

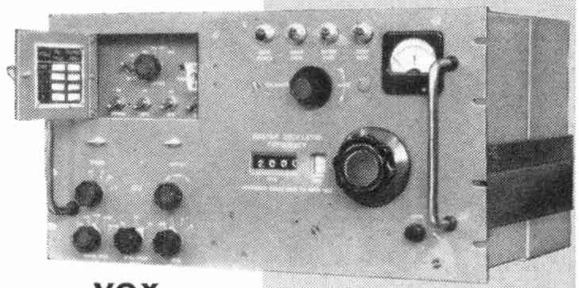
VOX (0-330/FR) . . . a direct reading, high stability, Variable Frequency Oscillator providing continuously variable output over the frequency range of 2—64 mcs. **Bulletin 134A**

XFL-2 . . . The TMC Frequency Shift Exciter System, Model XFL-2 is combined low and high frequency shift system. The system combines the TMC Low Frequency Adapter, Model LFA with TMC Frequency Shift Exciter, Model XFK to provide versatile operation over a wide range of frequencies—1 to 6.9 mcs. and 50 to 500 Kcs. .... **Bulletin 154**

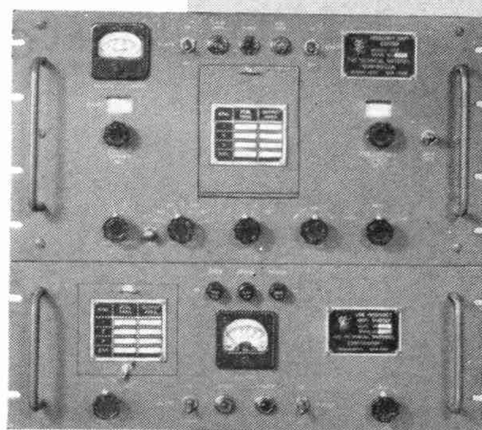
SBT-350 ( ) . . . Compact, rugged Radio Transmitter capable of at least 350 watts PEP from 2—32 mcs. SSB—ISB—DSB CW—MCW—FS low level AM—completely bandswitched—five models available. .... **Bulletin 220**

PTE-1 . . . Single Sideband Analyzer designed for the specific purpose of tuning and aligning single sideband exciters and transmitters permitting a visual analysis of intermodulation distortion products, hum and noise The PTE-1 consists of 3 basic TMC units: Spectrum Analyzer Model FSA (AN/URM-116); A VFO TMC Model VOX (0-330/FR) and a Two-tone Generator TMC Model TTG (C-579/URT). .... **Bulletin 231**

GPT-10K (AN/FRT-39) . . . is a conservatively rated general purpose radio transmitter capable of at least 10 KW PEP output from 4-28 mcs. All power amplifier stages are linear and the final incorporates a ceramic tube for greater efficiency and reliability. All components housed within a single attractive enclosure including sideband exciter—VFO, spectrum analyzer, F.S. Exciter and complete "on the air" testing circuitry. .... **Bulletin 207B**



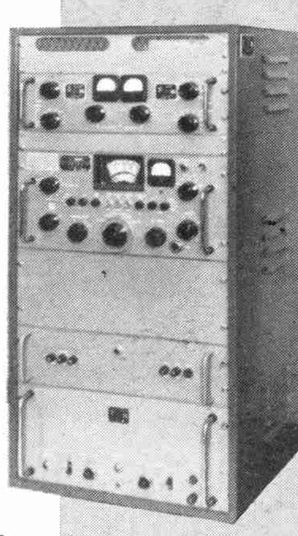
VOX



XFL-2

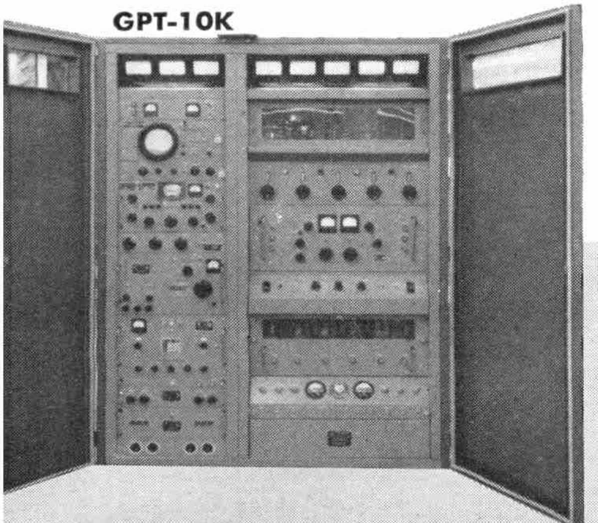
The TECHNICAL MATERIEL CORP.

MAMARONECK, NEW YORK



SBT-350 B

GPT-10K



PTE-1

electron tubes

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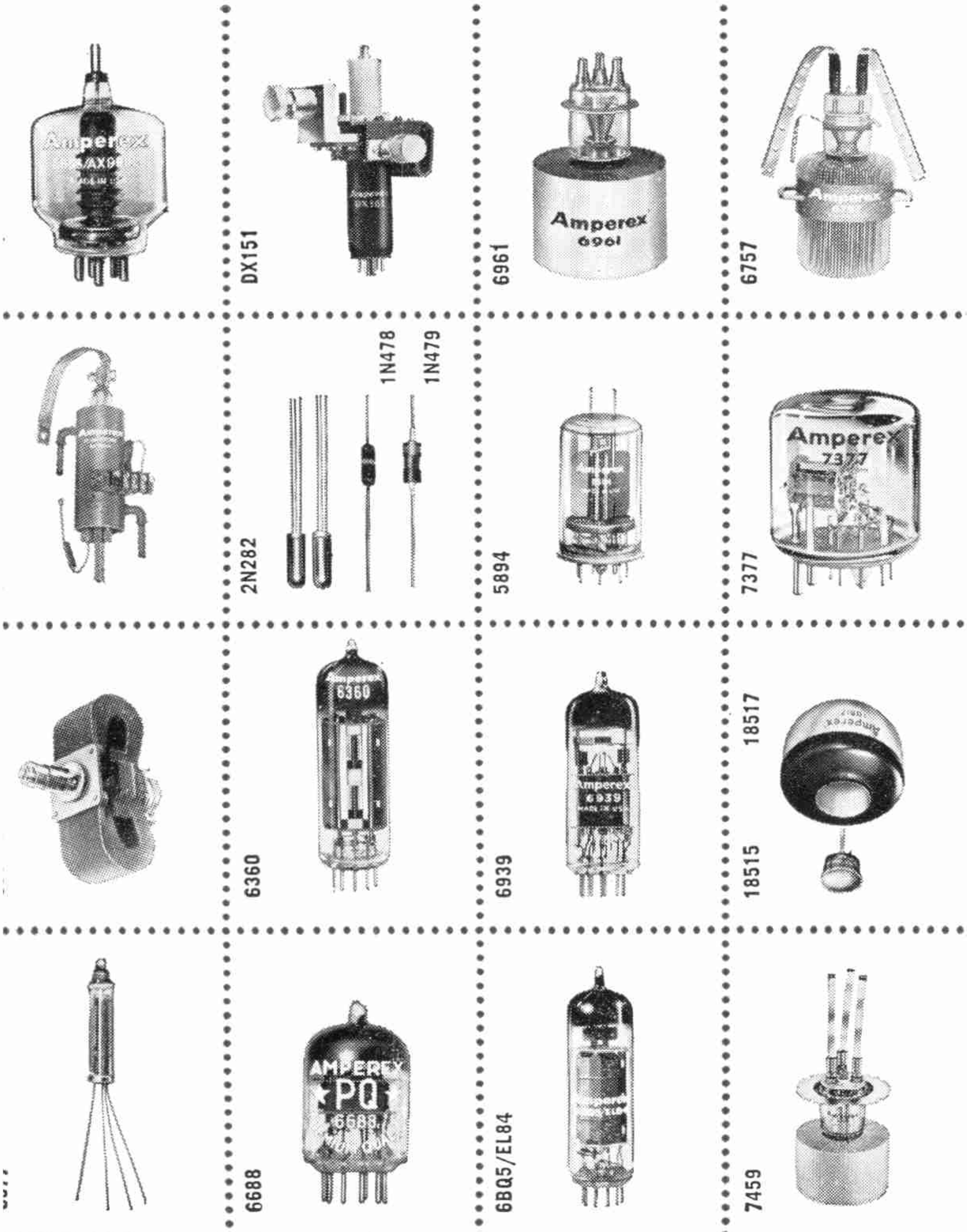

Detailed Data Sheets on any of these tubes, and applications engineering service are yours for the asking.

§The AMPEREX types 6268 and 6279 are not only improved versions but completely interchangeable in every respect with the Types 4C35 and 5C22 respectively. They have a minimum guaranteed life of 1,000 hours due to the self-contained, self-regulating sources of hydrogen.

‡Includes sensing plate. For thermostatic control, ordered separately either:

(a) "Water Saver" Thermostat Assembly, Cat. No. S-17024, Price $5.25.

(b) "Overload Protection" Thermostat Assembly, Cat. No. S-17025, $5.25.

**Price on request.

#Price for this tube includes 10% Federal Excise Tax.

Prices subject to change without notice.

