FRANK C.

Jones

ULTRA-High-Frequency Handbook

FIFTY CENTS

1937

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- Fil. Current 1.75A
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Jones
ULTRA-High-Frequency Handbook

By Frank C. Jones

1937
EDITION

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Contents

Introduction

THIS is the fourth edition of Frank C. Jones' work on ultra-high-frequency radio communication. Three previous editions sold readily; almost 100,000 copies were absorbed by amateurs and experimenters who found fascination in the 5-meter band.

This, the fourth edition, comes to you under a new title: "Jones Ultra-High-Frequency Handbook." It is no longer the "5-Meter Radiotelephony" book of old, because the newer printing covers a wider scope than the 5-meter band alone. Micro-Waves are treated in elaborate detail in this new edition and a number of excellent receivers, transmitters and transceivers are described.

The newer and better 5-meter equipment is designed to operate with the latest type tubes. Transceivers still find their place in these pages because they are being used in increasing numbers in localities where they do not interfere with other 5-meter transmissions and receptions. Then, too, the interest in 5-meters in foreign countries is growing by leaps and bounds, and the popular Jones transceivers are in use in practically every civilized country in the world. For this reason the author has seen fit to design a better group of transceivers for those who must use equipment of this type. The American amateur can take his choice from a number of excellent transmitter-receiver combinations which are herein described. Good sportsmanship demands that transceivers be operated only in non-congested areas.

Jones and 5-meter communication are synomymous. Construction of the gigantic San Francisco-Oakland Bay Bridge was aided by Jones-designed u.h.f. equipment which was in continuous service for a number of years. Other commercial services have also chosen the reliable Jones circuits for use in transmitters and receivers.

Thus the reader of this book is assured that the equipment herein described is not of an experimental nature; it has been tried and proven in actual use, not alone for amateur work but also for police, marine, airways and home-station service.

More powerful and more elaborate transmitters than those discussed in these pages are shown in a new Jones book which will be ready for distribution early in February, 1937. Its title is "Amateur Radiotelephony", and it covers all types of phone equipment for operation in any band from 160 to 5 meters. Likewise, the experimenter may enhance his knowledge of general amateur and allied radio subjects by procuring a copy of the 1937 edition of "Jones Radio Handbook" and its companion work: "Supplement To Jones Radio Handbook," which is included with the purchase price of the Handbook proper.

—*The Publisher.*

ULTRA-HIGH-FREQUENCY COMMUNICATION

● The portion of the short-wave radio spectrum that lies below 10 meters is commonly referred to as the *Ultra-High-Frequency* range. Beginning with the amateur band of 10 meters, and continuing down the spectrum in wavelength (upward in frequency), the following radio services are in operation:

7 to 9 meters, approximately, *Police and Experimental.*
5 to 8 meters, approximately, *Television and Experimental.*
5 meters, *Amateur.*
4 to 5 meters, approximately, *Television.*
3 meters, *Aircraft Beacons For Landing Services and Facsimile Systems.*
2½ Meters, *Amateur.*
From 2½ meters to 1 meter, *Experimental and Remote Pick-up* with the exception of the 1¼ meter band which is for *Amateurs.*
1 meter to 1 centimeter (0.1 meter), *Experimental Micro-Wave Region.*

The ultra-high-frequency amateur bands are in harmonic relation with one another, i.e., the harmonic frequencies fall in succeeding bands, such as 10, 5, 2½ and 1¼ meters. These wavelengths correspond to frequencies of 30, 60, 120 and 240 megacycles, respectively. A megacycle is 1,000,000 cycles; it is simply another term that expresses operating frequency.

The speed of light is approximately 300 million meters per second (approximately 186,000 miles per second), and in order to show the relation between the frequency and wavelength of radio waves the following formulas are given:

$$F = \frac{300,000,000}{\lambda}$$

$$\text{or } \lambda = \frac{300,000,000}{F}$$

Where F is the frequency in cycles per second. λ is the wavelength in meters.

The micro-waves extend into the region of heat-wavelengths, thence into wavelengths of light. Light waves are extremely short but there are other wavelengths still shorter, such as *X-rays, Gamma-rays* and *Cosmic-rays.*

A radio transmitter sends a wave into space; the required band width for each type of transmitter varies with the type of service. Some services, such as television, require an extremely wide band, and thus the actual number of channels available between 1 and 10 meters is not as great as would be indicated by the tremendous range of frequencies involved. A very large number of stations can be accommodated in the ultra-high-frequency spectrum. The theoretical number of available frequencies between 1 and 10 meters exceeds the range of the combined total of all short-wave, broadcast and long-wave services.

Radio experiments were first conducted before the close of the last century on the ultra-high-frequencies by *Hertz,* and others. Most of the practical developments, however, were contributed within the last ten years.

Ultra High-Frequency Phenomena

● Very short radio waves behave more like light waves, whereas longer radio waves are reflected back to earth by the *Heaviside Layer.* The direct or ground waves travel in optical paths. The wavelength, however, is thousands of times greater than that of light, resulting in a greater curvature of the paths of the waves. For this reason the range is greater than that which can be obtained by means of light rays, and signals can be received from points somewhat beyond the horizon. The range of transmission is governed by the height of the transmitting and receiving antennas. Objects that lie in the path between transmitting and receiving antennas introduce a *"shadow effect"* which often prevents reception of the transmitted signal. Objects such as hills, buildings, and even individual trees will often reflect or attenuate the radio wave. This shadow effect can be overcome to some extent by using greater power in the transmitter in order to produce a proportionately greater field strength at the receiving antenna. Long-distance communication is extremely erratic; occasionally the radio waves between 5 and 10 meters are reflected back to earth by the *Heaviside Layer* with the result that they are sometimes received over great distances. This effect depends upon the degree of ionization in the *Heaviside Layer,* which varies with the season of year, time of day, and also seems to depend on sunspot activity. At distances somewhat beyond the horizon, transmission and reception is often erratic because the atmosphere changes its degree of temperature in layers close to the earth, which in turn may change the degree of refraction of these ultra-short radio waves. Refraction bends the radio wave into a curve along the earth's circumference, and therefore increases the range of the radio wave beyond the optical distance.

Remarkably little power is required and for communication over a range of only a few miles of free space, a transceiver output of less than one watt will provide very satisfactory results.

Technical Considerations

● A simple ultra-high-frequency receiver circuit is shown in Fig. 1. It is similar to longer-wave receiver circuits, the only change being in the physical size of the components, such as the antenna, tuning coil and condenser, and the degree of regeneration. Another important factor in ultra-high-frequency receiver design is the length of the connecting leads in all radio-frequency circuits; these leads must be very short.

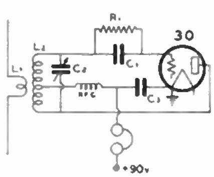


FIG. 1.

Fundamental U. H. F. Receiver Circuit.

Various forms of regenerative, super-regenerative and superheterodyne circuits are used for receiving. Fig. 1 can be operated in either a regenerative or *super-regenerative* condition, depending upon the applied plate voltage and the value of the grid-leak resistor *R1*.

Super-regeneration is regeneration carried *beyond* the point of oscillation without distortion to the received signal; this is accomplished by alowing the detector to oscillate, then damping-out the oscillation a great many times per second at a rate above audibility. Super-regeneration is a great deal more sensitive for weak signal reception, and becomes extremely effective in the ultra-short-wave range. The quenching or damping effect can be accomplished either by a blocking grid-leak action or by means of separate low-frequency oscillation applied to grid or plate voltage of the detector. The circuit in Fig. 1 can be used as a blocking grid-leak type of super-regenerator by choosing the values of *C3, R1* and *C1* in such a manner that radio-frequency oscillation is started and stopped at a rate above audibility. This circuit functions as an ordinary oscillator in which the resistance of the grid-leak is too high to permit the electrons on the grid to leak off at a rate that gives a constant value of grid-bias voltage. This blocking action causes a change in the average bias and stops the oscillation, because the plate current is decreased and the mutual conductance of the tube also decreases. If the circuit constants are correct, the blocking action takes place at an inaudible rate and super-regeneration is accomplished.

Another form of damping or quenching makes use of a separate oscillator functioning at approximately 100,000 cycles per second to control the ultra-high-frequency oscillation. The circuit is shown in Fig. 2.

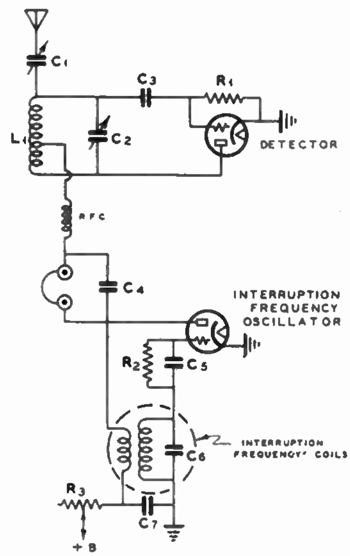


FIG. 2.

U. H. F. Receiver Circuit with Separate Oscillator.

The low-frequency oscillator voltage is coupled into the detector plate circuit. In this case, the interruption frequency varies the detector plate voltage to such an extent that the detector tube goes in and out of oscillation at a rate determined by the low-frequency oscillator. The circuit is similar to that of *Heising* Plate Modulation, as used in radio transmitters.

In either circuit, fairly heavy antenna loading is needed in order to obtain good quality and sensitivity; the antenna coupling can be varied by means of the coupling condenser C1 in Figs. 1 and 2, or by means of variable inductive coupling between the antenna and detector tuned circuit. Too much antenna coupling will tend to pull the detector out of super-regeneration.

