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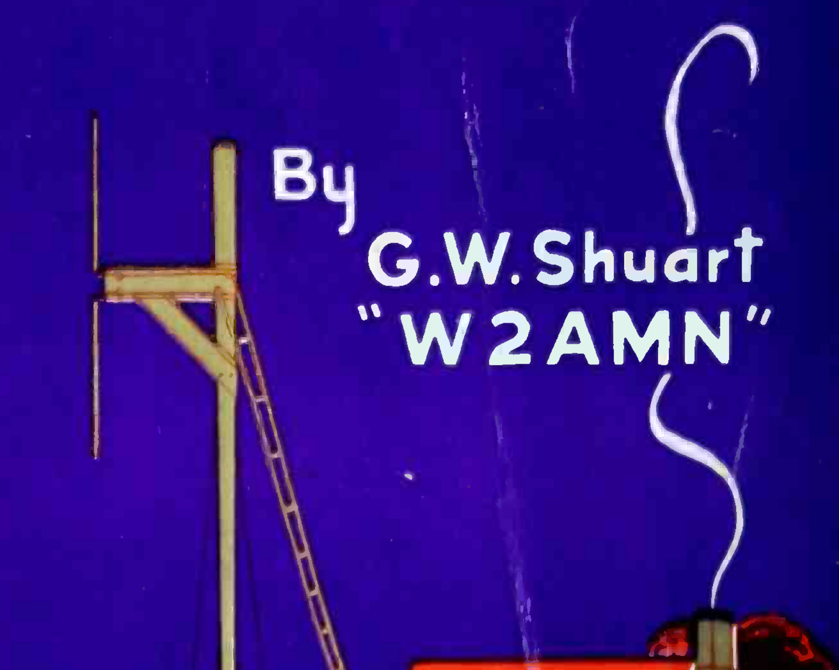
RADIO AMATEUR COURSE

By
G. W. Shuart
"W2AMN"



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If this were to take place in a period of one second it would be said to have a frequency of two cycles. Hence, the term 60 cycle A.C. which is commonly used for des-

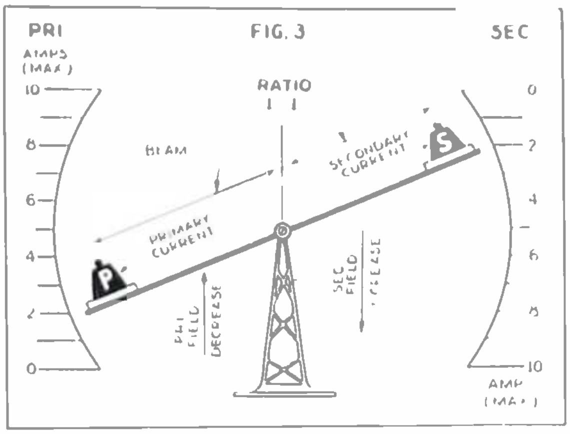


Fig. 3. Mechanical analogy of the action taking place in an A.C. transformer. As the secondary current represented by the weight "S" increases the primary current also increases.

ignating the type of electricity used in home service, means 60 complete cycles or 120 alternations per second. The frequency of alternating current is the number of times a complete cycle takes place in a period of one second.

To obtain a clear picture of the operation previously described let us refer to Fig. 1-B, which shows the hydraulic analogy. We have a cylinder pump with a complete loop through which a liquid can be pushed. The piston of this pump is driven by a motor or else by hand. If the drive wheel "A" is turned to the left the piston moves to the left, forcing the liquid through the tube "L," in one direction and causing the indicator at the top of the loop to indicate that pressure is being exerted upon it. When the piston is to the extreme left and the motor-driven disc has rotated through 180 degrees, the flow stops, allowing the indicator hand to return to zero, due to the two centering springs which are attached to it. This indicates half a cycle.

Then, as the motor is rotated through the remaining 180 degrees, the opposite of the previously mentioned action takes place, causing the vane or indicator to register a maximum in the opposite direction, and then return to zero after the half of the cycle is completed.

Associated with alternating current we also have voltage or pressure, termed E.M.F. or electromotive force. This voltage is alternating in the same manner as the current and at the same frequency.

The chief value of alternating current lies in the fact that it can be transmitted over long distances at high voltages and low currents, permitting the use of small wire and greater saving in cost and at intervals stepped down to lower voltages with high currents through the medium of the *transformer*. The action of the transformer, briefly explained, is to step the imposed voltage up or down depending upon what the case may require.

If we connect a coil of wire such as shown in Fig. 2A, preferably one that has an iron core, to a 110-volt 60-cycle A.C. source, or any A.C. generator for that matter, we find that the continuously alternating current flow through the coil induces a magnetic field (radiated lines of force) about the coil, see Fig. 2A. This field builds up and collapses twice for every cycle of the imposed alternating current.

Now, if we were to place another coil in close proximity to this coil and one of similar design, we would find that the fluctuating magnetic field in the one coil would induce an E.M.F. or voltage in the added coil; this is known as induction. The entire theory of a transformer is based upon this fact and operates on a plan or principle of mutual induction.

If the two coils shown in Fig. 2B have the same number of turns and we impose a potential of 110 volts upon the primary, then theoretically we will have 110 volts across the two terminals of the secondary. No current will flow in this secondary until it is either short-circuited wholly or in part, either by connecting the two terminals together or by inserting between the two terminals a resistor. The current which will then flow depends upon the resistance of the short circuit.

This resistor is known as the *load* circuit. If the load circuit is purely resistive, that is noninductive and non-capacitive, Ohm's Law can be applied in the same manner as when solving direct current problems. If no load is connected across the secondary terminals of the transformer, the only current which will be flowing in the primary will be that amount which is necessary to energize the primary circuit and is usually termed the *magnetization current*. But, just as soon as we impose a load upon the secondary and cause a current to flow in this circuit, which incidentally flows in a direction *opposite* to the current flow in the primary, we have an increase in the primary current.

In order to obtain a clearer picture of just what happens in the primary and secondary of a transformer we offer the mechanical analogy shown in Fig. 3. The two outer scales marked from 0 to 10 in steps of two units, represent the amount of current in either primary or secondary that would be shown on an ammeter.

The horizontal or tilting beam represents the fields of the primary and secondary moving in the opposite direction. The ratio of the transformer is 1:1. The field of any coil is analogous to the current flowing through it.

Weight "S" represents the secondary current: weight "P" represents the primary current. As weight "S" moves down the scale it increases the field or lines of force of the secondary which, because they are analogous to the current therein, are in opposition to the field already in the core and tend to decrease it, thus raising weight "P," which is the primary current, upward until the platform becomes horizontal, indicating the same amount of primary current as secondary current.

When the weight "S" is opposite one zero mark, weight "P" in this analogy, will also be opposite the other zero mark. However, as previously mentioned, there is always a slight amount of current flowing in the primary circuit in order that it may be energized.

Always remember that the current in the primary and secondary of the transformer are opposite and that the fields are also opposite.

In all cases, though, it is important to remember that the frequency of the alternating current in the secondary is absolutely the same as the frequency in the primary circuit.

So far as we have considered the two coils, the primary and secondary windings are identical and therefore the voltage in the secondary circuit will be the same as the voltage impressed upon the primary. However, if the number of turns in the secondary coil is one half the number of turns in the primary coil, the voltage will also be one half of the primary voltage. As an example: in transformer design, if we have a primary consisting of 550 turns and we impose a potential of 110 volts upon it, we find by dividing the number of turns by the imposed voltage we have five turns per volt.

In designing the secondary then all we have to remember is that for every volt required in the secondary circuit we should have five turns. Space and time do not permit the complete technical discussion of transformer design and we suggest that the readers refer to some of the excellent books which have been published covering this subject."

If one would like to obtain a visual picture of the field and action of alternating current when applied to a solenoid a simple experiment can be made by constructing the apparatus shown in Fig. 2C. This consists of a coil having an iron core and beside this core a thin piece of steel is mounted. By fastening a piece of pencil lead to this piece of steel and placing under it a piece of paper, so that the lead comes in contact with the paper as it is moved along, the electrical action can be transferred to the paper by applying 110-volts 60-cycle A.C. to the coil, when the thin strip of steel will vibrate back and forth rapidly.

Now as we pull the paper forward at the rate of 1 foot per second we will have approximately 60 complete cycles drawn on the paper, very much similar to these shown in Fig. 1A.

A hydraulic analogy of the action of a transformer is illustrated in Fig. 2D, in the form of a hydraulic jack. We have a small pump to the left, which pumps liquid into a large cylinder, forcing the piston of this cylinder upward.

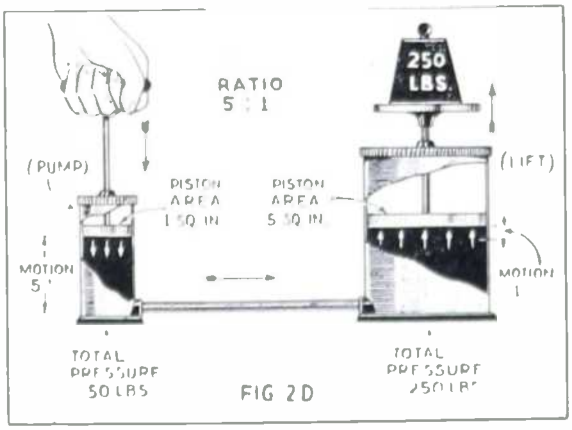
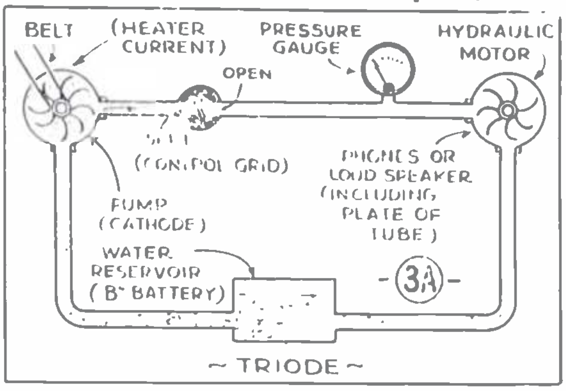


Fig. 2D above shows a very interesting analogy for the A.C. transformer, in which the voltage applied to the primary may be changed to a higher or lower voltage in the secondary. In the hydraulic press shown above, a pressure of 50 pounds exerted by the small downward moving piston at the left, is eventually transformed into an increased pressure of 250 pounds in the large cylinder at the right.

material, and charge it positively, we can draw or attract the electrons to it.

In Fig. 3 we show the action which takes place in a tube having a cathode and a plate or *anode*, as the plate is technically termed. By connecting a battery between the anode and cathode with the positive terminals of the battery connected to the *plate*, we at-



Simple hydraulic analogy to illustrate how the grid in an electron tube acts like a valve to regulate or control the amount of current (water) passing between the plate (motor) and the cathode (pump). The water reservoir in the analog diagram corresponds to the "B" battery or power supply unit in a radio circuit.

tract electrons to this plate or anode. Current will then flow between cathode and anode, remembering always that the current flow is analogous to the electron flow.

If we insert a meter in series with the circuit we will find that it will show the amount of current flowing in the circuit. This tube, as shown in Fig. 3, is known as the *diode* or one having *two elements.* If we remove the battery from the circuit and connect the negative side of the battery to the plate and the positive side to the cathode, no current will flow, because the negatively charged plate will reject the electrons.

Effect of A.C. on Tube

So far, we have considered a constant polarity of voltage applied between the cathode and anode. Now, if we were to apply an alternating voltage between these two elements (see explanations of alternating current electricity), the plate will be alternately charged *positive* and *negative*, which means that current will only flow through the circuit during the period when a positive voltage is applied to the anode. When the anode side of the circuit becomes negative, *current does not flow.* In Fig. 4 we illustrate what is termed *rectification.*

The input circuit is indicated as alternating current while the output circuit shows current flowing in only *one direction* during half of the time of the input cycle. We have flowing in the output circuit then, an interrupted direct current or what would otherwise be termed *half-wave* rectification. All tubes of the diode type are therefore termed half-wave rectifiers. The 81 is an example of this type of tube.

By using two anodes we can obtain *full-wave* rectification. This is shown in Fig. 4A. A rectifier of this type is termed a full-wave rectifier and an example is the 80 tube .

Returning to Fig. 3 we can readily understand that as we change the degree of positive potential (voltage) applied to the plate, we will change the volume of electrons which are attracted to it. A low potential of electrons will attract a small amount of electrons, while a high potential or high voltage will attract a greater number of electrons. An important point to bear in mind is that a negative potential repels electrons, while a positive potential attracts them. (Unlike charges attract and vice versa.)

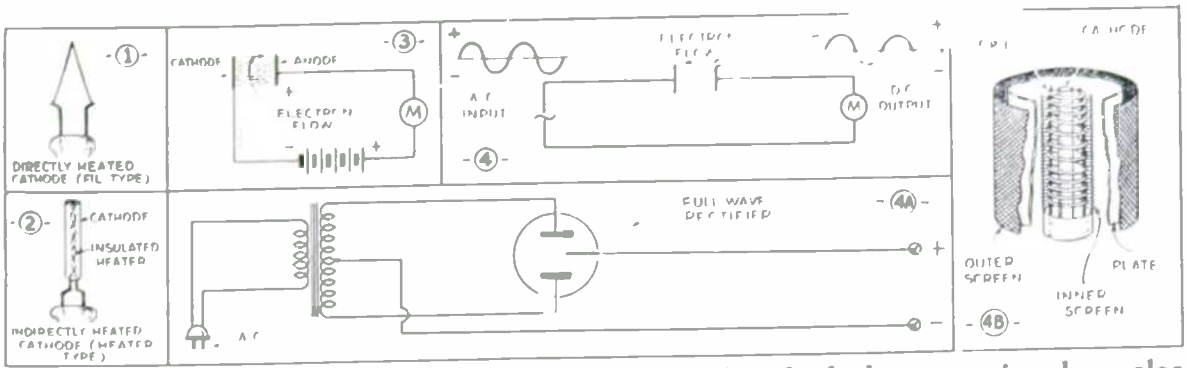
How the "Grid" Works

To have a better control over the amount of current flow in the plate circuit of the vacuum tube, we may insert a third element known as the *grid*. Tubes having three elements are termed *triodes* the prefix "tri" meaning three. This grid consists of a form of screen between the anode and cathode through which electrons must pass in order to reach the plate.

This grid being located nearer to the cathode or source of electrons, will have a greater effect upon the electron stream when it is charged either positively or negatively. In Fig. 5, we have the same circuit as in Fig. 3, excepting for the addition of the grid. Because of the great effect this grid has upon the electron flow, it is called the *control grid.*

We may now apply either a positive or a negative potential to this grid and obtain a change in plate current or a change in the number of electrons reaching the plate, because if the grid is charged negatively, it will tend to repel or retard the flow of electrons between the cathode and the plate. This grid can be made so negative (biased) that it will entirely cut off the flow of electrons, reducing the plate current to zero.

As the grid becomes more *positively* charged. an *increase* in the flow of electrons to the plate will take place. That is, providing the potential (voltage) of the grid is not



Diagrams above—Figs. 1 to 4A, show filament and cathode heater units; how electrons flow from cathode to anode (3); rectification of A. C. passing through an electron tube (4); hook-up of full-wave rectifier tube (4A); detail of tube element; 4B).

as great as that of the plate. As this grid becomes entirely positive, relative to the cathode, it will then collect a certain amount of electrons from the stream and return them to the cathode, causing current to flow in the grid circuit.

In receiving circuits the output of the vacuum tube depends upon the plate current change, that is, the increase and decrease in amplitude or, more simply stated, the magnitude of the change. So, we can readily see that by using this control grid, which is located close to the filament, we can effect great changes in the current flowing in the plate circuit of the vacuum tube with relatively small changes in the potential of the grid and thus obtain considerable amplification in radio circuits.

In Fig. 5a, we show what happens when A.C. is applied to the input circuit of a triode, biased (bias usually means applying a fixed negative or positive charge, independent of the signal voltage, to the grid of the tube) so that the plate current is of fairly low value, but nowhere near the cut-off point. We show the input signal to the grid as alternating current, where it rises above and falls below the zero mark. As the input signal swings the grid more positive, or better stated—less negative—the plate current begins to rise above what is commonly termed the "no-signal" (static) plate current value; that is, the normal value of plate current with no applied signal.

This constitutes one-half of the cycle of the input signals. On the other half of the input-signal cycle, the grid becomes more negative, causing the plate current to fall below its normal no-signal value. (See previous explanation under "How the Grid Works.") Now, in the plate circuit, we have apparently the same wave form as the input signal. The input signal was A.C.; however, A.C. does not flow in the plate circuit of the tube. This fluctuating replica of the input signal is termed the ***alternating component*** of the plate current. ("Plate current" is the current flowing through the circuit from cathode to plate, or anode, when the electron stream is established by heating the filament.)

If we were to connect earphones in series with the plate circuit, we would be able to hear the incoming signal reproduced and

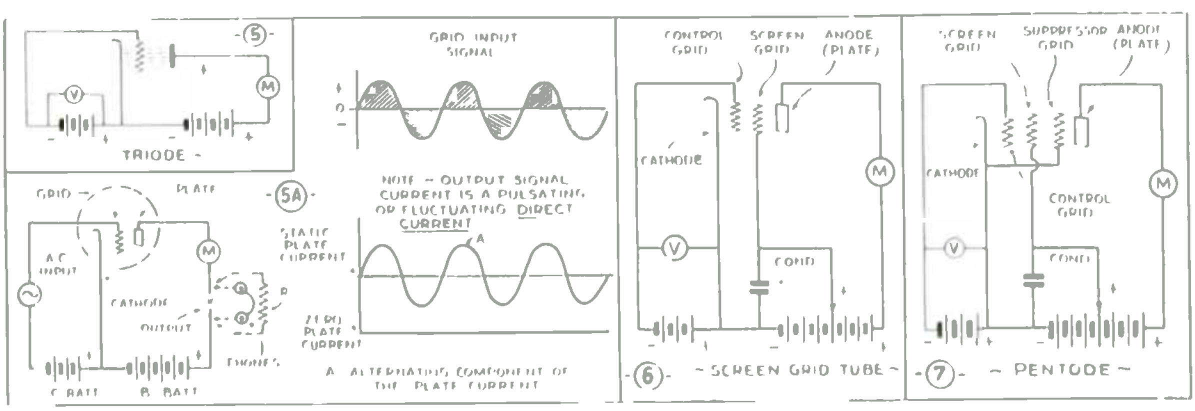
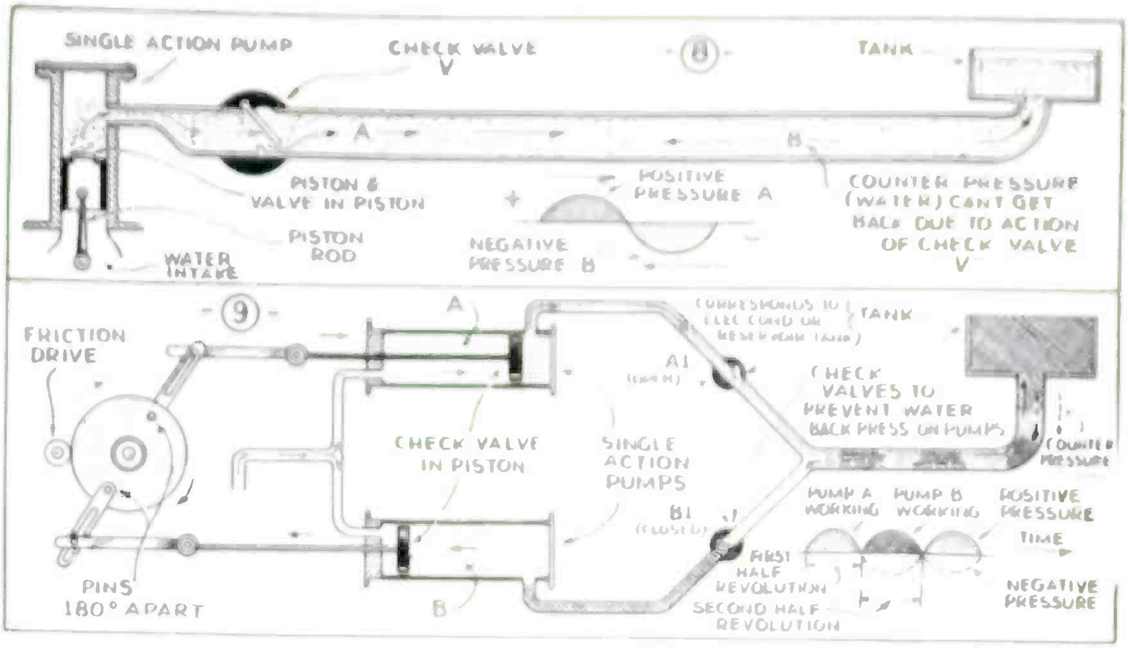


Fig. 5 shows action of triode tube; 5A, how A.C. input is changed into a rectified pulsating direct current by an electron tube; 6, arrangement of the elements in a screen-grid tube; how elements are arranged in a pentode at Fig. 7.



Hydraulic analogs showing action of half-and also full-wave rectifiers, the detector tube in a receiving circuit acting as a rectifier. The first diagram shows how a single-action pump and a check valve permits water to pass through the pipe up into the tank on each half stroke, while any counter water pressure is prevented from passing back into the pump by the check-valve. The second diagram shows how two half-wave rectifiers (pumps), with the aid of two check-valves cause a "full-wave" pressure to be developed in the main water line. When one is not working, the other is.

amplified in the plate circuit, that is if it was of low enough frequency to come within the range of the human ear.

The fluctuating plate current or the alternating component of the plate current would cause the diaphragm of the earphone to vibrate due to the varying current flowing through the phones and the change in the magnetic pull on the diaphragm.

So long as the voltage of the incoming signal does not exceed the value of the bias battery, there will be no grid current flowing through the phones and the change in the magnetic pull on the diaphragm.

So long as the voltage of the incoming signal does not exceed the value of the bias battery, there will be no grid current flowing, because the grid will never go completely positive. On the positive half of the input signal the grid, in reality, becomes just ***less negative***.

If we were to insert a resistor (R) in series with the plate circuit, the fluctuating current flowing through the resistor would cause a voltage drop across the resistor, varying directly with the plate current. The ratio of this ***varying*** voltage drop to the input signal voltage, is known as the ***gain*** of the tube or the ***voltage amplification***.

Tubes Have Capacity Between Elements

In all types of vacuum tubes, we have in reality a number of small condensers in that there is a definite electrical capacity, for instance, between the plate and the grid, between the grid and cathode, and also between the plate and cathode, for the simple reason that each of these elements can be likened to the plates of a small condenser (current absorber). The grid to cathode capacitance is termed the ***input capacitance***. The ***output capacitance*** is the capacity between the plate and cathode. In many very "high-gain" circuits, it is necessary to neutralize the plate to grid capacity in order that energy will not be fed back from the plate circuit to the grid circuit.

The Screen-Grid

This can be accomplished either by external methods of ***neutralizing***, which will be explained later, or by inserting a shield or a screen between the plate of the tube and the grid. This is commonly termed the ***screen-grid*** and tubes having a control grid and a ***screen-grid***, together with the anode and cathode, are termed ***tetrodes***.

This screen-grid is so designed that it will effectively shield the plate from the grid. While the plate to grid capacity of a triode may be as great as 8 mmf., the plate to grid capacitance of a screen-grid tube may be reduced to a value as low as .007 mmf. This screen must be constructed so that it will not materially obstruct the flow of electrons between the cathode and plate;

therefore, it is made in the form of wire mesh.

It also must not be negatively charged because the flow of electrons would also be impeded. Therefore, a positive potential is in most cases applied to the screen-grid in order to accelerate the flow of electrons to the plate. This screen being an electrostatic shield must be by-passed with a condenser to the cathode in order to be *grounded*, in so far as high frequency currents are concerned.

The voltage applied to the screen is usually lower than the plate voltage. The stream of electrons going to the plate being greatly accelerated by the screen-grid, may strike the plate at such a terrific speed that they will dislodge other electrons, which may be attracted to the screen, which is the nearest positively charged element. This is known as *secondary emission* and limits the output capabilities of the tube. This condition can be overcome by inserting between the screen and the plate another element which will not obstruct the flow of electrons to the plate but prevent them from returning to the screen.

In order to accomplish this, the third grid or *suppressor* is usually connected directly to the cathode in order that electrons dislodged from the plate may continue back via the suppressor to the cathode.

In some tubes such as the type 34 and 39 this suppressor is connected directly to the cathode of the tube internally. However, tubes such as types 57 and 58 have a separate pin on the base for this suppressor grid, in order that in special circuits a ***positive*** or a ***negative*** voltage may be applied to it. The values, of course, will be dependent upon the circuit requirements. In large transmitting tubes of the *pentode* type (pentode is a name given to all tubes having 5 elements), this suppressor is positively charged to the order of 30 or 40 volts.*

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*Some excellent books covering the electron theory and the operation of electron tubes are:

"Electrons at Work," by Charles D. Underhill.

"Radio Receiving Tubes," by Moyer & Wostrel. The RCA Tube Manual also contains a wealth of information covering the operation of various types of vacuum tubes.

"Principles of Radio Communication," Prof. John H. Morecroft.

CHAPTER 3 • • •

RESISTANCE, INDUCTANCE and CAPACITY

● RESISTANCE capacity and inductance, in order to understand how a vacuum tube oscillates, how tuned circuits work, and the function of a tuning condenser, it is necessary to become familiar with these three very important subjects.

Resistance

When electrical current flows through a wire or some other conducting medium it encounters resistance or opposition, the same as the flow of material substances. For instance, a certain amount of water, can be forced through a length of one inch pipe with a definite pressure. In other words, the size of the pipe offers resistance to the flow. The larger the pipe becomes, the greater amount of water can be forced through it at a definite pressure, or the larger the pipe becomes, the less its resistance will be.

This holds true in conductance of electricity inasmuch as a fine wire or conductor offers a greater amount of resistance than a heavy conductor. The resistance of a conductor is inversely proportional to its cross sectional area and with some materials, in fact most of them, the resistance also increases as the temperature rises.

In dealing with resistance in electrical circuits, we have what is known as Ohm's Law. In Ohm's Law, we have to consider three things: First, the flow of electricity, which is current; second, the force or pressure, which is voltage; and third, the resistance which the flow of electricity encounters. Three letters are assigned to the above, and they are:

I = Current
E = Voltage (EMF)
R = Resistance

The formulas for finding the resistance, voltage, or current, where either two of the three are known are as follows:

$$E = R \times I$$

When two or more resistors are connected in series the total value of the resistance is the *sum* of all the resistors. In other words, three 5 ohm resistors in series would have a total resistance of 15 ohms.

However, when resistors are connected in parallel the method of calculation is a bit more complicated. For instance, if we have three resistors connected in parallel, one has the resistance of 5 ohms, another of 10 and another of 20. The formula for expressing this is:

$$R = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}}$$

$$R = \frac{1}{.2 + .1 + .05}$$

$$R = \frac{1}{.35} \text{ or } R = 2.857+$$

Capacity

Most of us are familiar with the now well-known condenser which is an instrument capable of storing up a certain amount of electricity and consists of two or more plates placed adjacent to each other, with insulation of either air or some other insulating medium. When a constant direct voltage is applied between the plates of a condenser, current will flow into the condenser, until the condenser becomes

charged to its maximum capacity. The current then ceases to flow and the condenser is charged. Then, after the source of electricity (battery for example) is removed from the circuit, the condenser will hold its charge until, due to its inherent (conductivity of dielectric) resistance, the power is dissipated.

If the insulation is mica or parafined (waxed) paper, the condenser will hold its charge for a considerable length of time. In large condensers of one or two microfarads the charge may remain in the condenser for several hours. This can be proved by short-circuiting the two terminals of the condenser and noting the spark, or an ammeter could be connected across the condenser and it would indicate the current flowing until the condenser was completely discharged and the power dissipated. The unit of capacity is a *farad*; however, in radio work, we use considerably smaller units in our condensers.

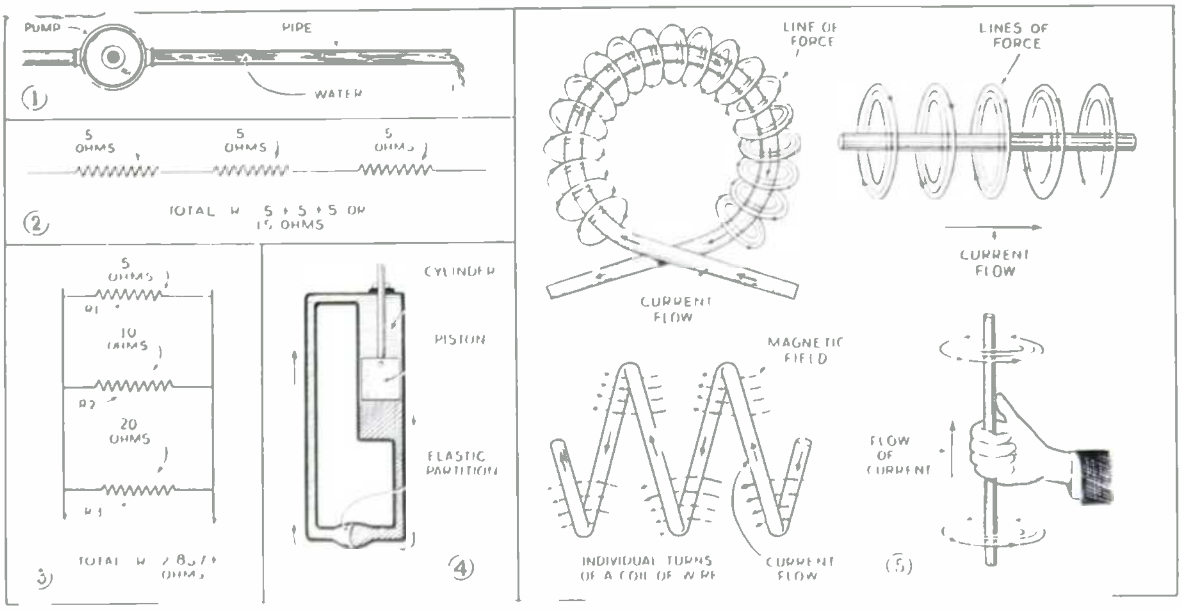
A *microfarad* is one millionth of a farad, and one *micro-micro-farad* is one millionth of a microfarad. The most vital part of a condenser is the dielectric or insulating material because, contrary to popular belief, it is in the dielectric that the charge resides. When a condenser is charged, the dielectric opposes the setting up of an electric displacement of an electric field in the dielectric and the charge is said to be the energy of the charging source stored up as electrostatic energy in the dielectric.

A simple analogy for the action of an electrical condenser is a sponge, which absorbs water when placed in a cupful of it, for example, and afterwards is pressure is exerted on the sponge, then it gives up the water stored in it. It requires 1 coulomb (ampere-second) to charge a condenser of 1 farad to a potential of 1 volt. A condenser having a capacity of 1 mf. (1 mf.=1 millionth of 1 farad) requires a charge of 1 millionth of 1 coulomb to charge it to a potential of 1 volt.

Inductance

The coils used in radio circuits are called *inductances* or *inductors*. In the drawings we see how an electro-magnetic field may be produced around the wire when a current is passed through it. If the flow of current through a conductor is constant (D.C.) a *steady* electro-magnetic field is produced around the conductor. However, when alternating current (abbreviated A.C.) flows through a conductor, the current flow is constantly changing and likewise the field is changing.

When current begins to flow through a wire the circular electro-magnetic field originates at the center of the conductor and travels outwardly away from the center in constantly increasing diameters and of course, extends into the space surrounding



In Fig. 1 we have a diagram showing how the size of a pipe governs the amount that can be forced through it. In Fig. 2 we have resistors connected in series; in Fig. 3 they are connected in parallel; the formulae are given in the text. In Fig. 4 is the hydraulic analogy for the action of a condenser when alternating current is applied to it. Fig. 5 shows the magnetic fields and direction of current flow in straight wires and coils; also the right-hand rule is given, where, if the thumb points in the direction of the current flow, the four fingers will curve around the conductor in the direction of the magnetic field

the wire. Until this field becomes of larger diameter than the wire, it causes a second current to flow in opposition to the main current.

When the current flow through the wire decreases or stops, the circular fields collapse and are then said to cut the wire in ever-diminishing diameters. This induces a current in the opposite direction to the field but in the same direction as the original (exciting) applied current, tending to prolong the flow of the exciting current.

This property of a coil or conductor to act upon itself or another inductor in close proximity to it, is called ***inductance***. The unit of inductance is the henry and in most formulas it is usually designated by the symbol "L." A ***henry*** is the inductance of a circuit in which the induced E.M.F. is one volt, when the (varying) current travels at the rate of one ampere in one second. Usually in radio circuits, inductance values are indicated as one thousandth of a henry or one ***milli-henry;*** a millionth of a henry is known as a ***micro-henry.*** The physical dimensions and form of a circuit, determine the amount of inductance and it is for this reason that our radio circuits consists of coils rather than straight wire, because a greater amount of inductance can be obtained by coiling the wire, also allowing considerably less D.C. resistance because less wire is used. A straight wire, of course, would have less inductance than one of the same length which was coiled.

Induction subdivides into two branches—***self and mutual induction***. If the current passing through a coil, for example, is rising from zero to maximum value, such as when the circuit is closed from a battery, (or the first half of an alternation of an alternating current) the magnetic field around the wire is expanding and while this is taking place there is induced in the conductor a counter-current (and counter e.m.f. or voltage) which tends to buck or oppose the current (and voltage) which is producing the field.

As one of the diagrams shows there is electrical energy stored up in an inductive circuit, just as if you had compressed a spring. The opening of the circuit, and spark at the switch, corresponds to releasing the compressed spring and heaving off the weight.

Another analogy is the flywheel. The inertia of the wheel opposes any force to set it in motion; once in motion, the energy tied up in the wheels tends to keep it going, if any effort is made to stop it.

Let us consider for a moment now the next phase of the action taking place when the circuit is opened or when the ***second half*** of the alternation of an applied A.C. is taking place. Now the magnetic field around the wire or turns of wire comprising the coil is contracting and while this occurs.

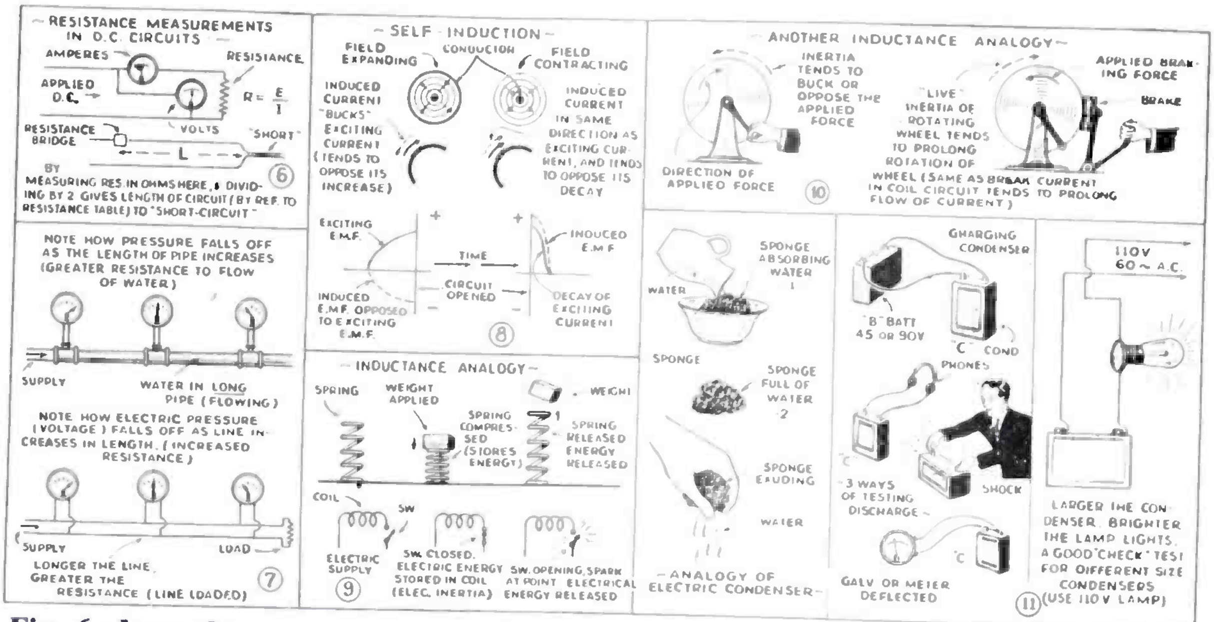


Fig. 6 above shows measurement of resistance. Fig. 7 shows how pressure or voltage decreases with increase in resistance to flow of water or electric current. Fig. 7 shows how pressure or voltage decreases with increase in resistance to flow of water or electric current. Fig. 8 shows action of expanding and contracting magnetic fields. Fig. 9 shows mechanical "spring" analogy for inductance; Fig. 10—Fly wheel analogy of inductance. Fig. 11—Analogies for condenser.

the lines of magnetic force are cutting the wire in the opposite direction and a current of opposite sign is induced in the wire, this current being in the same direction as the applied (exciting) current which is flowing around the wire and creating the magnetic field.

In other words, the self-induced e.m.f. is in the opposite direction, while the field is *expanding* about the wire, and tends to oppose it while the opposite is the case when the field is *contracting* and the current is then in the same direction or aids the inducing current and acts to prevent its decay.

It will be apparent, of course, that while the current is varying in strength or let us say increasing, the field about the coil is expanding, and the lines of magnetic force extending out from the coil composed of a number of turns, will induce a current by induction in a second coil, placed near or adjacent to the first or exciting coil.

If we term the exciting coil No. 1, and the adjacent *unconnected* coil as No. 2, coil 2 is said to have a current induced in it by *electro-magnetic induction*. As the magnetic field in coil No. 1 subsides, the magnetic lines of force surrounding coil No. 2 also subsides. At the same time these lines of force cut across the turns in coil No. 1 and induce therein an e.m.f. or voltage (also a current) and thus we have a third e.m.f. set up by induction.

To begin with, we have the original exciting e.m.f. in coil 1; secondly we find an induced e.m.f. in coil 2; and thirdly, there is *reinduced* e.m.f. in coil 1, due to the reaction of the magnetic field surrounding coil 2, and this effect is what is known as *mutual induction*.

The usual radio tuned circuit consists of a coil and a condenser, namely: ***inductance and capacity***. Coils or inductances have what is known as inductive reactance. When the capacity reactance minus the inductive reactance equals zero, at some certain frequency, the circuit is said to be in ***resonance***.

When the condition known as ***Resonance*** has been established in any given circuit, whether a series or parallel type circuit, then we know that the inductive and capacitive reactance are equal, and that they balance each other. When this condition has been achieved their reactive effect upon the circuit is zero. Under these conditions, or when the circuit has been made resonant, (by the proper adjustment of the capacity and the inductance of the circuit) any current flowing in the circuit due to an applied e.m.f. will be that due simply to the ohmic or direct current resistance in the circuit. Expressed another way, the current passing through such a resonant circuit will be given by the expression: $I=E \div R$.

The difference between the capacitive and inductive reactance of a circuit at some frequency is called the impedance. However, at resonance, this is always zero, and the losses in the circuit are due only to the usual D.C. resistance of the circuit, through which the currents are flowing.

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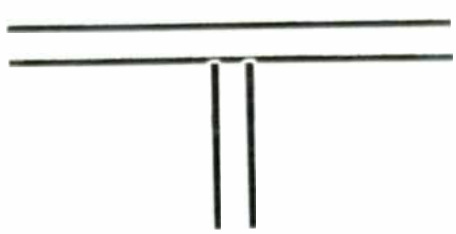

CHAPTER 3 • • •

RESISTANCE, INDUCTANCE and CAPACITY

● RESISTANCE capacity and inductance, in order to understand how a vacuum tube oscillates, how tuned circuits work, and the function of a tuning condenser, it is necessary to become familiar with these three very important subjects.

Resistance

When electrical current flows through a wire or some other conducting medium it encounters resistance or opposition, the same as the flow of material substances. For instance, a certain amount of water, can be forced through a length of one inch pipe with a definite pressure. In other words, the size of the pipe offers resistance to the flow. The larger the pipe becomes, the greater amount of water can be forced through it at a definite pressure, or the larger the pipe becomes, the less its resistance will be.

This holds true in conductance of electricity inasmuch as a fine wire or conductor offers a greater amount of resistance than a heavy conductor. The resistance of a conductor is inversely proportional to its cross sectional area and with some materials, in fact most of them, the resistance also increases as the temperature rises.

In dealing with resistance in electrical circuits, we have what is known as Ohm's Law. In Ohm's Law, we have to consider three things: First, the flow of electricity, which is current; second, the force or pressure, which is voltage; and third, the resistance which the flow of electricity encounters. Three letters are assigned to the above, and they are:

I = Current
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The formulas for finding the resistance, voltage, or current, where either two of the three are known are as follows:

I R X I

When two or more resistors are connected in series the total value of the resistance is the *sum* of all the resistors. In other words, three 5 ohm resistors in series would have a total resistance of 15 ohms.

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charged to its maximum capacity. The current then ceases to flow and the condenser is charged. Then, after the source of electricity (battery for example) is removed from the circuit, the condenser will hold its charge until, due to its inherent (conductivity of dielectric) resistance, the power is dissipated.

If the insulation is mica or parafined (waxed) paper, the condenser will hold its charge for a considerable length of time. In large condensers of one or two microfarads the charge may remain in the condenser for several hours. This can be proved by short-circuiting the two terminals of the condenser and noting the spark, or an ammeter could be connected across the condenser and it would indicate the current flowing until the condenser was completely discharged and the power dissipated. The unit of capacity is a *farad;* however, in radio work, we use considerably smaller units in our condensers.

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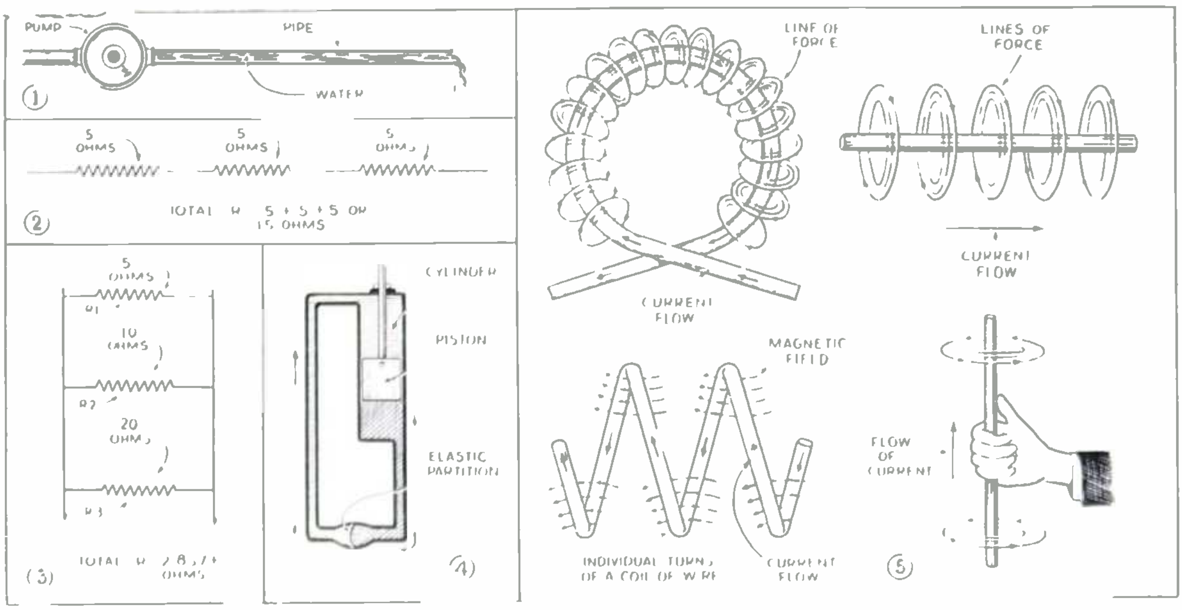

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the wire. Until this field becomes of larger diameter than the wire, it causes a second current to flow in opposition to the main current.

When the current flow through the wire decreases or stops, the circular fields collapse and are then said to cut the wire in ever-diminishing diameters. This induces a current in the opposite direction to the field but in the same direction as the original (exciting) applied current, tending to prolong the flow of the exciting current.

This property of a coil or conductor to act upon itself or another inductor in close proximity to it, is called *inductance*. The unit of inductance is the henry and in most formulas it is usually designated by the symbol "L." A *henry* is the inductance of a circuit in which the induced E.M.F. is one volt, when the (varying) current travels at the rate of one ampere in one second. Usually in radio circuits, inductance values are indicated as one thousandth of a henry or one *milli-henry;* a millionth of a henry is known as a *micro-henry*. The physical dimensions and form of a circuit, determine the amount of inductance and it is for this reason that our radio circuits consists of coils rather than straight wire, because a greater amount of inductance can be obtained by coiling the wire, also allowing considerably less D.C. resistance because less wire is used. A straight wire, of course, would have less inductance than one of the same length which was coiled.

Induction subdivides into two branches—*self and mutual induction*. If the current passing through a coil, for example, is rising from zero to maximum value, such as when the circuit is closed from a battery, (or the first half of an alternation of an alternating current) the magnetic field around the wire is expanding and while this is taking place there is induced in the conductor a counter-current (and counter e.m.f. or voltage) which tends to buck or oppose the current (and voltage) which is producing the field.

As one of the diagrams shows there is electrical energy stored up in an inductive circuit, just as if you had compressed a spring. The opening of the circuit, and spark at the switch, corresponds to releasing the compressed spring and heaving off the weight.

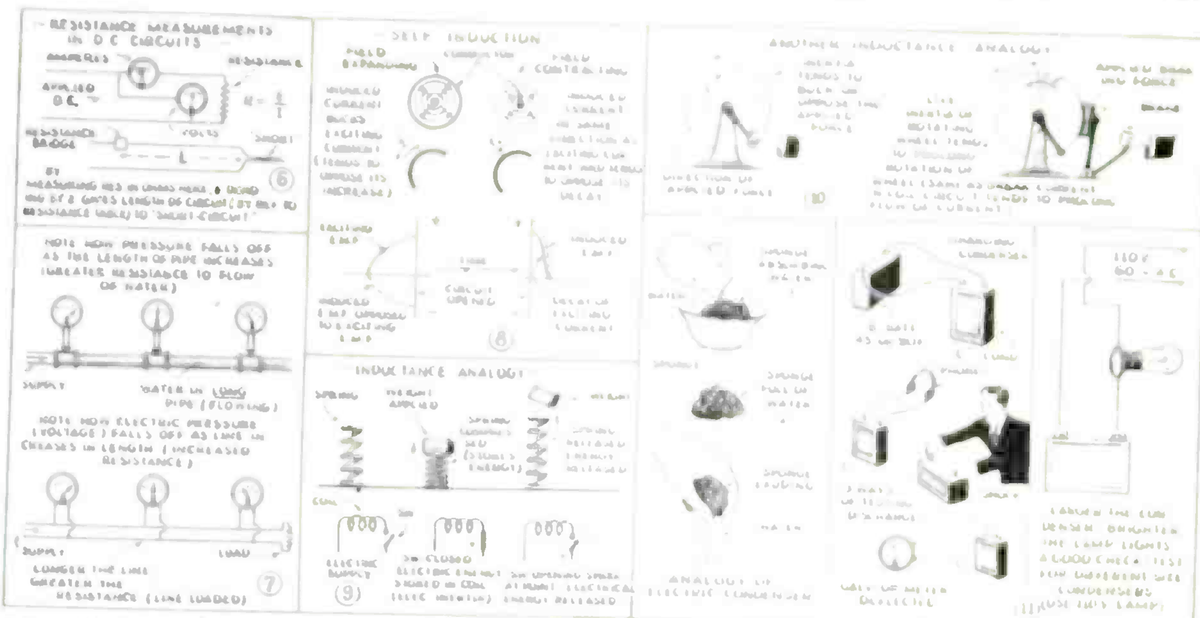

Fig. 6 above shows measurement of resistance. Fig. 7 shows how pressure or voltage decreases with increase in resistance to flow of water or electric current. Fig. 7 shows how pressure or voltage decreases with increase in resistance to flow of water or electric current. Fig. 8 shows action of expanding and contracting magnetic fields. Fig. 9 shows mechanical "spring" analogy for inductance; Fig. 10—Fly wheel analogy of inductance. Fig. 11—Analogies for condenser.

Another analogy is the flywheel. The inertia of the wheel opposes any force to set it in motion; once in motion, the energy tied up in the wheels tends to keep it going, if any effort is made to stop it.

Let us consider for a moment now the next phase of the action taking place when the circuit is opened or when the *second half* of the alternation of an applied A.C. is taking place. Now the magnetic field around the wire or turns of wire comprising the coil is contracting and while this occurs

the lines of magnetic force are cutting the wire in the opposite direction and a current of opposite sign is induced in the wire, this current being in the same direction as the applied (exciting) current which is flowing around the wire and creating the magnetic field.

In other words, the self-induced e.m.f. is in the opposite direction, while the field is ***expanding*** about the wire, and tends to oppose it while the opposite is the case when the field is ***contracting*** and the current is then in the same direction or aids the inducing current and acts to prevent its decay.

It will be apparent, of course, that while the current is varying in strength or let us say increasing, the field about the coil is expanding, and the lines of magnetic force expanding out from the coil composed of a number of turns, will induce a current by ***induction*** in a second coil, placed near or adjacent to the first or exciting coil.

If we term the exciting coil No. 1, and the adjacent ***unconnected*** coil as No. 2, coil 2 is said to have a current induced in it by ***electro-magnetic induction***. As the magnetic field in coil No. 1 subsides, the magnetic lines of force surrounding coil No. 2 also subsides. At the same time these lines of force cut across the turns in coil No. 1 and induce therein an e.m.f. or voltage (also a current) and thus we have a third e.m.f. set up by induction.

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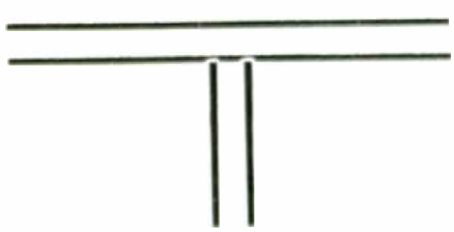

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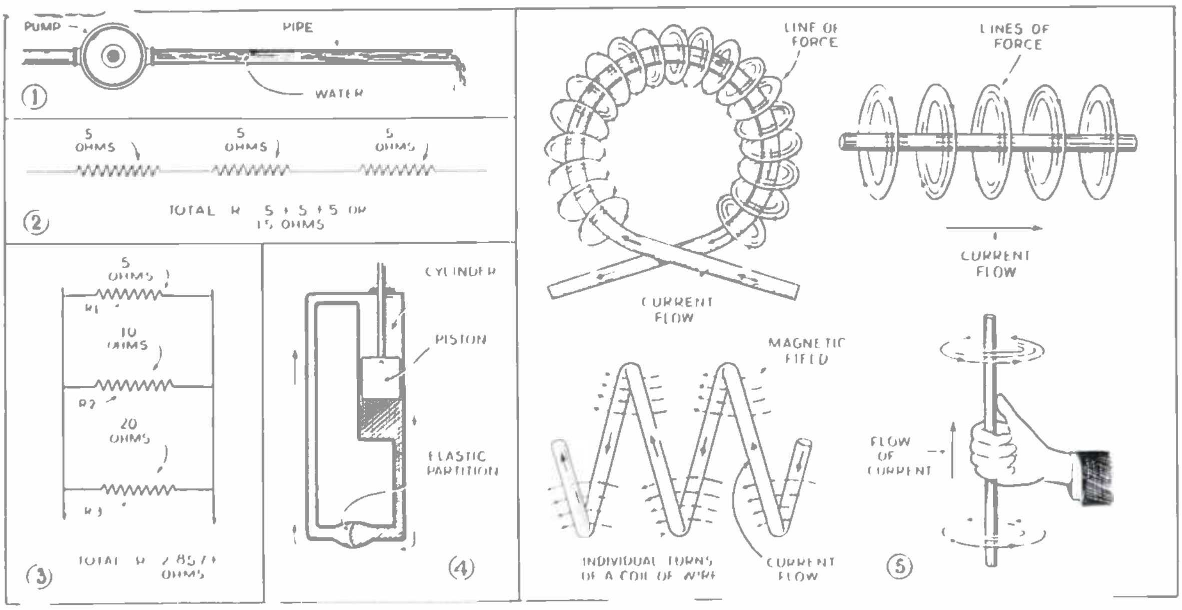

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A simple analogy for the action of an electrical condenser is a sponge, which absorbs water when placed in a cupful of it, for example, and afterwards is pressure is exerted on the sponge, then it gives up the water stored in it. It requires 1 coulomb (ampere-second) to charge a condenser of 1 farad to a potential of 1 volt. A condenser having a capacity of 1 mf. (1 mf.=1 millionth of 1 farad) requires a charge of 1 millionth of 1 coulomb to charge it to a potential of 1 volt.

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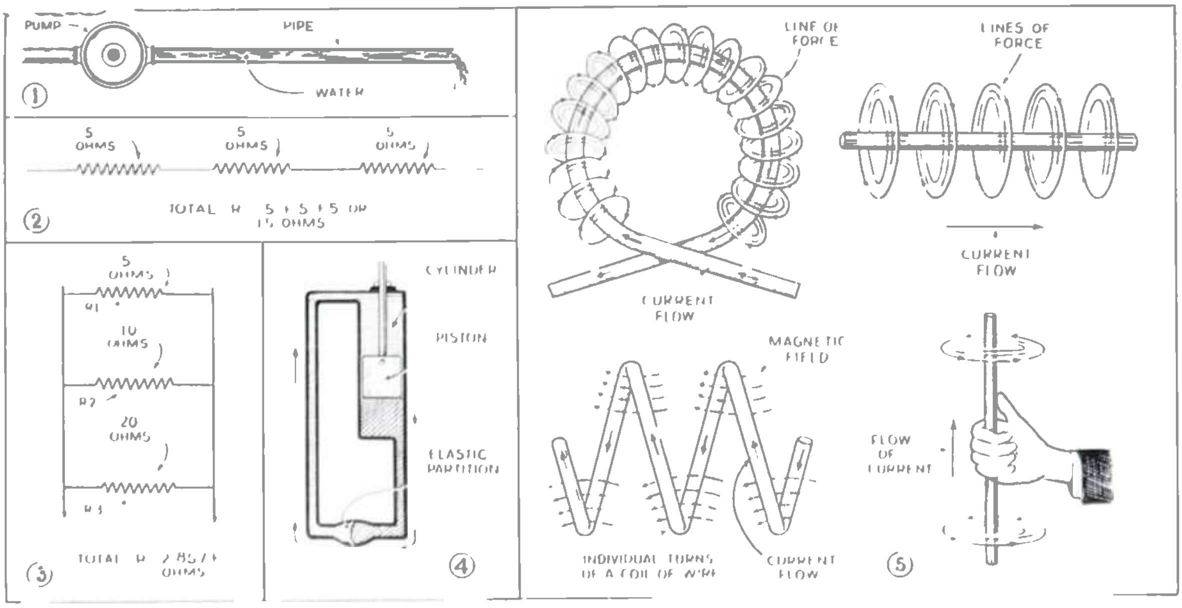

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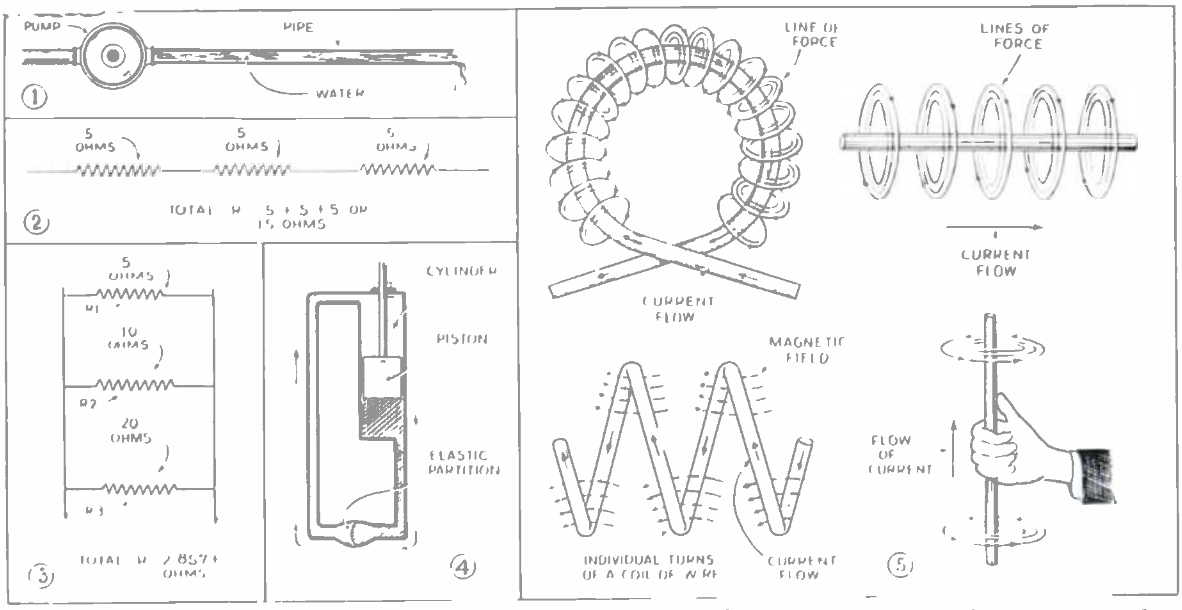

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CHAPTER 3 • • •

RESISTANCE, INDUCTANCE and CAPACITY

● RESISTANCE, capacity and inductance, in order to understand how a vacuum tube oscillates, how tuned circuits work, and the function of a tuning condenser, it is necessary to become familiar with these three very important subjects.