RADIATOR CREDIT FOR FORCED AIR-COOLED TUBES

Tube Type	Users Allowance
889RA	$20.00
891R, 892R	30.00
5604	75.00
5667	20.00
6445	30.00
6447	30.00
6757	75.00
6801	75.00

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BEAM POWER TUBES

Type No.	Price
807	$2.90
6146	5.00
6159	5.00
PE06/40N	5.95

DIODE, CLIPPER

Type No.	Price
6339	$44.50

COUNTERS, GEIGER

Type No.	Price
75N	$16.50
75NB3	16.50
80N	45.00
85NB3	22.70
90CB	27.00
90NB	27.00
90NB4	27.00
100C	54.00
100CB	58.00
100HB	54.00
100N	43.50
100NB	45.50
120C	90.00
120CB	95.00
120N	90.00
120NB	95.00
150N	61.00
150NB	66.00
153C	91.00
160G	66.00
170G	110.00
180G	50.00
200C	67.00
200CB	71.00
200HB	67.00
200N	56.00
200NB	58.50
230C	43.00
230N	41.00
240C	43.00
240N	41.00
912NB	53.00
18503	28.00
18508	127.00
18509-01	22.40
18510	127.00
18515	186.50
18516	206.25
18517	373.00
18518	412.50

CONDENSERS, VACUUM

Type No.	Price
VC25/20	$22.00
VC25/32	25.25
VC50/20	26.25
VC50/32	29.50
VC100/20	32.00
VC100/32	35.00
VC250/32	75.00

COUNTER, DECADE

Type No.	Price
6370/EIT	$16.50

DIODE, DAMPER

Type No.	Price
#6R3/EY81	$2.80

TWIN DIODE, "PREMIUM QUALITY"

Type No.	Price
#5726/E91AA	$2.10

DIODE, VTVM

Type No.	Price
6923/EA52	$13.00

IGNITRONS

Type No.	Price
‡5551A/652	$65.00
‡5552A/651	99.00
‡5553B/655	245.00
5555/653B	316.00
‡5822A	116.00

TUNING INDICATORS

Type No.	Price
#1M3/DM70	$1.95
#6BR5/EM80	2.45
#6CD7/EM34	3.65
#6DA5/EM81	2.45
#6FG6/EM84	2.95
#DM71	2.00

KLYSTRONS

Type No.	Price
DX122	**
DX123	**
DX124	**
DX151	**

KLYSTRON, REFLEX

Type No.	Price
2K25	$39.50

MAGNETRONS

Type No.	Price
2J42	$160.00
2J48	250.00
4J47	500.00
4J57	270.00
4J58	270.00
4J59	270.00
5586	417.00
5657	417.00
5780A	**
6589	**
6972	325.00

PENTODES

Type No.	Price
#6AU6	$ 2.10
828	27.50
6083/AX9909	14.25
EFP60	8.75

PENTODE, DUO-DIODE

Type No.	Price
#6DC8/EBF89	$3.25

PENTODE, FRAME GRID

Type No.	Price
5847	$18.21

PENTODES, HI-FI

Type No.	Price
#6BQ5/EL84	$2.35
#6CA7/EL34	6.20
#6CW5/EL86	3.50
#8BQ5/XL84	2.60
#6267/EF86	2.75
#7189	3.60

TRIODE-PENTODES, HI-FI

Type No.	Price
#6BM8/ECL82	$3.00
#50BM8/UCL82	3.00

PENTODES, "PREMIUM QUALITY"

Type No.	Price
5654/E95F	$3.20
6084/E80F	3.75
6227/E80L	3.75
6686/E81L	5.00
6688/E180F	8.00
6689/E83F	4.50
E90F	**
E99F	**

TRIODE-PENTODES

Type No.	Price
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#6BL8/ECF80	3.80

TRIODE-PENTODE "PREMIUM QUALITY"

Type No.	Price
E80CF	**

PENTODES, SUBMINIATURE

Type No.	Price
6007/5913	$1.50
6008/5911	1.50

RECTIFIERS

Type No.	Price
#1S2A/DY87	$2.75
#5AR4/GZ34	4.20
#5R4G-Y	1.90
#6CA4/EZ81	2.10
#6V4/EZ80	1.50
575A	22.15
673	22.15
8020AX	15.00

RECTIFIERS, MERCURY

Type No.	Price
857B	$235.00
866AX	2.65
869B	150.00
869BL	150.00
872AX	9.90
6508	80.00
6693	25.00
7136	25.00
8008AX	9.90

RECTIFIERS, XENON

Type No.	Price
3B28	$ 7.60
4B32	13.50

VOLTAGE REFERENCE TUBES

Type No.	Price
OE3/85A1	$2.50
OG3/85A2	2.50

VOLTAGE REFERENCE TUBE "PREMIUM QUALITY"

Type No.	Price
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VOLTAGE REGULATORS

Type No.	Price
OA2	$1.75
OB2	1.90
90C1	2.50
6354/150B2	3.00

TETRODES

Type No.	Price
4-125A	$ 36.00
4-250A	46.50
4-400A	55.00
4CX250B	45.00
4X150A	38.95
4X150D	38.95
4X250B	42.50
4X250F	42.50
4X500A	121.00
6075/AX9907	250.00
6076/AX9907R	305.00
6079/AX9908	60.00
6155	36.00
6156	46.50
6979	42.50
7527	55.00

TETRODES, BEAM

Type No.	Price
813	$22.65
7378	**

TWIN TETRODES

Type No.	Price
829B	$18.90
832A	15.85
5894/AX9903	25.00
6252/AX9910	25.00
6907	25.00
6939	14.00
7377	**

THYRATRONS

Type No.	Price
2D21	$ 2.05
3C23	11.98
5560/FG95	33.00
5632/C3J	15.50
5684/C3JA	19.80
5685/C6JA	29.30
5727/E91N	2.70
5949/1907	**
AX260	150.00

THYRATRONS, HYDROGEN

Type No.	Price
§6268/AX9911	$32.50
§6279/AX9912	45.00

THYRATRONS, MERCURY

Type No.	Price
5557/FG17/967/1701	$ 9.50
5559	22.00
5869/AGR9950	25.00
5870/AGR9951	100.00
6786	200.00
AX105/FG105	53.33

THYRATRONS, XENON

Type No.	Price
2050	$ 1.85
5544	38.41
5545	29.30

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Type No.	Price
#6Q4/EC80	$ 6.00
#6R4/EC81	2.50
450TH	77.00
450TL	77.00
501R/5759	225.00
502/5760	210.00
502R/5761	235.00
504R	245.00
805	20.00
810	25.55
811A	6.50
812A	6.50
833A	47.90
834	19.30
838	20.00
845	20.85
849	185.00
849A	185.00
880	565.00
889A	221.00
889RA	347.00
891	275.00
891R	430.00
892	270.00
892R	425.00
5604	570.00
5619	423.00
5658	565.00
5666	280.00
5667	370.00

TRIODES (Con't)

Type No.	Price
5771/356	$600.0
5866/AX9900	20.0
5867/AX9901	30.0
5868/AX9902	55.0
5923/AX9904	165.0
5924/AX9904R	231.0
5924A	275.0
6077/AX9906	1675.0
6078/AX9906R	1900.0
6333	**
6445	420.0
6446	305.0
6447	465.0
6756	388.0
6757	535.0
6758	173.0
6759	206.0
6800	350.0
6801	505.0
6960	150.0
6961	210.0
7092	125.0
7459	230.0
DX144/EC56	**
DX145/EC57	**
HF200	49.5
HF201A/468	34.5
HF300	40.5
ZB3200	390.0

TRIODES, FRAME GRID

Type No.	Price
#2ER5	$ 2.9
#3ER5	2.9
#4ER5	2.9
#6ER5/EC95	2.9
5842	18.2

TRIODE, INDICATOR "PREMIUM QUALITY"

Type No.	Price
6977/DM160	$3.5

TWIN TRIODES

Type No.	Price
#4ES8/XCC189	$4.5
#6AQ8/ECC85	2.6
#6DJ8/ECC88	4.5
#6ES8/ECC189	4.5
#6J6/ECC91	2.8
#9AQ8/PCC85	3.1
#12AT7/ECC81	3.0
#12AU7/ECC82	2.4
#12AX7/ECC83	2.5
#17EW8/HCC85	2.6
5920/E90CC PQ	2.4
6085/E80CC PQ	3.7
6201 PQ	3.2
6211 PQ	2.4
6360	**
6463 PQ	2.9
6922/E88CC PQ	4.7
7062/E180CC PQ	2.4
7119/E182CC PQ	4.1
7316	2.0
E92CC	2.4

TRIODE, GLOW DISCHARG

Type No.	Price
5823/Z900T	$2.5

TRIGGER TUBES, COLD CATHODE

Type No.	Price
Z50T	$2.2
Z70U	1.9
Z300T	4.9
Z804U	4.3

HEPTODE, DUAL CONTROL "PREMIUM QUALITY"

Type No.	Price
6687/E91H	$1.4

BEAM DEFLECTION TUB "PREMIUM QUALITY"

Type No.	Price
6218/E80T	$15.0

Bliley

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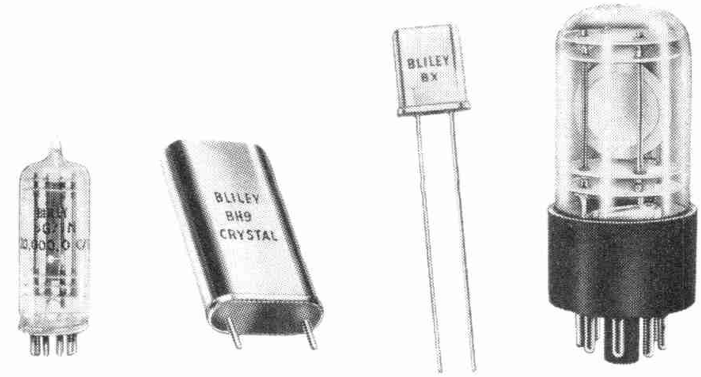
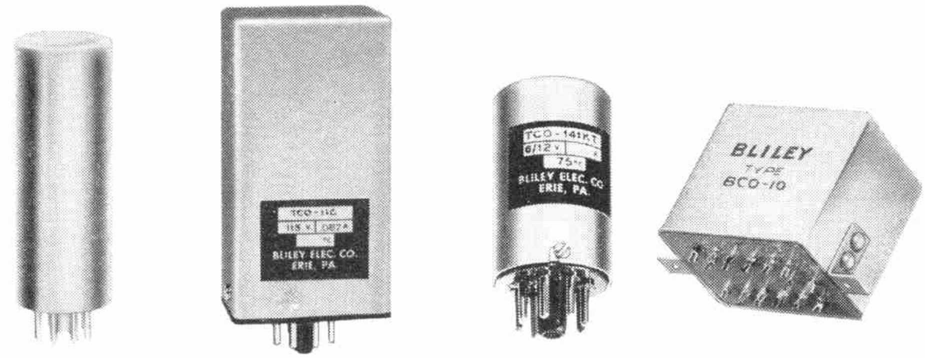