Super-regeneration has a very distinct advantage: it provides high sensitivity to weak signals, and low sensitivity to strong signals. This automatic volume control action greatly reduces automobile ignition interference because this kind of signal is of very short duration. The detector sensitivity automatically drops down during the small fraction of a second in which this impulse is present, and although the desired signal is also reduced the human ear will not respond to changes of such short duration. The ignition interference in this way does not cause an excessively loud signal in the audio amplifier output as compared with the strength of the received phone signal. Super-regeneration also provides very high sensitivity in relatively simple circuits. The hiss, or rushing sound, audible in the output of a super-regenerative receiver, is due to thermal and contact circuit noise. The detector is in an extremely sensitive operating condition when no signal is present, thus the noise is greatly amplified and made audible in the loud-speaker or head-set. A carrier signal automatically reduces the sensitivity and consequently decreases the background noise or hiss. A strong signal will completely eliminate the background noise.

Unlike ordinary regeneration, super-regeneration always broadens the tuning. Super-regenerative detectors radiate a signal fully modulated by the quenching frequency. This signal will cause bad interference in other receivers within a radius of several miles. The blocking grid-leak detector is more troublesome in this respect and a RF amplifier should be placed betwen the antenna and any super-regenerative detector in order to minimize radiation. The RF amplifier will also provide some increase in sensitivity.

Receivers designed for 5-meter operation are generally of the super-regenerative or super-heterodyne type. Regenerative or super-heterodyne circuits are more desirable for 10 meter reception because this band is used for both telegraph and phone. In the micro-wave range, below ½ meter, super-regeneration is difficult to obtain and *Barkhausen-Kurz* oscillator circuits are more suitable. The circuits are covered elsewhere in these pages.

Transmitters

● For short range portable operation, self-excited modulated oscillators are widely used. The circuit in Fig. 3 is a typical example of a transceiver and low-power transmitter.

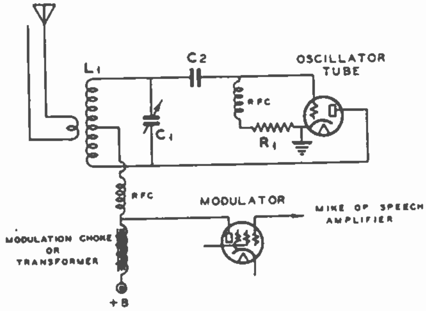


FIG. 3.

Self-Excited Modulated Oscillator.

The radio-frequency circuit is quite similar to that used for receiving, shown in Fig. 1, except that the value of grid-leak *R1* is so low that no blocking effect takes place and stable oscillation is maintained. The modulator supplies an audio-frequency voltage which varies the effective plate voltage of the oscillator tube, resulting in a modulated carrier signal.

In the micro-wave region below 1 meter, regenerative oscillators with Acorn tubes are suitable for operation down to approximately 40 centimeters. *Barkhausen-Kurz* or *Gill-Morrel* electronic oscillators are often used below 1 meter. *Magnetron* oscillators also provide a means of obtaining RF output down to a few centimeters in wave-length.

Crystal controlled transmitters give greater stability than any other form in the range between 3 and 10 meters, but at the disadvantage of requiring more tubes and equipment. Resonant line oscillators have fairly good frequency stability, consistent with economy, and they are very popular for ultra-high-frequency transmission.

Modulated oscillators with tuning coils and condensers are suitable for portable operation because of their compactness but these oscillators are subject to excessive frequency modulation. This effect is detrimental to audio quality and causes the transmitted signal to spread out over a band of frequencies several times as wide as normally required for transmission of intelligence.

Transmitters for portable operation can operate successfully with power outputs of one watt or less. Those for mobile operation should have an output of from 5 to 10 watts; fixed amateur stations require power outputs varying from 5 to 30 watts. Experimental and commercial stations require higher outputs; several hundred watts will provide general coverage over a radius of 25 or 30 miles.

Antennas and Transmission Lines

● Point-to-point communication is most economically accomplished by means of directional antennas which confine the radiated fields to a narrow beam in the desired direction. If the power is concentrated into a narrow beam, the apparent power of the transmitter, or the sensitivity of the receiver, is increased a great many times. For general coverage in all directions the half wave vertical antenna is almost universally used. A vertical antenna transmits a wave of low angle radiation parallel to the surface of the earth and is therefore especially satisfactory for ultra-short-wave operation. Horizontal antennas are more directional in two directions, but they waste a great deal of the radiation in an upward direction. The radiation in a direction parallel to the earth is the only portion that is useful. The radiation from a horizontal antenna is horizontally polarized, thus it is best received on a horizontal antenna. Vertically polarized radio waves are not as easily reflected upward by the surface of the earth as are horizontally polarized waves.

The antenna system for either transmitting or receiving should be as high as possible above the earth and nearby objects. The physical size of half wave antennas is small, thus an effective system of supplying power from the transmitter to the radiator must be provided. The same holds true for receiving. Transmission lines serve this purpose; they consist of twisted-pair wires, spaced wires, concentric lines or single wire feeders. Two-wire spaced feeders, such as two No. 14 or 16 gauge copper wires spaced 2 to 4 inches apart, have the lowest losses. Concentric line feeders have lower losses than twisted-pair lines and they are nearly as efficient as spaced feeders. Single-wire feeders are not much more efficient than tuned feeders, such as those used with Zepp. antennas. Tuned feeders are only desirable for very short transmission lines.

Circuit Design

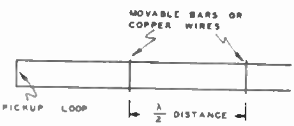
● Rigidity and compactness, with very high-quality insulation and correct arrangement of parts are essential in ultra-high-frequency equipment design. Ceramic materials or their equivalent should be used for sockets, condenser insulation, coil supports and stand-off insulators. All parts should be rigidly mounted so that no frequency variation will result from vibration. All radio-frequency wiring should be very short and direct, well soldered with non-corrosive solder. Pastes and acids must be avoided, as well as excessive amounts of rosin on the joint to be soldered. Tuning condensers must be remote from metal panels, and control shafts should extend to control dials by means of bakelite extension shafts. Slight changes in physical design often change the value of resistors and condensers for satisfactory operation in both transmitters and receivers.

Wavelength and Frequency Determination

Lecher Wires

● The wavelength of an ultra-high-frequency receiver or transmitter can be measured by means of parallel wires (*Lecher Wire Systems*), by wavemeters or by means of harmonics from calibrated low-frequency oscillators.

Lecher Wire measuring systems are shown in Figs. 4 and 5. They are suitable for wavelength measurements over the entire ultra-high-frequency range. An accuracy of approximately 1% can be expected; for more accurate frequency or wavelength determination the harmonic method should be used to supplement these measurements. A Lecher wire system consists of two parallel wires coupled to the transmitter or receiver by means of a closed loop or pickup coil, as shown by the *Oscillator Coil* in Fig. 5.



LECHER WIRE SYSTEM

FIG. 4.

Standing waves of voltage and current will occur along the parallel line, and these standing waves can be located with a sliding bar or copper wire, as shown in Fig. 5.

The parallel line can be constructed of bare copper wire, spaced about three inches apart. The length of each wire will depend upon the wavelength being measured, such as 35 or 40 feet for 5 and 10 meter measurements, 17 to 20 feet for 2½ meters, or 5 to 7 feet for wavelengths below 1 meter.

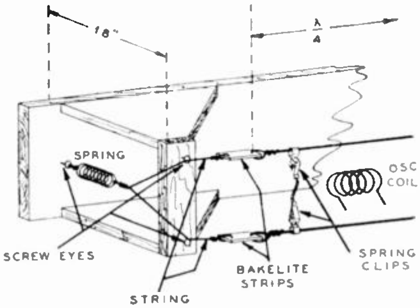


FIG. 5—Lecher Wire Measuring System.

When these wires are coupled to the oscillator, standing waves are produced in the wire, and the distances between points of maximum current are equal to half wavelengths. The oscillator should have an indicating device, such as a DC milliammeter in either its grid or plate circuit. When the wavelength of a receiver is being measured, a variation in super-regeneration or oscillation intensity will be audibly heard in the output of the receiver. Another indicator for transmitter measurements consists of a small turn of wire and a 6-volt flashlight globe, or a RF thermo-galvanometer coupled to the closed end of the Lecher Wire system. A deflection in plate current, or dimming of the lamp, will be noticed when the shorting link is across some half wave point on the parallel wires. The exact wavelength of the oscillating circuit is found by sliding the shorting link betwen the first and second points of indication, making note of the points, then measuring the distance with a scale or tape measure. To obtain the wavelength in meters, this distance must be converted from feet into meters by multiplying the number of feet by 0.656, or the number of inches by 0.0547. This factor takes into consideration the half wave points when converting the results into actual wavelength.

Wavemeters

● Lecher Wire systems are bulky and considerable time is consumed in making the desired measurements. Wavemeters are more convenient and easy to construct. A simple absorption wavemeter, having a range of between 4.7 and 7 meters, consists of a 25 mmfd. midget variable condenser paralleled with a 3-30 mmfd. semi-fixed condenser of the "padder" type, and a coil wound with 5 turns of No. 10 wire in a winding space of one-inch, a half-inch in diameter, self-supported.

Another form of absorption wavemeter, having a range of from 4 to 14 meters, can be made from a 150 mmfd. variable condenser connected across a 2-turn coil of No. 10 wire, 2-inches in diameter. See Fig. 6.

The coil should be supported on bakelite spacers. A neon lamp or vacuum-tube diode can be shunted across the circuit for indicating resonance. In the design of any wavemeter, the entire circuit should be rigidly constructed. Hand-capacity effects can be eliminated by tuning the condenser with an extension handle of wood or bakelite.

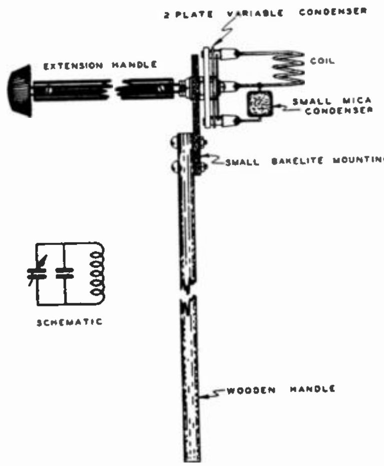
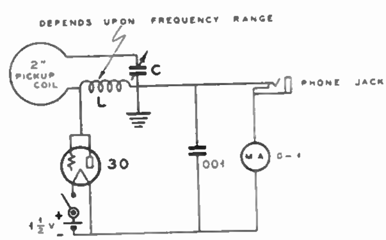


FIG. 6.