Resistance

When electrical current flows through a wire or some other conducting medium it encounters resistance or opposition, the same as the flow of material substances. For instance, a certain amount of water, can be forced through a length of one inch pipe with a definite pressure. In other words, the size of the pipe offers resistance to the flow. The larger the pipe becomes, the greater amount of water can be forced through it at a definite pressure, or the larger the pipe becomes, the less its resistance will be.

This holds true in conductance of electricity inasmuch as a fine wire or conductor offers a greater amount of resistance than a heavy conductor. The resistance of a conductor is inversely proportional to its cross sectional area and with some materials, in fact most of them, the resistance also increases as the temperature rises.

In dealing with resistance in electrical circuits, we have what is known as Ohm's Law. In Ohm's Law, we have to consider three things: First, the flow of electricity, which is current; second, the force or pressure, which is voltage; and third, the resistance which the flow of electricity encounters. Three letters are assigned to the above, and they are:

I = Current
E = Voltage (EMF)
R = Resistance

The formulas for finding the resistance, voltage, or current, where either two of the three are known are as follows:

When two or more resistors are connected in series the total value of the resistance is the *sum* of all the resistors. In other words, three 5 ohm resistors in series would have a total resistance of 15 ohms.

However when resistors are connected in parallel the method of calculation is a bit more complicated. For instance, if we have three resistors connected in parallel, one has the resistance of 5 ohms, another of 10 and another of 20. The formula for expressing this is

$$R = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}} \text{ etc.}$$

$$R = \frac{1}{.2 + .1 + .05} \text{ etc.}$$

$$R = \frac{1}{.35} \text{ or } R = 2.857+$$

Capacity

Most of us are familiar with the now well-known condenser which is an instrument capable of storing up a certain amount of electricity and consists of two or more plates placed adjacent to each other, with insulation of either air or some other insulating medium. When a constant direct voltage is applied between the plates of a condenser, current will flow into the condenser, until the condenser becomes

charged to its maximum capacity. The current then ceases to flow and the condenser is charged. Then, after the source of electricity (battery for example) is removed from the circuit, the condenser will hold its charge until, due to its inherent (conductivity of dielectric) resistance, the power is dissipated.

If the insulation is mica or parafined (waxed) paper, the condenser will hold its charge for a considerable length of time. In large condensers of one or two microfarads the charge may remain in the condenser for several hours. This can be proved by short-circuiting the two terminals of the condenser and noting the spark, or an ammeter could be connected across the condenser and it would indicate the current flowing until the condenser was completely discharged and the power dissipated. The unit of capacity is a *farad;* however, in radio work, we use considerably smaller units in our condensers.

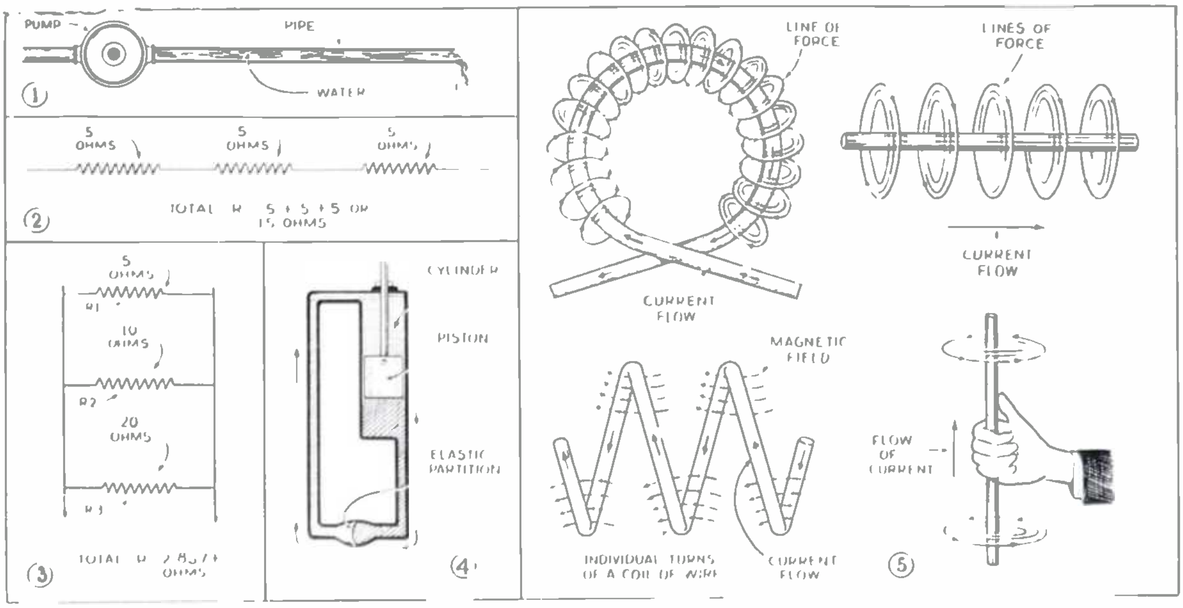
A *microfarad* is one millionth of a farad, and one *micro-micro-farad* is one millionth of a microfarad. The most vital part of a condenser is the dielectric or insulating material because, contrary to popular belief, it is in the dielectric that the charge resides. When a condenser is charged, the dielectric opposes the setting up of an electric displacement of an electric field in the dielectric and the charge is said to be the energy of the charging source stored up as electrostatic energy in the dielectric.

A simple analogy for the action of an electrical condenser is a sponge, which absorbs water when placed in a cupful of it, for example, and afterwards is pressure is exerted on the sponge, then it gives up the water stored in it. It requires 1 coulomb (ampere-second) to charge a condenser of 1 farad to a potential of 1 volt. A condenser having a capacity of 1 mf. (1 mf.=1 millionth of 1 farad) requires a charge of 1 millionth of 1 coulomb to charge it to a potential of 1 volt.

Inductance

The coils used in radio circuits are called *inductances* or *inductors.* In the drawings we see how an electro-magnetic field may be produced around the wire when a current is passed through it. If the flow of current through a conductor is constant (D.C.) a *steady* electro-magnetic field is produced around the conductor. However, when alternating current (abbreviated A.C.) flows through a conductor, the current flow is constantly changing and likewise the field is changing.

When current begins to flow through a wire the circular electro-magnetic field originates at the center of the conductor and travels outwardly away from the center in constantly increasing diameters and of course, extends into the space surrounding



In Fig. 1 we have a diagram showing how the size of a pipe governs the amount that can be forced through it. In Fig. 2 we have resistors connected in series; in Fig. 3 they are connected in parallel; the formulae are given in the text. In Fig. 4 is the hydraulic analogy for the action of a condenser when alternating current is applied to it. Fig. 5 shows the magnetic fields and direction of current flow in straight wires and coils; also the right-hand rule is given, where, if the thumb points in the direction of the current flow, the four fingers will curve around the conductor in the direction of the magnetic field

the wire. Until this field becomes of larger diameter than the wire, it causes a second current to flow in opposition to the main current.

When the current flow through the wire decreases or stops, the circular fields collapse and are then said to cut the wire in ever-diminishing diameters. This induces a current in the opposite direction to the field but in the same direction as the original (exciting) applied current, tending to prolong the flow of the exciting current.

This property of a coil or conductor to act upon itself or another inductor in close proximity to it, is called *inductance.* The unit of inductance is the henry and in most formulas it is usually designated by the symbol "L." A *henry* is the inductance of a circuit in which the induced E.M.F. is one volt, when the (varying) current travels at the rate of one ampere in one second. Usually in radio circuits, inductance values are indicated as one thousandth of a henry or one *milli-henry;* a millionth of a henry is known as a *micro-henry.* The physical dimensions and form of a circuit, determine the amount of inductance and it is for this reason that our radio circuits consists of coils rather than straight wire, because a greater amount of inductance can be obtained by coiling the wire, also allowing considerably less D.C. resistance because less wire is used. A straight wire, of course, would have less inductance than one of the same length which was coiled.

Induction subdivides into two branches—***self and mutual induction.*** If the current passing through a coil, for example, is rising from zero to maximum value, such as when the circuit is closed from a battery, (or the first half of an alternation of an alternating current) the magnetic field around the wire is expanding and while this is taking place there is induced in the conductor a counter-current (and counter e.m.f. or voltage) which tends to buck or oppose the current (and voltage) which is producing the field.

As one of the diagrams shows there is electrical energy stored up in an inductive circuit, just as if you had compressed a spring. The opening of the circuit, and spark at the switch, corresponds to releasing the compressed spring and heaving off the weight.

Another analogy is the flywheel. The inertia of the wheel opposes any force to set it in motion; once in motion, the energy tied up in the wheels tends to keep it going, if any effort is made to stop it.

Let us consider for a moment now the next phase of the action taking place when the circuit is opened or when the *second half* of the alternation of an applied A.C. is taking place. Now the magnetic field around the wire or turns of wire comprising the coil is contracting and while this occurs.

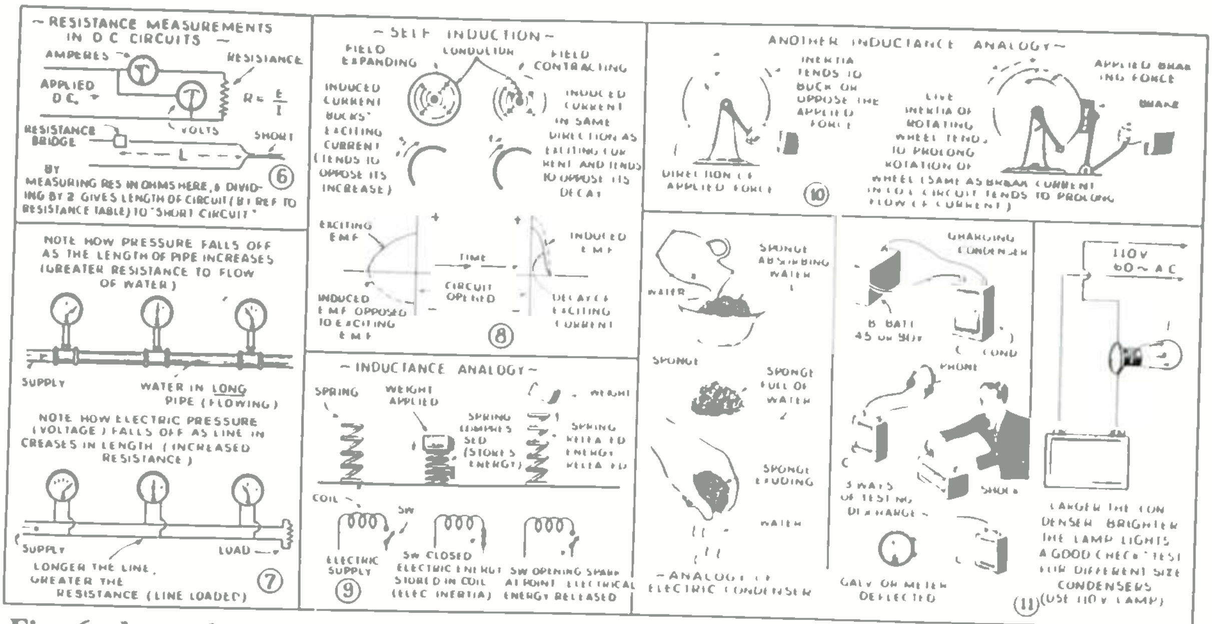


Fig. 6 above shows measurement of resistance. Fig. 7 shows how pressure or voltage decreases with increase in resistance to flow of water or electric current. Fig. 7 shows how pressure or voltage decreases with increase in resistance to flow of water or electric current. Fig. 8 shows action of expanding and contracting magnetic fields. Fig. 9 shows mechanical "spring" analogy for inductance; Fig. 10—Fly wheel analogy of inductance. Fig. 11—Analogies for condenser.

the lines of magnetic force are cutting the wire in the opposite direction and a current of opposite sign is induced in the wire, this current being in the same direction as the applied (exciting) current which is flowing around the wire and creating the magnetic field.

In other words, the self-induced e.m.f. is in the opposite direction, while the field is ***expanding*** about the wire, and tends to oppose it while the opposite is the case when the field is ***contracting*** and the current is then in the same direction or aids the inducing current and acts to prevent its decay.

It will be apparent, of course, that while the current is varying in strength or let us say increasing, the field about the coil is expanding, and the lines of magnetic force expanding out from the coil composed of a number of turns, will induce a current by ***induction*** in a second coil, placed near or adjacent to the first or exciting coil.

If we term the exciting coil No. 1, and the adjacent ***unconnected*** coil as No. 2, coil 2 is said to have a current induced in it by ***electro-magnetic induction***. As the magnetic field in coil No. 1 subsides, the magnetic lines of force surrounding coil No. 2 also subsides. At the same time these lines of force cut across the turns in coil No. 1 and induce therein an e.m.f. or voltage (also a current) and thus we have a third e.m.f. set up by induction.

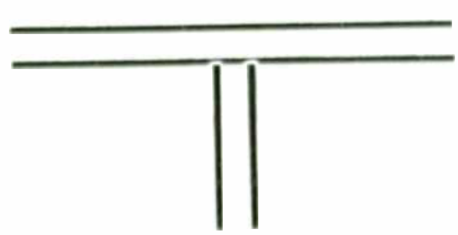
To begin with, we have the original exciting e.m.f. in coil 1; secondly we find an induced e.m f. in coil 2; and thirdly, there is a ***reinduced*** e.m.f. in coil 1, due to the reaction of the magnetic field surrounding coil 2, and this effect is what is known as ***mutual induction***.

The usual radio tuned circuit consists of a coil and a condenser, namely: ***inductance and capacity***. Coils or inductances have what is known as inductive reactance. When the capacity reactance minus the inductive reactance equals zero, at some certain frequency, the circuit is said to be in ***resonance***

When the condition known as ***Resonance*** has been established in any given circuit, whether a series or parallel type circuit, then we know that the inductive and capacitive reactance are equal, and that they balance each other. When this condition has been achieved their reactive effect upon the circuit is zero. Under these conditions, or when the circuit has been made resonant, (by the proper adjustment of the capacity and the inductance of the circuit) any current flowing in the circuit due to an applied e.m.f. will be that due simply to the ohmic or direct current resistance in the circuit. Expressed another way, the current passing through such a resonant circuit will be given by the expression: $I=E\div R$.

The difference between the capacitive and inductive reactance of a circuit at some frequency is called the impedance. However, at resonance, this is always zero, and the losses in the circuit are due only to the usual D.C. resistance of the circuit, through which the currents are flowing.

In Fig. 4 we see a hydraulic analogy of current flowing into a condenser. When the piston is moved forward, the elastic partition will bend or become curved but will not allow the liquid to be transferred from one side to the other.



CHAPTER 4

VACUUM TUBE AS A REGENERATOR AND OSCILLATOR

TO the average short wave "fan" or inexperienced amateur, the two words *regeneration* and *oscillation* are very mystifying, insofar as the technicalities of them are concerned. In Webster's Unabridged Dictionary, the word *oscillation* is defined as follows: "To move backward and forward; to vibrate like a pendulum, to vary or fluctuate between fixed limits." The word *regenerate* in the same dictionary is defined as follows: "Reborn, reformed or created again."

In the chapter covering *alternating current*, we find the current starting at a zero point building up to a maximum, decreasing again to zero, then building up in the opposite direction, and finally falling to zero thus completing one cycle or one oscillation. An oscillating vacuum tube is a *generator of alternating current*, but has the advantage over the usual generator employed in generating our house current, in that it can be made to generate electricity of a frequency as high as five hundred million cycles. Before oscillation takes place in a vacuum tube, connected as shown in the accompanying drawings, we must have regeneration. This regeneration represents power taken from the output of the tube and fed back into the input circuit, amplified through the tube and taken out of the plate circuit again. In Figure 1 we have a simple circuit using a triode, which is capable of regenerating and oscillating. If we were to impose a signal voltage on the grid of this tube at the point marked X1, this signal would be carried through the tube and amplified; then by placing coil L1 in inductive relation to coil L2 this signal would be fed back from Coil L1 to L2 and reamplified. This process continues over and over again. That is why our regenerative circuits are so very sensitive.

How Oscillations Are Set Up

The circuit in Fig. 1 shows Coil L1 and L2 very close together. Suppose the filament is lighted and the switch marked "SW" is open, no current will be flowing in the plate circuit. Now if we close the switch current will immediately start to flow through L1, through RFC and thence back to the filament.

Current flowing through L1 induces a field about the coil. This field is termed magnetic lines of force. As these lines of force thread through the turns of L2 a weak oscillating current is built up in the circuit composing L and C, these weak oscillations are transmitted to the grid and amplified by the tube. It so happens that these oscillations (fed back) are of the proper phase, so that one aids the other and as the feed back process continues, the oscillations build up in amplitude, as shown in Figure 2 (also Fig. 8). This build up in plate current would continue indefinitely if it were not for the automatic regulation which takes place due to the grid leak R. The grid current increases the same as the plate current increases, and this current flowing in the grid circuit causes a voltage drop across the resistor "R," and this drop is used to bias the tube, so that the plate current cannot rise above a certain fixed maximum. The "B" battery connected in the plate circuit, supplies the necessary power to perpetuate oscillations. In other words, there is no "perpetual motion" in the oscillator as some people might be led to believe. In our previous chapter on vacuum tubes, we learned that a positive charge on the grid would cause an increase in plate current flow, while a negative charge would cause a decrease in current flow. Assuming that the induced EMF first found in the circuit L2 applied a positive voltage to the grid, the plate current would rise ***above its normal value.*** This rise in current would strengthen the field around L1 and continue to increase the EMF induced in L2, and so the plate current would continue rising, remember that the energy used to cause the plate current to rise was taken from the plate circuit. This is the ***feed-back*** action. Due, as we said before, to the action of the grid-leak, this increase cannot continue indefinitely. When the plate current ***ceases to increase,*** the induced voltage in the grid circuit falls to zero. The plate current will then tend to decrease toward its normal resting value, and as it decreases, the magnetic field around L1 will begin to collapse or recede and thus move inward towards its center. The magnetic lines of force of this ***decreasing*** field now thread through the grid coil in a direction opposite to the movement when they were expanding; that is, when the plate current was rising. This induces an EMF in the grid circuit, but of the opposite polarity. Now, we assumed that the first impulse was ***positive*** to the grid; this one will then be ***negative,*** causing the plate current to continue to fall ***below*** its normal resting value; as the field is entirely collapsed, the plate current will tend to go up to its normal resting value. This will cause a field to again cut the coil L2, causing a positive voltage, the same as the original impulse to be applied to the grid. This action will be reciprocated, and will continue indefinitely, and is termed ***sustained oscillation,*** just as we show in Figure 2.

The Hartley Oscillator

So far, we have considered an oscillating circuit of the ***tickler*** feed-back variety commonly used as ***detectors*** in short wave receivers. There are many varieties of this circuit. In Figures 3 and 4, we have the ***Hartley*** circuits. The one in Figure 3 has its plate voltage fed through the section of the coil marked L1, while the plate voltage of

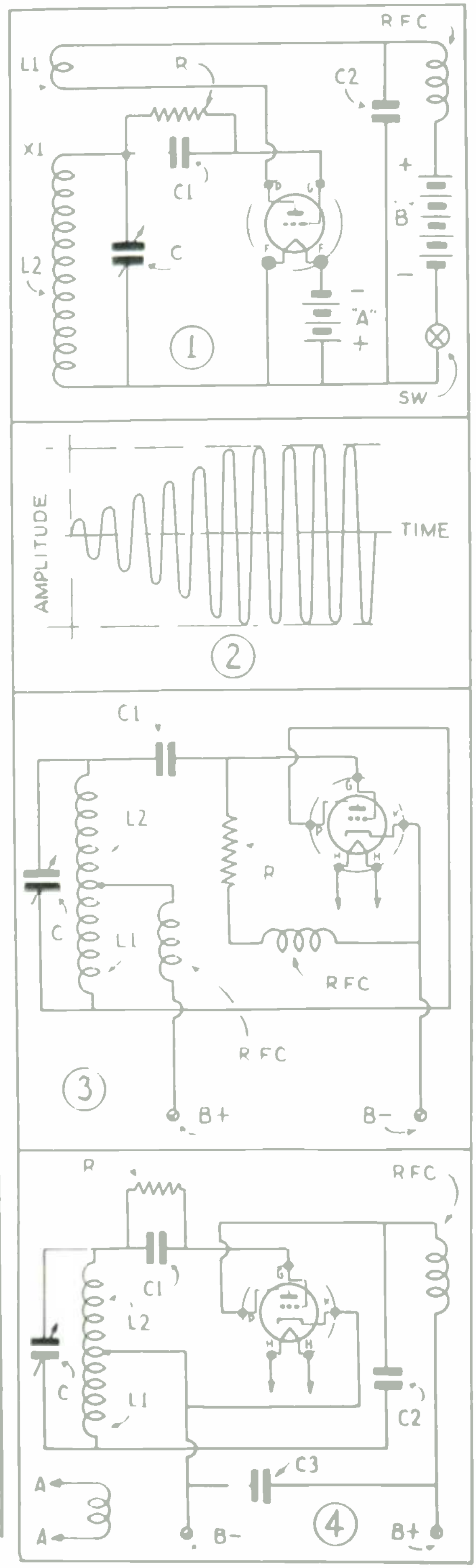
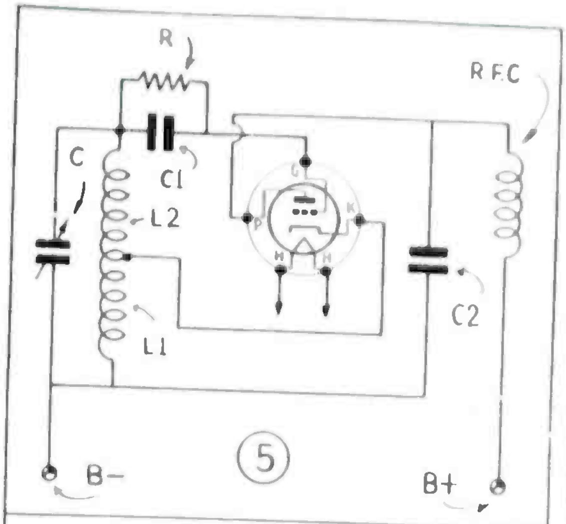
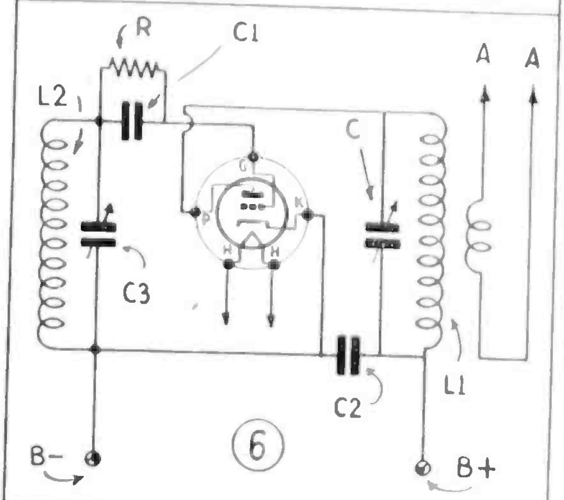


Fig. 1—The usual regenerative oscillating circuit used for receiving. Fig. 2—The build-up of oscillations start feebly and are gradually increased in amplitude due to "regeneration" or "feed-back." Figs. 3-4—Series and shunt-fed transmitting circuits.





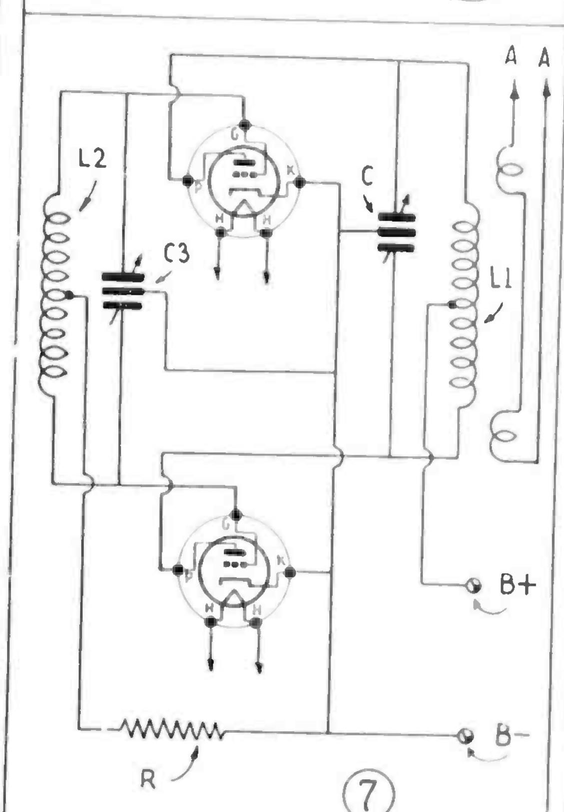


Figure 4 is fed directly to the plate of the tube through an R.F. choke. Figure 3 is known, as ***series*** feed, while Figure 4 is termed ***parallel*** or ***shunt*** feed. In both cases, we really have a tickler and grid coil as indicated by the letters L1 and L2. In present-day receiver circuits, and in some ***transmitting*** circuits, the cathode of the tube is connected to the coil in order to obtain feedback, and the plate is ***apparently*** not used. This may be quite mystifying to the average person, not technically inclined, but when comparing Figure 5, which has its cathode connected to the coil, with the diagram in Figure 4, we find there is really no difference in the circuit. All we have done is disconnect the "B" negative from the cathode and connected it to the bottom of L1, causing the "B" current to flow through the coil. By comparing and studying these two circuits, the cathode tap arrangement should not be the least bit confusing.

In all the diagrams and circuits so far, we have considered ***magnetic*** feed-back that is, energy fed from plate to grid by magnetically or inductively coupling the two coils together. In Figure 6, we show an oscillating circuit which does not have mag-

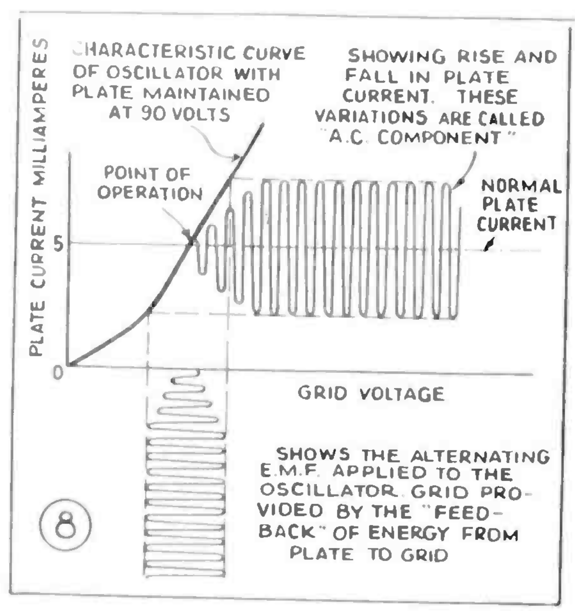


Fig. 5—Shows the cathode tap method of feed-back. Fig. 6—The tuned-plate tuned-grid oscillating circuit used for transmitting. Fig. 7—This circuit is the same as No. 6, except that two tubes are used in push-pull.

netic or inductive coupling. The feed-back in this case is due to the plate-to-grid-capacity within the tube. In triodes, this capacity may be anywhere from 3 to 10 mmf In this circuit, the grid and plate circuits must closely approach resonance with the same frequency, because the feed-back is not as strong or as great as in the other circuits. This is the tuned-plate tuned-grid circuit Screen-grid tubes will not oscillate in a circuit of this type, because the plate-to-grid capacity, as pointed out in a previous chapter, is too low to effect sufficient feed-back to cause oscillation.

That is why, in the I.F. amplifiers of our superhets, the plate and grid circuits are tuned to the same frequency, allowing extremely high gain with no feed-back. However, if there were coupling directly between L1 and L2 of this circuit, even though it used a screen-grid tube, oscillations would occur. In Figure 7, we have the same type of circuit—tuned-plate, tuned-grid, except that two tubes are used in push-pull, that is, each tube operates on alternate half-cycles. These circuits shown in Figures 3, 4, 6 and 7, can be and are used for *transmitting.*

How can we take R.F. power from such an oscillator and feed it into an antenna? The answer is quite simple, if you will bear in mind what we have said about the inductive relation between coils in a transformer. In figures 4, 6 and 7, we have additional coils coupled to L1. The high frequency alternating current in the tuned circuit, consisting of L1 and C, will induce similar currents in the coil coupled to it. This coil is then connected to the antenna, and the power from our oscillator, or a goodly part of it, is radiated.

What Determines Frequency of the Oscillator

The frequency of the oscillator is largely determined by the tuned circuit L1 and C, that is, in all diagrams except the first. In this circuit the frequency is controlled by L2 and C.

It takes a certain length of time for an oscillation or one complete cycle (reversal of current) to take place in any circuit, which consists of inductance and capacity, due to the electrical inertia of the circuit itself. This inertia or lag is readily apparent when we consider what has been studied previously regarding inductances. When a current is passed through a coil, it sets up a field within the wire which, starting at the center of the wire itself, expands outward in ever increasing diameters. These lines of force not only cut the wire going outward, but cut adjacent wires. This cutting induces a current in the conductor or inductance in the opposite direction to the original current, tending to oppose the increase in current flow, thus prolonging the length of time, between the application of current and the time when the current is flowing at maximum amplitude. Now, if we decrease the current flow, the lines of force contract to flow in an ***opposite direction to the field,*** but in the ***same direction as the original receding current;*** thus tending to prolong the current flow and preventing its decay.

CHAPTER 5 • • •

CLASS A, B and C AMPLIFIERS

● In this chapter of our *Radio Amateur Course,* we will deal with *radio* and *audio frequency,* class "A" "B" and "C" amplifiers, together with frequency multipliers. The first type of amplifier that the average radio experimenter comes in contact with is the well-known *Class "A" audio amplifier.* In a previous chapter discussing the vacuum tube action, we clearly explained the functions of the cathode grid and plate, also just how the changes in grid potential effect changes in plate current, thus amplifying the signal.

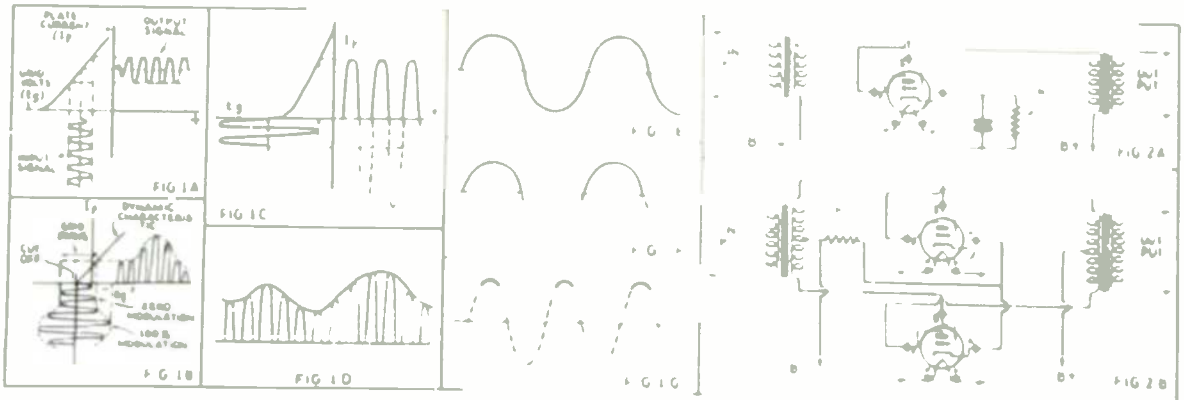
Before reading the following descriptions of amplifiers, it is well to review the previously described actions of the various elements in tubes because these will not be taken up again in detail, and a perusal of the chapter on tubes will greatly aid in obtaining a clear mental picture of various types of amplifiers.

In Figure 1-A, the tube is operated under conditions so that the *output* is an exact replica of the *input* signal. It can, therefore, be said that the tube is operated on the flat portion of its grid-voltage plate-current curve. By examining the drawing at Figure 1-A, we see that the grid never goes sufficiently negative to reduce the plate current to zero, and it is also not allowd to go positive, if it were the grid would draw current on the positive peaks, and this is not desirable in the usual Class "A" amplifier.

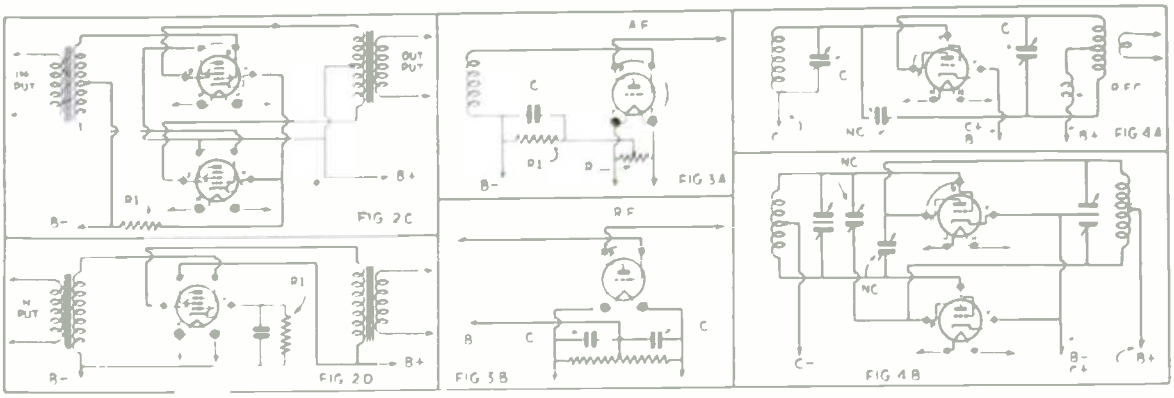
Class "A" Amplifiers

Class "A" amplifiers are capable of really faithful amplification, but are quite inefficient, insofar as power conversion is concerned. Usually these amplifiers are much less than 50 per cent efficient. In Figure 2-A we have a 1 tube audio frequency Class "A" amplifier circuit. In figure 2-B we have an amplifier of the push-pull variety wherein two tubes are used, each operating on alternate half cycles of the input signal. In Figure 1-B we have a diagram of the characteristics of a Class "B" radio frequency amplifier. The operating characteristics are essentially the same as a Class "B" audio amplifier, only in the R.F. amplifier, as indicated, the frequency is constant and the amplitude of it is varied by modulation. This is said to be a *Linear* amplifier.

In a Class "B" audio amplifier, the frequency would vary. However, the essential functions are the same. We find that the bias is such that it allows the grid to be



The above drawings show characteristics of Class "A," "B," and "C" amplifiers, together with amplifier diagrams.



Diagrams of pentode A.F. amplifiers, single and push-pull, together with neutralizing single and push-pull R.F. amplifiers.

come positive on one-half of the incoming signal, running the plate current way up. On the negative half of the cycle in the R.F. amplifier, we find that the plate current is zero and remains zero through the entire 180 degrees of the negative grid swing, and then it begins to rise as the grid goes positive. It can thus be seen that plate current flows over the 360 degrees of the grid swing in Class "A" amplifier, and only 180 degrees of the grid swing in a Class "B" amplifier. Now, in an audio system, it is essential that we reproduce an exact replica of the incoming signal; that is why in Class "B" amplifiers intended for audio frequency use, we use push-pull in order to reproduce *both halves* of the incoming signal.

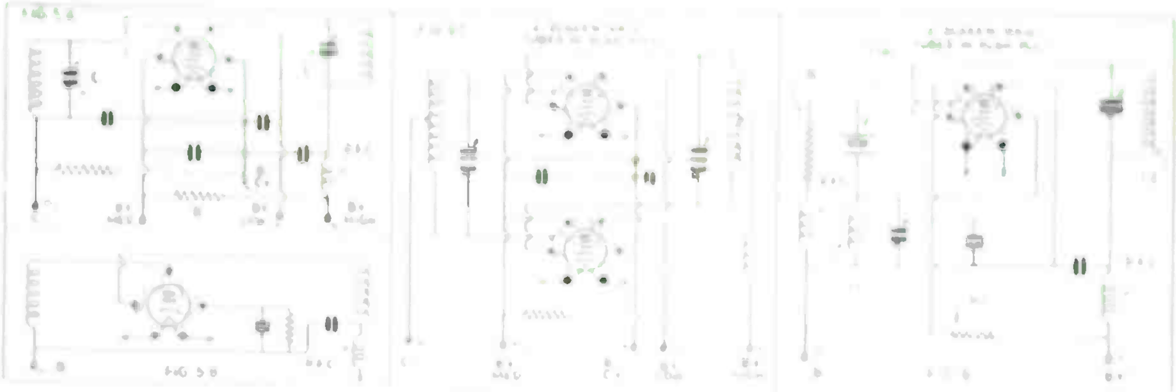
Class "B" Amplifiers

In R.F. amplifiers wherein the variations in amplitude of a constant frequency carrier constitutes our audio frequency signal, we do not need push-pull, because if we refer to Figure 1-D, we will see that complete A.F. variation is present on the one-half, although two tubes are often used in the Class "B" R.F. amplifier This is only done to increase the power output. We can very easily see why only one-half of the modulated R.F signal is needed; because of the action of our detector, really only one-half of it is used anyway. In Class "B" amplifiers of all descriptions, the grid-bias is adjusted so that the plate current is zero or nearly zero with no signal present in the grid circuit. In the now popular Class "AB" or "A" prime, audio frequency amplifiers, plate current flows throughout more than 180 degrees of the input cycle but less than 360 This means that the plate current may fall to zero and remain zero for just a small portion of the input cycle. In Figures 1-E, F and G, we clearly show how in the Class "A" amplifier, the plate current is continually flowing, and in the Class "B" amplifier, is only flows through 180 degrees of the input cycle, while on Class "C" amplifier, which is next to be discussed, on less than 180 degrees of the input cycle.

Class "C" Amplifiers

Class "C" amplifiers are usually used only for *radio frequency* amplification because of the tremendous amount of distortion which is present in the output wave. In Class "C" amplifiers, the bias is increased to about two times the value necessary to bring the plate current to zero. This means that a greater amount of excitation is required in order to make the plate current flow. This requires of course, that the grid be driven considerably *positive*. Vacuum tubes operated in the Class "C" category are capable of tremendous power output as compared to a Class "A" or "B" amplifier, and are usually quite a bit more efficient, insofar as plate-power conversion is concerned. Efficiencies as high as 85 per cent are quite easily obtained. Of course, the ratio of power amplification is reduced considerably in a Class "C" amplifier, because of the fact that plate current only flows on a small portion of the input cycle and because a Class "C" amplifier requires a good deal more excitation.

A class "C" amplifier in a radio frequency phone transmitter is modulated directly, i e, a powerful modulator is used to vary the plate input to the tube at audio frequencies, while a Class "B" amplifier used in a phone transmitter is not modulated directly, but a low-power, class "C" amplifier which is modulated at voice frequencies, is used to drive the Class "B" linear R F amplifier While the Class "B" amplifier is not as efficient as the Class "C" amplifier, it introduces a considerable saving in the cost of



Pentode single and push-pull R.F. amplifiers and crystal oscillator-frequency multiplier diagrams.

modulator equipment, because a fairly low-power stage is modulated, and the Class "B" amplifier is merely used to amplify the modulated output of this low-power stage.

Efficiency in Power Output

Efficiencies of around 70 per cent may be secured from a Class "B" amplifier with 100 per cent modulation on the driver stage, although an unmodulated Class "B" amplifier would be only about 35 per cent efficient. Speaking of plate efficiency or power conversion in the plate circuit of the vacuum tube, we mean the "power" *output* divided by the power *input*, times 100. For instance, if we have an amplifier with a power input of 100 watts and an output of 75 watts, we would have an amplifier which was 75 per cent efficient, the output being 75 per cent of the total plate input.

In figures 1-C and 1-G, we have illustrations of the operation of a Class "C" amplifier. To the lay reader, Figure 1-G would probably be the clearest, because herein we find a clearer picture, showing that the plate current flows on a very small portion of the *input* cycle. In Figures 2-C and 2-D, we have *pentodes* used as *audio frequency* amplifiers. Bias for these is obtained by inserting the resistor in series with the cathode, or if it is a filament type tube, a center-tap resistor is needed, as shown in Figures 2-A and 3-A. In an R.F. amplifier, usually the center-tapped resistor is *by-passed* with two condensers, as in Figure 3-B. Resistors "R" in Figure 2-C, 2-D, and 3-A, are the *self-biasing* resistors.

Neutralizing

With a *triode* used as a radio frequency amplifier and where the input and output circuits are tuned to the same frequency, a method of overcoming *self-oscillation* is required. This is accomplished by *neutralizing* as shown in Figure 4-A. What we have done here is to center tap the plate coil, making the two ends *out of phase 180 degrees*. Then a small condenser is connected between the grid of the tube and the end of the coil which is not connected to the plate. The condenser "NC," which is the neutralizing condenser, is then adjusted to feed an amount of R.F. from the plate circuit back to the grid, equal to the amount of R.F. fed from grid to plate, due to the internal capacity of the tube. This external method of feeding back R.F. 180 degrees out of phase, cancels the plate-to-grid feed-back within the tube.

Push-Pull With Triodes

In figure 4-B, we have *push-pull* amplification, using triodes, each operating 180 degrees out of phase, making neutralizing possible by just connecting small, variable condensers between the plate of one tube and the grid of the other. In other words, one tube furnishes the neutralizing voltage for the other.

In Figures 5-A and 5-B, we have R.F. amplifiers using screen grid tubes which *require no neutralizing*. One is a *push-pull* circuit, and the other is a *single-ended* affair. As we said before, in Class "B" and "C" amplifiers, both *audio* and *radio* frequency, grid current flows during either a portion or all the positive half-cycle of the exciting voltage. Now, this grid current can be utilized for biasing R. F. amplifiers by inserting a resistor in series with the grid return, the same as we have in an oscillator where bias is obtained with a grid leak. We can also obtain bias by the cathode method as shown in Figure 5-B. Grid-leak is never used in audio frequency Class "B" amplifiers. Screen-grid voltage in amplifiers, such as shown in Figures 5-D and 5-C, can either be obtained directly from a separate power supply or obtained through a voltage-dropping resistor, thus lowering the plate voltage to a sufficient value for the screen.

Frequency Multipliers

Radio frequency amplifiers can be used for *frequency multiplication.* For instance, we can feed a 3500 kc. signal into the grid of any one of the "single-ended," Class "B" or "C" R. F. amplifiers shown in the various diagrams; then by tuning the plate circuit to 7,000 kc. and taking power out of this circuit, we have doubled the frequency of the original exciting signal. Class "B" amplifiers are not well suited for frequency doubling, because there is less second harmonic present in the output circuit. A Class "C" amplifier is a very fine *frequency multiplier* where the even order of harmonics are to be obtained. A *push-pull* amplifier does not make a good second harmonic amplifier or frequency doubler because the push-pull output circuit tends to cancel out the even order of harmonics. The push-pull multiplier can be used as a frequency multiplier where the odd order of harmonics are desired. For instance, the 3rd, 5th, etc.

Push-pull amplifiers are generally used where *frequency tripling* is required. Through the use of the new pentode tubes, such as the 2A5, 42, 802, and 23, an oscillator and frequency multiplier can be combined within a single tube. In Figure 6, we have a pentode oscillator and multiplier. The crystal is connected between the cathode and the grid. A tuned circuit is inserted between the cathode and the "B" negative and is tuned to a frequency about midway between the crystal frequency and its second harmonic. This will cause the crystal to oscillate; then the plate circuit can be tuned to twice or even three times the crystal frequency, with a fair amount of power output. It can also be tuned to four times the crystal frequency, but the power output and plate efficiency are very much lower.

CHAPTER 6 . . .

M. O. P. A. — MASTER OSCILLATOR — POWER AMPLIFIER

● THIS chapter of our Amateur Radio Course will cover the M.O.P.A. (master oscillator-power amplifier) transmitter using crystal-control, frequency-multiplication buffers, etc.

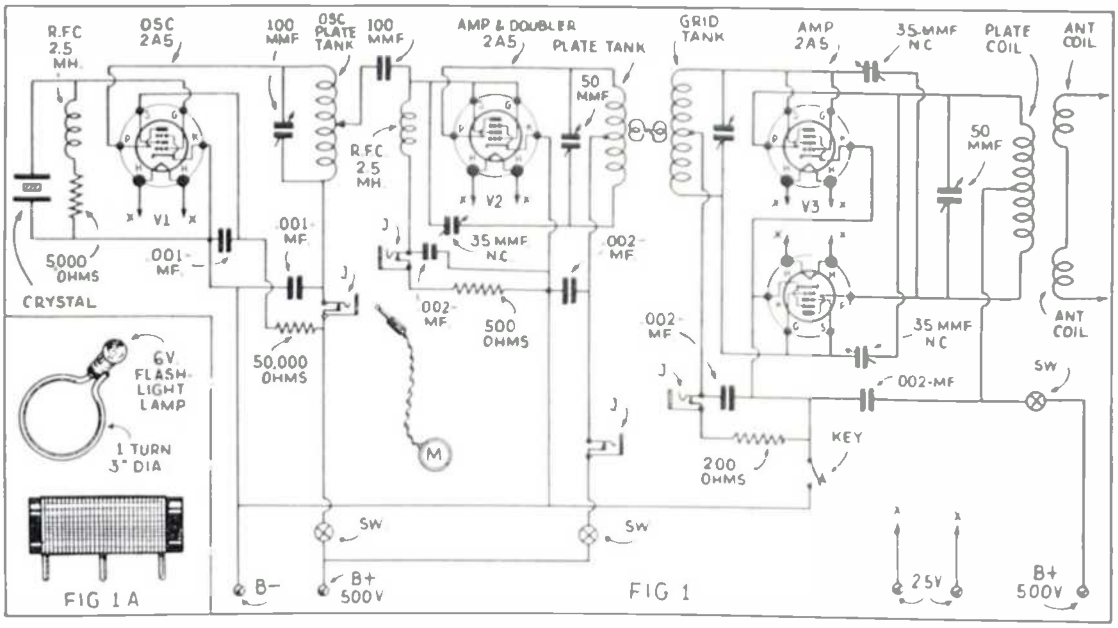
Amateur Radio has advanced to the point where multi-tube transmitters are almost a necessity, although single-tube crystal-controlled transmitters are usually very efficient insofar as *stability* and *power output* are concerned. On the other hand, for greatest flexibility and efficiency, an M.O.P.A., comprising at least three stages, is necessary if real efficiency is desired along with three or four band operation.

Today, the Ham does not need to spend a fortune in constructing a modern multi-stage transmitter with a fairly respectable power output, because in nearly all cases, receiving tubes may be used.

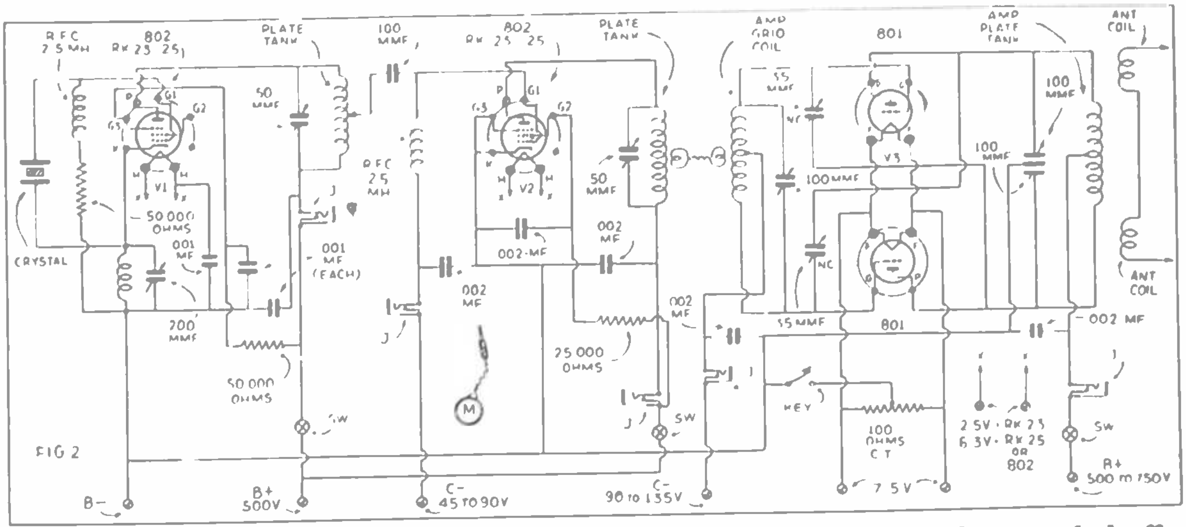
In Figure 1, we have a crystal-controlled transmitter built entirely around 2A5 tubes. Although few Hams realize it, this tube is ideally suited to low-power transmitters or in the oscillator, buffer and frequency multiplier stages In this transmitter ,we use a 2A5 connected as a pentode crystal oscillator. another 2A5 as a neutralized amplifier or frequency doubler, and in the third stage, 2—2A5's in push-pull, as amplifiers. When using the 2A5 as an amplifier or doubler, the control grid and screen grid should be tied together.

Pentode Oscillator

In the *pentode-oscillator* circuit of Figure 1, we have condenser coupling to the first amplifier. Experience has proven that the excitation tap on the plate coil should be connected between one-half and three quarters the length of the entire coil, from the



Complete diagram of 3-stage crystal-controlled M.O.P.A. (Master Oscillator Power Amplifier) transmitter with details of the tuning light and plug-in coil suggestion (1A).



3-stage M.O.P.A. transmitter using pentode oscillator-doubler and pentode-buffer doubler.

B plus side. If this tap were connected directly to the plate end of the coil, considerable instability in the oscillator circuit would result, and in many cases, the oscillator may fail to start oscillating when the transmitter is turned on.

With the two grids of the 2A5 connected together, this tube represents a high-mu triode similar to the 46, and no separate bias is necessary, although a small resistor, around 500 ohms ,in series with the grid return, increases the second harmonic output when doubling. Many who have used the 46 will recall that the plate current tends to ***creep up*** if the circuit is detuned or if too much excitation is applied. This trouble is entirely eliminated in the 2A5 no doubt due to the suppressor which is connected directly to the cathode inside the tube. We might also mention here that those having trouble with the 46 will do well to change to the 47, because this tube exhibits the same characteristics as the 2A5, and requires no change in circuits formerly using the 46, other than a reduction in the value of the grid bias resistor; 500 ohms seems to be the optimum value.

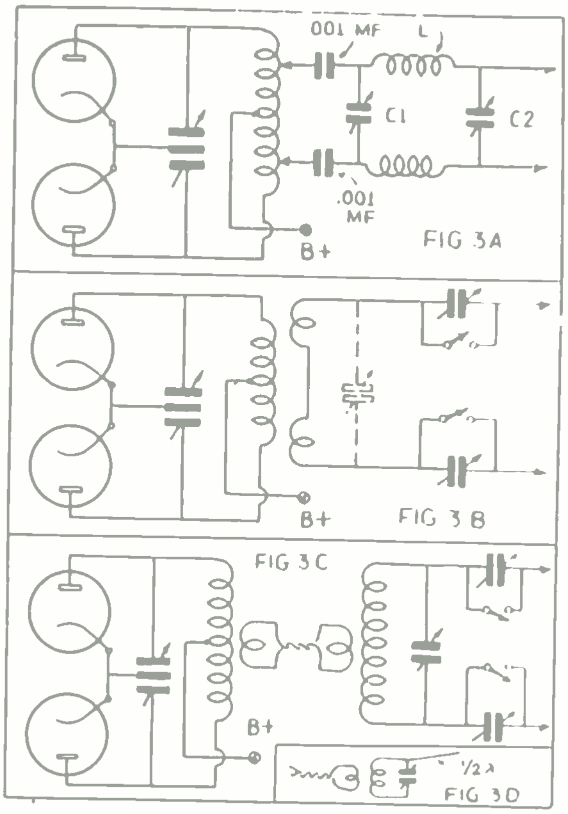
Advantages of Link Coupling

The final amplifier or push-pull stage of this transmitter (Fig. 1, is ***link-coupled*** to the first amplifier. Experiments have long ago proven ,where a "single-ended" driver is used in conjunction with a push-pull stage, that inductive coupling is far more efficient than any other method of coupling. Each coil of this link circuit should consist of two turns, coupled fairly close to the center of both the first amplifier plate coil and the push-pull amplifier grid coil. Both grid and plate circuits of the push-pull amplifier are tuned to the same frequency, and, therefore, neutralization is necessary For a more thorough discussion of neutralized amplifiers, we refer you to the fifth chapter.

All values of resistors and condensers are given. However, coil data is omitted because this will depend upon the particular band in which the transmitter is to be operated. A transmitter of this type should have an output of from 30 to 40 watts on 80 and 40 meters, and slightly less on 20.

Tuning Procedure

The tuning procedure for this transmitter is as follows: With all the B-plus voltages disconnected, the filaments or heaters allowed to heat up for at least two or three minutes. Then the plate and screen voltages should be applied to the oscillator with the excitation tap of the first amplifier removed from the oscillator plate coil. Then with a flash-light bulb connected to a single turn of wire, coupled rather closely to the plate coil in the oscillator, swing the plate condenser back and forth until a point is reached where the light glows the brightest. Back the pick-up coil away from the plate coil, and retune for a peak in brilliancy of the lamp. The excitation tap should now be connected to the oscillator somewhere around two-thirds the distance from the B-plus end of the coil. The plate milliammeter could have been used for tuning the oscillator. However, the maximum output does not come about with either a maximum or minimum reading on this plate meter but somewhere between the two. Now when the excitation tap is connected to the oscillator plate coil, the plate current will increase, as shown on the meter. With the neutralized condenser "nc" set at zero capacity, and the flashlight bulb coupled to the first amplifier (V2) plate coil, swing the plate condenser of this stage back and forth until the bulb lights. Now, if we are operating this amplifier at the same frequency as the oscillator, it must be neutralized. Increasing the capacity of the neutralized condenser gradually, and swinging the plate condenser back and forth through resonance, will eventually result in a setting of the neutralizing condenser where the flashlight bulb will not glow. A more



Various methods of coupling antennas to a push-pull amplifier.

accurate method of neutralizing can be used by plugging a zero to 50 ma. meter in the grid circuit of the amplifier. You will notice that rectified grid current will be present even though no plate voltage is applied to the tube. As the plate condenser is swung back and forth, you will also notice, if the amplifier is not perfectly neutralized, a slight "bump" in the grid current when the amplifier condenser swings through the resonant point. A further adjustment of the neutralizing condenser will eliminate this. After this stage is thoroughly neutralized, the plate voltage can be applied.

Tuning of the Push-Pull Amplifier

Our next job is to "tune up" the push-pull amplifier. Couple the flashlight bulb to the grid coil of the amplifier and tune the grid condenser for maximum brilliancy. The neutralizing condensers of this stage should be at minimum capacity; then couple the flash-light bulb to the plate coil of the push pull amplifier, and adjust the plate condenser for maximum brilliancy of the bulb. This stage is then neutralized the same as the first amplifier, except that both neutralizing condensers are adjusted simultaneously, and a point will be reached in the setting of these condensers where the flash light bulb will not glow, and the grid current meter when plugged into this circuit will not change.

A word of warning about push-pull amplifiers—unless a push-pull amplifier is perfectly symmetrical, ie., the two grid leads of *identical length*, and the tap on the grid coil in the *exact electrical center*,; the *plate leads identical*, and the B-plus tap on the plate coil in the *exact electrical center*, it cannot be neutralized. Also, identical makes of tubes should be used. In a perfectly symmetrical amplifier, the neutralizing condensers will be set at exactly the same capacity. The leads to these condensers should also be symmetrical; they should be mounted so that the grid leads to them are identical, and the plate leads both of the same dimensions. Many experimenters have given up push-pull amplification because they could not neutralize the amplifier, and this, undoubtedly, was due to *lack of symmetry*. If plug-in coils are used in the push-pull amplifier, do not use the usual plug-in receiver type coil with the pins in the base. The coils should be of the flat mounting type, such as shown in the drawing 1A. The other type of plug-in coil form will make the leads uneven in length.

