SECOND EDITION

PRACTICAL AMATEUR RADIO SERIES

5 METER RADIOTELEPHONY

by FRANK JONES

DESIGNER OF FIVE METER EQUIPMENT
FOR THE SAN FRANCISCO BAY BRIDGE

25¢

**DESIGN
CONSTRUCTION
OPERATION**

Published by "RADIO," The National Magazine for Amateurs and Short-Wave Experimenters

FIRST OF A SERIES OF PRACTICAL BOOKS FOR RADIO AMATEURS AND SHORT-WAVE EXPERIMENTERS

Second
Edition

5-METER RADIOTELEPHONY

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Published and Copyrighted, 1934, by PACIFIC RADIO PUBLISHING CO.
Pacific Building, San Francisco, U. S. A.

SECOND PRINTING,
DECEMBER, 1934

47 Years of 5-Meter Radio

- 5 meter—60 megacycle—radio communication is gray-headed.
- Between 1887 and 1891 Heinrich Hertz did his very first radio work on such wavelengths.
- Every existing 5 meter distance record, transcontinental and transoceanic, was made between 1925 and 1929 by Italian and American experimenters.
- No new effects seem to have been found in late years.
- The current monthly literature on 5 meters has shown a tendency toward retreat, in strange contrast to the progress made at other wavelengths. The receivers described this last year or more have rather uniformly been in (in essentials) the 1925 Frank Jones super-regenerator. The year 1935 will bring with it the first practical 5-meter superheterodyne by Frank C. Jones.
- Similarly transmitter descriptions have drifted back to the half-forgotten device called "modulated oscillator." Such equipment is simple—but belongs to 1925.
- The parade moved on in 1926. Let us follow it. That your guide is Frank C. Jones is sheer good fortune.

ROBERT S. KRUSE.

Technique and Principles of Ultra-High Frequency Communication

By Frank C. Jones, Ultra-Short Wave Editor of "RADIO", and designer of the 5-meter equipment for the San Francisco Bay Bridge.

THE following information collected after many years of specializing in this particular field while perhaps not new to all, will, we hope supply practical hints and ideas to many experimenters. The information is divided under separate headings.

1. Transmission Characteristics

ULTRA-HIGH frequency transmission of radio energy below approximately 7.5 meters or 40 megacycles has a field all its own. Its field of use is restricted to a great number of purposes where local communication is required, due to the fact that the wave does not return to the earth by reflection from the mirror-like Heaviside Layer. On very rare occasions it is possibie that this takes place for brief intervals but such transmission is of no value.

Because of this fact several advantages are gained for its local uses. The so-called ground radiation only is utilized and no fading or variation in signal strength occurs. The range of transmission may be governed by the elevation of the transmitting antenna and to some extent by the transmitter power. It is limited to a distance somewhat in excess of the radius of the horizon as seen from the transmitting antenna when the receiving points are at ground level and to a distance somewhat in excess of the combined horizon distances when both transmitter and receiver antenna are elevated.

Waves at these frequencies travel in optical paths like light and behave exactly according to the theories for light rays. Their wave lengths, however, are still millions of times greater than the wave lengths of light. For this reason the path of these waves is not a straight line joining the two points on the earth. Light waves bend in passing from one point to another very slightly, this effect becomes more and more pronounced as the wave length increases. In the ultra-high frequency bands this effect has become so pronounced that the optical path is no longer approximately straight but is curved along a line which is the circumference of a circle about 4 times the radius of the earth. This is due to refraction caused by the earth's atmosphere and its exact curvature is dependent upon the variation of density of the air with altitude. Since this changes from time to time the range beyond the true horizon may vary. One result which has been observed by us many times is the gradual increase in range or in the signal between two points after the sun goes down and darkness approaches. The reason is that the density of the atmosphere near the earth's surface increases as the temperature falls, this results in the optical path through the air becoming more curved so that it remains closer to the earth after passing the true horizon. In one case we have observed where the two stations were beyond the light horizon no signal at all was obtained during the day. Soon after the sun went down the signal began to come through and by the time it was dark a very reliable signal was received. Over another circuit 40 miles long the straight line of sight enters the ground at two miles from one station and six miles from the other. Both stations using 15 watts of antenna power are always in reliable two-way phone communication but the signal strength always improves at night. Between two such points 40 miles apart, if all the intervening space were at sea level, the earth curvature causes the surface to rise approximately 260 feet. In other words, over the ocean towers nearly 260 feet high would be required at each end to be visible to one another. A circuit over this path on 5 meters would require towers nowhere near this high on account of the increased curvature of the radio optical path. Over land the ground elevations above sea level are added to this curvature "bump" and result in increased attenuation, and of course become serious if the elevations of ground are great near the mid-point of the path.

The "light horizon" in miles from an elevated antenna location can be found by taking the square root of the height in feet of the antenna above sea level and multiplying it by 1.23. For instance if the antenna is 100 feet above sea level the horizon is 12.3 miles (the square root of 100 is 10 which multiplied by 1.23 gives 12.3 miles). The "radio horizon" is greater and the multiplying factor is approximately 1.4 instead of 1.23. In other words, communication is reliable over sea or over land at sea level for a distance approximately 20% greater than the light horizon.

The topography of the intervening terrain modifies this picture to a great extent. A fair picture of whether transmission is possible or not can be had by using the 'Haigis Method". A circle is drawn passing through the two station locations with a radius of 60 inches. Elevations taken from a contour map are plotted on this circle along extended radii with a scale of ⅛-in. equalling 10 feet in elevation. If a circle whose radius is 240 inches is drawn passing through both antenna locations and does not pass through any of the elevated points between, transmission is assured provided, of course, that the transmitters have sufficient power. If this line passes through one or more peaks on the way, transmission is usually still possible but each one increases the attenuation to some extent.

When one station is located in the shadow of a high hill other facts enter into the problem due to reflection and diffraction which make individual problems in themselves and they usually are solved by changes of antenna location, which may amount to only a few feet. These effects also come into play in all transmissions but it is the writer's opinion after extensive tests that refraction plays the most important role.

For estimating short distance circuits such as occur in a city and its immediate surroundings, if reasonably flat, a fair estimate of range can be obtained by use of the above formula tempered with good judgment as regards height of antenna necessary to overcome local obstacles such as tall buildings (which offer considerable attenuation) and intervening hills.

The power required is astoundingly small. Using a Transmitter-Receiver putting about .5 watt in the antenna we had no difficulty in contacting the amateurs within a range of from 6 to 15 miles in the Philadelphia area. This area is, of course, quite flat with no elevations of any account. With 15 watts power the 40 mile circuit described above is reliable.

One reason for the low power requirement is due to the fact that fully resonant antenna can be used. A highly efficient transfer of power into radiation is possible in such a system as compared to one where loading coils are necessary to bring the antenna to resonance. It is well to remember, also, that within the area to the horizon more power produces higher field intensity and that at points in this area where, due to obstacles, the signal is weak, more power will remedy the situation.

In free space, from an airplane where line of sight exists, power of the order of .5 watt is often sufficient for ranges up to 100 miles although greater power is required for the return circuit to produce a strong signal intensity at the plane. This is necessary so as to overcome the exceedingly high surrounding noise level through which the signal must be intelligible. With a plane flying at 1500 feet the "radio line of sight" is between 50 and 55 miles. Using .5 watt antenna power the attenuation is such that reliable communication using a sensitive super-regenerative receiver is just possible to the ground. By the reciprocal law .5 watt at the ground station will produce the same signal strength at the plane but this would not be reliable on account of the plane noise. By actual test to a balloon these statements were proven.

2. Receivers for Ultra-High Frequencies

THE super-regenerative type of receiver is in some form almost universally used for reception. Peculiarly and in contrast to the difficulties encountered in designing equipment to meet the requirements of higher and higher frequencies in the last few years, super-regenerative detection becomes less and less critical.

To explain, simply, exactly how this form of detection takes place is not a simple matter but some of its characteristics are easy to visualize. As it is used for phone and tone telegraph reception, the detector oscillates intermittently at a frequency above audibility (20 to 25 thousand cycles). In such an intermittently oscillating circuit, an incoming signal will build up to an enormous value depending only on the grid swing possible with the type of tube used. When no signal is present the tube and circuit noises are built up by this action until they produce the extremely high noise or rush level so familiar to those using this type of detection. It is well to remember that this noise is the result of extreme sensitivity and that it is not an inherent phenomenon of super-regenerative action but would be and is present in any form of detection of equal sensitivity.

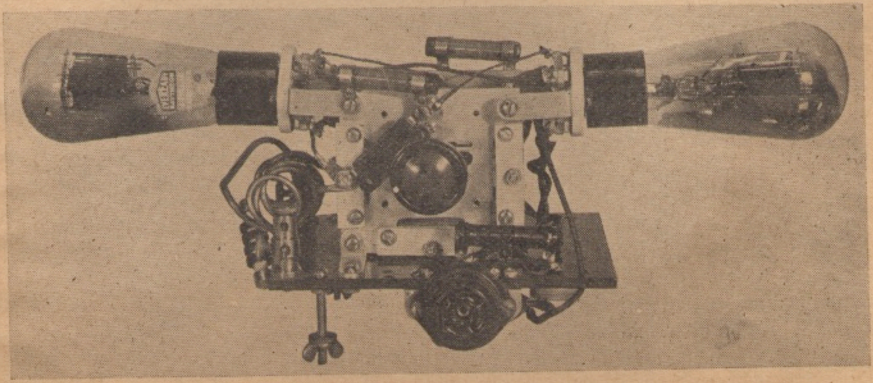
The noise is made up partly of the "Shot Effect" due to the irregularity of electron emission from the filament and partly due to the noises of the currents flowing in the tank circuits and leads. The part due to the emission can be eliminated to some extent by using tubes having filaments from which the electrons are emitted more regularly. Pure tungsten filaments seem best, next the thoriated type, then oxide-coated, and finally the heater type. There is little difference between the thoriated and oxide-coated type, but quite a large jump in noise takes place between the oxide type and heater type, not so much in the loudness of the noise but rather in the smoothness.

When a signal comes on, it will automatically reduce the sensitivity of the tube, and consequently the background noise by an amount depending on the strength of the incoming carrier. A weak signal well modulated can be heard through the noise even though it is only slightly reduced. A strong signal will completely remove all background noise. We consider a signal perfectly reliable if the background noise is reduced by 6 db. or more. Insofar as detecting action goes, the super-regenerative receiver behaves like a receiver with automatic volume control, the super-regenerative detector being inherently 100% automatic in controlling volume.

One particular disadvantage lies in the selectivity of such a detector. It is extremely broad due to the time-delay principal employed in building up the signal. It builds up in the circuit to its maximum value during the non-oscillating periods, and this action greatly reduces the selectivity. Another disadvantage is due to the radiation from the detector. When receiving, the detector oscillates intermittently and, of course, radiates a signal fully modulated by the quenching frequency. Another receiver operating within receiving range of the radiating receiver's carrier, picks it up and the beat notes between the quenching frequencies of the two receivers cause very serious interference. This may happen over quite large distances (a mile or more). The more sensitive a detector of this type is the more radiation it has and consequently the more trouble it makes. It makes little difference whether it be of the self-quenched oscillator type or of the type where the oscillator is intermittently stopped by a separate quenching tube. The self-quenched type is the more sensitive if constructed properly, since the stop and start of the oscillation period can be made sharper. This gives the signal more time to build up.

It is possible to use a RF amplifier as a blocking tube between the detector and antenna, and to really get some gain but it is not an easy job to do it. Even the best screened grid tubes at ultra-high frequency allow considerable energy to be by-passed in the wrong direction. Then again the power cable to the set is usually of sufficient length to act as a fairly efficient antenna. Choke coils in the individual leads do little good since the spurious capacities to the set at the cable entrance are sufficient to allow considerable RF power to pass to the cable.

The chief advantage of this type of receiver, namely its extreme sensitivity, should be an incentive to the experimenter and engineer alike in developing improvements to remove its disadvantages. Little intensive study has been made of this method and the writer believes that big strides can be made with it.

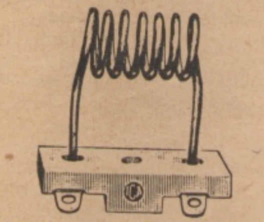


Raytheon Ultra-High Frequency Transmitter. Note compact arrangement of parts and leads.

The superheterodyne receiver for these frequencies will also find use in this field and will soon supersede the super-regenerative type. Until such time as the transmitters in general use have better frequency stability, there is little to be gained by its use. There are many difficulties in the design of such a receiver, but it is well to bear in mind that, if the sensitivity is increased to approach that of the super-regenerative type, there will be an equal amount of tube noise, if the receiver is not properly designed.

3. Transmitters

ALMOST any type of circuit will oscillate quite efficiently at frequencies down to 70 or 75 megacycles, if a few simple precautions are observed. By far the most popular type has been the tuned grid tuned plate type in push-pull arrangement. At the highest frequencies this has a distinct advantage, since the tube capacities are in series across the tank circuit, but at frequencies up to 60 megacycles, there is little choice between it and the same circuit single ended, other than the increased power result-



Conventional 5-Meter Inductance
The illustration is actual size

ing from two tubes. In designing any circuits for these frequencies, short leads are very essential. It is hard to believe that a straight piece of wire a few inches in length has sufficient inductance to offer any impedance but it is nevertheless true (an inductance of one microhenry offers a reactance of 400 ohms at 60 megacycles). For this reason the tank circuits should be connected to the tube elements by as short leads as possible. The design of ultra-high frequency equipment is as much mechanical as electrical, and the test "bread board" set-up cannot be transformed to a different layout in the finished set with equal success. The practice of some large laboratories of segregating electrical development and mechanical design in engineering radio equipment has not produced very satisfactory results in the ultra-high frequency field.

By and large the greatest number of transmitters operating in the amateur band are made up of directly modulated oscillators. In most sections of the country the frequency instability resulting from this does not cause any great interference. The time is rapidly approaching where this order of things will change. The master oscillator, power amplifier type should be the present goal of the amateur. With it will come an improvement it is well to mention. Frequency modulation occurs when the oscillator is modulated and becomes very noticeable when the percentage of modulation is high. Many side bands are produced and the energy is spread over them all instead of being concentrated in the two which are present when the carrier frequency is constant. This results in a weaker detected signal spread over quite a wide band. When detected in a super-regenerative receiver, the signal can be heard spread over a large proportion of the silent region. If a good M.O.P.A. transmitter is used, the voice is observed quite sharply in the center of the carrier, and since the side band power is concentrated at one point, the signal is louder for the same modulation percentage, and consequently greater range may be expected. In addition the amplifier may be modulated to 100%. In the M.O.P.A. transmitter it is well to note that the oscillator should be designed with proper circuit constants so that, as far as possible, frequency stability is assured even though the supply voltages may vary slightly. A sufficiently powerful oscillator is also a good thing in order that the coupling between it and the amplifier can be reduced sufficiently to prevent reaction of the modulated amplifier on it. Tubes of the same size in both oscillator and power amplifier have been found to be satisfactory.

Class B modulators are perfectly satisfactory and economy dictates their use. For the smaller units a single power supply for the entire equipment can be used if care is taken to insure extremely good regulation. For the larger units the Class B modulator should have its own power supply to prevent any frequency fluctuations of the oscillator due to the voltage drop in the supply when modulating. The oscillator and power amplifier may be supplied from a second unit quite satisfactorily, or three units may be used, the oscillator then having its own supply.

A well-designed 5 watt transmitter should be quite satisfactory for all amateur purposes. Increased power accomplishes little in extending the signal beyond the horizon, and, except in those cases where the location is shadowed, will produce sufficient signal strength within the horizon radius.

A word here about the gain to be expected from increased power. Little is gained by just doubling the power. The signal strength is increased by only 3 db. and this is just noticeable. For this reason power increases are generally made in multiples of 10, which give 10 db. gain for each step. In other words, if your location is so shadowed that 5 watts is unsatisfactory, little improvement will be noted unless a jump to a 50 watt carrier is made.

4. Antenna and Transmission Lines

THE antenna almost universally used for fixed stations is the vertical half wave dipole. A horizontal dipole is directional at right angles to its axis and it exhibits this characteristic very noticeably in free space and to a less degree where local reflections caused by buildings and hills change its pattern. A wave radiated from a horizontal dipole is polarized in such a way that it must also be received on a horizontal dipole so that the experimenter wishing to operate with stations in all directions from him, using vertical dipoles, must do so himself if results at all satisfactory are expected.

In the 56 to 60 megacycle band a rod one-half inch in diameter is resonant if cut to approximately 93% of the actual half wavelength of the frequency used. Since it has a high radiation resistance, (74 ohms), its resonance curve is very broad and its length is not very critical. A rod cut for 58 megacycles can be operated quite satisfactorily anywhere in the 56 to 60 megacycle band. It should be mounted as high and as free from all surroundings as possible. The supports for it should be near the middle rather than at the ends where voltage maxima exist, to reduce losses. If possible, it should be supported by brackets holding it away from the mast by 2 feet. The upper portion of the mast extending beyond the lower end of the dipole should be of wood, but the rest can be of metal. Guys should be attached at a point below the lower end of the rod. We have found little to be gained by breaking up the guys with insulators at these frequencies.

The antenna may be supplied with power from the transmitter by a transmission line, either of the matched impedance type or of the resonant tuned type. In either case some method must be used to determine when the antenna is at resonance. The writer believes this problem is the most difficult one confronting the ultra-high frequency experimenter. The direct method where thermocouple meters are inserted in the antenna is the most reliable, since definite assurance of radiation is thereby obtained.

Before taking up the transmission line let us consider some of the electrical characteristics of the half wave dipole. If the rod were cut in two at the middle and its impedance measured, it would be found to have a resistance of about 74 ohms, if it is several wavelengths above the ground. Near the ground this value may be anything from 10 to 100 ohms, but above one wavelength it never goes below 65 ohms or over 80. Due to this change, the method often used of making adjustment first, and then raising the antenna, is not a good one.

Now an antenna, even though it is a straight rod, has inductance and the two opposite ends have capacity to each other. As a rough approximation, the antenna can be considered as a coil shunted by a condenser similar to the tank circuit of an oscillator with 74 ohms of resistance inserted in series with the coil, to represent the radiation resistance of the antenna. If the tank circuit or antenna were tuned to say 60 megacycles, and the coil (or antenna) cut in the middle and the impedance measured, the resistance would be 74 ohms. If we don't cut the coil (or antenna), but simply measure the value of impedance across one turn (between two points equal distance from the center of the antenna) the impedance will be higher and will increase the farther out we go, until when we measure across the entire tank circuit (between the ends of the rod) we measure a very high impedance. For a well-designed tank circuit this maye be 10,000 ohms or more, for the antenna it is of the order of 13,000 ohms.

Now, to transfer the maximum amount of power from one circuit to another the impedance must match fairly closely. A mismatch of 2 to 1 is not very serious but we, of course, endeavor to match correctly.

A two-wire transmission line made up of two No. 14 bare copper wires spaced 2 inches apart has an impedance of approximately 500 ohms and if we want to match this to an antenna the simplest way is to attach it at two points equidistant from the center where our measurements show the impedance of the rod to be 500 ohms. The points at which this occurs are spaced 24% of a half wave length apart. As an example suppose we wish to set up a matched impedance antenna for 58 MC. The wave length is 5.17 meters or 203.5 inches. One-half wave length is 101.8 inches. The ½-inch diameter rod is cut 93% or 94.5 inches long. The tap-offs are made so that the points are 24% of the actual ½ wave length apart or 24% of 101.8 inches which equals 24.4 inches or 12.2 inches each side of center.

The line made up as indicated above is spread out from a point about 24 inches away and at right angles to the rod and attached. It may be run for any length to the transmitter. If the match were perfect there would be no standing waves on the wires and a neon light will show the same brilliancy when touched at any point of either wire. Such a perfect match is seldom obtained in practice and standing waves exist to some degree in most installations. The goal to strive for is to make them a minimum by changing the line length a few inches at a time, noting for each length the transmitter setting for minimum standing waves. A position will finally be found for the transmitter setting and length which is best.

This type of line is best connected directly to the tank circuit through fixed blocking condensers and no series or parallel tuning of the line is needed.

If four thermo-couple instruments are available having the same range this process can be simplified by connecting one in series with each line at the set and one in each line at a point approximately one quarter wave length away. Adjustment can then be made as indicated above until all four meters are made to read as near alike as possible.

A further and conclusive proof of correct adjustment can be had, if convenience permits, by placing a meter in each outer leg of the antenna itself at the tap-off point. Adjustment of the length of the line as indicated above until these meters read alike and maximum, together with tests of standing waves on the feeder line, make certain that best adjustment has been reached.

In this type of installation the use of a meter at the center of the antenna is not recommended as this meter will show a large reading when standing waves are present on the line which then acts as a Lecher Wire system and delivers no energy to the outer ends of the antenna which do practically all of the radiating. The line should be installed to clear surrounding objects by at least 10 inches and where bends are made they should be of as large a radius as possible.

There is on the market a form of matching transformer consisting of a coil which is connected to the matched impedance line and which has taps at 74 ohm points to which the antenna can be connected by cutting it at its center. There is no advantage in this method over the one described above and it is undoubtedly not as efficient.

There are two other methods of matching which should be mentioned because of their adaptability in certain installations. They both make use of a length of transmission line as a transformer. If a section of transmission line ¼ wave length long at the frequency we desire to operate is shorted by a jumper at one end and the antenna is attached to one wire at the other end, points can be found along these lines where the impedance is 500 ohms. To these points equidistant from the jumper the line is attached. This quarter wave transformer can be hung directly beneath the antenna rod and may be convenient to use in some cases, although no better results will be obtained than when the antenna itself is used for the matching.

The same principle can be employed by connecting a ½ wave length of line to the center of the antenna, shorting the far end. In this case two 500 ohm points can be found which are approximately the same distance from the antenna end and the shorted end. The line can be attached at either point and standing waves eliminated.

These ¼ and ½ wave line transformers are usually used in setting up directional arrays and are here described so that those caring to experiment may do so. The most all 'round practical type of matched impedance antenna is that described first in this section.

Nothing yet has been said about concentric tube lines where the two conductors are formed of pipe or tubing and arranged one inside the other. This type of line is more difficult and expensive to construct but has many advantages, one being that the energy is all confined inside the outer tube, the line itself cannot radiate, the outer tube may be grounded at any point along its length or even buried in the ground with no loss in efficiency.

Two wire lines cannot be constructed which have a very low impedance. For 6 inch spacing the impedance is 628 ohms, for 4 inch spacing 578 ohms, for two inch spacing 495 ohms, for 1 inch 413 ohms and when the wires are spaced only .1 inch or are practically in contact the impedance is 137 ohms. This drastic change of 60 times in the spacing has reduced the impedance to only 137 ohms from 628 or by a factor of 4.5. It can be seen from these figures that the wire spacing of a two wire line is not very critical and that variations in the spacing, unavoidable in construction, will have little effect.