For 2½ meter measurements, a one-turn coil of heavy wire, approximately 1-inch in diameter, and shunted with a 15 mmfd. midget variable condenser, will serve as an absorption wavemeter.

The wavemeter can be calibrated over the tuning condenser scale by coupling the coil to an oscillator circuit; the oscillator wavelength can be varied and its frequency determined by Lecher Wires. When the wavemeter is tuned to resonance, the oscillator milliammeter or RF indicator will provide an indication. After the wavemeter has been calibrated, it can always be used for measuring the wavelength of oscillating receivers and transmitters.



WAVEMETER WITH DIODE INDICATOR

FIG. 7.

Fig. 7 shows a wavemeter that is quite sensitive in the region of 3 to 10 meters. A type 30 tube with a single 1½ volt flashlight cell serves as a diode to rectify the radio-frequency. A 0-1 d-c milliammeter is the resonance indicator. A closed-circuit telephone jack enables this wavemeter to be used as a monitor for checking phone quality and over-modulation.

5-Meter Field Strength Meters

● Field strength meters give an indication of the power in a transmitter antenna. The circuit diagrams for two such devices are shown in Figs. 8 and 9. The field strength meter is placed in the vicinity of the transmitter antenna and maximum indication of the instrument denotes maximum antenna power. Field strength meters should be housed in completely shielded metal cans.

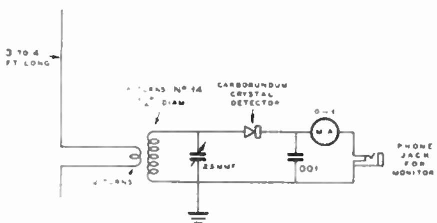


FIG. 8
5-Meter Field Strength Meter. The Two Antenna Wires Are Each 3 to 4 ft. Long.

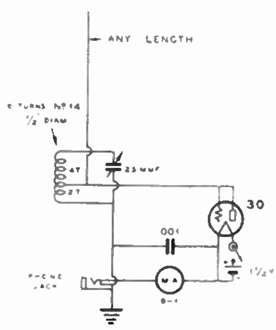


FIG. 9
Field Strength Meter with Diode Tube.

Harmonic Frequency Determination

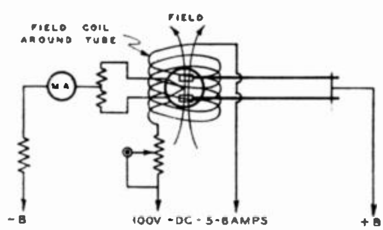
● The harmonics of a quartz crystal oscillator provide an accurate means of frequency determination. An oscillating crystal in the 160 meter or broadcast band will produce strong harmonics in the ultra-high-frequency region between 2 and 10 meters. A super-regenerative receiver, when tuned to this region while loosely coupled to the oscillator, will indicate the harmonics by sharp reductions in hiss level in the receiver output. An oscillating regenerative receiver can be tuned to zero-beat with these harmonics, and then to the ultra-high-frequency transmitter for accurate frequency determination. An absorption wavemeter is a necessary adjunct for approximate wave-length measurements in order to make certain that operation is secured from the desired harmonic.

Micro-Waves

● Micro-waves, as previously related, are those whose length is less than one meter. Micro-waves are generated by means of *Magnetrons, Electron-Orbit Oscillators,* and *Regenerative Oscillators.* Micro-waves are used by broadcast stations for remote pickup, by amateurs and experimenters, and for occasional telegraph and telephone communication, such as the British Channel spanning system. The technical problems of this field are numerous, yet new tubes designed for micro-waves have been instrumental in increasing the usefulness of the band.

The Magnetron Oscillator

● The Magnetron is a specially designed tube for very-short-wave operation. It consists of a filament or cathode between a split plate, as shown in Fig. 10.

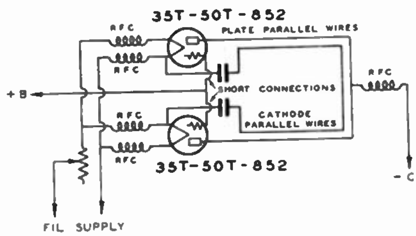


SPLIT MAGNETRON OSCILLATOR
FIG. 10

A magnetic field is produced at the filament by means of a large external field coil which is energized by several hundred watts of DC power. Ultra-high-frequency oscillations are produced in the split-plate circuit when this magnetic field is in the correct direction, and of the proper intensity. A parallel wire tuned circuit can be used for wavelengths below one meter, or for ordinary tuned circuits with wavelengths above one meter. These tubes are available for experimental purposes and will produce outputs of several watts. The frequency stability is not very good and it is difficult to obtain satisfactory voice modulation from Magnetron Oscillators.

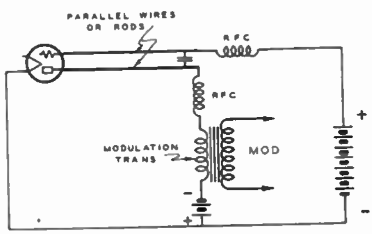
Electron Orbit Oscillator

● The range of oscillation in ordinary circuits is limited by time required for electrons to travel from cathode to anode. This transit time is negligible at low frequencies, but becomes an important factor below 5 meters. With ordinary tubes, oscillation cannot be secured below 1 meter, but by means of *Electron Orbit Oscillators,* in which the grid is made positive and the plate is kept at zero or slightly negative potential, oscillation can be obtained on wavelengths very much below 1 meter. Parallel wire tuning circuits can be connected to these tube oscillators in order to increase the power output and efficiency. The tubes most suitable for this type of operation have cylindrical plates and grids, and their output is limited by the amount of power which can be dissipated by the grids. For transmitting, tubes such as the 35T, 50T or 852 can be used in the circuit shown in Fig. 11, which is a modification of the *Gill-Morrel Oscillator.* More output is obtained by using a tuned cathode, instead of tuned grid, circuit. Modulation can be applied to either the plate or grid. The frequency stability is very poor. The circuit in Fig. 11 is an early type oscillator.



KOZANOWSKI OSCILLATOR

FIG. 11



B - K OR G - M OSCILLATOR

FIG. 12

Figs. 13 and 14 illustrate a ¾-meter transmitter and receiver used in 1933 by the author. The power output is rather low, but telephone communication over short distances can be satisfactorily accomplished.

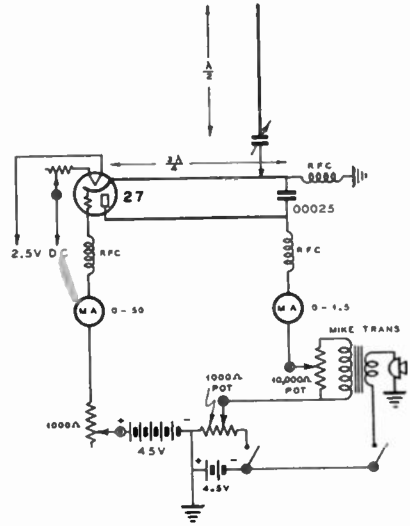


FIG. 13

¾ Meter Circuit Used by Jones in 1933.

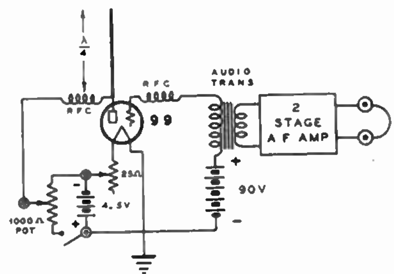


FIG. 14

¾ Meter Receiver (1933).

Regenerative Oscillators

● The introduction of the *RCA Acorn 955,* and *Western Electric* 316-A tubes made ½-meter regenerative oscillators practical. These tubes are more efficient than ordinary types for ultra-high-frequency work. Fig. 15 illustrates the RCA Acorn triode. Circuits, such as that shown in Fig. 16, and a constructional plan in Fig. 17, are satisfactory for low-power transmitters and super-regenerative receivers. The 955 Acorn can be used as an oscillator in super-heterodyne receiver circuits with its companion tube, *RCA 954 (or 956) Acord Pentode,* in the RF portions of the circuit. The regenerative circuits are quite similar to those for longer wavelengths, except for the physical size of condensers and coils. The tube element spacing in these *Acorn* tubes is made so small that electron transit time becomes a negligible factor for wavelengths above 0.6 meter.

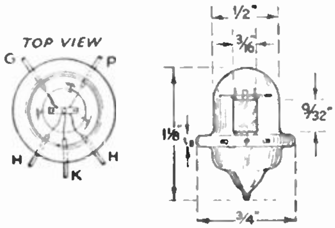


FIG. 15
RCA Acorn 955

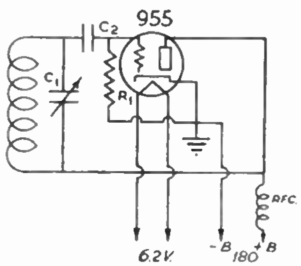


FIG. 16
RCA 955—Circuit Diagram and Suggested Layout.
L1—8 turns, 1/2-in. outside diameter, No. 18 wire, spaced 1/4-in. between turns.
C1—Tuning condenser; 2 circular brass plates 3/4-in. in diameter; 10/32 thread on adjusting screws.
C2—.00025 mica condenser, postage stamp type.
R1—15,000 ohms, 1 watt carbon resistor.
RFC—1/4-in. bakelite rod wound 1 1/2-in. with No. 32 DCC wire.

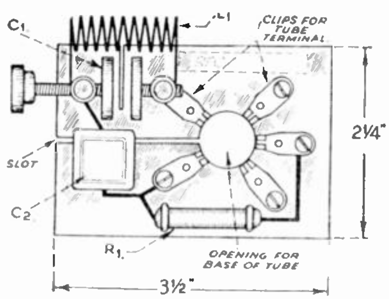


FIG. 17—Plan view of transmitter.