The push-pull amplifier in this transmitter is keyed in the cathode circuit, and the biasing resistor should be 200 ohms or larger. In the plate and grid circuits of the push-pull amplifier and the plate circuit of the first amplifier, single section condensers are used. This makes both ends of the condenser "hot" and an insulating shaft should be used for coupling to the knob or dial. For those who have split-stator condensers, or can afford their usage, they are highly recommended. This transmitter when used with an 80-meter crystal, can be used on the 80 and 40 meter bands. For 80 meters, all three stages are tuned to the crystal frequency; on 40 meters, the first amplifier (V2) is a doubler, and the second amplifier tuned to 40 meters. With a 40 meter crystal, all three stages can be tuned to 40, or we can operate on 20 by tuning the first amplifier (V2) and final (V3) to that band. All the power amplifier circuits are tuned the same whether they are frequency multiplier stages or not. After they have been neutralized, that is, if they require it, the plate voltage should be applied and the plate tuning condenser ***immediately*** adjusted for minimum reading on the plate milliammeter —this always indicates resonance.

Three-Stage Transmitter Using 2 S. G. Tubes

In Fig. 2, we have another 3-stage transmitter using two screen-grid tubes and two 801's in the final amplifier. Tuning the first amplifier and the final amplifier will be identical to the transmitter shown in Figure 1, except that the first amplifier (V2) need not be neutralized because a screen-grid tube is used. The oscillator here is quite different. Because we are using a screen-grid tube which will serve not only as an ***oscillator,*** but as a ***frequency-multiplier.*** With this transmitter and an 80-meter crystal, we can work on either 80, 40 or 20 meters without changing crystals. This is the well-known ***Tritet*** oscillator circuit, where a cathode coil is used to bring about oscillation of the crystal independent of the plate tuning circuit. This plate circuit can be tuned to either 80 or 40 meters. When operating on 80 meters all circuits will be tuned to that band. On 40 meters, the plate circuit of the oscillator, as well as other two stages, will be tuned to 40 meters. For 20-meter operation, we have the plate circuit of the oscillator tuned to 40, the first amplifier, V2, tuned to 20, and the final amplifier, V3, tuned to 20 meters. In this transmitter, external bias is needed for the amplifier stages This can be supplied by conventional B batteries or off an especially designed low-voltage power supply.

Method of Coupling Antenna

In Figure 3, we have shown the various methods of coupling an antenna to a push-pull amplifier. In Figure 3A, we have the ***impedance-matching*** network used with two-wire feed systems. In adjusting this type, the amplifier plate circuit is adjusted for minimum plate current without the net work attached to the amplifier coil; then the two feed wires are attached to the plate tank coil and Condenser C1 ***immediately*** adjusted for a minimum plate current in the amplifier. If a dip in the plate current cannot be obtained, C2 should be changed from minimum to maximum, or vice versa. If a minimum setting of C2 will not allow a dip in plate current when C1 is adjusted, then the maximum setting will. C1 and C2 should then be adjusted until the plate current of the amplifier rises to normal value for ***full-load*** conditions, always setting C1 to a point giving ***minimum plate-current.*** The plate tuning condenser should never be touched after it first has been adjusted without the feeders connected. In Figure 3B, we have the usual inductive coupling where either series or parallel tuning of the feeder system is employed. ***Link-coupling*** can also be used between the final amplifier and the antenna circuit, as shown in Figure 3C. In Figure 3D, we have ***link-coupling*** to a single wire antenna with a tuned circuit connected to one end of the antenna. In this case, the total antenna length from the tuned circuit to its farthest end should be slightly less than one-half wavelength.

CHAPTER 7

ANTENNAS and FEEDERS for AMATEUR STATIONS

● ONE of the most important parts of any short-wave station, transmitting or receiving, is the *antenna*. We will endeavor to point out in simple English the nature of each type of antenna and its various uses.

The "Half-Wave" Antenna

It is an established fact that a wire will resonate at a wave-length twice as great as the actual length of the antenna in meters. This is called in radio circles a ***half-wave*** antenna. On the other hand, certain antennas, which are apparently one-quarter wavelength long, may be used when operating against ***ground*** (Earth.) This is shown in Figure 1A. The current and voltage distribution along an antenna of this type, which is commonly called the ***Marconi antenna,*** is shown by the curves I and E. We notice that the point of maximum voltage is at the ***ungrounded*** end, while the point of maximum current is at the ***grounded*** end. In Figure B and C, we show how this type of antenna may be tuned and coupled to a transmitter or receiver. In Figure D, we show a method of operating a Marconi antenna with an ***untuned*** transmission line. This transmission line is connected to the antenna a short distance from the grounded end. Usually, this distance should be equal to 28% of the length of the antenna which as stated before, is one-quarter of a wavelength. In Figure 2A, we have the well-known ***one-half wave*** antenna. The length of this antenna in feet for any given frequency is expressed by the following formula:

$$L = \frac{492{,}000}{F} \times K = \text{feet}$$

Where L is the length of the antenna in feet, and F is the frequency in KC., and K is the correction factor. Below 3,000 kc., K=.96. From 3,000 to 28,,000 kc., K=.95, and above 28,000, K=.94.

Points of Maximum Voltage and Current

In Figure 2A, we find that the point of ***maximum current*** is in the ***center*** of the antenna, and the point of ***maximum voltage*** is at the ***ends*** of the antenna. This ***half-wave*** antenna is undoubtedly the most popular of all types.

In Figure AA, we find the entire current distribution group for an antenna a half wavelength long, one wavelength long, 1½ wavelengths long, and two wavelengths long. This corresponds to a single antenna operated on any one of three amateur bands. If it were cut to operate as a half-wave antenna on 80 meters, for instance, it would be a full wave antenna on 40 meters, and the current distribution would be shown by curve B. It would then be said that the antenna was operating on the second harmonic, as a full-wave antenna. If the same antenna were operated on the 20-meter band, the curve D, indicates that it is operated on its fourth harmonic, and the antenna would be two wavelengths long. Now, curve C shows the current distribution when the antenna is operated on its third harmonic, or when there are three half waves standing on the antenna. For instance, if we wish to construct an antenna operated on its third harmonic in the 40-meter band, the antenna would have a length of three half waves or 60 meters. Third harmonic antennas are not very popular because the average Ham desires an antenna as short as possible. Antennas are usually fed or excited at either point of high current, or a point of maximum voltage when tuned feed lines are used. For instance, in the Zeppelin type antenna where the feeders are connected to the end of the antenna for a point of high voltage, the antenna is said to be voltage-fed. In the doublet type, where the feeders are connected to the center of the antenna, i.e., a half-wave antenna, it is said to be current-fed. Antennas fed at the center are only current-fed when they are a half wavelength long. This is clearly shown by the curves A and C in Figure AA. If an antenna had a current distribution as shown by Fig. B or D and was fed in the center, it would be said to be voltage-fed. Another method of exciting an antenna, which will be described later, is by an untuned transmission line matched in impedance to the antenna at any point which may provide the necessary impedance match. In Fig. 2—B, C and D, we have this sort of an antenna.

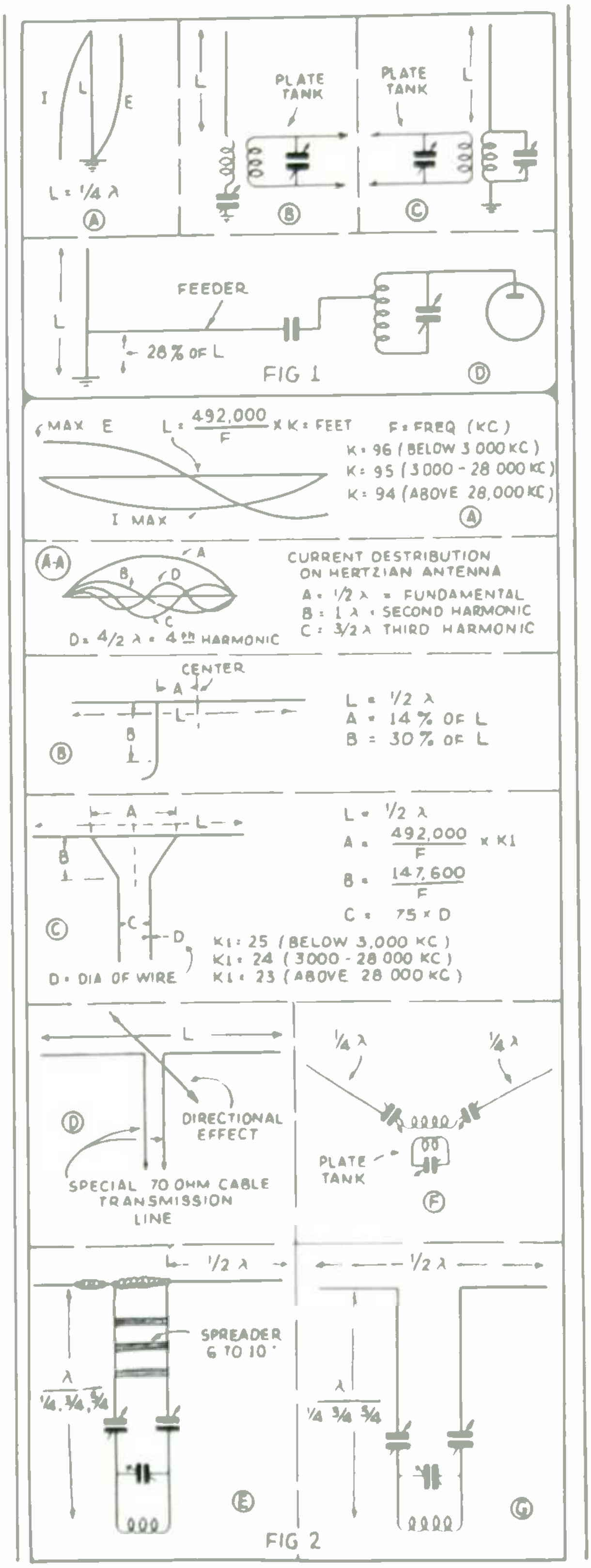
In Figure 2B, we have what is known as the ***single wire matched-impedance*** feed system which consists of a single wire attached to the flat-top ***slightly off center.*** The distance (A) between the center of the antenna and the point where the feeder is attached, is equal to 14% of the total length of the antenna flat top. With this type of antenna, the feeder should be run at right-angles to the flat-top for a distance of at least 30% of the length of the antenna. In Figure 2C, we have the two-wire feed matched impedance antenna, using a 600 ohm transmission line. The dimensions are:

$$A = \frac{492{,}000}{F} \times K^1$$

$$B = \frac{147{,}600}{F}$$

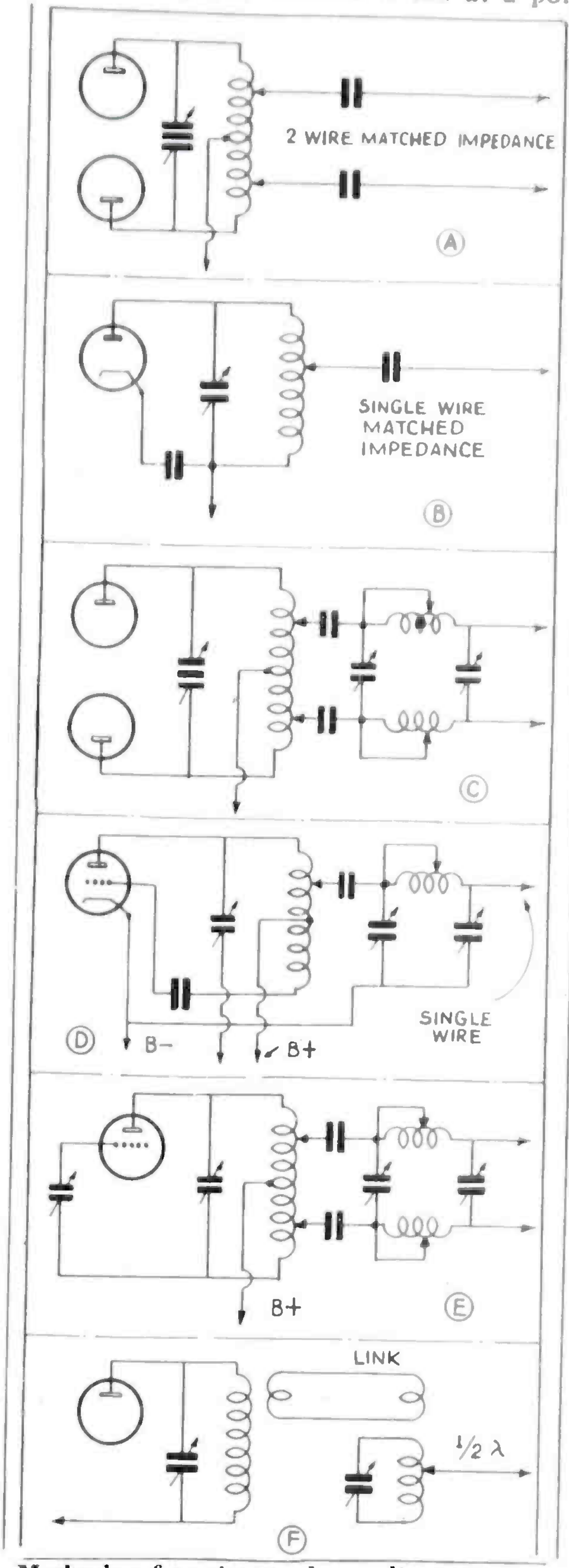
and C=75 X D. K= .25 for frequencies below 3,000 kc., .24 from 3,000 to 28,000 kc. and .23 for all frequencies above 28,000 kc., and D is the diameter of the wire. In other words, the spacing between the two feeders should be equal to 75 times the diameter of the wire. This antenna should also have its feeder system running at right angle to the flat top for a considerable distance. Tests have proven that when a halfwave antenna is split in the center (Fig. 2D) it represents an impedance of 70 ohms at this point. Recently, various cables have been introduced on the market having a characteristic impedance of 70 ohms. This type of cable can be connected directly to the center of a half-wave antenna.

In Figure 2E, we have the very popular ***half-wave Zepp*** antenna which is voltage fed by a pair of "folded-up" feeders. The length of the feeder systems, in this case, is quite important because they form part of the antenna, although they do not radiate because the fields about the two wires cancel,



Details of the Marconi and Hertzian type antennas showing the voltage and current distribution.

being 180 degrees out of phase. In Figure 2F, we have the half-wave antenna *current-fed* (meaning the antenna is fed at a point of maximum current) in the center with a coil and two tuning condensers used for tuning the antenna to exact resonance with the transmitter frequency. The disadvantage of this type antenna, of course, is that the *radiating* portion of the antenna is usually brought directly into the transmitter room.



Methods of tuning and coupling antennas to the final amplifier of your transmitter; also "impedance-matching" networks which provide a great increase in the efficiency of the antenna system.

In Figure 2G, we have the half-wave antenna with a tuned feeder system connected to its center. This is also a *current-fed* antenna system when the total flat top length is equal to one-half wavelength. The feeders of this system will have approximately the same dimensions as those for the Zeppelin antenna, i. e., they can be 1/4, 3/4, 5/4, etc., any odd number of quarter waves in length. All of these half-wave Hertzian antennas are quite directional in directions at right angles with the plane of the antenna; in other words, should an antenna point north and south, it would be directional east and west.

Aerial Constructional Details

The most important elements of any antenna systems are its height and insulation. The Hertzian antennas, regardless of the type or how it is energized, should be as high as possible. The average height above ground for best results should be at least 1/4 wavelength. Insulation, wherever used, should be glass or preferably glazed, porcelain or isolantite, and the insulation at the ends of the antenna should be from 8 to 12 inches. In draping the feeders about the "shack," all sharp bends should be avoided. Wherever a bend is necessary, it should be well rounded out rather than making a sharp angle. Another important part of an antenna system is the method of coupling to the transmitter. In Figure 3A, we have the usual connections for the two wire-matched impedance antenna. In Figure 3B, we have the *single-wire* antenna connected to a single-ended power amplifier. Both of these antennas should be connected through condensers in order to keep D. C. plate voltages out of the antenna system. In Figure 3C, we have the well-known *impedance-matching* network, wherein two variable condensers and two coils are used for tuning and matching a two-wire feed system to the transmitter. With a tuning device of this type, and the correct impedance match which it provides between the antenna feeders and the amplifier have proven to be very efficient, and many times increase the effective radiated power of the transmitter a goodly percentage.

In Figure 3D, we have the same type of antenna-matching device except that only a single coil is used. This is for coupling a single feed system or a single wire of any convenient length to a single-ended amplifier. The two-wire feeder system can be coupled to the single-ended amplifier merely by making both ends of the tank coil *hot.* This is done by feeding the B plus or the low R.F. potential portion to the center of the coil. This is clearly illustrated in Figure 3E. Many amateurs have reported excellent results with a well-known German antenna wherein a separate tuned circuit is used to couple the antenna to the transmitter. In Figure 3F, we show the Fuchs antenna link-coupled to the plate coil of the amplifier. With this type of antenna a very loose coupling is needed, otherwise it would be almost impossible to get the antenna into resonance with the transmitter frequency. In Figure 3G, we have the usual inductive coupling where the antenna coil is coupled to the low potential end of the plate coil and the transmitter. Coupling is varied by changing the distance between the two coils. This type of feeder system may also be link-coupled to the amplifier, as shown in Figure 3H.

All types of tuned coupling, except impedance-matching networks, should be

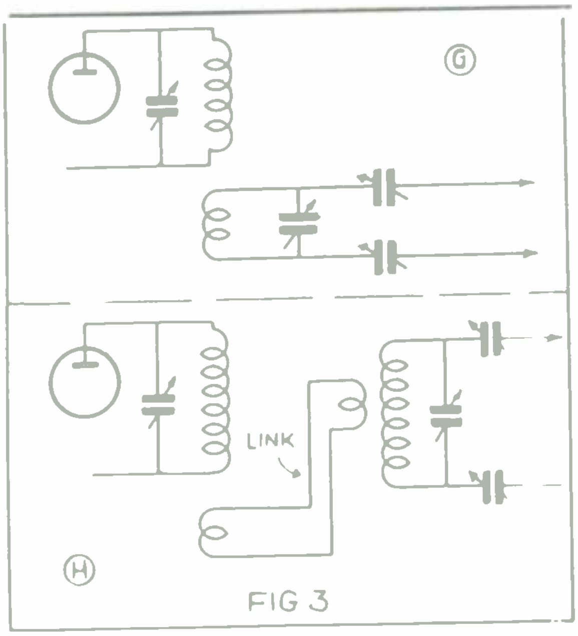


FIG 3

tuned to exact resonance and the coupling made loose rather than close coupling with a detuned antenna. This takes in the usual systems used with the Zepp and the doublet type antennas, which are tuned with a coil and condenser combination.

The plate circuit of the amplifier should also be reset to resonance after each antenna adjustment, except where the matching network is used.

CHAPTER 8

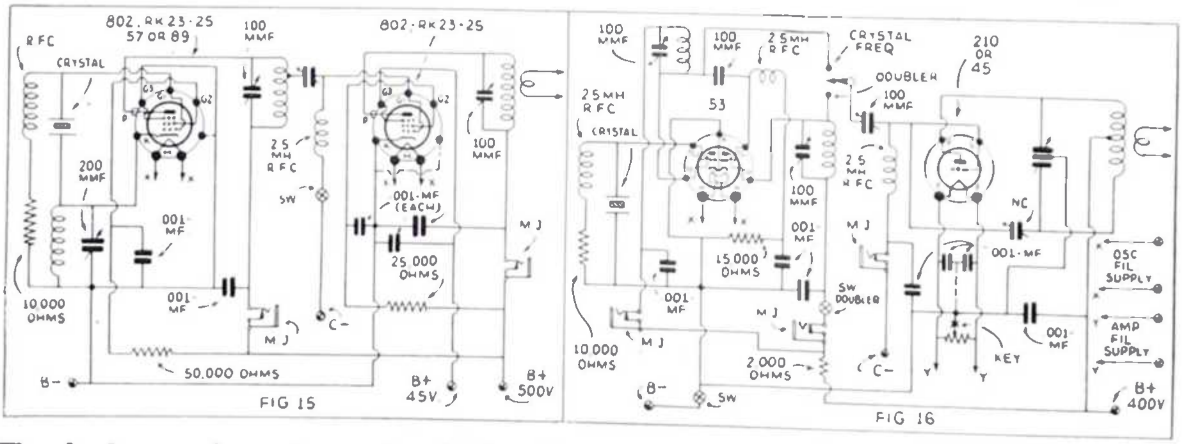
SELECTION OF TUBES FOR LOW-POWER EXCITER STAGES

● THE choice of tubes for the *oscillator, buffer,* or *multiplier* stages of a transmitter is always quite a problem to the amateur. Also the circuits to use are numerous, especially with the recent tube developments. In Fig. 1, we have the conventional triode *crystal oscillator* circuit; with this tube the crystal is used in the grid circuit and oscillation is brought about when the plate circuit is tuned to approximately the crystal frequency. This circuit was the first to be used among amateurs when crystals were still a *luxury.* Either series or parallel plate feed may be used in this circuit. Fig. 1 shows the *series* method, while Fig. 2 is the same set-up but with *parallel* feed. Number 2 allows the rotor plate tuning condenser to be independent of the high voltage, and it can be mounted on a metal panel or chassis with no insulation.

The next popular crystal circuit was that using the 47 pentode; this was a considerable improvement over the former circuits. In Fig. 3, we find the conventional 47 pentode, which proved to be an excellent crystal controlled oscillator and allowed less R.F. crystal current; thus lightening the load on the crystal. In Fig. 4 we have the same circuit except that the heater—cathode type tube is used; such as the 59, 2A5, etc. There is little advantage in this circuit over the 47 aside from the fact that the heater is separate and no filament bypass condensers are necessary.

Tritet Oscillator

Later developments in pentode circuits brought forth the well-known Tritet oscillator as shown; this is a modification of the Dow oscillator. In this circuit we can multiply the crystal frequency in the plate tuned circuit, independent of the crystal oscillatory circuit. However, the plate circuit can not be tuned to the crystal frequency because of insufficient internal shielding in the tube. This circuit is shown in Fig. 5, and a number of different type of tubes may be used as is indicated. A more flexible adaptation of this same circuit is shown in Fig. 6 where the screen grid pentode tubes are used, the shielding in these



The dual pentode exciter unit, which will operate on any one of three bands, with one crystal and drive the average medium-power amplifier.

Fig. 16: The 53 twin triode is used as an oscillator and multiplier. This will also excite the average medium-power "final" amplifier.

tubes is sufficient to allow plate circuit to be tuned to the crystal frequency or an harmonic of it Here the power pentodes such as the 802, RK23, 807 or RK39, etc., may be used, or the pentode receiving type tubes where only low-power stages are required. Where a number of multiplications are necessary, the *receiving type* tubes, such as the 57 and 59, are recommended, because of their low cost, and very respectable power "out-put." In the receiving type tubes though there seems to be little advantage in applying a positive potential to the suppressor, while in the power-type tubes this does increase the out-put appreciably.

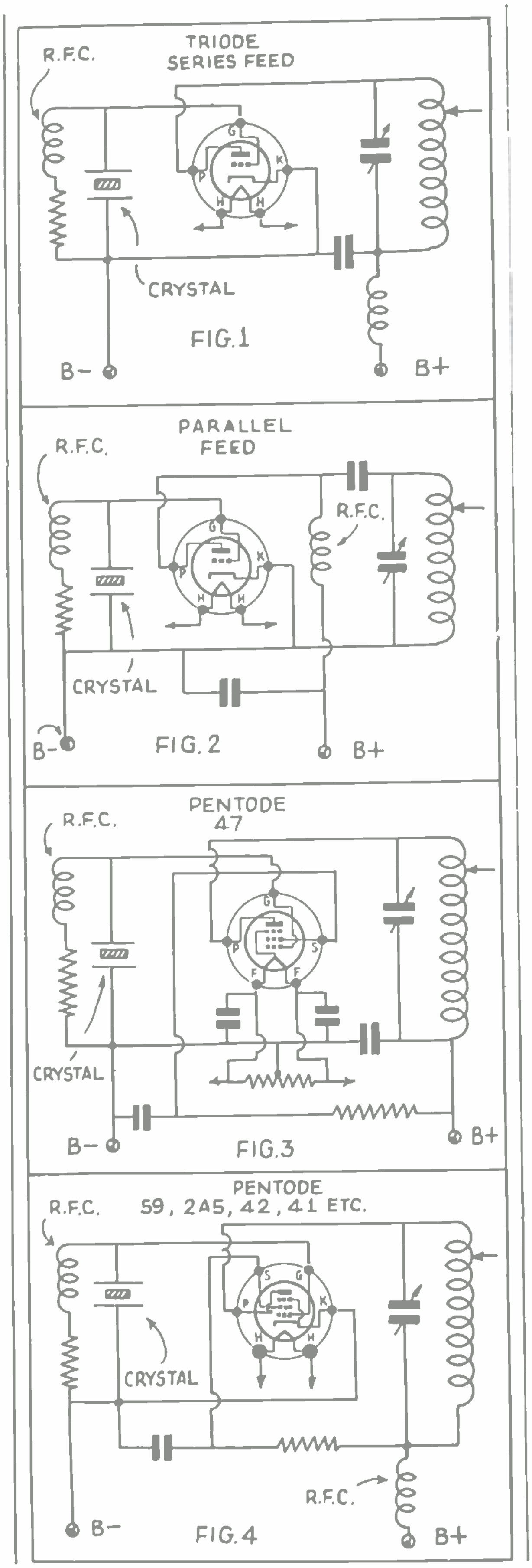
Neutralization

So much for the oscillator circuits. We now consider Fig. 7 in which an amplifier tube is added to the oscillator. Here we have a triode neutralized amplifier when operating on a crystal frequency. For a frequency multiplication *neutralization* is not absolutely necessary, although the neutralizing condenser and the tapped coil arrangement should be employed, because a certain amount of regeneration may be obtained by the proper adjustment of this condenser N.C. and thus increase the harmonic out-put considerably. Those who have not tried this method of *frequency doubling* will be well rewarded with a considerable increase in "output," through the use of the neutralizing condenser, which then becomes merely a *feed-back control.* The coupling between the two stages in this instance is *capacitive.*

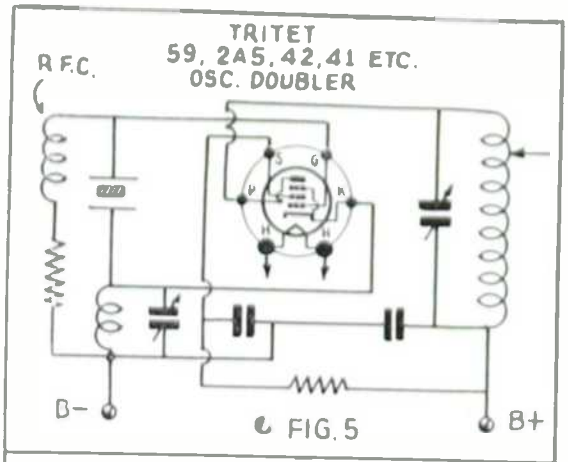
Link Coupling

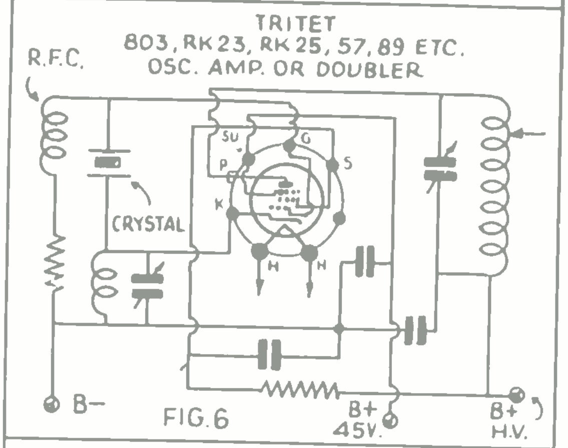
In Fig. 8 we have both the grid and plate circuits of the amplifier tuned and link coupled to the preceding stage. This *link coupling* may consists of one or two turns connected with a twisted pair of insulated wires coupled to both tank circuits. This is a recommended method where the extra coil and condenser can be incorporated conveniently in. the set-up, although where a great many multiple stages are used, as pointed out previously, employing receiving type tubes, this method would be entirely too complicated and the advantages would probably be slight. It is only in the last *buffer* or between the last *buffer* and the *final amplifier* stages where this method is really a distinct advantage.

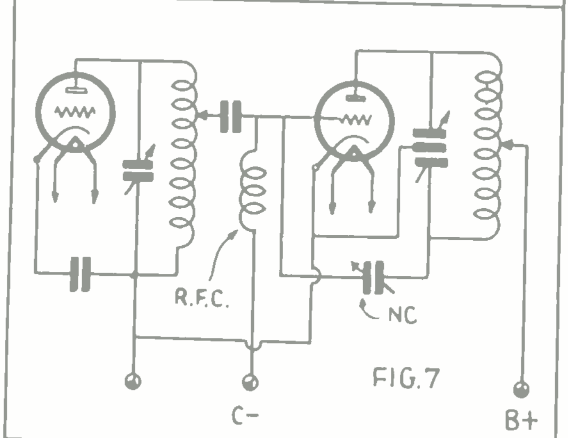
In Fig. 9 we have the same circuit except that we use two tubes in *push-pull.* In this case one link coil is coupled to the B plus end of the driver tube, and the other coupled to the center of the grid tuned circuit,

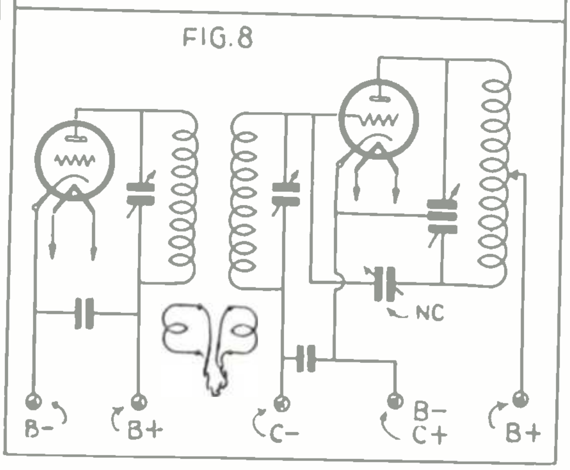


Above we have the triode and pentode crystal oscillator, using conventional circuits.









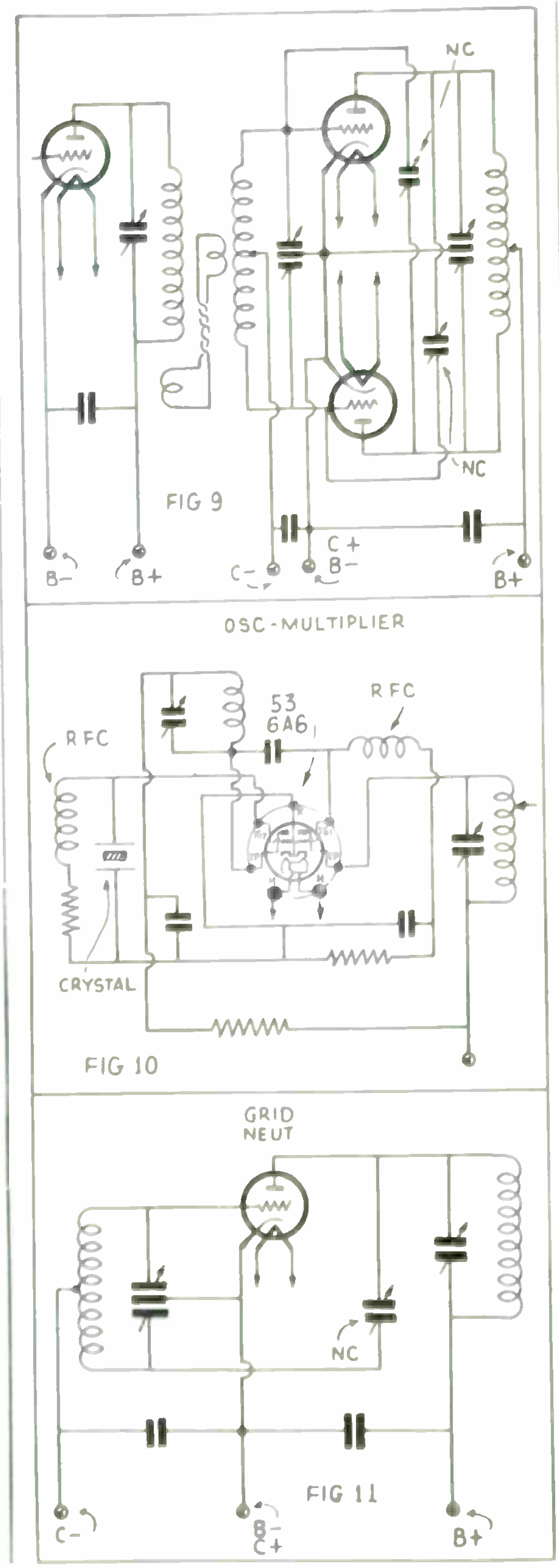
Here we have the oscillator—multiplier—and also neutralized amplifier and doubler.

while in Fig. 8, both coupling coils were coupled to the low potential end of the tuned circuits. The push-pull circuit, of course, is not suited for *frequency doubling* although it is recommended for *tripling*. However, *frequency tripling* is *not* commonly used in the amateur bands.

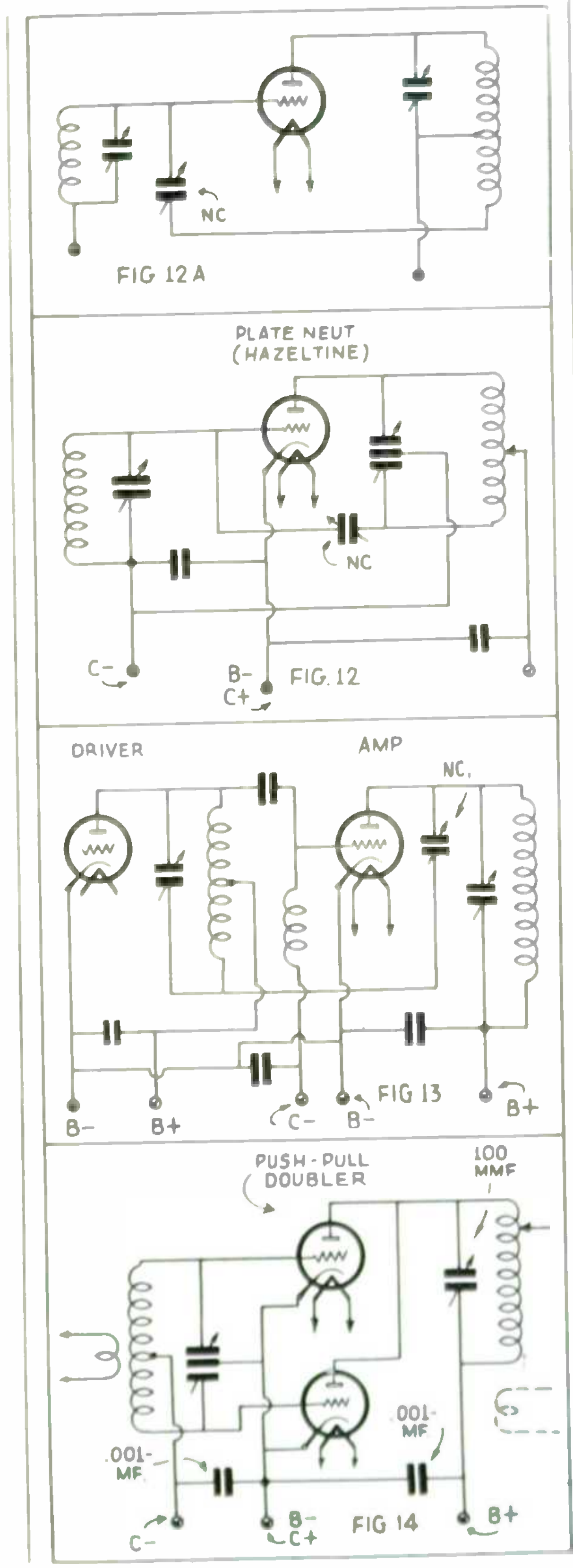
We can also obtain frequency multiplication with a single tube in another manner as shown in Fig. 10. This is the twin triode type, such as the 53 and the 6A6, where one section is used as a plate-tuned *crystal oscillator* and the other triode section capacitively coupled to it, is used as a *harmonic amplifier*. Choosing the proper method of neutralizing amplifiers is another problem which very often confronts the amateur. Either *grid neutralization*, as shown in Fig. 11, or *plate neutralization* (Hazeltine) may be used. There is really no difference in the two circuits where adequate driving power is employed. However, in some instances the plate neutralization method may be slightly superior. In both of these circuits, we have used a center-tapped coil, with the tuning capacity shunted across the entire inductance. Another method of accomplishing this is shown in Fig. 12A, where the tuning condenser is only shunted across the plate section of the coil. If the plate coils are well constructed and tapped in the *exact electrical center*, the methods shown in Figs. 11 and 12 are more convenient, because coils may be changed without requiring a *resetting* of the neutralizing condenser. Neutralization voltage may be also obtained as shown in Fig. 13; that is, directly from the driver-stage tank coil.

If push-pull circuits are to be used for frequency doubling, then the connections, as shown in Fig. 14, must be employed. In this case, the grids are connected in the usual push-pull manner, while the plates are connected in parallel. This is a very efficient *frequency doubler* although it employs two tubes instead of one, and unless the increased power obtained in this manner is really necessary, the complication does not warrant the use of this type of multiplier. The most versatile and efficient oscillator and multiplier circuits where low-powered exciters with an out-put of around 10 or 15 watts is required, are shown in Fig. 15 and 16. In 15 we have the pentode *Tritet "oscillator buffer"* or *multiplier*, which in turn drives another screen-grid tube. This arrangement will provide 10 to 15 watts output used as amplifier and not a multiplier, and around 5 to 10 watts when *doubling* takes place in the plate circuit of the amplifier.

In Fig. 16 we have used the combination oscillator and multiplier with the 53 tube, using a two-point switch for operation either at the crystal frequencies or the second harmonic of it, and a 210 or type 45 tube is used as an amplifier.



Here we have various types of multiplier and buffer stages.



Different methods of neutralizing and also push-pull doubler.

CHAPTER 9

THE FUNDAMENTALS OF AMPLITUDE MODULATION

THE term modulation alone might scare the uninitiated, but, really, the radio transmission of voice and music is not in the least complicated if a few of the basic principles are clearly understood. An ordinary continuous wave or CW transmitter emits a wave of constant power or amplitude when the key is held down. Theoretically when transmitting code signals, the transmitter is modulated in the form of dots and dashes. In this case, however, the wave is cut off abruptly to form the characters. In the case of radio telephony, the audio frequency modulation varies the power output of the transmitter in accordance with the intensity of the audio frequency variation imposed upon the microphone.

The analogue shown in the drawing Fig. 1. where we have a person standing on a hose indicates a hydraulic analogy of modulation. For instance, if the gentleman in question were to press his foot down, shutting off half the water flow, he would then by moving his foot up and down be able to either increase or decrease the flow of water. The degree by which he may increase or decrease the water would be analogous to the volume of the imposed voice signal, and the rapidity with which he may repeat this motion would be analogous to the voice frequency. In other words, modulation does nothing more or less than vary the output of the transmitter at voice or audible frequencies. The degree of variation is the percentage of modulation, and the number of times it makes a complete change is the frequency of the audio component. In diagram 2 we have graphically illustrated how modulation affects the transmitted wave. In the beginning at "A" we have the normal carrier amplitude. Now if we increase this 75%, for example, on one-half of the audio cycle it would naturally be followed by a similar decrease below

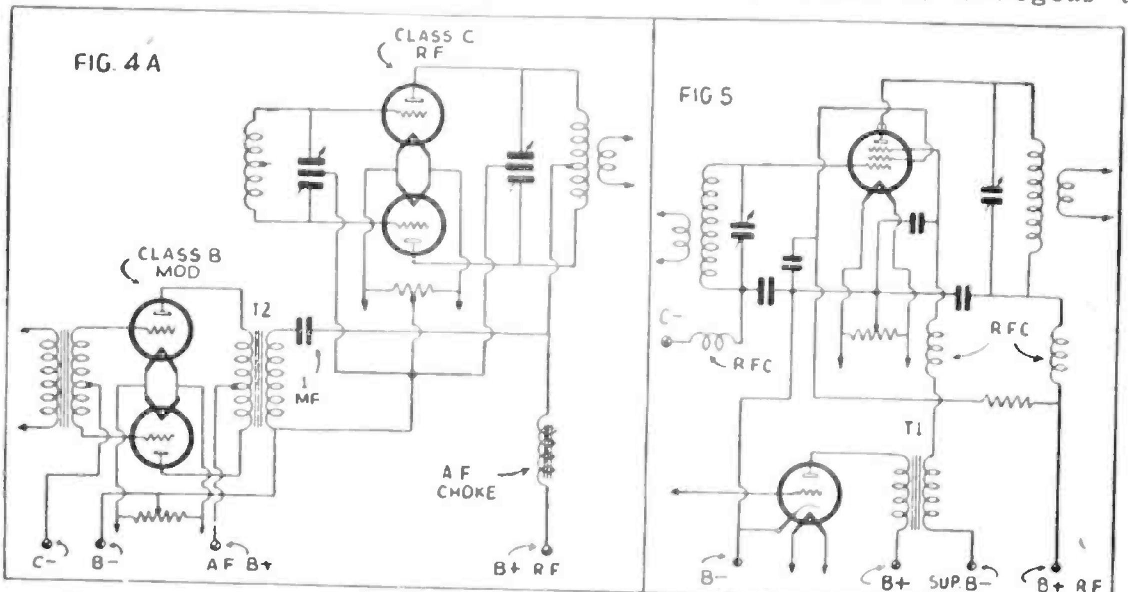
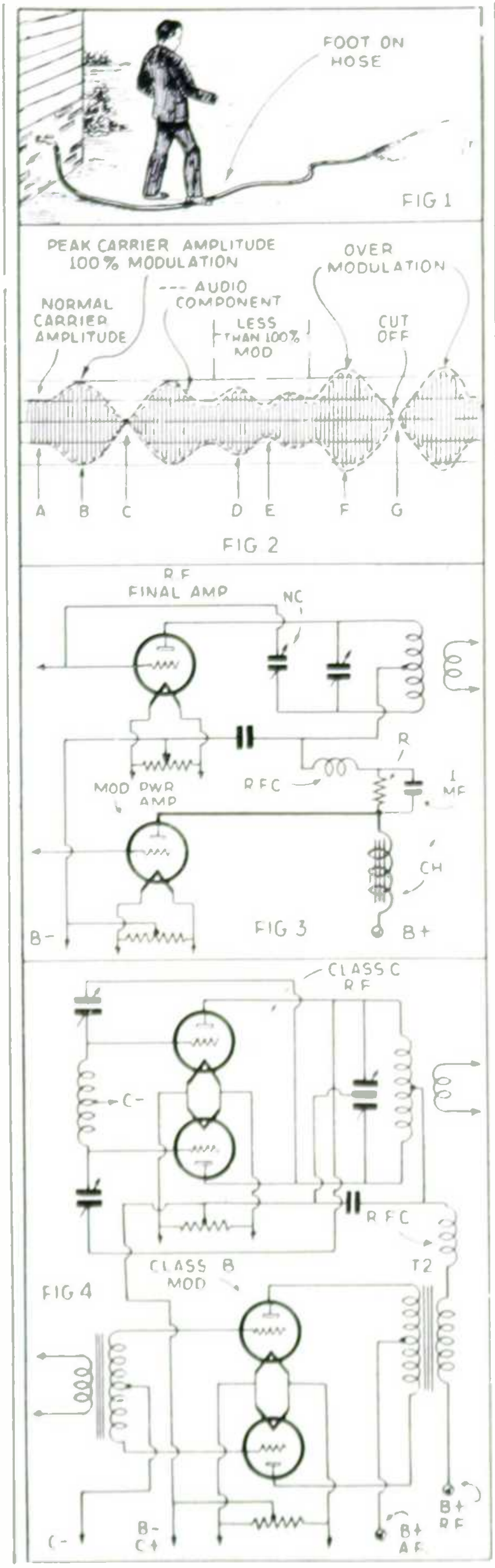


Diagram of Class "B" modulator and also suppressor grid modulation.



Methods of coupling modulator to R.F. amplifier.

normal, during the opposite half of the audio cycle.

Therefore, it can be seen by referring to the diagram, that we have limits to the increase and decrease. This limit is commonly termed 100% modulation. At point "B" we find the carrier has been doubled in amplitude, then this is followed by the reverse of this action and the carrier is reduced to zero at point "C." If we only modulated the carrier slightly or some amount less than 100%, it does not cut off completely, and neither does it increase to double the amplitude. This is shown in points "D" and "E." We may, however, modulate the transmitter more than 100% as shown in points "F" and "G." The peaks here are well over twice the normal carrier and while the transmitter output can be reduced no further than zero, distortion comes about due to the fact that the output remains zero for the same length of time that it was greater than twice the amplitude. This causes considerable distortion and interference and should be avoided in all cases.

Thoroughly studying the hydraulic analogue, together with the graphic illustration in Fig. 2, should provide anyone with the necessary knowledge of how modulation is accomplished.

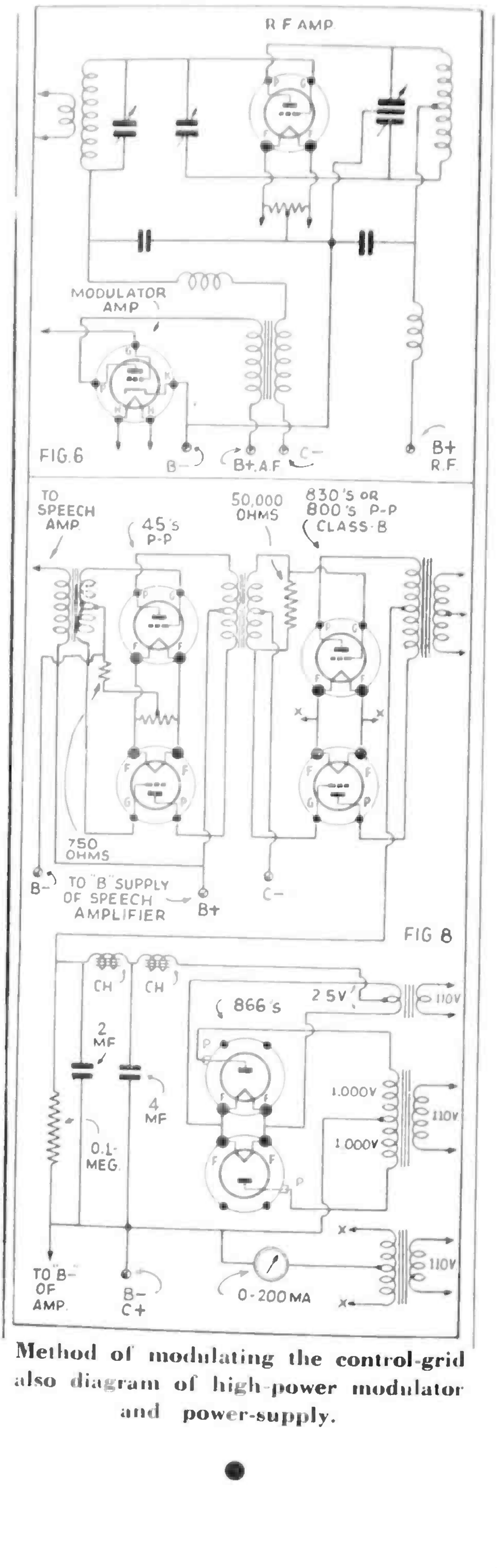
Modulation of a transmitter may be accomplished electrically in a number of ways. The plate voltage to the final amplifier of a transmitter may be varied as shown in Fig. 3 or 4, or by other well-known methods.

In Fig. 3 the modulator merely changes the plate power input to the rf. amplifier at voice frequencies. By connecting the output circuits of the modulator and rf. amplifier in parallel and feeding the D.C. voltage to the two tubes through the audio frequency choke CH, the audio voltage is developed across the choke and either adds to the effective plate voltage applied to the amplifier or cancels it. If we were to develop 300 volts of audio frequency across the choke and the voltage applied to the rf amplifier without modulation was 300 volts, we would find that on the plus half of the AF cycle we would have 600 volts applied to the rf amplifier. This would be the 300 original volts and the 300 volts developed on the modulator. Now on the negative half of the cycle we have 300 volts minus which actually nullifies the original 300 volts applied to the rf amplifier, resulting in zero plate voltage. The rf. amplifier in this case is operated *class C*, as described in a previous chapter, where the changes in power output is directly proportional to changes in the power input. Therefore, when plate voltage is redoubled the amplitude of the carrier is doubled and when the plate voltage is reduced to zero, of course the output is also zero. In Fig. 4 we have other methods of accomplishing the same conditions through the use of push-pull modulators coupled to the amplifier through transformers.

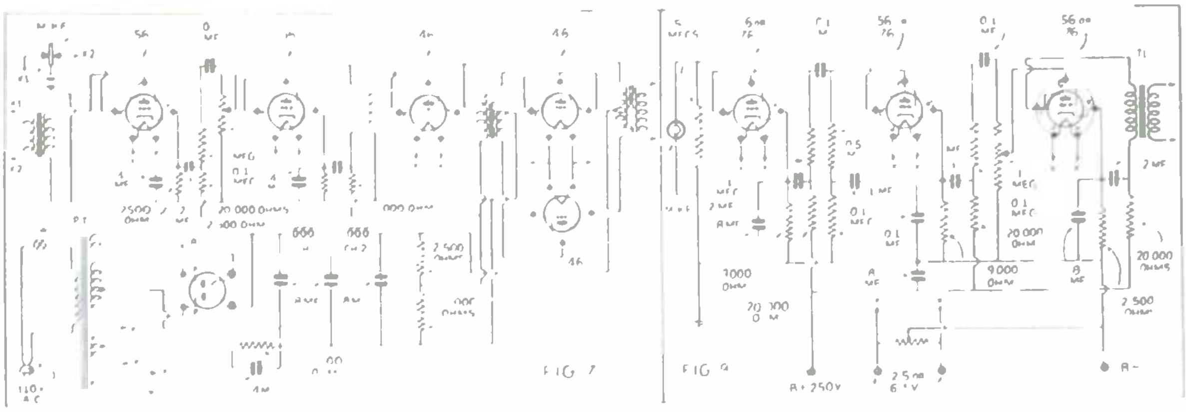
Another method of varying the output of the transmitter is shown in Fig. 5. This is the recently introduced suppressor modulation, where changes in suppressor voltage have direct control over the output of the amplifier. These tubes are pentodes such as the 802, 803, RK20, and many others. In this case, however, the audio power requirements are not as severe as when plate modulation is used. For in plate modulation if we have 50 watts input to the R.F. amplifier, that is D.C. plate voltage times D.C. plate current, we need at least 25 watts of audio power. In other words, for plate modulation the audio requirements are just 50% of the power input to the modulated amplifier for 100% modulation. In figure 5, the audio requirements are, of course, much less. Usually 5 or 6 watts of audio is more than sufficient to modulate even the largest of pentodes. The adjustment of a suppressor modulated amplifier is quite simple. The suppressor voltage is adjusted until the output of the amplifiers is reduced to about 25%. This is accomplished by running the suppressor *negative*. The audio voltage is then coupled to the suppressor through a suitable transformer, and in this manner will increase and decrease the suppressor voltage, thus causing an increase and decrease in the power output of the tube.

In Fig. 6, we have grid modulation. This is accomplished by adjusting the RF. amplifier so that the variation in output is directly in proportion to the changes in grid voltage Here, too, only a low-powered modulator is required. The output of a grid modulator may even be less than that required for suppressor modulation.

In Fig. 7, we have a diagram of a complete modulator with an output of around 25 watts. We have two stages of speech amplification using type 56 tubes, coupled to a 46 connected as a triode driver for the class B 46's. The output transformer should be of proper design to match the output of



Method of modulating the control-grid also diagram of high-power modulator and power-supply.



Complete 25-watt modulator and speech amplifier diagram together with a speech amplifier for a "low-level" microphone.

the modulator to the input circuit of the modulated amplifier. Such a modulator will modulate any transmitter having a plate input of 50 watts. For higher power inputs, naturally greater modulator power is necessary.

In Fig. 8 we have the type 830B's or 800's as class "B" modulators with type 45's as ***drivers***. These tubes will modulate up to a 200-watt power input. The output of such an amplifier is around 100 watts. The speech amplifier in Figure 7 will serve for the average double-button carbon microphone or a crystal microphone. For lower-level microphones, naturally greater amplification is necessary, and in Fig. 9 we have shown three stages of resistance coupled triodes.

In dealing with high-gain speech amplifiers of this sort, sufficient circuit isolation or de-coupling must be employed in order to eliminate feed-back and audio frequency oscillation.

T1 in diagram 9 should be coupled to the driver stage of any modulator. For instance, it would be coupled to the 45's in push-pull of figure 8.

Below is a list of modulators which may be used with various types of power amplifiers. These are all, of course, for plate modulation.

R.F. Amp. Tubes	*Input to R.F. Amp.*	*Modulation Tubes*	*Mod Output*
46's, 10, single push-pull or par.	50W	46's Class B	25W
801's in push-pull	100W	10's in Class B	50-60W
800's in push-pull	150W	800's in Class B	100W
211-03A-838-830B	up to 200W	800's in Class B	100W
For inputs exceeding	200W	use 838's or 203A's Class B	200 to 260W

CHAPTER 10 • • •

POWER SUPPLIES FOR AMATEUR SETS

● THE most important part of a transmitter, or any piece of radio apparatus, is the source of power or the *power supply unit.* In nearly all cases the power for operating radio transmitters and receivers is taken directly from the alternating current power mains. In Fig. 1, we have the various types of rectifier units for operation directly from alternating current. Principles of alternating current and the action taking place in rectifier circuits have been clearly defined in previous lessons of this course In Fig. 1A, we find a representative drawing of alternating current with each half of the cycle numbered starting with 1.

The Half-Wave Rectifier

In Fig. 1B, we have the well-known half-wave rectifier with its pulsating D.C. output also illustrated. We find that the first impulse is transmitted to the output of the rectifier system. The second impulse though, as shown by the dotted line is not transmitted, and then No. 3 which is in the same direction as No. 1 is also transmitted, and so on to No. 5. Here we find a considerable space in between each impulse which is received at the output terminals of the rectifier system. This is characteristic of all half-wave systems, and it will be seen that this is much harder to filter or *smooth out*, due to the great time space occurring between the direct impulses.

Full-Wave Rectifier

However, we can utilize the other half of this A.C. input cycle, by what is known as the *full-wave* rectifier system, diagrammed in Fig. C. In this case we have no particular time space between the impulses as shown in the drawing accompanying Fig. C. This current, of course, is much easier to filter because of the relative *smoothness* compared with the output of the rectifier in Fig. B. In Fig. C, we utilize a center-tapped transformer, where the output voltage of the rectifier is approximately equal to ½ of the entire secondary voltage, or approximately equal to the voltage existing on either side of the center tap.

Voltage Either Side of Center Tap

This transformer, for instance, may deliver 500 volts at the output terminals of the rectifying system. This would require that each side of the center tap deliver 500 volts, making a total secondary voltage of 1,000. This same transformer can be made to deliver 1,000 volts at the output terminals of the rectifying system if the entire secondary is used in a *half-wave* system, as shown in Fig. B. On the other hand, this would be difficult to filter. With a suitable rectifying system, we can obtain full-wave rectification and have the entire secondary voltage appear at the output terminals of the rectifier.

The Bridge Rectifier

In Fig. D we have the bridge rectifier system which requires four ½-wave rectifiers. Here the output is just as smooth as that shown in Fig. C, and the voltage is *twice as great!*

When selecting the power transformer, there are many things to consider besides the voltage rating. Of course, the primary of the transformer must be designed to operate at the voltage of the power mains. 110-volt mains require a transformer with a 110-volt primary, and if the power mains deliver 220 volts, then of course a like primary would be needed. We also have to consider the frequency of the A.C. service. The average of course is 60 cycles. However, in different parts of the United States, and in various foreign countries, the frequency may be anywhere from 25 to 60 cycles. The average 60-cycle power transformer will operate satisfactory on either 50 or 60 cycles. However, where 25 or 30 cycle power is available, a transformer designed especially to operate at that frequency will be required.