A concentric tube line can easily be constructed to have much lower impedances. If the ratio of the outer diameter of the inner conductor (which may be either solid or tubing) to the inner diameter of the outer tubing is 3.44 the line will have an impedance of 74 ohms independent of the size of pipe and will form a matched impedance system into the center of a dipole, the outer tube to one side and the inner to the other. A line made of ¾-inch outside diameter tubing having 1/32-inch wall for the outer sheath and No. 4 B & S copper wire for the inside meets these specifications very closely. Thin bakelite spacers can be used at intervals to hold the inner conductor in place.

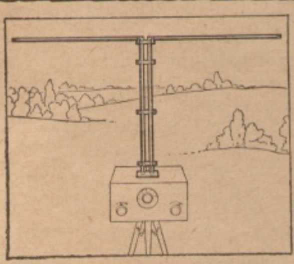
Such types of line as applied to ultra-high frequency uses are more particularly adaptable to mobile automobile and plane installations since they can be bent to conform with the car body or plane fuselage much easier than an open wire line.

For such mobile installations another type of antenna is often more convenient to install. A quarter wave rod is used extending upward through the car roof or through the fuselage in the rear of the plane. The metal framework of the car or plane is used as a counterpoise, extra foil, metal screen, or wires being added around the base of the rod if necessary. This antenna is really a ¼ wave Marconi Type radiator and shows an impedance between its base and the surrounding counterpoise of 37 ohms, half that of a dipole or ½ wave antenna. A concentric tube line can be made to feed this type, the ratio of diameters to make the line 37 ohms being 1.86. Using ¾-inch o.d. pipe with 1/32-inch wall the inner conductor will be .367-inch outside diameter. The use of ⅜-inch o.d. tubing is satisfactory.

5-Meter Antenna Systems

THE subject of five meter antennas has always been of interest because the results obtained with these miniature systems sometimes can be useful in the design of lower frequency antennas. More and more interest will be shown in 5 meter antenna design as this band becomes more popular for amateur use and as television progresses.

In the transmission and reception of 5 meter signals the direct, or ground wave is used. At longer wavelengths a skywave is utilized and thus great distances are possible by means of reflections from the Heaviside layer. The five meter signals usually seem to penetrate this layer with little reflection back to earth and therefore it is necessary to depend upon the direct wave. The earth is a good reflector for short waves and it is necessary for the transmitting and receiving stations to be within visual range of each other. A hill on the earth's curvature is enough of a "mirror" or reflector to literally bend or push the five meter signals upward to a much greater extent than at longer wavelengths. For this reason an airplane can go from 100 to 200 miles away from a transmitter and still receive five meter signals if it can climb to a high enough altitude, as was previously told.



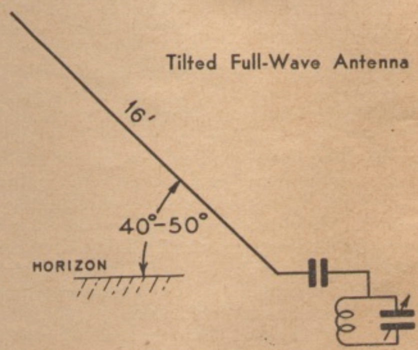
Johnson "Q" Antenna for 5-Meters

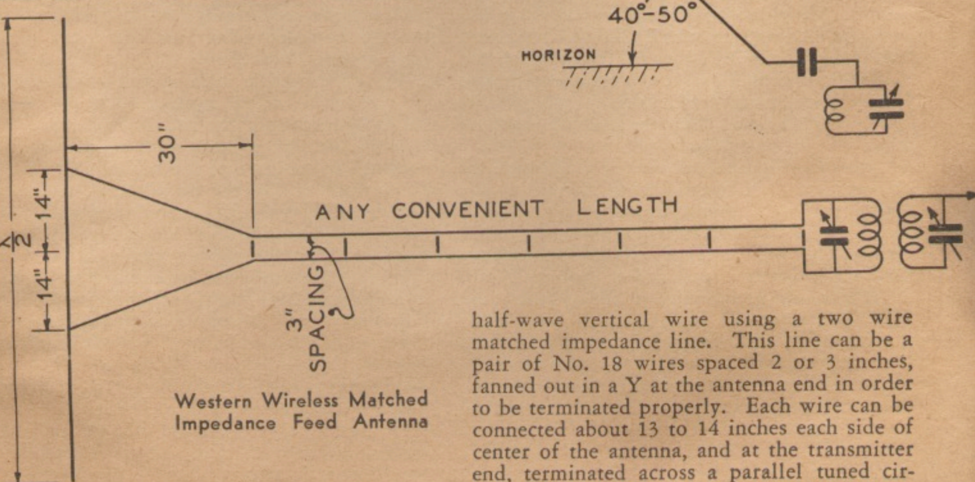
The point to be emphasized in the preceding paragraph is that as much height should be used as possible at both the transmitter and receiving antennas. Since the direct wave is used, an antenna should be used which has a low angle of radiation both for transmission and reception. Vertical polarization has been proven to be much more effective than horizontal polarization and thus vertical antennas are indicated if they are of the simple half-wave type.

Half-wave antennas have been used very successfully because their radiation pattern is a figure 8 with the greatest radiation parallel to the earth. In this case the wave is transmitted at a low angle with respect to the earth, since it acts as a reflector tending to bend the wave front up away from the ground. There is less tendency for upward bend with vertical polarization, otherwise a half-wave horizontal antenna would be just as effective. Of course, the horizontal antenna would have to have its axis perpendicular to the receiving station in order to get maximum effect from the figure 8 radiation pattern, and it would have to be at least a wavelength above ground. Our 20 and 40 meter antennas are usually less than a half-wavelength above ground, therefore the earth acts as an antenna reflector wire and shoots the wave upward at what is termed "high angle radiation."

For transmission an effective antenna is a half-wave vertical wire using a two wire matched impedance line. This line can be a pair of No. 18 wires spaced 2 or 3 inches, fanned out in a Y at the antenna end in order to be terminated properly. Each wire can be connected about 13 to 14 inches each side of center of the antenna, and at the transmitter end, terminated across a parallel tuned cir-

Tilted Full-Wave Antenna





Western Wireless Matched Impedance Feed Antenna cuit which is coupled to the oscillator or amplifier tank circuit. This type of line can be spaced with dowel rod and string spacers, or transposition blocks could probably be used.

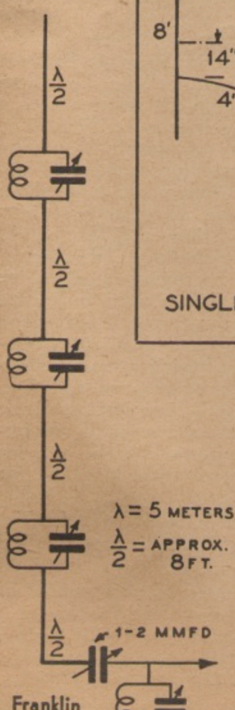
In some locations a directional antenna can be used for both transmitting and receiving with a gain of several D.B. units. The simplest form uses parasitic reflectors or directors or combinations of the two. Reflector wires are longer than the antenna and are placed a quarter-wave behind the antenna and a half-wave away if used on the sides of the antenna. Director wires are different in that they are always placed in a straight line in front of the antenna at spacings of ⅜ wavelength from it and each succeeding director. The beam can be made very sharp if enough director wires are used, and back or side radiation can be minimized by the use of reflector wires which also increase the intensity in the desired direction. These spacings are 6⅓ feet for director wires, for an average 5 meter antenna resonant at the middle of the amateur band, 4½ feet back and 8½ feet at each side of reflector wires. The following chart gives the proper lengths for these antenna, allowing for end effects:

Wave-length	Freq. MC	Antenna Length	Director Length	Reflector Length
5.0	56	8′ 4″	7′ 7″	8′ 7″
5.17	58	8′ 1″	7′ 4″	8′ 4″
5.36	60	7′ 9″	7′ 1″	8′ 1″
10.65	28.2	16′ 8″	15′ 2″	17′ 1″

A SURPRISINGLY good receiving antenna consists of an eight foot wire with its lower end coupled through a very small capacity to the grid circuit of the receiver. This type works well in any type of building not constructed with too much steel and "chicken wire", such as used in stucco coated exteriors. Moving this antenna a few feet in a room will often increase the signal several fold due to reflective or directive effects of nearby objects, such as house wiring. If most of this antenna wire can be vertical, or nearly so, very good results are usually obtained.

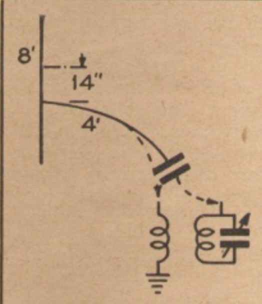
A good transmitting antenna always makes a good receiving antenna, but for purposes of two-way phone operation, or for a person interested in receiving only, other forms of antennas are useful, such as the one described above. Another more effective five meter antenna is the Franklin type which consists of a number of half wave sections with a resonant circuit between each section.

The Franklin antenna is very interesting in that the received signal can be at least doubled with a three section wire 24 feet long with two tuned circuits cut in at 8 ft. intervals. These tuned circuits can be 6 turns of No. 10 or 12 wire on ⅝ inch diameter with a little spacing between turns and tuned by a three

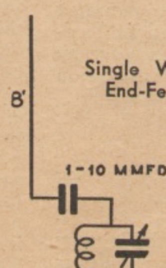


Franklin Antenna

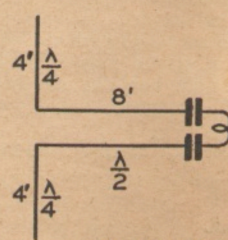
RECEIVER



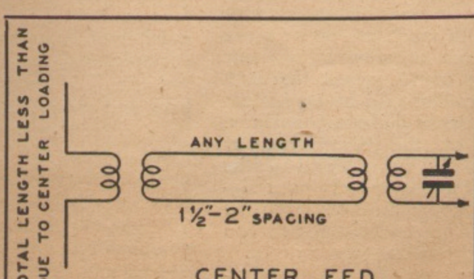
SINGLE WIRE FEED



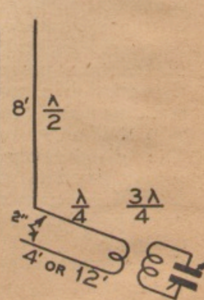
Single Wire End-Fed



DOUBLET



CENTER FED
SIMILAR TO PICARD TYPE



ZEPP

or four plate midget tuning condenser. These coils can be soldered directly across the condenser terminals and the eight foot antenna sections also soldered on these connections. These circuits are easily tuned to five meters by previous adjustment when the coil and condenser are coupled like a wavemeter to a transmitter or receiver circuit. With an outside antenna, these tuned trap circuits should be protected against moisture. Any number of sections can be used in order to increase the effective height above ground.

The purpose of these tuned circuits is to prevent phase reversal of standing waves of voltage and current in an antenna of several half wavelengths. These "phasing coils" reverse the phase without themselves radiating to any extent; the desired effect of a number of antennas all radiating in phase is obtained.

A full-wave antenna, 16 feet long, without a phasing coil and condenser trap circuit has a radiation pattern like a shamrock, or four leaf clover, without much energy going out at right angles to the antenna. This radiation pattern should have a maximum in a direction parallel to the earth for five meter transmission or reception, so a 16 foot antenna can be used if it is tilted at an angle of 40 or 50 degrees toward or away from the desired directions. It should be more effective if tilted towards the desired direction since its upper "loop" would be used parallel to the earth, and because the upper loop would be useful, the effective height would be greater.

Any form of antenna can be used for five meter work, even a wire several hundred feet long, but best results are obtained if the antenna is designed only for five meter use. The vertical half-wave antennas mounted on roof tops with two wire matched RF feeders, or the simple Franklin antennas are by far the best for non-directional transmission and reception.

Directional Antennas

THE VALUE of directional transmitting antennas is that they can be made to radiate most of their power in one direction rather than broadcasting this energy in all possible directions. The result is equivalent to increasing the effective power of the transmitting station by an amount which can be made as much as 100 or more times. From the point of view of amateur transmission a gain of 50 means that 100 watts properly directed would be equivalent to 5 KW on an ordinary half-wave antenna. The disadvantage of the directivity, of course, is that stations in other than the favored direction receive extremely poor signals (i.e., the 100 watt transmitter might be no more effective in an undesired direction than a 5-watt non-directional transmitter).

The first thing to consider about directional antennas is the type and amount of directivity desirable. Experience with commercial directional antennas has shown very definitely that it is possible to have too much directivity, since the waves do not always travel laong the same path in reaching the receiver, and that the amount of diiectivity in the vertical and horizontal planes which can be tolerated is quite different. In general, it is found that the waves travel very closely along the great circle path to the receiver, and that very sharp directivity can be used in the horizontal plane. When it comes to directivity in the vertical plane, however, the situation is somewhat different, as it appears that the best angle above the horizon varies from time to time. Experience indicates that the main beam should be directed at an angle not lower than 10 to 12 degrees and not higher than 25 to 30 degrees, and that the vertical directivity should not be too sharp.

Although many types of directivity antennas have been devised, the present trend is towards a few relatively simple types involving a small number of long wires, rather than a large number of small antennas. The best examples of these are the horizontal V, used by RCA, and the horizontal diamond, developed by the Bell system. Antennas of these types are shown in Figs. 1 and 2. It will be noted that both of these antenna systems involve relatively simple structures which are correspondingly simple to build and easy to tune.

The principal factor controlling the design of the V antenna is the angle between the wires. This is determined by the length of the wire according to the relation shown in Fig. 3, and is relatively critical. The amount of directivity obtainable is greater the longer the wires, and commercial antennas of this type are commonly made about eight wavelengths long. A reasonable directivity can be expected, however, for lengths of two to four wavelengths. A number of feeding systems may be employed, of which perhaps the simplest is to make each wire an odd number of quarter-wavelengths long (as, for example, 3¾) and then use a resonant transmission line having a current maximum at the junction of antenna and line. The tuning-up process is then just as simple as any current-fed antenna system. If voltage-feed is desired the wires should be an even number of quarter-wavelengths long (as, for example, 3½).

A single V antenna is bi-directional. The back end radiation can be redirected forward by a reflecting antenna similar to the radiating antenna but located an odd number of quarter-wavelengths behind and faced so that the two antennas are supplied with current 90° out of phase. The exact details of accomplishing this result are somewhat involved and should not be undertaken unless one has had some experience with problems of this sort.

The diamond antenna operates in a manner considerably different from the usual antenna employed by amateurs. This antenna is non-resonant and possesses a current distribution which dies away uniformly from the input corner to the terminating resistance. As a result of this behavior, the diamond antenna is not critical with respect to frequency and can be used without any change of adjustment over a frequency range of at least 2 to 1. The antenna is, furthermore, uni-directional, since the terminating resistance eliminates the radiation which would otherwise take place in the backward direction. These properties make the diamond antenna desriable from many points of view. It can, for example, be used at 20 meters in the daytime and 40 meters at night without any change. In constructing a diamond antenna the proper thing to keep in mind is the angle θ which is related to the length of the legs as shown in Fig. 4. The terminating resistance should then be given the value which eliminates the resonances along the line and will be in the order of 800 ohms. The antenna also offers a resistance load of about 800 ohms to the transmission line.

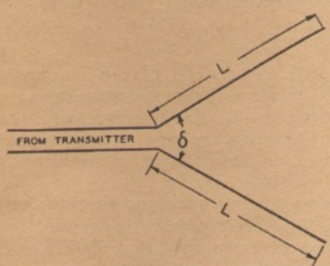


FIG. 1

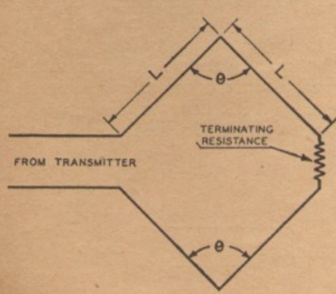


FIG. 2

The vertical directivity of horizontal antennas such as have been described depends primarily upon the height of the antenna above ground rather than upon other characteristics of the antenna. This is because the ground reflects the energy radiated in its direction and this reflected energy combines with the main energy either to reinforce or to cause cancellation, depending upon the vertical angle. The higher the antenna the lower (i.e., the nearer the horizontal) will the reflected energy reinforce the directly radiated energy with the result that the higher the antenna above ground the closer to the horizontal will be the radiation. This is shown in Fig. 5 from which it is seen that if the height is one wavelength then the bulk of energy will be directed at a vertical angle of approximately 16°, while if the height is one-half wavelength, the angle will be 30°. Horizontal antennas should, therefore never be less than ½ wavelength above the ground if they are to be used for long distance communication.

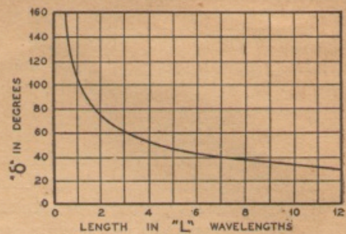


FIG. 3

These charts courtesy of Prof. F. E. Terman.

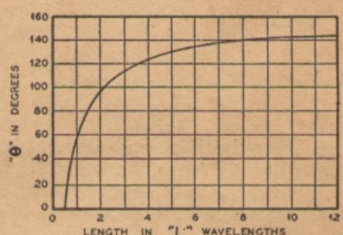


FIG. 4

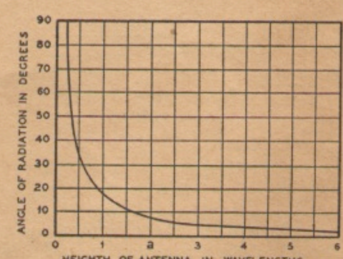


FIG. 5

5-Meter Tuned Diamond Antenna

A TUNED Diamond Antenna has given better results than the Diamond Antenna with a resistor at the far end. By carefully tuning each side of the Diamond Antenna, the resistor can be eliminated.

For the sake of convenience, take the approximate center of the Five Meter Band, namely, 5.172 meters, as a basis for the working arrangements and discussions. Experimentally, the figure, 1.56 has proved to be a reliable one. Multiply 1.56 x the wave length, and the correct half wave length can be found without much experimentation. However, the type of surrounding objects all enter into consideration, so if anyone is anxious to have a fine, good working diamond antenna, the following procedure should be carried out.

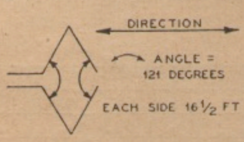


FIG. 1

Each side of the Diamond (Fig. 1) should be one full wave length, namely 16 feet 2 inches. The angle in the case shown, that is, for one wave length a side, is 121 degrees.

If more space is available the diamond shown in Fig. 2 can be used, where each side is two wave lengths, or 32 feet 4 inches. In this case the angle must be 87 degrees. The

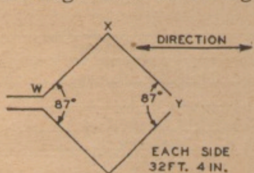


FIG. 2

arrow at the top of the diagram shows the direction of wave propagation and also the direction of best reception.

The antenna shown in Fig. 2 will give a stronger wave in the direction indicated, as compared with the antenna in Fig. 1.

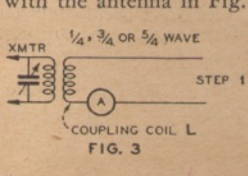


FIG. 3

The first step in tuning of the antenna is shown in Fig. 3, namely, a quarter wave feeder. A five-meter quarter-wave feeder is only four feet and one-half inch long, so any multiple of four feet, one-half inch, can be used.

For instance, the odd multiple would be

4 ft. ½ inch.
12 ft. 1½ inches
20 ft. 2½ inches
28 ft. 3½ inches
36 ft. 4½ inches, etc.

The most convenient feeder length can then be chosen and the transmitter coupled to the Antenna Coupling Coil as shown in Fig. 3.

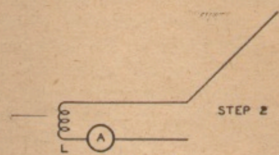


FIG. 4

A glow lamp can be placed in the antenna at "A" or a small ammeter, sufficient to give a reading while the transmitter is on low power, can also be used. Be sure the transmitter is on low power, otherwise the ammeter will burn out.

Move the clips back and forth on coupling coil "L" until resonance is secured with the transmitter set at the required wave length, which in this case is 5.172 meters.

Then lower the feeders, attach one side of the diamond, say 32 ft. 4 inches, hoist the feeders with the 32 ft. 4 inch side on it, and repeat the process. If the clip on coupling coil "L" comes out on the same turn, then the 32 ft. 4 inch section is right. If more turns have to be used, then the 32 ft. portion should be made longer. If less turns have to be used, then cut off a few inches of the 32 ft. wire until it reaches maximum resonance at the same point as it did in Fig. 3.

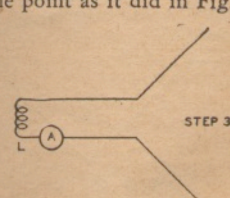


FIG. 5

In Fig. 5 is shown two sides of the Diamond. The tuning process is repeated here. In this case, both of the sides should be the same length.

Fig. 6 shows the completed diamond. It should likewise check-out just the same as did the coupling Coil "L" near the previous stages. We now have a completed Diamond. The angle shown by the curved arrow should remain at 87 degrees throughout the test. When completed, this antenna will radiate very strongly in both the directions shown by the arrow and, will also receive strongly from those directions.

If one of the directions is not wanted, then

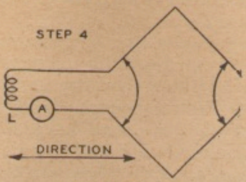


FIG. 6

the back wave can be cut off by inserting the resistor in the open end, as shown in Fig. 7. This resistor should be non-inductive of wattage equal to ½ the transmitter output and should have a value from 600 to 800 ohms. The tuning process can also be re-

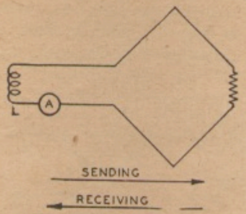


FIG. 7

peated in this case, and it will be found to remain the same, although the resistor takes the definite resonance point out of the tuning and cancels the back wave. We then find the direction of transmission as shown on the single-ended arrow, and likewise receiving is started from the direction on the receiving arrow.

If the antenna is slanted so that, for example in Fig. 2, "W" is higher than "Y", then the signals will be stronger towards the direction of "Y", i.e., away from "W".

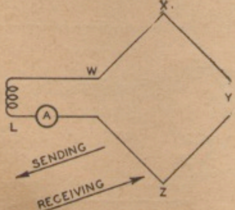


FIG. 8

If "Y" is made higher than "W", the reverse is true, i.e., signals will be stronger towards "W" and away from "Y".

The reverse is true for receiving, namely, the same direction in which transmission is strongest is the direction from which best reception is secured.

If the two edges "X" and "Z" cannot be made the same height no serious difficulty will be encountered. However, in this case there will be a sort of angular change. For instance, if "X" and "Y" are higher than "W" and "Z", the direction of transmission will be as shown in Fig. 8, but by raising any one of the four corners, a stronger signal can be sent away from any one of the four raised corners.