Micro-Wave Transmitters

● A micro-wave transmitter for operation slightly below 1 meter is illustrated in Fig. 18. The *RCA 955 Acorn* is used in a parallel-rod oscillator with cathode, rather than grid-leak, bias. Another 955 serves as the modulator. This transmitter is similar to one built into a silk-top hat, and used by the NBC for remote pickup of commercial broadcasts. The antenna protrudes through the hat, the batteries and modulator are carried in a leather belt. A similar oscillator was built into a walking cane, the cane holds both the parallel-rod oscillator and antenna. Signals have been received over distances of 3 miles. Automobile ignition interference is practically absent at wavelengths below 1 meter.

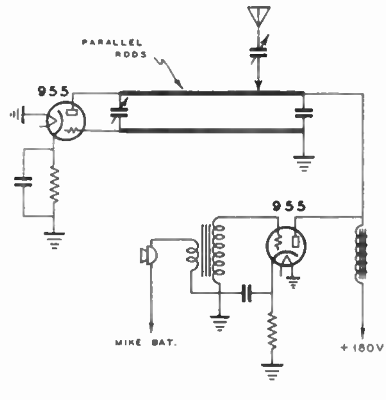
Micro-Wave Tube Characteristics

RCA 954 PENTODE

Heater voltage	6.3
Heater current	0.15 amp.
Grid-to-plate capacity	.007 mmfd.
Input capacity	3 mmfd.
Output capacity	3 mmfd.
Max. plate voltage	25 volts.
Max. screen voltage	100 volts.
Grid voltage	—3 volts.
Suppressor tied to cathode	
Amplification factor	Over 2000.
Plate resistance	Over 1.5 megohm.
Mutual conductance	1400 mhos.
Plate current	2 ma.
Screen current	0.7 ma.

RCA 955 TRIODE

Heater voltage	6.3
Heater current	0.15 amp.
Max. plate voltage	180 volts.
Max. plate current	7 ma.
Amp. factor	25.
Plate resistance	12,500 ohms.
Mutual conductance	2,000 mhos.



320MC TRANSMITTER
FIG. 18

66 CM (2/3-Meter) Transceiver

● This is perhaps the first disclosure of a transceiver that operates successfully on 1/2- or 2/3rds-meter. Operation at these very short wavelengths is accomplished with an Acorn triode and parallel wire circuits for grid, plate and filament. See Fig. 19. The filament cathode circuit is tuned with a quarter wave parallel wire section which is adjusted by sliding a .001 mfd. mica condenser along the parallel wires. See Fig. 20.

plate and grid parallel wires. For ⅔-meter, this bridging condenser is about 1½ in. away from the glass envelope of the 955 Acorn tube. 40 CM oscillation takes place when the condenser is bridged across the wires at the point of connection to the terminal clips of the tube. The wavelength of

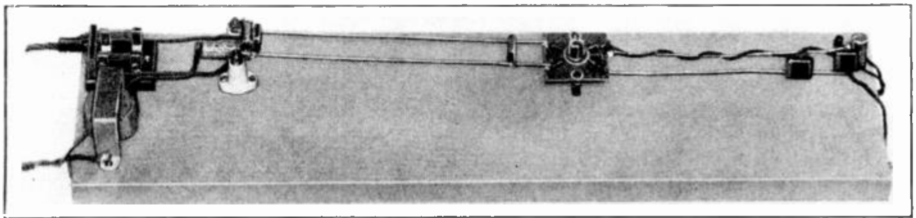


FIG. 19—66 cm. Transceiver with 955 Acorn Triode.

When this filament circuit is properly tuned, oscillation and super-regeneration can be obtained with relatively low values of plate voltage, even at wavelengths of 40 CM. This adjustment is not very critical over a range of a few centimeters. The ends of the quarter wave section have high RF potential; the short-circuited end (.001 bridging condenser) have zero RF potential, and thus the parallel wires can extend a few inches beyond the short-circuited end. The cathode resistor, filament by-pass and cathode by-pass condensers can then be connected in place without need of varying their position for tuning purposes. The insulated filament lead is twisted around the cathode filament wire in order to make the combination act as a single RF conductor. A small mica condenser connected between this wire and the cathode or ground wire will increase the capacity and prevent RF absorption by the extended filament leads. The latter may connect to either a 6.3 volt AC source, or to a 6-volt storage battery.

operation increases as this condenser is slid outwardly along the parallel wires toward the other .0001 mfd. bridging condenser near the end of the parallel wires, at which point 1½ meter operation can be secured.

As illustrated in the photograph and circuit diagram, the portion of plate-grid parallel wires between the two .0001 mfd. condensers serves as a quarter wave tuning section which provides high efficiency when operating below ¾-meter. The RF potential across the .0001 mfd. condenser nearest the tube is not exactly zero at the ends of the condenser, since the physical length of the condenser becomes an appreciable portion of the tuned circuit between grid and plate. The quarter wave section, which at ⅔rds-meter is about 6½ inches, serves the purpose of two radio-frequency chokes for connection to the audio components of the transceiver. A quarter wave section is much more effective than RF chokes in the micro-wave region.

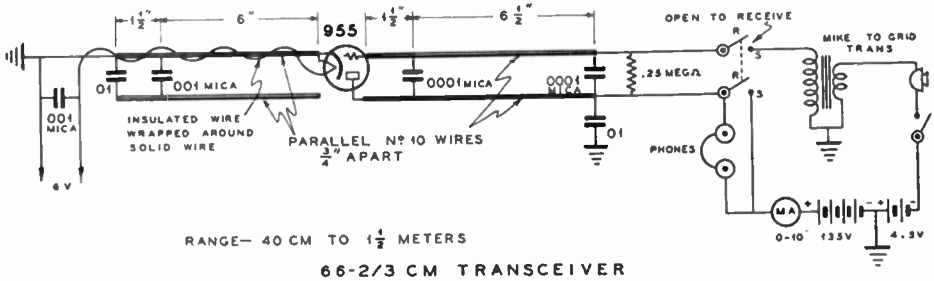


FIG. 20

The frequency or wavelength is adjusted to the desired value by means of a .0001 mfd. mica condenser connected across the

The antenna can be inductively coupled to this transceiver by supporting a ¾-turn loop (¾ in. dia.) close to the parallel wires in the grid and plate circuits of the 955 tube. This loop should be coupled to the oscillator between the tube and the .0001 mfd. bridging condenser nearest the tube. A half wave antenna for ⅔rds-meter is approximately 13 inches long. A two-wire Zepp. feeder, or matched impedance line, couples the antenna to the transceiver. A directive antenna array, or a *Yagi* antenna, is infinitely better for increased range at these very short wavelengths.

With the DPST switch closed, the 955 operates as a grid-modulated oscillator with plate current of approximately 6 to 7 MA.

With the switch open, the headphones are connected in the plate circuit, and the microphone transformer is disconnected from the grid circuit. Reception is obtained by superregeneration in the detector circuit, and the plate current drops to a value of between 1 and 2 milliamperes.

Plate modulation in the transmitter will give two to three times as much output, if more output is needed.

The RF circuit is very effective below 1 meter and outputs of ¼ to ½ watt can be expected between ½ and 1 meter. At 66⅔ (⅔rds-meter) the transmitter output is high enough to give more than half-scale deflection on a thermo-galvanometer having a range of 115 MA.

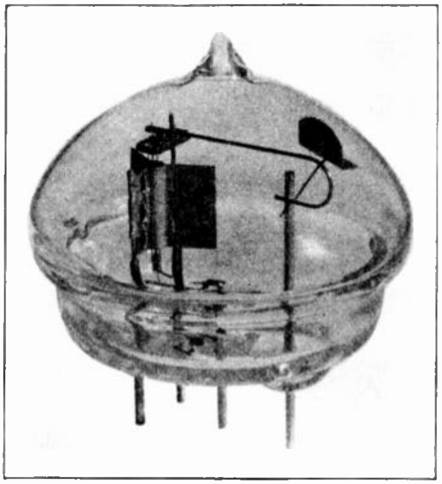


FIG. 21—W.E.-316A U.H.F. Triode.

W.E.316-A Micro-Wave Oscillator

● Western Electric has produced a new micro-wave triode which delivers from 5 to 10 watts output on wavelengths as low as ½ meter. The element spacing is so close that the tube operates efficiently as a regenerative oscillator with negative grid and positive plate for frequencies as high as 750 mc. The maximum plate dissipation is 30 watts. The transmitter illustrated in Fig. 22 delivers aproximately 7.5 watts with 400 volts on the plate. This power output is sufficient for coverage over a visual range, although in one case a ¾-meter signal was heard over a distance of 80 miles, which is far beyond the optical path. A large variety of circuits could be suggested for microwave operation, but the most simple of these is the one shown in Fig. 22. It consists of two parallel half wave rods, spaced about ¼-inch apart, to provide a ¾-meter tuned circuit of fairly-high "Q". See Fig. 23. The grid and plate of the tube are connected to the copper rods; this capacity causes the physical length to be less than a half wavelength. As can be seen from the photograph, the plate RF choke and grid-leak do not connect to the center of the rods, but rather across the voltage node. The distance between this point and the free ends of the rods is a quarter wavelength. The other distance is shortened by the tube capacity. Filament RF chokes, or tuned filament leads, are desirable for operation below 1-meter be-

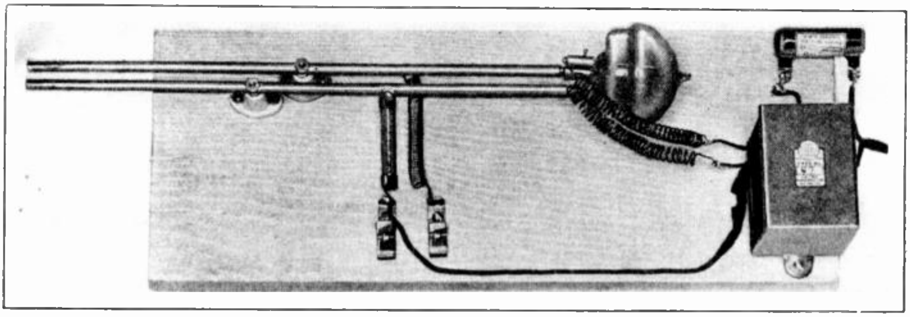


FIG. 22—W.E.-316A ¾-Meter Oscillator.