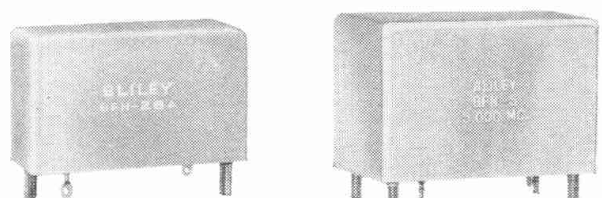
BG7 SERIES BH9 SERIES BX SERIES BG9 SERIES

QUARTZ CRYSTALS



BTC-2 SERIES TCO-11 SERIES TCO-141 SERIES BCO-10 SERIES

OVENS



BFN-28A BFN-5

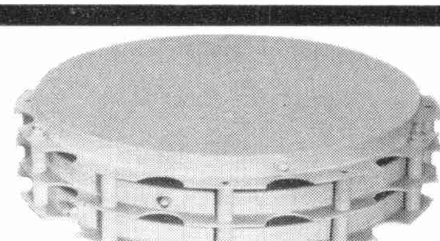
CRYSTAL FILTERS

CCO-7 SERIES

PACKAGED OSCILLATORS

DOUBLE ENDED RINGING LINE

SET OF THREE MATCHED DELAY LINES



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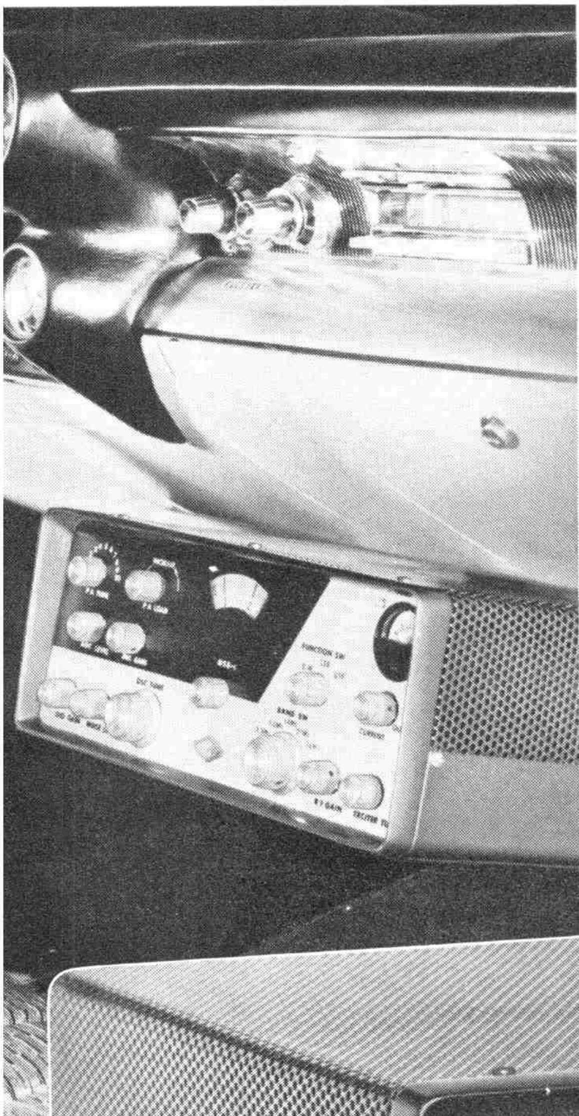

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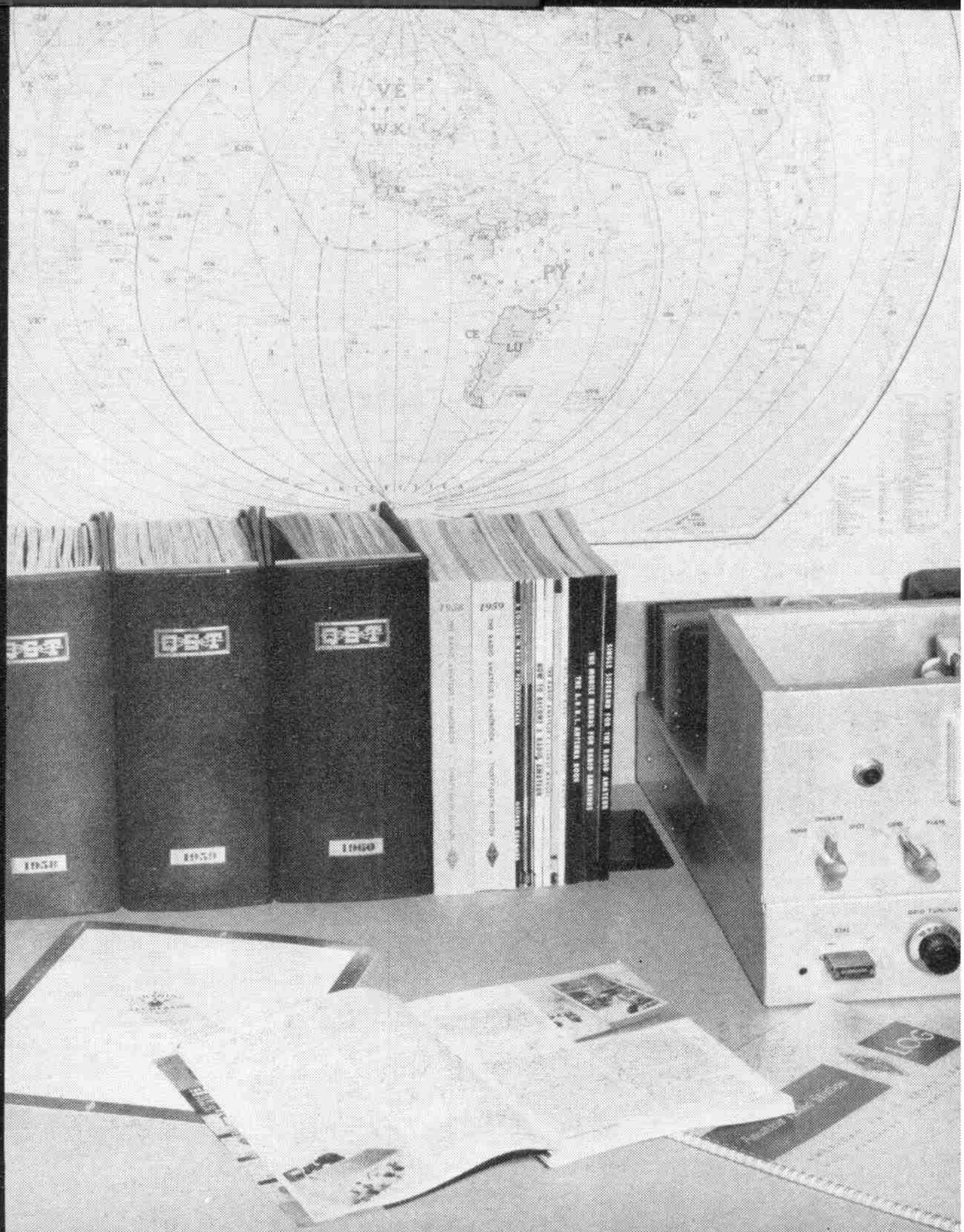
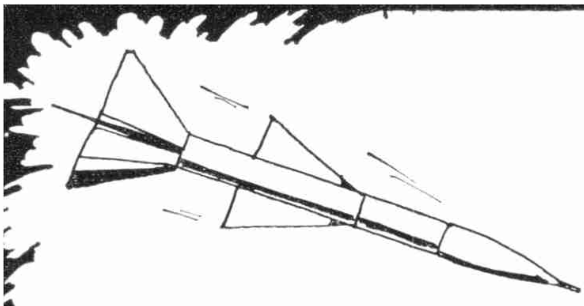


THE AMERICAN RADIO RELAY LEAGUE • WEST HARTFORD 7, CONN.