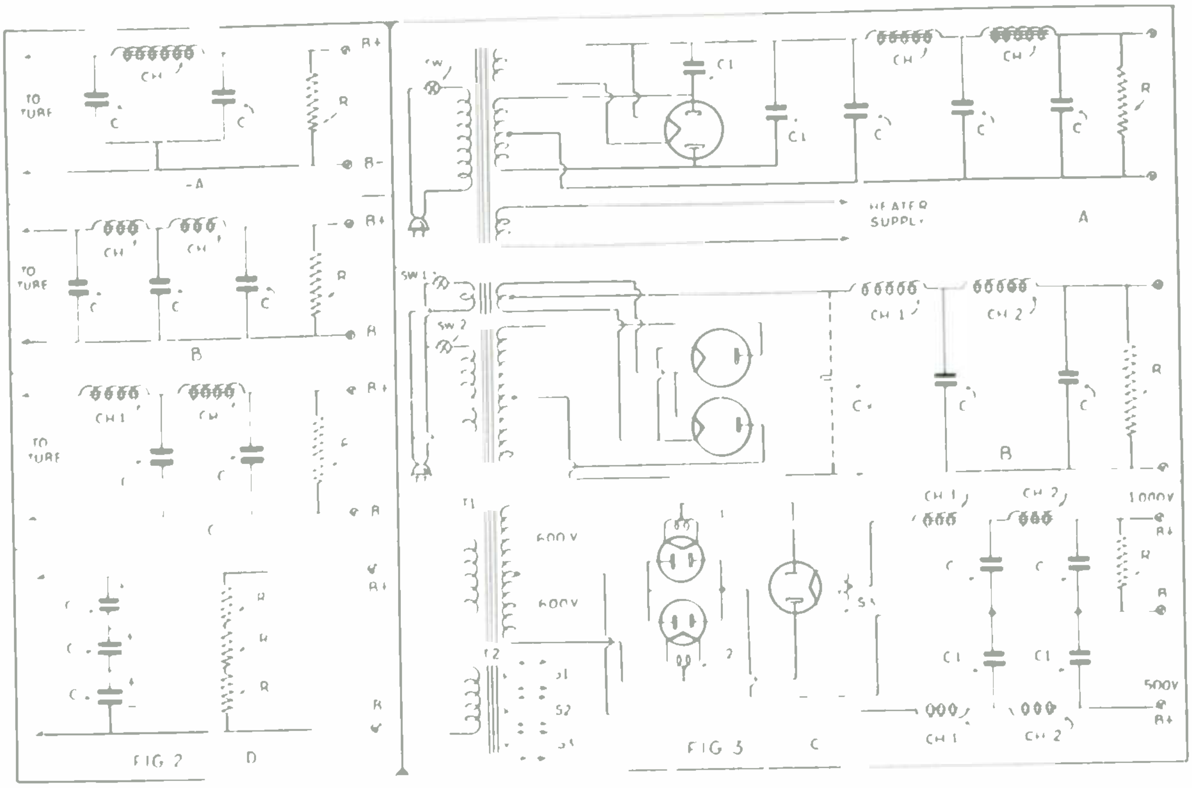
Power Rating of Transformer

The ***power rating*** of the secondary of the average transformer is given in volts and milliamperes. The voltage rating is determined entirely by the rating of the vacuum tube for which the transformer is intended to furnish power. For instance, the average 50-watt tube operates at around 1,000 volts, therefore, a transformer delivering from 1,000 to 1,250 volts will be required. Usually, the voltage rating of the transformer is slightly greater than the tube rating, in order to allow for a voltage drop in the filtering system. If the total load on the power supply, for instance, is to be 250 ma. (milliamperes), the current rating of the transformer will have to be 250 ma., plus the current drawn by the bleeder resistor. The bleeder will be covered later on in this chapter.

Choice of Rectifier Tube

The ***choice of the rectifier tubes*** is quite an important one. There are two types of rectifiers generally used among amateurs and experimenters. These are of the ***high vacuum*** type and the ***mercury vapor*** type. The high vacuum rectifier in former years was so designed that there was a considerable drop in voltage through the tube. Then to overcome this mercury was added to the tube and the ionization thus coming about during operation, lowered the resistance to a negligible amount, and, therefore, the voltage drop was practically eliminated. The rated voltage drop of the average ***mercury vapor tube*** is 15 volts.

For power supplies up to 300 volts the type 80 tube is recommended. For power supplies delivering in the neighborhood of 500 volts, the type 5Z3 is suitable. For good regulation in the 500-volt category, either the mercury vapor tube may be used or the new high vacuum "83V". The "83V" provides excellent regulation and has an extremely low voltage drop, due to the very close spacing of the elements. For the average power supply delivering in the neighborhood of 1,000 volts, with a center-tapped transformer, the type "866" which is a one half wave mercury vapor rectifier or the high vacuum type 836 are recommended. In fact, both of these tubes work well in power supplies delivering as high as 2,000 volts. The "866" may be used on voltages well above this figure.



In Figs. 2, A, B, C, and D, we have various types of filter networks together with a method of connecting condensers in series. In Figs. 3, A, B, and C, we have the three fundamental power supply systems. The receiving type, the low-powered transmitting type, and finally the dual power-supply, using the "bridge" rectifier system.

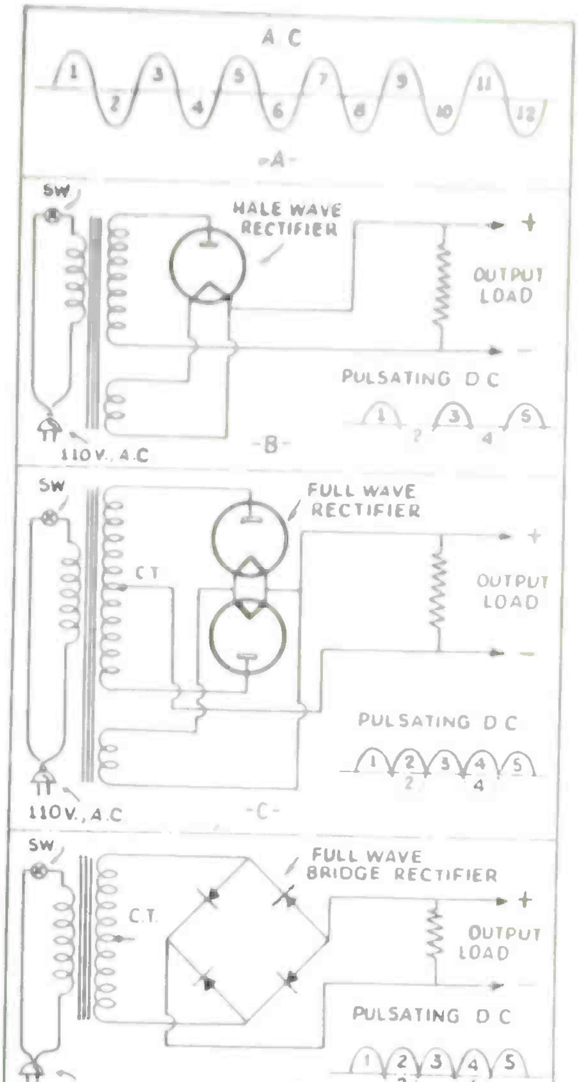


FIG. 1

In Fig. 1, A, B, C, and D, we have various types of rectifying circuits, including the half-wave, full-wave with center-tapped transformer, and the full-wave "Bridge" circuit.

The Filter Circuit

After the alternating current has been rectified, we have to use some sort of *smoothing* or *filtering* circuit in order to deliver pure D.C. to the transmitting vacuum tubes. In Fig. 2, we show various filter systems. In 2A, we have the so-called "brute force" filter, wherein a single choke and two condensers are used. The current carrying capacity of the choke should be identical to the transformer rating. The inductance of the choke for low-voltage filters should be around 30 henries, and is not at all critical. In Fig. 2B, we have the double-section filter using two chokes and three condensers. This provides greater smoothing than the one shown in Fig. A. Both of these are known as the *condenser input* types. Either of these filter systems work very well with the average 500-volt transformer, when the capacities of the condensers are at least 2 mf. each and the inductance of the choke CH is 30 henries each. For voltages below 500, the electrolytic condenser may be used to an advantage because of its low cost. The usual capacity of the electrolytic condenser is 8 mf. There are two types of these condensers; one is the wet, where the electrolyte is in the form of a liquid, and the other is the so-called *dry*, where the electrolyte is in the form of a paste. The advantage of the wet condenser is in that it may be overloaded and not damaged because of the *self-healing* effect which normally comes about in this type of condenser. The dry type, when punctured, usually has to be replaced.

For voltages over 500, of course the paper type condenser is really the best, and this should be of the *oil-impregnated* type. The voltage ratings of the condensers are given in peak voltage and D.C. working voltage. The D.C. *working voltage* (W.V.) should be slightly higher than the average voltage ouput of the power supply. For instance, a 1,000-volt power supply would require condensers having a W.V. rating of from 1,200 to 1,500 volts. In Fig. 2, we have the conventional filter arrangement used in the power supplies that develop 1,000 volts or over. In this case, we have *choke input*, meaning that there is no condenser across the input to the filter.

Filter Chokes

The regulation of a power supply of this type, regulation pertaining to the difference in output voltage during changes from minimum to maximum load, is better than the condenser input system. The input chokes CH1 should be of the *swinging* type. The second choke CH2 can be of the usual 30-henry type; or, in fact, anything from 15 to 30 henries seems to work well, where the input power is obtained from a 60-cycle source. When the power supply is to be operated from a 25-cycle source, the choke inductance and capacities of the condensers should be increased approximately 2.5 times to obtain the same amount of filtering at the output of each one of the filter systems shown.

In Figs. 2 A, B, and C, we must employ a so-called *bleeder resistor* or what might be called a "buffer load." The amount of power consumed by the bleeder resistor bears a definite relation to the variation of the power taken from the filter. However, values which give satisfactory results under known conditions are as follows: for 300 volts a 15,000-ohm, 25 to 35-watt resistor; 500 volts 20,000 ohms, 50 watts; for 1,000 volts, 25,000 ohms, 100 watts; 1,500 volts 35,000 ohms, 150 watts; 2,000 volts, 100,000 ohms, 200 watts. In some cases, the amateur may find that he has, for instance, two 1,000-volt condensers and desires to employ them in a filter circuit of 2,000-volt power supply.

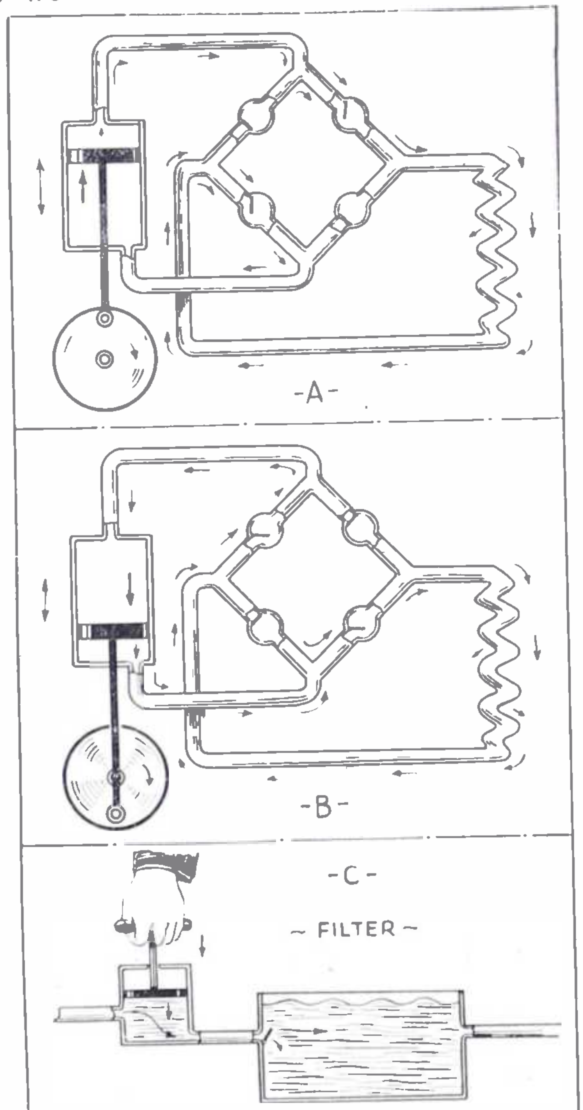
In Fig. 2 D, we have shown a method of connecting condensers in series and in order to obtain equal voltage across each one of these condensers a voltage divider must be connected across the condensers, as shown in 2 Fig. D. This is also necessary if electrolytic condensers are used in series and the polarity has been indicated. The value of R is not critical, and may be anywhere from 150,000 to 500,000 ohms each. This parallel resistor reduces the effective filtering capacity of the condenser slightly, but can be ignored for all general purposes.

3 Power Supply Line-Ups

In Fig. 3, we have three complete power supplies. Fig. 3A, shows the receiving type power supply using the type 80 tube. This circuit is satisfactory for voltages up to around 400. The two condensers marked C1 are used solely to reduce *tunable hums*, and the capacity is not critical. Something in the order of .002 to .006 mf. seems to work satisfactory. The ratings of the chokes depend upon the amount of current taken from the power supply, and also the current drawn by the bleeder R. The inductance, however, should be 30 henries, and the capacity of the condensers C should be 8 mf., electrolytics being the most economical.

In Fig. 3B, we have a full-wave power supply, using separate half-wave rectifiers. If the type 81 vacuum type tubes are used, condensers CX may be employed: that is, *condenser input* may be used to the filter, 1 to 2 mf. being the proper capacity of this condenser. For the mercury vapor type tubes, condenser CX should be eliminated. CH1 should be a *swinging choke* having an inductance of approximately 20 to 100 henries. CH2 may be in the order of 15 to 30 henries. Separate transformers are used for the high-voltage and filament supplies. In all cases, the filaments of the tubes should be switched on several minutes before the switch SW2 is closed.

In Fig. 3C we have the Bridge rectifier circuit used in a power supply capable of delivering two voltages; this is really two power supplies in one. Here we have utilized a center-tap transformer giving approximately 600 volts each side of the center tap. This delivers 1,000 volts through the filter on one side of the B negative, and 500 volts on the other side of B negative. A filament transformer having three separate filament windings is required. The tubes used are three types "83" mercury vapor rectifiers. CH1 in both cases should be *swinging chokes* and CH2 may be from 15 to 30 henries, the same as in 3B. The condensers C, of course, will have to have a rating high enough to safely stand the 1,000 volts, but condensers C1 will require only one-half this rating. If the power transformer, T1, is capable of supplying 300 to 400 ma., this power supply makes an excellent combination to run an entire transmitter, including the low-power stages as well as the final ampiifier.



Here we have analogies of the "bridge" rectifier circuit in hydraulic form, and also an hydraulic analogy of the "filter network."

CHAPTER 11

S-W RECEIVERS . . BANDSPREAD . . REGENERATION . . COUPLING METHODS . . .

THIS chapter will be devoted entirely to a discussion of ***simple receiver*** circuits, in so far as various types of feed-backs, regeneration controls, and many other minor details are concerned. The theory of the circuits will not be discussed, because this was given in previous chapters.

The most important consideration in simple regenerative detectors is the method by which ***regeneration*** is obtained. This may be done in a number of ways. The two most prominent are the ***plate feed-back*** method, as shown in Fig. 1, and the ***cathode*** method, shown in Fig. 2.

Controlling the regeneration of any receiver may be accomplished by a ***variation in voltage*** of one of the elements of the tube or by ***varying the degree of feed-back coupling.*** In Fig. 1, we show both the throttle condenser control of regeneration which is indicated by condenser "C", or the variation of plate voltage by the potentiometer "R". For any detector circuit using a triode there is an optimum range of plate voltage within which the detector operates most efficiently and smoothly. It is strongly advised that both the resistor "R" and condenser "C" be employed to obtain best results. Resistor "R" may be a part of the power supply, and when once adjusted regeneration may be further controlled with the throttle condenser "C". The ***number of tickler turns*** is also very important. No definite rule can be given for the number of tickler turns which will work satisfactorily for all conditions. If the throttle condenser "C" has a maximum capacity of 140 mmf. the tickler turns should be adjusted simultaneously with the plate voltage for maximum sensitivity, with the plates of your condenser "C" about ¾ meshed. This will allow smooth control of regeneration with the remaining 25 per cent of the capacity of the condenser.

An example of what might happen and a situation which in many cases has prevented the experimenter from obtaining a high degree of sensitivity in the receiver follows: For instance, suppose the tickler turns were considered greater than the number necessary to bring about oscillation with a plate voltage of say 45. This would mean that the voltage on the plate would have to be reduced considerably below this value in order to stop oscillation, thus resulting in operation of the tube at a plate voltage which does not permit maximum sensitivity. This holds true with the screen-grid detector as shown in Fig. 2. In this case, the screen voltage is the critical potential. The diagram shown employs the cathode tap, or so-called ***electron-coupled*** arrangement. This tap should be varied exactly the same as suggested for the tickler turns in diagram 1.

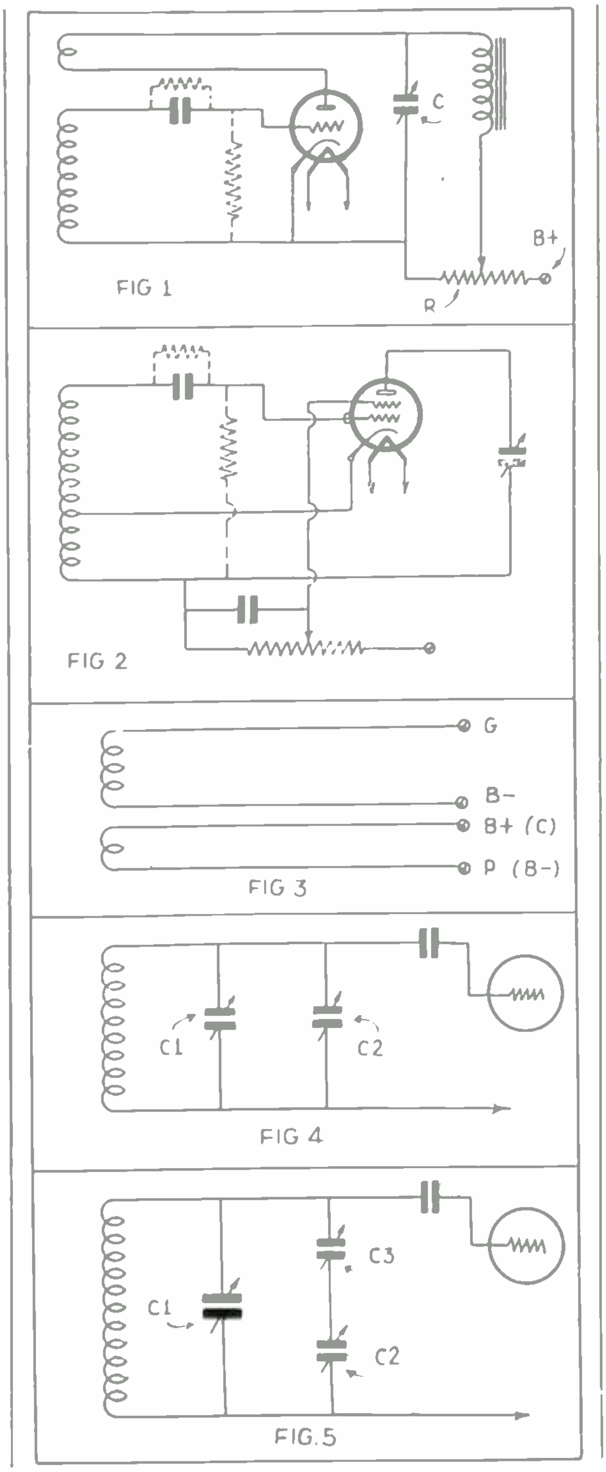
In Fig. 3, we endeavor to show the proper connections for plate and cathode feed-back where separate coils are used. For instance; starting at the top of the coil form, and providing the two windings are both wound in the ***same direction,*** we have the terminal going to the grid or grid-condenser and grid-leak. This is the grid coil, the lower terminal of which connects to the "B" negative.

Feed-back Connections Important

Now for ***plate feed-back,*** the B plus connects to the top of the tickler and the plate of the tube to the bottom. If we are using ***cathode feed-back*** with this coil, the top connection of the tickler will go to the cathode, and the bottom connection will go to the B negative.

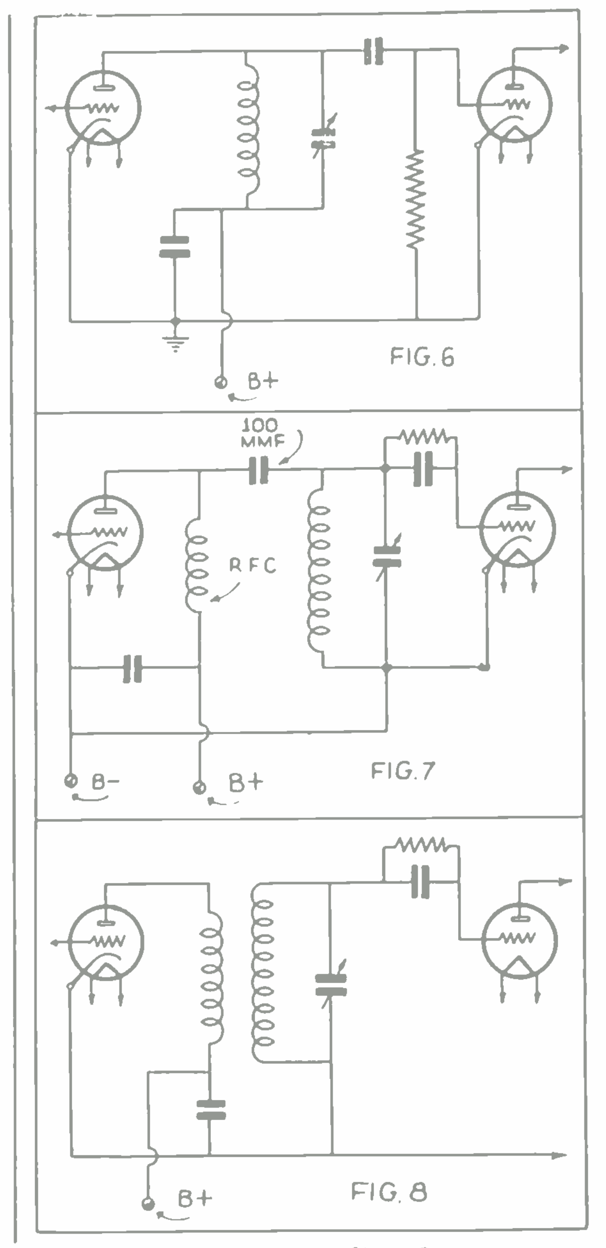
We trust that the reader will familiarize himself with the above statements regarding coil connections. It is surprising the number of mistakes made in the connection of the coils.

Going back to Figs. 1 and 2, we find that the grid-leak is shown both across the condenser and directly from grid to "B" negative; each has its advantage. The grid-leak being across the condenser is not a



In the above drawing we show various methods of obtaining regeneration and band-spread tuning.

parallel shunt to the tuned circuit and introduces no losses. However, it can easily be seen, and many will recall, that when the plug-in coil is removed the grid circuit is open and in nearly all cases a tremendous howl or hum will result. Connecting the grid-leak directly from grid to the "B" negative side of the circuit, instead of across the grid condenser, eliminates this irritating occurrence of noise. Practically, there



Various types of coupling between two stages of a receiver are illustrated above.

will be no noticeable decrease in efficiency of the detector because the resistance is so high it offers extremely small losses in the tuned circuit. Therefore, the writer believes that it is the most logical connection.

Band-spread Problem

Band-spread has always been a considerable problem and dozens of methods have been put forward. In Fig. 4, we have the parallel condenser arrangement which consists of a fairly large tuning capacity "C1" which is used for setting the range of the smaller condensers "C2". For a fair degree of band-spread when "C1" is 140 mmf., "C2" should be around 20 to 35 mmf. However, with this arrangement the degree of band-spread is not the same for different settings of "C1". In other words, the band-spread is considerably greater when "C1" (the *band-setting* condenser) is at maximum capacity than it is when "C1" is at minimum. This can be overcome with the arrangement shown in Fig. 5. Here we have "C1" the regular *band-setting* control and "C2" the band-spread unit, with another large condenser similar to "C1" in series with it. This condenser is "C-3". By proper adjustment of "C3" and "C1", exactly the same amount of *band-spread* may be obtained at any point of the entire tuning range of the circuit. For great band-spread, "C3" will have a small amount of capacity and for a small amount of band-spread, "C3" will be increased in capacity. This undoubtedly is the most satisfactory method of the two, if a *constant* band-spread ratio is to be maintained.

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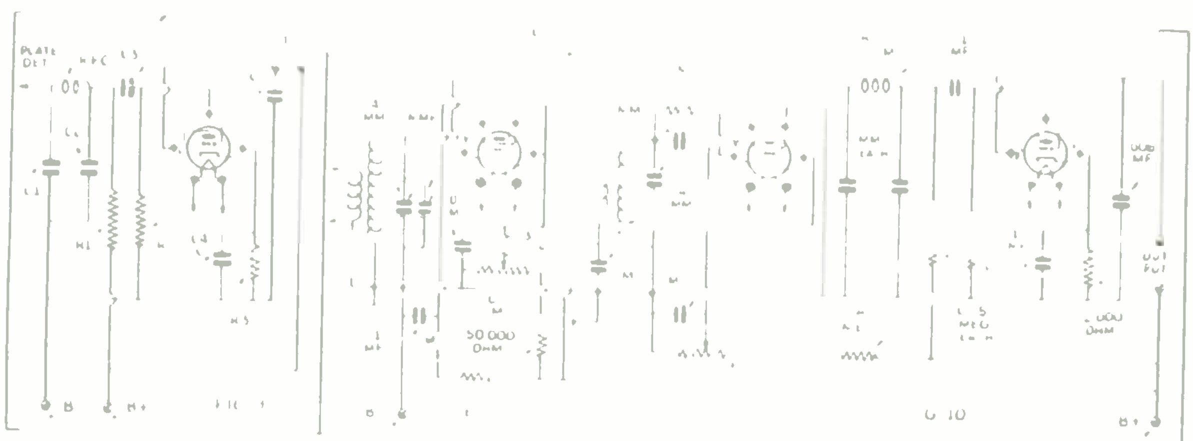
In Fig. 8, we have the latest and most popular and, undoubtedly, the most efficient method of coupling an R.F. stage to the detector or to provide coupling, for that matter, between any two tubes. Here we have the plate coil usually interwound with the grid coil and the inductance of the plate coil is usually proportioned to provide max-



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Resistance coupling, as shown in Fig. 9, may be used for triodes as well as pentodes In this case, "R1" would be anywhere from 50,000 to 100,000 ohms. 250,000 ohms is the proper value for screen-grid pentode tubes such as the 57 and 58.

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The R F filter circuit shown in Fig 9, consisting of R F C., C1, and C2, is really necessary for stable operation The capacity of "C1" should be about 0001 mf, while that of "C2" is about 0005 mf., for the general short-wave bands from 45 to 200 meters.

In Fig 10, we have endeavored to incorporate all the various features mentioned in this discussion into a 3-tube receiver, consisting of a pentode, R.F. amplifier, pentode detector, and triode audio amplifier In tuned R F circuits of this type, shielding is necessary as indicated in the diagram This should separate the two stages completely.

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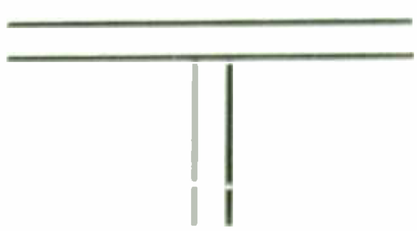

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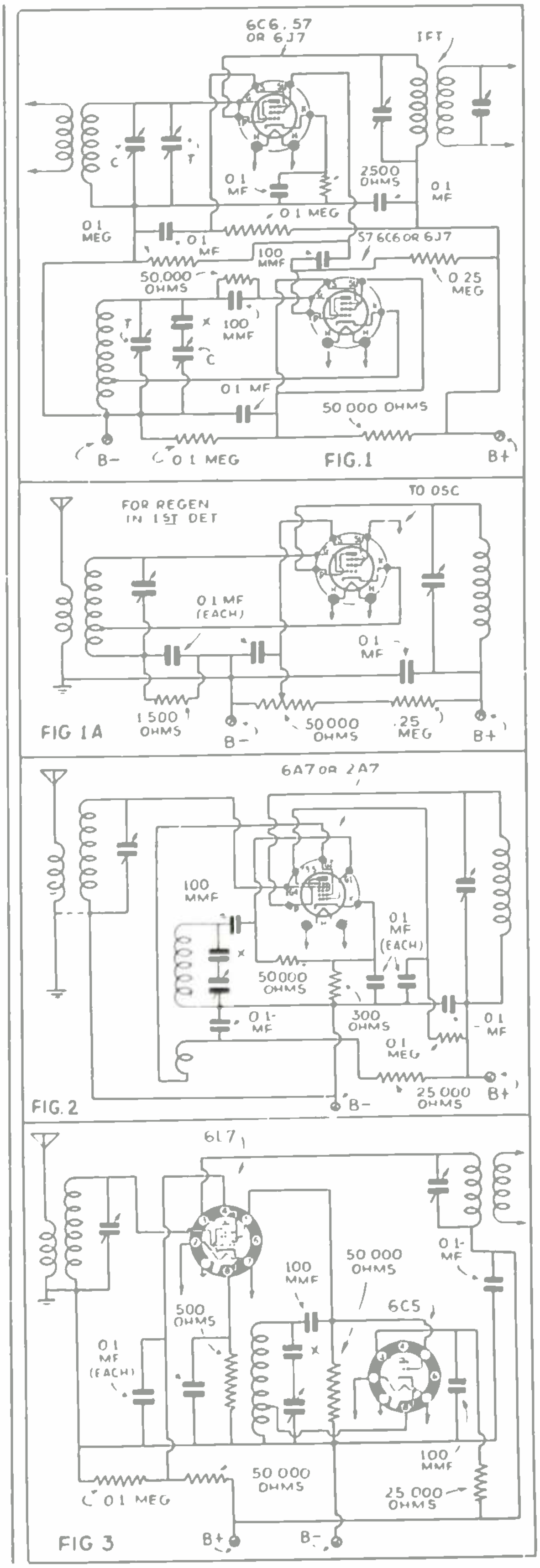

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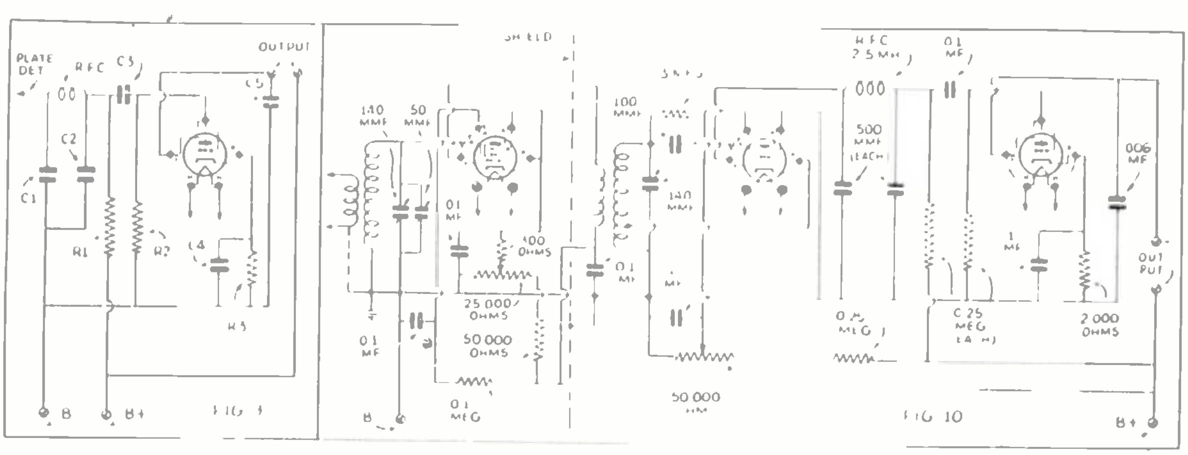

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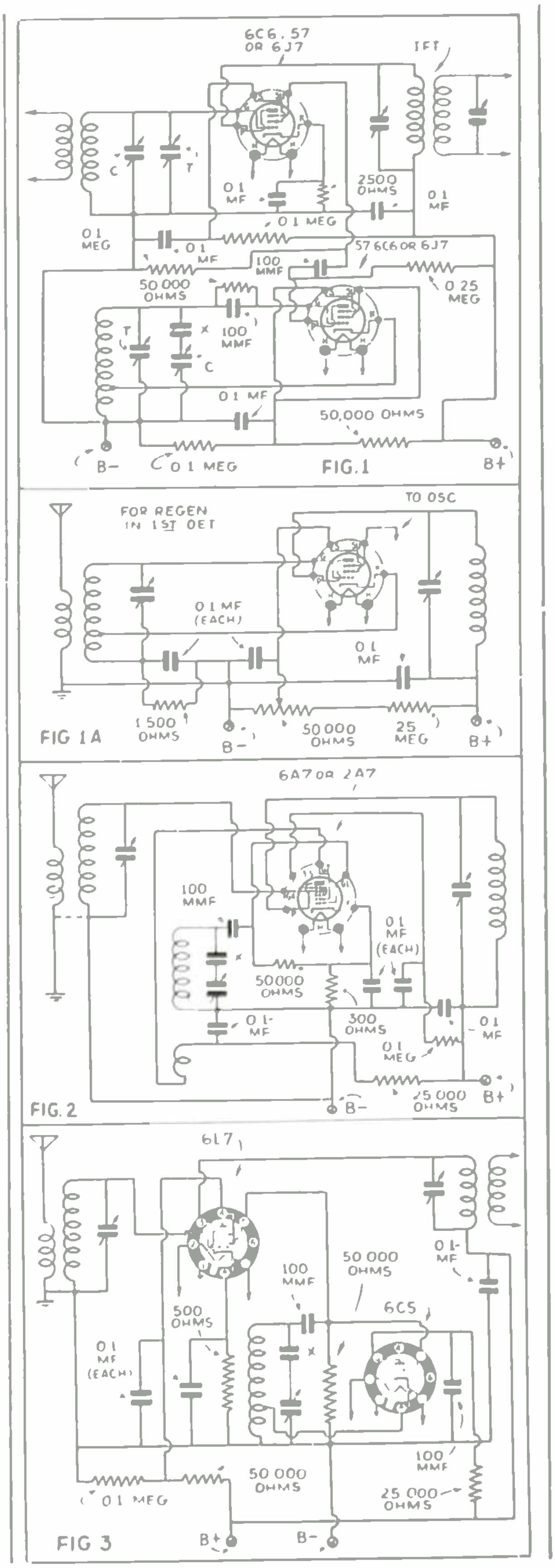

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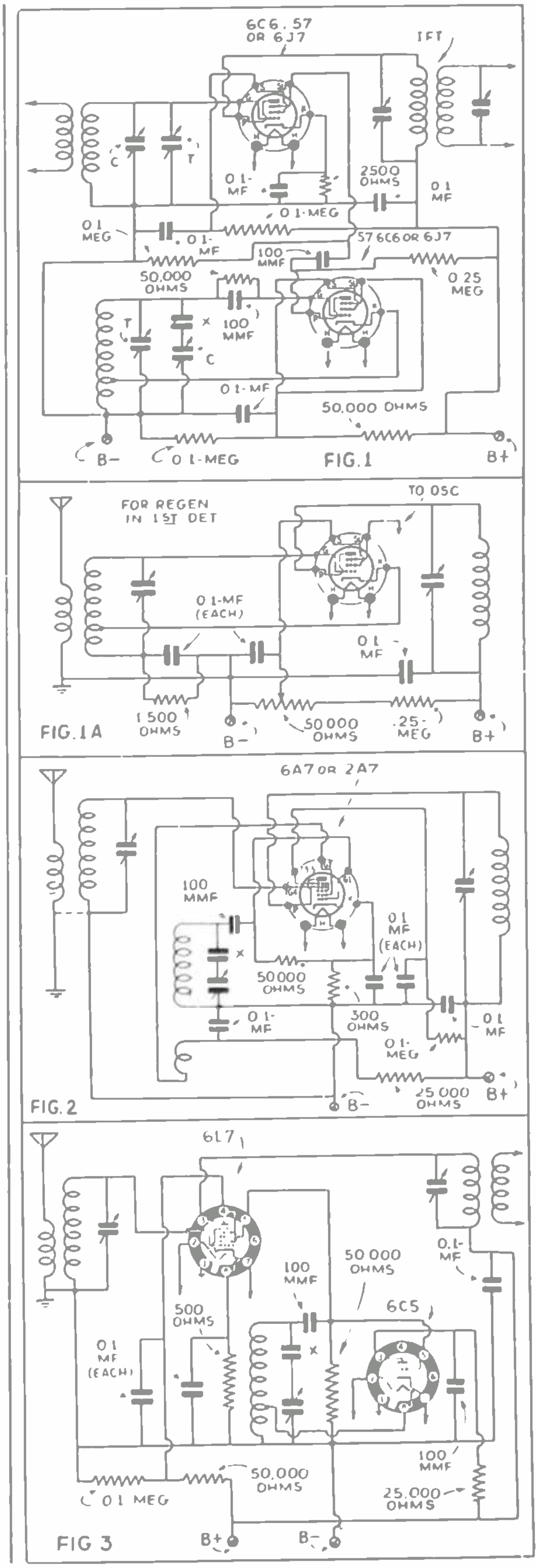

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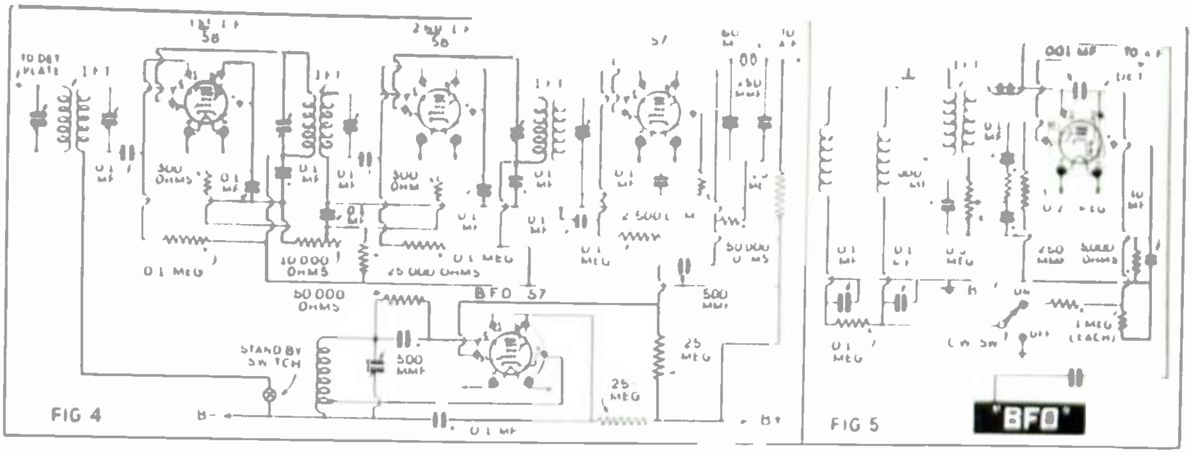


A tuned R.F. stage added to the popular 5-meter receiver, thus increasing sensitivity and eliminating radiation.

placing the wire of the grid and plate circuits.

Beat Oscillator—Its Purpose

In Fig. 4 we have a two-stage I.F. amplifier, the second detector and the beat frequency oscillator. The beat oscillator, of course, is necessary for continuous wave (CW) reception, as we must have some means of bringing about an audible tone from a pure unmodulated carrier. No audio amplifier is shown in this diagram, however, a single 3A5 or 3 watt pentode of any design will provide sufficient audio amplification. Coupling between the beat frequency oscillator (B.F.O.) and the second detector is accomplished through the suppressor of the detector, the same as was done in the original diagram in Fig. 1. This provides an excellent method of coupling the beat oscillator to the second detector. However, the power output of the B.F.O. must be greater with this system than if it were coupled to the grid circuit of the second detector or the second I.F. amplifier. Coupling to the I.F. amplifier or grid circuit of the detector allows a greater chance of running into difficulties than the method shown. For instance, coupling to a grid circuit we may have the tube, to which the oscillator is coupled, considerably overloaded due to the output of the oscillator driving the grid positive. In many commercial receivers coupling is accomplished merely by running a wire from the tuned circuit of the beat oscillator near a grid wire. Should the distance between the two or the couplings change appreciably, a considerable change in results would be noticed. If the coupling becomes too great the entire amplifier may "go dead," in so far as the incoming signal is concerned, because of the fact that it is already overloaded by the signal generated by the B.F.O. In reality there would be an optimum coupling for each value of signal going through the amplifier which we wish to heterodyne. The best that can be hoped for is a "happy medium" adjustment.

We suggest that the experimenter be very careful in using the above mentioned methods, and wherever possible avoid them.

The amplifier shown in Fig. 4 is equipped with automatic volume control, which is more or less essential for *phone* reception, but does not work out to advantage with code. In Fig. 5, we have shown how automatic volume control (A.V.C.) may be incorporated in a receiver of similar design. Here we have used a *duo-diode triode* as the second detector and first stage of audio amplification. In the second detector circuit, we rectify a portion of the incoming signal and feed it back to the grids of the I.F. amplifiers in the form of negative bias, which cuts down the *gain* of the receiver. In this manner, a strong signal will allow a large amount of negative bias to be applied to the grids thus cutting the *gain* of the receiver to a further degree than would a weaker signal. In this respect we obtain a fairly constant signal level. In this second detector circuit it is necessary to couple the oscillator to one of the diode leads. Here we must be very careful, because excessive coupling would, when the switch was in the A.V.C. position, reduce the gain of the receiver the same as would a strong signal or station. It is not so critical in the C.W position, that is, when the A.V.C. switch is in the *off* position. But, at the same time, considerable cut and try will be necessary in order to bring about an optimum in coupling. The diode second detector, of course, cuts down the gain of the receiver considerably. In the 57 we had quite a gain, while in the diode there is actually a loss.

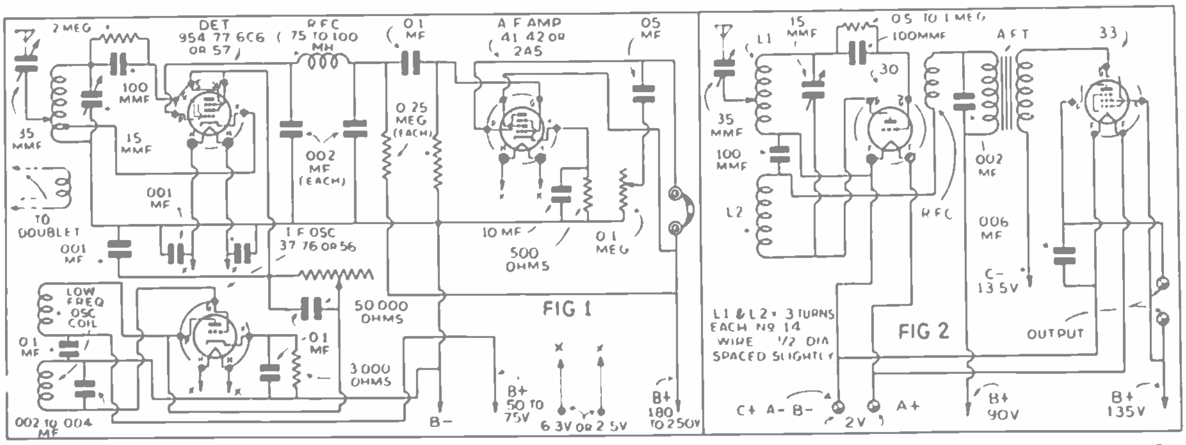
CHAPTER 13

ULTRA-HIGH FREQUENCY RECEIVERS —FOR 5 METER AMATEUR BAND

● THERE is probably nothing so fascinating in the radio field as experimenting on the *ultra high frequencies.* In this field lies the future of radio and a great opportunity for all ambitious experimenters. In this lesson we will deal with the more or less standard super-regenerative receivers, which have become the most important part of ultra high frequency reception. The super-regenerator is capable of excellent *sensitivity* and is probably, without doubt, the most sensitive *simple* receiver which ever was or will be devised. This does not mean, though, that time will not change the method of reception of ultra high frequency signals, but for the time being the most interesting and most popular receiver is the *super-regenerator.*

Reviewing what we have already learned about *regenerative detectors* and bearing this in mind, we may easily understand the simple functions of the super-regenerator. A regenerative detector is one wherein a signal is built up by regeneration to a point, where, if we employ further regeneration—the tube will break into sustained operation oscillation.

In this unstable condition a fairly weak signal will cause the detector to commence oscillating, and these will continue to build up to an amplitude permitted by the tube constants. However, the receiver cannot reproduce the signal because after the oscillations once start they would not cease. Therefore the *interruption frequency* oscillator is employed to stop the detector from oscillating at intervals, which depend upon the frequency of this interrupting oscillator. It is assumed that on the upward swing a signal is built up along with oscillations, but this procedure is halted before the self-oscillations reach a value comparable with the signal.



Super-regenerator using a separate quenching oscillator, together with diagram of a battery operated 5-meter receiver.

This same action can also be obtained without the use of the low frequency oscillator. The single tube can be made to oscillate at two frequencies; one the signal frequency, and the other of super-audible frequency in the neighborhood of 15 to 50 kc. The best all-around frequency for the quenching oscillation has been found to be from 15 to 25 kc.

The selectivity of the super-regenerator is also governed by the interruption frequency. As the interruption frequency becomes higher, the receiver becomes broader or more unselective. Therefore, the lowest possible frequency commensurate with good quality reproduction is desirable.

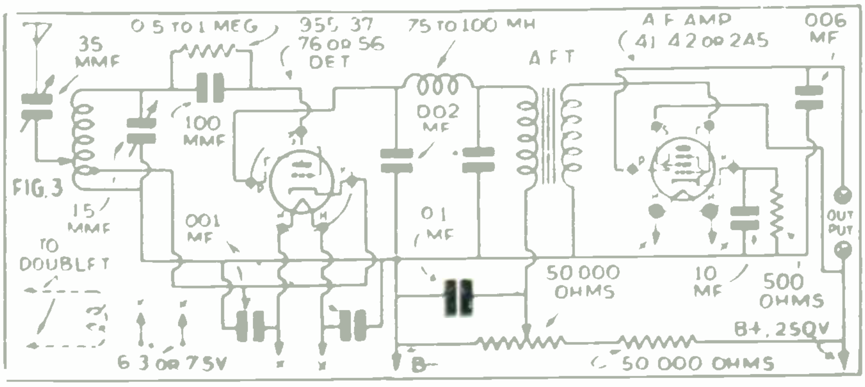
In Fig. 1 we have either a tetrode or pentode detector. In the case of the pentode the suppressor is connected to the screen-grid; either will give the same results. However, the 954 Acorn tube, especially designed for ultra high frequencies, is preferable when operating the receiver at frequencies higher than 60 meg. At 5 meters or 56 megs. it is defficult to notice the difference between the signal sensitivity of the 954 and the usual tetrode or pentode. It will be noticed, though, that the conventional receiving tubes such as the 6C6 or the 57 will give greater volume, and in this respect, it may be somewhat superior inasmuch as less audio frequency amplification is needed. Of course, this is only true in cases of a super-regenerator detector. In an R.F. amplifier circuit the 954 would be far superior to the other tubes. In the circuit in Fig. 1, the screen is modulated by connecting it in parallel with the plate circuit of the interruption frequency oscillator. The voltage to the screen is variable through the use of a variable resistor, independent of the oscillator plate voltage. It is advisable to also adjust the voltage applied to the oscillator plate for maximum sensitivity and best super-regeneration action of the detector.

It will be found that the voltage fed to the I.F. oscillator is quite critical inasmuch as with high voltage on the oscillator we will have tremendous distortion in the signal and with very low voltage on the oscillator we are liable to have *repeat* spots, that is, the station may appear at several points on the dial very close together. As we said before, there is just one value of plate voltage which gives the cleanest regenerative action in the detector circuit. We should also make sure that the detector is not *super-regenerating* by itself, that is, that it is not *self-quenching* along with the applied voltage of the I.F. oscillator. This can be determined by noting the smoothness of the regeneration control in the detector screen circui. This should be very smooth in operation and the hiss of the detector should appear gradually as the resistance in the control is decreased. It should not *plop* into oscillation.

One cause of poor operation in a super-regenerator circuit of the type shown in Fig. 1 may be found in the I.F. oscillator circuit. Usually the detector, if the tube is o.k., will function properly. There are two types of I.F. or low frequency oscillator coils available on the market; one is the shielded and the other is the unshielded type. It has been found that some of the shielded type introduces a loss in the oscillator circuit, sufficient to cause the necessity of high plate voltage in order to make the oscillator function. In turn, this raises the voltage to the screen above the point where there is not enough resistance in the 50,000-ohm control to bring the detector out of oscillation. The unshielded low frequency coils, however, work perfectly. Regardless of the type of oscillator coil used, make sure that it is possible to bring the detector out of oscillation *smoothly* with the regeneration control "R."

Low-Frequency Oscillator Coils

There seems to be no set standard for the value of inductance used in the low-frequency oscillator coils. Therefore, we have shown a capacity of .002 to .004 mf. in the grid circuit across the grid coil. This condenser is used to lower the frequency of the I.F. oscillator and its capacity will depend upon the original design of the coil. In any event, place sufficient capacity across this to bring the I.F. oscillations down to around 20 kc. A good method to follow is to connect a number of .001 mf. condensers across this secondary, bringing the oscillator into the audible range, so that a very high pitched whistle is heard; then remove one condenser at a time, until this whistle becomes inaudible to the ear. Adjusting the low frequency oscillator and its plate voltage is quite important, contrary to popular belief. With excessive voltage on the plate of the oscillator, it may take on "R8" signal to make a "sizeable" dent in the rush of the super-regenerator, where with the proper value, that is a voltage just in excess of the amount that causes repeat spots to appear, will permit even a very weak signal to cause an appreciable "dent" in the characteristic rushing sound of the super-regenerator. In the output circuit of the super-regenerative detector, we find indicated a 75 to 100 mh. R.F. choke by-passed with two .002 mf. condensers. Theoretically, this choke should be relatively large. However, actual practice has proven that the usual 2½ mh. R.F. choke is entirely satisfactory. The idea of this filter is to keep the low frequency oscillations out of the A.F. amplifier grid circuit.



The most popular of all 5-meter receivers — a self-quenched triode. with a pentode audio amplifier.

Battery-type Receiver

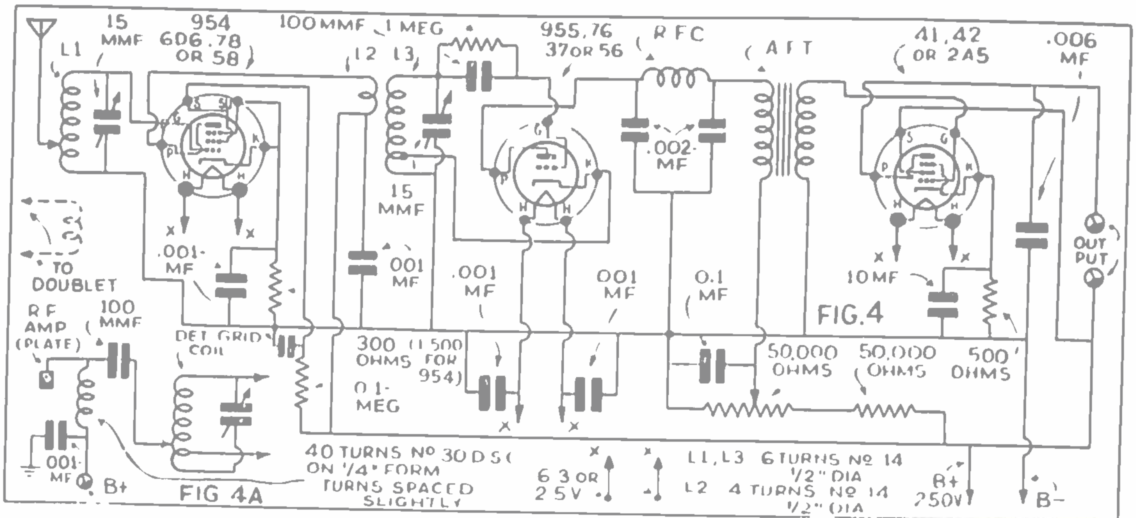
In Fig. 2, we find a ***self-quenching*** battery-type, 5-meter receiver, which is generally accepted as a good design for portable equipment. This uses a split-coil circuit and sufficient feed-back is employed to cause ***self-quenching*** in the detector circuit. The frequency of this "quench" is governed largely by the amount of feed-back, the size of the grid-leak, and the size of the grid condenser. The values given in the diagram are generally found satisfactory.

In Fig. 3 we have what is probably the most "popular" of all super-regenerative receivers. This is a self-quenching triode-detector with the pentode audio amplifier. This was originally introduced in the November, 1934, issue of ***Short Wave Craft*** and from it sprung a great number of receivers of the self-quenching variety. When first introduced, this receiver caused many unfavorable comments. The "old guard" experts frowned unfavorably upon this method, but gradually conceded that it is the best simple arrangement after all. It possesses many desirable qualities inasmuch as it is entirely self-regulating and when adjusted for the proper amount of feed back, it is an extremely sensitive affair; undoubtedly more sensitive than the usual run of the older type separately quenched detectors. We here have used the cathode as an active R.F. element by connecting it two or three turns from the low potential end of the grid coil. In adjusting this type of detector, starting off with no plate voltage and raising it gradually, we find that at one point the detector will click into oscillation. And as the regeneration control is advanced further, raising the plate voltage, the detector will click again—this time into ***super-regeneration***. It is just at the point beyond the second state of oscillation, where the detector is the most sensitive. Here too the 955 ultra high frequency tube may be used, but in 5 meters the conventional type, such as the 37, 76, 6J5-G, or 56 will provide a much stronger audio signal. With the 955 two stages of audio frequency amplication would be necessary.

Tuned R. F. Stage Ahead of Detector

In Fig. 4 we have a more advanced receiver, employing a tuned R.F. stage ahead of the super-regenerative detector. The main advantage in this case is in the elimination of undesirable radiation of the detector. Super-regenerative detectors emit a strong equealing or modulated signal, which will interfere with other receivers located nearby, where only a detector is used without R.F. ahead of it, the antenna coupling should be ***loose;*** and also the tubes should be operated with as low plate voltage as possible in order to limit this interference. Aside from overcoming this evil, the tuned R.F. stage provides an appreciable gain in sensitivity and makes the super-regenerative detector more easy to handle and smoother in operation. In the diagram in Fig. 4 we show a pentode in the R.F. stage which may be of the conventional glass type, or of the newer metal type tubes, or the Acorn 954 pentode. The 954 in this case is decidedly better than the others, in so far as ***gain*** is concerned. The detector and A.F. portions of this receiver are identical to the one shown in Fig. 3. Inductive coupling is preferable between the R.F. and detector stages. However, in Fig. 4A, we show a method of coupling through a capacity with shunt voltage feed to the plate of the R.F. amplifier. In this case the most effective coupling is brought about by tapping on to the detector coil at about the mid-point.

In each of the circuits we have shown the antenna either tapped on to the grid coil of the input stage, or through a coupling coil. However, if a doublet antenna is used the coupling coil of course, is recommended. However, for a single-wire an-



A tuned R.F. stage added to the popular 5-meter receiver, thus increasing sensitivity and eliminating radiation. Fig. 4.

tenna or one having a single-lead, tapping the antenna on to the grid coil, near the low potential end, is preferable to the older method of tapping it directly on to the grid side of the coil. The method shown in the diagrams permits a greater variation in the degree of coupling, without appreciably affecting the calibration of the grid tuning condenser. Tuning of the R.F. stage is similar to all other receivers, as the R.F. stages comes into resonance with the detector stage, there will be a slight *dip* or decrease in the rushing sound and it will be necessary to advance the regeneration control for proper results.

Type of Antenna

Nearly any type of antenna will work with the 5-meter receiver. Aside from the doublet, the most effective antenna has been found to be a single eight foot wire with a lead-in tapped directly on the top. The lead-in should come directly from the top of the antenna, at an angle of approximately 45 degrees, and should be no closer than this to the antenna proper. The length of lead-in does not seem to be important and tests have proven that stations which could not be heard on many other antennas came in at an R5 and 6 strength with the one shown.

In the tuned circuits of each receiver we have shown a 15 mmf. condenser and have given the sizes of the inductances. This does not provide an appreciable amount of band-spread and to increase this, remove one or two plates from the 15 mmf. condenser and add turns to the coil. The Acorn tubes will require a greater number of metal tubes. In each case the coil may be adjusted by spreading or collapsing the turns, in order to place the band well within the range of the dial. This same method is used for tracking the R.F. and detector stages.

CHAPTER 14

ADVANCED ULTRA-HIGH FREQUENCY RECEIVERS

● Previously we considered the use of the super-regenerative receiver for ultra high frequency reception. While, as previously explained, the superheterodyne has qualities not found in any other set, it also has certain disadvantages which may be rather important under certain conditions. Eventually, the superheterodyne will be perfected for ultra high frequency use because of its controllable selectivity and exceptional sensitivity.

In the early days of ultra high frequency experiments, the broad super-generator was desirable because of the type of transmitting apparatus employed, such as modulated oscillators. As time goes on, these modulated oscillators will be dispensed with, and the more stable MOPAs, with and without *crystal-control*, will be used. There are two good reasons why the transmitter will change and is changing—and they are: first—the ever-increasing number of amateur stations operating in the metropolitan areas, and the desire for better quality signals. The average modulated oscillator occupies a band width in the ultra high frequency region of from 50 to 100 kc., and in many cases a considerably wider band where the equipment is none too carefully constructed and operated.

The super-regenerator in most cases has about the same band-width as the modulated oscillator. Therefore, as the transmitters are stabilized and held down to a band of from 10 to 15 kc., immediately we need a more selective receiver if we are to cope with the ever-increasing number of stations. The answer to this, of course is the *super-heterodyne.* The most popular superheterodyne for ultra high frequency reception at this writing is the well-known *resistance-coupled* design in which the I. F. stages are resistance-coupled and the values are chosen to permit a band width of from 10 to 100 kc. In time, even this receiver will not be selective enough, although it can be made considerably more selective than the super-regenerator.