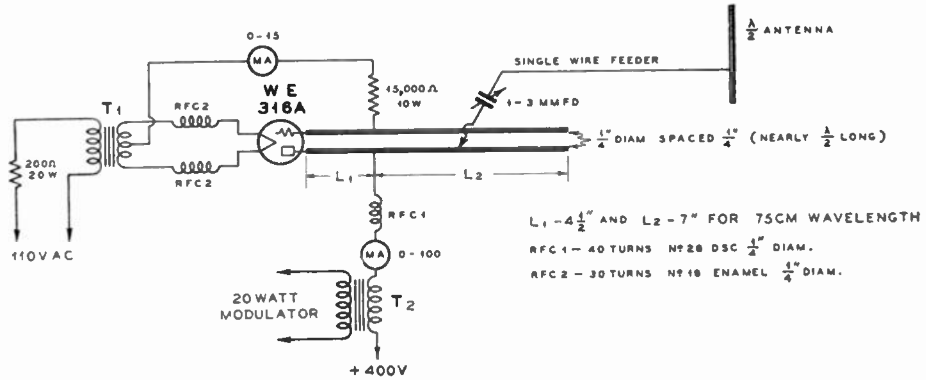


FIG. 23—W.E.-316A ¾-Meter Oscillator Circuit.

cause the filament is near a point of high RF potential in the oscillating circuit. These filament chokes consist of 30 turns of No. 16 enameled wire, wound on a ¼-inch rod, then removed from the rod and air-supported, as the picture shows. The length of these chokes is aproximately 3 inches. A 200 ohm resistor is placed in series with the 110-volt AC line to the filament transformer in order to reduce the transformer secondary voltage from 2½ to 2 volts, because the filament of the tube operates on 2 volts at 3.65 amperes. This particular oscillator gave outputs in excess of 5 watts on ¾ meters, even when no filament RF chokes were used.

This oscillator, when loaded with antenna, draws from 70 to 80 milliamperes at 400 volts plate supply. An audio modulator, such as a pair of 2A3 tubes, class AB connection, will supply approximately 15 watts of audio power for modulation. The oscillator should be tested at reduced plate voltage, preferably by means of a 1000 to 2000 ohm resistor in series with the positive B lead, until oscillation has been checked. A flashlight globe and loop of wire can be coupled to the parallel rods at a point near the voltage node, in order to indicate oscillation.

A 15-inch antenna rod or wire can be fed by a one-or-two-wire feeder of the non-resonant type. A single-wire feeder can be capacitively coupled to the plate rod, either side of the voltage node, through a small blocking condenser. If a two-wire feeder is employed, a small coupling loop, placed parallel to the oscillator rods, with the closed end of the loop near the voltage node of the oscillator, will provide a satisfactory means of coupling to the antenna. The power output is high enough so that operation is as simple as any 40 meter c-w transmitter.

W. E. 316-A Characteristics

Filament voltage	2 volts a-c or d-c.
Filament current	3.65 amperes.
Average thermionic emission	0.45 amperes.
Amplification factor	6.5.
Plate-to-grid capacitance	1.6 mmfd.
Grid-to-filament	1.2 mmfd.
Plate-to-filament	0.8 mmfd.
Max. plate dissipation	30 watts.
Max. d-c plate voltage	450 volts.
Max. d-c plate current	80 MA.
Max. d-c grid current	12 MA.

1¼ Meter Receiver

● Extremely small capacity between tube elements, and very small values of tuning capacities and inductances are essential for 1½ meter receivers. Conventional triode tubes have too much grid-to-plate capacity for effective operation at 1¼ meters. However, once the correct components are chosen, it is a very simple matter to build a high-sensitivity 1¼ meter receiver. See Fig. 24.

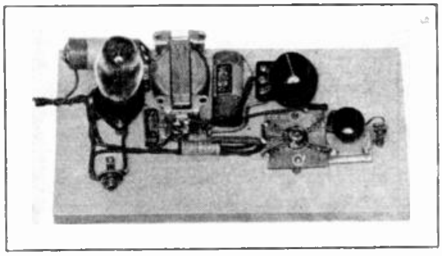


FIG. 24
1¼-Meter Receiver.

The grid and plate leads to the tuning condenser are so short as to be almost negligible. Either a coil or parallel wires forms an inductance for connection across the tuning condenser. Parallel wires occupy a few inches more of space, but they are more efficient because the circuit "Q" is higher.

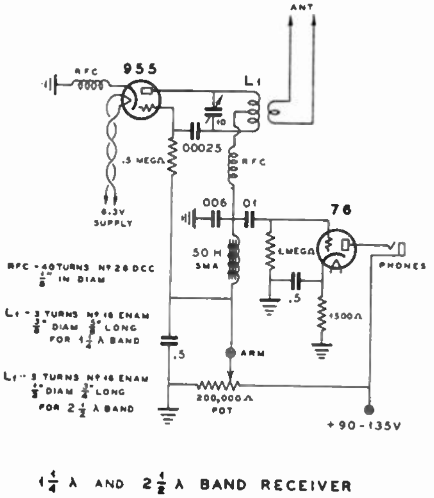


FIG. 25

The circuit shown in Fig. 25 is almost self-explanatory. Super-regeneration is secured by means of a blocking grid-leak condenser system. A cathode RF choke is generally necessary in order to obtain super-regeneration. Impedance coupling is shown between the detector and 76 audio stage because this method of coupling gives sufficient volume for headset reception. An audio transformer could be substituted, together with a type 41 pentode tube, if loudspeaker reception is wanted. A potentiometer controls the plate voltage to the super-regenerative detector; adjustment should be made for greatest detector sensitivity. Insufficient detector plate voltage will generally result in an audio howl. Super-regeneration takes place at slightly higher voltages, up to the full battery voltage supply. Greatest sensitivity occurs when the actual detector plate potential is nearly 45 volts. The proper setting will depend upon the characteristics of the particular 955 Acorn tube in the circuit, and the degree of antenna coupling.

The RF coil, L1, can be compressed or extended in order to permit the tuning condenser to cover the 1¼ or 2½ meter bands. Lecher wires provide a most convenient method for checking the wavelength of the receiver.

1¼ Meter Transmitter with RCA-834 UHF Tube

● The advent of several new tubes particularly designed for the ultra high frequencies makes possible the construction of a transmitter which will deliver from 10 to 50 watts on wavelengths below 5 meters. Ratheon RK-32, Western Electric 304-B, and RCA 834 are equally suitable for use in the transmitter shown in Fig. 26. The characteristics of all three tubes are similar.

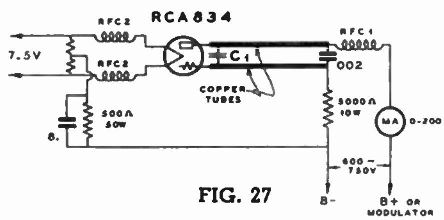


FIG. 27

1¼-Meter Transmitter.

C1—Aluminum Plates, 1¼ in. square.
Copper Tubes—3-in. long for 1¼ Meters. 9 in. long for 2½ Meters.
RFC1—40 turns No. 28 DSC, ¼-in. dia.
RFC2—25 turns No. 14 Enam., ½-in. dia.

The grid and plate leads are brought out through the top of the tube envelope in all cases, resulting in operation down to ¾-meter.

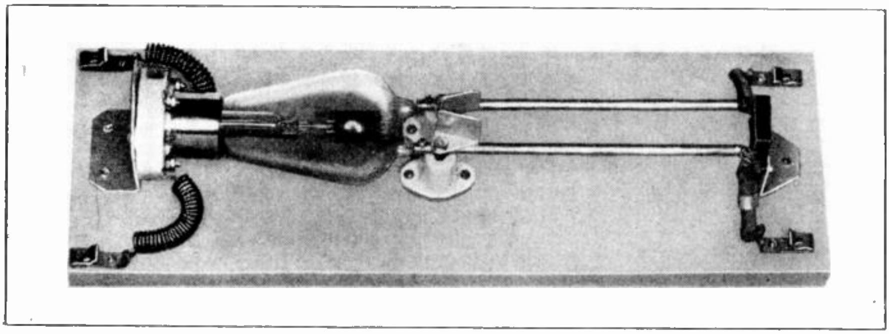


FIG. 26—1¼-Meter Transmitter with RCA 834 U.H.F. Triode.

The circuit in Fig. 27 is suitable for oscillation between 1 and 3 meters, depending upon the length of the parallel rods or pipes.

A slight variation of frequency is possible if two condenser plates each ¾ in. square, are connected across the pipes near the tube leads. This type of circuit works more efficiently than a conventional coil and condenser oscillator circuit. The tube leads fit into the ends of copper pipes, and small set screws provide good electrical contact between pipe and tube leads. This type of mounting must be used with care in order to avoid breakage of the tube envelope. The tube socket mounting strip should have slotted holes in order to make correct alignment with the copper pipes.

Filament RF chokes are necessary below 3 meters in order to secure oscillation. At 1¼ meters, the metal shell of the tube socket, and the metal support that holds the socket, introduce excessive capacity to the filament circuit of the tube, resulting in stoppage of oscillation if either of these metal surfaces is grounded. A non-metallic socket and bakelite socket support would be preferable if operation in the neighborhood of 1-meter is wanted. A tuned filament circuit, somewhat similar to that illustrated in the *66 CM Transceiver*, will work more effectively than RF chokes for wavelengths below 1½ meters.