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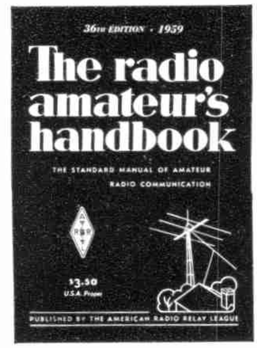

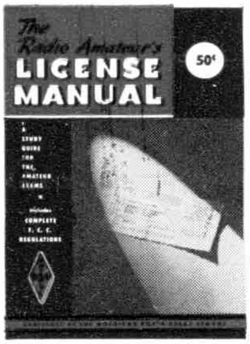

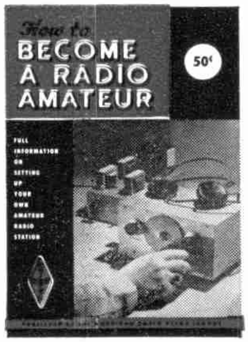

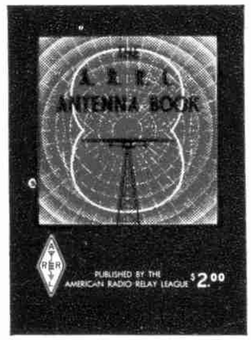

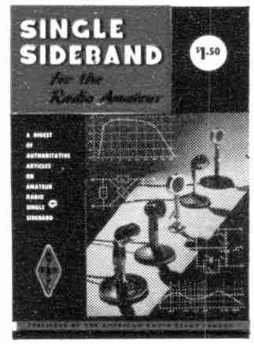

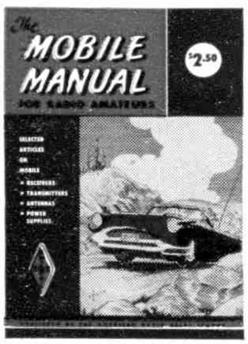

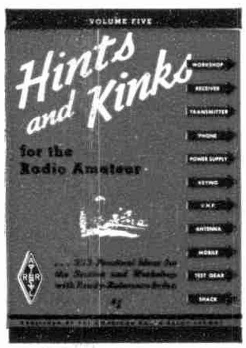

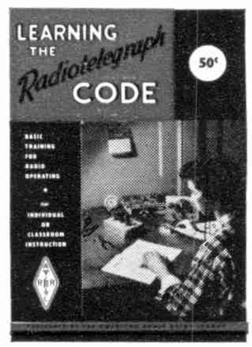

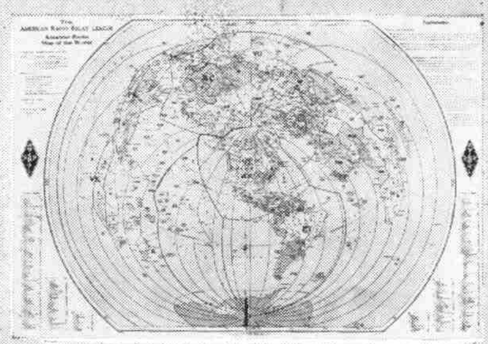

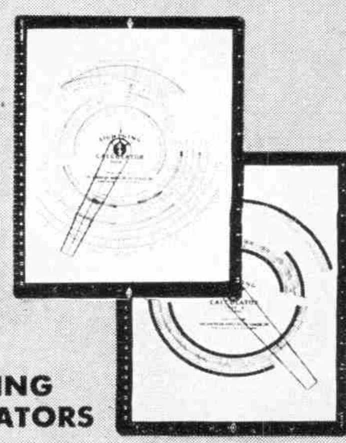

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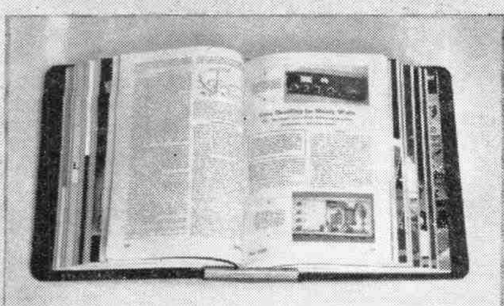

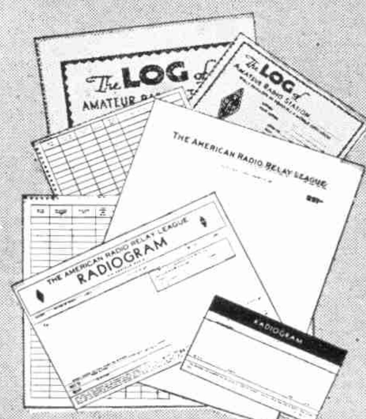

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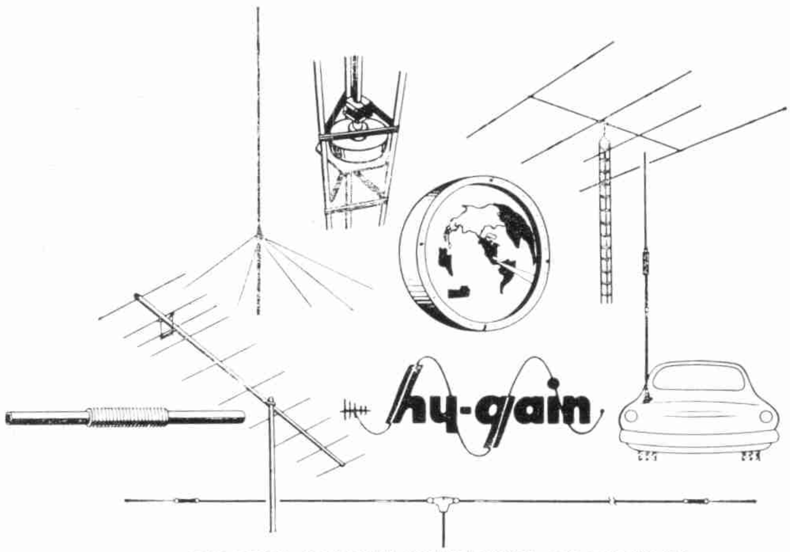

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HAM BAND RECEIVER

Model 6900

Amateur Net

$349.00

The design and production of communications receivers today is considerably different than in past years for two principal reasons. Costs have risen precipitously; to manufacture a receiver in the face of this and keep the price reasonable requires good tooling, long runs, and little allowance for error. Secondly, there are greater demands placed on receiver operation than ever before, versatility . . . handling ease . . . yes, amateurs have come to ask for parameters of performance almost unheard of in past years.

RME in announcing the new 6900 states without equivocation that this receiver performance is unmatched by anything near its price class. The 6900 is engineered to give optimum service for all modes of amateur communications — not merely one. Engineered under the supervision of Russ Planck, W9RGH, the 6900 has as many advanced pioneering features as its extraordinary namesake, the world famous RME69, which was the first band-switching communications receiver ever produced — over 20 years ago and still widely used today.

What makes the 6900 so Hot? First, meticulous attention to details so that every circuit is performing in an optimum manner. Second, an ingenious function selector, the Modemaster. Every circuit in the 6900 is designed to provide high selectivity; frequency stability, sensitivity and low internal noise. Finally, inclusion of *all* function controls necessary for a modern communications receiver . . . vernier control knob with overide clutch for fast tuning; RF gain; AF gain; antenna trimmer; band selector, stand-by/receive/calibrate/transmit; ANL; T-notch filter; calibrate adjustment; band selector.

Whether you operate CW; SSB; or AM, you will have the almost uncanny feeling the 6900 was designed solely for you — this is the test of a modern communications receiver that we believe only ours can meet on the operating desk.

- **CONTROLS: 11½" Single Slide Rule Tuning Dial; Logging Scale.**
- **COVERAGE: 80, 40, 20, 15 and 10 on 5 bands plus 10 to 11 mc for WWV or WWVH.**
- **Peak Selectivity plus tunable "T" Notch.**
- **Internal 100 kc Hermetically Sealed Crystal Calibrator.**
- **500-ohm Output.**
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- **S Meter Calibrated in 6 db Steps Above S9 for Better Reading.**
- **Improved Fast Attack AVC Circuit.**
- **Selectable Sideband.**
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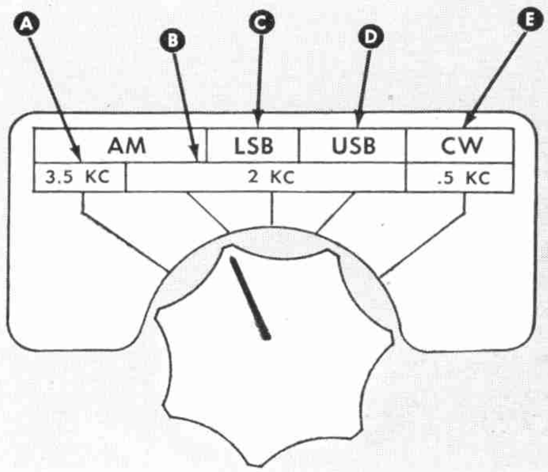
- **Front Panel Controls Re-Grouped for Ultimate Operating Ease and Convenience.**
- **SENSITIVITY: 1 mv. 30% Modulation for 100 mw output.**
- **S-N-R: 10 db at 1 mv Input.**
- **SELECTIVITY: 500 cps, 6 db down, in CW mode.**

offers optimum performance on SSB, AM or CW with no compromises

NEW...VERSATILE
Model 6900
MODEMASTER SWITCH



Gives One Hand Knob Control of 5 Distinct Functions

A When in the indicated AM position, a *full-wave* diode detector is used. The IF frequency response curve is 3.5 kc wide at 6 db down and, the AVC system is switched for fast attack/fast decay operation. The AM band width for this area is 3.5 kc.

B In this AM position all of the conditions described for function A above remain the same except that the IF response curve is narrowed to 2 kc to reject nearby signals on crowded bands.

C In the LSB (Lower Side Band of SSB carrier) position a series of steps occur.

(1) The AVC system is switched to a fast attack/slow decay performance.

(2) The Beat Frequency Oscillator is turned on and positioned for desired sideband reception.

(3) The second conversion oscillator frequency also shifts for reception of desired sideband while the IF response curve remains the same.

(4) An advanced Product Detector switches in to replace the Diode Detector in all SSB and CW positions.

D In the USB (Upper Side Band) the changes cited in function C above also occur but are designed to accommodate the Upper Side Band.

E When switched to the CW position:

(1) The band pass of the IF System is reduced to 500 cycles (.5kc)

(2) The BFO Injection Control and BFO Pitch Control becomes operational.

(3) The AVC system is changed for optimum when operating under CW conditions.

(4) The second conversion oscillator is positioned for reception of the upper sideband beat note.