If it is desired to radiate in an exactly horizontal position, the chart shown by Professor Terman in these pages should be consulted. His Fig. 5 shows the angle of radiation in degrees, depending upon the height of the antenna in wave lengths. Take a specific case, for example. If 36 feet 4½ inch feeders are used, this length would be approximately two wavelengths, and two wavelengths would be 32 ft. 4 inches off the ground. The angle of radiation is 7 degrees, as shown in Professor Terman's chart. If the antenna is slanted 6 degrees the angle of radiation would be exactly horizontal.

The Diamond Antenna and particularly the tuned Diamond Antenna in use at W6AM has put consistenly more energy into the air than any other type of antenna ever used. It is larger and requires a little more space than other types of antennas. For a 5-meter antenna the space required is not large, and even the antenna shown in Fig. 2 can be put in the average location. The ideal condition would be to have two or three antennas placed at opposite ends of the property, so that directional transmission could take place in any desired direction.

THE information in this article, while primarily intended for 5-meter operation, is likewise applicable to 20 and 40 meter work. For 20 meter operation, multiply the dimensions by 4, for 40 meter operation, multiply the dimensions by 8. The factor 1.56 can still be used to work on the exact frequency of the crystal in use. Final tuning adjustments are the same as for 5 meter work.

Use of Professor Terman's chart for angle radiation will also enable you to utilize desired skip effects. Because the average 40 and 20 meter Diamond antennas for amateur work will not be very high above the ground level, in terms of wavelength, they are at their best when tipped; the low portion of the Diamond is pointed in the direction of the distant stations which the operator desires to work.

The back-wave radiation from a Diamond is wasted, or absorbed by the resistor, but the remaining signal strength is so greatly increased that no consideration need be given to the waste from back-wave radiation.

Measuring the Wave at 5-Meters

A GREAT many notions have had to be modified since the time when amateurs first took an interest in five meter operation. Chief of these is the idea that harmonics are satisfactory for calibration of wave and frequency meters used on this band. True, the band is nicely located with relation to our other amateur bands so that excellent harmonics can be produced and effectively used as indicators, but how many amateurs will agree which is the fourth harmonic of 14,000 KC when they are endeavoring to place their transmitter in operation within the band? Not many. But if they could measure the wave with a common yardstick and be absolutely certain that they were accurate at 5 meters I doubt if there would be much agrument.

Turning back the pages of scientific history we come across the old Lecher wire system described in every high school textbook on Physics, but little understood by the average amateur. This method of measuring a minute wave is much simpler than checking harmonics with a wavemeter. Moreover, the transmitted wave can be measured with surprising accuracy.

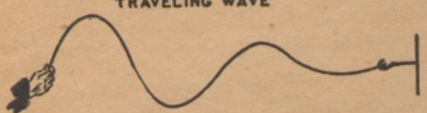


FIG. 1

By way of explanation, suppose that you tie a rope to the garage and start shaking the free end up and down. As soon as you have found the correct rate for your hand, waves start to run along the rope toward the garage as shown in Fig. 1. As soon as these waves are reflected back to your hand there is set up a system of standing waves that does not seem to move at all, as shown in Fig. 2.

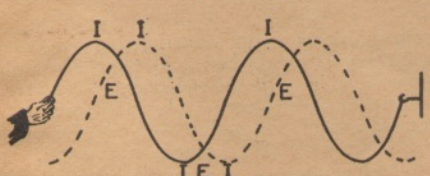


FIG. 2—Points I move up and down while points E stand still

Now this same thing is done in an antenna every time we send. Generally an antenna has only a ¼ wave on it, i.e., current at the bottom and voltage at the top. In the event that a counterpoise is used we have a ½ wave with current at the antenna inductance and voltage at the ends of both the antenna and the counterpoise.

Working the antenna at a harmonic will result in several places in between the ends where voltage will show up as illustrated in Fig. 2. While the rope showed up only the vertical or up and down wave, the electrical system consists of two waves, a voltage and a current wave. And whenever there is current present there is little voltage as shown in Fig. 3, but note that there is voltage at the far end of the antenna. In fact, it can be laid down as a general rule that there cannot ever be any current at the end of the antenna, therefore voltage must always be present.

Assuming, therefore, that we stick to the voltage wave and stop worrying about the current wave, let us stretch a pair of wires as shown in Fig. 4. This system, which will be similar to a one wire antenna and one wire counterpoise, should be 21 feet long and the wires should be separated about 8 inches for best results. Turn on the oscillator and tune the antenna system just built until the neon tube at the far end glows brightly.

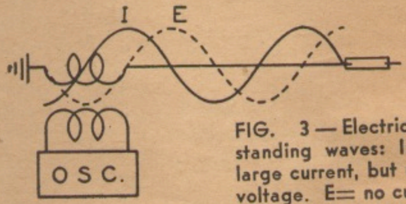


FIG. 3 — Electrical standing waves: I= large current, but no voltage. E= no current, but large voltage

When this point has been reached, resonance has been reached between the oscillator and dummy radiator system. But what is the frequency? To find this, slide the neon tube along the wires toward the oscillator, pushing it with a newspaper or other long insulator. Be sure to keep your own body as far away from the entire system as possible. After the tube goes out keep on pushing it along slowly until it lights up again. This

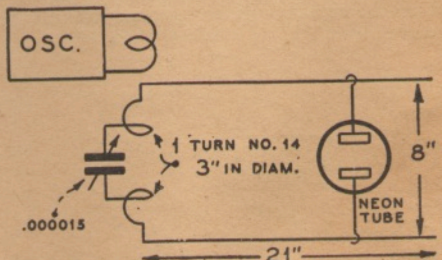


FIG. 4—C1=.000015 mfd. L1=1 turn, No. 14 wire, 3-in. diameter

operation is the most critical of all and should be done carefully in order to avoid any error. Find where the bulb lights brightest and leave it there! This point is identified as the center of a ½ wave and it is now only necessary to find the ends of this ½ wave. To do this find the place where a short-circuiting bridge between the two wires has no effect. When such a place has been found it is evident that there can be no voltage at that point, therefore we have found the end of the ½ wave.

To construct the short-circuiting bridges, two of which are needed, cut a straight stiff wire 10 inches long and bend it so that one-half inch on each end is bent at right angles to the nine inch sliding portion of the bridge as shown in Fig. 4. Now lay one of these across the two wires and start sliding it back and forth until a place is found where the tube will still light. This adjustment can be made within ½ to ¼ inch to five meters. Now take the second bridge and do the same thing on the other side of the neon tube.

With these two bridges in place and the neon tube still glowing you can be certain

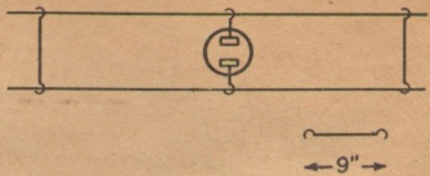


FIG. 5

that the two bridges are just ½ wavelength apart. The distance between the two should now be measured with a yardstick, multiplied by two, reduced from inches to meters and the result is the wavelength of the oscillator. For example, we find that the two bridges are just 106 inches apart:

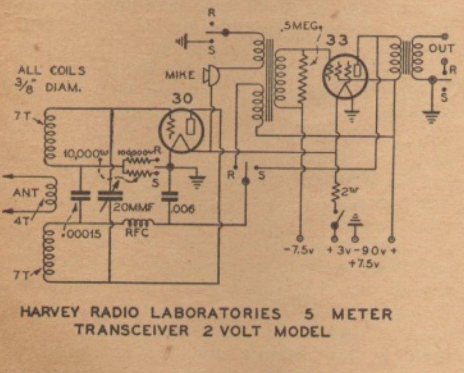
106 in. x 2 = 212 in. = wavelength in inches.

Since 39.37 inches equals one meter then,

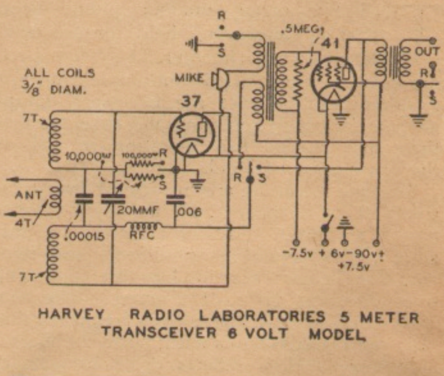
39.37/212| 5.384 meters

With such a system as this it is quite possible to obtain a number of very reliable points easily, and by the usual means calibrate a first class five meter (or lower) wavemeter.

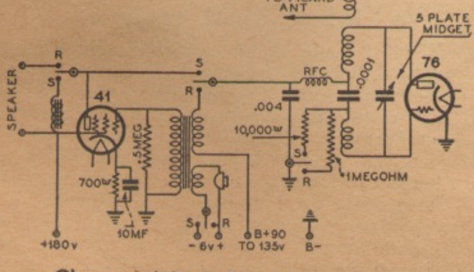
Circuit Diagrams of Factory-Built 5-Meter Sets



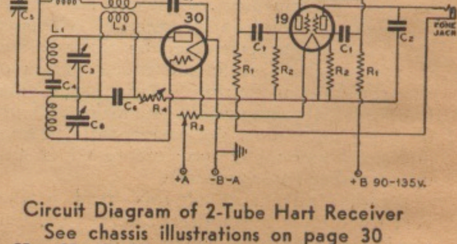
HARVEY RADIO LABORATORIES 5 METER TRANSCEIVER 2 VOLT MODEL



HARVEY RADIO LABORATORIES 5 METER TRANSCEIVER 6 VOLT MODEL



Chauncey Wing's Sons, Transceiver.



Circuit Diagram of 2-Tube Hart Receiver

See chassis illustrations on page 30

C1—.01 mfd. C2—.001 mfd. C3—.00002 mfd. variable. C4—.0001 mfd. fixed. C5—.0001 mfd. variable. C6—.002 mfd. C7—.004 mfd. R1—0.1 megohm. R2—0.5 megohm. R3—20 ohm rheostat.

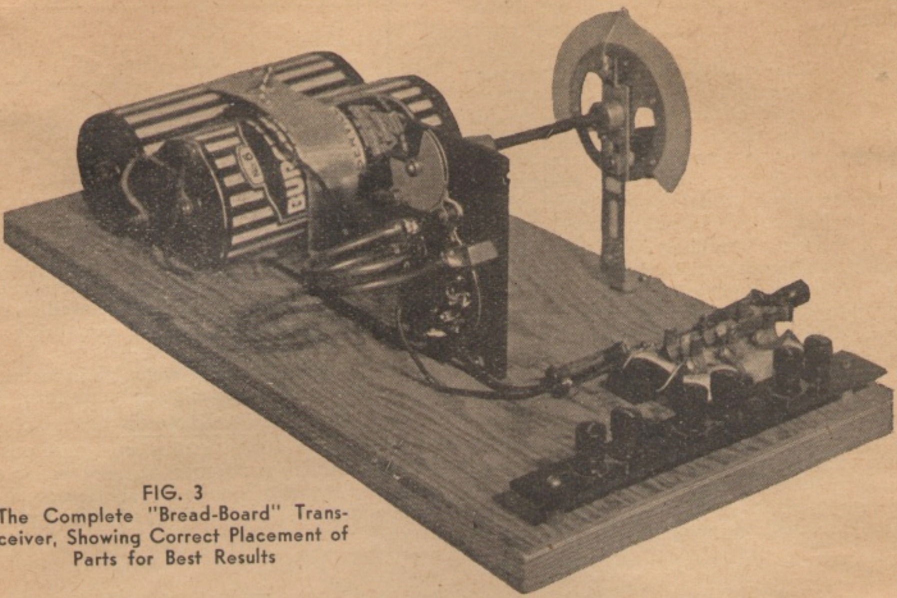


FIG. 3
The Complete "Bread-Board" Transceiver, Showing Correct Placement of Parts for Best Results

Frank Jones One-Tube 5-Meter Transceiver

Introduction

THE five meter amateur phone band offers an interesting field for the newcomer and experimenter. This band is not too crowded; in fact it is unoccupied in most communities, and yet the necessary equipment is simple to construct and costs far less than that needed for operation in any of the other amateur bands.

The five meter signals are useful over relatively short distances . . . usually not over five to ten miles. Greater distances are possible under favorable conditions, and two-way phone communication has been conducted over distances up to 150 miles. The low wavelengths are of such a high frequency that only the direct wave is used, since the Heaviside layer seldom reflects these frequencies back to earth, as is done on longer wavelengths. Herein lies one of the advantages of this band, since no interference is created beyond a range determined by the apparent curvature of the earth and the elevation of the transmitting station. This means that hundreds of communities can make full use of this band without the overcrowding effects and great amount of interference which fills up the other amateur bands.

Another advantage of this band is that very low-power transmitters can be used. This results in a decided saving to one's pocketbook. The receivers are also simple and economical to build. The low-power receiving type tubes can be used for both transmitting and receiving, and a great deal of fun can be had where friends in a neighborhood wish to make tests and talk to each other. Even to an old-time "CW" amateur, there is a thrill in using phone, although the other station may be only a few houses away.

Greater power, such as can be had from type 210 or 800 tubes operated in m.o.p.a. or crystal controlled circuits, has its place and is a future step to those really interested in the amateur game. The complication of such circuits and the peculiarities of adjustments calls for considerable experience. The advantages of such circuits on five meters are freedom from frequency modulation, ability to put the signals into small valleys or behind small hills, and a personal satisfaction of transmitter accomplishment. This field is more for the advanced experimenter, or for ultra-short wave police and television stations.

Five Meter Circuit Analysis

FIVE meter circuits can be compared with the circuits used in broadcast or short-wave sets. The functions are similar—an antenna is needed to pick up the signals and provide electrical energy which can be detected, amplified, and made audible in a headset or loudspeaker. The transmitter must have some form of oscillator, a method of modulating the carrier signal, an antenna to radiate it and, of course, a microphone to change the voice or sound energy into electrical energy. The functions of capacity, inductance and resistance are exactly the same as in any other longer-wave radio circuit. The difference lies in the size of the inductances and capacities used in the radio frequency circuits. For example, a broadcast receiver coil can be made by winding 30 to 40 feet of wire on a coil, tuned by a large variable condenser having 15 to 20 plates. For five meters, a foot of wire or tubing, wound into a coil, is usually ample when tuned by a midget two or three plate condenser. Theoretically, the vacuum tubes should be smaller for greater efficiency; however some types of commercially available tubes are suitable.

A typical five meter receiver circuit is

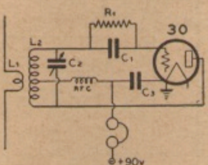


FIG 1

shown in Fig. 1. The five meter wave cuts through the antenna and induces an electric current in it. This oscillating current induces another into L2 if L1 and L2 are near each other. L2 may be of from one to ten turns, depending upon the diameter of the turns. For example, the set herein described has 2 turns, 2 inches in diameter. The inductance L2 is tuned to resonance by means of C2 in order to make the receiver responsive to the desired wavelength within the five meter band. The reactance of L2 and C2 are opposite in phase, or cancel each other, leaving only the resistance in the tuned circuit at resonance to limit the value of induced current. Thus a relatively large value of induced current flows through the inductance and around through the tuning condenser C2 and its shunt capacities, due to the wiring and tube. The voltage across either the inductance or capacity depends upon the reactance of that particular element, consequently the actual voltage across the input to the detector tube is increased enormously by resonance. This tube is a voltage operated device; the greater the signal voltage, the greater the audio signal across the telephone receivers.

Since the field intensity at the receiving antenna is in terms of microvolts or millionths of a volt, due to the use of low-powered transmitters and wave attenuation, the receiver must have a great deal of amplification. The most practical way to accomplish this is by means of extreme regeneration, or what is called "super-regeneration". Regeneration consists of feeding part of the signal voltage in the plate circuit back into the grid circuit and thus obtaining an amplifying action. This effect can be continued with increased amplification until the tube breaks into continuous oscillation, which ruins the detection characteristic of the tube. Super-regeneration consists of a means of increasing the tube regeneration until it goes into oscillation, then automatically backing it off into a non-oscillating condition. This action continues at some frequency which is above the audible values in the range of from 15,000 to 200,000 times per second. This super-regeneration amplifies a weak signal many thousand times. This effect is especially applicable to the five

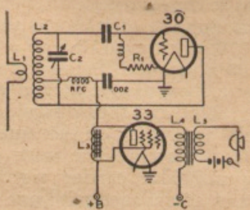


FIG 2

meter band, and at present is the most practical method for obtaining the necessary sensitivity to weak signals.

The circuit shown in Fig. 1 is a good oscillator, but proper proportions of R1, C1, C3 and the plate supply voltage allow the super-regenerative effect to take place. R1 and C1 cause a blocking action which throws the detector in and out of oscillation at a high rate of frequency. R1 can be returned to filament or to +B as shown, depending upon its value, but for less overloading and distortion effect on strong five meter signals the connection shown is highly desirable. C3 must be large enough to by-pass the high super-regenerative surges back to filament, but not large enough to short-circuit the audio frequencies in a modulated signal which must be impressed across the telephone receivers or audio amplifier. Common values for R1 are from ¼ to 2 megohms, C1 of .00025 mfd. and .006 mfd. for C3.

In Fig. 2 is shown a five meter transmitter such as is used in many present day low-power sets. The microphone causes a variation of current through L5 due to sound waves from one's voice striking the diaphragm, and thus varying the resistance. L5 is coupled closely to L4 by means of an iron core which is permissable because only audio frequencies are being used at this point. L4 and L5 are the two coils of a microphone transformer. Usually the coil L4 has 15 or 20 times as many turns as L5, resulting in that same proportionate increase of voltage and decrease of current. Since no resonance to any particular audio frequency is desired (which would result in distortion, because it would be amplified more than the other audio frequencies), no tuned circuit is used in either the plate or grid circuit of this modulator tube. The modulator tube amplifies the audio voltage across its grid circuit, and applies it across the modulation choke L3 which offers a high reactance to audio frequencies. This voltage adds and subtracts, over its cycle, to the steady DC plate voltage which supplies the oscillator. For example, if there is a 90-volt sine wave AC peak voltage across the choke L3 due to the action of the microphone, this voltage will add to and subtract from the DC supply, which may be 180 volts of B battery. This means that over the audio cycle the actual plate voltage on the oscillator is varying from 90 up to 270 volts, even though a DC supply of only 180 volts of B battery is used. The power output of the oscillator varies with the plate voltage and thus a signal of varying amplitude is impressed on the antenna. This variation is in accordance with the microphone input. The carrier signal may be modulated in accordance with one's voice.

The oscillator in Fig. 2 is quite similar to the one shown in Fig. 1 but it uses a lower value of grid leak. The lower value of R1 allows steady oscillation to take place, and energy can be fed to the antenna system through the coupling between L2 and L1. Capacitive coupling can be used instead of inductive coupling with equal results.

Antennas

For either transmitting or receiving, the antenna should be as high above ground as possible. A half-wave antenna coupled directly to the set, either by a very small capacity at the end to the grid or by means of a small coil as shown in Fig. 1, will work satisfactorily but greater distance can be attained by using a high antenna. This usually means some form of RF feeders, such as shown in June (1934) "RADIO". Even an ordinary broadcast or short-wave receiving antenna may be used on five meters because of the harmonic effect. Such an antenna was used successfully to talk over a distance of ten to twelve miles between San Francisco and Oakland, using the small combination transmitter and receiver shown in Fig. 4.

Wavelength or Frequency Determination

SOME means of adjustment of the transmitters and receivers must be made in order to operate within the amateur five meter band of from 56 to 60 megacycles. This band is over four times as wide as the whole American broadcast band, yet it covers only a third of a meter in this range. In localities where there is some five meter activity a frequency check can be given by other amateurs who have calibrated frequency meters or receivers. Otherwise one must use a calibrated frequency meter, or wavemeter, in order to be certain of legal operation. Parallel or Lecher wire systems may also be used for measurement to within an accuracy of about 1%.

Parallel wires suitable for this purpose can be strung between two supports from 35 to 40 feet apart. Bare wire, No. 18 to 14 gauge, should be used with a spacing of

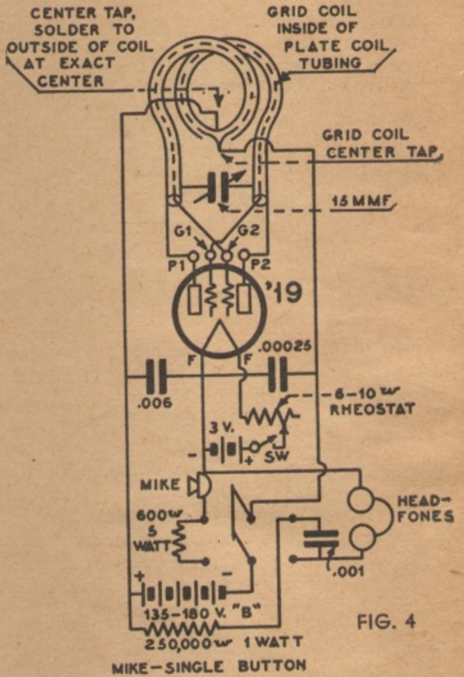


FIG. 4

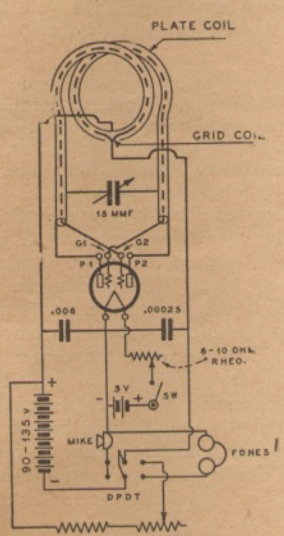
SCHEMATIC OF COMPLETE TRANCEIVER

This is the Circuit for the Transceiver Shown in the Picture (Fig. 3)

about three inches between wires. Resonance indication is obtained by coupling the oscillator coil to the closed loop end of the parallel wires, and then sliding a short-circuiting copper link along the wires. An indication can be obtained by means of a milliammeter in the oscillator grid or plate circuit, or more preferably by means of a variation of RF current. This can be done by means of a small turn of wire connected in series with a 6-volt radio dial light or RF thermogalvanometer and coupled to the oscillator coil along with the parallel wire loop. A decided change of current will be had when the shorting link of wire is across some half-wave point on the parallel wires. Sliding this link along between the first and second points of indication, and careful measurement with a scale or tape measure, will give the wavelength of the oscillator. This distance should be between 16.40 and 17.55 feet for oscillation in the amateur band of from 56 to 60 megacycles, which is from 20 or 25 feet of parallel wires. This length can be used and a small variable condenser connected across the loop end, about 3 inches from it, in order to bring the first indication point up to within 2 or 3 feet of the loop end. The second indicated point will still be 16.4 to 17.55 feet from the first for proper operation. A little absorption-type wavemeter can be conveniently calibrated from this set-up and a very accurate check obtained from a harmonic calibration from a known frequency quartz crystal oscillator.