Resistance-Coupled Superhet

In Fig. 1, we have the resistance-coupled I.F. superheterodyne, employing a stage of tuned radio frequency, an autodyne first detector, two stages of I. F. amplification, a second detector, and a pentode audio amplifier. Conversion in this receiver is accomplished by slightly de-tuning the detector

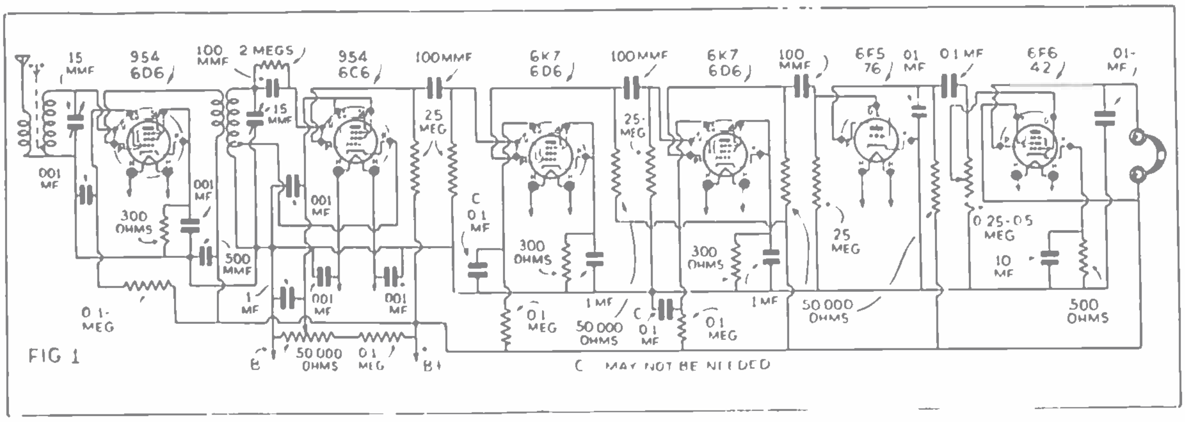


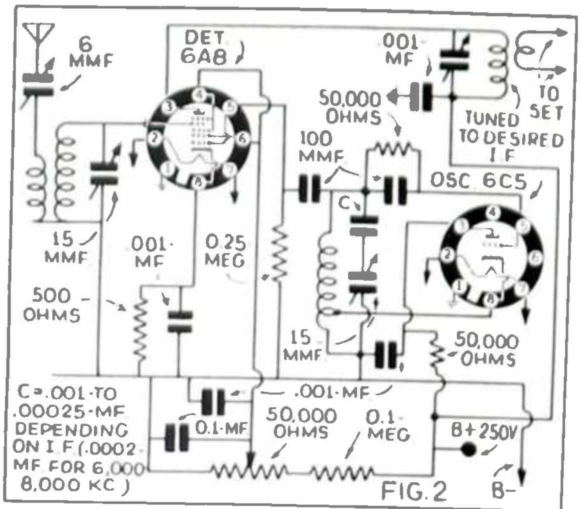
FIG 1

A complete resistance-coupled ultra high frequency superheterodyne, suitable for "Ham" reception.

from the signal frequency. Thus, if we were to assume that the I.F. was 50 kc., the first detector would be detuned 50 kc. from the signal frequency. This means that 50 kc. either side of the resonant point will receive the station. We then have to allow a band width of over 100 kc. for that station because directly between the two beats we hear the "carrier" of the station, the same as you would on an oscillating detector. This carrier whistle is heard because the amplifier stages, as well as the second detector and audio stages, are operating as straight audio frequency amplifier. The R.F. stage is not entirely necessary and may be dispensed with and the antenna connected to the cathode tap on the coil through a 15 mmf. variable condenser. The R.F. stage helps somewhat in working *duplex* and also increases the *sensitivity* slightly when the regular glass type tubes are used, and a considerable increase in sensitivity is brought about through the use of the Acorn pentode 954. The best arrangement, of course, would be to use 954's or 956's in both the R.F. and detector stages.

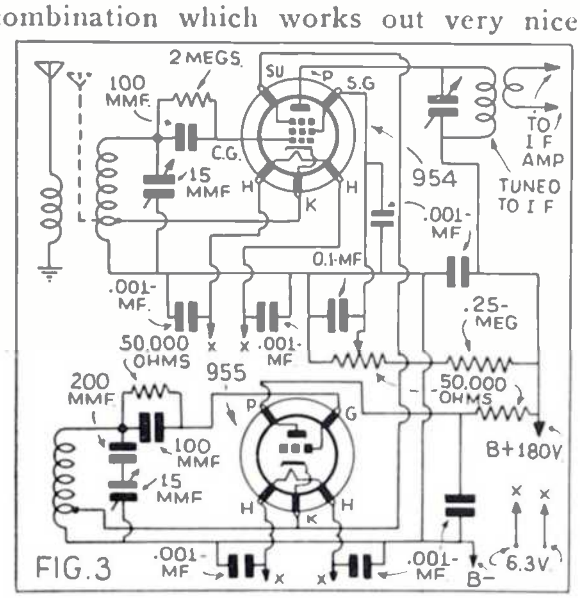
The "Converter"

With the increasing number of stabilized transmitters, one's thought naturally turns to the *converter,* which may be connected before the regular superheterodyne receiver. This makes an excellent combination when a sensitive receiver and converter are employed. Of course, the sensitivity of such a combination is far beyond the amount which can be used, because of the relatively high background noise in the average metropolitan location. A converter combination which works out very nicely



A converter circuit for ultra high frequency reception, using metal tubes.

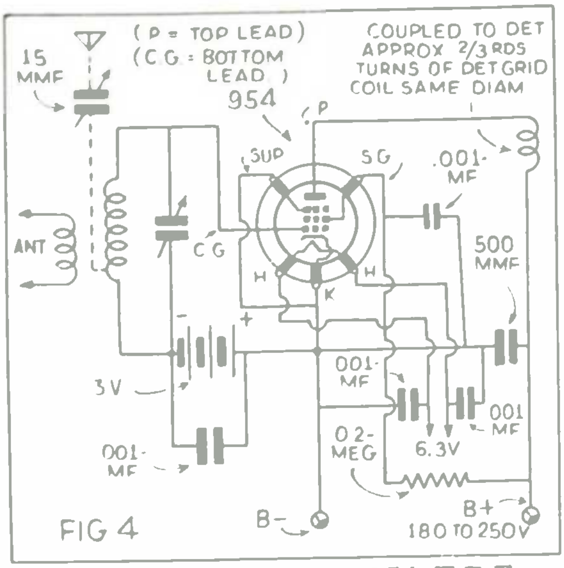
is shown in Fig. 2 and consists of a 6A8 metal tube pentagrid and a 6C5 triode. The 6A8 is used as the first detector and grid number 1 is used for injecting the oscillator voltage supplied by the 6C5 oscillator. It has been found that by applying the proper screen voltage to the 6A8 and using very loose antenna coupling, considerable regeneration will come about in this circuit and for this reason we have shown a potentiometer for controlling the screen-grid voltage. This converter works best with a receiver tuned to a frequency of at least 2000 kc., and preferably higher. In choosing this intermediate frequency, we have to bear in mind harmonics of the oscillator in the superhet receiver with which the converter is being used. The receiver should be adjusted so that any harmonics would fall out of the range desired to be covered with a converter. Also, keeping the high I.F. frequency makes images a considerable distance apart and less bothersome. This particular converter in conjunction with an I.F. amplifier tuned to 8000 kc. gave marvelous results, and no image interfernce was experienced because of the high selectivity of the regenerative detector stage and the wide separation in frequency of the images.



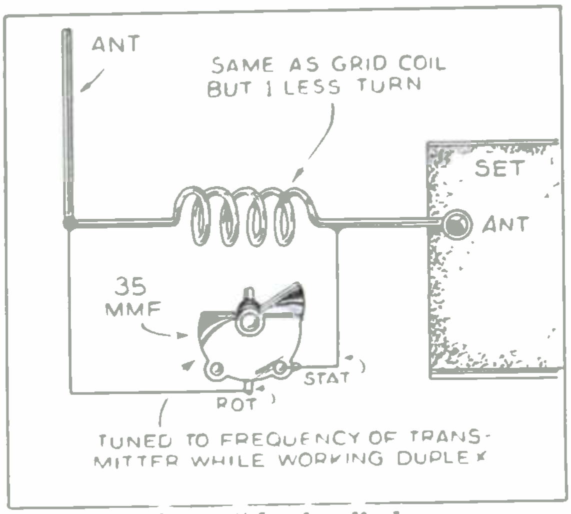
Converter diagram employing the Acorn tubes, 954 and 955.

Acorn Tube Converter for High Frequencies

In Fig. 3, we have a similar *converter,* except that here the Acorn tubes are employed. The detector is a 954 Acorn triode. Here regeneration is also employed to further the degree sensitivity. The advantage of the converter using the Acorn tubes, of course, is that it may be operated at a much higher frequency than the one using the metal tubes. These two converters are shown for operation directly from the an-



Circuit diagram of a 954 T.R.F. Amplifier.

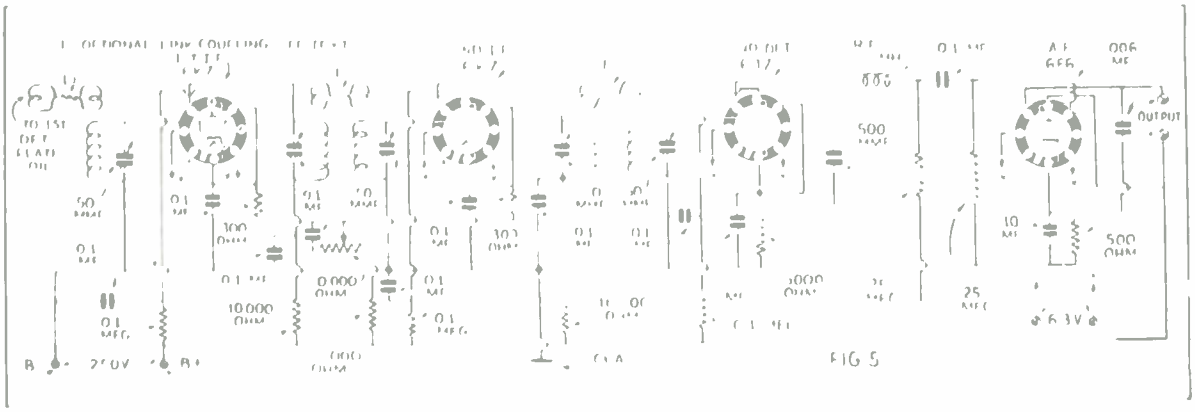


When working "duplex," the wave-trap shown above should be tuned to your own transmitter frequency. This will practically eliminate acoustical feedback between speaker and mike.

tenna, while the R.F. stage shown in Fig. 4, may be employed with these converters it is not entirely necessary, but will improve sensitivity by a noticeable amount. A complete *high frequency* I.F. amplifier is shown in Fig. 5 for those who want a somewhat broader receiver, but one still not as broad as the resistance-coupled affair shown in Fig. 1.

The I.F. amplifier of Fig. 5 may be used in conjunction with either of the *converters* shown in Fig. 2 or 3. In this diagram we have employed only two I.F. stages, while some experimenters prefer three. However, if carefully designed, two stages will be entirely satisfactory. The I.F. transformers may be constructed the same as the conventional I.F. transformers, i.e., the primary and secondary wound on the same form or spool, or each may be housed in separate compartments, and the only coupling between the primary and secondary due to the length of twisted pair which is indicated above the I.F. transformers. In this case, the primary would be housed in one shield can with its associated tuning condenser, and the secondary in another, with a single turn coupled to each coil and connected by a link of twisted pair. Such an amplifier, having a range of from approximately 6000 to 8000 c. would require I. F. transformers consisting of 14 micro-henries inductances and a 50 mmf. variable condenser connected across it. Each coil would consist of 27 turns of No. 28 enamelled wire, close wound on ¾ inch dia. form.

With the increasing activity in *television* production on the *ultra high frequencies*, a receiver of this type is sorely needed. For greater selectivity, of course, the intermediate frequency should be lowered. If used entirely for stabilized ultra high frequencies transmitters of the phone or code variety, an intermediate frequency of 2000 to 3000 kc. should be entirely satisfactory.



I.F. detector and A.F. circuits for an ultra high frequency superheterodyne. For Television and "Ham" reception the I.F. frequency should be somewhere between 6000 and 8000 kc.

CHAPTER 15

U. H. F. TRANSMITTERS

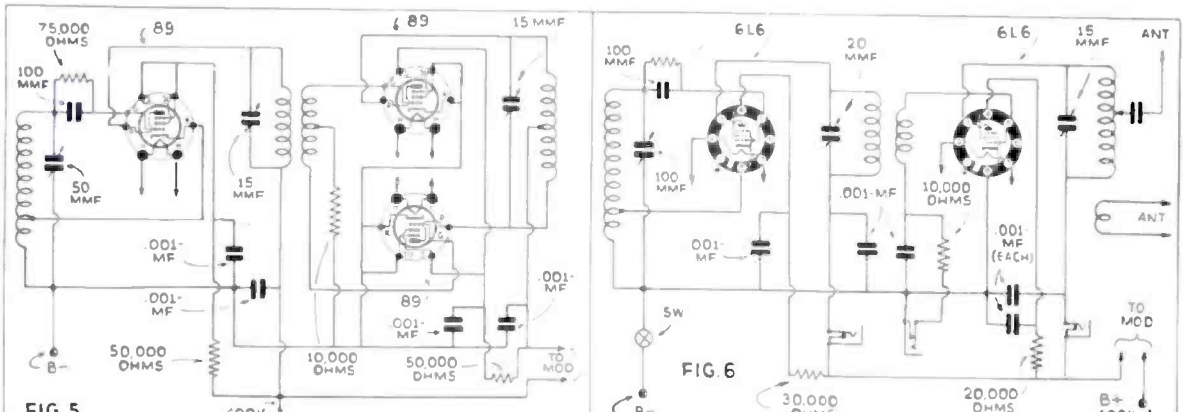
● IN this chapter of the ***Course*** we will consider various types of ultra high frequency transmitters, not including, of course, the well-known ***transceiver.*** Fundamental circuits of the more important and efficient transmitters are shown and will be discussed.

In Fig. 1, we have the unity-coupled circuit using two triodes in push-pull. Either two separate tubes may be employed or the dual triode tubes, such as the 53, 6A6, and others. For those desiring a compact oscillator circuit of simplicity this one is recommended. Its inherent stability is no better than the usual tuned oscillator, although it is more easily controlled and usually better results are obtained because no critical adjustment of grid circuit tuning is necessary.

The inductance consists of a fairly heavy piece of copper tubing, through which a finer insulated wire is run. The inside wire is the grid coil, while the copper tubing is in the plate circuit. It will be noticed that the grid of one triode enters the copper tubing at the plate end of the other triode This is necessary to obtain a ***feed-back.*** In the center of the copper tubing opposite to the tubes the grid return lead is brought out. In a sketch in Fig. 1 we have shown just how this coil is constructed.

The antenna may be coupled to the plate coil at points "A", that is on either side of the "B" plus lead, or another single-turn "loop" the same as the plate coil may be employed for antenna coupling.

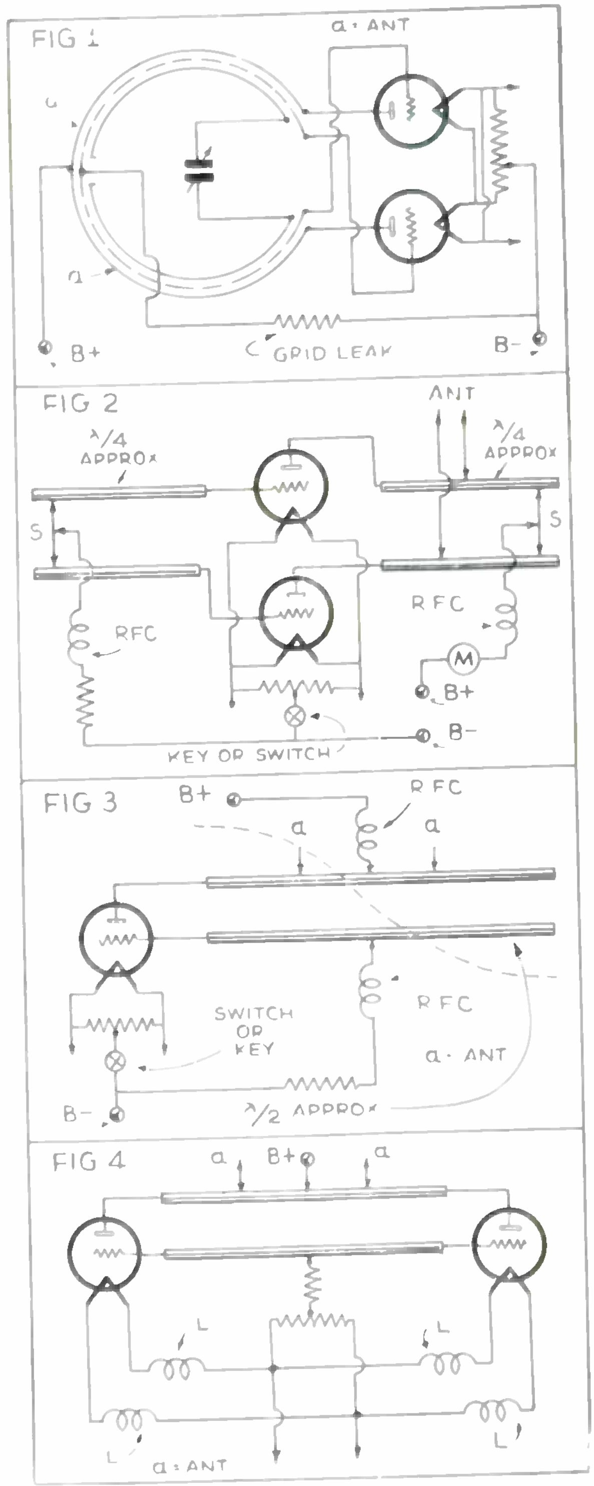
In Fig. 2, we have the very popular ***long-line*** oscillator, sometimes called a linear oscillator. Here we have extended the tuned circuits by employing two heavy copper rods or pipes in each circuit. The tuning is accomplished by sliding the bars marked "S" either toward or away from the tubes, making the circuits shorter or longer. As they become shorter of course, they resonate at a higher frequency. Theoretically, these lines should be approximately ¼ wavelength long, but due to the internal capacities of the tubes and the inductance of the tube leads and connecting leads from the copper pipes to the tubes, the length of the line will be somewhat shorter than ¼ wavelength.



Two very popular 5-meter MOPA's; one uses type 89's while the other uses type 6L6's

For the special ultra high frequency tube, such as the 800 or 304A and 304B, the lines will be longer than if 210's or 801's are employed. A good length would be somewhere around 46 inches. This would serve for any type of tube in the 5-meter band. Best results have been obtained when the spacing between the two rods is equal to the diameter of one of the rods. In other words, if ½ inch rods are used the spacing between them would be ½ inch. Complete information on this is shown in Fig. 2. When operating on wavelengths shorter than 5 meters the lines of this system become uncomfortably short. In Fig. 3, we show the ***open-end*** line which theoretically at resonance would be ½ wavelength long used in conjunction with a single tube. Here, also, the line will be somewhat shorter than ½ wavelength because of the losses introduced by the tube. The "B" plus and the grid lead are tapped on to the rods ¼ wavelength from the open end or the end opposite to the tube. This is the point marked "X" in the diagram and at which no R.F. voltage will appear. This system works exceptionally well on wavelengths as low as 1½ meters and exceptionally well on 2½ meters with the average present-day tube.

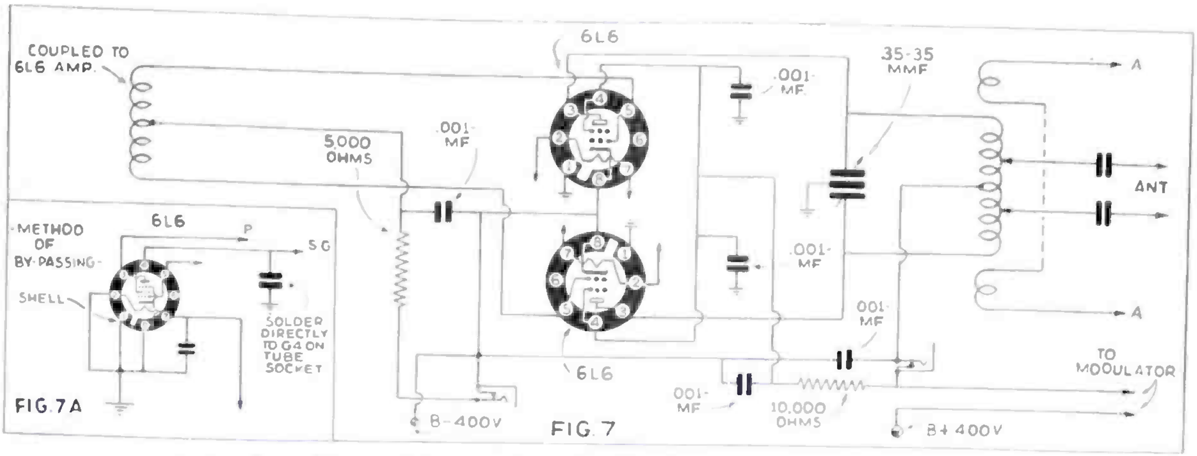
Special tubes, such as the new WE-316A will give more satisfactory results, of course, and may be employed in the ***push-pull*** arrangement of the same circuit shown in Fig. 4. While the oscillator circuits, already explained and shown in the diagram, are efficient and have served the purpose for the past four or five years, during which the ultra high frequency region has been most popular, they eventually will have to be dispensed with and replaced by the more modern type of transmitter, such as used on the lower frequency amateur band.



The simplest of all ultra-high frequency transmitters is shown in Fig. 1. Figs. 2, 3 and 4 show "long lines" or linear oscillator.

The master-oscillator, power-amplifier (MOPA), is unquestionably the most satisfactory on frequencies as high as 60 megacycles. However, as we approach higher frequencies, the circuit become more unwieldly and very difficult to manage. On the 5-meter (56 to 60 mc.) band, the MOPA should be adopted by every "Ham" who is seriously interested in the betterment of conditions now existing.

In Fig. 5, we have shown the MOPA which uses the type 89 receiving tubes. One is used as an oscillator in the ***tritet*** circuit with its grid circuit tuned to 10 meters and the plate circuit to 5. This is followed by two 89's employed as screen-grid amplifiers in push-pull. This is very much superior to the previously described circuits inasmuch while the amplifier is being modulated there is no appreciable frequency shift, due to the fact that there is considerable isolation between the actual signal generator and the modulated amplifier. The amplifier being removed by 30 megacycles from the frequency



A push-pull amplifier using 6L6's for the 2-tube 6L6 MOPA.

of the oscillator accounts for its excellent stability during modulation. While in the previously explained circuit the oscillator will change frequency as much as 100 kc. during modulation.

In Fig. 6 we have the 6L6 Beam tube used in the MOPA circuit. This is unquestionably the most superior arrangement up to the time of this writing. Due to the construction of the tube excellent efficiency may be obtained in the 5-meter band even with a single-ended-amplifier. The circuit lineup is essentially the same as the 89 transmitter shown in Fig. 5. The oscillator is tuned to 10 meters and "doubling" takes place in the plate circuit, while the second 6L6 operates as a screen-grid amplifier. With 400 volts on the plate, it is possible to obtain 20 watts of R.F. output from the 6L6 amplifier. It may be advisable to include a word of warning at this point that the 6L6's are made in two types; one with a glass envelope and another with a metal envelope. For 5 meters, the metal tube is recommended, inasmuch as a number of extensive tests have proven that it is more stable and far superior in opertion, requiring no *neutralizing* while the excitation voltage is being applied. No intricate shielding was found necessary with these tubes while the glass tubes required considerable shielding together with neutralizing and were no more efficient.

If one is not satisfied with the 20 watts output from the circuit shown in Fig. 6, two 6L6 amplifiers may be added and the diagram is shown in Fig. 7. The amplifier in Fig. 7 added to the two tube transmitter in Fig. 6 will provide some 50 watts output. Here also the *metal* tubes should be used. For best results with the 6L6, bypassing should be done *right at the tube socket!* In Fig. 7A we have shown how the metal shell, the cathode, and one side of the heater are all connected right at the socket and grounded to the metal chassis. (a metal chassis is recommended in all cases for ultra-high frequency circuits of this type), the other side of the heater is by-passed immediately at the tube socket. The same is true of the screen grid. While in the diagram Fig. 7 we show a single bypass condenser with the two screen-grids connected together, it is advisable to employ two condensers—one for each grid. Various methods of coupling the antenna to these circuits have been shown and will depend entirely upon the antenna and feeder system employed in the transmitting station.

CHAPTER 16

RELAYS SIMPLIFY OPERATION OF STATION

● UNQUESTIONABLY the up-to-date amateur station should be relay operated. The use of relays in connection with radio and electrical apparatus not only provides a very desirable convenience but in many cases safeguards the apparatus and the operator against damage or injury.

The first application of a relay in an amateur station is for keying the transmitter. There are a number of reasons why this works out most effectively, and they are: It removes high voltage from the metal parts of the key and permits uniform characters to be transmitted, especially when a "bug" is employed. The connections for this relay are shown in Fig. 1. The next application is for turning the transmitter *on* and *off*. In cases of low power, where filaments and plate voltage may be applied to the rectifier at the same time in the power supply, only one relay is required, as shown in Fig. 2. When using this particular method, it is advisable to have a switch in the B negative or B plus supply of the transmitter power supply, so that the plate voltage will not be applied to the tubes before the filaments are thoroughly heated.

By employing the system shown in Fig. 3 in conjunction with Fig. 2, we have a very satisfactory arrangement. This should be used as we said before where a low voltage power supply is employed so that there is no danger of damaging the rectifier tubes. The circuit in Fig. 3 primarily opens the B negative circuit right at the power transformer secondary. In addition, we have shown how the receiver may be operated in conjunction with this arrangement to permit *stand-by* for *rapid change-over* during communication. Two relays are employed here—one to disconnect the B minus center tap of the high-voltage secondary, thus turning off the power to all stages in the transmitter, and another relay to turn the receiver on by connecting the center tap in the high voltage secondary of the receiver power transformer; this is for *standing-by*. In order to transmit, merely make contact with the *stand-by* switch; this turns the high voltage on to all tubes in the transmitter and at the same time turns the receiver off.

Where higher power is used it is neces-

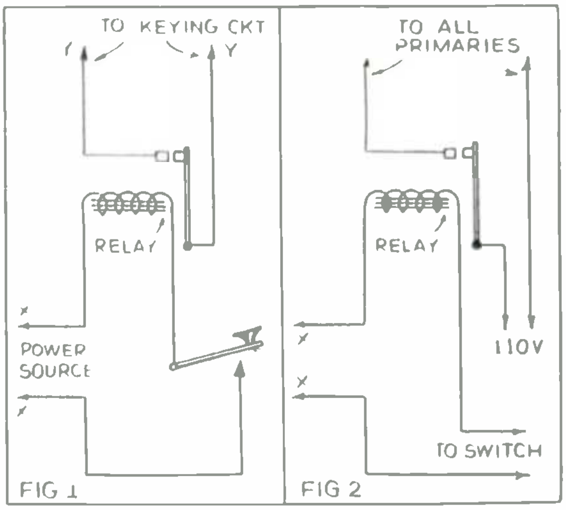


Fig. 1—Keying relay. Fig. 2—Simple circuit for turning transmitter "on" and "off."

sary to heat the filaments for a period of at least 15 or 20 seconds and in some cases a few minutes before plate voltage is applied. This may be accomplished with *time-delay* relays or more simply and more economically by the system shown in Fig. 4. Here a single double-pole, single-throw relay is used to turn on the filament transformers. The other pair of contacts on this relay complete the circuit for the high-voltage relay. Thus, when the plate switch makes contact the primaries of the high-voltage transformers are thrown on and we are ready for operation. If the plate switch

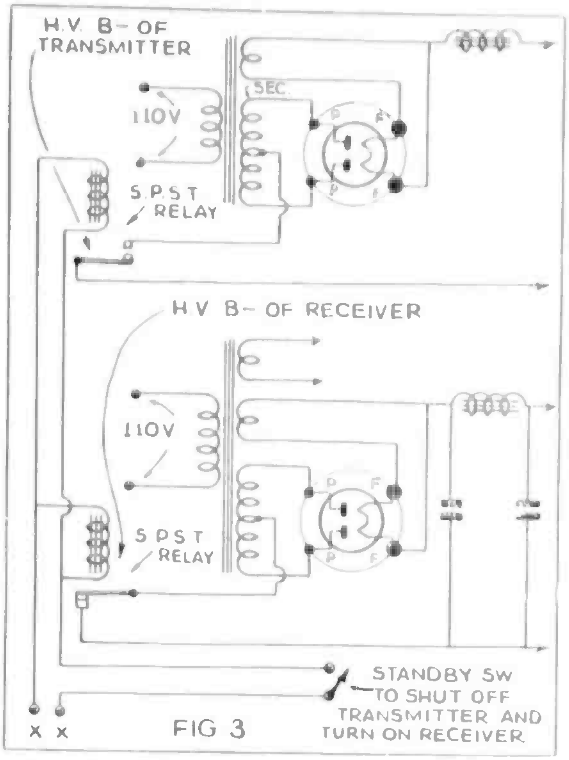


Fig. 3—This system provides rapid change-over from transmit to receive and speeds up operation.

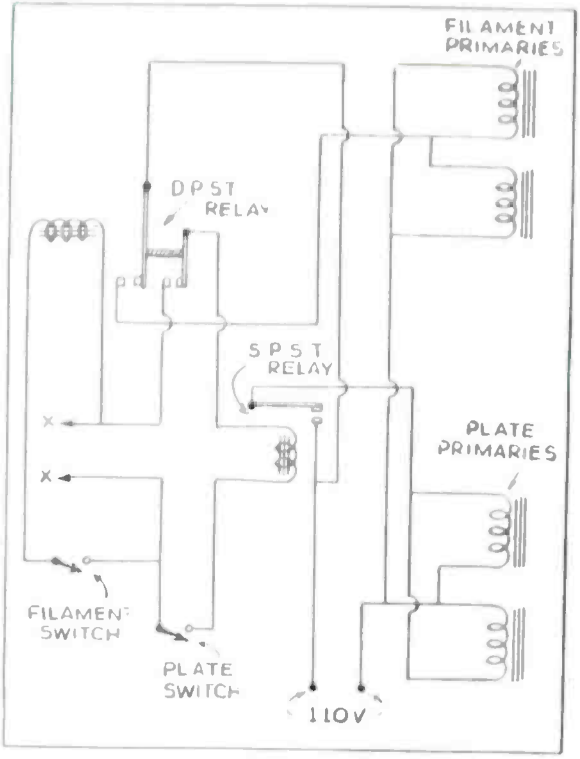
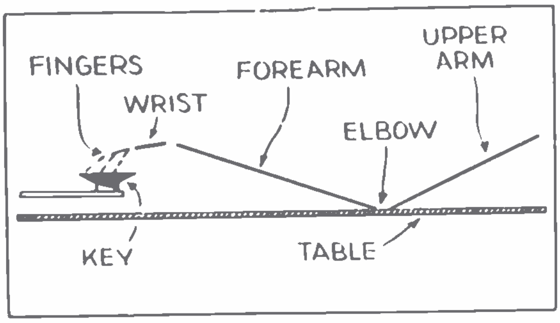


Fig. 4—How two relays are employed in a high-voltage power-supply, using separate transformers for plates and filaments.

is pulled open, only the filaments remain on; while if the filament switch is pulled open while the plate switch is closed, they all go off at the same time, which is a reasonable measure of safety. The only danger is in throwing the filament switch on when the plate switch is already closed. The operator should make sure that *this is never done!*

The entire group shown in the four different diagrams represent a complete installation. A combination for relatively high voltage would be Fig. 4 for starting the station. In the case of Fig. 4 for relatively high voltage power supplies, where separate filament and plate transformers are employed, ***break-in*** can be accomplished with the plate switch, merely by disconnecting the high voltage primary. In this case, the field of the relay operating the receiver would be connected in parallel with the field of the plate relay. Of course, if a number of separate power supplies are employed, then the number of relays will have to be increased. This will depend upon the particular station layout. If relays are installed, there is no doubt that they will prove the most valuable accessory the operator ever employed.

LEARNING THE CODE



Correct arm position

● Before one may operate an amateur station one must learn the code and be able to send and receive it at the rate of 13 words per minute, (5 letters to the word. The code test is the first part of the examination given, if this is failed, the applicant must wait 3 months before taking another examination.

Our suggestion would be that anyone applying for a license should be able to copy code at least 15 words per minute. Undoubtedly, the reader has heard many arguments pro and con as to the methods of teaching and learning code, and also has heard much about certain people not being able to learn code at all.

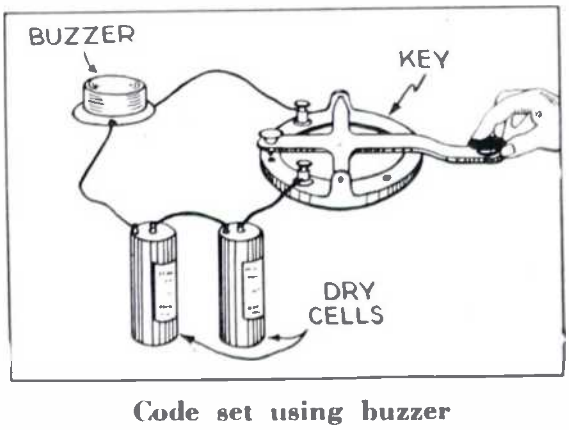
There is considerable latitude regarding one point. All the various methods available for learning code are good, but there is no such thing as "can't" in learning the code. The most important of all is PRACTICE. The radio code symbols are known as dots and dashes, but in practice sounds are called, dits and dahs.

The relative lengths of the dots and dashes and spaces between them are as follows; A dash is equal to three dots, the space between parts of one letter, or between dots and dashes of one letter is equal to one dot, and the space between 2 letters should equal three dots; and the space between two words should be equal to approximately five dots.

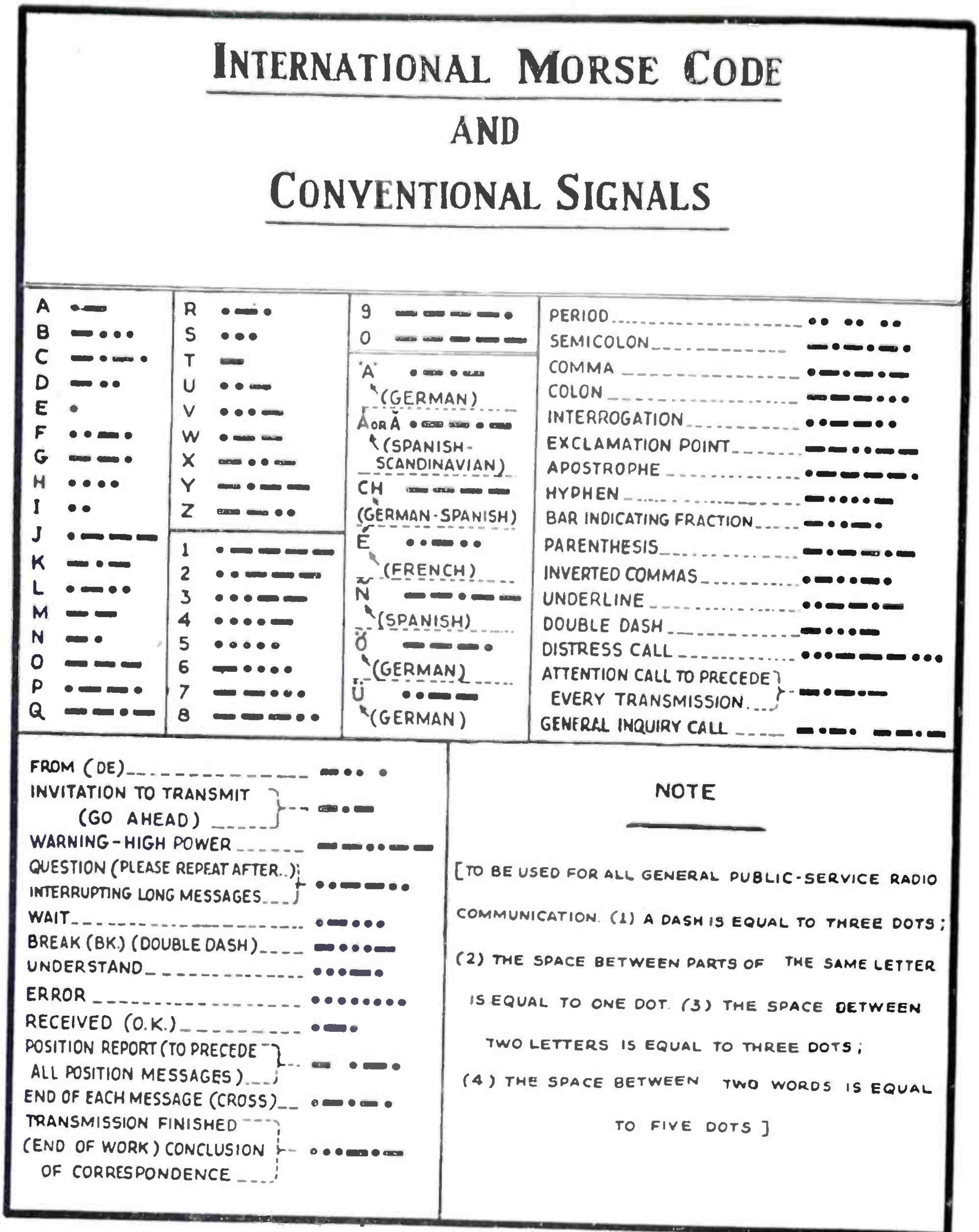
Various code teachers prefer different methods for learning the alphabet. Some prefer learning all the dot groups and dash groups separately. However, since they all must be learned, there would seem to be no better method than learning them in mixed groups or choosing letters at random. In fact, learning them in alphabetical order provides a well mixed formation.

Listening to commercial transmitters sending press and various secret codes will provide the student with the sound of the various characters. Most important is the proper formation of the characters composing a single letter, for instance, A in the chart is shown as one dot and one dash. To obtain an idea as to how this would sound, the dot and dash should be pronounced dit and dah as stated before, and as rapidly as possible leaving almost no space between the two. In other words, the dash should be pronounced or sent as soon as possible after the completion of the dots. (ditdah).

After this is done several times, the letter will have a certain rhythm, and, it is this rhythm, and the proper recognition of it, that makes a successful telegrapher.



Code set using buzzer

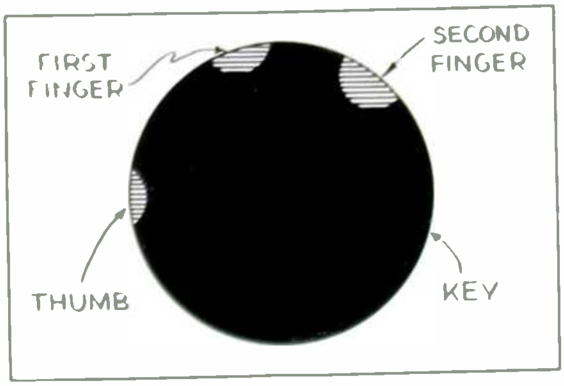


Complete Code Chart

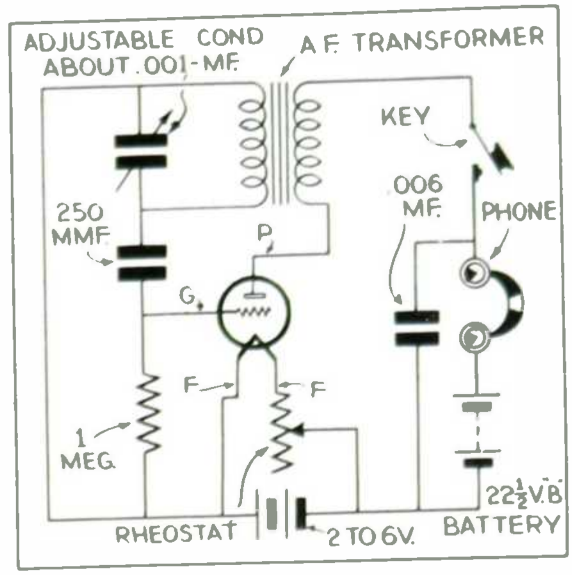
As the student becomes more proficient, letters will not be recognized for the dot and dash content, but by a certain rhythmic sound which they have.

We have shown a diagram of a simple code practice oscillator and a drawing showing how the key should be held. The secret of good transmitting is the lack of tense muscles. In fact, in receiving or transmitting, one should be more or less relaxed and should copy in a leisurely manner. Make it a practice of writing slowly, just fast enough to keep up with the rate of transmission. If you find yourself waiting for letters to be sent, you will immediately know that your method is wrong.

For the beginner we would suggest forming the letter just after it is sent, and form it slowly, then he will find that the next letter is being sent before the letter which is being written down is completed. This method serves for slow speeds from 5 to 10 words a minute. Above this speed he should copy further behind.



How to grip the key.



Simple audio oscillator for code practice

PRACTICE EXERCISE 1. This practice exercise contains the all-dash letters listed in memorizing group. T dah; M dah dah; O dah dah dah.

Two-Letter Code Groups

TT	MM	OO	MO	OM	TT	MM	MT	MO	TM
TO	MO	TM	OT	MT	OM	TM	TO	OT	OM

Three-letter Code Groups

TOM	MOO	OTO	TOM	OMO	MOO
TTM	OMO	MMT	MMT	OTM	TMO
TOO	MTM	MOM	TOM	TMO	MTM
MOT	TMT	OTM	TOO	OMT	OOM
TMT	TOT	OOM	OOT	MTO	TOM

Four-letter Code Groups

TOMO	TMTM	OTOT	MMOT	MOTO
MTMT	MOMO	TMOM	MOTT	OTOM
TMTO	MTTM	MTMO	TMOT	TOTO
OTMO	MTOM	TOTM	OMTM	TOOM
MOTO	OMTT	TOMT	OTMT	MOTM
OMOT	TOTO	TOMO	MOOT	OTTO

Five-letter Code Groups

TOTOM	MTMOT	TOTTO	OTTOM
MOTMT	MMOOT	MTMOT	TOMOT
OOMTT	TOMTO	MTOTM	MTOMO
MOTTO	MTOTM	OTOMO	OMTTO
TOTMO	OMMOT	TOMOT	TMOTO
MOTOT	OTMTO	MOTTO	MTOMT
TMOTT	TMOTM	TOTOO	TOMMT
TOMOT	OTTOM	MTOMT	MOMOT
OTMOT	TOTOO	MOTOM	TOMOT
MOTTM	TOTOM	OMOTT	OMOTO

Watch your spacing in the above groups, both between letters and between groups. Notice that these groups can be sent from left to right, or backwards from right to left; also both up and down.

PRACTICE EXERCISE 2: Next send dots or dot letters such as I, IS, E, EH, HI, HS, SI, and SE. Write up a drill exercise similar to the one which follows. As you write down the letters in the drill exercise say them mentally to yourself, using "dit" and "dah" instead of dot and dash (letter E is dit, I is dit dit, S, dit dit dit, etc.)

This exercise is for sending and receiving the all-dot letters listed in memorizing group 2.

E I S H

Two-Letter Code Groups

EI	EH	SH	SI	IH
SS	II	HI	HS	EH
ES	IS	SE	IE	IE
HH	EE	HE	EI	ES

Three-letter Code Groups

SIS	SIE	ISI	ESH	HIH	ESI
ESE	EIE	ESE	ISH	HIS	SEI
HSI	IEI	ISI	EIE	SIH	
HEH	ISE	IHI	SHE	EIS	
EHE	HSH	ESI	EHS	ISE	

Four-letter Code Groups

SISE	ISIS	HSEI	SEIS	EHIS
ESHE	SHEE	HIHI	EHIE	HSIE
ISHE	HISE	SEHS	SISI	SISE
HESE	ESHI	SIES	HISH	
HISI	EIEI	SEHI	ISHE	
ISES	HISH	HEHE	SHEI	
SHIS	SHIE	ISHE	ISHI	

A SIMPLE ROTARY 5 - METER BEAM ANTENNA

● SOMEWHAT more than fifteen years ago we secured a piece of well seasoned lumber three inches square and twenty feet long. The edges were trimmed off and the top was tapered so that it would not appear too unsightly and then the stick was given several coats of paint. It has been fastened to one of the studs on the side wall of the house in a corner besides the chimney, by four rather large lag bolts. Telescopic Fishpole antennas, designed for mounting on automobile bumpers and apartment house windows gave us the notion, stated Arthur H. Lynch, W2DKJ, that they could be used very satisfactorily in connection with the building of multi-element ultra hi-frequency antenna systems.

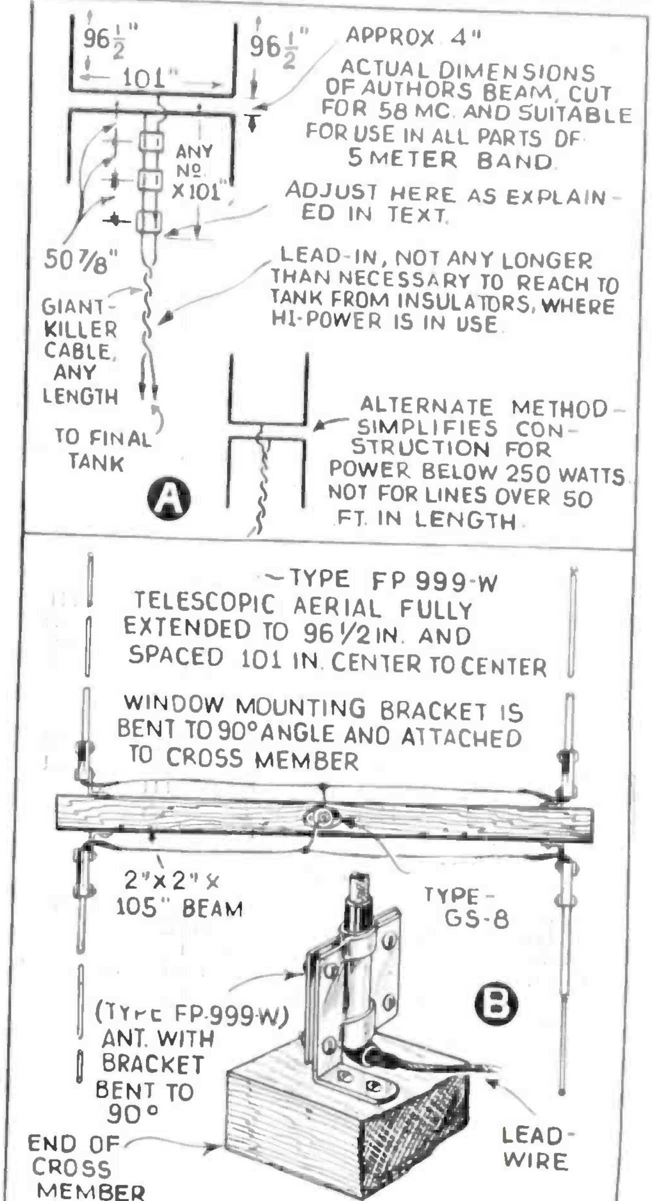


Diagram and side view of 5-meter rotary beam antenna

The type FP-999-W broadcast antenna poles are provided with a mounting bracket which is bent to an angle of forty-five degrees. We bent this bracket to an angle of ninety degrees and it formed an ideal support for the antenna itself.

It happens that our crystal has been cut to oscillate on a frequency of 7,245 kilocycles and by suitable doubling, we came to an ultimate frequency in the final stage of 57,960 kilocycles. Extending the telescopic fishpoles to their limit produces rods which are 96½" long and that is just about correct for the frequency on which we are transmitting. Such poles can be used satisfactorily from the middle to the high frequency end of the five meter band but they are not satisfactory for frequencies below 58 megacycles.

The crossarm that we use, states Mr. Lynch, is made of a piece of well seasoned pine two inches square and one-hundred and five inches long. Two radiators are mounted on the lower side. A piece of heavy, insulated wire is provided with this type of fishpole and by joining these lead wires from the two upper radiators at the center and following the same procedure with the two lower radiators we have an "H" beam which might very well be fed by a low impedance transmission line.

In our case, however, we preferred to use an open line for a part of the run to the shack and a junction to the open line is made, without introducing any serious difficulties by sliding the ends of the low impedance twisted pair up and down the last foot or so of the open line until the best point is found, in the usual way. A satisfactory point for starting to locate the optimum junction between the open line and the low impedance twisted pair is to make the open line any number of half wavelengths long.

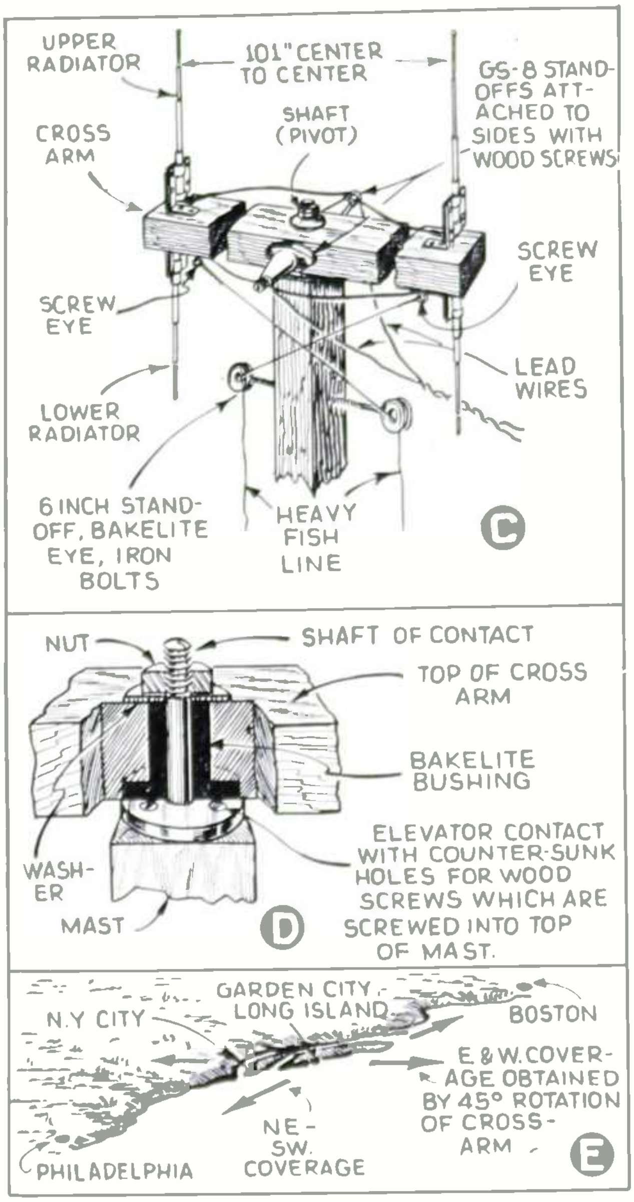
A Simple Spaced Pair

A few years ago we designed a special type of transmission block, for use in connection with the making of noise-reducing antenna. These blocks provide one of the simplest methods of making open transmission line because they keep the wires separated the correct distance, they can be inserted in the line without any tie-wires and any time that it is found desirable to insert additional spreaders these transposition blocks can be used very satisfactorily. When a transmission line of this type is made it should be borne in mind that the wires are NOT transposed. The wire we used is approximately the equivalent of No. 14 solid and, as it becomes automatically spaced with the use of these transposition blocks, we provide ourselves with a line having an impedance of approximately 450 ohms. The losses in a line of this kind are negligible, even at five meters. This is not true of any twisted pair nor is it true of any type of coaxial conductor. So, wherever an open spaced pair can be used, particularly on the ultra hi-frequencies, it should be used and the use of nothing but the best twisted pair should be used in conjunction with it.

Making the Beam Rotate

The simplest method for mounting the 2 x 2 inch cross-member on the top of our 3 x 3 mast would be to drill a reasonably small hole through the 2 x 2 and run a fairly long lag screw into the top of the mast, placing a metal washer between the head of the lag screw and the top of the cross member and another one between the bottom of the cross-member and the top of the mast. Such an arrangement is all right for a temporary affair but it is certinly not workmanlike and we believe that the arrangement that we have used will be welcomed by those amateurs who contemplate making their rotary beams more substantial. The arrangement that we have used is a very simple but very effective one.

We secured a copper contact, of the type which is used on large elevator controls. The contact had an outside diameter of 2¼" The base is ⅜" thick, the pin is 2⅞" long and the diameter of the pin is ½". We drilled three holes through the base and



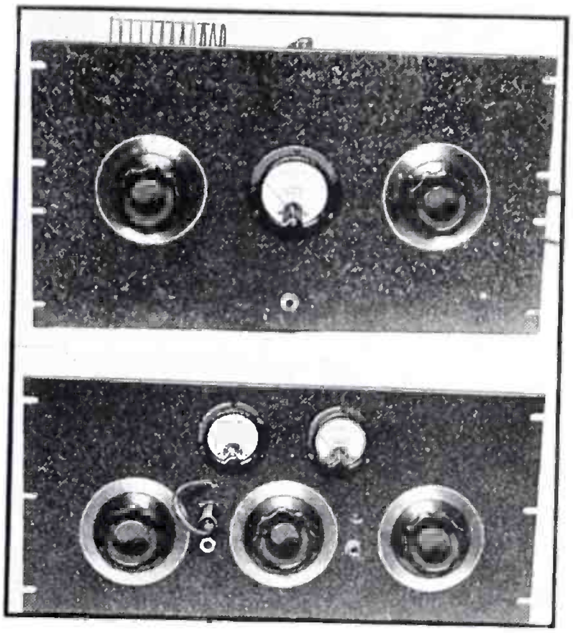
Details of suspension of rotary beam antenna are shown above.

then counter-sunk the holes so that the contact itself could be fastened to the top of the mast with three wood screws. Insulating bushings for these copper contacts are stock items and they are made of molded bakelite. They have a bottom surface which is equivalent to the surface of the base of the copper contact. We drilled a hole through the cross-member and sunk the bakelite bushing into the hole and that gave us a very satisfactory bearing and prevented any side swaying of the cross-member. Plenty of vaseline was applied to the upper surface of the copper contact and the lower surface of the bakelite bushing. The complete antenna can be rotated so easily that it turns as though it was mounted on ball bearings.

806 "ALL-BAND" TRANSMITTER DELIVERS 400 WATTS

● THE main purpose in the design of this transmitter was flexibility and simplicity. It as an easy matter to make an *all-band* transmitter employing a large number of stages. On the other hand, if proper tubes and circuit arrangements are employed, the problem is not quite so complicated as it may seem.

In transmitters having fairly high-power amplifier stages, that is somewher around ½ kw., (500 watts) the ***driver stage*** should receive greatest care in the choice of components. The tube used as the driver determines whether or not the transmitter must be complicated. If the tube used in this position requires only a few watts excitation, then we can produce all-band operation with a single crystal. With this transmitter we have chosen the 804, which works exceptionlly well down to 10 meters. The excitation requirements of this tube are extremely modest, less than 1 watt being sufficient for maximum output.



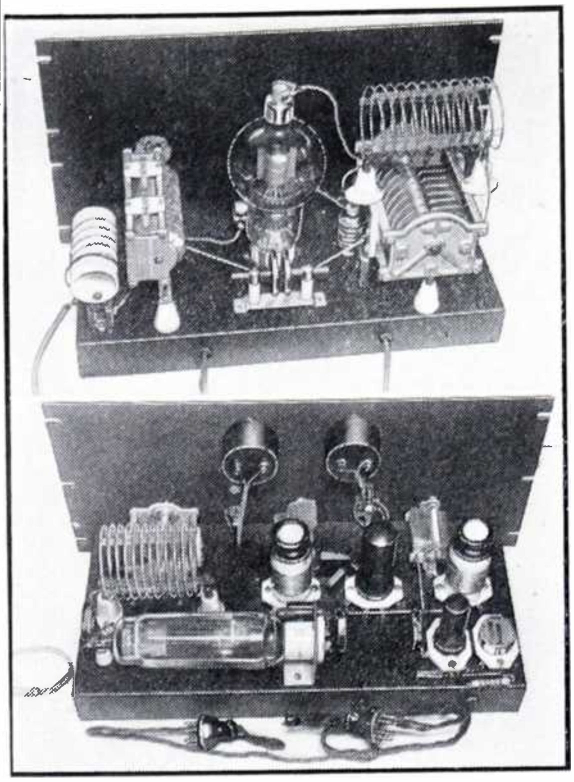
Front view of the complete transmitter. The "exciter" and "driver" stages are built on the lower panel and sub-base; the 806 "final-amplifier" and control panel being the top one.