The antenna feeder is coupled to the parallel pipes or tubes by means of a coupling loop. A half or quarter wave antenna can be capacitively coupled through a very small variable condenser to the plate rod at a point approximately one to two inches from the plate blocking condenser. Transmission ranges of 3 to 50 miles are possible if the antenna is located at high elevation. Even 1¼ meter waves tend to curve along the surface of the earth to such an extent that communication can often be obtained beyond the optical range.

2½ Meter Transmitter

● An RK-34 twin-triode tube is connected in a tuned-grid-tuned-plate circuit for 2½ meter operation in the transmitter illustrated in Fig. 28. A parallel rod or wire tuned-plate circuit gives good efficiency on 2½ meters, proved by tests where efficiencies of

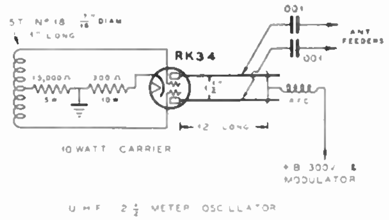


FIG. 28

approximately 50% were realized. A carrier power output of 10 to 15 watts is easily obtainable on 2½ meters. The circuit is shown in Fig. 28. If a more powerful modulator is connected to the oscillator, together with plate potentials of 500 to 600 volts, outputs of 25 to 30 watts can be secured.

A 15,000 ohm grid-leak and 300 ohm cathode resistor give stable grid bias for the oscillator. The cathode resistor prevents all tendency for the plate current to "run away" during operation. The grid coil consists of 5 turns of No. 18 wire, wound to cover a length of one inch, with an inside diameter of 7/16-inch. This coil is soldered directly to the tube socket terminals. The antenna feeders can be capacitively coupled to the plate circuit through a pair of .001 mfd. mica condensers. If a two-wire spaced feeder is used, these wires tap across the plate rods about two inches from the shorting bar.

The plate circuit is tuned to the desired frequency by sliding the shorting-bar along the rods. Antenna coupling is adjusted by

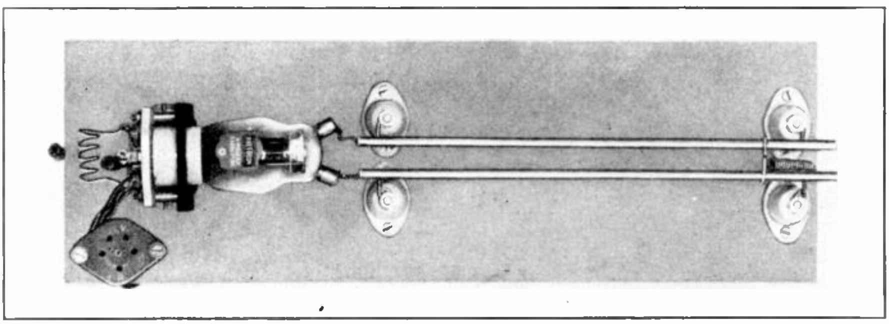


FIG. 29—Raytheon RK-34 2½-Meter Oscillator.

sliding the antenna taps along these rods until normal plate current is drawn. The inductance in the grid circuit can be slightly varied in order to obtain the best amount of feedback for high output.

A suitable modulator consists of a pair of type 42 pentode tubes driven by a 76 speech amplifier. The 42 tubes can be operated from the common 350 volt plate supply by means of a 30 henry, 150 ma., modulation choke. The screen voltage should be reduced through a resistor from the 250 volt supply; a 10 watt, 10,000 ohm resistor is of the correct size. A ½ mfd. bypass condenser from screen to ground will pass the audio frequencies from screen to ground for normal operation. The cathode resistor of 300 ohms, 10 watt rating, should be bypassed by means of a 25 mfd. low voltage condenser. If greater input is applied to the oscillator, a more powerful modulator is needed. Class B 46 tubes, or push-pull 6L6 tubes, will give ample audio power for inputs as high as 40 or 50 watts on the RK-34 tube. Normal plate current to the latter is 80 ma., although in actual practice this oscillator has been operated over considerable periods of time at 100 ma. plate current.

Single-Tube 2½ Meter Transceiver

● An exceedingly simple 2½ and 5 meter transceiver can be built to operate from a type 76 tube. The set is shown in Fig. 30.

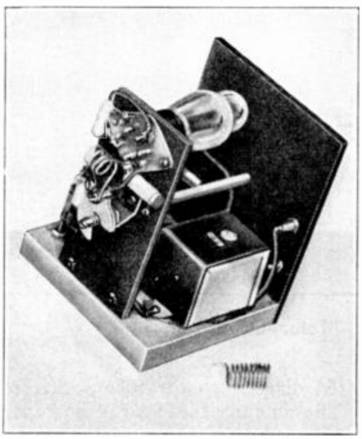


FIG. 30—Single-Tube Transceiver.

The 76 has low interelectrode capacities and high mutual conductance, thus it performs better than most other types of conventional tubes on 2½ meters.

The 76 tube acts as a grid-modulated oscillator for transmitting, and as a super-regenerative detector for receiving, in the circuit shown in Fig. 31. Switching from send to receive is accomplished with a DPST switch, the "on" position shorts-out the headset, and connects-in the grid modulation transformer when transmitting. In the receive position, the half-megohm (500,000 ohm) grid-leak produces super-regeneration.

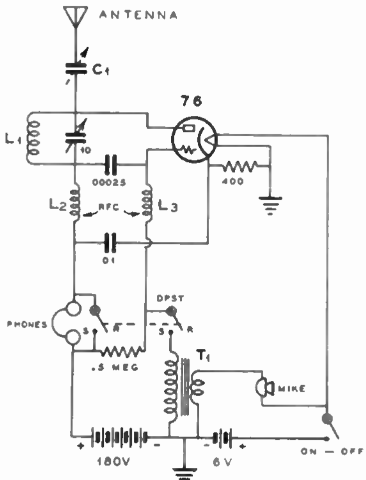


FIG. 31—Circuit Diagram.
T1—Mike-to-grid transformer.
C1—Antenna lead twisted around plate lead.
L2-L3—(RFC)—Two RF chokes, each 100 turns.
No. 34 DSC, ⅜-in. diameter.

The modulation transformer can be any type of carbon microphone-to-grid transformer with a secondary resistance (grid winding) of from 3,000 to 5,000 ohms. The primary is connected in series with a single-button microphone and battery. If AC is used on the heater of the 76 tube, a 4½ volt "C" battery can be connected in series with the microphone, switch and transformer primary, without a connection to the tube heater circuit. A 6-volt storage battery or four dry cells in series will normally provide heater and microphone current, as shown in the circuit diagram.

For receiving, the ½-megohm grid-leak connects to plus *B* in order to provide high audio output from the super-regenerative detector. When transmitting, grid-bias is supplied by a 400 ohm cathode resistor and

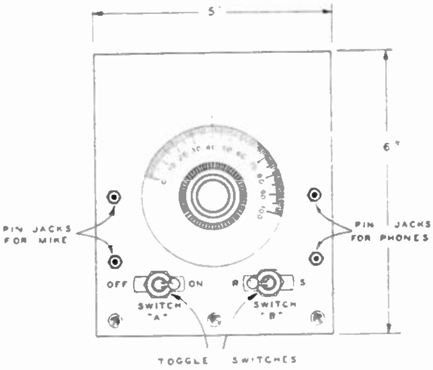


FIG. 32—Front Panel Layout.

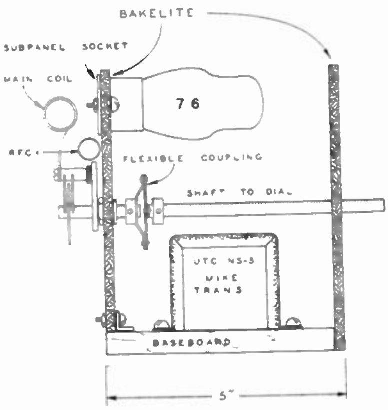


FIG. 33
Side View, Showing Coil Support and Condenser Extension Shaft.

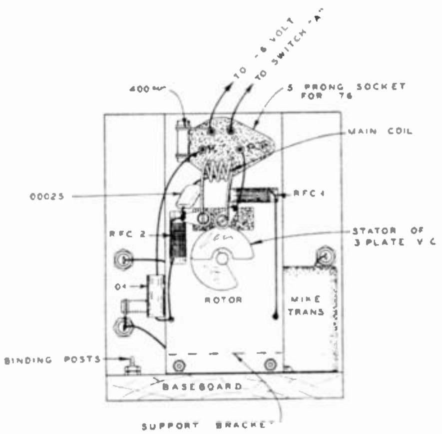


FIG. 34—Rear View.

the grid current through the resistance of the modulation transformer. Understandable voice modulation can be secured from grid modulation with a minimum of parts.

Very short leads to the grid and plate terminals of the 76 tube socket permit operation in the 2½ meter band. The tuning condenser shaft is insulated from the front dial with a flexible shaft coupling and extension shaft to the variable tuning condenser. The antenna is coupled by twisting one to three turns of insulated hook-up wire around the plate lead of the 76 tube. This capacity coupling should be as great as possible, *without causing a cessation of the super-regenerative hiss in the headphones when the control switch is in the receive position.* Coupling must be as tight as possible, however, in order to obtain a high degree of modulation when transmitting.

2½ and 5 Meter Transceiver

● A simple breadboard-mounted transceiver is shown in Figs. 35 and 36. It uses a 76 tube as an oscillator and super-regenerative detector and a 41 tube as a modulator and audio amplifier. A DPDT switch changes the 76 tube from a super-regenerative detector into a RF oscillator for transmitting; at the same time the 41 tube is changed from an audio amplifier into a modulator for transmitting. The circuit is shown in Fig. 37.

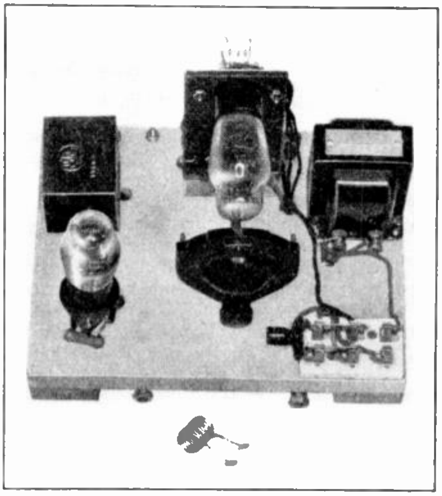


FIG. 35

Simple 2½ 5-Meter Transceiver. The 5-Meter Coil Is in the Foreground.