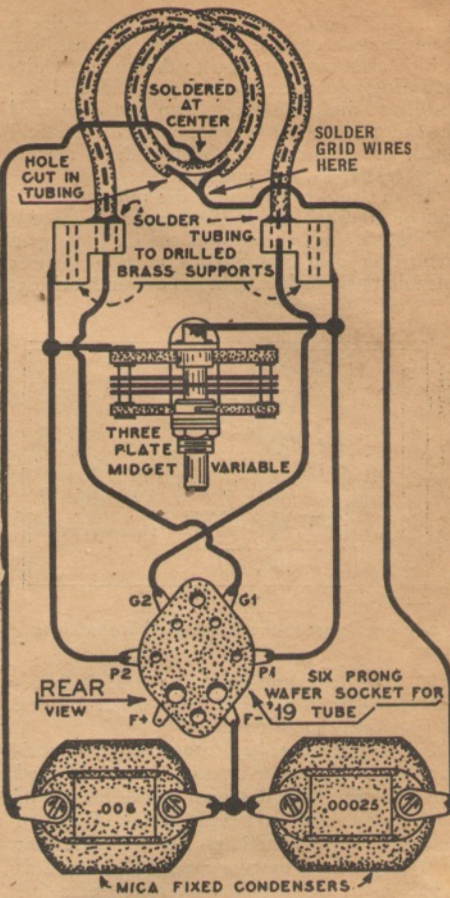
Combination One Tube Transmitter-Receiver

FOR the newcomer in the five meter band, the set shown in Fig. 4 is about as simple as one can possibly build, consistent with worthwhile results. It puts out a well-modulated, strong signal as a transmitter and functions as a sensitive super-regenerative detector in the receive position.



Revised Jones 5-Meter Circuit as used by Allied Radio Corp. in the "Knight" Transceiver.

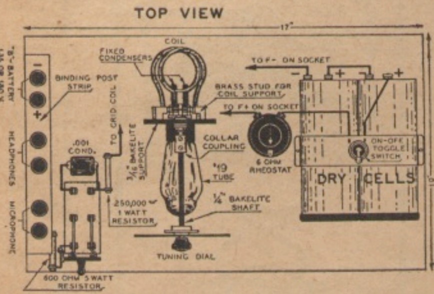
This circuit uses a type 19 two-volt filament tube as a push-pull oscillator and detector. As an oscillator or transmitter, grid circuit modulation is used because of the extreme simplicity. The microphone, an ordinary single button telephone transmitter, is in the negative B battery lead and the voltage drop and variation of voltage is used as grid bias. There is a steady voltage drop across the risistance of the microphone and when it is spoken into. The variation of resistance causes a variable grid bias on the oscillator. The 19 tube is a "high mu", or high amplification type of tube and a fixed bias type rather than a grid-leak oscillator circuit is used in order to simplify the modulation circuit. This tube is really two "high mu" triode tubes in one envelope. It can readily be used in a push-pull oscillator circuit.



Pictorial of the RF Portion of Fig. 4. The plate coil is a two-turn loop of $\frac{3}{16}$-in. diameter copper tubing. The grid coil (push-back insulated wire) is woven into the copper tubing and a center-tap of the grid coil brought out through a hole in the tubing as shown above.

Unity coupling is used because the set must stay on the same frequency in both transmit and receive positions. Tuned grid-tuned plate, or TNT oscillator circuits require a compensator on one of the switch positions, which adds complication to the circuit. Unity coupling is obtained by running the grid coil inside of the plate coil. Two turns are used in order to conserve space and coil external field, and also to give short leads to the by-pass condensers C2 and C3.

In the receive position, the microphone is cut out of the negative B battery lead and a pair of telephone receivers cut in. The grid return is also switched-over to a quarter megohm grid leak in order to obtain blocking-



Looking Down on the Assembled Transceiver

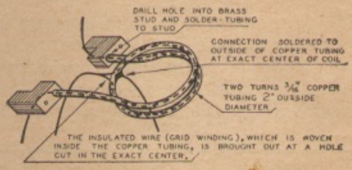
grid super-regeneration. The grid leak returns to +B in order to give better results, as previously mentioned.

Unless one has had considerable experience with five meter circuits, it is suggested that the exact layout shown in the picture of the "breadboard" set and circuit of Fig. 4 be followed. Sometimes the misplacement of a single lead or condenser by as little as a half inch will ruin the operation of a five meter set. A straight piece of wire one inch long has a very appreciable inductance and capacitance on these ultra-high frequencies.

The oscillator coil consists of a small coil of 3/16-in. or 1/4-in. soft copper tubing with a well-insulated piece of rubber or cambric covered wire woven through it for the grid coil. The copper tubing coil consists of 1⅝ turns, two inches inside diameter, with a center-tap on both coils. The grid coil center-tap can most easily be made by cutting a small slot (about 1/2-in. long) in the copper tubing, at the center of this plate coil. The grid coil can be threaded through the tubing in two sections with the center connection soldered together in a small "pig-tail" connection about 1/4-in. clear of the copper tube center opening. The ends of the plate coil tubing can be fastened into small brass end blocks or soldered directly to the two plate terminals on the 19 tube socket. The ends of this coil extend down about an inch, or slightly less, in order to keep the coil center-taps clear of the other tube socket terminals. The two inside, or grid leads cross over to opposite socket grid terminals. The tuning condenser mounts besides the tube socket and thus the leads to the condenser are only an inch long. A bakelite extension to the dial shaft is necessary in order to eliminate hand capacity effects.

For convenience the two B battery leads, microphone and headset connections are brought out to six binding posts. Either 135 or 180 volts of B batteries or a small B eliminator may be used. The plate current is from 5 to 50 milliamperes on transmit, and about 5 on the receive position. Most headsets work better when the 5 MA plate current flows through them; a reversal of the phone tips often increases sensitivity.

The transmitter should illuminate a 6-volt dial light when the latter is coupled to the

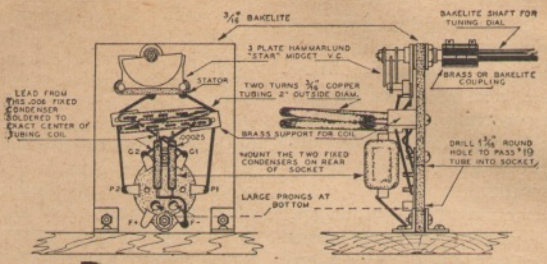


Showing How to Make the Plate Coil, with Grid Winding Inside of Plate Coil

oscillator coil by means of a two-inch turn of wire soldered to the lamp terminals. A single turn with lamp is a very useful oscillation indicator for any transmitter, since it is fairly sensitive. Modulation can be roughly checked by this same means.

The receiver should give a hissing sound when it is functioning properly. A good five meter signal always reduces or eliminates the background hiss. The antenna can be most conveniently coupled to the set by means of a clip on the copper tube inductance. This clip should be set near the center tap, but as far away from it as possible to still get the super-regenerative hiss over the tuning dial range. Usually the clip will be not over an inch along the inductance from the center-tap. Any wire can be used as an aerial, even values up to several hundred feet in length. For most local work a four-foot wire or rod can be used, connected to the oscillator by means of the clip mentioned. For better results a wire 12 feet long is recommended; it gives a quarter-plus-a-half-wave antenna. The 4-foot section acts as a quarter-wave antenna with the set and batteries acting as a ground or counterpoise. Probably an aluminum plate about the size of the breadboard and underneath it should aid in this effect, if it is connected to one of the 19 tube filament terminals by means of a short lead.

Trouble shooting the set is fairly simple. For the newcomer or beginner, the polarity and voltages of the A and B batteries should be checked. The values of the resistors and mica by-pass condensers are important. The filament rheostat should be set so as to give 2 volts across the 19 tube filaments. Good soldered joints should be made throughout and all RF leads made as short and direct as possible. The 19 tube should be a good one and a check can be made by inserting a milliammeter in series with the B battery. It should read from 50 to 60 milliamperes when transmitting, and drop to about 10 or 15 when not oscillating, such as when touching a plate or grid terminal with the antenna or one's finger.



Rear and Side Views of the RF Portion—Note Short Connections

For receiving, the plate current should read about 5 milliamperes.

If it is possible to obtain a high-level single button mike of about 200 ohms resistance, the 600 ohm plate resistor R2 can be eliminated and more power output obtained without excessive plate current. This resistor holds the plate voltage to about 100 to 120 volts, since the mike used had only about 20 ohms resistance with rather low grid bias voltage. The set has worked very satisfactorily over distances of ten miles, without either location being more than 50 feet above ground.

Super-Regeneration Simplified

SUPER-REGENERATION is used in nearly all receivers operating on wavelengths between 3 and 10 meters because of its extremely high sensitivity. Radio frequency amplification and present day superheterodyne circuits are coming into prominence for 5-meter operation, but super-regeneration provides a practical method of receiving weak signals.

An ordinary detector circuit can be made a great many times more sensitive and selective by the use of regeneration. This consists of using some form of circuit in which part of the plate circuit RF signal is fed back to the grid circuit, and since the tube acts as an amplifier as well as detector, the signal is increased. This feed-back voltage or effect can be carried to the point of self-oscillation with increasing amplification on weak input signals. Beyond the point of oscillation, the quality on voice or music is ruined and the sensitivity begins to drop, due to less efficient detection.

If the feedback effect could be carried on long enough, the only limit to the final signal strength would be the overloading point of the detector. Super-regeneration is a method of carrying this feedback past the point of self-oscillation without ruining the detector audio quality. This is done by allowing the tube to oscillate, then damping-out the oscillation a great many times per second. Usually this is done at such a fast rate that the damping oscillations are above audibility.

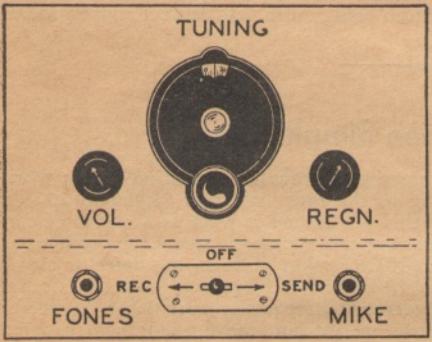
This damping or quenching effect can be accomplished in a number of different ways. Sometimes a regular oscillation circuit working in the range of from 20,000 to 200,000 cycles per second is used as a means of controlling the ultra-high frequency oscillations. The latter takes place in the detector circuit so the other low frequency (sometimes called interruption frequency) oscillator can feed a little energy into the detector grid or plate circuit. The most common method is to couple the two tube plate circuits together for a form of Heising or plate modulation. In this case, the interruption frequency varies the detector plate voltage enough so that this tube spills in and out of oscillation at a rate determined by the interruption frequency. This same detector tube can also be used as an interruption frequency oscillator by putting the tuned circuits for the latter into the detector circuit.

Another form of super-regeneration makes use of a blocking grid leak-condenser action so that no extra tube or low frequency coils are necessary. Such a circuit functions as an ordinary oscillator in which the grid leak is too high to allow the electrons on the grid to leak off at a rate to give constant value of grid bias voltage. This causes a change in average bias and stops the oscillation because the plate current is decreased and the mutual conductance of the tube drops. If the circuit constants are correct, including a fairly high decrement in the detector tuned circuit, the blocking action takes place at an inaudible rate and super-regeneration is accomplished. The decrement of even a low-loss five meter circuit is sufficiently high to allow this circuit to function well.

Frank Jones 5-10 Transceiver

FIVE or ten meter phone work offers an interesting possibility for tests between cars, or between a car on a mountain side and some city in the distance below. Requests for a powerful transceiver have been made and the circuit shown should fulfill this need. Some sets of this type have been in service for several months on the construction work of the great San Francisco-Oakland Bay bridge and have always put out a good strong signal of excellent intelligibility.

The power output ranges from about one watt carrier at 160 volts plate supply to about three watts at 250 volts. These powers are suitable for use in cities or level forests of from two to six miles on five meters. These same sets will transmit and receive up to any visual distance (a hundred miles or more) between mountain sides. On 10 meters the absorption and reflection by buildings and small hills is much less and the short distance ranges are greatly increased. Occasionally a 10 meter signal may come in from a point 500 to 800 miles away on days which are particularly suitable for this frequency. This form of receiver is quite sensitive since it is an efficient super-regenerative circuit on the receive position. It also emits bad interference since it is a grid-leak type of super-regenerator. However, this form of detection has proven very satisfactory when using type 41, 42 or 2A5 pentode tubes from a standpoint of good sensitivity and ability to detect, without undue distortion, weak or extremely strong signals. The latter effect is obtained by returning the grid leak to a high positive potential which makes it act more nearly like an AVC receiver than any other form of super-regenerator.



Front View of Transceiver

High sensitivity is obtained by relatively tight coupling to a resonant antenna and operation of the super-regenerative detector at a moderate value of actual plate potential and grid bias, followed by a high gain audio stage. Too many super-regenerative sets give too much noise and too little signal because of improper circuit constants and too little audio amplification following the detector.

The circuit consists of two tubes such as the type 42 six volt pentode power tube. A four pole double throw anti-capacity or spring leaf switch is used to either transmit or receive with six volt power supply being shut off in the center, or off position of the switch. A tuning control, volume control, and receiver super-regeneration control are also provided since the adjustment of the later minimizes receiver radiation. In the receiver position, one tube acts as a super-regenerative detector and the other as an audio amplifier. In the transmit position, the actual plate voltage on the former tube is increased greatly and a low value of grid leak makes it into a powerful oscillator. The audio amplifier becomes the modulator and the headset is cut off and the single button mike cut on in the transmit position.

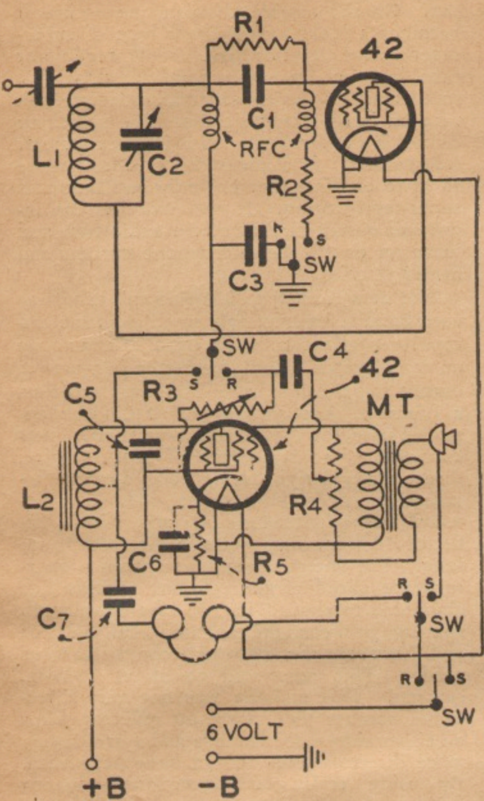
The transmitting oscillator draws relatively high plate current on these short wavelengths and best results are obtained when the modulator has a step-down output transformer or choke for coupling. A center-tapped output transformer or a center-tapped 30 or 40 henry choke works very nicely and gives a high percentage of modulation as compared to the usual Heising choke coupling to the oscillator. This choke carries the combined oscillator and modulator plate current so it should be one having a suitable air gap if good speech quality is desired.

The mike transformer can be any single button-to-grid type of transformer. The volume control for receiving allows any volume range desired on the receive position but has no effect on the transmitter except to act as a fixed resistor load across the mike transformer secondary, thereby improving the audio quality.

The regeneration control is desirable since the relative feedback is greater on 10 meters than on 5 meters and it can also be set at a value near the breaking-off point of super-regeneration. This minimizes receiver radiation. This variable resistor should be capable of carrying two or three milliamperes of detector plate current and serves as a resistance coupling to the audio amplifier. This resistance coupling drops the plate voltage on receive position.

The values of condensers and resistors shown in the detector circuit are quite important for proper super-regeneration, especially the plate return and grid blocking condensers. The leads from the tuning condenser to the tube should be as short as possible, not

5 & 10 TRANSCEIVER

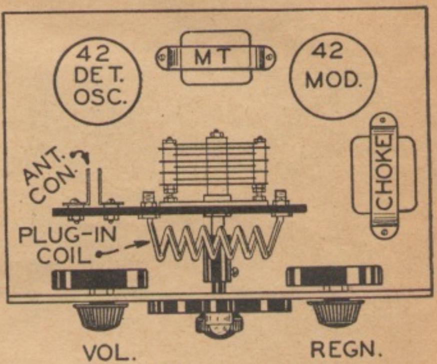


L1—56 MC-6T No. 12—⅝-in. diam. spaced ⅛-in. between turns. 28 MC-12T No. 12—⅝-in. diam. spaced 1/32-in. between turns.

L2—Center-tapped choke.	C1—.00025
R1—1 Megohm.	C2—15 Mmfd.
R2—5000w 1 Watt.	C3—.006
R3—50,000w.	C4—.1 Mfd.
R4—250,000w POT.	C5—.006
R5—600w 1 Watt.	C6—10 Mfd.
SW—4 Pdt. center is "off".	C7—.5 Mfd.

over two inches at the most. The plug-in coil should have its two pin jacks mounted very close to the tuning condenser terminals, preferably on the same piece of bakelite or hard-rubber sub-panel. This coil should be at least ¾ of an inch away from any metal shields. The tuning condenser must have an insulating coupling in its shaft connection to the tuning dial. The complete receiver should be enclosed in a metal cabinet with a metal front panel for shielding and prevention of hand capacity. The antenna coupling condenser can be two right angle brackets about ⅛ inch apart and ⅝ inches square. A slot should be cut in the mounting screw hole of one of these brackets in order to have a slight variation of coupling in order to adjust it to a point where the receiver has a tendency to pull out of super-regeneration with the regeneration control set at about half way position. This condenser should also be mounted on the tuning condenser vertical subpanel.

The tubes can be mounted on a metal or bakelite horizontal subpanel with the tuning condenser and coil above and the send-receive



Correct Placement of Parts

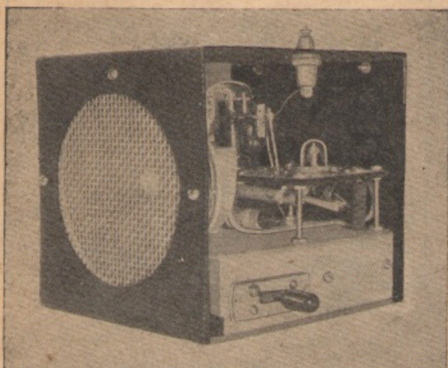
switch below. The RF chokes should be mounted beneath this subpanel near the grid condenser and grid terminal of the oscillator socket. The chokes which have proven most satisfactory for both 10 and 5 meters, are made by winding No. 30 DSC wire for 1¼ inches on a ⅜ inch diameter bakelite rod. These chokes can be mounted by means of a short 6-32 machine screw which does not extend into the RF choke winding itself. The chokes should be dipped in clear lacquer or coil "dope" and dried before using.

An 8 mfd. electrolytic condenser is shown connected across the B plate supply as most dynamotors or B eliminators are not well filtered. Even with B battery power supply this condenser is useful because it prevents a sort of fringe howl in the receiver when the batteries become old and have high internal resistance. The 10 mfd. electrolytic by-pass condenser across the 2 watt 600 ohm cathode resistor can be of the 25 volt type. For coupling into a single wire feeder a condenser spacing of about 1/16 to ⅛ inch is usually correct. An antenna that has given excellent results in a car, is a quarter wave rod mounted on one of the front fenders with a stud bolt. The fender acts as the ground plate to which the bottom of the quarter wave rod should make good electrical contact. The single wire feeder should then be connected to a sliding clamp ring for final coupling adjustment. This point is always about one-fourth of the way up from the base of the rod.

¾-Meter Transceiver Using the 955 "Acorn" Tube

A PRACTICAL ¾-meter transceiver is here described.

The circuits shown are not the ultimate in design, by any stretch of the imagination. However, the sets work satisfactorily, both as transmitters and receivers. Undoubtedly much more output for a given input can be obtained if the grid excitation could be adjusted properly, such as by the use of a semi-variable grid condenser and proper location of that condenser in the LC circuit. Some experimenters report much greater output by means of these adjustments.

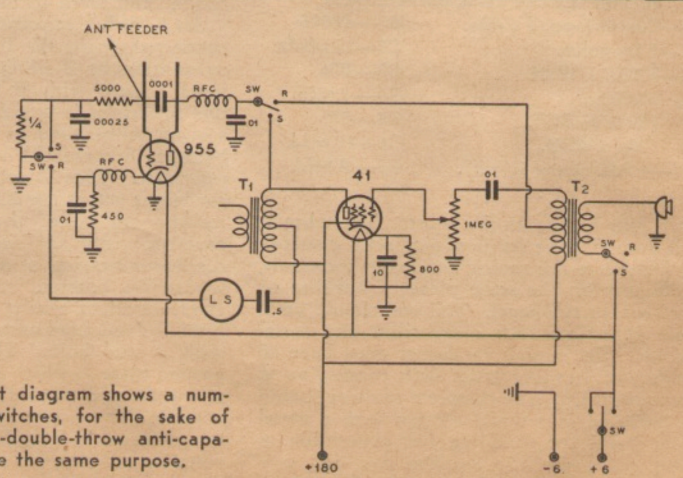


The ¾-Meter Transceiver in metal case. A midget loud speaker is built-in. The RCA-955 "Acorn" tube is plainly visible.

In the circuit shown, the similarity to the usual 5 meter transceiver is quite apparent. The transmitting oscillator is modulated by a type 41 tube with a single-button mike input. On the receive position, the oscillator becomes a blocking grid-leak type of super-regenerative detector, and the 41 modulator tube becomes an audio amplifier driving a small magnetic loudspeaker to moderate volume on fairly-strong signals. The switching circuit is similar to that used in most 5 meter transceivers. It changes the grid-leak value so as to obtain either ordinary oscillation or super-regeneration. It also switches the input and output circuits of the audio tube and turns on or off the microphone current and heater circuits.

The new RCA type 955 "acorn" tube was used because its extremely small elements and capacities allow it to function satisfactorily on wavelengths below one meter. Its power output is quite low as an oscillator and thus a beam antenna should be used. The antennas used for the first tests with these sets consisted of short lengths of No. 10 wire, thrust through tight-fitting holes along a ⅜-inch diameter wooden dowel rod. The antenna was a wire 13¾-in. long with a reflector 14¼-in. long and two directors 13-in. long. The antenna wire was spaced a quarter-wave ahead of the reflector wire, which amounted to about 7-in. (⅜ of a wavelength spacing between the antenna and director and between the two director wires was used). This amounted to about 10½-in. spacing. This antenna was not very directional because there were no reflector wires on either side of the antenna and a great many more director wires should have been used. By using really-good directional antenna systems, the apparent low power of the transmitters can be increased so that it should

¾-Meter Circuit

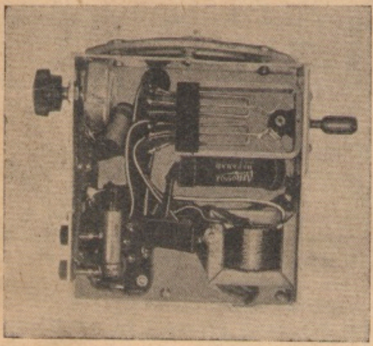


The RF Choke consists of about 25 turns of No. 22 DSC wire, wound on a ¼-inch diameter form. T1 and T2 are Output transformers. Those used in the Transceiver here shown are of the 2A5 P.P. Output type.