"Pen-tet" Exciter Employed

In order to obtain the utmost in flexibility, we resorted to the "Pen-tet" exciter. This unit consists of nothing more than 6F6 pentode crystal-oscillator, followed by a 6L6 multiplier. This arrangement makes it possible to quadruple the crystal frequency with excellent efficiency. With 400 volts on the plates of the oscillator and multiplier, the output of the fourth harmonic and 80 meter crystal is more than sufficient to drive the 804 driver and it is necessary to adjust the coupling in order not to overdrive the large pentode. The 804 pentode seems to be the ideal driver for the 806 final amplifier used in this transmitter, as its output ranges from 50 to 80 watts, depending upon the circuit connections and the voltages applied to the tube.

50 Watts From Driver

In our case we used the tetrode connection and applied 1,000 volts to the plate of the tube. The output with this arrangement was approximately 50 watts with an excitation requirement of only .65 watt. This output, of course, is slightly greater than the 25 to 30 watts required for the 806, when operated as a plate-modulated class C amplifier. However, the driver stage, especially in a phone transmitter should have ***good regulation*** and a ***fair surplus of power;*** proper excitation being obtained by ***varying the coupling*** between the driver and the final stage.



A peek behind the front panels—top, the 806 "final-amplifier," and below—the "exciter" and "driver" stages, with crystal.

Since link coupling is used, a variation of he excitation is simply a matter of the roper placement of the link coil. The mount of grid current present in the final mplifier stage is the best guide to proper xcitation adjustment. For class C telegaphy, the final amplifier grid current should e in the neighborhood of 25 to 40 mills. M.A.) This can be obtained with a 15,000 hm grid-leak.

Smaller values of grid-leaks may be used vith lower voltages.

Phone or CW Operation

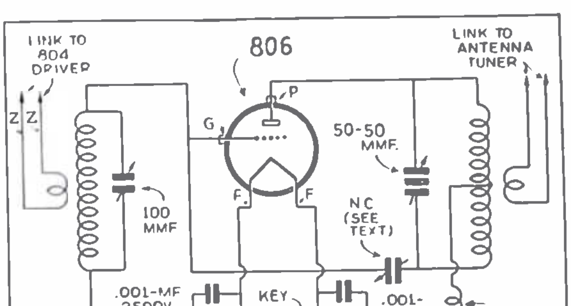
For phone operation, the grid current should be at least 40 mills, slightly higher values—not exceeding 50 milliamperes—may in some instances improve the linearity of the amplifier. For CW or *code* operation, the plate voltage to the final amplifier can run as high as 3,000 volts. However, for phone use, the maximum rating is 2,000 and this seems to provide the best all-around operation. These values will serve for the 80, 40 and 20 meter band. However, in some cases, it may be advisable to reduce the plate voltage slightly, probably to 1500 to 1800 on the final amplifier. Although we have operated the tube with 2,000 volts on 10 meters with no signs of ill effects, the manufacturers claim that for this service the tubes should be cooled, preferably with an electric fan. While this may be an inconvenience in some cases, should it become necessary, we believe that a slightly lower plate voltage would overcome the problem. The slight reduction on 10 meters would not be worth mentioning, insofar as actual service is concerned.

Single Chassis for "Exciter" and "Driver"

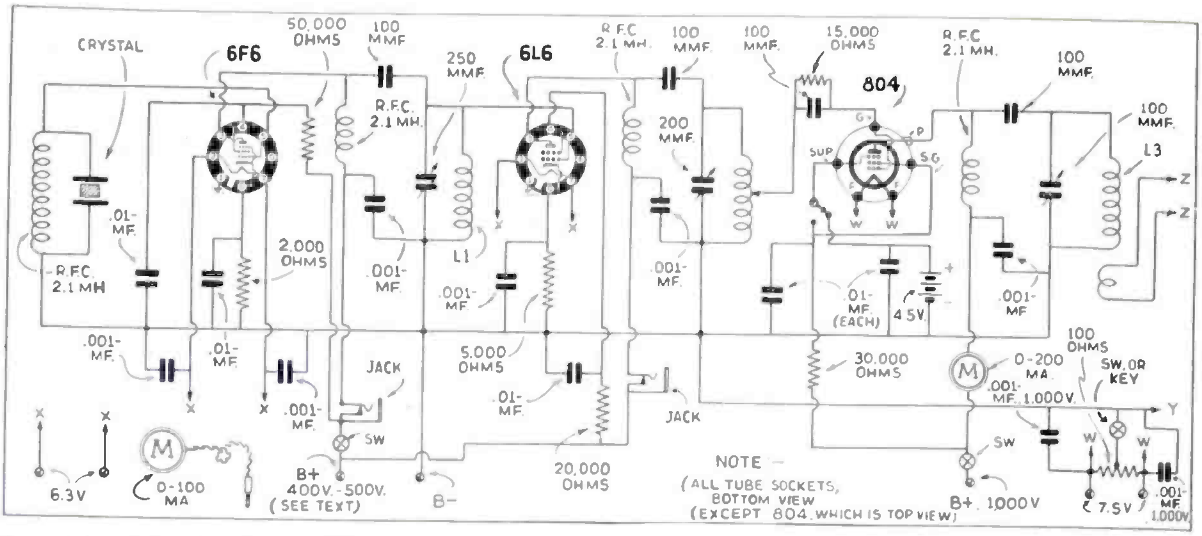
The photographs show the general construction of the *exciter* unit, as well as the *final-amplifier* unit. The exciter and driver stage are contained on a single chassis and it can be seen that this is a very simple unit—only three tubes are used. The panel dimensions are 8¾" x 19" while the chassis is 2" x 7" by 17". The chassis for the final stage is the same size and the panel is slightly higher or 10¾". The final amplifier tank condenser is of the *split-stator* variety and has a capacity of 50 mmf. per section. This unit originally was a 6,000 volt 100 mmf. condenser, the stator was later split. However, a standard split-stator condenser is readily available. For operation on the 80 meter band, this capacity is slightly small; we would recommend the use of a condenser having 100 mmf. per section if one is interested in high power operation on 80 meters.

Exciter Unit Can Be Used As 90-Watt Transmitter

Our suggestion is that the final amplifier be eliminated for 80 meter operation, and by applying approximately 45 volts to the



The 400 watt final amplifier, using 806. The neutralizing condenser is a disc type, high-voltage neutralizing condenser. See photos for details.



Complete Exciter Unit 50-to-90 watts; for operation of the exciter alone, the switch in the suppressor-grid circuit should be in the position which puts 45 volts on the suppressor.

suppressor of the 804, we have a 90 watt transmitter which should be thoroughly capable of meeting all requirements on the 80 meter band. In fact, this is the way the original transmitter was operated.

The high power final stage is only used on 40, 20 and 10 meters. The grid tuning condenser for the final amplifier stage appears to be a split-stator condenser of quite large dimensions. This was used in the first arrangement of the transmitter in an endeavor to employ a single-section plate condenser by the simple expedient of *grid neutralization.* However, satisfactory results can be more easily obtained with the split-stator condenser in the plate circuit, and a single condenser in the grid circuit. When using *grid neutralization*, the output of the driver stage, operated as shown in the diagram, would not provide sufficient excitation for efficient phone operation on the higher frequencies. Plate neutralization is shown in the diagram and eliminates this problem.

The complete transmitter as described, provides one of the smoothest operating "rigs" ever tried. Its excellent output of 400 watts on *all* bands provides an impressive signal.

Coil Data

80 and 40 meter oscillator 17 turns; 6L6 multiplier, 18 turns. 20 meter multiplier coil, 8 turns. These coils are wound on a 1½" isolantite form with the winding spaced to a length of 1½ inches.

Data for the amplifier is as follows: 80 meters—22 turns, No. 12, 2½" diameter; for 40 meters 14 turns, No. 12, 2½" diameter; 20 meter, 6 turns No. 12, 2½" diameter; 10 meter, 4 turns No. 12, 1¾" diameter. These coils are of the self-supporting type with a length of 4". The 806 grid coils are wound on 1¾" dia. isolantite forms. The coils are wound to a length of 3" with No. 18 tinned wire. The turns are as follows: 22 turns for 40 meters; 12 turns, for 20 meter; and 5 turns for 10 meters.

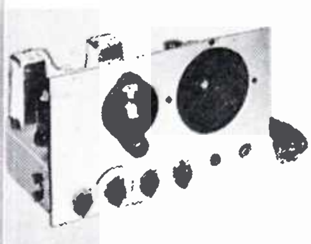
The 806 plate coils are of the same construction as the 804 plate coils, however, they are wound to a length of 5" and have a diameter of 2½". The 40 meter coil has 26 turns; 20 meter coil has 12 turns. The 10 meter coil has 4 turns of the same diameter but is only spaced to a length of 4".

The self-supporting coils are constructed with No. 12 tinned copper wire of the soft-drawn variety. The supporting strips are made of 1/16" celluloid strips ¼" wide.

LESSON NO. 1 FOR

ADIO AMATEURS· SET BUILDERS· EXPERIMENTERS·

AKE ALLIED'S CATALOG UR RADIO BUYING GUIDE!



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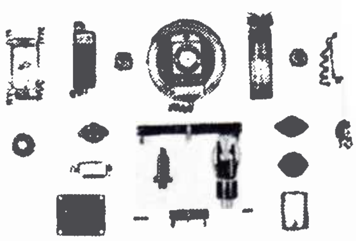

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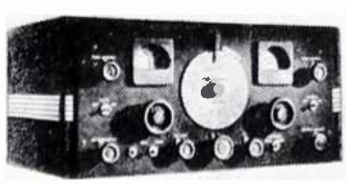

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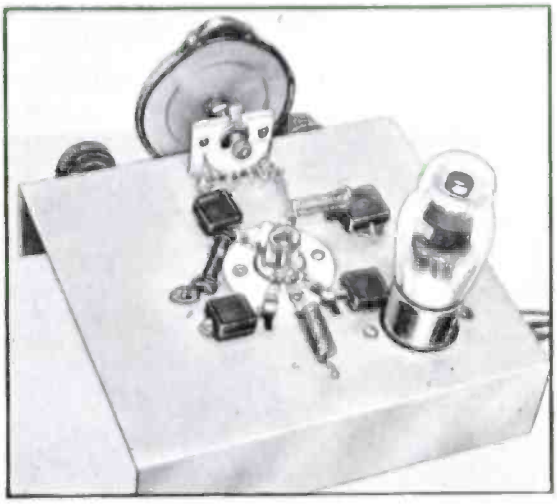
ONE METER WAVES FOR "SHORT-HAUL" QSOs



Top view of 1-meter receiver.

● THE amateur has done little experimenting on the real ultra-high frequencies for the simple reason that proper equipment has only recently become available. It is a well-known fact that it is almost impossible to get any appreciable power from the conventional type of vacuum tube at wave-lengths as short as 1 meter.

With the advent of the new Western Electric 316A tube, there is no reason why the amateur who can afford it should not carry on experiments in the ½ to 1½-meter regions. This new tube can be operated at fairly high efficiency at ½-meter, and has a power output of from five to eight watts. There are many advantages in working on frequencies in the neighborhood of 300 megacycles or higher; principally the entire lack of *outside interference*.

No Interference Noticed

For instance, during the several months of experimental work, we did not hear a single automobile ignition system, or for that matter, any other type of electrical disturbance; in fact we heard nothing *save our own signals* and we believe that this real ultra-high frequency business offers the amateur an excellent opportunity for *short range direct communication*. We further believe that a successful amateur band could be organized in these regions, and probably produce more interesting results than the present 5-meter band. Of course, the transmission range is more limited as the frequency increases and the higher we go, the more it seems to take on the *optical effect*.

In oher words, in wavelengths around 1-meter, distances of around 25 miles would seem to be "DX," unless we experience some unusual conditions similiar to those now current on the five meter band, where atmospheric conditions play a prominent part. Before any definite opinions can be reached, it will be necessary for the amateurs to occupy these high frequency regions in large numbers and thereby prove whether or not present theories and findings are definitely correct. In any event, we believe it affords an excellent opportunity for *intra-city communication*.

The transmitter employed during our ex-

The 400-volt power-supply used with the oscillator.

periments was a single 316A, plate-modulated with about 400-volts on the plate. In the photographs you see the actual transmitter that operated in the neighborhood of 275 megacycles. The circuit is exactly the same as that described by the author in the November 1934 issue of ***Short Wave Craft***, and this circuit seems to be the only logical one at the present time ***for 1-meter operation.***

Constructional Details

The general constructional details can be learned by referring to the photograph. Here we see that the tube is fastened to the ends of a pair of copper tubes. These tubes are ¼-in. in diameter, and the spacing between them is slightly over a ¼-inch. The spacing in fact is identical to the spacing of the plate and grid prongs of the tube. The length of these copper rods of course, depends upon the frequency at which you wish to transmit. The over-all length of the external circuit from the tube to the far end of the copper tubing is 15½-inches, and the frequency of oscillation is approximately 275 megacycles. The frequency may be increased by shortening the length of the two copper electrodes. The plate and grid re-turn leads are taken from a point of zero R.F. voltage on this oscillatory line. R.F. chokes are used at this point and they consist of 20 turns of No. 18 or 20 wire, wound on ¼-inch dowel stick. After the winding form is removed the turns are spaced so that the over-all length is approximately 2-inches. Similiar chokes are also used in series with each leg of the filament.

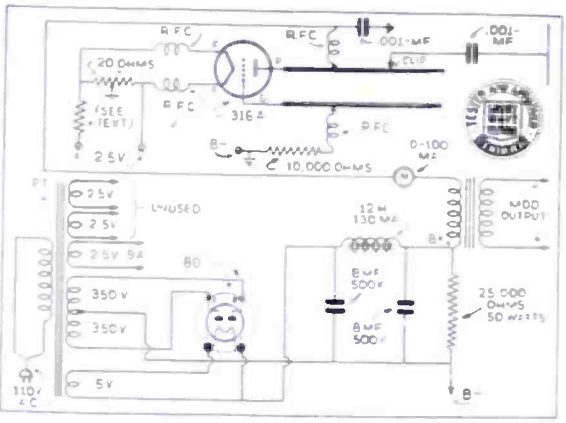


Diagram showing the transmitter connections.

If the directions given are followed the oscillator will work the first try and no tricky adjusments will be necessary. The one and only adjustment is the placing of the grid and plate connections on the copper rods, and this is done with the aid of a small neon bulb, after the transmitter is operating and the two clips connected to about the mid-point of the copper-rods until a point is reached where no glow is apparent. This is the point where the two clips should be attached.

The antenna used in our experiments consisted of a single copper rod one-half wavelength long. Its length was determined by the standing wave on the linear circuit of the oscillator. The distance from the free end of the copper tubes to the point where the neon bulb went out may be roughly considered as ¼-wave, and the length of the half-wave antenna will be twice this length. The antenna feeder consisted of a single wire, tapped on to the antenna a short distance from the center. This distance is equal to approximately 14% of the total length of the antenna.

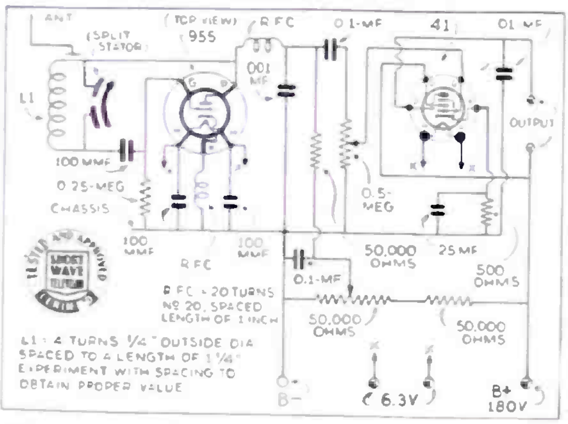
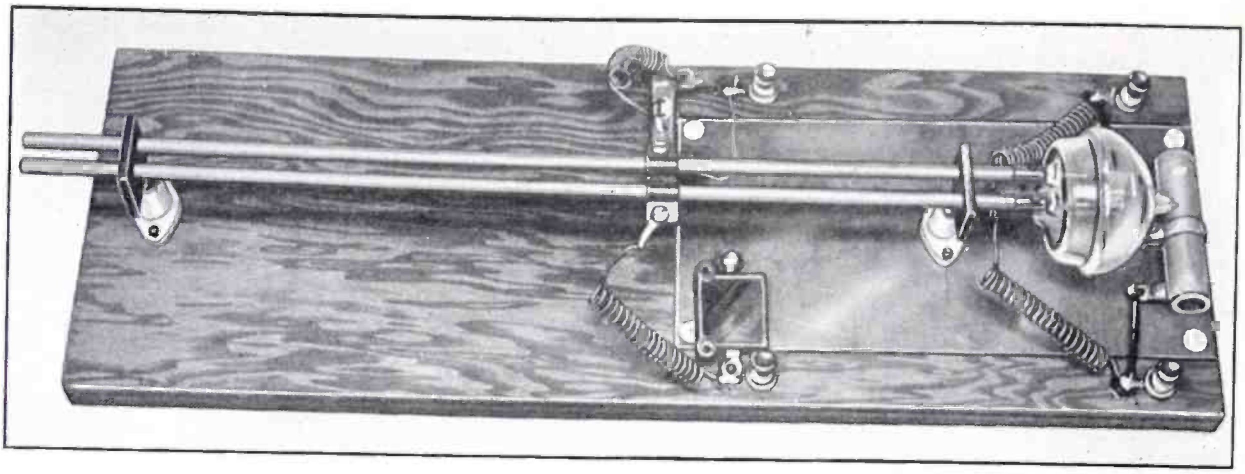


Diagram of the 1-meter experimental receiver.

1-Meter Receiver

No directional antennas were tried because the receiver was most of the time located in a moving automobile and therefore a directional antenna would not have served our purpose. The receiver employed is also shown in the photograph, and consisted of an acorn 955 triode, and a 41 audio amplifier. The tuning condenser was a two-plate Trim-air with the stator plate split in the center. Complete data is also given in the diagram covering the construction of the choke coils and the inductance for the grid circuit.

The ***power supply*** for the transmitter was a very simple affair and the diagram explains it in detail. As 2½ volt windings are the nearest obtainable, in the average power transformer, a resistance is necessary in order to reduce it to 2 volts for the filament.



Complete 1-meter oscillator.

This resistance can be a short length of resistance wire, the proper length determined with the use of a voltmeter, the exact resistance should be 1369 ohms.

The modulator used in the transmitter, but not shown in the photographs, consisted of a pair of 2A5's in class A,B. However, any audio unit with about 15-watts output will be entirely sufficient.

In the test conducted all known rules on ultra-high frequency transmission were found to be predominant. In other words, the higher the antenna, whether it is for receiving or transmitting, the better the signal strength; also hills have an appreciable effect on the signal, when either the transmitter or receiver are located close to the base of the hill. The ill-effects of the hills becoming less noticeable as the transmitter or receiver is moved farther away from it.

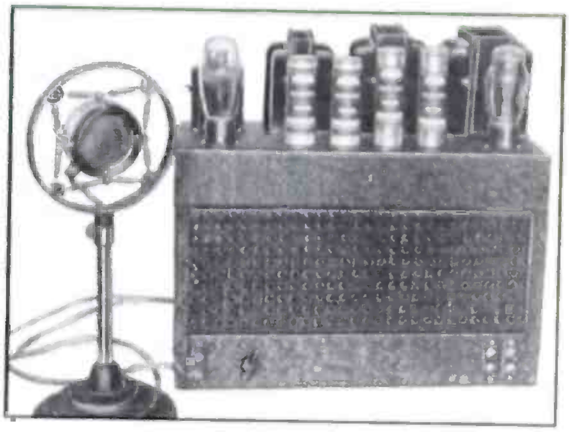
All in all, our tests proved that the amateur can occupy the ultra high frequency region with just as much satisfaction as he now can obtain from the 5-meter band.

One Meter Set—Parts List

OSCILLATOR

1—WE-316A tube
2—.001 mf. 1,000 volt condensers
1—10.000 10-watt resistor
1—100 ohm center tapped resistor
1—power transformer; see diagram for ratings
1—12 H. 130 ma. filter choke
2—8 mf. 500 V. electrolytic condensers
1—25,000 ohm 50 watt resistor
1—type 80 tube
1—¼ meg. resistor ½-watt
1—50,000 ohm resistor ½-watt
1—500 ohm resistor 1-watt
1—50,000 ohm resistor 1-watt
1—50,000 ohm potentiometer
1—½-meg. potentiometer
3—.0001 mf. mica condensers
1—.001 mica condenser
2—.1 mf. paper condensers
1—.01 mf. paper condenser
1—25 mf. electrolytic condenser
1—Trim-Air 2-plate condenser with split stator (XV-5-TS)
1—Acorn tube socket
1—6-prong wafer socket
1—955 Acorn tube
1—41 tube

THE 6L6 MODULATOR



Complete modulator, including the crystal microphone.

● THE famous 6L6 tube, although not very old, has become one of the most popular of all tubes manufactured and is to say the least, the most interesting. Previous articles have shown its adaptability to transmitting apparatus in the R.F. portion and in this article we will describe a *modulator* using them in the output stage.

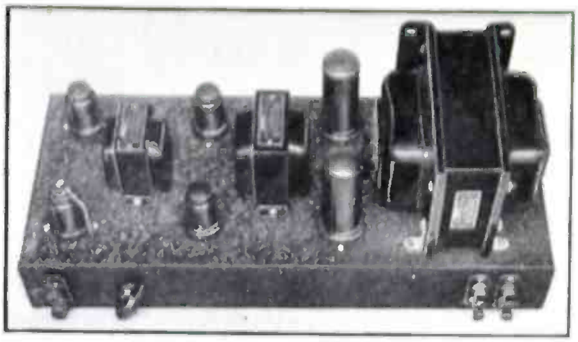
Two of these tubes in Class A-B in this modulator will deliver over 50 watts of audio and are capable of modulating an R.F amplifier with inputs up to 100 watts. This modulator is designed to work in conjunction with a crystal microphone and uses metal tubes throughout, except in the *power-supply*. The diagram reveals that we start out with a hi-mu triode, as the first stage of speech amplification, a low-mu triode in the second stage of speech, two in push-pull as drivers for the push-pull 6L6's. Resistance coupling is used in the first two stages which employ a 6F5 and a 6C5. The speech amplifier is "transformer-coupled" to the ***driver*** stages which, in turn, make use of special transformers for the inpu and output circuits.

The output transformer is designed for 2500, 5000, and 7000 ohm loads, and is capable of carrying the plate current of the modulated amplifier. The entire audio portion is built on a 7 x 17 inch, crackel-finished chassis, 2 inches deep, and has a metal cane style cover. The power supplies—there are two of them, one for the power stage and another for the three amplifier stages—are mounted on a similar chassis, A cage was not employed here, but would undoubtedly improve its appearance.

Separate Power-Supplies Used

The photographs show the complete unit ready to couple to the R.F. amplifier with the power supply sitting on the top of the speech equipment. The other two photographs show close-ups of both the speech and the power-supply portions. Due to the rather heavy current requirements of the power-stage and extra good regulation being necessary, separate power-supplies were used. The one delivers 400 volts at 250 mills (ma.) and has only to serve the plates of the 6L6's. Another power-supply, delivering 250 volts, supplies the plate voltages for the three low-power stages and screen-voltage for the 6L6's. The screen voltage was taken from the low voltage power-supply in order to obtain perfect regulation and maintain the screen voltage constant during current swings of the power stage.

The transformers available would not permit a single 6.3 volt winding to feed all of the heaters and, therefore, as the diagram shows, the heaters were split up, some being run off the low-voltage power-supply, and some from the high-voltage power-supply. This is not at all inconvenient because the windings are already present on the transformer and are taken care of in the plug arrangement. In the rear



The speech or audio part of the equipment.

of the speech unit we have two sockets which are receptacles for the power-supply leads and from the power-supply unit there are two cables with plugs attached to fit the sockets. In the high-voltage supply, we used an 83 rectifier and an 80 in the low-voltage power-supply. If the 83 causes a ***hash*** in the receiver, merely substitute it with an 83V which is a special vacuum tube, with regulation nearly as good as the 83. The 83 provided slightly better results.

"Gain-Control" and Bias Arrangements

Good equipment must be used in the construction of the power-supply and the modulator, because poor regulation can ***not*** be tolerated, otherwise you will have serious distortion and low-power output. The ***gain-control*** is incorporated in the grid circuit of the second speech amplifier. This is a 500,000 ohm potentiometer and usually has to be turned on about 60 per cent for comfortable speaking into the microphone.

Plenty of circuit-isolating resistors and condensers are incorporated in the speech amplifiers and are absolutely necessary wherever shown in order to obtain maximum stability.

The 6L6 stage may be operated with automatic bias or fixed bias. The battery bias, or fixed bias arrangement, permits slightly greater power output. Although this grid voltage might have been obtained from the low-voltage power-supply, a separate battery was used. The small variety work well because of the low voltage requirements and also due to the very slight amount of grid current that flows during peak power-outputs, which has very little effect upon a good battery. Automatic bias is used throughout the rest of the modulator in the conventional manner.

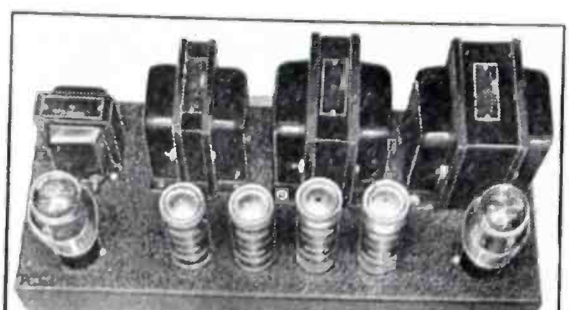
Both the grid leads of the two speech-amplifier tubes are ***shielded*** with regular shielding braid. This was found necessary in order to reduce hum pickup and also possible feed-back. Under operating conditions, the amplifier, as we said before, gave over 50 watts audio, and the ***quality*** is extremely good. In fact, many who have heard it "over the air" claim that it sounds as good as anything they have ever heard and equivalent to "broadcast" quality.

There is absolutely no noise in the amplifier itself when using a crystal microphone, and not the slightest trace of hum—which also makes for better quality.

There are two types of output transformers available for the 6L6's. One is shown in this particular modulator, and another which has low-impedance outputs ranging up to 500 ohms. It has been found desirable in many cases to use an "out-put" transformer with a 500-ohm output secondary and coupled to the modulated amplifier through a 500-ohm transmission line. Although this requires another transformer for matching the 500-ohm line into the modulated amplifier, it eliminates "feed-back" difficulties in that the modulator may be operated at quite a distance from the R. F. amplifier, and thus there will be little chance of R.F. getting into the modulating equipment. Of course, if care is used in setting up the apparatus, no R. F. should be present in the audio system. But one of the best ways of getting around this possible evil is to use the above method and employ a 500-ohm line between the modulator and the modulated amplifier.

Parts List for Modulator

1—5 meg. resistor
1—3500 ohm resistor
1—50,000 ohm resistor
1—200,000 ohm resistor
1—200,000 ohm resistor
1—2,500 ohm resistor
(The above resistors are all ½ watt)
1—20,000 ohm voltage divider
1—15,000 ohm voltage divider
1—.5 meg. potentiometer
2—4 mf. condensers, 100 volt
2—2 mf. condensers, 400 volt
5—8 mf. condensers, 600 volt
1—.1 mf. by-pass condenser
1—10,000 ohm resistor
1—500 ohm resistor



The two power-supplies conbined in one unit, which are used for the 6L6 modulator.

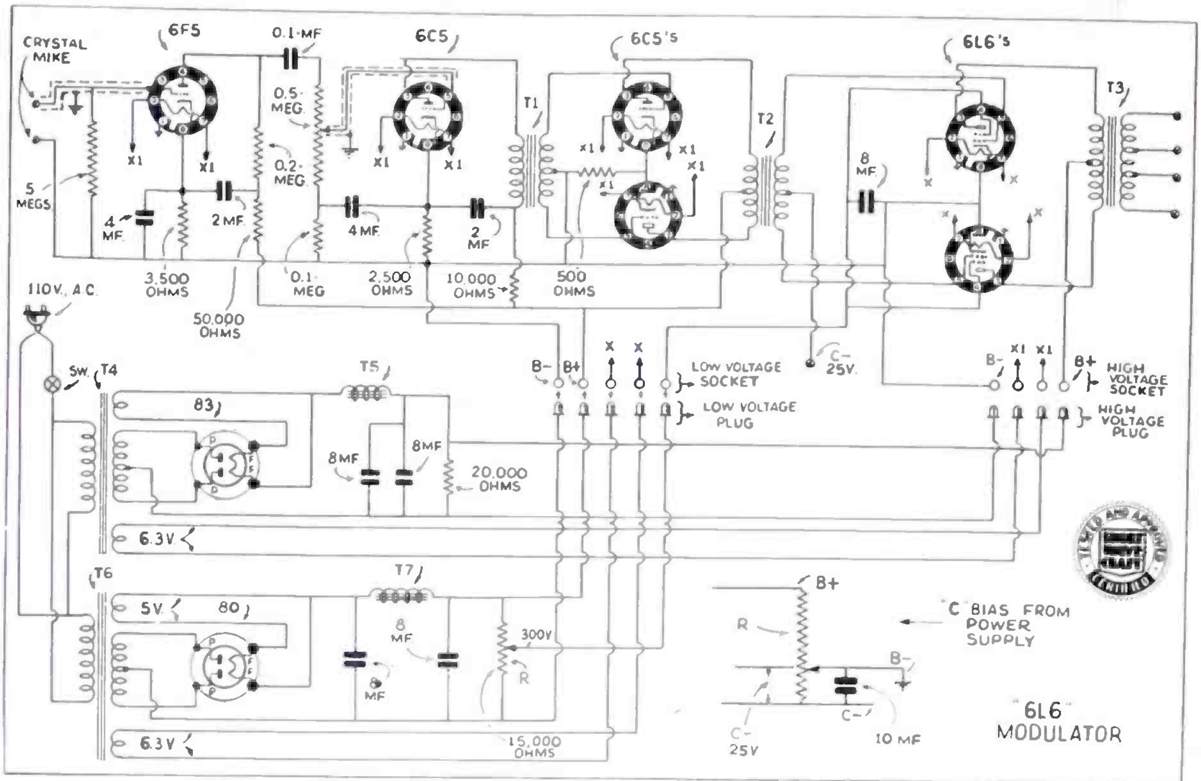


Diagram of the complete modulator and power supplies

2—7 x 17 x 2½ inch chassis, with bottom plates and one cane type cage, black crackle finish
6—Bakelite wafer sockets, octal
1—6F5 tube 3—6C5 tubes
2—6L6 tubes
1—83 tube
1—80 tube
1—crystal microphone

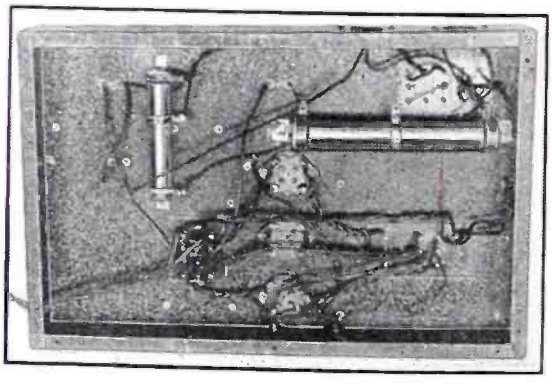
UNIVERSAL POWER SUPPLY FOR THE HAM

● THE problem of supplying voltages to a transmitter is constantly confronting the average amateur.

In most cases two separate power-supplies were used; one furnishing low voltage, that is around 500; another supplying the high voltage, usually around 1,000 to 1,500 volts. It is also possible to obtain the same results with a single power-supply by using a tapped voltage divider. However, this latter method is electrically unsound because of the poor regulation afforded and power wasted. The low-power stages suffer when the high-voltage amplifier is keyed.

The new special triple-winding transformer which is described in this article, and shown in the photographs, permits the entire problem to be solved economically and in an electrically sound manner.

In most of the amateur stations where the



Bottom view showing the wiring.

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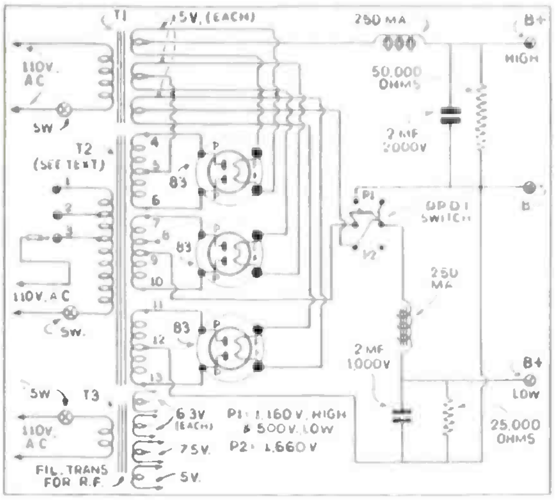
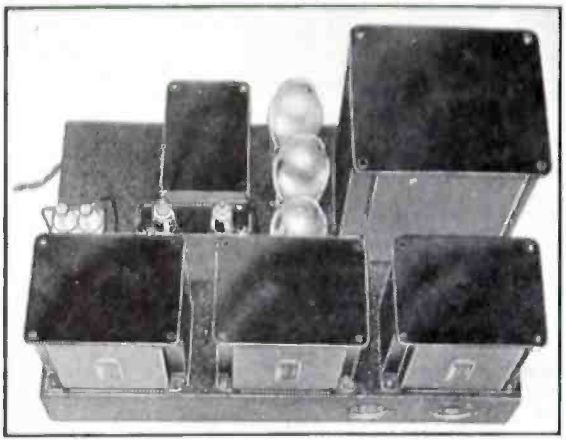


Circuit diagram showing the various connections.



Top view of the Multi-purpose power-supply.

average power output is around 100 to 250 watts, two voltages are required, 500 and 1,000. The 500 volt potential is usually applied to the oscillator and buffer stages, while the 1,000 volt supply furnishes power for the final amplifier alone, and it was for this particular purpose and arrangement that this power-supply was designed.

Here we have in effect, two power-supplies employing only one transformer for the high voltages and using three type 83 rectifiers. A switch is also provided so that a single output of some 1,600 volts may be obtained if needed; however, this does away with the low voltage supply. Elsewhere in this book we describe a transmitter which can satisfactorily employ this particular power-supply. The transformer which supplies the various filament voltages contains two 6.3, 7.5 and a 5-volt winding. One 6.3 and the 7.5 windings are both employed.

By employing a rather long filament cable, the voltage is dropped to around 10¼ volts which is entirely satisfactory. The remaining 6.3 volt winding is employed for the low-power stages. Each output section of the power supply will provide the voltages indicated in the diagram at 250 milliamperes, this is entirely satisfactory for almost any medium power amateur transmitter.

Numerous other combinations may be employed aside from those shown in the diagram. The only variations we found necessary were the double-throw switch for switching from one single output, at 1,600 volts, to two delivering 500 and 1,100 volts, together with three taps on the primary. The voltages shown in the diagram are obtained by employing tap No. ***three*** on the primary. Taps ***one*** and ***two*** will give correspondingly lower voltages.

T-1 in the diagram is a triple-winding, 5-volt filament transformer, and permits the many combination hook-ups with this power-supply. The filter section of the supply may seem rather meager; however, careful examination has shown that a single choke and condenser is entirely sufficient to provide an absolutely ***pure note*** from an efficiently designed transmitter.

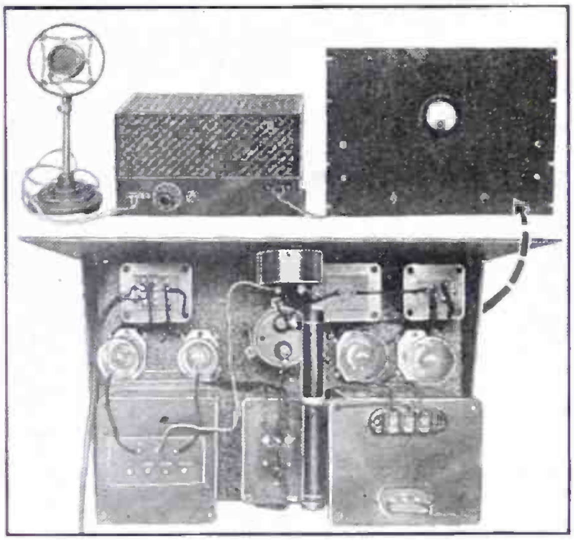
Of course, the ***crystal*** when used in the oscillator circuit goes a long way toward ironing out any ripple that might be caused by the power-supply.

Tests on the air with a number of transmitters proved that this power-supply gives a perfect note, and one need not incorporate additional chokes or condensers in the filter section.

Parts List—Power Supply

1—Triple winding transformer (250 ma.)
1—4-winding filament transformer, see text
1—3-winding filament transformer
2—14 henry—250 ma. filter chokes
1—50,000 ohm—50 watt resistor
1—25,000 ohm—50 watt resistor
1—2 mf. 2,000 volt filter condenser
1—2 mf. 1,000 volt filter condenser
1—17 by 12 by 3 inch crackle finished chassis
3—4-prong wafer sockets

AN EFFICIENT 125-WATT MODULATOR USING 35T's

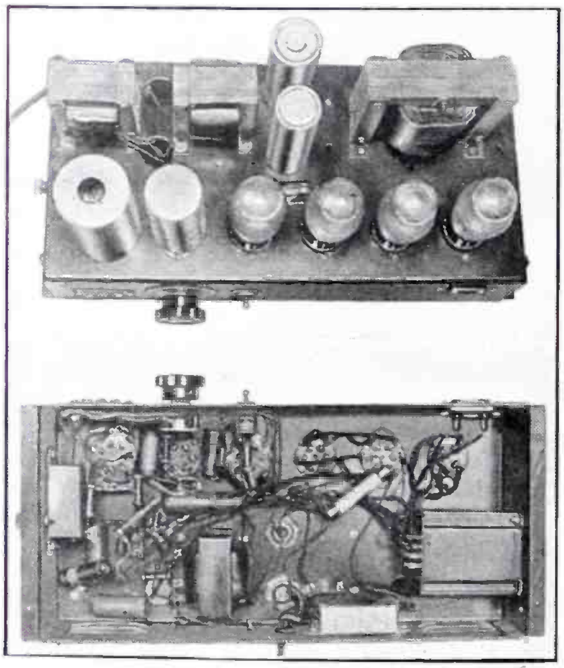


Complete view of modulator and speech equipment, together with an "inside shot" of the high-power stage and its power-supply

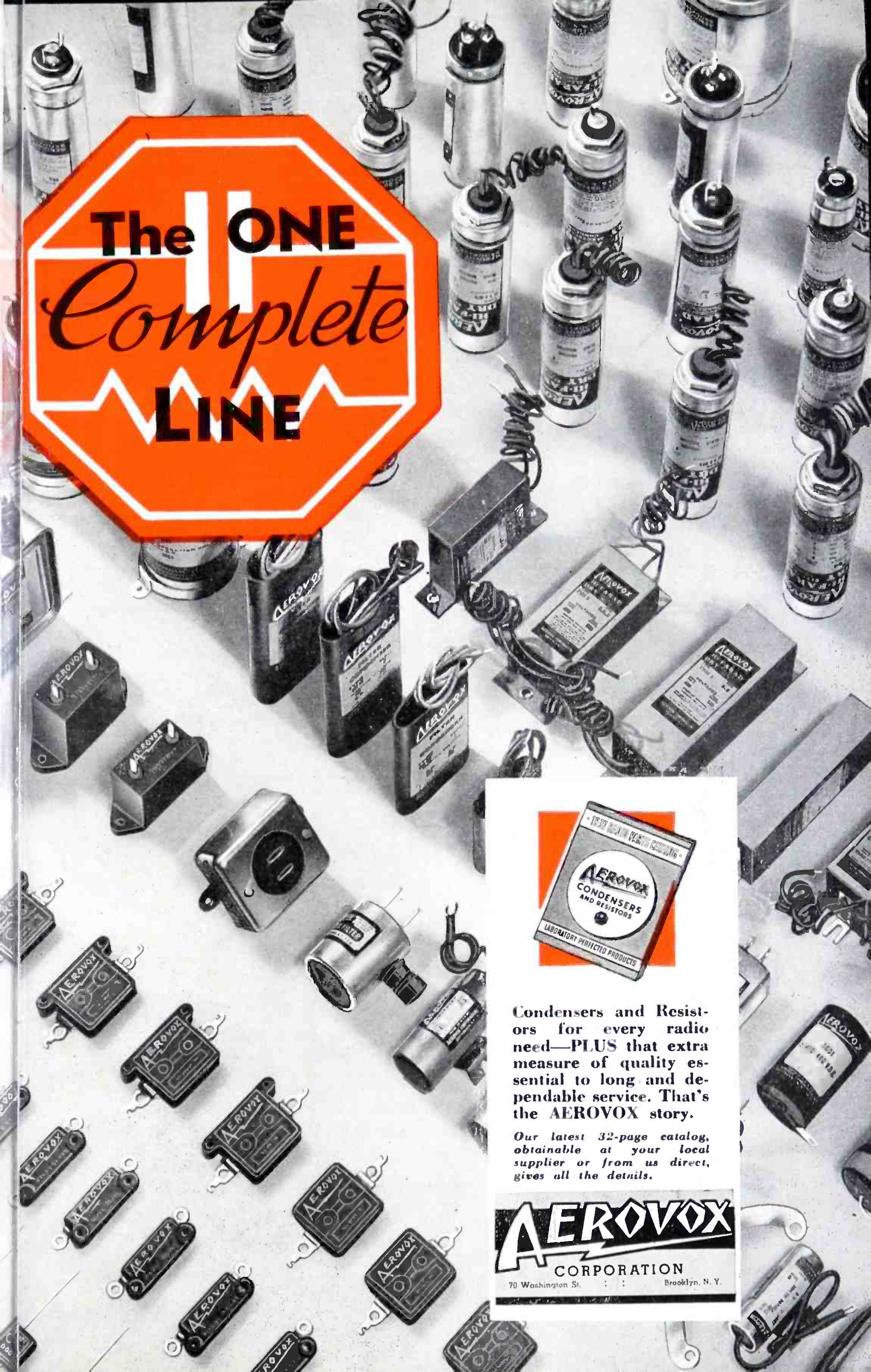
● IN previous articles we have described transmitters ranging from 100 to 300 and 400 watts input, and all of these transmitters are capable of ***phone*** operation. The ***modulator*** described in this article is a fitting addition to any one of the previously described transmitters.

The modulator consists of two units; one is a combination ***speech amplifier*** and ***driver***. consisting of three 56's and two 2A5's connected in push-pull class A. The class B power stage employs two Eimac 35-T's, with from 1,000 to 1,100 volts on the plates and is capable of an output of over 125 watts.

Referring to the diagram, we find that we start out with a crystal microphone and three stages of triode amplification. Resistance coupling is used to permit good quality, and if the values given in the diagram are followed carefully, there will be no danger of instability or feedback. The plate circuit of each of the amplifier tubes contains a resistor, condenser and filter. The third triode is transformer coupled to the 2A5's. Transformer coupling is used in this position to simplify construction and design. The 2A5's in push-pull serve as a driver stage for the 35-T's. The 2A5's with from 250 to 300 volts on the plates are entirely adequate for driving the final class B stage. Slightly better quality would be possible with a pair of 2A3's or 45's in class A. However, the combination shown in the diagram provides excellent quality, that is as good as can be found on the amateur bands, and we must agree that there are many fine phone stations now in operation. The output transformer of the 2A5's is a universal affair, designed to match the 2A5's into various loads from 500 ohms downward. Therefore, the input transformer on



Top and bottom view of the "speech amplifier" and "driver" unit.



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the class B stage is designed to couple a low-impedance line to the 35-T's. The 500 ohm line was chosen and provides the best all-around results. The turn ratio of the input transformer should be 2.8 to 1 step up from the 500 ohm line.

In a good many cases the driving stage and even the voice amplifier stages are included in the same unit with the high-power class B stage. While this can be done successfully, it is much more advisable to follow the arrangement there described, which permits the modulator stage to be mounted in the rack with the rest of the transmitter and the speech amplifier and driver on the operating desk, well out of the field of the transmitter. In this respect there is less likelihood of it picking up R.F. and, at the same time, the amplifier is located close to the microphone where the gain control is readily accessible.

Referring to the photograph of the *final-amplifier* stage, we find that here too, the power supply is mounted on the same chassis with the amplifier. This power-supply makes use of a transformer which has a high and low primary tap, providing an output of 1,100 volts on one tap, and some 1,400 on the other. Either may be used with the audio transformers listed in the parts list. However, some juggling of the load impedance on the 35-T class B stage will be necessary when the higher voltage is employed. In other words, the 6,000 ohm output tap may have to be used with a load impedance as high as 8,000 ohms in order to reflect the proper load into the 35-T's. However, we recommend adhering to the 1,000 to 1,100 volt supply for best all-around results, unless the input of the modulator amplifier is in excess of 500 watts and cannot be applied to the modulator

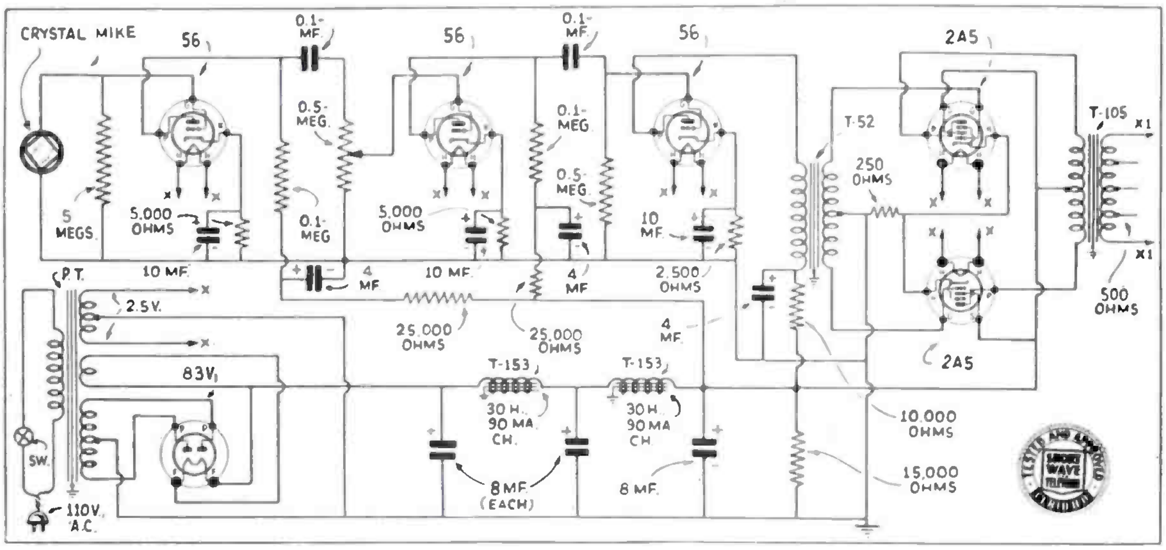


Diagram of the speech amplifier and driver

tubes. With the plate voltage indicated in the diagram, the plate meter on modulation peaks will show about 180 to 190 milliamperes; higher values than this should not be permitted.

The power-supply, the speech amplifier and driver stage are all included on the same chassis. Reference to the photograph will show the general construction of this unit. Any fairly high-gain audio amplifier with an output of approximately 7 to 8 watts will drive the 35-T's, and if such an amplifier is readily available completely constructed matters are greatly simplified. There are a number of 6 to 8 watt high-gain amplifiers now being sold by various radio supply houses which can be purchased just as cheaply as they can be constructed, and any of these which have a 500 ohm output winding will work satisfactorily with the class B stage.

The output transformer employed with these tubes was designed to be used with the type 800 tubes. Since the load impedance of the 35-T's with the voltage specified in this article is slightly less than the value for the 800's, the load impedance represented by the final amplifier input should be slightly less than the values indicated on the output taps of the transformer. For instance, the 6,000 ohm tap should be used for a load of slightly over 5,500 ohms for

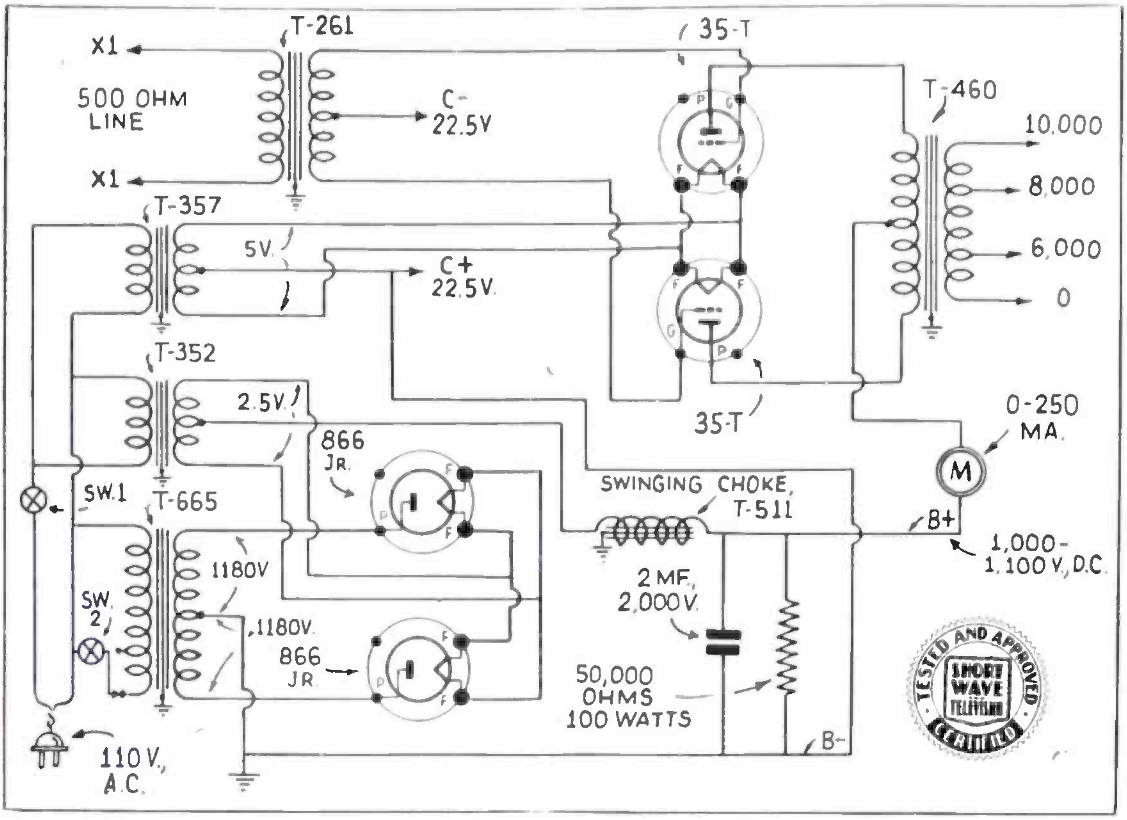


Diagram of the Class "B" stage and its "power supply."

a perfect match. However, such a slight deviation will not impair the quality at voice frequencies, and for all general purposes the tap may be connected into loads simiiar to the listings on the transformers.

Parts List for Modulator

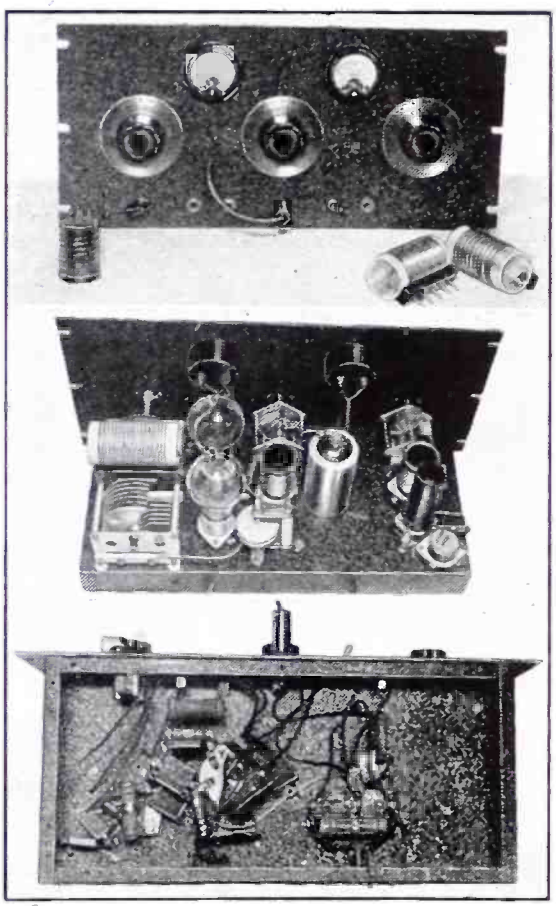
Speech Amplifier and Driver.

1—5 meg. resistor—½-watt.
2—5,000 ohm resistors—1-watt.
2—100,000 ohm resistors 1-watt.
2—25,000 ohm resistors 1-watt.
1—.5 meg. resistor ½-watt.
1—2,500 ohm resistor 1-watt.
1—10,000 ohm resistor 1-watt.
1—250 ohm resistor 2-watts.
1—.5 meg. potentiometer.
1—50,000 ohm 50-watt resistor.
2—.1 mf. condensers.
3—10 mf. electrolytic condensers.
3—4 mf. electrolytic condensers.
3—8 mf. electrolytic condensers (wet 500 volts).
1—push-pull input transformer, T-52.
1—push-pull output to low impedance line, T-105.
2—30 henry 90 ma. filter chokes, T-153
1—power transformer 250 to 300 V., D.C., output, 90 to 100 ma.
3—5 prong wafer sockets.
2—6 prong wafer sockets.
1—4 prong wafer socket.
1—D-104 crystal microphone.
3—Type 56 tubes.
2—2A5 tubes.
1—83 V. tube.
1—Amplifier foundation unit chassis and cover. Class B power stage.
1—Input transformer T-261; variable ratio 500 ohms to class B grids.
1—T-460 output transformer with tapped secondary.
1—T-357 filament transformer for 35-T's.
1—T-352 filament transformer for 866's.
1—T665 plate transformer 1,180 volt output, with primary tap.
1—T-511 swinging choke.
1—2 mf. 2,000 volt oil condenser.
1—50,000 ohm 100-watt resistor.
1—0-250-ma. meter, large bakelite case.
4—4 prong sockets.
1—17 by 3 by 11 inches chassis black crackle finish.
1—10 by 10¼ panel, black crackle finish.
2—Eimac 35-T's.
2—866 Jrs.

THE C-O-M 150 WATT TRANSMITTER

• • •

● THE trend of late has been toward compact ad simplified transmitters. This, of course is due to popular demand but it is only made possible by the increased efficiency of our transmitting tubes. This transmitter is really compact and efficient, and above all is very simple to build and operate. The output consists of a pair of RK 37's in parallel with an RK 39 driver. The crystal-oscillator circuit is built around the "old-faithful" 6L6. The entire transmitter, exclusive of power-supply of course, is built on a 8 by 17-inch chassis, with a 8¾-inch panel 19 inches long. The complete power-supply unit for this transmitter could easily be built on a similiar size chassis and panel, making a complete job of small dimensions and capable of putting out a really "husky" signal. The transmitter is simplified and easy to construct and operate.



Top: Front view of the complete 150-watt Transmitter. Center: A peek at the rear of the 150-watt Transmitter. Note that the final-amplifier plug-in coil is mounted between the two sections of the split-stator condenser. Lower photo shows bottom view of Transmitter.

New Frequency-Doubling Circuit!