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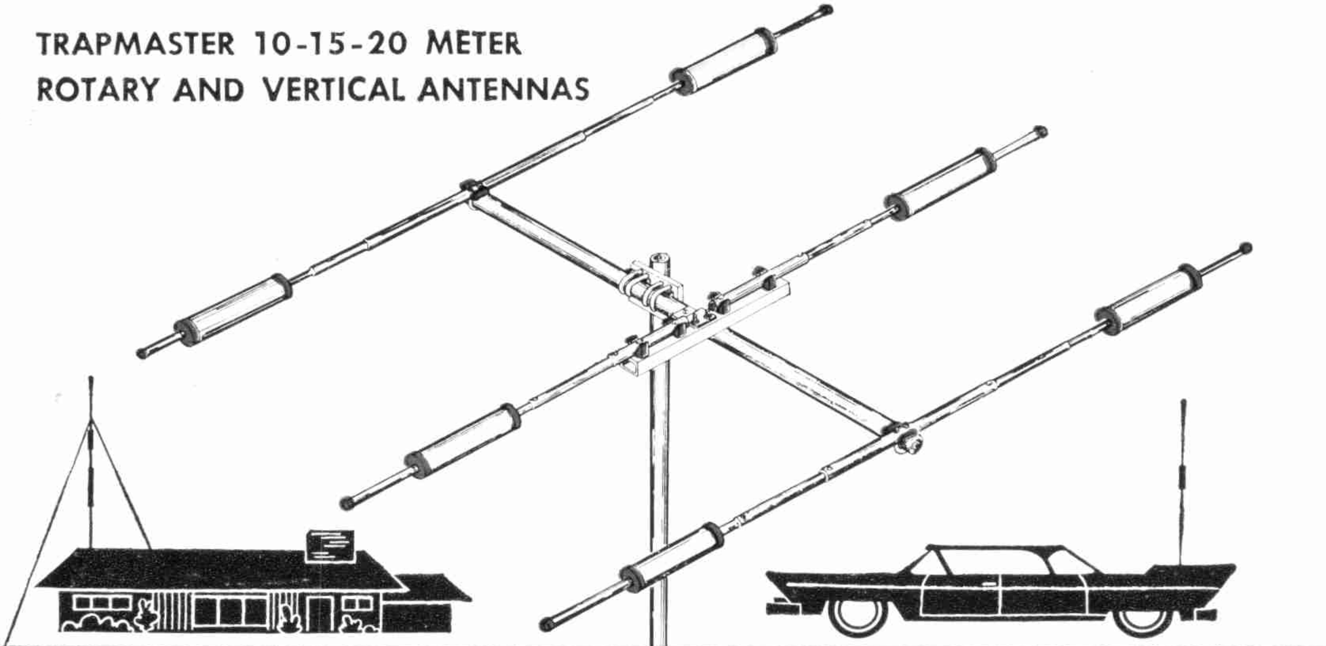

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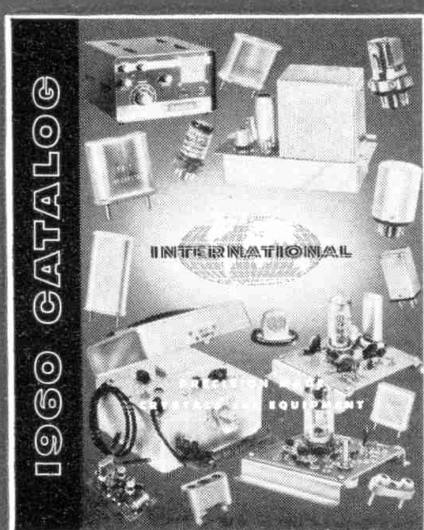

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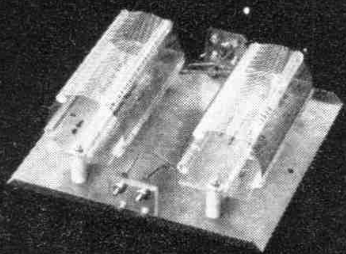

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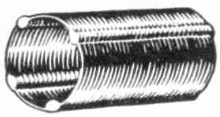

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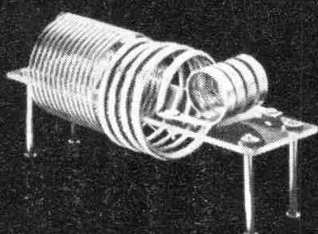

1 KW pi dux

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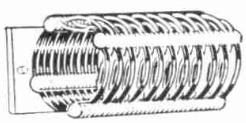

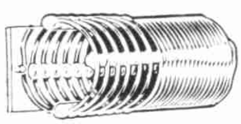

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Cat. No.	Dia	TPI	Wire Size	Length of Coil	L uh.
816A	1	16	18	3 3/16	18.0
1014A	1 1/4	14	18	2 25/32	18.3
1212A	1 1/2	12	16	2 3/4	18.3
1411A	1 3/4	11	14	2 5/8	18.0
1609A	2	9	14	3	18.1
2007A	2 1/2	7	12	3 1/4	18.6
2406A	3	6	10	3 5/16	18.7

vari-pitch pi dux®

Cat. No.	Dia	TPI	Wire Size	Length of Coil	L uh.
820D10	1	20 & 10	18	3 1/4	18.0
1212D6	1 1/2	12 & 6	14	3 13/16	18.6
1608D6	2	8 & 6	12	4 1/8	18.1
2008D5	2 1/2	8 & 5	12	3 3/4	18.2
2408D4	3	8 & 4	10	3 3/4	18.6

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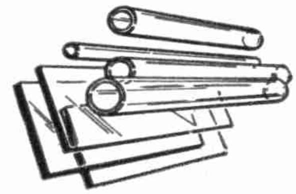
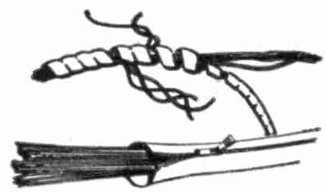


Also HARNESSING and CABLING materials:



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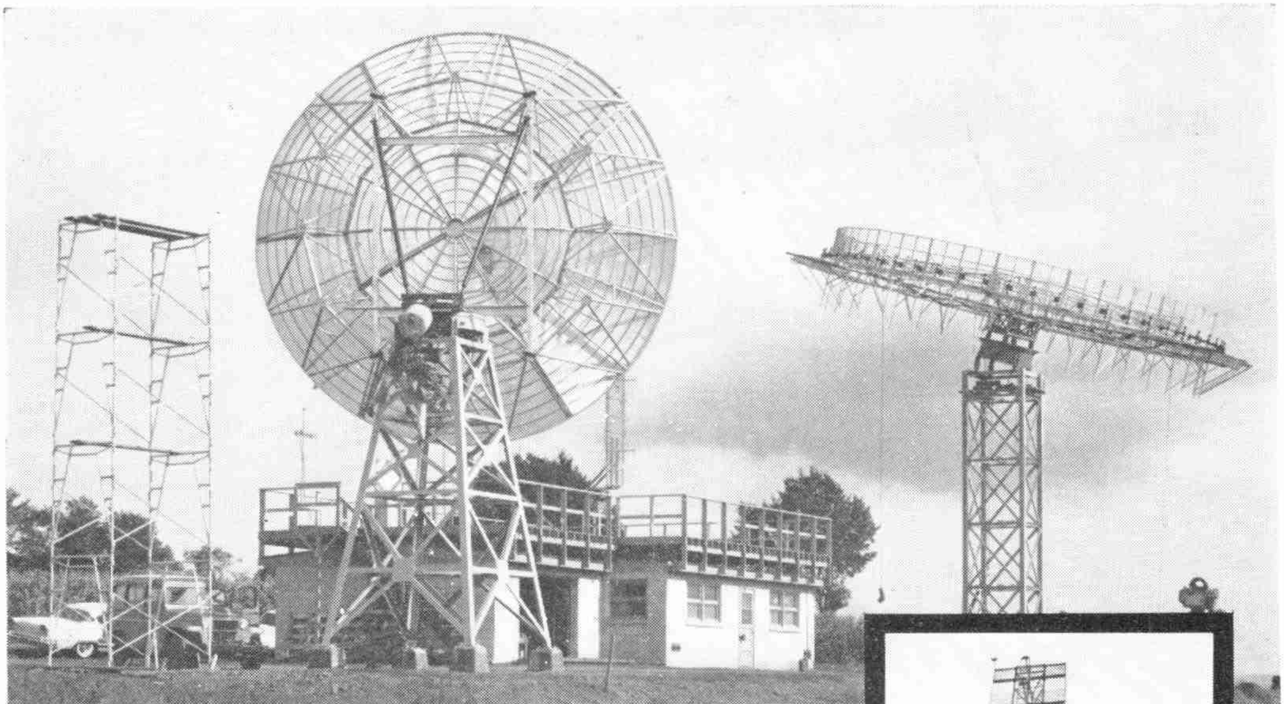

Test Site where TACO antennas are developed and 'performance tested.'

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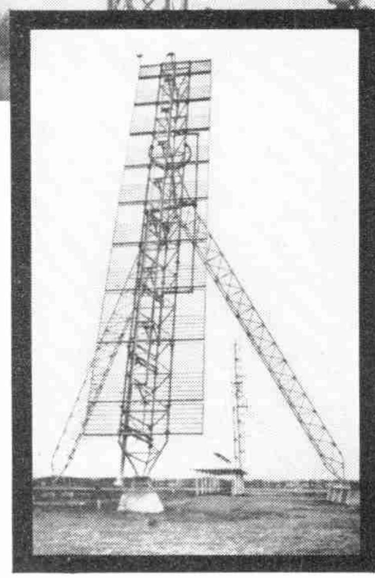
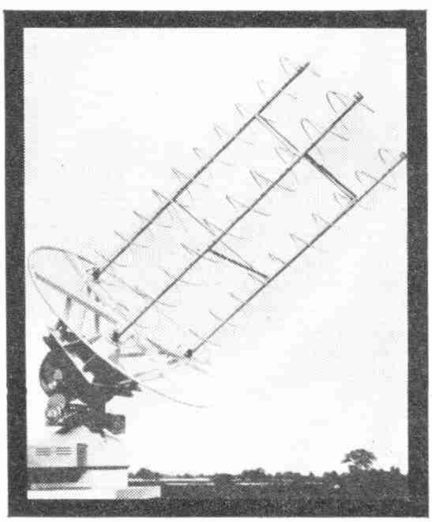
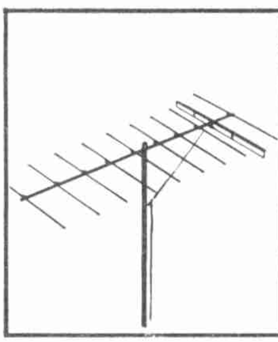


The Doploc antenna system for tracking orbital bodies. Designed, produced and installed by TACO.