Although the circuit diagram shows a number of separate switches, for the sake of simplicity, a 4-pole-double-throw anti-capacity switch will serve the same purpose.

be possible to communicate over air line distances of several miles.

The RCA 955 tube is inclined to be microphonic and it also has a tendency to "run away", similar to the action which takes place with an overloaded type 46 tube. It is necessary to keep the plate and grid currents within the limits recommended by the tube manufacturer. One way to prevent the tube from creeping-up in plate current is to use cathode bias and a fairly low value of grid leak. Then as the plate current starts to climb, the grid bias increases and tends to

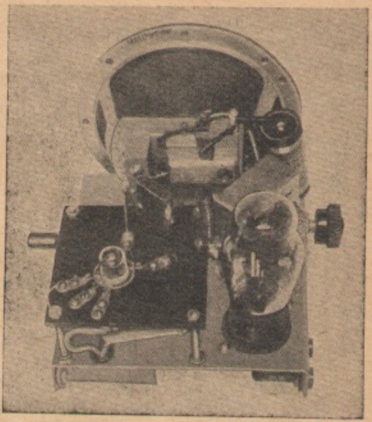


Under-chassis view, showing correct location for mounting the 4PDT anti-capacity switch and the output transformer.

reduce the plate current. The use of this method seems to solve the problem of tube life.

To obtain oscillation in these particular sets, it was necessary to use a cathode RF choke. The 450 ohm cathode resistor prevented super-regeneration until it was by-passed with a .01 mfd. condenser. This condenser by-passes the super-regenerative hiss frequency, although it would probably have been equally satisfactory to return the plate by-pass .01 mfd. condenser to the lower end of the cathode RF choke instead of to ground. The number of turns in the RF chokes seems to be somewhat critical. A variation of from 10 or 15 turns causes trouble. This is probably due to the high RF impedance of the path back to the nodal point of the tube and LC circuit. It is difficult to by-pass effectively at these frequencies and thus a few experiments with RF choke turns, location of leads and chokes, and contact resistance of the tube clips will remedy this source of trouble. Oscillation should always be checked by means of a plate circuit milliammeter. The plate current should never exceed about 7 milliamperes on the transmit position, if one expects more than a few minutes of tube life.

The oscillating circuit consists of the tube capacities and a parallel wire LC circuit. At ¾ meters the parallel wire length is slightly over an inch in length and is made by soldering a pair of No. 14 bare copper wires to



Showing how the RCA-955 "Acorn" tube is mounted on a Bakelite sub-base which is isolated from the metal chassis deck.

the tube grid and plate clips. The parallel wire bridge consists of the .0001 grid condenser.

Antenna coupling can be accomplished by connecting the antenna feeder to some point along the parallel wires, or preferably by inductive coupling. The usual two-wire feeder would undoubtedly be better than the single-wire feeder used in these first tests. The latter was connected to the antenna 2 inches off center. A two-wire feeder can be made of No. 24 or 26 wire, spaced about an inch and tapped across the center of the antenna in the usual Y connection. The antenna coils are wound directly over the plate coil; they use the same number of turns as the plate coil.

The modulator control is the key to the left of the panel. The toggle switch to the right controls the incoming power. The two flashlight cells alongside the microphone transformer are for the microphone supply. The control in the center is the volume control, mounted directly between the two meters. The meter in the plate circuit of the class B stage reads the current, which should be 60-65 milliamperes for full modulation. The arrangement shown here is the only one that gave the minimum amount of hum.

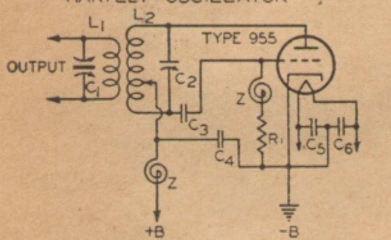
IN ACTION:

This transmitter has been operating for several months in a congested area on the three phone bands and has done very well, considering the great number of higher-power stations on the air most of the time. The antenna used is 132 feet long, with a

.0005 condenser in series for tuning. The reports given with the antenna four feet off of the ground were as good as when it was 40 feet in the air, for local operation.

Standard RCA Circuits and Constants For 955 Tube

ULTRA-HIGH-FREQUENCY HARTLEY OSCILLATOR



L_1C_1, L_2C_2 = DEPEND ON FREQUENCY RANGE DESIRED

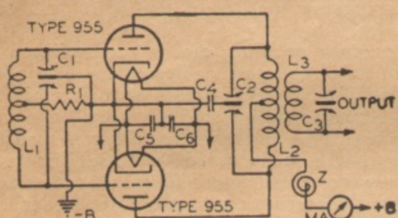
C_3 = 0.00005 μf

C_4, C_5, C_6 = 0.0001 μf

R_1 = 20 000 TO 25 000 OHMS, ½ WATT

Z = R-F CHOKE

PUSH-PULL OSCILLATOR
TUNED-PLATE TUNED-GRID TYPE

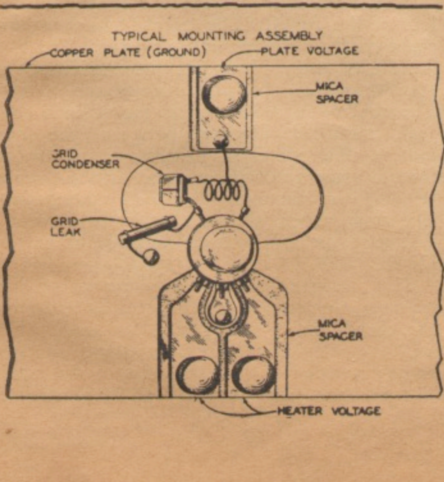


L_1C_1, L_2C_2, L_3C_3 = DEPEND ON FREQUENCY RANGE DESIRED

C_4, C_5, C_6 = 0.0001 μf

R_1 = 10000 TO 12 500 OHMS, ½ WATT

TYPICAL MOUNTING ASSEMBLY



Five-Meter Filter Circuits

One of the major problems of five-meter auto radio is a suitable plate voltage supply. B-batteries are cumbersome and expensive, if often replaced. A small B-eliminator or dynamotor, operating from the car 6-volt battery, is the solution to this problem. The eliminator or dynamotor occupies but little space and the device can be made to supply from 150 to 300 volts of DC voltage.

However, most amateurs who have tried these systems have experienced trouble from a hash of noise in either the transmitter or receiver, or both. Additional audio filter in +B leads seem to be of little help. The trouble is caused by RF disturbances which get into both the A and B leads to the 5 meter set.

RF disturbances can be confined to the dynamotor or vibrator eliminator itself by means of simple RF chokes. The circuit in Fig. A has worked satisfactorily when used in connection with various dynamotors. The 8 mfd condenser acts as an audio filter and low impedance by-pass for the audio or modulator return circuits. The RF choke in the +B leads prevents RF from running up this lead to the set. All RF chokes should be mounted as close to the power supply unit as possible.

The RF chokes in the 6 volt leads must be made of heavy enough wire to carry the continuous load of this unit, which may be from 2 to 10 amperes, depending upon its rated power input and load. Usually No. 12 enameled wire, close wound on a ⅝-in. dowel rod for a length of about 2-in., will be suitable for these 6-volt lead chokes. The plate RF choke should have more turns of fine wire, such as No. 32 to No. 34 DSC on a ⅜-in. diameter rod, for about a 1-in. length. This number of turns in the larger chokes would make them unreasonably bulky, so an effective compromise is made to keep the size fairly small.

Occasionally a ½ mfd. condenser must be connected from the hot side of the battery at the dynamotor terminal to some particular spot on the dynamotor frame or housing.

The circuit shown in Fig. D has often been used to remove the hash from a 5 meter transmitter when using a dynamotor power supply, or to prevent the clicking noise from a vibrator supply unit. Sometimes these units will be quiet enough for use on a receiver of the super-regenerative type but they will introduce noise in the transmitter due to lack of mike circuit filtering. A simple filter consists of a 20 to 50 mfd. 25-volt electrolytic condenser to complete the voice frequency circuit, and a 100 to 200 ohm 1-watt resistor in the hot side of the 6-volt supply. Care must be taken to see that the polarity of the electrolytic condenser is correct; its negative side is toward the negative 6-volt supply, and the positive terminal toward the positive 6-volt supply lead. Either the negative or positive terminal of car batteries is

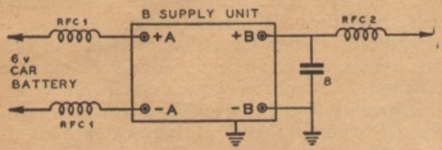


FIG. A

RFC1—25 turns No. 12 wire on ½ to ⅝ inch dia. form.

RFC2—75 turns No. 32 to 34 DSC wire on ¼ inch dia. dowel or bakelite rod.

Either positive-A or negative-A battery terminal of car can be grounded.

grounded to the car frame; thus it is always necessary to first check the polarity.

The circuits of Fig. B and Fig. C are useful in preventing noise from getting into either the transmitter or receiver. The resistor-type filter cannot be used here, since the current drain through it would be too

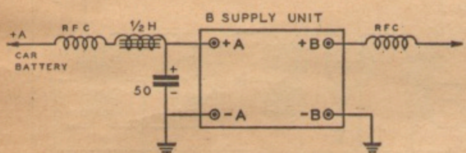


FIG. B

great. A low resistance choke of from 0.1 to ½ henry inductance, and small fraction of an ohm of resistance, is somewhat a problem, but it can be solved. Some small dynamotors are equipped with such a choke, but usually without the 50 mfd. condenser or RF chokes. If no audio filter is furnished with the dynamotor, at least an 8 mfd. electrolytic

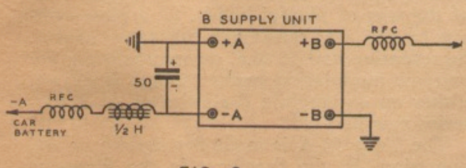


FIG. C

condenser must be connected across the plate supply, either in the 5 meter set or at the power supply terminals.

Fig. B and Fig. C are somewhat similar and are given in order to show the change of connections necessary when the car battery is grounded to −6 in one case, and +6 in the other.

The RF filters should be mounted close to the dynamotor or eliminator in order to

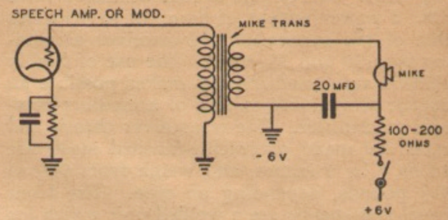


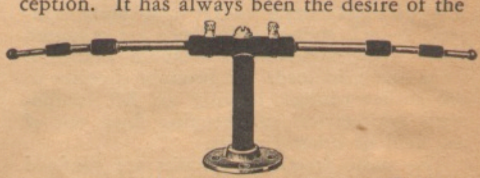
FIG. D

be effective. Ample space can be found inside the dynamotor container for these RF chokes. If not, the chokes should be mounted rigidly in a metal can adjacent to the unit. Needless to say, the 6-volt supply to the 5 meter set should come from the battery side of the RF filters.

It is always good practice to run the power leads directly to the car battery in order to avoid car ignition noises. The usual resistor-type spark plug and distributor suppressors will kill 5 meter interference. The conventional by-pass condenser at the car generator is advisable. Fortunately, the car ignition system noise is easily minimized, but the broadcast type RF choke type suppressors will not work on 5 meters. These suppressors are usually layer-wound and they are useless at high frequencies.

2½ and Five-Meter Doublet Antenna

The new American Radio Hardware Co. 2½ and 5-meter Doublet Antenna is a good solution to the antenna problems encountered in ultra-high frequency transmission and reception. It has always been the desire of the



amateur to obtain the maximum efficiency from each piece of equipment used. Tests conducted within the last few months prove that successful high frequency transmission depends to a great extent on the type of antenna system employed. In most cases, 5 meter antennas were made by the cut and try method and it took hours to "tailor" the antenna for the particular transmitter or receiver. With this new antenna with its special force type locking devices, it is a simple matter to obtain the proper length and this is important—maintain these adjustments for long periods of time.

The Frank C. Jacobs 5-Meter Transceiver

THE push-pull oscillator, class B modulator transceivers herein described have a power output of from 10 to 50 times that of the conventional transceiver employing type 30 and 33 tubes. The use of highly efficient tubes and circuits makes possible an output comparable to that of a medium-powered transmitter. The transceiver chassis and cases are made of crackle-finished steel, are 10 by 7 by 5 inches, and weigh from 7½ to 9½ pounds, depending on type. The front panel and chassis are a welded unit which fits into the hinged top cabinet. Special models with speaker grill and battery or generator compartment follow the same chassis design.

Twin triodes are the foundation of the Jacobs transceivers. Their use makes possible short leads so important at ultra-high frequencies, and simplifies the problem of realizing high output power. These tubes are available in three styles, the 19 for 2-volt operation, the 53 for 2.5-volt, and the 79 and 6A6 for 6 volts. The 19, 53 and 6A6 are peculiarly adaptable to 5-meter oscillators, having all plate and grid leads in the base. The 79 has one grid terminal in the cap, making symmetrical push-pull connections awkward.

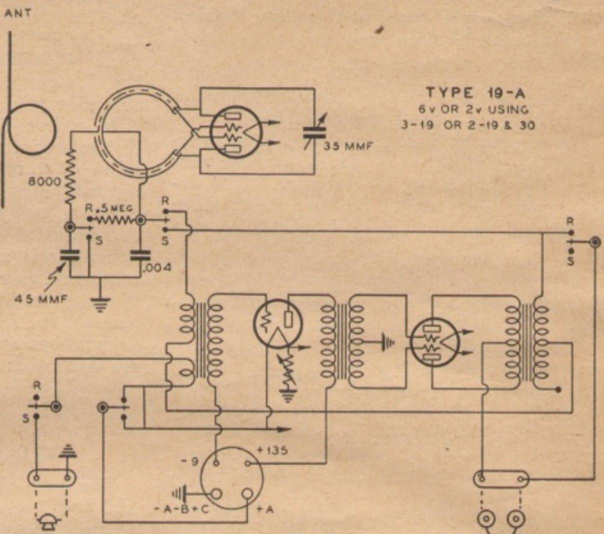
The Jacobs transceivers use twin triodes as oscillators and twin triodes as class B modulators; which, with a class A driver, make the equivalent of a five-tube transceiver, although employing only three tubes. The oscillator tube socket and unity coupled $\frac{3}{16}$-inch copper inductance are mounted above the chassis on a bakelite platform. Plate and grid leads are brought directly to the socket prongs, making all RF components symmetrical and keeping them out of the field of other circuits.

The audio frequency circuits are confined to the region below the chassis subpanel. No wiring other than the plate, grid and filament leads to the oscillator circuit come above the base.

When the send-receive knob is thrown to the receive position the RF panel assembly becomes a push-pull super-regenerative detector feeding into a special primary winding on the microphone transformer. After being amplied by the driver and class B amplifier tubes, sufficient energy is developed to operate a loudspeaker. The 19-A transceiver delivers 2.1 watts U.O.P. to a speaker, greater power than that of many broadcast receivers; and the 53 (or 6A6) gives a maximum undistorted power of 10 watts.

Throwing the knob to "Transmit" changes the RF assembly into a high-powered oscillator circuit and connects the microphone to its transformer.

The 19-A transceiver may be used either as a portable or as a mobile station. Filament voltages of 2 or 6 volts from No. 6 dry cells may be employed. When four No. 6 dry cells

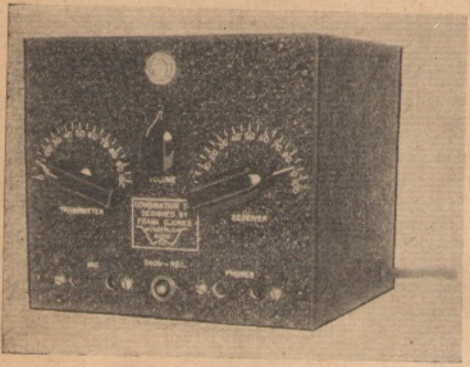


are employed the current draw is only 0.25 amperes; three 19s being employed with filaments in series. Battery life is approximately 130 hours. A rheostat to compensate for the deterioration of dry cells is incorporated. Access is had by means of a slotted shaft in the rear of the cabinet; out of the way of playful hands. At a plate voltage of 135 the transceiver consumes 20 m.a. on reception and 50 m.a. on transmission. On extreme modulation peaks 75 m.a. is drawn. Either an automobile B-eliminator or B batteries may be used.

The Type 53-A is made for mobile or AC operation. In the former role the filaments are wired for connection to a 6-volt storage battery, while in the latter the filaments are heated from a 2.5-volt source.

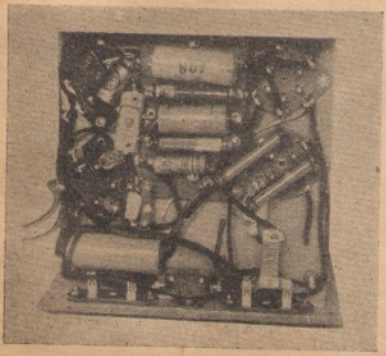
A Separate 5-Meter Transmitter and Receiver

THE greatly increased popularity of the 5 meter amateur band has resulted in the use of transceivers, i.e., a combination of transmitter and receiver. These transceivers have some disadvantages if very many of them are used in one locality at any one time. The receiver portion radiates strongly and the radiation can be heard nearly as far as the transmitter itself, in some cases. The



Wunderlich TR model in metal case.

transmitter is tuned to the same frequency as the receiver; it crowds-up all of the stations on one frequency. Some transceivers possess the annoying feature of not transmitting on the exact frequency of the receiver. Thus two similar sets will chase each other right across the band . . . sometimes even beyond the band during a QSO. The power output is low because the antenna coupling



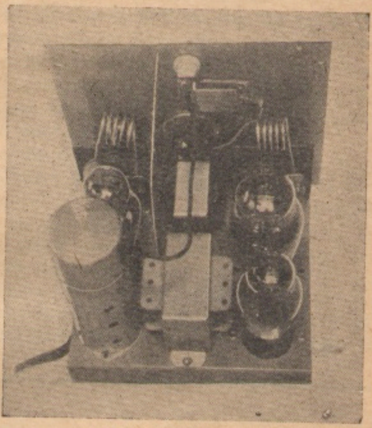
Under-chassis view.

must be very loose in order to prevent pulling the detector out of super-regeneration.

As more 5 meter sets come into use, some means for overcoming these faults must be found. At the same time, the cost of construction must not increase appreciably. The circuit diagram shows a 5 meter set which has several advantages over the usual transceiver. It can be built into a 7-inch square case.

This circuit is the result of considerable experimenting and it has several interesting feaures. The transmit-receive switch can be an ordinary single-pole-double-throw snap switch, instead of the usual 4-PDT switch. The receiver has a separate tuning control and thus the transmitter can be left on one fixed frequency. The antenna coupling can be greatly increased, with the result that for a given plate voltage the power into the antenna is doubled or tripled.

The receiver portion uses a stage of radio-frequency amplification. It does not radiate



Arrangement of coils, tubes and transformer.

appreciably if the transmitter section is shielded from the receiver. By using a resonant antenna the grid circuit is tuned somewhat, and the plate circuit is coupled to the super-regenerative detector by means of a small mica-type trimmer condenser of about 25 mmfd. maximum capacity. The RF gain in this stage is practically nil but it serves to prevent radiation from the receiver and permits the use of a very satisfactory method of coupling to a resonant antenna without the usual "pulling effect" on the detector.

The detector circuit uses a type 76 tube which super-regenerates nicely at low plate voltages. This permits the use of resistance coupling to the modulator or amplifier tube. The grid leak of the detector returns to +B voltage in order to obtain less distortion on strong 5 meter signals. The sensitivity, when this method is used, is the same as when the grid leak returns to −B, but a much better automatic volume control effect is obtained.

The modulator tube is a 41 which, in combination with a center-tap output choke, will modulate the 71A oscillator nicely with better quality than the usual modulation choke arrangement. This tube also serves as the audio amplifier for reception.

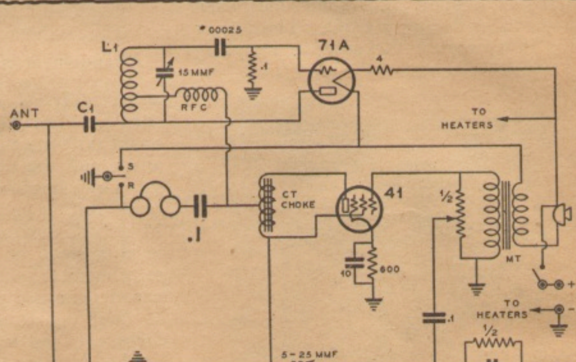
The transmitter section uses a 71A oscillator because this tube is quite effective at moderate plate potentials on 5 meters. The 71A tube heats quickly and the send-receive switching arrangement acts fairly rapidly. A 12A tube is also quite efficient, but the lower value of grid-leak for the 12A necessitates the use of an RF choke in series. The grid-leak value for a 71A is so high (100,000 ohms), that no grid RF choke is needed.

The send-receive switch is only a SPDT switch but it performs several functions. In the transmitting position it turns on the 71A filament and allows the oscillator to function; it also turns on the microphone current, cuts the head-set off, opens the cathode circuit of the RF tube so that it will not load-up the transmitter, and opens up the detector cathode circuit so that it will not super-regenerate and modulate the transmitter. In the receive position all the functions are reversed. In order to keep the side-tone low while transmitting, the cathode by-pass condensers must be small, .0001 condensers are satisfactory.

The circuit diagram gives nearly all of the circuit constants. The 5 meter coils are made of No. 12 wire, space-wound on ½-in. form, 5 turns, center-tapped. The tuning condensers can be 15 mmfd. midgets, such as those used in the receiver. It is possible to use a center-tapped loudspeaker output transformers for the modulator choke and mike transformer shown in the diagram.

The transmitter output into a 500 ohm resistor should run between 1 and 2 watts with 135 to 180 volts plate supply. The output will increase rapidly with higher plate voltage. However, about 230 to 250 volts is all that a 71A tube will handle for any period of time as a 5 meter oscillator. The method of coupling to an antenna depends upon the type of feeders used. A convenient method is to use two 1-inch square plates with about 1/16-in. spacing as an antenna coupling condenser. With this arrangement either a single-wire feeder or two-wire matched impedance feed can be used to the antenna. A two-wire feeder will function satisfactorily by connecting one feeder to the chassis and the other to the coupling condensers. For automobile use, a single-wire feeder is quite convenient; the antenna being a 4 ft. quarter-wave rod. The lower end of this rod should be grounded to the car body or bumper, and the feeder attached about 12 to 14 inches above the grounded end.