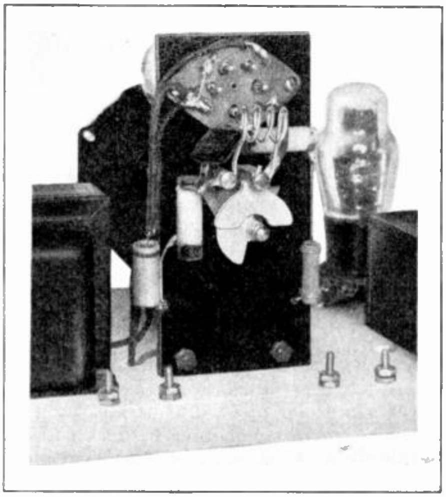


FIG. 36
Close-up of Mounting Bracket, Showing Correct Placement of Condenser, Coil, Chokes, Resistor, etc.

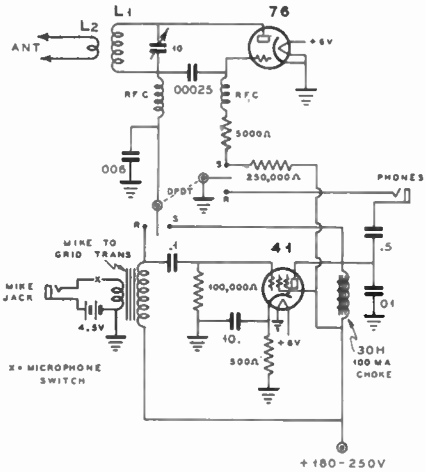


FIG. 37
2½- and 5-Meter Transceiver.
L1—4 Turns No. 14, ⅜-in. dia., ⅝-in. long for 2½ Meters.
L1—9 Turns No. 14, ⅛-in. dia., 1¼-in. long for 5 Meters.
L2—1 Turn Hook-up Wire Over Center of L1.
RFC—100 Turns No. 34 DSC on ⅜-in. rod.
Resistors—All One-Watt Rating.

The transceiver is mounted on either a wood or metal chassis, 7 in. x 8 in. The tuning dial is connected to the condenser through an insulated coupling. The 76 tube is mounted horizontally on an insulating sub-panel, 2½ in. x 5 in. This method of mounting facilitates the use of very short and direct leads to the tuning condenser and coils, resulting in high efficiency on both 2½ and 5 meters. The home-made RF choke coils are rather critical as to their number of turns, if operation on both bands is desired. If the values are not correct, dead spots will be found within the tuning ranges. This effect can also be checked by coupling a 6.3 volt pilot lamp in series with a turn of wire to the RF coil in the transmit position. If the light goes out within the tuning range, RF choke trouble can be suspected. Modulation can also be checked with the aid of this lamp indicator. Brilliance should increase when the microphone is spoken into.

Antenna coupling should be as tight as possible without loss of super-regeneration, as evidenced by a loud hiss in the receive position. Either an AC power pack or batteries can be used for the power supply. The "B" voltage can be any value from 180 to 250 volts. A conventional single-button microphone and a 4½ volt C battery can be used in the mike circuit. A switch should be connected either in the microphone circuit or as an integral part of the microphone so as to cut off the microphone current when the transceiver is either in the receive position or not in use. The layout of the transceiver should be as shown in the illustrations. If the leads are too long, or if the resistor and condenser values are not as specified, the set will not super-regenerate or oscillate on 2½ meters, and possibly not even on 5 meters. The 76 tube socket should be of a good grade of bakelite, or preferably ceramic material. Either a 76 and 41, or the 6C5 and 6F6 metal tube equivalents can be used. The transmit-receive switch can be of the toggle or knife variety.

The antenna coupling coil consists of one turn of insulated hookup wire slid between the center turns of the transceiver coil. Capacity coupling can be used, if desired, in which case one to three turns of insulated wire would be wrapped around the grid or plate lead of the 76 tube. The output of this set is approximately ½ to 1 watt, depending upon the plate voltage.

76-41 2½ or 5 Meter Transceiver

● The power drain of a 2½ or 5 meter transceiver is low because the same tubes are used for both phone transmission and reception. On the other hand, the receiver radiates badly, causing "whistles" and interference in other sets within a radius mile or two. Generally the receiver frequency is not exactly the same as the transmitted frequency, even though the same tuned circuits and tubes are used in both cases. The change of grid or plate voltage when switching from transmit to receive always tends to change the tube element capacities which are in shunt with the tuned circuit, thus causing a change in frequency. This effect is usually more pronounced on 2½ than on 5 meters, but it can be minimized by proper design. In spite of these disadvantages, the low first cost, economy of operation and compactness warrants the use of transceivers in many cases.

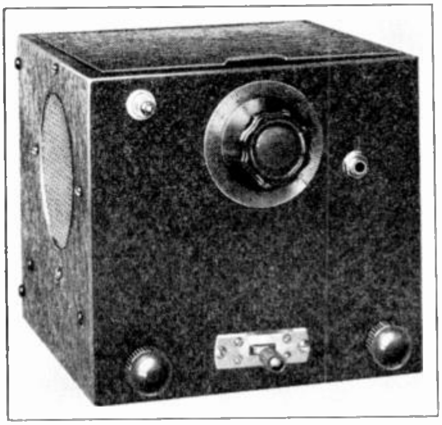


FIG. 38
Front View of 2½ or 5 Meter Transceiver. Loud Speaker Grille on Left Side.

● This transceiver has a 76 and a 41 tube in a conventional circuit, with certain refinements. The 76 acts as a super-regenerative detector of the blocking grid-leak type, transformer coupled to the 41 pentode audio amplifier in the receive position. In the transmit position the 76 acts as an oscillator, modulated by the 41 tube which serves as an amplifier for a single-button microphone. When receiving, a variable control of plate voltage for the 76 tube prevents excessive receiver radiation and holds the hiss level to a minimum, thus maximum sensitivity is realized. The 4-pole-double-throw switch connects the loudspeaker, increases the 76 grid-leak resistance for super-regeneration, cuts in an audio amplifying transformer and converts the 41 tube into a power audio amplifier for loudspeaker reception. The receiver audio volume control operates only on the grid of the 41 tube while actually receiving, so it has no effect on the microphone-to-grid circuit, such as is the case in most transceivers. The complete circuit is shown in Fig. 40.

In the transmit position the switch opens the loudspeaker circuit, reduces the grid-leak to the proper value for transmitting, connects-in the microphone circuits, and converts the 41 tube into a modulator system. A 41 tube will furnish sufficient audio gain and output to fully modulate a 76 tube for a plate voltage range of from 180 to 250 volts. An ordinary single-button hand microphone has enough electrical output for voice input and thus it is not necessary to shout into the "mike" in order to obtain a high degree of modulation.

A separate 4½ volt C battery serves as a microphone battery in order to simplify the power supply. The latter consists of 180 to 250 volts of either B batteries or rectified and filtered AC power supply, and either a 6 volt storage battery or 6.3 volt AC supply for the heaters. The separate "mike" battery makes it possible to use AC on the 76 and 41 tube heaters when an AC power supply is preferred, such as at a fixed station.

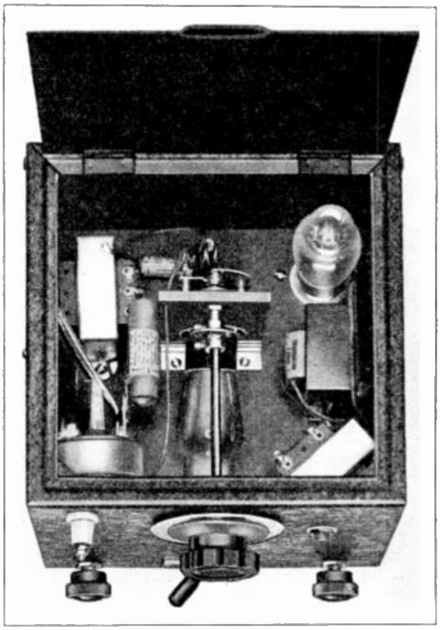


FIG. 39
Looking Into the 2½ or 5 Meter Transceiver.

● The transceiver is built into a 7¾ in. x 7¾ in. x 7 in. can, with a chassis 1¾ in. high for sub-base mounting of parts. The power socket is mounted at the rear, so that either battery or AC power pack supplies can be plugged in at will.

The tuning condenser has two plates. One rotor plate is first removed from a standard 3-plate midget condenser. This small condenser capacity gives better bandspread on 2½ or 5 meters. The condenser and the 76 tube socket are mounted on a vertical bakelite sub-panel, 2¼ in. x 4 in. x 3/16 in., which in turn mounts on chassis with a right-angle bracket. This tuning condenser must be well insulated from the chassis. A 1/4 in. diameter bakelite rod couples the dial to the condenser. The RF leads for 2½ meters must be extremely short. A horizontal mounting of the 76 tube places the grid and plate terminals near the tuning condenser and coil. Change from 2½ to 5 meters is accomplished by changing the 4-turn coil to one with about 9 turns of No. 14 wire, ½ in. diameter, and spaced slightly between turns. The coil is soldered to the condenser.

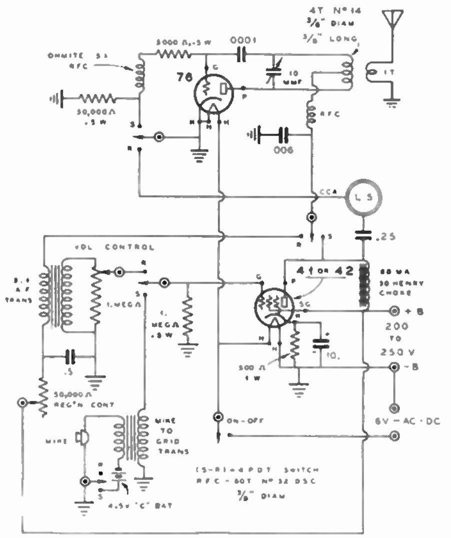


FIG. 40

2½- and 5-Meter Transceiver for Loud Speaker Operation.