TACO telemetering antennas for all commercial and military needs.



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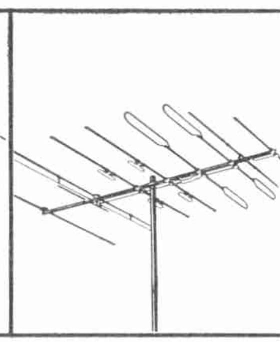

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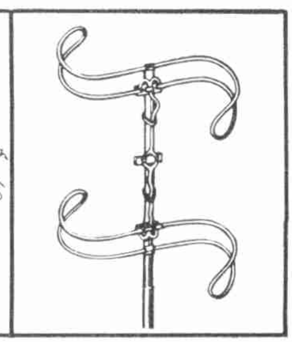

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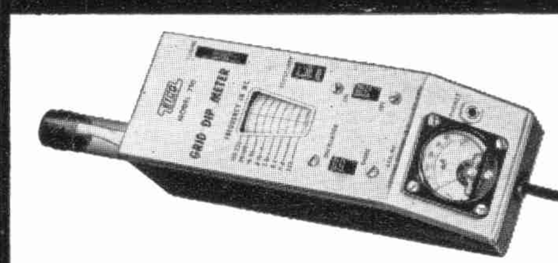

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★ BUILT-IN RELIABILITY...Preproduction Models field tested in 5 states and 3 foreign countries before starting production.

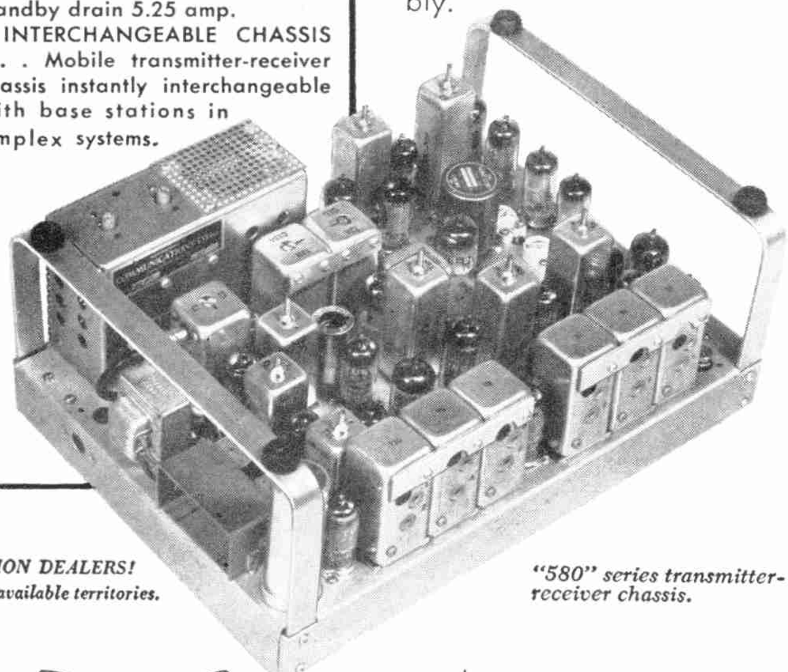
★ SMALL AND LIGHT WEIGHT...Chassis in case 13"x9⁵⁄₁₆"x5½". Control-power Supply-Speaker case 5"x5"x3³⁄₁₆". Complete Mobile installations 24 lbs.

★ EASY TO INSTALL . . . "Two-unit" package so small most installations are under dash.

★ LOW COST . . . Complete mobile package **$398** f.o.b. factory

★ EFFICIENT . . . Transistor power supply gives high efficiency. Total standby drain 5.25 amp.

★ INTERCHANGEABLE CHASSIS . . . Mobile transmitter-receiver chassis instantly interchangeable with base stations in simplex systems.



"580" series transmitter-receiver chassis.

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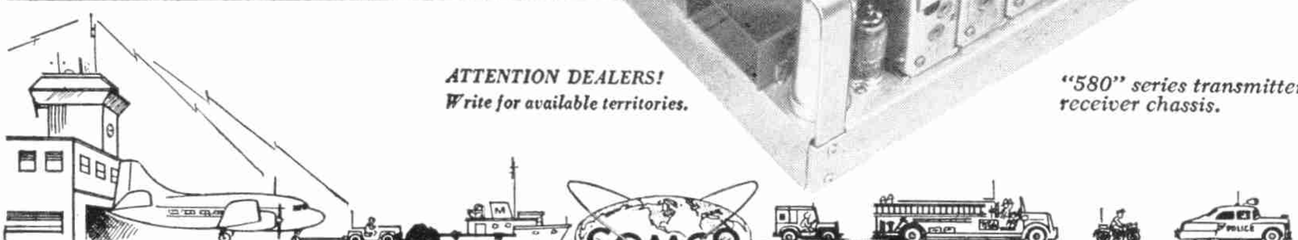

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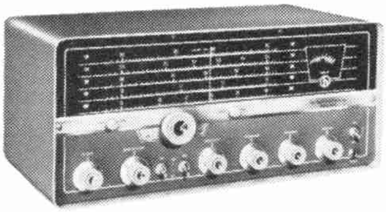
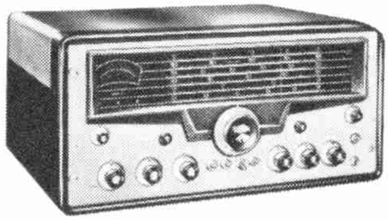


SX-111 NEW LOW COST RECEIVER—Dual conversion. CW, AM, SSB reception. Complete coverage of 80, 40, 20, 15 and 10 meters in 5 separate bands plus 6th band tunable to 10 Mc for WWV. Upper/lower sideband selection. Sensitivity: 1 microvolt on all bands. 5 steps of selectivity, 500 to 5000 cycles. Famous Tee-Notch filter. Calibrated S-meter, series noise limiter. Built-in crystal calibrator.
98F066. NET............. 249.50



SX-101A-MARK III—7 Band Receiver 160-10 meters. Slide rule dial with 40:1 tuning knob ratio. Full gear drive. Built-in 100 kc. crystal calibrator. Precision temperature compensation plus heat cycling for lowest drift, second conversion oscillators crystal controlled. Sensitivity —one uv or less. Dual conversion, upper-lower side band selection . . . Selectivity 5 kc to 500 cycles at 6 db down. Tee-notch filter.
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SX-100 — 4 Band Receiver — dual conversion, with 538-1580 kc and 1.7-34 mc coverage. "Upper-lower" SSB selection, plus notch filter reject unwanted heterodynes. Selectivity variable in 5 steps: 5 kc to 500 cycles. Built-in 100 kc. crystal calibrator. Sensitivity less than 1 uv on all bands. Trimmer compensates for various impedance antennas. 18½" W, 9" H, 11" D. Less speaker. 42 lbs.
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HT-37 — New SSB and AM TRANSMITTER VFO with double reduction disc drive, fixed T.C. Sideband Suppression 40db. 70-100 watts P.E.P. output CW or SSB. 17-25 watts carrier on AM phone. Two 6146's in the final. 3rd and 5th order distortion products down 30 db. Carrier suppression: 40 db. or better. CAL System: Instant CW CAL signal from any transmission mode. Convection cooling. Size: 9½" H, 18¼" W, 16¾" D.
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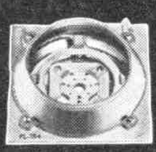
PL-184 Complete Socket for PL-172

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PL-175*	5.0	14.5	400	4,000	350	800	50.00
PL-177A*	6.0	3.3	75	2,000	175	600	25.00
PL-6549	6.0	3.3	75	2,000	175	600	25.00
PL-4E27A	5.0	7.5	125	4,000	200	750	40.00
TETRODES							
PL-4D21 (4-125A)	5.0	6.5	125	3,000	225	600	36.00
PL-4D21A	5.0	6.5	175	3,000	225	600	37.50
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PL-4-400A	5.0	14.5	400	4,000	350	800	48.00
TRIODES *(Grounded-Grid Types)*							
PL-6569	5.0	14.5	250	4,000	300	μ=45	37.50
PL-6580	5.0	14.5	400	4,000	350	μ=45	45.00
HIGH-VOLTAGE RECTIFIER							
PL-250R	5.0	10.5	...	60,000**	250	...	30.50
HYDROGEN THYRATRONS *(Low-Jitter Types)*							
PL-5C22/HT415	6.3	10.5	...	16,000	325 amp	...	36.00
PL-161	6.3	10.5	...	16,000	325 amp	...	48.00
PL-165A	6.3	7.8	...	12,000	225 amp	...	48.00
PL-174/6587	6.3	10.5	...	16,000	325 amp	...	48.00

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▲ A True Table-top Station with NO Sacrifice of Performance