The RF tube coupling condenser to the detector should be adjusted so that the detector will just super-regenerate well with the plate voltage supply used. Best sensitivity is thus secured. Care should be taken to keep all RF tube by-pass condenser grounds to one point, preferably very close to the socket. The RF chokes can be made by winding No. 34 DSC wire for about 1 inch on a ⅜-inch bakelite or dowel rod.



5-Meter Transmitter and Receiver Circuit

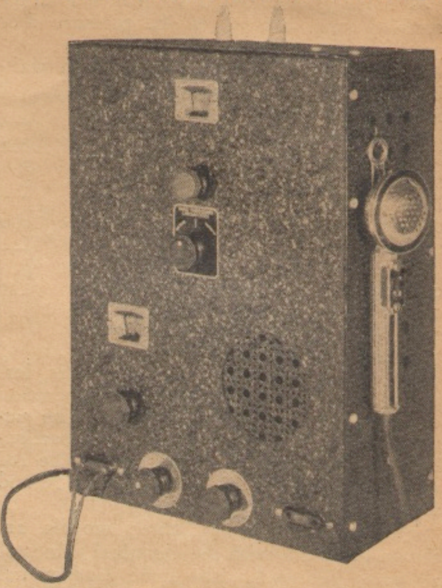
This is not a Transceiver, but a 5-meter unit known as a Transmitter-Receiver. More widespread use of this type of equipment will aid in solving some of the problems of 5-meter congestion in localities where many 5-meter sets are in operation. The circuit here shown in the model "TR" Wunderlich.

Duplex Transmitter-Receiver

THE Radio Transceiver Laboratories Type 53-6A6 Duplex Unit employs a radiophone transmitter similar to that of the Jacobs' 53-6A6 Transceiver. Like the transceiver, it employs twin-triodes, unity coupling and class B modulation; but in addition, the TR unit has a separate four-tube super regenerative receiver and a dynamic speaker. Receiver radiation interference is eliminated and duplex operation is thus made possible. Duplex, or break-in operation is two-way transmission and reception, similar to that of a land telephone circuit. The operator talks and listens without throwing a switch. He can interrupt the conversation at will, or "break-in". A panel switch knob is provided for turning off the transmitter when listening on the transmitting frequency.

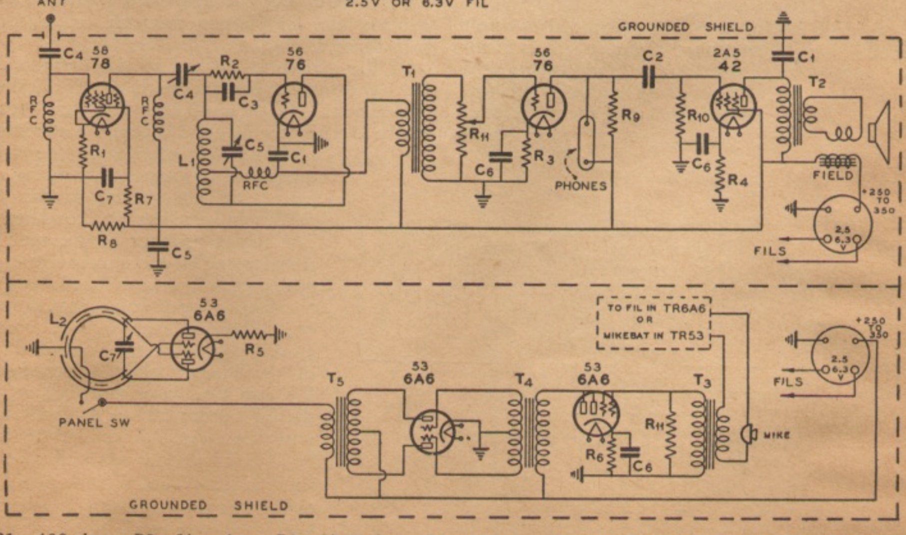
Transmitter and receiver are separate units, completely shielded from each other, and each has its own power supply socket. The unit can be installed with individual power supplies for transmitter and receiver, or both may be connected to the same power source. Supply cables should be shielded to prevent receiver radiation. The entire duplex unit is housed in a black crackle finished steel case, 10x14x5-in. and is provided with ventilating holes and two handles. The latter may be used for securing a strap for carrying or for fastenings in mobile use.

The receiver employs a super-regenerative detector of the indirectly heated cathode type.



Exterior View of Radio Transceiver Laboratories Duplex Transmitter Receiver

28 OR 56 MC AMATEUR BAND - OR 37 MC EXPERIMENTAL BAND
TYPE TR 53-6A6 DUPLEX TRANSMITTER - RECEIVER
2.5V OR 6.3V FIL



R1—400 ohms. R2—½ meghom. R3—2700 ohms. R4—500 ohms, 2 watt. R5—500 ohms, 2 watt. R6—1000 ohms. R7—50,000 ohms. R8—40,000 ohms. R9—100,000 ohms. R10—250,000 ohms. R11—500,000 ohms. RFC—50 turns No. 30 DSC on 5/16-in. dowel. C1—.004 ufd. C2—.05 ufd. C3—.00025 ufd. C4—35 uufd. C5—1 ufd, 450 v. C6—5 ufd, 25 v. C7—15 uufd Cardwell. L1—9 turns No. 12, 5/8-in. dia. (60 MC) spaced thickness of wire and tapped at 6 turns. L2—2 turns, 3/16-in. copper tubing, 2-in. dia., with piece of No. 19 Corlac 1300 v. insulated solid wire threaded through for Grid Coil (60MC). T1—3:1 Audio Trans. T2—Pentode Output Trans. T3—Mic. Trans. T4—Class B Input, UTC HB1 or NS29. T5—Class B Output, UTC HBM or NS33.

I.C.A. 5-Meter Transceiver Kits

THERE are many experimenters interested in five-meter work who would much rather build a set than buy an assembled unit, because of the pleasure they get out of building it.

Home constructors who have been waiting for some firm to recognize their requirements in this regard will be interested in three new transceiver kits recently brought out by the Insuline Corporation of America, New York. These kits are really complete, down to the last nut and soldering lug.

All three sets use the same steel cabinet, which is finished in black crackle enamel. The box measures only 6¼ inches long, 5 inches high and 3⅝ inches deep and the completed outfits weigh only 4 pounds, less batteries. The two-volt model, for operation on dry cells, uses a 30 and a 33. The six-volt model, for storage battery use, particularly in a car, uses a 37 and a 41. The AC model uses either a 37 and a 41 or a 56 and a 2A5.

The diagrams of all three models are shown herewith, with the electrical values of all parts indicated. The same fundamental RF-AF circuit is used in all cases, with minor differences occasioned by the nature of the power supply.

The circuit is very simple, but many people are confused by the dual functioning of the tubes.

Consider Fig. 1, which shows the 2-volt model. If the transmit-receive switch is pushed to the "receive" position, the 30 acts as a self-quenching super-regenerative detector. It is called "self-quenching" because it supplies its own low-frequency oscillations, which in other types of circuits are produced by a separate tube. The oscillation at low frequency is a function of the grid leak value, in this case 250,000 ohms.

The signals received by the detector are led through the switch to the upper primary

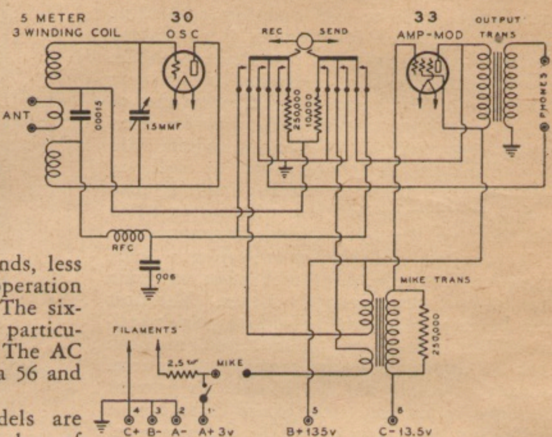


FIG. 1

of a special double-primary transformer, which in the receive position of the switch acts as a perfectly normal AF amplifying transformer. The secondary goes to the 33 output tube, and the amplified signal finally reaches the earphones through an output transformer.

If the switch is pushed to the "transmit" side, the same tubes and parts act altogether differently. With a 10,000 ohm grid leak in the circuit, the 30 tube becomes a straightforward RF oscillator, the frequency of its output depending of course on the setting of the 15 mmf. midget tuning condenser. The lower primary of the special transformer is cut into the microphone circuit, and the transformer becomes a modulating transformer. Likewise, the 33 tube, which is still connected to the secondary of the latter, becomes a regular Heising modulator and modulates the RF output of the 30 oscillator with the speech picked up by the hand microphone attached to the transceiver. The phone circuit is opened in the "transmit" position, so the primary of the output transformer functions as a straight audio choke. The principle of Heising modulation has been used for years and is well known.

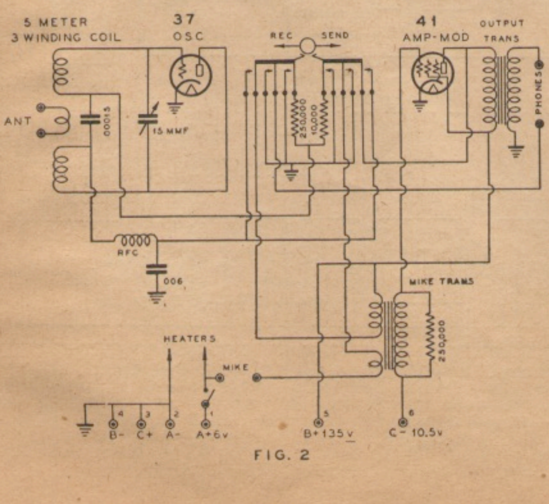


FIG. 2

There is nothing at all complicated about the receiving and transmitting operations; all they require is manipulation of the change-over switch and the single tuning knob.

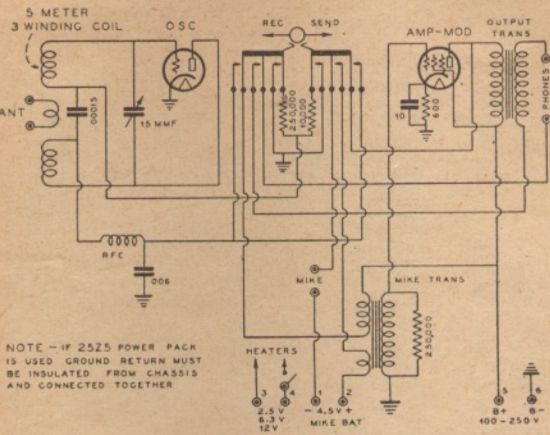


FIG. 3

During receiving, the transceiver produces a steady, rushing noise in the earphones. However, when a carrier wave is tuned in, the noise disappears and the voice comes through clearly. This peculiar operation is characteristic of super-regenerative receivers.

The mechanical placement of the parts in the ICA transceivers is arranged so that the wiring leads are as short and direct as possible. The photograph shows the simplicity of the low-cost model. The layout is symmetrical. The 15 mmf. midget condenser

HEATER CONNECTIONS FOR A C MODEL

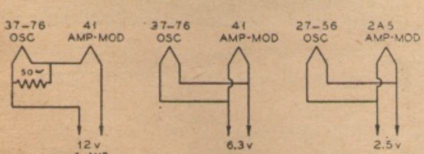


FIG. 4

occupies the center of the front panel, with the change-over switch above it and the split winding tuning coil below and behind it. Just behind the binding post strip are the audio transformers. The various small resistors and condensers are mounted by their own terminal wires, all the connections being short and direct.

The carrying case is made of two pieces: an L-shaped front and bottom, and a complete cover. The latter has two holes in the top for stand-off insulators that carry the antenna connections, and an opening in the back for the binding post strip. Detailed assembly directions and picture wiring diagrams are supplied with the kits. Anyone who can handle a screwdriver, soldering iron and pair of pliers can put together a complete outfit in a single evening.

The two small binding posts on the top of the case, which connect to a small coupling winding between the sections of the oscillator coil, permit the use of various types of antenna. For portable operation probably the simplest aerial is a four-foot length of copper, brass or aluminum rod or tubing fastened directly to one post, with the other left free or grounded. Tuned feeders connecting to a half-wave Hertz antenna may also be used, in accordance with all the principles that govern antenna construction and operation on the lower frequencies. The various methods for connecting the filament circuit, depending upon the type of tubes used, is shown in Fig. 4. The 37-76 oscillator tube and the 41 amplifier-modulator tube can be operated with the

The I.C.A. Kit in its Metal Cabinet.

filaments connected in series if a 12-volt battery is used. A number of the popular makes of automobiles use a 12-volt storage battery. A 50 ohm resistor is connected across the filament terminals of the oscillator tube, as shown. This resistor should be of the heavy-duty small wire-wound type.

3-Tube Unity-Coupled 5-Meter Transceiver

ONE of the most interesting pieces of apparatus in amateur radio is the five-meter "transceiver," which gets its name from the fact that it is a combination transmitter and receiver using the same tubes and accessories for both purposes. A recent ruling of the Federal Communications Commission permitting mobile as well as portable operation on five meters has greatly accelerated amateur activity along these lines, and amateurs everywhere are deserting the hopelessly crowded 20, 40 and 80 meter bands to find considerable pleasure on the shorter wave.

Five meters offers many opportunities because one can pack a complete outfit into a box about the size of a typewriter case and set it up for operation in a few seconds. A 5-meter set can be operated in a car in motion, and dozens of different "hams" can be contacted as you drive from one town to another. Five-meter "fiield days" held on Saturdays or Sundays, are getting to be regular affairs in amateur circles.

In recognition of this growing acclaim of five meters, the writer has designed a three-tube transceiver which has proved exceptionally successful, and can be purchased complete for a price that would have been considered low a few years ago for just an ordinary power pack.

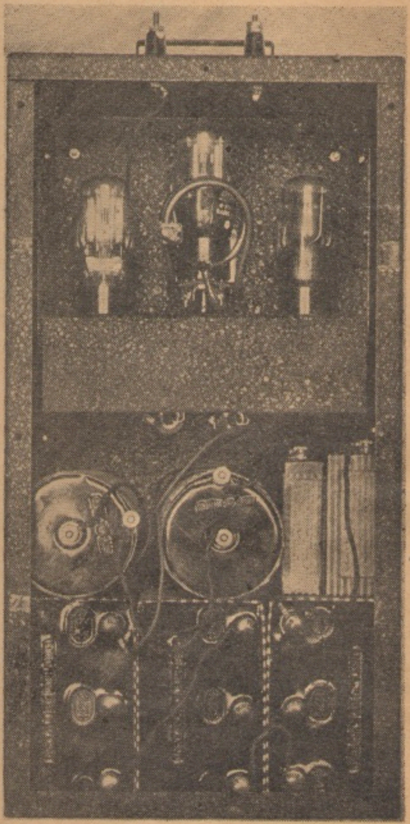
A single case, made of steel finished in durable black crackle, and measuring 15¼ inches high, 8 inches wide and 7 inches deep, houses the complete outfit, which is known as the Lafayette Transceiver. Why steel and not aluminum for a portable job? you may ask. The writer has found that steel stands the punishment of portable service better than aluminum, and its extra weight pays for itself in durability.

As shown in the illustrations, the case is formed on four sides and has removable front and back panels. A man-sized carrying handle is fastened to the top. The upper half of the box is occupied by the transceiver proper, the lower by all the required filament, plate and microphone batteries. A decorative plate for the front panel carries three controls and two jacks; the former are the main tuning knob, in the upper center, volume control, lower left, and receive-transmit throwover switch, lower right. The jacks are for earphones and a small hand microphone.

The knobs are of the new pointer type and look very distinctive. A plain knob and not a vernier dial is used for the tuning condenser (C1 in the diagram) because the tuning is not critical and a knob permits quick scanning of the entire five-meter band.

The three tubes in the Lafayette Transceiver actually do the work of five, and this accounts to some degree for the effectiveness of this little outfit. The diagram shows all of the connections in detail.

Transceiver hookups always look confusing at first sight, but this particular one is really easy to understand if you follow it through carefully. Tubes V1 and V3 are both



Interior view of Transceiver, showing unity-coupled coil and battery compartment.

type 19 double triodes, V2 a type 30. The four switches marked S are all part of a single four-pole, two-position unit; the points marked T represent the transmit position; the points R the receive position. The variable resistor R1, which acts as volume control, is combined with the filament switch SW. C1, R1 and S are the only variable instruments in the whole transceiver.

The coil marked L2 looks a bit peculiar. It consists of two turns of ¼-inch copper tubing about 2 inches in diameter, with a split length of insulated flexible wire inside. The tubing acts as the plate coil, the wire as the grid coil, of a simple push-pull oscillator. The close coupling between the two coils makes this a powerful oscillator indeed. Tuning condenser C1 (a 15 mmfd. midget) is connected across the ends of the plate or "tank" coil and to the plates of V1, with a center tap for plate voltage. The grid coil connects to the corersponding grids and is similarly tapped.

Let us throw the changeover switch to the receive position and see what happens. Tube V1 now acts as a self-quenching super-regenerative detector, with C4-R3 as the grid condenser-leak combination. Transformer T1, with primary P1 functioning, acts as an ordinary amplifying transformer, working into V2 as first audio stage. V2 in turn feeds into T2 and V3, which act together as a complete class B audio output stage, the output transformer T3 operating the earphones.

Now switch to the transmit position, and the same parts act altogether differently. V1 becomes a push-pull oscillator. Primary P2 of transformer T1 is cut in, and T1 becomes a microphone coupling transformer. The secondary of T3 is switched from the phones to the plates of V3, so T3 is now the modulation transformer.

In the receive position, R1 is a volume control on the received signals. In the transmit position, it is a mike gain control.

The whole idea works out perfectly, with the tubes performing their dual functions just as efficiently as if the receiver and transmitter were separate units.

Two binding posts are provided on the top of the case for antenna or feeder connections. Best results were obtained with a quarter-wave antenna, consisting of a four-foot length of aluminum tubing, fitted at one end with a threaded brass insert that screws directly to one of the stand-off insulators. An eight-foot, half-wave antenna has also been found good. The four-foot tube is convenient because it is shorter. It is especially valuable when used on a car in motion, because it whips around less.

For power supply, dry batteries are used throughout. Two standard No. 6 dry cells light the filaments. Three 45-volt B batteries energize the plates. A 7½-volt C battery furnishes bias for V2. A separate 4½-volt C battery is used for microphone current, one of the switch sections opening this circuit when the transceiver is in the receive position. A single set of batteries withstood two months of experimental service, and still seem to be all right.

As for actual results, the five-meter band is full of surprises, the right kind of surprises. Although these waves are supposed to be of the quasi-optical type, and a receiver and a transmitter must be practically within sight of each other for communication, the writer has worked more than ten miles "blind" between 100 Sixth avenue, New York, and some of the outlying sections of the city. Some of the contacts were made with stations apparently blanketed by steel buildings. In fact, one QSO was accomplished with this transceiver on the fifth floor of a 17-story steel building, and the other station about three miles uptown! One of the beautiful features about a transceiver like this is that you can pick it up and move on, if one location isn't so good, and if another looks better.

The owner of a car can spend whole months running around with this transceiver. to look up the address of sime five-meter ham, drive around the corner from him and then "QSO him" over the air. The strength of the received signals is not always an indication of the transmitter's location.

Parts List for the Lafayette Transceiver

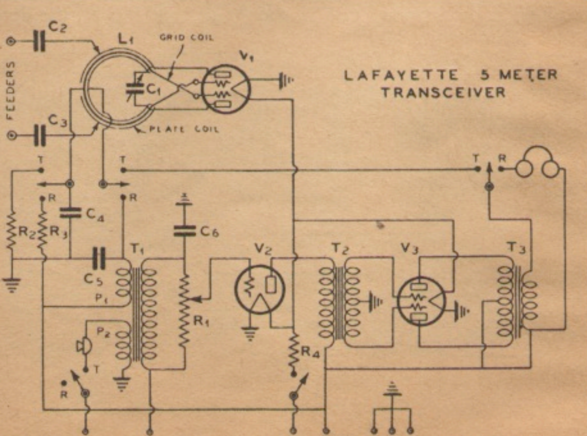
C1—15 mmf. midget.
C2—.002 mfd. mica.
C3—.002 mfd. mica
C4—.00025 mfd. mica.
C5—.004 mfd. mica.
C6—.00005 mfd. mica.

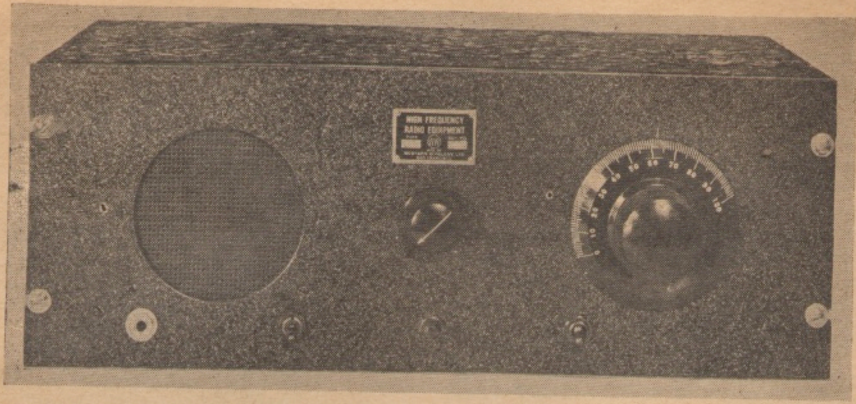
R1—1 megohm.
R2— 5000 ohms.
R3—200,000 ohms.
R4—1.5 ohms.

L1—Tank coil as described.
T1—Special Lafayette double primary transformer.

T2, T3—Class C AF transformers.

V1, V3—Type 19 tubes.
V2—Type 30 tube.





Ideal A.C. Operated 5-Meter Amateur Receiver

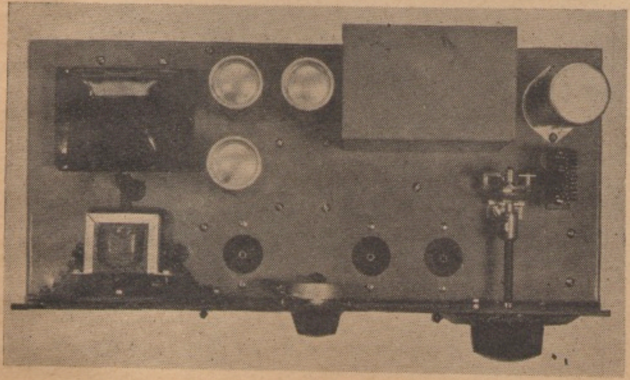
Ultra-short wave superheterodyne receivers can be made quite sensitive by the use of extreme regeneration, and can even be made broad enough in tuning to serve for standby operation. However, these sets are apparently much more sensitive to neon sign and auto ignition interference than super-regenerative sets. The fact remains that a good "stiff" super-regenerative receiver gives a better signal-to-noise ratio for average, moderate-strength signals. By a "stiff" super is meant one in which the detector is super-regenerating quite strongly.