From the diagram it would appear that the crystal-oscillator is a conventional tetrode arrangement, however careful examination and operation prove it to be quite the contrary. The plate circuit of the 6L6 oscillator may be tuned to either the crystal frequency ***or the second harmonic*** (*twice* the crystal frequency). It will be noticed that the diagram shows a 400 ohm cathode bias resistor with a 140 mmf. variable condenser ***connected across it***. This may seem rather unusual, but it is this trick that permits ***frequency doubling*** in the oscillator with only ***one*** tuned circuit. With the 140 mmf. set at mid-scale, the crystal will oscillate ***regardless of the frequency at which the plate circuit is resonant.*** The condenser shunted across the cathode biasing resistor could have been made fixed; however, different crystals require slight changes in this capacity. Also when ***doubling*** in the plate circuit a slightly different adjustment is required over that which provides stable operation when the plate circuit is tuned to the crystal frequency. This 400 ohm biasing resistor in this particular transmitter is a wire-wound affair, and we also note that the shell of the 6L6 is connected directly to the cathode. These were not according to schedule, for originally the 400 ohm cathode resistor was a metal-

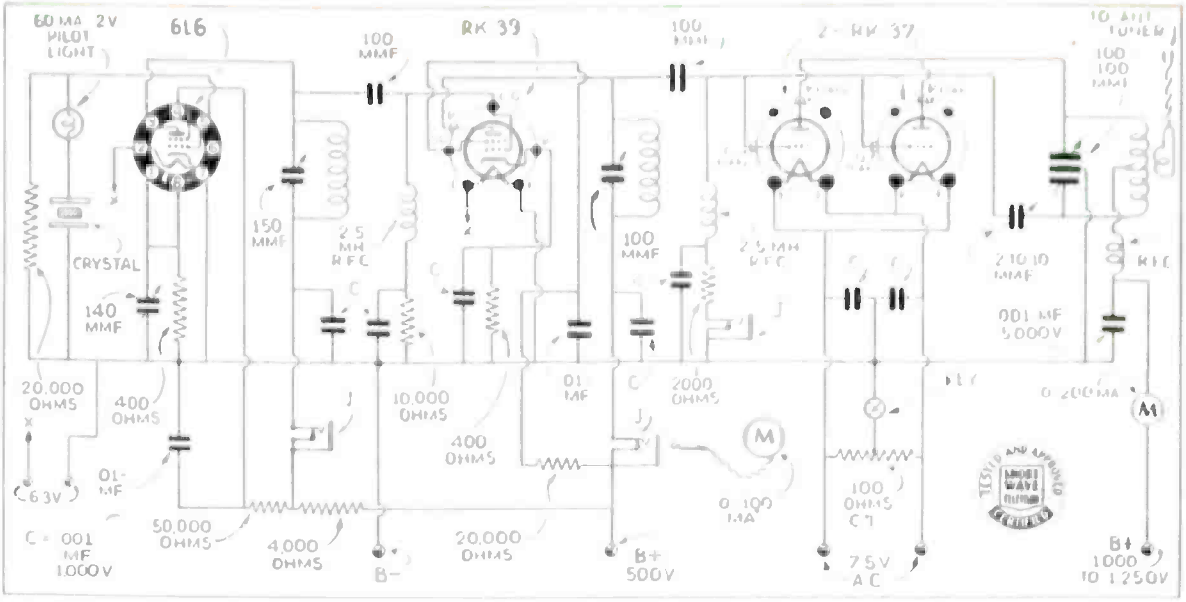


Diagram of the Class-B stage and its "power-supply."

lized affair and the shield of the 6L6 was connected to the "B" negative. This was in the original experimental oscillator and it performed excellently, and there is more than sufficient output on the *second harmonic* to excite a pair of RK39's in push-pull. When the original idea was incorporated in this finished transmitter it was found that after the rig was tuned up, the crystal would not start oscillating when the 6L6 and 39 plate voltages were switched on at the same time. In other words, it would have required two switches to be thrown each time it was put on the air during a QSO. This was a rather bothersome arrangement, so the shield was connected to the cathode to provide a slight amount of feed-back which started the crystal off even when the two stages were turned on simultaneously. In the original circuit, as in this one, we employed a 60 ma. two-volt pilot-light bulb connected in series with the crystal to indicate crystal current, and also as a precautionary measure. Should the crystal current rise above 75 or 80 ma. the bulb will blow, thus acting as a fuse .This 60 ma. bulb in the original experimental model showed no signs of glow, not even a dull cherry red, when the plate circuit was tuned to either the crystal frequency or the second harmonic with the plate circuit of the oscillator unloaded.

However, with the arrangement shown in the finished transmitter, there will be a considerable indication of crystal current when the plate circuit is unloaded, and when tuned to the crystal frequency; although in the finished transmitter the plate circuit in the oscillator is permanently "loaded," and therefore there is practically no indication of crystal current as would be evidenced by a glow in the lamp.

Should any reader desire to follow the original arrangement, we believe it offers the ***most perfect oscillator*** and ***multiplier arrangement*** so far developed. We would recommend of course, that the shell of the 6L6 be grounded and link coupling used between the 6L6 plate and the tube which the oscillator is to drive. Even with 600-volts on the plate of the oscillator, absolutely no indication of a glow was present in the pilot light, either with the plate circuit loaded or unloaded, and it makes relatively no difference whether the 400 ohm resistor is wire-wound, metallized or even of the carbon type. With this circuit, or course, a ***good active*** crystal must be used. Many of the cheaper and not accurately ground crystals will, of course, fail to start off in this circuit. But this is no drawback, because even ***good*** crystals are relatively inexpensive at the present time. So much for the ***oscillator*** circuit.

The 39 Stage

Progressing to the 39 stage of the transmitter we find that it is a conventional ***tuned-plate*** affair and it is capacity-coupled to the oscillator. This stage is thoroughly capable of driving the two RK 37's even when the 39 acts as a doubler, for it is possible to drive the grid current to 65 milliamperes in the final amplifier, which is considerably greater than the manufacturers

recommend for efficient operation. It is very important that the RK 39 be shielded. The shield should extend up to the top of the tube and should not fit too closely around it. Also it is advisable to have a number of holes around the bottom and top of the shield in order to provide adequate ventilation. The final amplifier is also very simple and conventional. It is capacitively coupled to the driver stage in order to simplify matters.

The two tubes were used in parallel in an effort to further simplify the transmitter, for in push-pull an additional tuned circuit would have been required, and the plate circuit of the driver would also have been more complicated. Down to 10 meters there is apparently no difference in the output of the 2 tubes, whether they are connected in push-pull or parallel. The plug-in coils for the oscillator and buffer-doubler are wound with heavy tinned copper wire on R-39 forms. The plate coil of the final amplifier is wound on the new XR forms and presents a very convenient arrangement, inasmuch as this coil and its mounting can be mounted directly on the tuning condenser.

Plate Current Values

A rough indication of what might be expected in the way of plate currents in the various stages will undoubtedly help the reader in knowing whether or not his transmitter is functioning properly. The oscillator under load should have a plate current from 30 mills when operated at the crystal frequency and 40 to 45 mills when the plate circuit is tuned to the second harmonic of the crystal. The RK 39 plate current will be around 10 mills with the key of the final amplifier open, and when the 39 is used as a straight amplifier, and about 20 milliamperes when it is used as a doubler. With the final amplifier delivering power to the antenna the plate current of the 39 when operated either as a doubler or straight amplifiers will be in the neighborhood of 80 to 90 milliamperes.

The final amplifier with the plate circuit unloaded should show a plate current of around 15 to 20 milliamperes and with 1,000 volts on the plate, under full load the plate current should not exceed 200 milliamperes. With 1,250 volts on the plate of the tubes, 190 ma. will be approximately correct.

There is no fixed bias on the final amplifier, and therefore the key should not be closed unless excitation is being applied to the grids of the two amplifier tubes. However, if anyone building this transmitter happens to be using the vacuum-tube "keying" arrangement, there will be sufficient automatic bias due to the voltage drop across the keying tubes, to furnish enough grid bias to eliminate all danger, should the excitation fail at any time with the key closed. This is another good feature of the tube keying arrangements.

The final amplifier can be used as a doubler-stage at considerably reduced power output, but it would be best to always use it as a straight amplifier. If used as a frequency doubler, the grid resistor should be increased from the present 2,000, to 3,000 or 4,000 ohms. Also, the plate current should be kept down to approximately 135 or 140 ma., otherwise the tubes will be dissipating too much power, and "short life" will be the result.

Parts List—150 Watt Transmitter

7—.001 mf. mica cond. (1000 V.)
2—.01 mf. mica cond. (1000 V.)
2—100 mmf. mica cond. (1000 V.)
1—.001 mf. mica cond. (5000 V.)
1—150 mmf. var. cond.
1—100 mmf. var. cond.
1—100-100 mmf. var. cond.
1—neutralizing cond.
1—140 mmf. var. cond.
5—5prong coil forms
3—coil forms
3—plug base
3—plug socket
4—5 prong sockets
1—8 prong socket
2—4 prong sockets
2—2.5 mh. RF chokes
1—1 mh., RF choke
1—2000 ohm 10 watt resistor
1—400 ohm 10 watt resistor
1—50,000 ohm 20 watt resistor
1—4,000 ohm 20 watt resistor
1—10,000 ohm 20 watt resistor
1—400 ohm 20 watt resistor
1—20,000 ohm 20 watt resistor
1—2000 ohm 20 watt resistor
1—100 ohm center-tapped resistor
1—0-100 ma. meter (small)
1—0-200 ma. meter (small)
1—6L6
1—RK39
2—RK37
1—8¾ x 19 inch black crackle panel
1—8 x 17 x 2 inch black crackle base
1—crystal holder
1—60 ma. 2 V. pilot light
1—socket for pilot light
4—single closed circuit jacks
2—phone plugs (for meter and key)

Coil Data for Xmitter

*Osc and buffer coils

Band	Turns	Wire
80 m.	30	No. 18 tinned
40 m.	16	No. 18 tinned
20 m.	7½	No. 16 tinned

*Wound full length on R39 form

* final amp.

Band	Turns	Wire
80 m.	40	No. 18 tinned
40 m	24	No. 16 tinned
20 m.	16	No. 16 tinned

*Wound full length on XR13 form

POWER SUPPLY FOR LOW POWER TRANSMITTERS . . .

● ON the front of the power-supply panel we have two switches and a pilot light. One switch for turning the entire supply on and is connected in the 110 volt line, while the other breaks the center tap of the high-voltage winding on the transformer, allowing the B voltage to be removed for stand-by purposes during communication. The power-supply panel is of the same dimensions as most others being 7x18 inches and is fastened to a 2 inch sub-base.

The power transformer is a combination filament and plate transformer. The high-voltage secondary is 625 volts either side of the center tap. There is one 5-volt, 3 ampere winding for the rectifier and two 6.3 volt windings at 3 amperes each.

In this particular unit we used a heavy-duty type 80 tube together with choke input in the filter system, in order to limit the output voltage to a value of around 425 to 450 volts.

An 83 mercury vapor tube may be used to advantage because of the higher voltage it would provide. The two filter choke coils are rated at 11 henries at 300 ma. current carrying capacity. While the transformer is only rated at 250 ma., these chokes were used because they were designed as companion units to the transformer.

For the filter condensers we used 8 mf. electrolytic condenser with a 500 volt peak rating. Two of these were connected in series in each section, resulting in 4 mf. capacity with a working voltage of well over 800, thus allowing a good "safety factor."

With the use of two filter chokes and the condenser arrangement shown in the diagram, absolutely pure D.C. is obtained at 250 mills. The output of the filter system is loaded with a 25,000 ohm, 50-watt wire-wound resistor in order to prevent voltage surges and improve regulation.

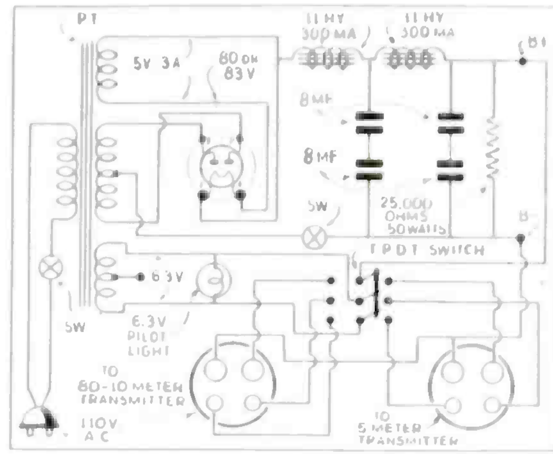
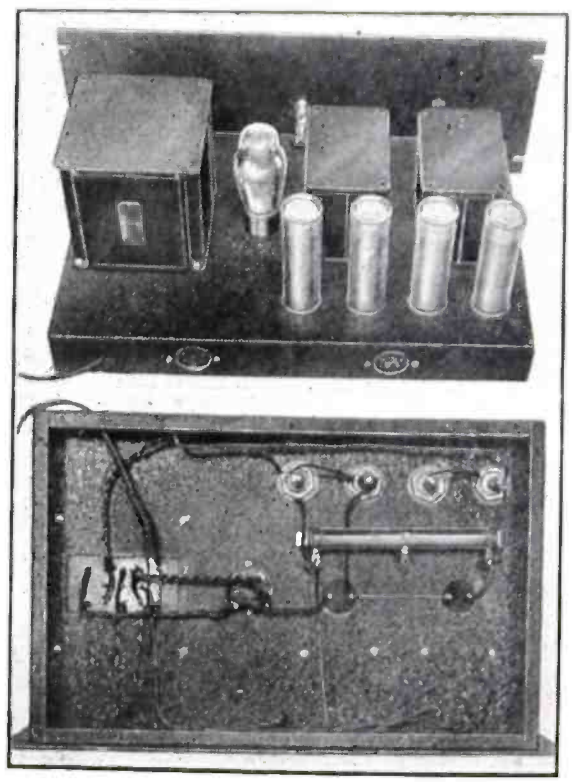


Diagram of power-supply



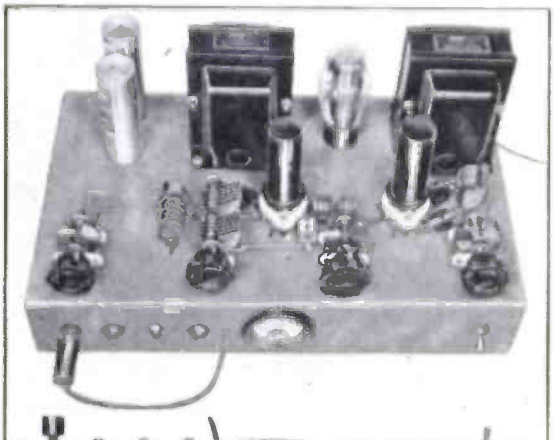
Top and bottom views of power unit.

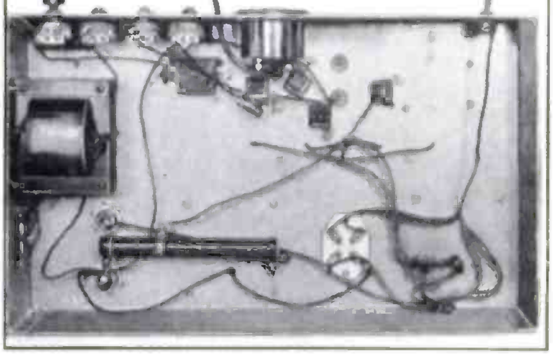
Parts List

1—power transformer (for rating see text)
2—chokes (see text)
4—8 mf. 500 volt electrolytic condensers
1—25,000, 50-watt wire-wound resistor
1—7x19x⅛ inch crackle finish steel panel
1—2x11x17 inch crackle finish chassis
1—26 inch standard relay cabinet, crackle finish
2—toggle switches
3—4 prong wafer sockets
1—type 83-V. or 1 type 80 rectifier tube

THE "W2AMN" 5-METER MOPA

● IT is now possible to build a well ***stabilized*** transmitter with fairly respectable output for as little as a good modulated oscillator of the present-day design would cost. The new 6L6 beam tube which has been featured in other transmitter articles has been found to give excellent per-





Two photos above show respectively top and bottom views of the 5-meter MOPA, utilizing two of the new 6L6 Beam tubes.

formance on the ultra-high frequencies. In the transmitter shown in the photographs, and outlined in the diagram, we use only two of these tubes—one as an electron-coupled oscillator with the grid circuit tuned to 10 meters and the plate circuit tuned to 5. This, in turn, drives a 6L6 as a straight amplifier on 5 meters. Both tubes have the same plate voltage applied to them, and run with nearly the same input. The 5-meter output of the oscillator is more than sufficient to drive the 6L6 amplifier and permits an untuned loosely-coupled grid circuit, further isolating the two stages.

As a tritet oscillator on 10 meters, the 6L6 exhibits excellent stability characteristics. The oscillator, after the tube has once been heated, does not shift frequency when it is switched on and off. The amount of creeping has been found to be less than a multi-stage transmitter using a low-frequency crystal and operating on 5 meters.

"Crystal-Stability" Reported

A regular "communications" type receiver, operating with a 5-meter converter, proved that this transmitter had no frequency modulation and even when the crystal filter was in the circuit, the thousand-cycle beat note did not vary during complete modulation. With from 400 to 425 volts on the plates of the tubes, the following voltage and current readings are recommended, when the amplifier is delivering power to an antenna 50 ma.; oscillator screen, 250-275 volts; oscillator screen current, 12 ma.; amplifier plate current, 70-80 ma.; screen voltage, 150; amplifier grid current, maximum 10 ma.—minimum 6 ma. It is important that the grid current be held between 6 and 8 milliamperes for maximum efficiency and proper modulation capabilities of the amplifier. The amplifier plate current, when not delivering power to the antenna, will drop to approximately 29 ma. As the grid current is driven higher than 6 or 8 ma. the plate current will swing lower than 20 ma., but the power output will decrease.

Detuning the amplifier circuit will show a rise in plate current up to approximately

WOW!

THAT MUST BE A utah

TRANSMITTER

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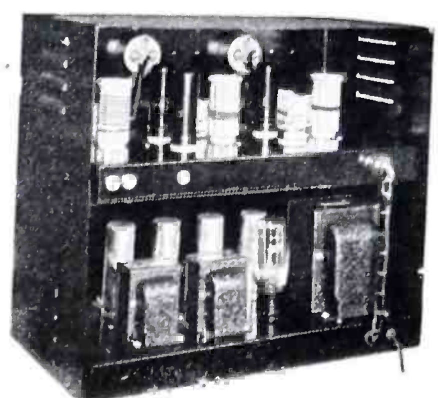

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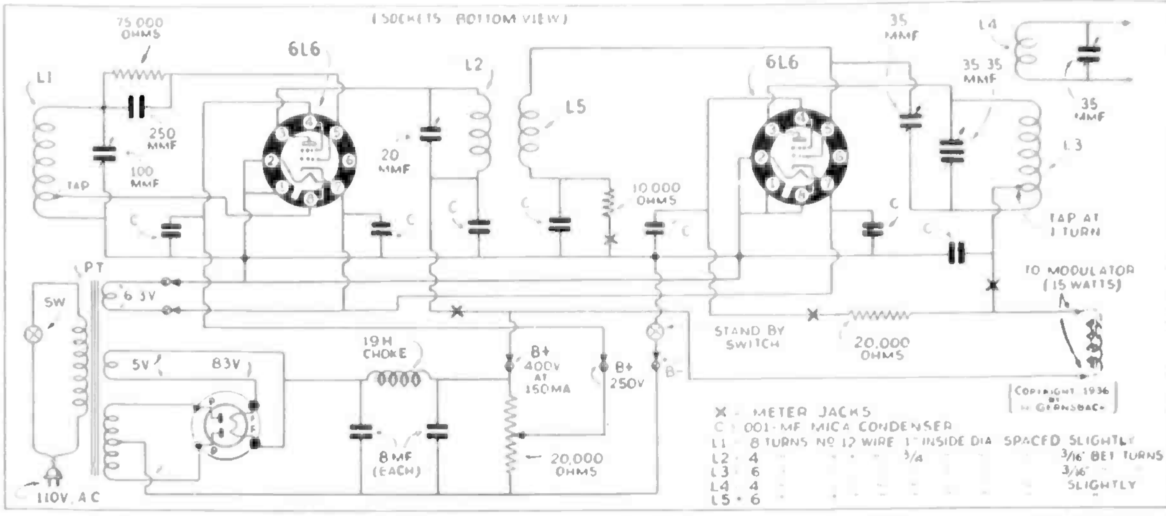
125 ma. The amplifier is still capable of supplying more R.F. to the antenna when loaded to over 100 ma. plate current. However, for efficient operation it is recommended that the plate current be kept between 70 and 80 milliamperes. In the diagram we notice that the ***final amplifier*** is neutralized by tapping off one turn of the plate coil and using a 35 mmf. condenser. there is no need for automatic bias. However, it may be incorporated should anyone desire it. The value of the biasing resistor should be somewhere around 100 ohms and be by-passed with a .001 mf. condenser.

Adjustment of Transmitter Not Critical

The cathode tap on the oscillator grid coil is somewhat critical and if the dimensions given in the drawing are carefully followed, this tap should be exactly 1½ turns from the "B" minus side of the coil. Outside of this there is no critical adjustment in the entire transmitter, and no one should have any trouble in obtaining excellent results. Measured power output of the final amplifier stage was just slightly over 20 watts, with approximately 35 watts input to the plate circuit.



Wiring diagram of the "W2AMN 5-meter MOPA."

The Question of Neutralization

Experiments have proven that neutralizing is unnecesary when the tube is being excited properly, and particularly with the untuned, loosely-coupled grid circuit. Neutralizing is employed merely as a matter of precaution against possible changes in tube design. In each case, the cathodes, the metal shell of the tubes, and one side of the heater circuit are connected together and grounded to the "B" negative. The other side of the heater circuit is by-passed with a .001 mf. condenser. It is very important that the screen, plate, and heater by-pass condensers be connected close to the circuit to be by-passed and with very short leads. Also, in the diagram we show that the plate and screen are modulated simultaneously. It has been found that the plate could be modulated alone and the screen tied down to approximately 150 volts. Grid-leak is used in the amplifier stage and is the only method which will give satisfactory performance; fixed bias is not recommended in this case. No automatic biasing is incorporated in the cathode circuit because the oscillator and amplifier are switched on and off at the same time. And since it is almost impossible for the electron-coupled circuit to drop out of oscillation, as may happen with a crystal,

In the power supply portion which is built on the same chassis, as the R.F. unit, we have used an ordinary receiving type transformer. This transformer was rated at 365 volts each side of center-tap at 145 ma. With 8 mf. condenser input and low-resistance choke, this power supply delivers slightly over 400 volts to the transmitter. If a 450-volt transformer were used, it would be necessary to employ choke input in order to reduce the voltage. We do not recommend that over 425 volts be applied to the plates of the tubes. Almost any antenna may be used in conjunction with this transmitter. If the transmission line to the antenna is untuned, then one or two turns should be used as a coupling coil. The arrangement shown is for tuned feeders.

During the tests a vertical 8 foot rod, with a single-wire "feeder" tapped approximately 13 inches off center was used. This

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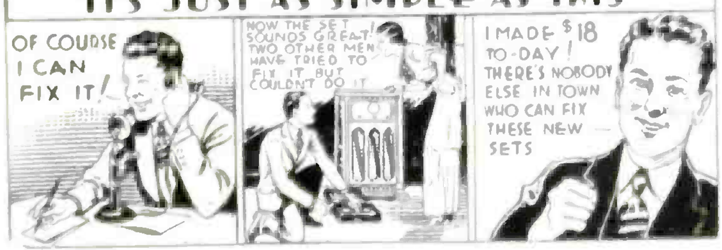

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was clipped directly to the plate coil about three turns from the plate side. With this arrangement no coupling coil is necessary. The audio requirement for this transmitter is exceptionally modest. 15 to 18 watts should do very nicely and this is obtainable from a pair of 6L6's or a pair of 2A5's in class A-B.

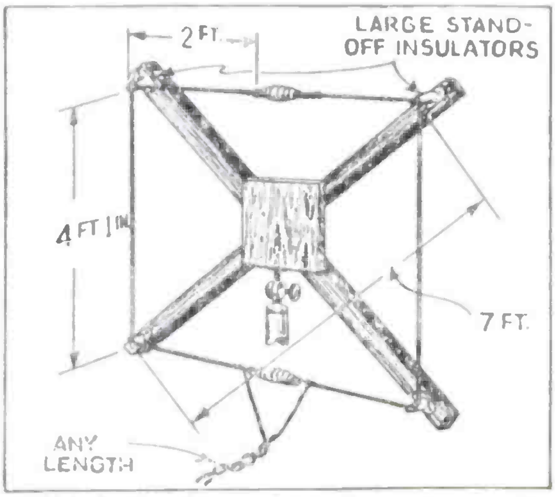
This transmitter has been in operation for about 2½ months, and every one hearing it, without exception, has expressed the most flattering compliments regarding the ***high quality*** and ***stability*** of the signal. Several of these amateurs were using receivers with a selectivity which permitted only the most stable signals to come through. It is now possible to construct a ***low-cost stabilized*** 5-meter transmitter that can be compared in quality with any other transmitter of amateur design operating on any band. This may seem like a "broad statement," but it is absolutely true, and we know that if the 5-meter "gang" take heed and construct something of this type, the results will be a much happier 5-meter family, and we will them command the respect of amateurs on the other bands as well as broadcast listeners who are also listening in on the 5 meter band.

Parts List

1—100 mmf. tuning condenser
1—20 mmf. tuning condenser
1—split-stator condenser, 35 mmf. per section
1—35 mmf. tuning condenser
1—plate and filament transformer (see text)
1—250 ma., 19 henry filter choke
1—0-100 ma. meter
1—20,000 ohm wire wound resistor, 15 watts
1—75,000 ohm resistor, 2-watt carbon type
6—.001 mf. mica condensers, receiving type, Aerovox
1—.001 mf. mica condenser, 1,000-volt Aerovox
1—.00025 mf. mica condenser, receiving type
2—8 prong isolantite sockets
1—10 x 17 x 3 inches electralloy chassis
2—8 mf. 500-volt wet electrolytic condensers
2—6L6 tubes

A FOLDED DOUBLET FOR TRANSMITTING

● THE antenna shown herewith is in use at the writer's station. I thought that it might be of interest to amateurs who desire the directive advantages of an "array" without having the required space. To the best of my knowledge this antenna has not been described in any publication.



Folded Doublet which has shown fine results.

It is suitable for either 5, 10 or 20 meter operation and even on 20 meters takes up a space only eight feet square.

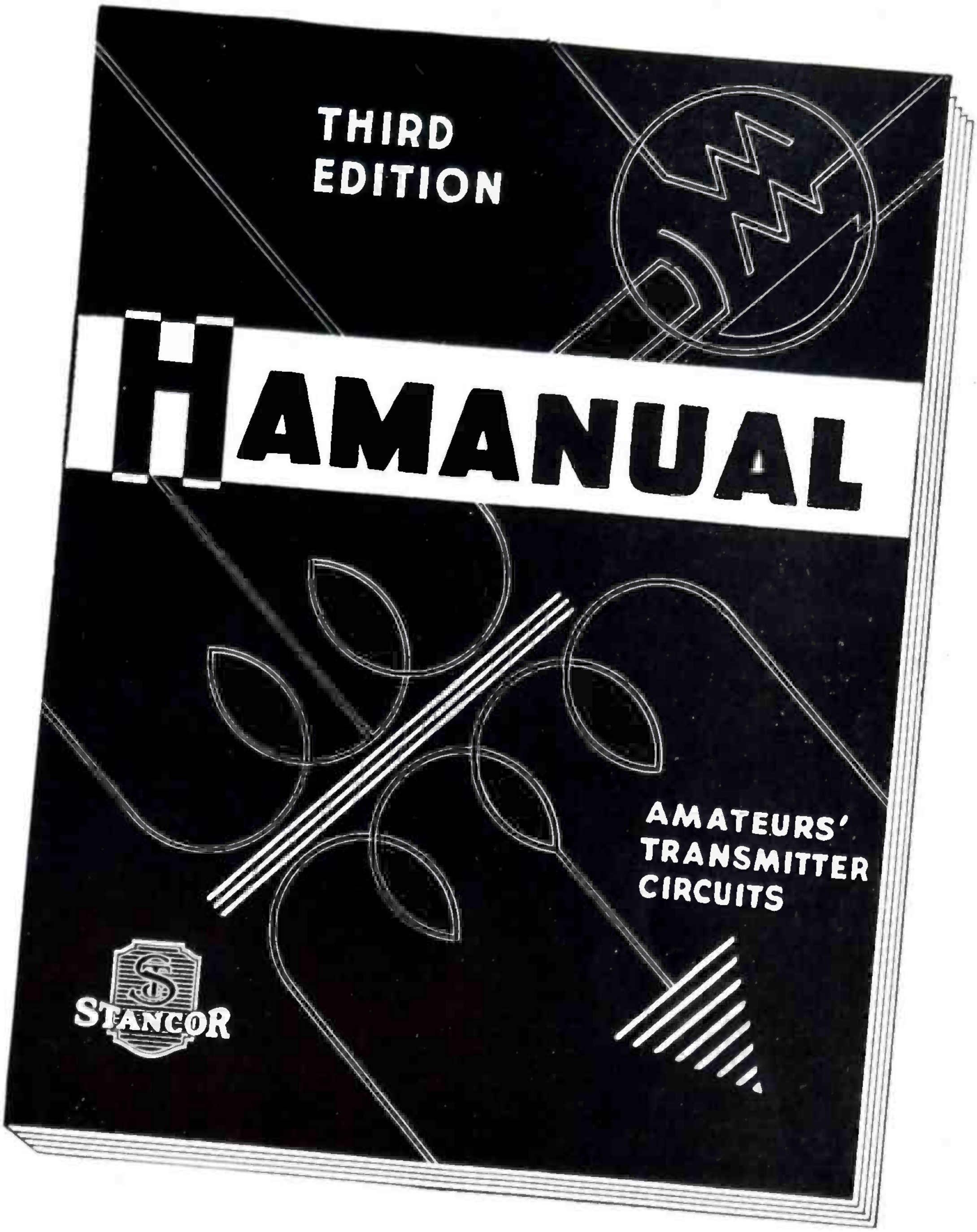
At this station it is being used for 10 meter operation, and, at present, is installed inside in the attic. The first experiments were highly gratifying as a matter of fact the first contact made with this antenna ws K6MVV in Hawaii, a distance of about 5,000 miles!

At the time this contact was made the antenna was directed broadside W.S.W. We received a report of QSA. R6-7 on this contact with 60 watts input. We next swung the antenna south and worked K4EPO receiving an R8 report in Porto Rico. Tests were made with several other outdoor antennas, namely a half-way vertical and three half-waves horizontal. In all cases and in every direction this simple ***loop antenna*** provided as good or better reports than could be obtained with any outdoor antenna.

We also tried it for ***reception*** on 10 meters and found that in many cases an R6 signal could be brought up to R8 by swinging the antenna ***broadside*** to the incoming signal.

The constructional details are simple; cut a doublet to a half-wave on the desired frequency and bend it back against itself as shown in the diagram. For example, on 10 meters each leg is 8 ft. 3 inches long. The feeders used at this station consist of a length of RCA cable that was originally used for a doublet receiving antenna. I believe that the diagram will be easily understood.

Harold B. Rhodes, W2IKW.


THIRD
EDITION
HAMANUAL
AMATEURS'
TRANSMITTER
CIRCUITS
STANCOR

A METAL TUBE U. H. F. SUPERHET

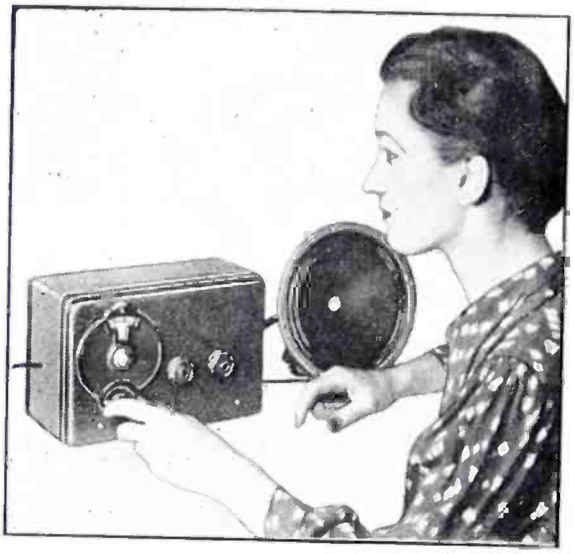
● MANY of our readers are familiar with the now quite popular resistance-coupled, ultra-high frequency superheterodyne. Many questions have been asked about this type of receiver and among the most prominent, was whether or not *metal* tubes could be used to an advantage. The writer constructed the receiver shown in the photograph for the express purpose of trying out these tubes and comparing it with other receivers. We endeavored to keep this set as simple as possible, not including some of the fancier frills which may be added to almost any receiver.

There is apparently one distinct advantage in the use of *metal* tubes, and that is in the thorough shielding. It is possible, due to their small size and the fact that they require no shields, to make the set very compact and still not crowded to the point where operating efficiency would be sacrificed. Conventional metal tubes were used in the I.F. and A.F. portions. We mention this because in the detector we used one of the newer type which have an Isolantite insulated grid connection; this will be discussed later.

Simplicity and Low Cost

The outstanding advantage of a receiver of this type, of course, is in the simplicity of its construction and its relatively low cost. One building it is almost sure to obtain excellent results, if the few hints given in this article are followed. One need not worry about the delicate task of aligning I. F. transformers or similar adjustments.

The principle of the receiver is one of the oldest; in fact, this was one of the first types of superheterodyne receivers used. The oscillating first detector works on the autodyne principle, with a very low frequency I.F. amplifier, which has a relatively wide band width. The range of the I.F. amplifier, in the neighborhood of 10 to 100 kc., means that the first detector may be tuned anywhere between 10 and 100 kc. either side of the signal frequency and still permit reception. Or, looking at it from the other side, the incoming signal may swing from 10 to 100 kc. and still come through the I.F. amplifier with relatively good quality. This feature is what has made it exceptionally valuable in the ultra high frequency amateur bands, where modulated oscillators are employed in the transmitters.



The 5-meter superhet pulling in "Ham" phone stations.

Television Reception Possible

A receiver of this type may also serve as a forerunner for any one who is desirous of experimenting with *television reception* now that we have at least two stations in the *ultra-high frequency* region broadcasting television signals. RCA Empire State Transmitter (in New York City) and Don Lee Station in Los Angeles.

Getting back to the *first detector*, we find that when it is tuned approximately to the

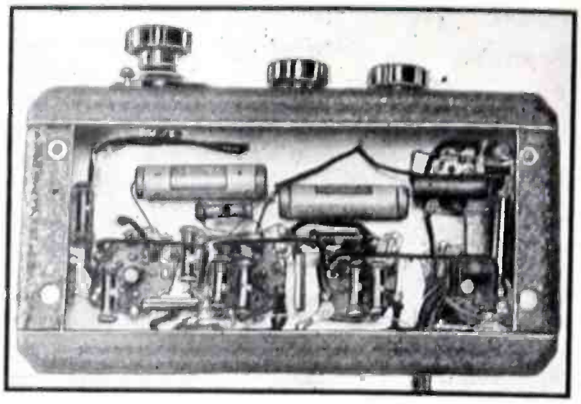
The original receiver, using glass tubes, required higher screen voltage and permitted by-pass condensers at points marked "C" in the diagram. However, when the metal tubes were installed, best results were obtained with ¼ meg. resistance in the screen leads and no by-pass condensers. Experiments showed that .001 mf. condensers in position "C" increased the overall volume of the signal, but with it the tube noises also; thus the net result was just about the same as without the condensers.

However, different constructional layouts might prove to demand changes in this

Rear View, showing general construction.

part of the circuit, and we recommend that the builder try condensers up to .1 mf. for *by-passing* screen leads.

The receiver is housed in a 5x9½x6 inch metal cabinet and the chassis is 9x4x1½. The photos show top and bottom views and indicate how the parts are placed.



Note the neat wiring and placement of resistors.

Antenna

Best results were obtained with the antenna connected directly on to the grid coil, at about ½ turn from the B negative end. No *dead-spots* were noticed with this rather loose coupling, but should they occur with other types of antennas, it is suggested that a 35 mmf. condenser be connected in series with the antenna.

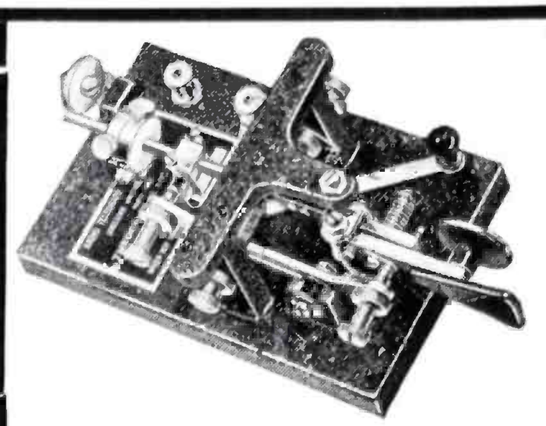
Parts List

1—20 mmf. midget condenser (one plate removed)
4—.0001 mf. mica condensers
3—5 mf. electrolytic condensers
2—.01 mf. condensers
2—1 mf. condensers
7—¼ meg. ½ watt resistors
1—2 meg., ½ watt resistor
3—50,000 ohm, ½ watt resistors
2—400 ohm resistors
1—50,000 ohm potentiometer
1—500,000 ohm potentiometer
1—vernier dial
5—laminated octal sockets
1 set of tubes, see diagram and text

NOW! The World's Champion Telegrapher -- T. R. McELROY

Offers YOU His Radio Key!

For Speedy, Tireless,



Rhythmic, Sending

NEW 1938 De Luxe Model MAC KEY

T. R. McELROY — The Fastest Radio Operator of all time! His official receiving speed is 69 words per minute. Realizing perhaps more than anyone else the limitations of commercial telegraph keys, McElroy worked for many years on perfecting this important instrument. To McElroy's credit, he refused to market a key until it not only excelled any other, but until it satisfied his own delicate sense of balance and "feel." Every MAC item is designed, built tested and approved by Champion McElroy himself. Every MAC item is an exclusive opportunity for both the beginner or advanced operator to improve his code technique and efficiency.

Here is the most amazing value in telegraph history. A semi-automatic key so beautifully balanced and designed, that speedy, tireless, rhythmic sending is now easy for any operator. Has a remarkable new dot stabilizer—a specially tensioned Swedish steel main spring—a solid base that really "stays put"—big silver contacts—large adjustment screws—in every detail this key is the finest ever produced! You must see it—at your jobbers. In no time at all you'll be sending out the kind of stuff they love to listen to. Only $9.50—but don't wait. Get yours now! Also Standard Model. Same construction but with less costly finish, $7.50.

IF YOU WANT A STRAIGHT KEY—just remember this. " . . . the New 1938 Mac Straight Key is the sweetest ever built." It's beautifully balanced, sturdy, and designed to save your energy and your arm. Priced so that every amateur can have one. Only $1.50 at your jobber's.

EVERY AMBITIOUS AMATEUR should have a MAC HUMMER. This mechanical oscillator gives wonderful performance—yet sells for only $1.50 to operators. With just a 4½ volt C battery, you can get a 1000 cycle note as clear as a bell.

FOR A *REAL* PRACTICE SET—be sure you say "MAC" to your jobber. He'll give you the sweetest outfit every made for this purpose. It's a combination of the New MAC HUMMER and the New MAC STRAIGHT KEY—all on one sturdy base. "It's a honey." And the price? Only $2.95!

MAC-AUTO—World's finest electrical automatic transmitter—only $69.

T. R. McELROY 175 Congress Street, BOSTON, MASS.

WORLD'S CHAMPION TELEGRAPHER

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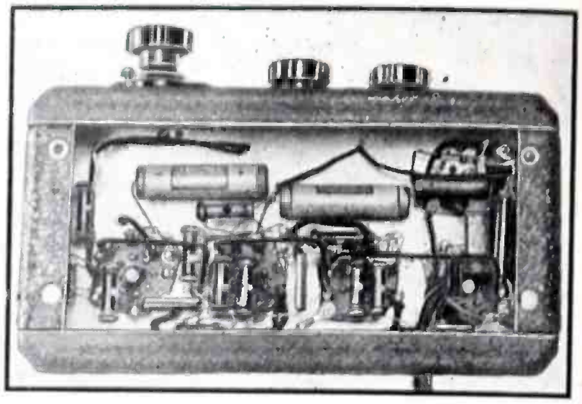

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1—50,000 ohm potentiometer
1—500,000 ohm potentiometer
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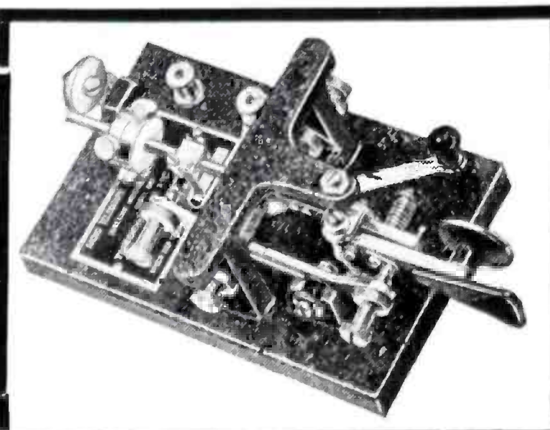

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MAC-AUTO—World's finest electrical automatic transmitter—only $69.

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WORLD'S CHAMPION TELEGRAPHER

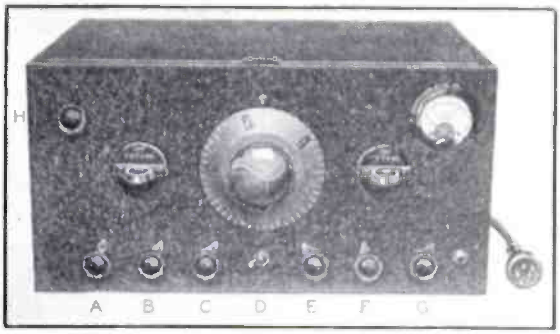
THE "S. W. & T." COMMUNICATIONS RECEIVER . . .

● For really high efficiency we do not believe it is possible for the home constructor to build a coil-switching arrangement which can compare with efficient plug-in coils; therefore, the best compromise is plug-in coils made to plug-in through the front panel, the same as the National-FB-7. In fact, ready-made FB7 coils were employed.

Complete data is given should the reader desire to try his hand at constructing them.

Regen. "Acorn" Detector Stage Solves Many Problems

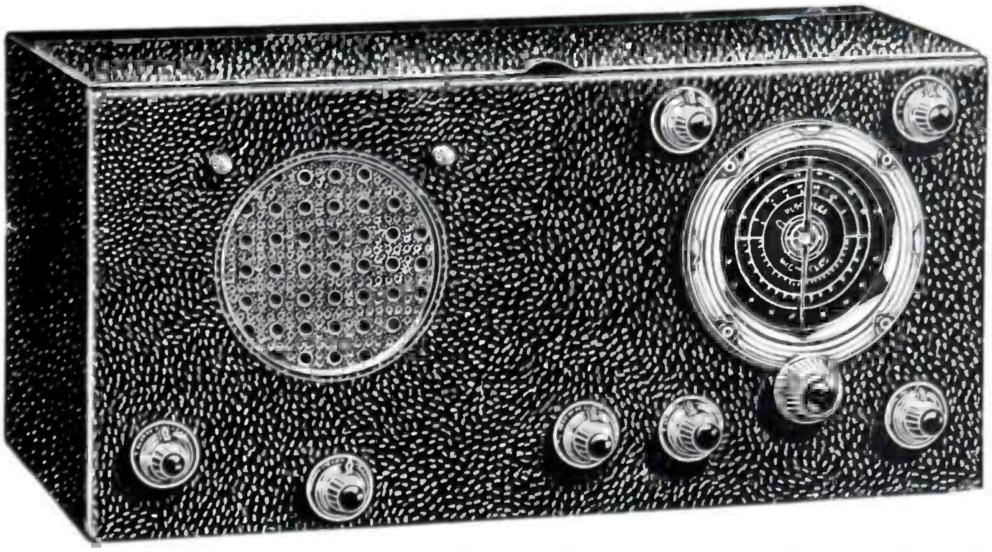
The next problem how much R.F. to use ahead of the first detector. In order to determine this, considerable experimental work had to be done. We found that to do the job right, two stages of R.F. should be used. One stage would still permit a noticeable amount of image to get through. Then, also, we were sure that regeneration in the first detector would provide at least as much gain as would one stage of tuned radio frequency. However, regeneration usually brings about considerable noise. Having recalled the low noise-level of receivers employing acorn tubes, we decided to try a regenerative 954 acorn detector and eliminate all R.F. stages. This yielded remarkable results, the image rejection was as good, if not better than would have been obtained with conventional tubes and one stage of R.F., and the sensitivity was even better. Also the noise generated in the regenerative first detector was practically nil! Using this arrangment eliminated an extra tuning condenser and eliminated one plug-in coil, which is quite a saving inasmuch as the results are as good, if not much superior.



Front view of the receiver, the controls are as follows: A—first detector regeneration, B—Detector trimmer, C—R.F. gain and AVC switch, D—Beat oscillator switch, E—Noise silencer, F—A.F. volume control, G—Tone control, H—Crystal band-width control. The jack in the extreme right-hand corner is for earphone operation.

How Good AVC Action was Provided

Next was the problem of I.F. amplification and a method of attaining automatic volume control; immediately we decided that iron core I.F. transformers should be used, and it had been demonstrated long ago that one stage of I.F. was not entirely satisfactory, although very good results can be obtained with that arrangement, so two stages of amplification was decided upon. Efficient AVC meant incorporating at least another tube to get satisfactory results following conventional arrangements. This difficulty was overcome by employing 6L7's in the I. F. stages with grids No. 1 and No. 3 connected in parallel insofar as AVC action is concerned, thus permitting very sharp cut-off, and the voltage developed in the diode second detector proved to be more than sufficient for excellent AVC action. In fact, we have yet to see a set using conventional AVC methods which worked any more satisfactorily than this one. As a means of checking signal strength and aiding tuning we employed a 0 to 5 ma. meter in the plate circuit of the first I.F. tube.



Model D-6 Six-Tube Amateur communications Receiver covers all Ham bands—5-10-20-40-80-160 meters. uses either glass or metal tubes, 6K7G tuned RF, 6K7G tuned electron coupled detector, 6C5G first driver audio stage, 6L6G beam-power audio output amplifier and 6J5G 5 meter detector. Covers 5 to 3000 meters. Amateur model is supplied with special bandspread coils covering only the 20, 40, 80, 160 meter bands plus coils for the regular broadcast band. If general coverage coils covering from 12 to 200 meters are desired they are available at $2.00 additional.

Complete, ready to use .... **$25.00** In Kit form, less tubes and unwired **$18.50**

HG-35 TRANSMITTER

Powerful and efficient transmitter available for 59 TRI-TET crystal oscillator, 2—46's as a final amplifier of 89 crystal oscillator and 2—6L6G type tubes as a final amplifier.

RG-35 Kit, including all parts, coils for any band, diagram, and simple instructions (completely assembled and ready to wire	$21.95
Matched Arcturus tubes, 59, 46, 46	1.95
89, 6L6G, 6L6G	3.25
Crystals (80-160 meter band)	1.95
(40 meter band)	2.75
Crystal holder	1.00
Coils for additional bands per set	1.45

FREE: New 1937 catalogue

of short wave receivers, transmitters, and 5 meter apparatus. Send stamp to cover mailing costs on YOUR copy.

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7C 5-Tube

Short Wave Receiver

Bigger and More Powerful Than Ever A Giant in Performance

FULL 6 TUBE PERFORMANCE plus THE NEW K92A SERIES TUBE makes this an outstanding value. Equipped with a powerful 3 stage audio frequency amplifier.

Uses 6K7G-6F7 (twin 2 in 1 tube)—6C5—K92A-12A7 (twin tube) tubes as RF amplifier, screen grid regenerative detector, powerful 3 stage audio amplifier with pentode output stage, rectifier and complete built-in power supply. Operates entirely from 105 to 130 volt AC or DC light socket.

BAND SPREAD TUNING — smooth regeneration control—built-in high quality loudspeaker—automatic headphone jack—large, illuminated airplane type vernier dial—large 3 electron coupled low-loss inductances. Heavy, black shrivel finish metal chassis and cabinet. Must be seen to be appreciated. Satisfied owners report as high as 35 foreign countries on the loudspeaker with this model. You may do the same under fair conditions. Order YOURS TODAY! YOU WILL NOT REGRET IT!

Complete, ready to use, with coils from 9½ to 600 meters **$15.00**

In kit form, less tubes and unwired, but factory assembled **$10.95**

OSCAR B. KUSTERMAN
68 BARCLAY ST.
NEW YORK CITY
Dept. H

The second detector is a 6H6 duo-diode, one section being used for rectification, and the other as a noise-limiter in an effort to reduce ignition interference.

Beat Oscillator—Improved Type

In order to keep the number of tubes down, a twin triode was employed in the first stage of audio amplification, one section is used as an audio amplifier, while the other section is the beat-oscillator. This eliminates the necessity for a beat oscillator tuning control on the front panel; and in the two months during which this receiver has been operating, the beat oscillator adjustment has never been changed; merely set it for the most pleasing tone and forget about it..

The audio amplifier is a conventional 6F6 pentode with a phone jack between the two stages for earphone operation.

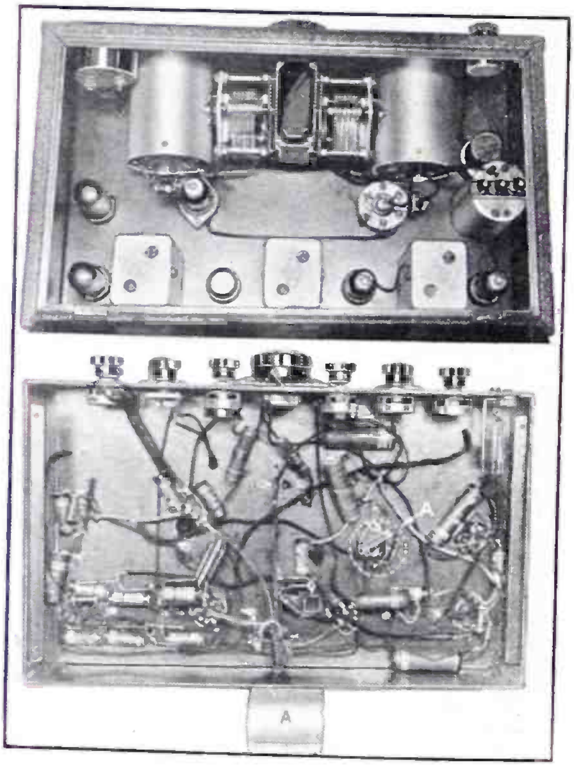
Trans-filter Affords Single-Signal Reception

In order to take care of the selectivity problem we employed the new Brush Trans-filter, this permitted excellent selectivity in the phone bands and practical *single-signal* reception on C.W. There is a *control* in the crystal circuit to change the *band-width*. However, it is left in the maximum selectivity position because even at this point it is not too selective for fair tone quality on phone signals. For *band-spread* tuning, of course, in a good receiver there is only one solution and that is the use of the National micrometer dial. This is really an excellent device and makes operating a real pleasure. Employing FB-7 *band-spread* coils, the amount of spread obtained with this combination can be gauged by the fact that the 80 meter CW band covers from 135 to 315 on the dial, while the 80 meter phone band takes in that portion between 315 and 390. the entire 40 meter band is spread from 250 to 420, and the 20 meter phone band, as well as the 20 meter CW portion, is also spread out in a similiar fashion; one division is approximately ¼ inch.

Regeneration

In order to obtain regeneration in the first detector circuit, a small winding must be added to the FB-7 detector coils. If care is exercised in taking the padder out of the coil, the job is really easy and can be done in short order. Merely place a hot soldering iron against the two prongs to be easily removed. This small cathode coil which this padder is connected and it can is wound just below the "B" minus end of the *grid* coil. In some coils there is space enough on the large portion of the form and on others this regeneration coil will have to be wound in the narrow slot at the bottom of the form. Complete data as to the number of turns is contained in the coil table. This coil should be wound in the direction opposite to that of the grid coil. Fortunately, there was a prong in the FB-7 detector coil, only five prongs were originally used. The blank prong is used for the cathode terminal, the other end of the coil is soldered into the prong used for the "B" negative side of the *grid* coil. An additional hole has to be drilled in the back of the mounting shields, that is, the shield can which supports the coil socket, in order to bring out the cathode lead. There already are five holes in the can corresponding to the five prongs used for the coil.

Naturally, with the extreme selectivity obtained at the regenerative detector stage, a panel trimmer will be needed. This condenser should have a maximum capacity of from 10 to 15 mmf. The lower the capacity used, the better because its adjustment is really critical. A change of two or three degrees will nearly eliminate an R-7 signal. This condenser will require a slight re-adjustment when changing from one end of a given band to the other; however, the circuits "track" excellently, and once an optimum setting is found, it need not be touched unless an extremely weak signal



Top and bottom view of receiver showing construction and layout.

ELGIN "AIR ROAMER" III

3-Tube Receiver

Features:

* A.C. D.C. operation
* Dynamic Speaker
* Airplane Tuning Dial
* Vernier Regeneration Control Kit or Wired Models

Features:

* Headphone Jack
* World Wide Reception
* Neat Professional Appearance

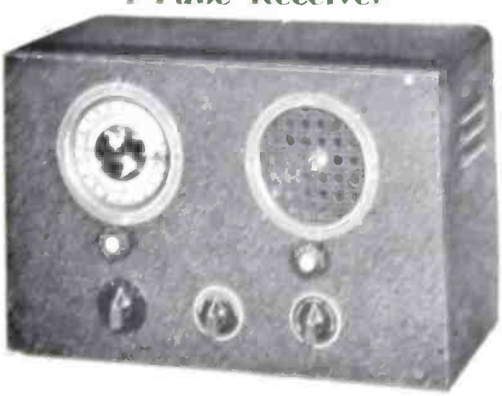
Completely outclasses any receiver of similar design. Its ability to reach out and pull in signals from all parts of the world has gained it an enviable reputation. Although it was only designed a short time ago it has already caught the fancy of technical and non-technical radiomen as being an outstanding unit. Plug-in coils, the most efficient tuning system in receivers of this design, are employed. Any band from 9½ to 2000 meters may be covered by merely changing the coil. A novel arrangement permits insertion of coils without turning receiver about. Four tube performance is obtained from the three employed, 1-6F7 combination detector and first audio feeds into a 43 power amplifier. A 25Z5 is used for rectification purposes. The 5" dynamic capably handles the full output.

Elgin Air Roamer three Kit of Pats, with coils tuning from 15 to 550 meters, less tubes, cabinets and extra coils, unwired.

Your Cost	**$8.12**
Wiring and testing	1.50
Metal cabinet	1.25
Set of 3 matched tubes	2.08
9½-15 meter coil	.29
200-500 meter coil	.29
550 to 2000 meter coils	.89

ELGIN "AIR ROAMER" IV

4-Tube Receiver



A popular model that persists in being the amateurs' favorite receiver. It has proven itself time and time again to thousands of users.

Requires no plug-in coils. A band switching arrangement permits you to select any band from 15 to 550 meters by a mere twist of the wrist. Band spread tuning of any of the amateur bands enables seperation of signals on the overcrowded 20-40-60-80 and 160 meter bands. Four tubes are employed. They include, 2-6J7's, 1-43 and 1-25Z5. The circuit itself has been refined to provide maximum sensitivity and selectivity. It has been designed so that satisfactory selectivity, on the broadcast band, heretofore unobtainable in receivers of this type, is provided.

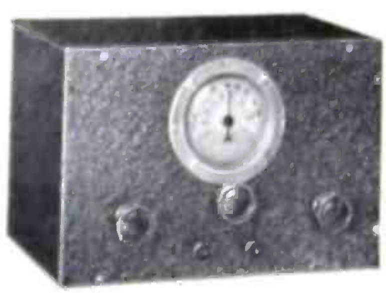
Available in wired or knocked down form. The kit includes all necessary parts for construction. Base and panel are drilled and punched to eliminate many tedious hours of unnecessary labor.

Complete kit of parts, less tubes, cabinet, unwired

Amateurs price	**$10.50**
Wiring and testing	2.25
Metal crystal finished cabinet	2.25
Set of 4 Matched tubes	2.75

ELGIN "BUDDY TWO"

2-Tube Receiver



A favorite with beginners and established "hams" alike. Its simple and yet very effective circuit has earned it an enviable reputation. Ideally suited for headphone reception.

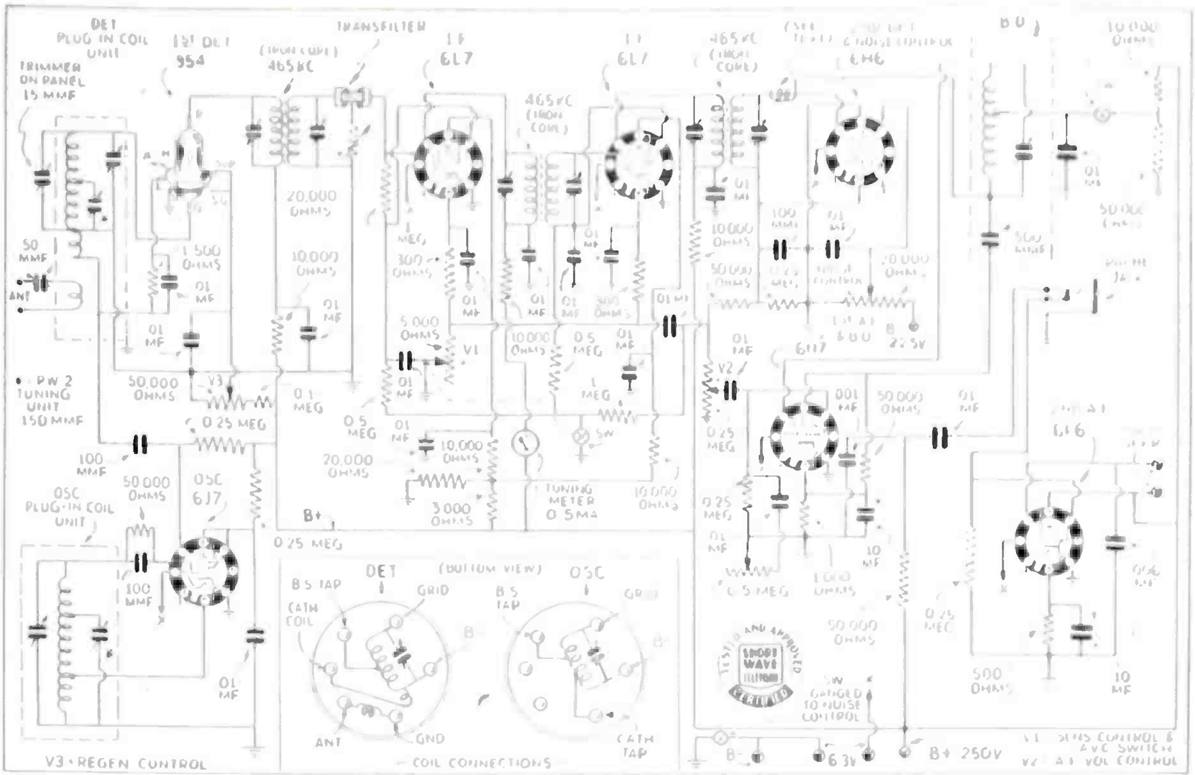
Makes use of two high efficiency tubes to provide maximum power output. Although designed to operate with headphones, locals may be heard on loudspeaker. This is primarily due to the use of the 12A7 tube which serves the purpose of a pentode output and combined rectifier. .7 watts output is obtainable. A 6J7 precedes the 12A7 and provides maximum amplification to the power tube. Furnished with four coils to tune from 15 to 200 meters. Additional coils to tune from 9½-15 and 200 to 3000 meters are available.