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UNWANTED SIDEBAND: 42 db down
DISTORTION (SSB): Third order products approx. 32 db down
FREQUENCY STABILITY: Drift less than 100 cycles.
CALIBRATION: Built-in 100 kc marker
AUDIO CHARACTERISTICS: 200-3100 cps
MIKE INPUT: High impedance
VOX: Built-in
LEVEL: Automatic level control
METERING: Screen, plate, and grid current, plus RF output
RF OUTPUT: 52 ohms
VFO's: Dual VFO's permit transmitting on the receive or any other frequency
CONTROLS: Vox, Qt, ALC, Grid Tuning, Plate Tuning, Antenna Loading, Audio Gain, Band Switch, Meter Switch

RECEIVER

SENSITIVITY: 1 microvolt for 6 db S/N
SELECTIVITY: 3.1 kc mechanical filter plus a T-notch filter
STABILITY: Drift less than 100 cycles from a cold start at room ambient
TUNING KNOBS: Coarse gear ratio of 20:1, fine gear ratio of 100:1 gives a 1 kc dial reading per division
CALIBRATION: Built-in 100 kc marker
IMAGE AND IF REJECTION: Better than 50 db
AUDIO DETECTOR: Balanced detector for SSB and CW, diode detector for AM
MODE SWITCH: Selects up or low SSB, or up low AM, or CW
DUAL RECEPTION: Two VFO's permit reception of any two frequencies on one band with the flick of a switch
BFO: Crystal controlled
METERING: S-meter
CONTROLS: T-notch filter, audio gain, RF gain, antenna trimming, tune selector, phone jack, tune A and B

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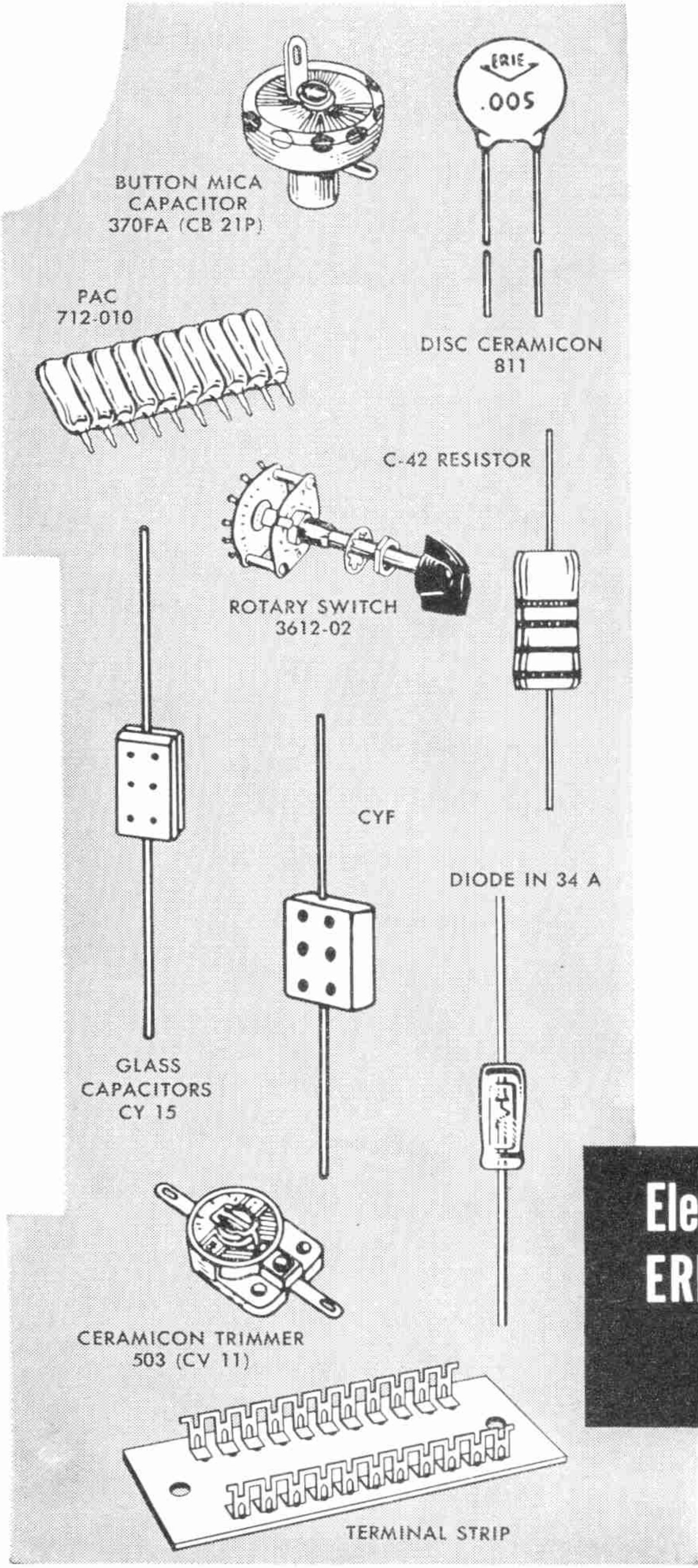

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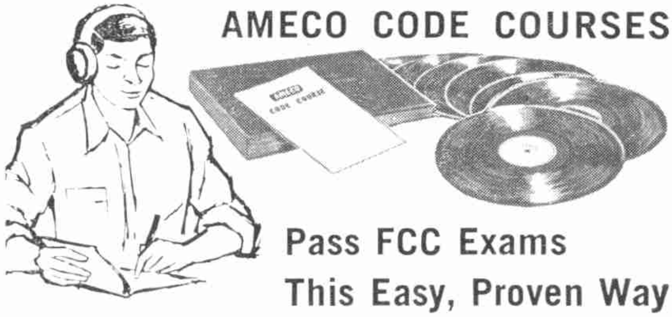

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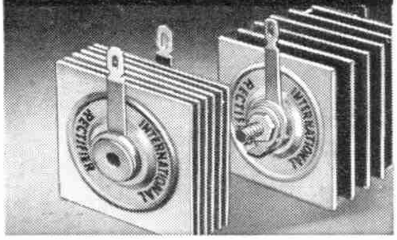

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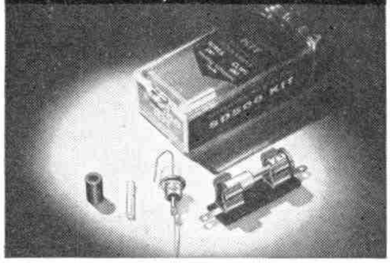

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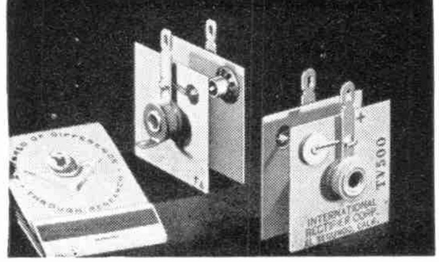

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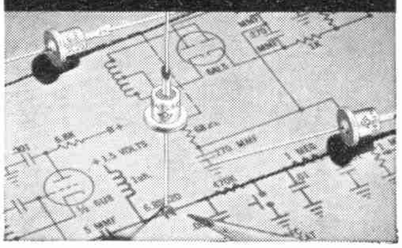

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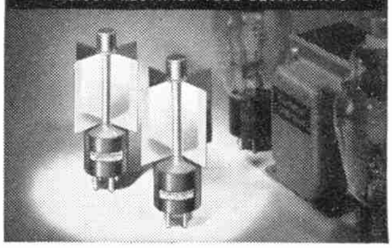

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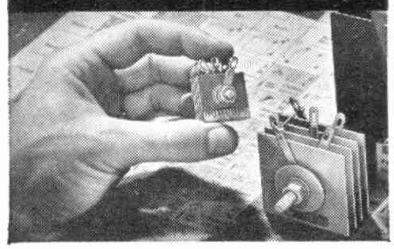

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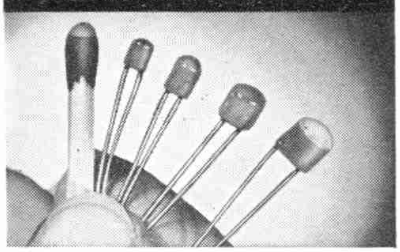

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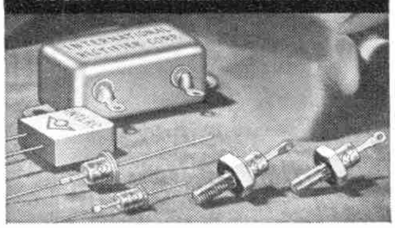

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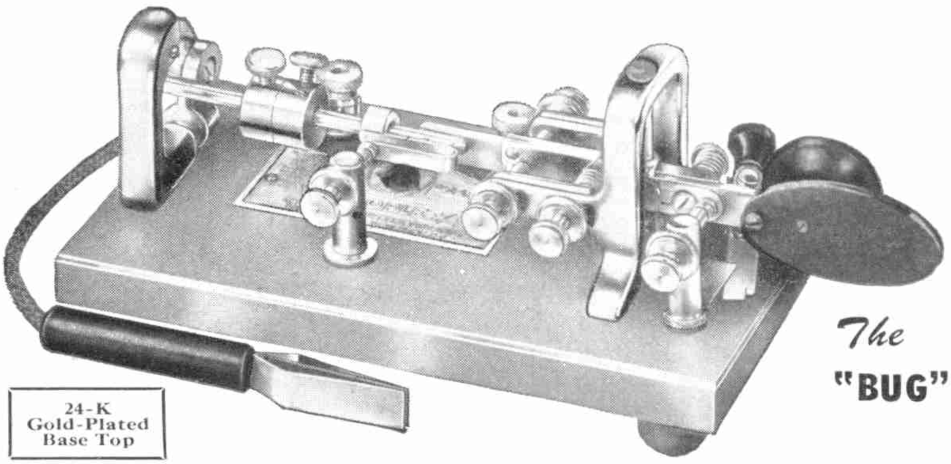