This latter condition makes for bad receiver radiation unless a radio-frequency stage is used to couple the antenna to the detector. The actual gain in the RF stage is relatively small, being from 1 to 8, as against several thousand in the detector circuit. Its main use is in preventing radiation, which is terrific when the detector is even coupled loosely to an antenna.

The RF tube can be coupled to the detector in several ways; one is shown in this receiver circuit. This scheme permits an adjustable amount of coupling and consequently does not load the detector input circuit too much. The RF signal completes its path through the internal capacities of the detector tube, and external circuit to ground capacities. Either an RF choke input can be used with a resonant receiving antenna, or a small semi-fixed tuned input circuit can be used.

Since an RF stage is used, any super-regenerative detector circuit could be utilized. The receiver here shown uses a blocking grid-leak detector system in which the grid leak return is to a high positive potential. When the detector is coupled directly to an antenna, this particular type of circuit radiates about three times as much as the more usual form using a separate IF oscillator.

The sensitivity of the usual form of blocking grid-leak with ground or cathode return is about the same as in this circuit in which the grid leak return is to +B voltage. However, the detector overloading effect is greatly reduced when receiving strong signals and, in general, the tone quality is much better. The action is similar in effect to a receiver with automatic volume control, so that nearly all signals are received at the same volume and only an audio volume control is necessary.



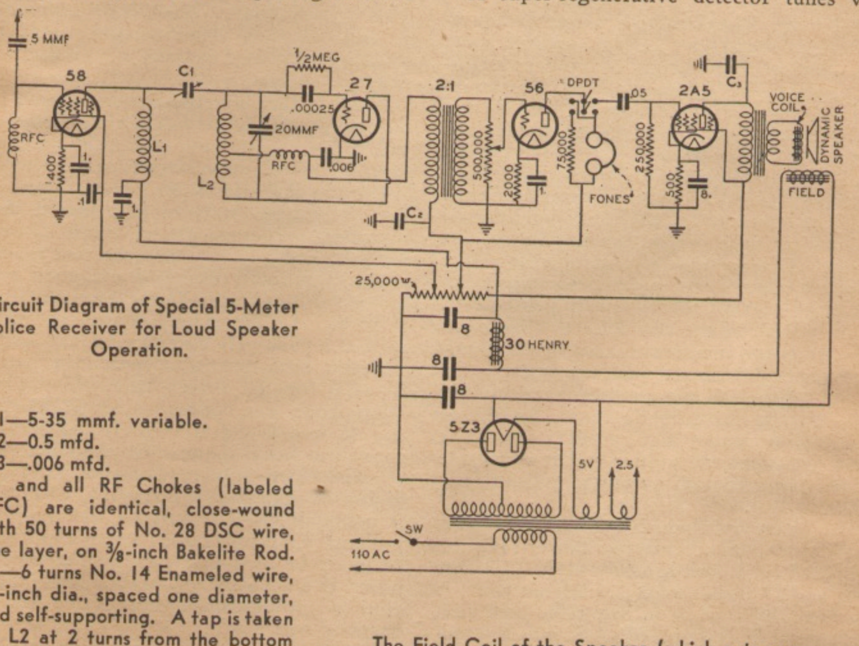
The RF Stage is in the small shield can at right

The detector consists of a regular Colpitts oscillator circuit in which the internal capacities of the tube act as the voltage dividing elements and hence produce oscillation. The grid leak is of such a high value that even with a positive return it still builds up a negative voltage, due to grid current. The circuit decrement and values of grid leak and condenser, and plate return by-pass to cathode are such as to cause a blocking action, producing super-regeneration and the familiar loud hissing sound when no signals are being received.

THIS circuit seems to function as an ordinary oscillator in which the grid leak is too high in value to allow the electrons on the grid to leak off at a rate which would give a constant value of grid voltage. This causes a change of average bias and stops oscillation because the plate current is decreased and the mutual conductance of the tube drops. The grid leak and condenser values and circuit decrement determine the rate and discharge, or number of cycles-per-second that this occurs; in this case an inaudible rate. Apparently the plate circuit must maintain a fairly low impedance path to cathode at this inaudible frequency because the plate by-pass should be at least .002 mfd., whereas .006 mfd. seems none too large. With either resistive or transformer coupling to the audio amplifier, no super-regeneration will take place without a fairly large plate-to-cathode return by-pass condenser. In the circuit shown, this by-pass condenser has no effect on the RF portion, since it is on the low RF potential side of the RF choke.

TWO stages of audio amplification are used in order to insure more than ample volume under all conditions of reception. In some locations local noise is high, and a loud signal is required in order to make it intelligible. Many ultra-high frequency transmitters are of the modulated oscillator type which have a strong carrier signal with moderate or weak values of modulation. A strong carrier will eliminate the super-regenerative hiss or roar, but the actual voice signal will be weak unless plenty of audio amplification is used. Since a high value of audio amplification is available, it was necessary to use a well-filtered power supply, as shown in the circuit diagram. The pentode power tube, used as an output amplifier, provides ample power for the small dynamic loudspeaker. Head-set operation is possible by means of the switch which cuts-in either the headset and the first audio amplifier, or both stages and loudspeaker.

A super-regenerative detector tunes very



Circuit Diagram of Special 5-Meter Police Receiver for Loud Speaker Operation.

C1—5-35 mmf. variable.
C2—0.5 mfd.
C3—.006 mfd.
L1 and all RF Chokes (labeled RFC) are identical, close-wound with 50 turns of No. 28 DSC wire, one layer, on ⅜-inch Bakelite Rod.
L2—6 turns No. 14 Enameled wire, ⅝-inch dia., spaced one diameter, and self-supporting. A tap is taken on L2 at 2 turns from the bottom (plate side of L2 which connects to the '27 Tube).

The Transformer between the plate of the 2A5 and the Voice Coil of the Dynamic Speaker is an 8000-10 step-down of any standard make.

The Field Coil of the Speaker (which acts as one filter choke) can be made the output choke, instead of input choke as shown, if hum develops.
Plate Voltages should be adjusted as follows: To L1 and to Step-down Output Transformer, 250 volts. To Interstage Transformer (between '27 and '56 tube) and to Fones, 120 volts. To Screen of '57 RF Tube, 90 volts.

broadly, normally covering a band of at least 100 KC. It is thus satisfactory for standby operation when receiving modulated oscillator transmitters or mopa transmitters in which there is a carrier frequency drift due to temperature changes. This broad tuning effect is readily explained when it is realized that the detector circuit is oscillating periodically over a wide band of frequencies, usually from 60 to 200 KC in width. An ordinary 6 or 7 meter oscillator will vary its frequency 30 to 100 KC when its DC plate voltage is varied 50%. A super-regenerative detector is an oscillator which has its plate voltage, or grid voltage, varied over much wider limits. As it goes in and out of oscillation (super-regeneration effect) a great many thousand times per second, it also varies its high frequency oscillation period, which gives the broad tuning effect. This is a decided asset in some cases, such as the purpose for which this receiver was designed.

5-Meter M-O-P-A Companion Transmitter For Receiver Described Above

THE trend in ultra-high frequency equipment shows a tendency toward some form of master-oscillator, power amplifier combination. The reason is obvious; an increasing number of commercial, police and others are finding the ultra-high frequencies useful for their needs. The broad modulated oscillator type of transmitter must eventually give way to some form of driven amplifier circuits so that high percentage modulation with its attendent effectiveness can be utilized. Crystal control is far from impossible but it still presents so many complications that its use is hardly justified.

The advent of the new RCA 801 served as a stimulus for the construction of the transmitter here described. The 801 is driven by a '45. Although the internal capacities of the '45 tube leave much to be desired, it nevertheless makes an excellent oscillator for a five-meter transmitter and it is capable of delivering enough output to satisfactorily drive the 801.

The entire unit, which includes oscillator, amplifier, modulator and two power supplies, is housed on a deck 6 inches high, 12 inches deep and 17 inches long. The front panel is standard, 10½ by 19 inches, relay rack size, since the unit is designed to fit into a standard relay rack with its associated receiver mounted on the lower panel of the rack. As the photograph shows, none of the main tuning controls come out to the panel; instead they are accessible through the screened door opening out from the panel. The importance of short direct leads can hardly be stressed too strongly. The leads are made shorter by not attempting to line up the various controls on the panel, and thus the added convenience in tuning is sacrificed for the sake of added efficiency.

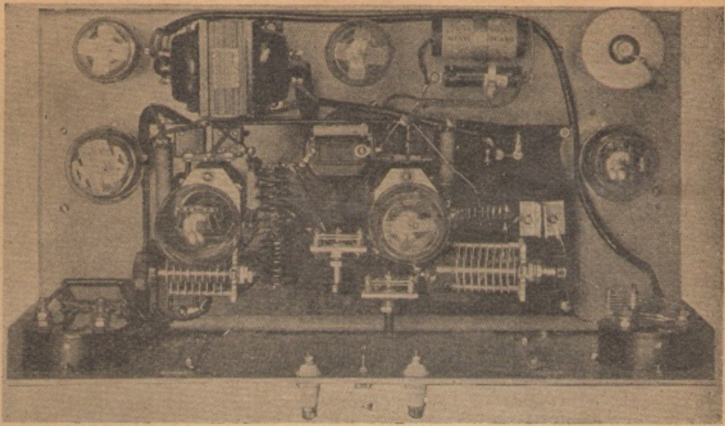
Fig. 1 shows the complete circuit diagram. The oscillator is inductively coupled to the amplifier. A regular tuned circuit is used in the grid of the amplifier in order to provide a voltage step-up as well as to enable the use of series-grid-feed, which eliminates the necessity for an RF choke. Peculiarly enough, RF chokes are quite efficient at five meters and shunt feed is often used. The best choke is none too good, hence the use of series feed.

The amplifier stage is not unlike that used for any of the lower frequencies; the essential difference is in the use of small condensers (low C being used throughout, except in the oscillator), and the use of small diameter inductances. Isolantite sockets are used for both oscillator and amplifier to lessen the loss, which is always appreciable at these frequencies. Shunt-plate-feed is desirable in the amplifier in order to keep the DC off the tank coil, and in the transmitter here described shunt-feed made for correct neutralization. In practice, either inductive or conductive coupling to the antenna is used. Both systems have their advantages, as well as their disadvantages. Inductive coupling was used because of its flexibility and ease of handling.

Good quality of reproduction, as well as a high percentage of modulation was demanded and, therefore, the audio system was designed to conform to these requirements.

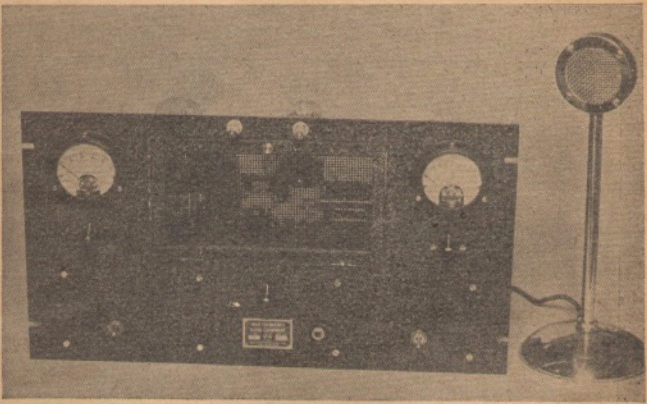
Because the transmitter has a 20-watt carrier, it was necessary to use class B audio in order to provide the necessary 10 or 12 watts of audio to give 100 per cent modulation. If properly designed and good transformers are used, the 53 makes a good class B tube. As the circuit shows, one 53 is used as a push-pull, class B tube, and another 53 with both sets of elements in parallel is used for the driver tube. The crystal microphone was approximately 60DB down and it was found a stage of 56 was not enough to bring the level of the mike up to a satisfactory value. Consequently, a 57 high-gain amplifier was used. When a 57 is used, all circuits must be well by-passed and under no circumstances should less than 12 mikes be used in the cathode resistor by-pass. If a smaller condenser is used, degeneration and subsequent loss of the low frequencies will result.

The O-100 milliammeter is connected permanently in the positive high voltage of the class B amplifier. This meter is helpful in determining correct setting of the gain control and assures the operator that the modulator and speech amplifier stages are working properly. An O-1 meter in conjunction with a Yaxley, two-section, six-position, rotary switch indicates oscillator plate current, amplifier grid current and amplifier plate current. Each meter position has its own shunt so that a low range reading is possible for the grid current reading, a medium range for the oscillator plate current and a O-100 range for the amplifier plate current. Alternate switch points are used on the rotary switch so as to avoid the possibility of arcing when the switch is rotated. The use of individual shunts has a further advantage in that it makes all circuits complete when the meter is not in use.



Looking down on the RF portion. The arrangement of the inductances L1 and L2 is plainly shown. The tuning condensers are wide-spaced Cardwell midgets. The R.F. tubes sockets (Isolantite) are raised well above the chassis.

Both power supplies, associated chokes and filters are mounted beneath the chassis. One power supply furnishes power for the speech amplifier and modulator and the other supplies power for the oscillator and amplifier. The use of two power supplies is almost necessary to provide the regulation for good class B operation. The high voltage for the amplifier is fed directly through the secondary of the output transformer, instead of through a choke-condenser arrangement. This method is satisfactory because the output transformer is well designed and the secondary is easily capable of passing the amplifier plate current. The secondary is designed to work into an 8000 ohm load. While this may seem somewhat higher than the usual secondary load, it works out to best advantage since the class C amplifier presents this load with a plate voltage of 400 volts and a plate current of 600 milliamperes. $\frac{400}{.060} = 8000$ ohms, while 400 X .060 = 24 watts, the correct input. There is nothing particularly sacred in exactly matching the class C load to the modulator since small amounts of mismatch change the modulator output but slightly.



There are no tuning controls on the front panel of this 5-meter MOPA. All tuning adjustments are made by opening the small screen doors on the front panel. Symmetry gives way to efficiency.

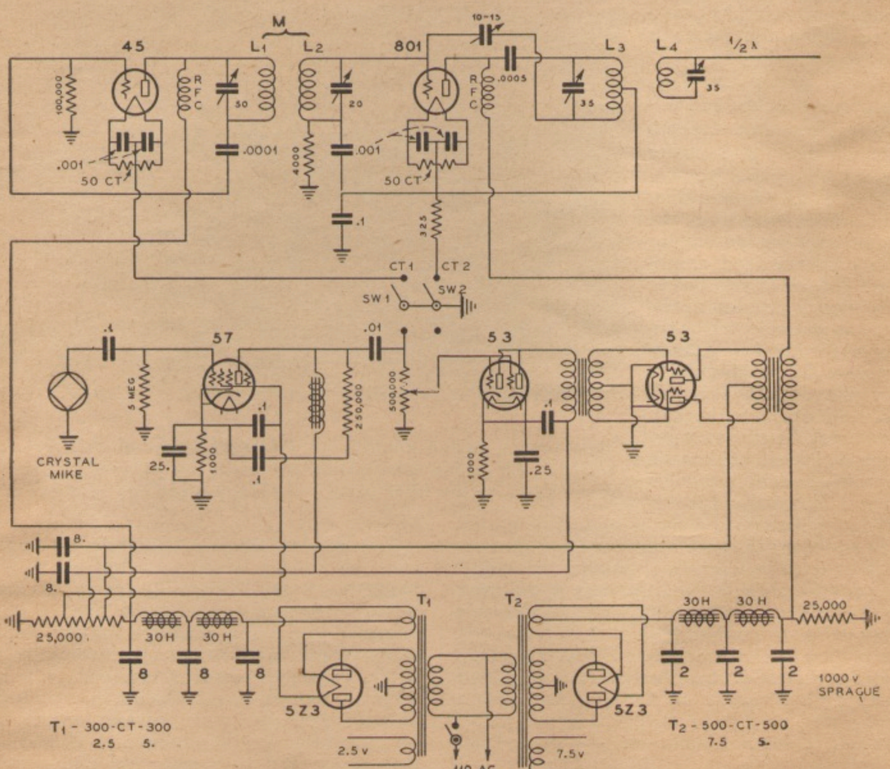
This transmitter is completely AC operated; no battery is required for the microphone since this device generates its own voltage. A small amount of fixed bias is necessary as a safety measure for the amplifier stage and this bias was obtained by means of the automatic resistor method. The resistor in the center-tap circuit is arbitrarily adjusted with the plate current set to the working value by the antenna load, and the drop across it is then measured with a voltmeter. This resistance is so adjusted as to have approximately 25 volts drop across it. The voltage drop is then measured across the grid leak and the two bias voltages are added in order to obtain the effective bias on the tube. The values of these two resistors are changed until the correct bias is obtained. The amount of drop across the cathode resistor should be kept to the smallest possible value so as to keep the plate current within safe limits, should the excitation fail. The bias for class C operation is determined with small error by the formula:

$$\frac{\text{mu}}{\text{Plate voltage}} \times 2$$

On the final adjustment, the sum of the two biases should equal this amount. During the course of this adjustment it is well to bear in mind the fact that changes in the bias will likewise change the plate current and consequently the load resistance which the class C stage offers to the modulator. It is necessary to keep the plate current fairly constant during adjustment, by simply changing the antenna coupling.

In tuning the transmitter, the following procedure is used: First the oscillator should be set to the desired frequency by use of a frequency meter. The plate voltage on the final amplifier should be disconnected during the course of the preliminary adjustment. The milliammeter is now switched over to read grid current, and the grid tank condenser is adjusted for maximum reading. The final amplifier condenser is then tuned to resonance, as indicated by a dip in the grid current. Bring the grid current back to an optimum value, which will still be below its former value, and then adjust the neutralizing condenser until the grid current remains constant when the final amplifier tank is tuned through resonance. Plate voltage should then be applied to the final and the milliammeter switched into the amplifier plate circuit. The plate current should then be tuned for a minimum reading, by adjusting the final tank condenser.

The quality of voice from this transmitter leaves little to be desired. It speaks for the advantages of the driven amplifier type of ultra-high frequency equipment.



Complete RF, Speech and Power Supply Circuit Diagram of 5-Meter M-O-P-A.

Coil-Winding Data for 5-Meter Operation: L1—6 turns, No. 12 enameled wire, spaced one inch between turns and wound on a 1-inch diameter form. L2—4 turns, No. 12 enameled wire, self-supporting, air-spaced between turns, 1-inch diameter. This coil is placed 1 inch away from L1. L3, L4—6 turns, No. 12 enameled wire, spaced ⅛-inch between turns on 1-inch dia. form.

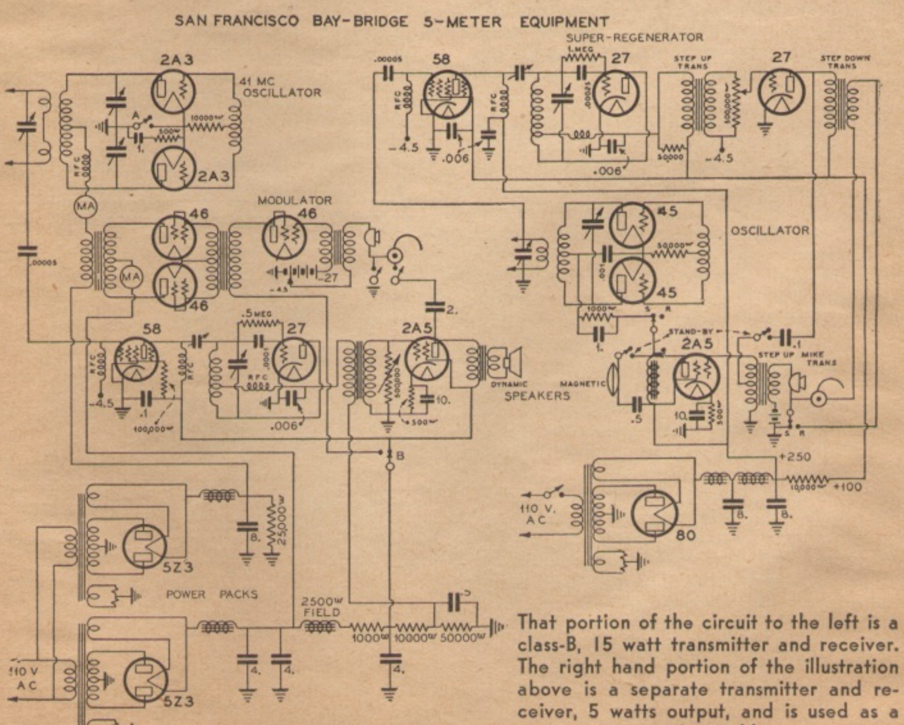
San Francisco Bay Bridge 5-Meter Transmitter and Receiver

THIS transmitter and receiver, which is completely AC operated, consists of a pair of 2A3 tubes in push pull with approximately 40 watts input. It is modulated by a Class B system using a pair of 46 tubes which in turn are driven by another 46 tube in Class A. The Class A stage is driven from the output of a telephone type microphone. In order to permit better frequency stability, two separate power supplies are utilized, one for the oscillator and the other for the Class B. This equipment is built into a standard table type relay rack and is mounted on four panels. The top panel consists of the 2A3s with their associated equipment; the second panel contains the driver and Class B stage. On the third panel the two power supplies mentioned above are mounted, and the receiving equipment is mounted on the bottom panel. The receiver consists of a type 58 tube as a semi-tuned R.F. amplifier, followed by a type 27 super regenerative detector and a type 2A5 audio amplifier. The output of the receiver operates either the telephone type handset or a dynamic speaker. The switch on the handset cradle turns on and off the microphone battery supply and also switches from the monitor speaker to the receiver in the handset. The low impedance handset effectively short circuits the loudspeaker and since a pentode output tube is used, the receiver volume is reduced to the proper volume automatically without a noticeable increase in distortion.

This transmitter may be operated from any remote point by means of a 110 volt AC control circuit and a 3-wire circuit for the handset.

This control permits talk and receive by means of a switch in the handset itself which operates an AC relay in the transmitter proper. This relay cuts off the R.F. amplifier and pentode plate voltage and turns on the modulator and oscillator plate supplies when talking and the reverse when receiving.

Two separate transmitters and receivers are shown in the circuit diagram below. The one to left is the type 10W, the one to the right is the type 3A



That portion of the circuit to the left is a class-B, 15 watt transmitter and receiver. The right hand portion of the illustration above is a separate transmitter and receiver, 5 watts output, and is used as a semi-portable.

"Jayenay" 5-Meter Stabilized Transmitter

DUE TO THE optical limitations on distant communication on the short wavelengths below ten meters, it is evident that interference will be a problem only in and around a metropolitan area. In the country, QRM will be practically unknown. However, in and near the larger cities, QRM is bound to become troublesome, especially if the practice of modulating self excited oscillators is continued. Modulated oscillators were abandoned years ago on the lower frequencies (longer waves) because of the inability to obtain a high percentage of modulation with frequency stability.