Complete kit of parts, less tubes, cabinet, extra coils, unwired.

Amateur Price	**$4.95**
Set of 2 matched tubes	1.75
Metal crystal cabinet	.95
Wiring and testing	1.25
9½ to 15 meter coil	.29
200 to 550 meter coil	.29
550 to 2000 meter coils	.89

TRY-MO RADIO CO., INC.

85A CORTLANDT ST. *Send For New 1938 Catalog* **N. Y. C., N. Y.**



The complete schematic diagram of the "S.W.&T." Communications Receiver.

is being dealt with. Likewise, an optimum setting of the regeneration control for any given band will easily be found and this also will need no adjustment except on extremely weak signals.

The detector coil has a separate antenna winding both terminals of which are available for connection to a doublet. Best results, were obtained with a 50 mmf. condenser in series, with one leg of this coil connected to a single wire antenna with the other side grounded. The antenna which works satisfactorily for all amateur bands is a 66 ft. flat-top, tapped some 9 ft. off center, employing a single-wire feeder.

Of course, the oscillator coil needs no changing. A conventional 6J7 metal tube is used in the oscillator circuit. The use of an ***acorn*** tube here would not provide a noticeable improvement, inasmuch as the stability of this oscillator, even on 10 meters, is almost perfect. The method of injecting the oscillator voltage into the detector is a result of much experimenting. With the values shown this method provided a lower background level than any other of the several methods tried, with the result that the gain control can be run "wide open" with the receiver remaining ***absolutely quiet***, insofar as receiver noise is concerned.

Incidentally, the secret of success in a receiver of this type is low receiver noise-level, and this receiver really has an ***extremely low background noise level***. The urge may be felt to deviate from some of the values shown, and even to employ different tubes and slight modifications of circuits; however, we strongly advise against this, because this receiver is really a perfect working job and we don't recommend changes. That is, if the performance of the original one is to be duplicated. If the builder desires a higher degree of selectivity a conventional quartz crystal of course, may be incorporated.

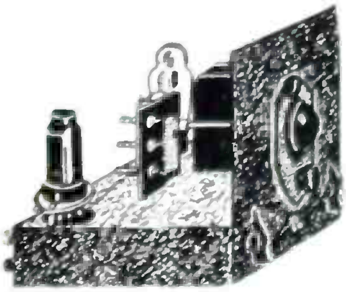
Reference to the photographs will give an idea of the layout used. In the bottom view you will notice a dotted circle and a shield can at the bottom of the chassis; an explanation may be necessary. After the receiver was finished the I.F. showed a tendency to go into oscillation with the AVC switch in the off position and the sensitivity control ***wide open***. This was traced to the H.F. oscillator stage. Due to the wiring arrangement, the by-pass condensers and resistors for the oscillator stage were mounted beneath the chassis directly under the 6J7 tube. It seems that there was sufficient radiation from these parts to throw the I.F. stages into oscillation with the gain control full on. Placing a small shield can over all of these parts, (the by-pass condensers and the plate and screen

Calling all

HAMS

CQ

MATEUR BAND ECEIVER FOR ONSISTENT RE EPTION ON HE LOUD PEAKER ½-5-10 Meters



Eagle Minuteman

The classic standby for the "Ham"

INUTE IAN KIT	**$4.75**	POWER SUPPLY	**$2.95**
ess tubes, power sup- ly, speaker, unwired		less tube, speaker, unwired	
TUBES C5 & 42	**$1.50**	80 RECTIFIER TUBE 30c EXTRA 5-in. loud speaker	**$1.19**
IRING HARGE Optional)	**$1.25**	Power Supply Wired	**50c**

FOR A. C. OPERATION 1-Tube

Just the receiver for duplex work. The most sensitive and selective super regenerator receiver known, uses metal and glass tubes. The last word in performance and simplicity of design. The 1st 2½ to 10 meter receiver ever offered to the amateur at such ridiculously low price. No license necessary to operate it.

And NOW . . Go on "5" with the

EAGLE FB2 6L6-6A6 PHONE TRANSMITTER

Stable 8 Watt Carrier 100% Modulated — Complete Kit **$6.95** Less Tubes

A highly efficient 5 meter Transmitter for portable or home use. The EAGLE FB2 Transmitter is a worthy companion to the famous MINUTE-MAN RECEIVER. The combination will give you a powerful 5 Meter Station at the lowest price obtainable.

EAGLE FB2 Transmitter Kit	**$6.95**
Two Tubes, 6L6, 6A6	**$1.95**
Heavy Duty Power Supply Kit with sufficient output to operate Transmitter and Receiver	**$3.95**
523 Tube for Power Supply	**59c**
Wiring Charge (optional) EAGLE FB2	**$2.00**
Wiring Charge (optional) FB2 Power Supply	**75c**
Black Crackeled Metal Cabinet 8½x8x6 for either Transmitter or Receiver	**50c**
Extra Large Black Crackeled Cabinet for Transmitter and Power Supply or Receiver and Power Supply	**$2.50**

Acclaimed by HAMS!

EAGLE 6L6 MODULATOR AND SPEECH AMPLIFIER

The exceptionally fine quality of the Eagle speech amplifier and modulator coupled with the fact that it may be used as a powerful public address system with no changes except the shunting of two regular speakers across the output transformer, make it the ideal unit for the ham who would like to improve the quality of his signal or the fellow who likes to make a little money on the side renting it out.

Some of the features of this unit are: Input for all types of microphones; power sufficient to modulate 50-60 watts input to any class "C" stage; overall gain of approximately 90 db and low hum level. Uses 6N7, 2-6L6 and 6F5 in a phase inverter circuit, class AB.

EAGLE MODULATOR KIT	**$10.95**
The kit includes heavy duty Kenyon mod. trans. to 2,500 ohm load, also rack panel with brackets. Multi-match Thordarson trans to match any tubes up to 50 watts optional	**$2.00**
Set of 4 guaranteed Tubes	**$3.95**
Triplet 0-200 Mil. Meter	**$2.94**
Modulator wired and tested additional	**$3.00**

MORE BANDS PER CRYSTAL—IT'S BI-PUSH.

Bi-Push All Band Exciter or Transmitter 45—50 Watt

This new development in exciters, recently described in "RADIO", by W. W. Smith W6BCX, has met with wide approval. The BI-PUSH is the most advanced design in really flexible band switching. The change from one band to another can be made in thirty seconds. Output sufficient for moderate dx and exceptionally good ten meter performance, with only an inexpensive power supply required. With our excellent design and careful choice of parts, peak efficiency on all bands is assured.

Work 3 bands on one crystal with only three coils. Your choice of 10-20-40 meters, or, 40-80-160 meters. A combination of all 5 bands can be obtained with the complete set of coils. Complete kit of high quality parts includes: — drilled chassis and rack panel; fully constructed coils for 3 bands; Bi-Push uses two 6A6's and two 6L6's with isolantite base (RK49's).

Complete Kit less crystal	**$18.95**
Set of 4 RCA or Raytheon Tubes	**$4.80**

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84 CORTLANDT STREET
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resistors) cured the trouble. Then there was absolutely no sign of instability at maximum gain setting. With a slightly different arrangement in wiring employed in a duplicate of this receiver, of course, the results would be entirely different and there may be no tendency toward feed-back. However, we mention this to show what a slight amount of oscillator radiation can do to a very high gain I.F. amplifier. In an effort to eliminate R.F. in the filament circuit one side of each heater in the tube is connected to ground, and this proved to be entirely adequate. However, in some cases it may be found necessary to by-pass the other leg of the heater circuit right at the first detector and oscillator sockets.

So far as stability in the *high-frequency* portion is concerned, this set leaves practically nothing to be desired. The regeneration control in the first detector circuit does *not affect* the tuning, of either the oscillator or first detector. Also the detector trimmer does *not* pull the oscillator. The entire high frequency portion is absolutely stable in all respects.

As for the sensitivity of the receiver, no measurements were taken and we will not attempt to estimate its sensitivity in microvolts. We will say this—from actual experience and comparison with other sets, it is not found wanting. During its operation we have not found a single signal that could not be brought up to an R-7 value, and we experienced no cases where we could hear signals but too weak to be copied. This is undoubtedly due to the low noise-level of the receiver for any-one experienced with receivers will recall hearing stations, and many at that, which are too weak to be brought in. We found that if they can be heard at all on this receiver, they can be copied solid, providing there is no QRN or QRM.

Aside from being an efficient receiver, its appearance is also modern and business-lik, especially with the crackle finished cabinet.

Coil Data for "S.W.&T." Receiver

Osc. Coils

Band	Grid Turns	Cath Tap	B B Tap	Length Winding	Wire
80	34	7	14	1½"	No 24 enam
40	9	3	3⅛	⅝"	No 24 enam
20	4	2	1¼	½"	No 24 enam
10	2½	½	⅝	⅛" space between turns	No 22 enam

Det. Coils

Band	Grid Turns	† Cath Coil	B B Tap	*Ant Coil	Length Winding	Wire
80	35	1½	15	7	1⅜"	No 24 enam
40	17	1	4¾	3	1¼"	No 24 enam
20	8	1	1½	1¾	1"	No 24 enam
10	2⅔	1	series cond used (35 mf.)	1½	⅛" space between turns	No 22 enam

*Interwound with B— end of grid coil No 30 d c c wire

†Wound in opposite direction to grid coil at B end No 30 d c c wire

The 10 meter detector coil is not tapped for bandspread, a 35 mmf padder is connected in series with tuning condenser, this padder is also inside of coil form as well as the 50 mmf parallel padder. The small padder (35 mmf.) is mounted with stiff wire so that it can be adjusted through hole in bottom of coil form.

The padders in the coils are 50 mmf.

Parts List

18—.01 mf. high frequency condensers
3—.0001 mf. mica condensers
1—.005 mf. mica condenser
1—.006 mica condenser
2—10 mf. low voltage electrolytics
4—50,000 ohm ½-watt resistors
5—10,000 ohm ½-watt resistors
2—300 ohm ½ watt resistors
1—1,000 ohm ½ watt resistor
5—¼ meg ohm ½ watt resistors
1—.1 meg. ohm ½ watt resistors
2—1 meg. ohm ½ watt resistors
1—500 ohm 1 watt resistor
1—10,000 ohm 10-watt resistor
1—50,000 ohm 10-watt resistor
1—3,000 ohm 20 watt resistor
1—20,000 ohm 20 watt resistor
2—20,000 ohm potentiometers (one with switch)
1—5,000 ohm potentiometer (with switch)
1—50,000 ohm potentiometer
1—250,000 ohm potentiometer
1—500,000 ohm potentiometer
1—PW-2 150 mmf. tuning assembly, with micrometer dial
1—set each 80, 40, 20 and 10 meter FB 7 coils
2—Octal tube sockets
1—Acorn tube socket
2—shield and socket assemblies for plug-in coils
3—465 kc. iron core I.F. transformers
1—beat oscillator assembly 465 kc.
1—HRO cabinet
1—15 mmf. midget trimmer
1—50 mmf. midget trimmer
1—954 acorn tube
1—6J7 tube (isolantite)
2—6L7 tubes (isolantite)
1—6H6
1—6N7
1—6F6
1—Transfilter 465 kc.
1—small bakelite case meter 0-5 ma.
5—Octal sockets (one hole mounting type)
1—toggle switch

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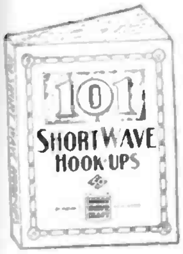
101 SHORT-WAVE HOOKUPS



Each diagram illustrated is accompanied by a thorough text explanation. What parts are required, coil-winding information, values of resistors, etc., in fact, everything needed to build the set or look up the data required.

All the important sets which have appeared in print during the past few years are in this book. Sets such as the Doerle, Dinsmore, the "19" Twinplex, Oscillodyne, Denton "Stand-by," Megadyne Triple X 2, "Globe-Trotter," 2-Tube Superhet, Minidyne, "Loop" Receiver, "Doerle" 2-tube Battery, "Doerle 3-tube Battery, "Doerle" 2-tube A.C., "Doerle" 3-tube A. C., Doerle "Signal Gripper," Duo R.F. 4-tube Receiver, The Sargent 9-33 Tapped Coil Receiver, Globe-Girdler 7, The 2-Tube "Champ"—2 Tubes Equal 3, Ham-Band "2-Tube Pee-Wee" Wyeth All-Way 6, Denton Economy 3, 2-Tube "Regenerative-Oscillodyne" will be found here, with full descriptions. In many cases, we have included a picture hook-up in addition to the regular symbolic hook-up.

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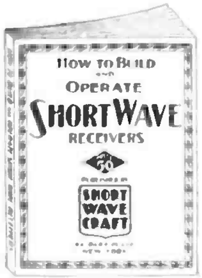
This is the most up-to-date book n the subject. It has been prepared y the editors of SHORT WAVE RAFT, and contains a wealth of aterial on the building and operaion, not only of typical short-wave eceivers, but short-wave converters s well. Dozens of short-wave sets re found in this book, which conains hundreds of illustrations; actual hotographs of sets built, hookups nd diagrams galore.



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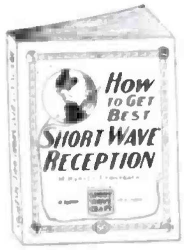
Why is one radio listener enabled to pull in stations from all over the globe, even small 100 watters, 10,000 miles away, and why is it that the next fellow, with much better and more expensive equipment, can only pull in powerful stations?

The reason is intimate knowledge of short waves and how they behave.



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HOW TO BECOME AN AMATEUR RADIO OPERATOR

We chose Lieut. Myron F. Eddy to write this book because his experience in the amateur field has made him preeminent in this line. He is a member of the I.R.E. (Institute of Radio Engineers), also the Veteran Wireless Operators' Association.

If you intend to become a licensed code operator, if you wish to take up phone work eventually—this is the book you must get.

PARTIAL LIST OF CONTENTS

Ways of learning the code. A system of sending, receiving with necessary drill words. Concise definitions of radio terms, units, laws, descriptions of commonly used radio equipment. Symbols used to indicate various parts of radio circuits. General radio theory as it applies to beginners. Electron theory is briefly given, waves—their creation, propagation, reception. Fundamental laws of electric circuits, particularly for radio. Descriptions of modern receivers used with success by amateurs. How to build and operate these sets. Amateur transmitters. Diagrams with specifications. Power equipment used with transmitters and receivers, rectifiers, filters, batteries, etc. Regulations that apply to amateur operators. International "Q" signals, conversion tables for reference purposes.

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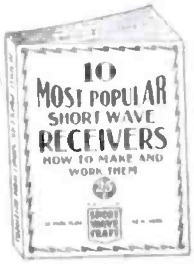

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RADIO LAWS . . . PERTAINING TO AMATEURS

● The amateur and the prospective amateur should be thoroughly familiar with the extracts of the Rules and Regulations of the F.C.C. for amateur stations which follow. Although it is not necessary to know the exact wording it is again stressed that the amateur be thoroughly familiar with them as half of the examination is devoted to the topics of Laws, Regulations and Penalties.

Extracts from the Communications Act of 1934

Section 1. For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of national defense, and for the purpose of securing a more effective execution of this policy by centralizing authority heretofore granted by law to several agencies and by granting additional authority with respect to interstate and foreign commerce in wire and radio communication, there is hereby created a commission to be known as the "Federal Communications Commission," which shall be constituted as hereinafter provided, and which shall execute and enforce the provisions of this Act.

Sec. 2. (a) The provisions of this Act shall apply to all interstate and foreign communication by wire or radio and all interstate and foreign transmission of energy by radio, which originates and/or is received within the United States, and to all persons engaged within the United States in such communication or such transmission of energy by radio, and to the licensing and regulating of all radio stations as hereinafter provided; but it shall not apply to persons engaged in wire or radio communication or transmission in the Philippine Islands or the Canal Zone, or to wire or radio communication or transmission wholly within the Philippine Islands or the Canal Zone.

Sec. 4. (a) The Federal Communications Commission (in this Act referred to as the "Commission") shall be composed of seven commissioners appointed by the President, by and with the advice and consent of the Senate, one of whom the President shall designate as chairman.

Section 301. It is the purpose of this Act, among other things to maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels, but not the ownership thereof, by persons for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license. No person shall use or operate any apparatus for the transmission of energy or communications or signals by radio (a) from one place in any Territory or possession of the United States or in the District of Columbia to another place in the same Territory, possession, or District; or (b) from any State, Territory, or possession of the United States, or from the District of Columbia to any other State, Territory, or possession of the United States; or (c) from any place in any State, Territory, or possession of the United States, or in the District of Columbia, to any place in any foreign country or to any vessel; or (d) within any State when the effects of such use extend beyond the borders of said State, or when interference is caused by such use or operation with the transmission of such energy, communications, or signals from within said State to any place beyond its borders, or from any place beyond its borders to any place within said State, or with the transmission or

reception of such energy, communications, or signals from and/or to places beyond the borders of said State; or (e) upon any vessel or aircraft of the United States; or (f) upon any other mobile stations within the jurisdiction of the United States, except under and in accordance with this Act and with a license in that behalf granted under the provisions of this Act.

Sec. 303. Except as otherwise provided in this Act, the Commission from time to time, as public convenience, interest, or necessity requires, shall—

(a) Classify radio stations:

(b) Prescribe the nature of the service to be rendered by each class of licensed stations and each station within any class;

(c) Assign bands of frequencies to the various classes of stations, and assign frequencies for each individual station and determine the power which each station shall use and the time during which it may operate;

(d) Determine the location of classes of stations or individual stations;

(e) Regulate the kind of apparatus to be used with respect to its external effects and the purity and sharpness of the emissions from each station and from the apparatus therein;

(f) Make such regulations not inconsistent with law as it may deem necessary to prevent interference between stations and to carry out the provisions of this Act: **Provided, however,** That changes in the frequencies, authorized power, or in the times of operation of any station, shall not be made without the consent of the station licensee unless, after a public hearing, the Commission shall determine that such changes will promote public convenience or interest or will serve public necessity, or the provisions of this Act will be more fully complied with;

(g) Study new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio in the public interest.

(j) Have authority to make general rules and regulations requiring stations to keep such records of programs, transmissions of energy, communications, or signals as it may deem desirable;

(l) Have authority to prescribe the qualifications of station operators, to classify them according to the duties to be performed, to fix the forms of such licenses, and to issue them to such citizens of the United States as the Commission finds qualified;

(m) Have authority to suspend the license of any operator for a period not exceeding two years upon proof sufficient to satisfy the Commission that the licensee (1) has violated any provision of any Act or treaty binding on the United States which the Commission is authorized by this Act to administer or any regulation made by the Commission under any such Act or treaty; or (2) has failed to carry out the lawful orders of the master of the vessel on which he is employed; or (3) has wilfully damaged or permitted radio apparatus to be damaged; or (4) has transmitted superfluous radio communications or signals or radio communications containing profane or obscene words or language; or (5) has wilfully or maliciously interfered with any other radio communications or signals;

(n) Have authority to inspect all transmitting apparatus to ascertain whether in construction and operation it conforms to the requirements of this Act, the rules and regulations of the Commission, and the license under which it is constructed or operated;

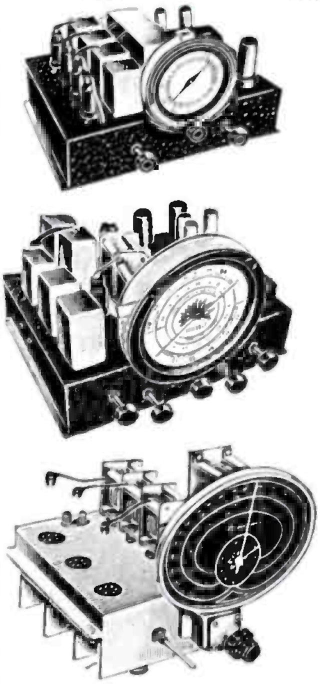
(o) Have authority to designate call letters of all stations;

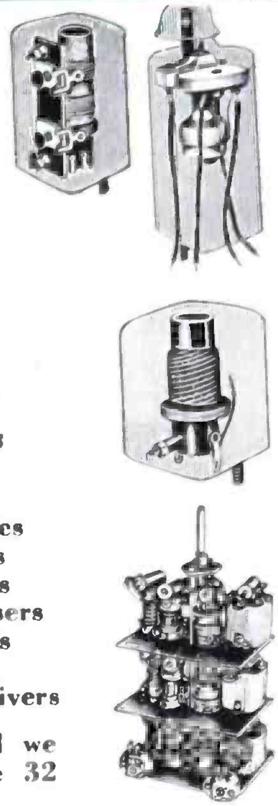
(p) Have authority to cause to be published such call letters and such other announcements and data as in the judgment of the Commission may be required for the efficient operation of radio stations subject to the jurisdiction of the United States and for the proper enforcement of this Act;

Sec. 309. (a) (If upon examination of any application for a station license or for the renewal or modification of a station license the Commission shall determine that public interest, convenience, or necessity would be served by the granting thereof, it shall authorize the issuance, renewal, or modification thereof in accordance with said finding. In the event the Commission upon examination of any such application does not reach such decision with respect thereto, it shall notify the applicant thereof, shall fix and give notice of a time and place for hearing thereon, and shall afford such applicant an opportunity to be heard under such rules and regulations as it may prescribe.

Sec. 318 The actual operation of all transmitting apparatus in any radio station for which a station license is required by this Act shall be carried on only by a person holding an operator's license issued hereunder. No person shall operate any such apparatus in such station except under and in accordance with such operator's license issued to him by the Commission.

Sec. 321. (B) All radio stations, including Government stations on board foreign vessels when within the territorial waters of the United States, shall give absolute priority to radio communications or signals relating to ships in distress; shall cease all sending on frequencies which will interfere with hearing a radio communication or signal of distress, and, except when engaged in answering or aiding the ship in distress, shall refrain from sending any radio communications or signals until there is as-





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A201	440-480	465 kc	110	13	31	......	6D6-75	Diode	3.00
A200M	440-480	465 kc	113	19	51	......	6K7-6H6	Diode	3.00
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A125	360-380	370 kc	49	......	16	53	6A7-6D6	Converter	3.00
A125	360-380	370 kc	220	......	15	47	6D6-6D6	Interstage	3.00
A225	360-380	370 kc	110	12	31	......	6D6-75	Diode	3.00
A150	250-270	260 kc	62	......	15	54	6A7-6D6	Converter	3.00
A150	250-270	260 kc	330	......	13	41	6D6-6D6	Interstage	3.00
A250	250-270	260 kc	120	11	31	......	6D6-75	Diode	3.00
A175	165-185	175 kc	54	......	11	50	6A7-6D6	Converter	3.06
A175	165-185	175 kc	300	......	9	30	6D6-6D6	Interstage	3.00
A275	165-185	175 kc	135	8	24	......	6D6-75	Diode	3.00
A185	105-125	115 kc	81	......	10	34	6A7-6D6	Converter	3.00
A185	105-125	115 kc	370	......	9	28	6D6-6D6	Interstage	3.00
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1,978,568	1,982,689	2,002,500	2,028,534	2,035,439	2,059,393	2,082,595

Other patents pending

surance that no interference will be caused with the radio communications or signals relating thereto, and shall assist the vessel in distress, so far as possible, by complying with it instructions.

Sec. 324. In all circumstances, except in case of radio communications or signals relating to vessels in distress, all radio stations, including those owned and operated by the United States, shall use the minimum amount of power necessary to carry out the communication desired.

Sec. 325. (a) No person within the jurisdiction of the United States shall knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent signal of distress, or communication relating thereto, nor shall any broadcasting station rebroadcast the program or any part thereof of another broadcasting station without the express authority of the originating station.

Sec. 326. Nothing in this Act shall be understood or construed to give the Commission the power of censorship over the radio communications or signals transmitted by any radio station, and no regulation or condition shall be promulgated or fixed by the Commjssion which shall interfere with the right of free speech by means of radio communication. No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.

Sec. 501. Any person who wilfully and knowingly does or causes or suffers to be done any act, matter, or thing, in this Act prohibited or declared to be unlawful, or who wilfully and knowingly omits or fails to do any act, matter, or thing in this Act required to be done, or willfully and knowingly causes or suffers such omission or failure, shall, upon conviction thereof, be punished for such offense, for which no penalty (other than a forfeiture) is provided herein, by a fine of not more than $10.000 or by imprisonment for a term of not more than two years, or both.

Sec. 502. Any person who wilfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission under authority of this Act, or any rule, regulation, restriction, or condition made or imposed by any international radio or wire communications treaty or convention, or regulations annexed thereto, to which the United States is or may hereafter become a party, shall, in addition to any other penalties provided by law, be punished, upon conviction thereof, by a fine of not more than $500 for each and every day during which such offense occurs.

Sec. 605. No person receiving or assisting in receiving, or transmitting, or assisting in transmitting, any interstate or foreign communication by wire or radio shall divulge or publish the existence, contents, substance, purport, effect, or meaning thereof, except through authorized channels of transmission or reception, to any person other than the addressee, his agent, or attorney, or to a person employed or authorized to forward such communication to its destination, or to proper accounting or distributing officers of the various communicating centers over which the communication may be passed, or to the master of a ship under whom he is serving, or in response to a subpeona issued by a court of competent jurisdiction, or on demand of other lawful authority; and no person not being authorized by the sender shall intercept any communication and divulge or publish the existence, contents, substance, purport, effect, or meaning of such intercepted communication to any person; and no person not being entitled thereto shall receive or assist in receiving any interstate or foreign communication by wire or radio and use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto; and no person having received such intercepted communication or having become acquainted with the contents, substance, purport, effect, or meaning of thesame or any part thereof, knowing that such information was so obtained, shall divulge or publish the existence, contents, substance, purport, effect, or meaning of the same or any part thereof, or use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto: **Provided**, that this section shall not apply to the receiving, divulging, publishing, or utilizing the contents of any radio communication broadcast, or transmitted by amateurs or others for the use of the general public, or relating to ships in distress.

Sec. 606. (c) Upon proclamation by the President that there exists war or a threat of war or a state of public peril or disaster or other national emergency, or in order to preserve the neutrality of the United States, the President may suspend or amend, for such time as he may see fit, the rules and regulations applicable to any or all stations within the jurisdiction of the United States as prescribed by the Commission, and may cause the closing of any station for radio communication and the removal therefrom of its apparatus and equipment, or he may authorize the use or control of any such station and or its apparatus and equipment by any department of the Government under such regulations as he may prescribe, upon just compensation to the owners.

Extracts from the Rules and Regulations of the F.C.C. for Amateur Stations

1. **Prescribed application forms.**—Each application for an instrument of authorization shall be made in writing on the appropriate form prescribed by the Commission for the purpose. Separate application shall be filed for each instrument of authorization. The required forms except as provided in paragraph 408 for amateur applicants, may be obtained from the Commission or from the office of any inspector. For a list of such offices and related geographical districts, see paragraph 30.

2. **Filing of application.**—

h. Each application for amateur facilities shall be filed in accordance with the following instructions:	
(1) Applications for amateur station and/or operators' licenses from applicants residing within 125 miles of Washington, D. C., a radio district office of the Commission, or an examining city (see par. 30).	1 copy to the inspector in charge of the radio district in which the applicant resides
(2) Applications for amateur station and/or operators' licenses from applicants residing more than 125 miles from Washington, D. C., a radio district office of the Commission, or an examining city (see par. 30).	1 copy direct to the Federal Communications Commission, Washington, D. C., in accordance with the instructions specifically set forth on the application form

14. **License where construction permit is not required.**—Each application for new license, where a construction permit is not prerequisite thereto, shall be filed at least 60 days prior to the contemplated operation of the station.

16. **Renewal of license.**—Unless otherwise directed by the Commission, each application for renewal of license shall be filed at least 60 days prior to the expiration date of the license sought to be renewed.

20. **Penalty for transfer of license without the consent of Commission.**—The transfer of a radio station license, or the rights granted thereunder, without consent of the Commission shall be sufficient ground for the revocation of such license or denial of any application for its renewal. Amateur station licenses and call signals are not transferable.

22. **Special authorizations.**—The Commission may grant special authority to the licensee of an existing station authorizing the operation of such station for a limited time in a manner, to an extent or for a service other or beyond that authorized in the license.

24. **Answering notice of violation.**—Any licensee receiving official notice of a violation of Federal laws, the Commission's rules and regulations, or the terms and conditions of a license shall, within 3 days from such receipt, send a written reply direct to the Federal Communications Commission at Washington, D. C. The answer to each notice shall be complete in itself and shall not be abbreviated by reference to other communications or answers to other notices. If the notice relates to some violation that may be due to the physical or electrical characteristics of the transmitting apparatus, the answer shall state fully what steps, if any, are taken to prevent future violations, and if any new apparatus is to be installed, the date such apparatus was ordered, the name of the manufacturer, and promised date of delivery.

26. If the notice of violation relates to some lack of attention or improper operation of the transmitter, the name and license number of the operator in charge shall be given.

27. **Normal license periods.**—All station licenses will be issued so as to expire at the hour of 3 A. M. Eastern standard time.

e. The licenses for amateur stations will be issued for a normal license period of 3 years from the date of expiration of old license or the date of granting a new license or modification of a license.

28. **Designation of call signals.**—Insofar as practicable, call signals of radio stations will be designated in alphabetical order from groups available for assignment, depending upon the class of station to be licensed. Because of the large number of amateur radio stations, calls will be assigned thereto in regular order and requests for particular calls will not be considered.

29. **Deletion of call signals.**—Call signals of stations will be deleted in each of the following cases:

a. Where an existing instrument of authorization has expired and no application for renewal or extension thereof has been filed.

b. Where a license has been revoked.

c. Where a license is surrendered or canceled.

d. Other cause, such as death, loss of citizenship, or adjudged insanity of the station licensee. Such occurrences coming to notice should be reported to the Commission, preferably accompanied by the station license for cancellation, if available.

30. **Radio districts.**—The following list of the radio districts gives the address of each field office of the Federal Communications Commission and the territory embraced in each district:

Radio district	Address of the inspector in charge	Territory within district	
		States	Counties
1	Customhouse, Boston, Mass.	Connecticut	All Counties.
		Maine	Do.
		Massachusetts	Do.
		New Hampshire	Do.
		Rhode Island	Do.
		Vermont	Do.
2	United States Subtreasury Building, New York, N. Y.	New York	Albany, Bronx, Columbia, Delaware, Dutchess, Greene, Kings, Nassau, New York, Orange, Putnam, Queens, Rensselaer, Richmond, Rockland, Schenectady, Suffolk, Sullivan, Ulster and Westchester.
		New Jersey	Bergen, Essex, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union and Warren.
3	Gimbel Building, 35 South Ninth Street, Philadelphia, Pa.	Pennsylvania	Adams, Berks, Bucks, Carbon, Chester, Cumberland, Dauphin, Delaware, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Perry, Philadelphia, Schuylkill, and York.
		New Jersey	Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Ocean and Salem.
		Delaware	Newcastle.
4	Fort McHenry, Baltimore, Md.	Maryland	All Counties.
		District of Columbia	Do.
		Virginia	Arlington, Clark, Fairfax, Fauquier, Frederick, Loudoun, Page, Prince William, Rappahannock, Shenandoah, and Warren.
		Delaware	Kent and Sussex.
5	Customhouse, Norfolk, Va.	Virginia	All except district 4.
		North Carolina	All except district 6.
		Alabama	All Counties.
6	411 New P. O. Bldg., Atlanta, Ga.	Georgia	Do.
		South Carolina	Do.
		Tennessee	Do.
		North Carolina	Ashe, Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Cleveland, Graham, Haywood, Henderson, Jackson, McDowell, Macon, Madison, Mitchell, Polk, Rutherford, Swain, Transylvania, Watauga, and Yancey.
7	P. O. Box 150, Miami, Fla.	Florida	All Counties.
		Puerto Rico	Do.
		Virgin Islands	Do.
8	Customhouse, New Orleans, La.	Arkansas	Do.
		Louisiana	Do.
		Mississippi	Do.
		Texas	City of Texarkana only.

Radio district	Address of the inspector in charge	Territory within district	
		States	Counties
9	209 Prudential Building, Galveston, Tex.	Texas	Aransas, Brazoria, Brooks, Calhoun, Cameron, Chambers, Fort Bend, Galveston, Goliad, Harris, Hidalgo, Jackson, Jefferson, Jim Wells, Kennedy, Kleberg, Matagorda, Nueces, Refugio, San Patricio, Victoria, Wharton, and Willacy.
10	164 Federal Building, Dallas, Tex.	Texas	All except district 9 and the city of Texarkana.
		Oklahoma	All Counties.
		New Mexico	Do.
11	1105 Rives-Strong Building, Los Angeles, Calif.	Arizona	Do.
		Nevada	Clarke.
		California	Imperial, Kern, Kings, Los Angeles, Monterey, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, Tulare, and Ventura.
12	Customhouse, San Francisco, Cal.	California	All except district 11.
		Nevada	All except Clarke.
		Hawaiian Islands	All Counties.
		Guam	Do.
		American Samoa	Do.
13	207 New U. S. Court House Bldg., Portland, Ore.	Oregon	Do.
		Idaho	All except district 14.
14	808 Federal Office Building, Seattle, Wash.	Alaska	All Counties.
		Washington	Do.
		Idaho	Benewah, Bonner, Boundary, Clearwater, Idaho, Kootenai Latah, Lewis, Nez Perce and Shoshone.
		Montana	Beaverhead, Broadwater, Cascade, Deerlodge, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis and Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Pondera, Powell, Ravalli, Sanders, Silver Bow, Teton, and Toole.
15	538 Customhouse, Denver, Colo.	Colorado	All Counties.
		Utah	Do.
		Wyoming	Do.
		Montana	Except district 14.
16	Room 927, New P. O. Bldg., St. Paul, Minn.	North Dakota	All Counties.
		South Dakota	Do.
		Minnesota	Do.
		Michigan	Alger, Baraga, Chippewa, Delta, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Luce, Mackinac, Marquette, Menominee, Antonagon, and Schoolcraft.
		Wisconsin	All except district 18.
17	410 Federal Bldg., Kansas City, Mo.	Nebraska	All Counties.
		Kansas	Do.
		Missouri	Do.
		Iowa	All except district 18.
18	2022 Engineering Building, Chicago, Ill.	Indiana	All Counties.
		Illinois	Do.
		Iowa	Allamakee, Buchanan, Cedar, Clayton, Clinton, Delaware,

			Des Moines, Dubuque, Fayette Henry, Jackson. Johnson Jones, Lee, Linn, Louisa, Muscatine, Scott, Washington, and Winneshiek.
		Wisconsin	Columbia, Crawford, Dane, Dodge, Grant, Green, Iowa, Jefferson, Kenosha, Lafayette, Milwaukee, Ozaukee, Racine, Richmond, Rock, Sauk, Walworth, Washington, and Waukesha.
19	1025 New Federal Bldg., Detroit, Michigan	Michigan	All except district 16.
		Ohio	All Counties.
		Kentucky	Do.
		West Virginia	Do.
20	514 Federal Building, Buffalo, N. Y.	New York	All except district 2.
		Pennsylvania	All except district 3.

30a. **Examining Cities**—Examinations for all classes of radio operator licenses will be given frequently at Washington, D. C., and the District Offices of the Commission in accordance with announced schedules.

(1) Such examinations will be held quarterly at:
Schenectady, N. Y.
Winston-Salem, N. C.
Nashville, Tenn.
San Antonio, Tex.
Oklahoma City, Okla.
Des Moines, Iowa
St. Louis, Mo.
Pittsburgh, Pa.
Cleveland. Ohio
Cincinnati, Ohio
Columbus, Ohio

(2) Examinations will be held not more than twice annually at:
Albuquerque, N. Mex.
Billings, Montana
Bismark, N. Dakota
Boise, Idaho
Butte, Montana
Jacksonville, Fla.
Little Rock, Ark.
Phoenix, Ariz.
Salt Lake City, Utah
Spokane, Washington

188. **Station.**—The term "station" means all of the radio-transmitting apparatus used at a particular location for one class of service and operated under a single instrument of authorization. In the case of every station other than broadcast, the location of the station shall be considered as that of the radiating antenna.

192. **Portable station.**—The term "portable station" means a station so constructed that it may conveniently be moved about from place to place for communication and that is in fact so moved about from time to time, but not used while in motion.

a. **Portable-mobile station.**—The term "portable-mobile station" means a station so constructed that it may conveniently be moved from one mobile unit to another for communication, and that is, in fact, so moved about from time to time and ordinarily used while in motion.

204. **Allocation of bands of frequencies to services.**—Allocations of bands of frequencies to services, such as mobile, fixed, broadcast, amateur, etc., are set forth in article 5 of the General Regulations annexed to the International Radiotelegraph Convention and in the North American Radio Agreement. These allocations will be adhered to in all assignment to stations capable of causing international interference.

207—**Interference, prevention of.**—Licensees shall use radio transmitters, the emissions of which do not cause interference, outside the authorized band, that is detrimental to traffic and programs of other authorized stations.

210......**Distress messages.**—Radio communications or signals relating to ships or aircraft in distress shall be given absolute priority. Upon notice from any station, Government or commercial, all other transmission shall cease on such frequencies and for such time as may, in any way, interfere with the reception of distress signals or related traffic.

213. **Operators.**—One or more licensed operators, of the grade specified by these regulations shall be on duty at the place where the transmitting apparatus of each station is located and whenever it is being operated; provided, however, that for a station licensed for service other than broadcasting, and remote control is used, the Commission may modify the foregoing requirements, upon proper application and showing being made, so that such operaor or operators may be on duty at the control station in lieu of the place where the transmitting apparatus is located. Such modification shall be subject to the following conditions:

a. The transmitter shall be capable of operation and shall be operated in accordance with the terms of the station license.

b. The transmitter shall be monitored from the control station with apparatus that will permit placing the transmitter in an inoperative condition in the event there is a deviation from the terms of the license, in which case the radiation of the transmitter shall be suspended immediately until corrective measures are effectively applied to place the transmitter in proper condition for operation in accordance with the terms of the station license.

c. The transmitter shall be so located or housed that it is not accessible to other than duly authorized persons.

214. **Licensed operator required.**—Only an operator holding radiotelegraph class of operators' license may manipulate the transmitting key of a manually operated coastal telegraph or mobile telegraph station in the international service; and only a licensed amateur operator may manipulate the transmitting key at a manually operated amateur station. The licenses of other stations operated under the constant supervision of duly licensed operators may permit any persons whether licensed or not, to transmit by voice or otherwise, in accordance with the types of emission specified by the respective licenses.

220. **Maintenance tests.**—Licenses of stations other than broadcast stations are authorized to carry on such routine tests as may be required for the proper maintenance of the stations: Provided, however, that these tests shall be so conducted as not to cause interference with the service of other stations.

221. **Licenses, posting of.**—The original of each station license, except amateur, portable and portable-mobile stations shall be posted by the licensee in a conspicuous place in the room in which the transmitter is located. In the case of amateur, portable, and portable-mobile stations the original license, or a photostat copy thereof, shall be similiarly posted or kept in the personal possession of the operator on duty.

a. The original license of each station operator, except amateur and aircraft radio station operators of portable and portable-mobile stations, shall be posted in a conspicuous place in the room occupied by such operator while on duty. In the case of an amateur or aircraft radio operator, and operators of portable or portable-mobile stations, the oiginal operator's license shall be similarly posted or kept in his personal possession and available for inspection at all times while the operator is on duty.

(b) When an operator's license cannot be posted because it has been mailed to an office of the Federal Communications Commission for endorsement or other change, such operator may continue to operate stations in accordance with the class of license held, for a period not to exceed 30 days, but in no case beyond the date of operation of the license.

361. **Definitions, amateur service.**—The term "amateur service" means a radio service carried on by amateur stations.

362. **Definition, amateur station.**—The term "amateur station" means a station used by an "amateur," that is, a duly authorized person interested in radio technique solely with a personal aim and without pecuniary interest.

364. **Definition amateur operator.**—The term "amateur radio operator" means a person holding a valid license issued by the Federal Radio Commission who is authorized under the regulations to operate amateur radio stations.

365. **Definition, amateur radio communication.**—The term "amateur radio-communication" means radio-communication between amateur radio stations solely with a personal aim and without pecuniary interest.

366. **Station licenses.**—An amateur station license may be issued only to a licensed amateur radio operator who has made a satisfactory showing of ownership or control of proper transmitting apparatus: **Provided, however,** that in the case of a military or naval reserve radio station located in approved public quarters and established for training purposes, but not operated by the United States Government, a station license may be issued to the person in charge of such a station who may not possess an amateur operator's license.

(a.) **Operator's license.**—An amateur operator's license may be granted to a person who does not desire an amateur station license, provided such applicant waives his right to apply for an amateur station license for 90 days subsequent to the date of application for operator's license.

367. **Eligibility for license.**—Amateur radio station licenses shall not be issued to corporation, associations, or other organizations; **Provided, however,** that in the case of a bona fide amateur radio society station license may be issued to a licensed amateur radio operator as trustee for such society.

368. **Mobile stations.**—Licenses for mobile stations and portable mobile stations will not be granted to amateurs for operation on frequencies below 28,000 kc. However, the licensee of a fixed amateur station may operate portable amateur stations (Rule 192) in accordance with the provisions of Rules 384, 386, and 387; and also portable and portable-mobile amateur stations (Rules 192 and 192a) on authorized amateur frequencies above 28,000 kc. in accordance with Rules 384 and 386, but without regard to Rule 387.

370. **Points of communication.**—Amateur stations shall be used only for amateur

service, except that in emergencies or for testing purposes they may be used also for communication with commercial or Government radio stations. In addition, amateur stations may communicate with any mobile radio station which is licensed by the Commission to communicate with amateur stations, and with stations of expeditions which may also be authorized to communicate with amateur stations.

371. **Amateur stations not to be used for broadcasting.**—Amateur stations shall not be used for broadcasting any form of entertainment, nor for the simultaneous retransmission by automatic means of programs or signals emanating from any class of station other than amateur.

372. **Radiotelephone tests.**—Amateur stations may be used for the transmission of music for test purposes of short duration in connection with the development of experimental radiotelephone equipment.

373. **Amateur stations not for hire.**—Amateur radio stations shall not be used to transmit or receive messages for hire, nor for communication for material compensation, direct or indirect, paid or promised.

374. **Frequency bands assigned.**—The following bands of frequencies are allocated exclusively for use by amateur stations:

1,715 to 2,000 kilocycles
3,500 to 4,000 kilocycles
7,000 to 7,300 kilocycles
14,000 to 14,400 kilocycles
28,000 to 30,000 kilocycles
56,000 to 60,000 kilocycles
400,000 to 401,000 kilocycles

374a, The licensee of an amateur station may, subject to change upon further order, operate amateur stations on any frequency above 110,000 kilocycles, without separate license therefor, provided:

(1) That such operation in every respect complies with the Commissions rules governing the operation of amateur stations in the amateur service.

(2) That records are maintained of all transmissions in accordance with the provisions of Rule 386.

375. **Types of emission.**—All bands of frequencies so assigned may be used for radio telegraphy, type A-1 emission. Type A-2 emission may be used in the following bands of frequencies only:

28,000 to 30,000 kilocycles
56,000 to 60,000 kilocycles
400,000 to 401,000 kilocycles

376. **Frequency bands for telephony.** The following bands of frequencies are allocated for use by amateur stations using radiotelephony, type A-3 emission:

1,800 to 2,000 kilocycles
28,000 to 29,000 kilocycles
56,000 to 60,000 kilocycles
400,000 to 401,000 kilocycles

377. **Additional bands for telephony.**—Provided the station shall be operated by a person who holds an amateur operator's license endorsed for class A privileges, an amateur radio station may use radiotelephony, type A-3 emission, in the following additional bands of frequencies:

3,900 to 4,000 kilocycles
14,150 to 14,250 kilocycles

378. **Amateur television, facsimile, and picture transmission.**—The following bands of frequencies are allocated for use by amateur stations for television, facsimile, and picture transmission.

1,715 to 2,000 kilocycles
56,000 to 60,000 kilocycles

379. **Licenses will not specify individual frequencies.**—Transmissions by an amateur station may be on any frequency within an amateur band above assigned.

380. **Aliens.**—An amateur radio station shall not be located upon premises controlled by an alien.

381. **Prevention of interference.**—Spurious radiations from an amateur transmitter operating on a frequency below 30,000 kilocycles shall be reduced or eliminated in accordance with good engineering practice and shall not be of sufficient intensity to cause interference on receiving sets of modern design which are tuned outside the frequency band of emission normally required for the type of emission employed. In the case of A-3 emission, the transmitter shall not be modulated in excess of its modulation capability to the extent that interfering spurious radiations occur, and in no case shall the emitted carrier be amplitude-modulated in excess of 100 per cent. Means shall be employed to insure that the transmitter is not modulated in excess of its modulation capability. A spurious radiation is any radiation from a transmitter which is outside the frequency band of emission normal for the type of transmission employed, including any component whose frequency is an integral multiple or submultiple of the carrier frequency (harmonics and subharmonics), spurious modulation products, key clicks and other transient effects, and parasitic oscillations.

381. **Waiver of Rule 381.**—The following order was adopted by the Telegraph Division on August 1, 1934:

> "Until further notice, the provisions of Rule 381 shall not be construed to apply to amateur operation on frequencies above 56,000 kilocycles."

382. **Power supply to transmitter.**—Licensees of amateur stations using frequencies below 30,000 kilocycles, shall use adequately filtered direct-current power supply for the transmitting equipment, to minimize frequency modulation and to prevent the emission of broad signals.

383. **Authorized power.**—Licensees of amateur stations are authorized to use a maximum of power input of 1 kilowatt to the plate circuit of the final amplifier stage of an oscillator-amplifier transmitter or to the plate circuit of an oscilator transmitter.

384. Transmission of call.—An operator of an amateur station shall transmit its assigned call at least once during each 15 minutes of operation and at the end of each transmission. In addition, an operator of an amateur portable, or portable-mobile radiotelegraph station shall transmit immediately after the call of the station, the break sign (*BT*) followed by the number of the amateur call area in which the portable or portable-mobile amateur station is then operating, as for example:

Example 1. Portable or portable-mobile amateur station operating in the third amateur call area calls a fixed amateur station: W1ABC W1ABC W1ABC DE W2DEF, ***BT3*** W2DEF *BT3* W2DEF ***BT3*** ***AR***

Example 2. Fixed amateur station answers the portable or portable-mobile amateur station: W2DEF W2DEF W2DEF DE W1ABC W1ABC W1-ABC ***K***

Example 3. Portable or portable-mobile amateur station calls a portable or portable-mobile amateur station: W3GHI W3-GHI W3GHI DE W4JKL ***BT4*** W4JKL ***BT4*** W4JKL ***BT4 AR***

If telephony is used, the call sign of the station shall be followed by an announcement of the amateur call area in which the portable or portable-mobile station is operating.

384a. In the case of an amateur licensee whose station is licensed to a regularly commissioned or enlisted member of the United States Naval Reserve, the Commandant of the naval district in which such reservist resides may authorize in his discretion the use of the call letter prefix "N," in lieu of the prefix "W" or "K" assigned in the license issued by the Commission, provided that such "N" prefix shall be used only when operating in the frequency bands 1715-2000 kilocycles, 3500-4000 kilocycles, 56,000 to 60,000 kilocycles and 400,000 to 401,000 kilocycles in accordance with instructions to be issued by the Navy Department.

385. **Quiet hours.**—In the event that the operation of an amateur radio station causes general interference to the reception of broadcast programs with receivers of modern design, that amateur station shall not operate during the hours from 8 o'clock p.m. to 10:30p.m., local time, and on Sunday from 10:30 a.m., until 1 p.m., local time, upon such frequencies as cause such interference.

386. **Logs.**—Each licensee of an amateur station shall keep an accurate log of station operation to be made available upon request by authorized Government representatives, as follows:

a. The date and time of each transmission. The date need only be entered once for each day's operation. The expression "time of each transmission" means the time of making a call and need not be repeated during the sequence of communication immediately follows; however, an entry shall be made in the log when "signing off" so as to show the period during which communication was carried on.)

b. The name of the person manipulating the transmitting key of a radiotelegraph transmitter or the name of the person operating a transmitter of any other type (type A13 or A14 emission) with statement as to type of emission. (The name need only be entered once in the log provided the log contains a statement that all transmissions were made by the person named except where otherwise stated. The name of any other person who operates the station shall be entered in the proper space for his transmissions.)

c. Call letters of the station called. (This entry need not be repeated for calls made to the same station during any sequence of communication provided the time of "signing off" is given.)

d. The input power to the oscillator, or to the final amplifier stage where an oscillator amplifier transmitter is employed. (This need be entered only once providing the input power is not changed.)

e. The frequency band used. (This information need be entered only once in the log for all transmissions until there is a change in the frequency to another amateur band.)

f. The location of a portable or portable-mobile station at the time of each transmission. This need be entered only once, provided the location of the station is not changed. However, suitable entry shall be made in the log upon changing location, showing the type of vehicle or mobile unit in which the station is operated, and the approximate geographical location of the station at the time of operation.)

g. The message traffic handled. (If record communications are handled in regular message form, a copy of each message sent and received shall be entered in the log or retained on file for at least one year.)

387. **Portable stations.**—Advance notice of all locations in which portable amateur stations will be operated shall be given by the licensee to the inspector in charge of

the district in which the station is to be operated. Such notices shall be made by letter or other means prior to any operation contemplated and shall state the station call, name of licensee, the date of proposed operation and the approximate locations, as by city, town or county. An amateur station operating under this rule shall not be operated during any period exceeding 30 days without giving further notice to the inspector in charge of the radio inspection district in which the station will be operated. This rule does not apply to the operation of portable or portable-mobile amateur stations on frequencies above 28,000 kc. authorized by amateur stations. (See Rule 368)

400. **Only amateur operators may operate amateur stations.**—An amateur station may be operated only by a person holding a valid amateur operator's license, and then only to the extent provided for by the class of privileges for which the operator's license is endorsed.

401. **Validity of operator's license.**—Amateur operator's licenses are valid only for the operation of licensed amateur stations, provided, however, any person holding a valid radio operator's license of any class may operate stations in the experimental service licensed for, and operating on, frequencies above 30,000 kilocycles.

402. **Proof of use.**—Amateur station licenses and or amateur operator licenses may, upon proper application, be renewed provided: (1) the applicant has used his station to communicate by radio with at least three other amateur stations during the 3-month period prior to the date of submitting the application, or (2) in the case of an applicant possessing only an operator's license, that he has similarly communicated with amateur stations during the same period. Proof of such communication must be included in the application by stating the call letters of the station with which communication was carried on and the time and date of each communication. Lacking such proof, the applicant will be ineligible for a license for a period of 90 days.

This rule shall not prevent renewal of an amateur station license to an applicant who has recently qualified for license as an amateur operator.

403. **Class of operator and privileges.**—There shall be but one main class of amateur operator's license, to be known as "amateur class," but each such license shall be limited in scope by the signature of the examining officer opposite the particular class or classes of privileges which apply, as follows:

Class A.—Unlimited privileges.

Class B.—Unlimited radiotelegraph privileges. Limited in the operation of radiotelephone amateur stations to the following bands of frequencies: 1,800 to 2,000 kilocycles; 28,000 to 29,000 kilocycles; 56,000 to 60,000 kilocycles; 400,000 to 401,000 kilocycles.

Class C.—Same as class B privileges, except that the Commission may require the licensee to appear at an examining point for a supervisory written examination and practical code test during the license term. Failing to appear for examination when directed to do so, or failing to pass the supervisory examination, the license held will be canceled and the holder thereof will not be issued another license for the class C privileges.

404. **Scope and places of examinations.**—The scope of examinations for amateur operators' licenses shall be based on the class of privileges the applicant desires, as follows:

Class A.—To be eligible for examination for the class A amateur operator's privileges the applicant must have been a licensed amateur operator for at least 1 year and must personally appear at one of the Commission's examining offices, and take the supervisory written examination and code test. See pars. 2h (1), 30, and 408.) Examinations will be conducted at Washington, D. C. on Thursday of each week, and at each radio district office of the Commission on the days designated by the inspector in charge of such office. In addition, examinations will be held quarterly in the examining cities listed in paragraph 30 on the dates to be designated by the inspector in charge of the radio district in which the examining city is situated. The examination will include the following:

a. Applicant's ability to send and receive in plain language messages in the Continental Morse Code (5 character to the word) at a speed of not less than 13 words per minute.

b. Technical knowledge of amateur radio apparatus, both telegraph and telephone.

c. Knowledge of the provisions of the Communications Act of 1934, subsequent acts, treaties, and rules and regulations of the Federal Communications Commission, affecting amateur licensees.

Class B.—The requirements for class B amateur operators' privileges are similar to those for the class A, except that no experience is required and the questions on radiotelephone apparatus are not so comprehensive in scope.

Class C.—The requirements for class C amateur operators' privileges shall be the same as for the class B except the examination will be given by mail. Applicants for class C privileges must reside more than 125 miles air line from the nearest examining point for class B privileges, or in a camp of the Civilian Conservation Corps.

or be in the regular military or naval service of the United States at a military post or naval station; or be shown by physician's certificate to be unable to appear for examination due to protracted disability.

405. **Recognition of other classes of licenses.**—An applicant for any class of amateur operator's privileges who has held a radiotelephone second-class operator's license or higher, or an equivalent commercial grade license, or who has been accorded unlimited amateur radiotelephone privileges, within 5 years of the date of application may only be required to submit additional proof as to code ability and/or knowledge of the laws, treaties, and regulations affecting amateur licensees.

406. An applicant for the class B or C amateur operator's privileges who has held a radiotelegraph third-class operators' license or higher, or an equivalent commercial grade license, or who has held an amateur extra first-class license within 5 years of the date of application may be accorded a license by passing an examination in laws, treaties, and regulations affecting amateur licensees.

407. **Code ability to be certified by licensed operator.**—An applicant for the class C amateur operator's privileges must have his application signed in the presence of a person authorized to administer oaths by (1) a licensed radiotelegraph operator other than an amateur operator possessing only the class C privileges or former temporary amateur class license, or (2) by a person who can show evidence of employment as a radiotelegraph operator in the government service of the United States. In either case the radio telegraph code examiner shall attest to the applicant's ability to send and receive messages in plain language in the continental Morse code (5 characters to the word) at a speed of not less than 13 words per minute. The code certification may be omitted if the applicant can show proof of code ability in accordance with the preceding rule.

408. **Applications.**—Each application for an instrument of authorization shall be made in writing, under oath of the applicant, on a form prescribed and furnished by the Commission. Separate application shall be filed for each instrument of authorization requested.

The required forms may be obtained from the Commission or from any of its field offices.

409. **Grading of examinations.**—The percentage that must be obtained as a passing mark in each examination is 75 out of a possible 100. No credit will be given in the grading of papers for experience or knowledge of the code. If an applicant answers only the questions relating to laws, treaties, and regulations by reason of his right to submit other subjects because of having held a recognized class of license, a percentage of 75 out of a possible 100 must be obtained on the questions answered.

410. **Operator's and station licenses to run concurrently.**—An amateur station license shall be issued so as to run concurrently with the amateur operator's license and both licenses shall run for 3 years from the date of issuance. If either the station license or the operator's license is modified during the license term, both licenses shall be reissued for the full 3-year term: Provided, however, if an operator's license is modified only with respect to the class of operator's privileges, the old license may be endorsed, in which case the expiration date will not change.

411. **Eligibility for reexamination.**—No applicant who fails to qualify for an operator's license will be reexamined within 90 days from the date of previous examination.

412. **Penalty.**—Any attempt to obtain an operator's license by fraudulent means, or by attempting to impersonate another, or copying or divulging questions used in examinations, or, if found unqualified or unfit, will constitute a violation of the regulations for which the licensee may suffer suspension of license or be refused a license and/or debarment from further examination for a period not exceeding 2 years at the discretion of the licensing authority.

413. **Duplicate licenses.**—Any licensee applying for a duplicate license to replace an original which has been lost, mutilated, or destroyed, shall submit an affidavit to the Commission attesting to the facts regarding the manner in which the original was lost. Duplicates will be issued in exact conformity with the original and will be marked "duplicate" on the face of the license.

414. **Oath of secrecy.**—Licenses are not valid until the oath of secrecy has been executed and the signature of the licensee affixed thereto.

415. **Examination to be written in longhand.**—All examinations including the code test, must be written in longhand by the applicant.

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