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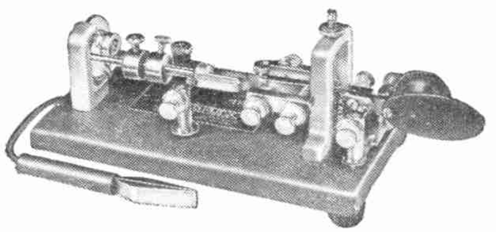

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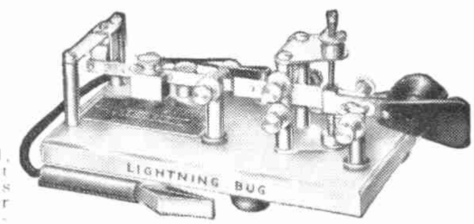

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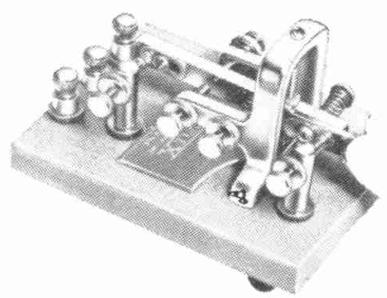

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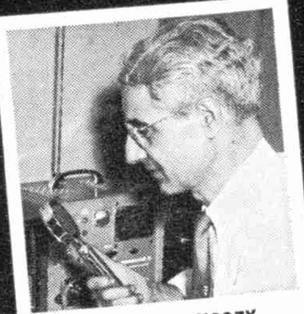

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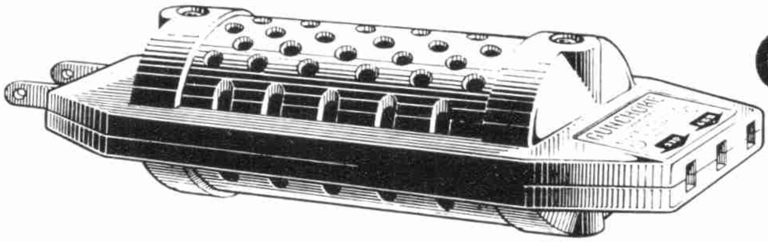

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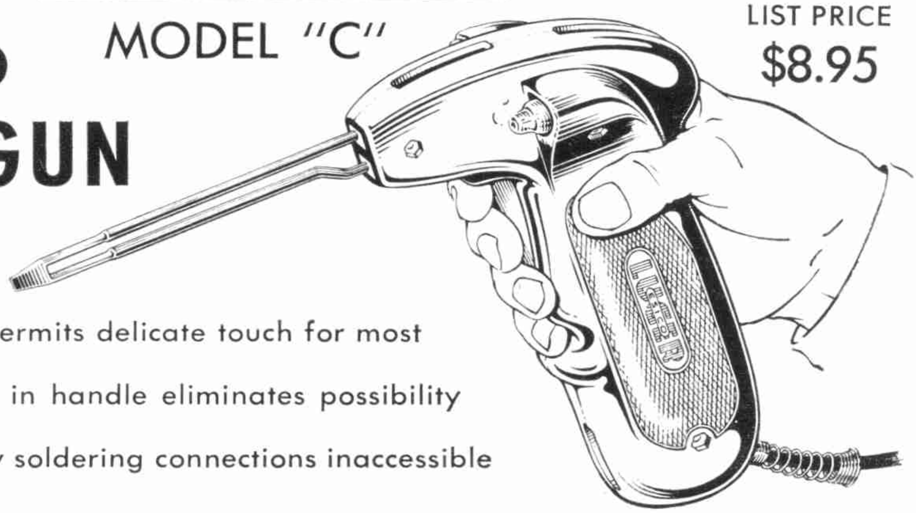

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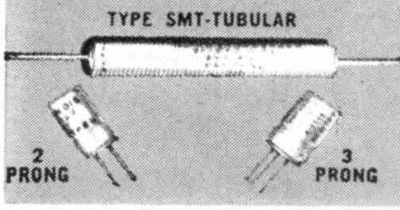

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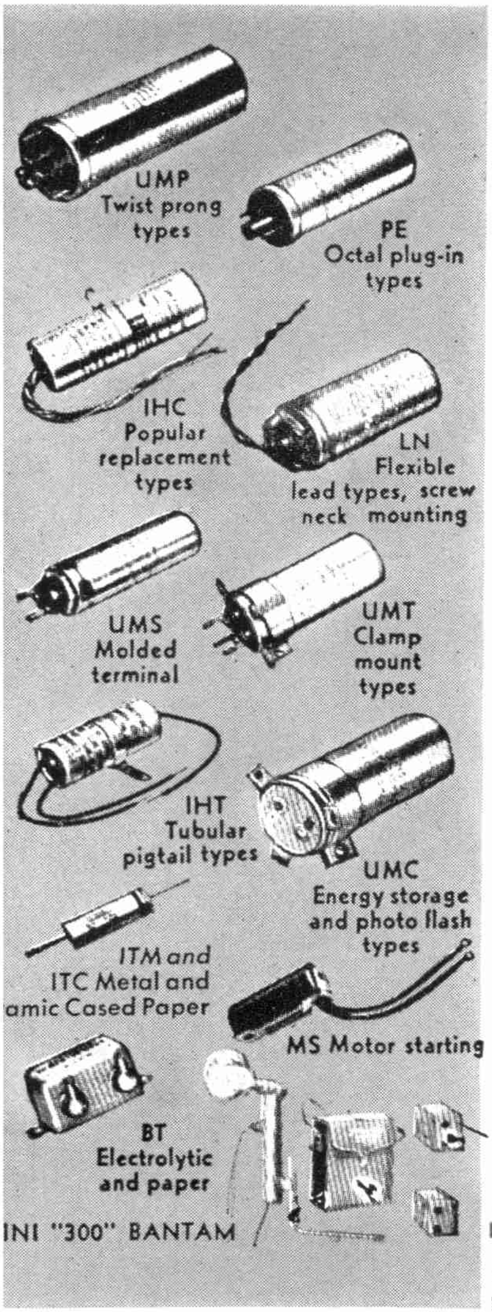

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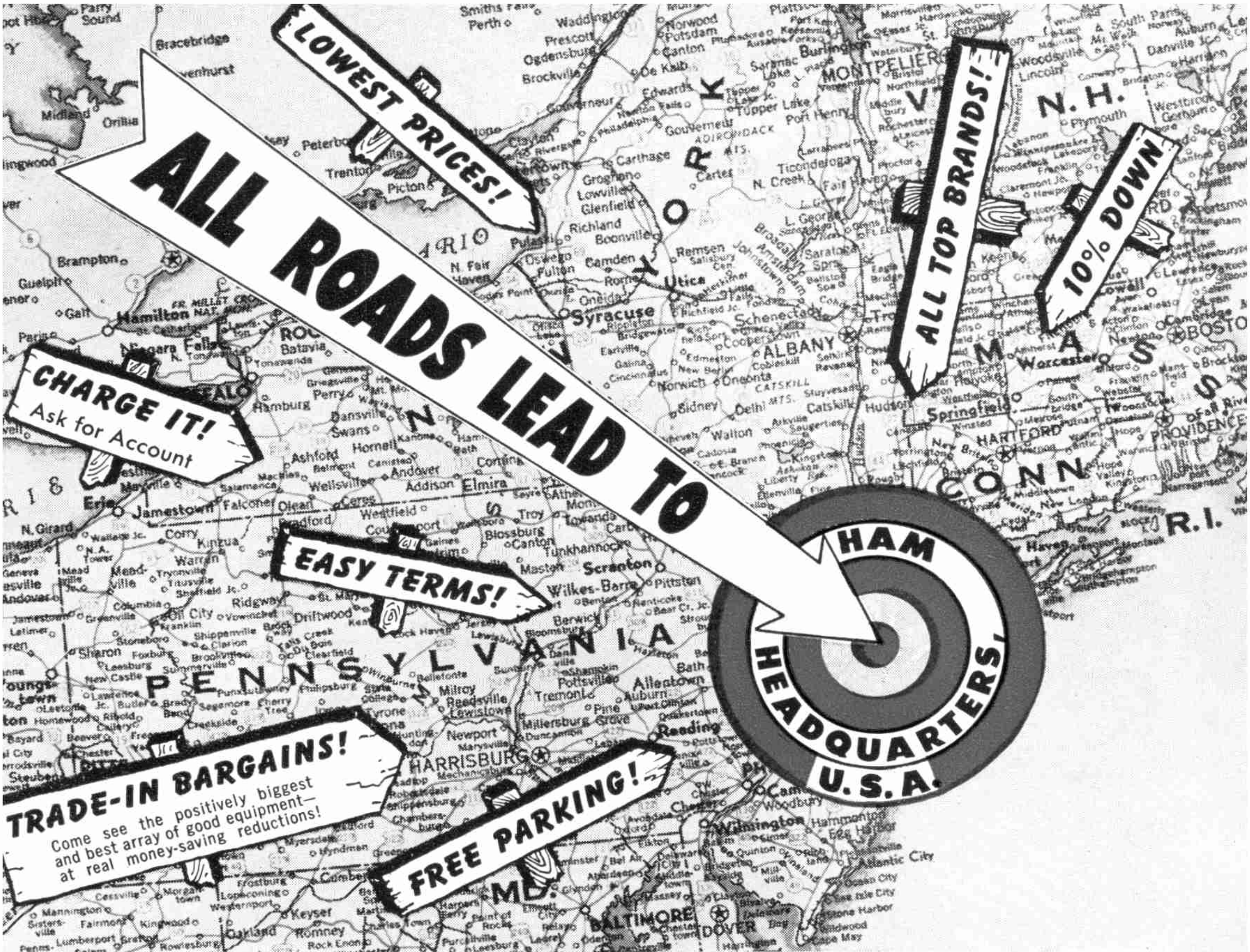

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