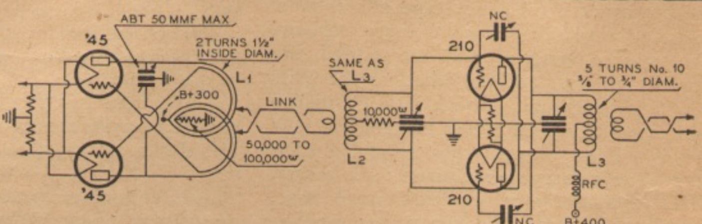
Thus, some form of oscillator-amplifier transmitter will undoubtedly become standard practice as activity on the higher frequencies increases. In Fig. 1 in shown a simple MOPA transmitter which uses a pair of push-pull 45's as unity-coupled oscillators and a pair of neutralized 210's in push-pull in the power amplifier. The oscillator is designed for maximum stability, while the final amplifier is designed for maximum output. These two characteristics never go together in the same stage. You can have either stability or high output, but rarely both, because entirely different operating conditions are necessary for the two characteristics. The oscillator uses relatively high C in the tank circuit so that changes in tube capacity and plate resistance will have the least possible effect on the frequency of oscillation. On the other hand, the amplifier stage should have as little tuning capacity as possible in order to avoid losses.

The oscillator grid coil is wound inside of the copper tubing which forms the plate coil, and the grid coil must be connected properly, if satisfactory operation is desired. The ends of the grid coil connect to the grid of the tube whose plate is connected to the OPPOSITE end of the plate coil. The stage will oscillate weakly if the grid coil is improperly phased, but will be very unstable.

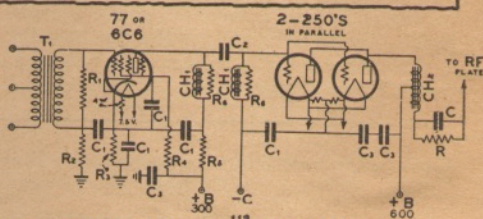
The coupling link between the two stages is tapped across about a third of a turn of the plate coil of the oscillator, and helps to isolate the oscillator from the amplifier.

Fig. 2 shows a speech amplifier which may be used to modulate the transmitter shown in Fig 1. It will completely modulate a twenty-five watt input to the power amplifier and provides enough gain to give full output when excited by a damped two-button carbon microphone.

The monthly "Ham Hints" page in "RADIO" by "Jayenay" contains many timely suggestions for 5 meter operation. Here is the M.O.P.A. circuit used by "Jayenay" himself.

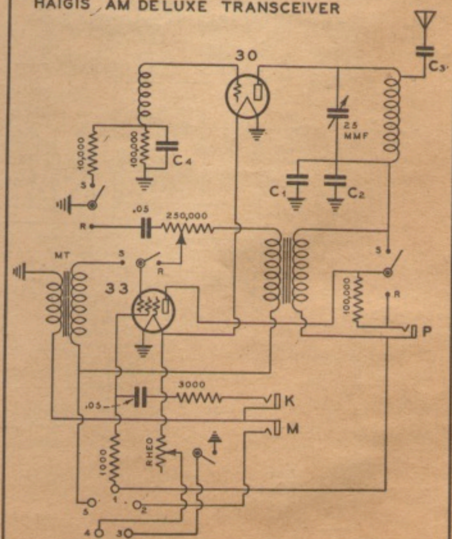


5 METER M.O.P.A.



R1—250,000 ohms, 2 watt; R2—100,000 ohms, 2 watt; R3—500 ohms, 5 watt; R4—500,000 ohms, 2 watt; R5—50,000 ohms, 5 watt; R6—300,000 ohms, 2 watt; C1—1 ufd., 400 volts; C2—.01 ufd.; C3—8 ufds., 450 volts; T1—Line or mike to grid transformer; CH1—400 henry audio choke; CH2—Tapped modulation choke, 25 to 40 henries at 75 MA.

HAIGIS AM DELUXE TRANSCEIVER



400-Watt Carrier 5-Meter Final

HERETOFORE it has been difficult to obtain stable operation on five meters with the higher-power tubes due to various reasons. Among them are: (1) High inter-electrode capacity in certain types of tubes, (2) The necessity for long leads from grid to plate, (3) The refusal of practically all of the common tubes to amplify at a reasonably low plate voltage on 5 meters. A tube that will not amplify properly will not oscillate without excessive grid losses, (4) A rugged grid and grid lead is essential because of the high radio-frequency grid current that flows at 60 MC, even in the low capacity tubes.

THE tantalum grid used in the 354, 50T or 150T led us to believe that it could be the answer to the high-power 5-meter problem. Experiments confirmed this belief and exceeded our fondest expectations, especially on the score of plate efficiency, which is usually so hard to obtain at 5 meters. Efficiencies of 35% in oscillators or class C amplifiers have been as high as one could realize in the "pre-354 era". We realized a plate efficiency of over 55% when using the conventional TNT oscillator circuit shown in Fig. 1. By substituting about 5 feet of No. 14 wire, as in Fig. 2, for about $10 worth of tank coil and condenser, the efficiency promptly jumped to over 66% and 400 watts of (measured) output was obtained with only 600 watts input, instead of 700 watts necessary when the conventional plate tank circuit was used.

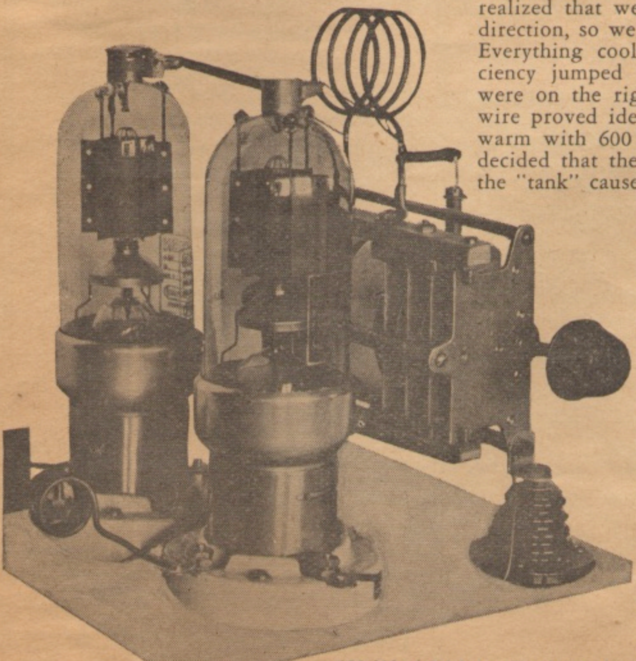
The tank circuit in Fig. 2 is nothing but a pair of Lecher wires suspended vertically from the plate caps of the tubes, and held in position by the aid of an ordinary piece of wrapping string. The transmission line to the Johnson "Q" antenna was clipped on the Lecher wires at a point approximately 2 inches each side from the RF choke through which plate voltage is supplied.

As an example of how theory can be confounded by practice, the first Lecher wires consisted of 1/4 inch copper tubing; the tubing became warm under operation and the efficiency was a little better than when the conventional tank circuit was used.

It has been said—"If a conductor heats up, use a larger conductor". So half-inch copper tubing was tried. This became distinctly hot and the efficiency dropped materially. Becoming slightly puzzled, we used some one and-one-quarter-inch copper tubing and dared the efficiency to stay down. This large tubing became very hot. At this point we realized that we were headed in the wrong direction, so we tried 1/8-inch copper tubing. Everything cooled-off at once and the efficiency jumped 'way up, which proved we were on the right track. No. 16 enameled wire proved ideal and did not even become warm with 600 watts input. It was finally decided that the excess metal in the field of the "tank" caused these excessive losses.

The exceptionally high "Q" of this "tank" improved the frequency stability of the oscillator to a marked degree, always welcomed at 5 meters. We intend to try this "tank" on 10 and 20 meters at an early date. Who knows but that our Zepp feeders may yet prove to be the perfect tank coil? Comments from readers who are inclined to conduct such experiments are solicited.

The breadboard is covered with a thin sheet of aluminum, tacked at the edges of the board to hold it in place. Try this on your own breadboard transmitters, on any band, because it often straightens-out that stage which refuses to neutralize, due to improved grounding and shielding.



400 Watt 5-Meter Final Amplifier using Tank Coil and Condenser. Equally satisfactory results were secured when Lecher Wires replaced the coil and condenser. The tubes are HK-354s.

Sheet copper is just as good as aluminum and has the further advantage that solder will stick to it. This shield also reduces dielectric losses in a breadboard, often quite high, unless the wood is very dry. It may interest the reader

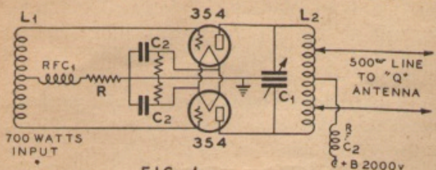


FIG. 1

Circuit Diagram of High-Power 5-Meter Transmitter.

L1—5 turns, No. 10 wire, ¾-in. diameter.
L2—4 turns, ⅛-in. tubing, 1½-in. diameter.
C1—40 mmf. per section, 3000 volt condenser.
C2—.001 mfd., low voltage condenser.
R—10,000 ohms, 100 watt.
RFC1, RFC2—50 turns, No. 28 DSC on 3/16-in. Bakelite Rod.

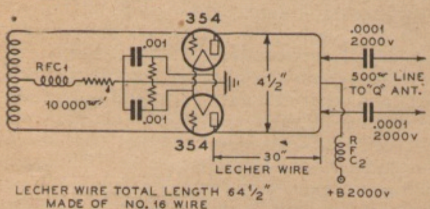


FIG. 2

Antenna tap at ⅜ turn each side of center.

to know that some breadboards can become distinctly warm when subjected to a strong electrostatic field, as in the final amplifier of a high-power transmitter, because of the poor dielectric nature of soft woods.

The remainder of the circuit is conventional TNT practice and the frequency is determined by the length of the tank which, as is shown in Fig. 3, is a single loop of wire. A similar tank was used in the grid circuit but proved unsatisfactory. The 300 watts of audio power necessary to modulate this oscillator was obtained from another pair of 354s in class B, running at 1000 volts.

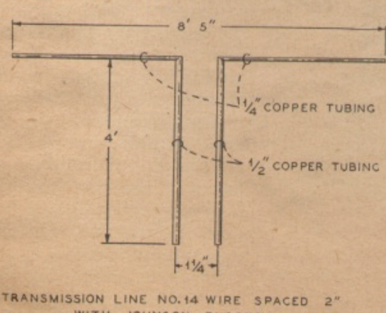


FIG. 3

A Modern Link-Coupled Phone

IT CAN easily be imagined that the much neglected ten-meter band will become increasingly popular during the winter months. The new regulations allowing the use of phone on a portion of this band, coupled with the fact that DX conditions appear to be unusually favorable, would seem to give strength to such an assumption. However, there are a number of requirements that must be complied with, if good phone communication reasonably free from QRM, is to be enjoyed.

A comparison of the five and ten-meter bands may possibly serve to illustrate this point. This comparison is probably timely, due to the fact that the amateurs on five have already acquired a degree of proficiency in the operation of ultra high frequency equipment. It is logical to assume that these men will be among the first to migrate to this new and virgin phone territory. The first point to observe is that the ten-meter phone band is only about one-eighth as wide as that of its higher frequency neighbor. (The whole five-meter band is open to phone but only 500 kc. on ten meters.) The extreme width of the former band and the difficulty of obtaining easy frequency stabilization probably justify the use of self-excited, modulated oscillators. The quasi-optical effect is also a further justification for their use because stations even short distances away are at times unable to hear one another. On ten, the story is somewhat different. Stations within a ten-mile radius (and probably even greater) are able to carry on communication at any time, day or night. This greater ground wave range and the potential DX possibilities further add to the interference problem. It rather goes without saying then, that the use of self-excited, modulated oscillators and their attendant broadness (due to frequency modulation) are definitely out. All of which leads to the crux of the whole matter—frequency stabilization.

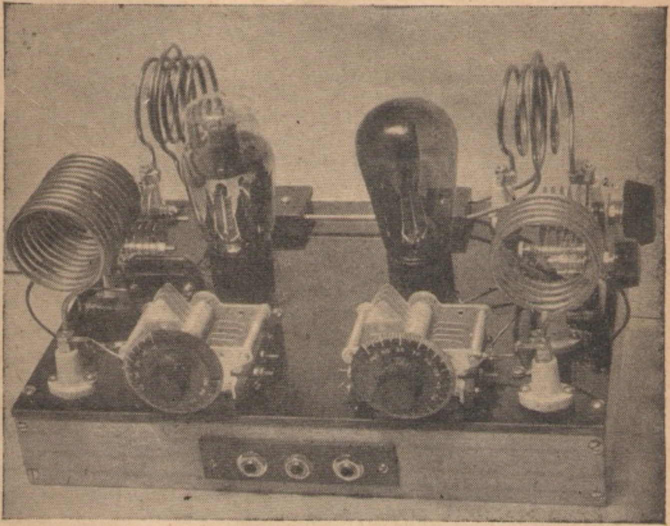
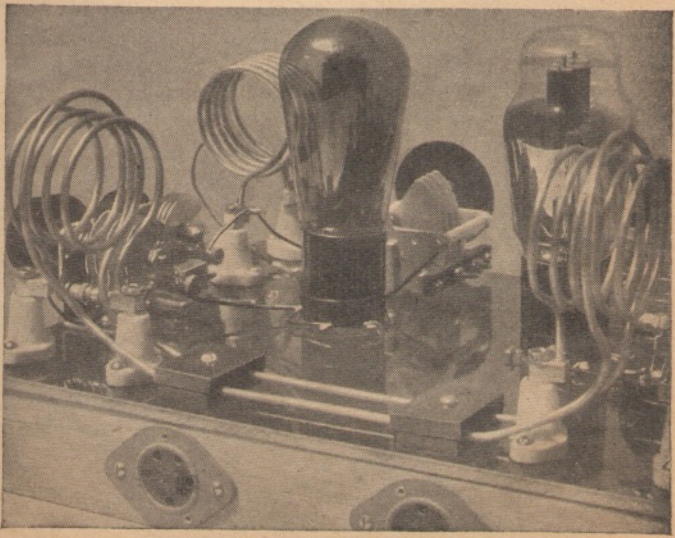


Fig. 1—Front View of Transmitter.



Rear View, Showing Coil Supports and Coupling Arrangement.

Probably the best method of achieving frequency stabilization is by the use of crystal control. This methods should present no particular difficulty to the 20-meter phone men who have all the necessary equipment, with the possible exception of another frequency doubler; but it is a hard nut to crack for the 5-meter experimenters, most of whom have only self-excited sets. However, crystal control isn't the only answer. Its runner-up, the Electron Coupled Oscillator, is a very able substitute.

The property of an electron coupled oscillator to deliver high harmonic output makes its use particularly feasible for ten-meter work. By taking advantage of this peculiarity (or is it a blessing?) it becomes possible to operate the grid circuit, which largely determines the frequency drift, on a lower frequency where its action is apt to be more stable. Then, by doubling in the plate circuit, there is developed a nice, steady signal on the band where it is wanted. This, incidentally, eliminates doublers and their attendant apparatus — and evils. Having decided on the type of oscillator we wish to use, the next thing to consider is the choice of a suitable tube.

There are on the market at the present time several tubes that are suitable as electron coupled oscillators; among these, the 59, 2A5, 57, and 24A are the best bets. The 59 was selected over the others because of its ability to deliver larger output. It was found, though, that the 59s made by different companies varied greatly in their ability to perform the required task, some refusing to operate at all after running about five minutes. This should not be a deterrent, however, because tubes made by the leading manufacturers were found to be entirely satisfactory. Now, having disposed of the oscillator tube, the next step is to decide what the amplifier tube is to be.

It is hardly good practice to attempt to select the amplifier tube without first considering the carrier power desired and the percentage of modulation we intend to use. In fact, it is much more important that we first consider what modulator tube to use. We will worry about the amplifier later. For 100% modulation it is necessary to have half as much audio power as we have carrier. There are very few audio tubes in the low price class that can furnish more than about three watts of reasonably undistorted output. This means, simply, that we cannot allow our r.f. carrier to be higher than six watts, if we want to come even close to doing a good,

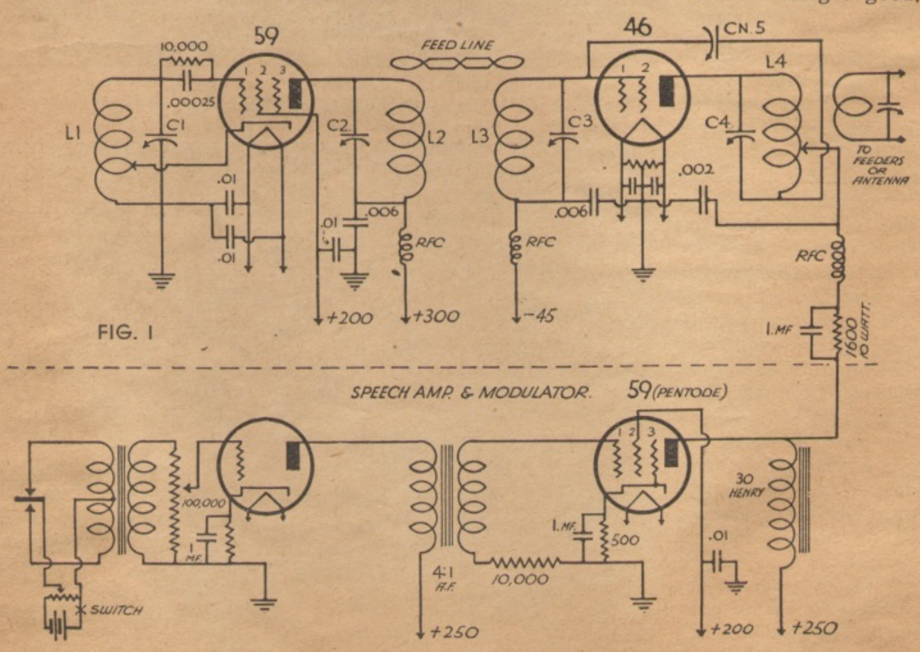


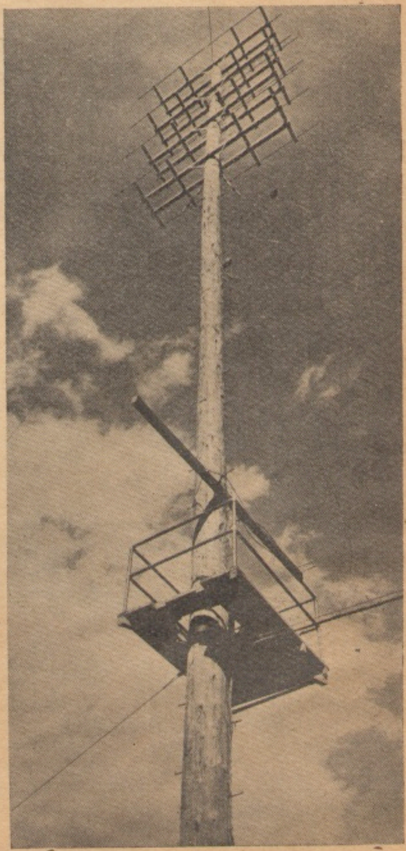
Fig. 2—Circuit Diagram, Showing All Values, for 10-Meter Phone.

A Type 56 is used as speech amplifier.
L1—9 turns, 2-in. dia., 1/8-in. copper tubing.
L2-L3-L4—4 turns each, 2-in. dia., 1/8-in. copper tubing.
C1, C4—13 plate condensers, with alternate plates removed. Cardwell Type 405-B.
C2, C3—100 mmfd. Midget Variables with alternate plates removed.
CN5—5 plate Midget, single spaced.
RFC—Radio Frequency Chokes, No. 36 D.C.C. wire, 1/4-in. form, winding space 2½-in. long, single layer of wire.

high percentage job of modulating. The 59, as a pentode, will deliver three watts and has the further advantage that it can be driven directly by a good high gain single button mike, no speech amplifier being necessary. In the case of a double button mike (almost a necessary refinement) a stage of speech is needed, a 56 being used for this purpose. The speech amplifier should be used even with the single button mike because it insures sufficient swing to the modulator and allows a finer adjustment of that swing, an essential factor in a distortionless Class A amplifier. By limiting the carrier to six watts the selection of the final RF tube becomes a very simple matter. A 46 was used because, with the two grids tied together, the tube works very near to cutoff, thereby requiring only a small amount of bias to operate the tube as a Class C amplifier. It has the further advantages of being easily capable of standing the modulation peaks (24 watts) and being an easy tube to excite. It is conceivable that some slight amount of amplitude distortion is likely to be present, due to the fact that no buffer tube is used to build up the excitation. This distortion, however, should be limited to a very small amount if the oscillator is adjusted for maximum output.

Fig. 1 shows the RF portion of the outfit. It incorporates some features not usually considered. Where the oscillator is self-excited (as it is in this case), the utmost care must be taken to avoid any mechanical vibration. No matter how stable the oscillator may be, the whole system can be ruined by mechanical vibration. With this fact in mind, extreme care was taken to make all leads as short and direct as possible, without recourse to the fancy bends and twirls sometimes used. The tubing on the inductances is heavy enough to do justice to a well loaded ten with about ten times the input used on the 46. A special mechanical arrangement was used to anchor the coupling loops and the feed line between the oscillator plate tank and the amplifier grid tank. All midget condensers are double-spaced to lessen the likelihood of change in capacity, due to vibration. The coils were not made plug-in but were fastened permanently to the stand-off insulators. In the case of the oscillator coil it would probably be advisable to mount a hard rubber strip across the top to lessen the tendency for this coil to start vibrating. The ten-meter coils have so few turns that no trouble is experienced from this source. The outfit is tuned in the conventional manner, the only precaution being that the tap on the oscillator coil (cathode) has a great effect on the harmonic output, and consequent excitation to the amplifier stage. Three turns from the ground end was found to be the best position in this unit, though this will probably vary in other arrangements. The three jacks shown on the front baseboard are, respectively, C bias lead of final, Center-tap of final (to insert key in case of CW), and High Voltage lead of final. The meter can be plugged into the C bias lead to determine the correct adjustment of the excitation from the oscillator, and the grid meter can further be used to neutralize in the conventional manner. No trouble was experienced in neutralizing, though it might be well to point out that the high voltage clip on the final will go more toward the center of the coil than is usual in other tubes.

For the benefit of those who don't like to figure, it might be stated that the proper value of load resistance the Class C amplifier offers to the modulator is obtained at 30 mills at 200 volts (6666 ohms—close enough to the value of load resistance for maximum output from the 59, i.e., 6000 ohms.) These values of current and voltage when multiplied give the required input of six watts. See Fig. 2 for proper value of drop resistor and other details.



Elaborate High-Frequency Antenna System used by Bell Telephone Engineers.