No particular care need be exercised in the audio wiring circuit. The parts can be placed in any convenient location and ordinary push-back hook-up wire serves for all connections. The *C* battery, or microphone battery, can be placed either under or on top of the chassis, or wedged behind an audio transformer.

Ground leads often cause trouble on 2½ meters. By changing the length of these leads, the output may be doubled. A 6.3 volt pilot lamp connected through a 3/4 in. diameter loop of wire will serve as a good test for RF output and degree of modulation when coupled to the transceiver coil. The lamp should light with a moderate yellow color, and increase in brilliance when the microphone is spoken into. On 5 meters the effect of the length of the ground lead is not very pronounced, and the location of the .01 mfd. by-pass condenser ground, 76 cathode ground and heater ground leads are not as critical. When the set is functioning properly it should super-regenerate easily over the entire dial range, and the RF output should not drop appreciably over the entire dial range when transmitting.

The audio output is sufficient to operate the small magnetic loudspeaker which is mounted behind a wire-screen grill on the side of the cabinet.

A one-turn antenna coupling loop is self-supporting. The antenna lead connects to a through-type insulator on the front panel and passes through a hole in the bakelite panel, where it is cemented into the hole in order to give it rigidity.

● The receiver should super-regenerate over the 2½ meter range when 180 volts or more of plate potential is applied. The regeneration control in the plate circuit of the 76 tube is of more practical use on 5 meters than on 2½, since lower plate voltages will cause super-regeneration on the longer wavelength.

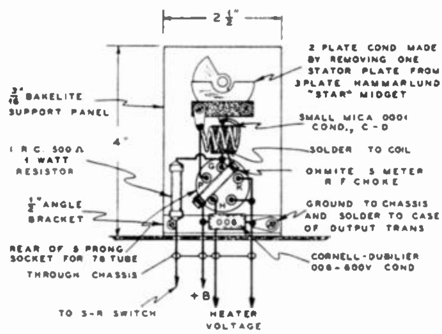


FIG. 41

Rear of Control Panel.

The voice quality when transmitting should be checked by listening to a phone monitor, or on another 2½ meter receiver. With a good microphone, the voice is clear and comparable to that on an ordinary telephone line. High quality audio and microphone transformers are not needed for amateur service. Small units are desirable in order to conserve space and weight.

A Lecher wire system, absorption wavemeter or another 2½ meter (or 5 meter) station can be used to check the 2½ meter band location on the tuning dial.

The possible range of this transceiver depends upon the type of antenna and its height above nearby objects or ground. A range of 2 or 3 miles can be expected.

Metal Tube 5-Meter Transmitter-Receiver

This 5-meter transmitter and receiver has a separate RF unit and a conventional audio amplifier for loudspeaker and modulator operation. Metal tubes conserve space and give entire satisfaction on 5 meters. The 6D5 tubes are similar to glass type 45s. The beam power tube 6L6 serves as a modulator. A 6J7 pentode functions as a regenerative RF amplifier which gives some amplification and minimizes radiation from the self-quenching super-regenerative 6C5 detector. This set is designed around standard circuits that have given most satisfactory service for portable 5-meter operation.

The principles of operation and construction are similar to those of the 6A6 glass tube 5 meter transmitter-receiver, described at more length elsewhere in these pages. The detector is self-quenching with a blocking grid-leak. A 6L6 serves the same purpose as the 6A6 driver and 6A6 class B stage shown in the 6A6 glass tube set previously referred to. The 6D5 tubes give about the same carrier output as a 6A6 push-pull oscillator.

This set requires less space than most other sets of similar general design. The chassis is only 9 in. x 6 in. x 1¾ in. The cabinet is 2 in. longer in order to make space for a small magnetic loudspeaker at one end. The cabinet measures approximately 6 in. x 6 in. x 11 in. and is formed by two U-shaped pieces with a flange along the edges of one piece. Self-tapping screws hold the top-back-bottom piece in place. The 6D5 grid coil consists of 14 turns of No. 14 wire, ½-in. diameter, 1¾-in. long, with a center-tap. The plate coil has 7 turns of No. 10 wire, center tapped, ⅝-in. diameter,

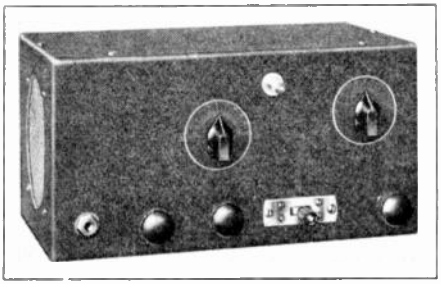


FIG. 42—Front and Side View of Metal Tube Transmitter Receiver, Showing Loud-Speaker Grille on Left Side of Cabinet.

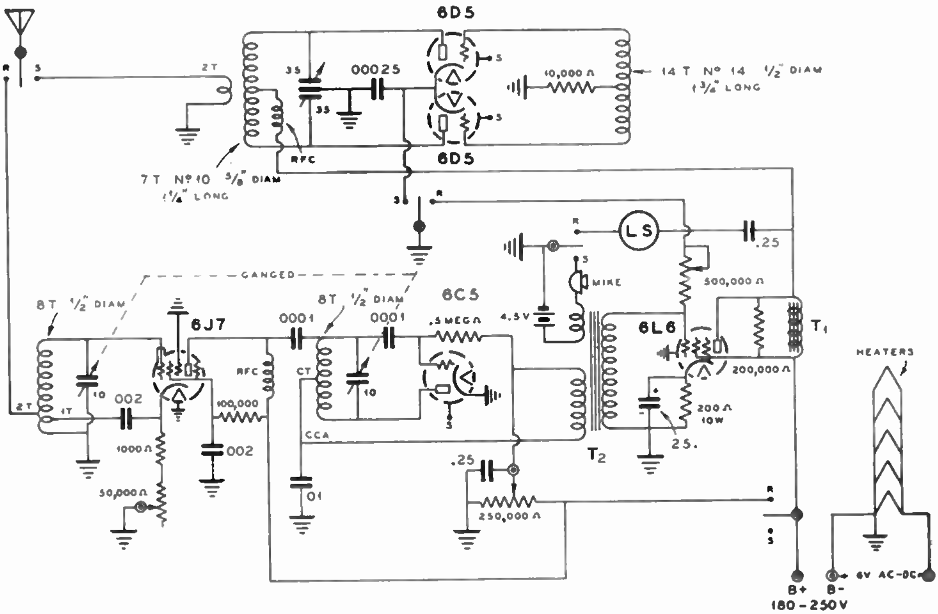


FIG. 43.

Metal Tube 5-Meter Transmitter Circuit. Type 6C5 Tubes Can Be Substituted for 6D5s, Shown in the Circuit, if the Value of the Grid-Leak Is Reduced to 2,500 Ohms.

1¼-in. long. A 2-turn pick-up coil of 18 ga. hook-up wire serves as an antenna coil which connects through the low capacity send-receive switch. All RF chokes can be made of 75 turns of No. 34 DSC wire, close wound on a ⅜-in. bakelite rod. The modulation choke should have at least 15 henrys inductance at 150 ma. DC. The audio input transformer can be any type of three-winding transceiver transformer.

The 6J7 RF coil has 8 turns, ½-in. diameter, about 1¼-in. long, and is similar to the detector coil except for location of taps. The cathode tap is made on the first (one) turn, the antenna tap at two turns, or a separate antenna coil can be used. The detector coil is center-tapped. These two circuits are made to track by compressing the turns on the coils, also by bending one of the plates on each of the 2-plate condensers which are ganged together for single-dial tuning. The RF and detector tuning adjustments are not very critical. A regeneration control on the super regenerative detector permits adjustment of plate voltage to the value of lowest hiss level, with good sensitivity and ability to handle strong signal inputs. A 50,000 ohm cathode resistor provides a combination regenerative RF volume control for the 6J7. The latter was selected in preference to a 6K7, because 5-meter signals are seldom strong enough to cause cross-talk in the RF stage; the high value of the cathode fixed resistor (1000 ohms) acts as a RF choke to force the cathode RF current through the cathode condenser and cathode coil tap. Short RF leads are essential in the RF and detector stages. The shields of the 6D5 and 6C5 are not grounded.

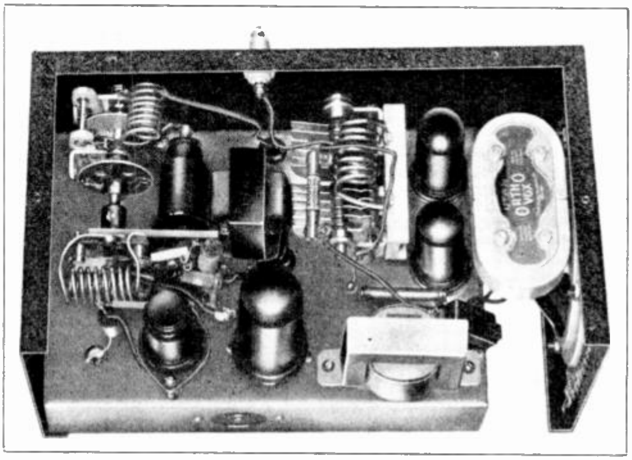


FIG. 44.
Looking Into the 5-Meter Transmitter and Receiver.

A separate 4½ volt microphone battery enables the tube heaters to be connected to either a 6-volt storage battery or to a 6.3-volt AC source. Heavy-duty B batteries for portable operation, or an AC line power supply can be plugged-in for operation at a fixed station location. Approximately 5 watts of carrier output can be secured from a 230 to 250 volt power supply. The constructor is urged to closely adhere to the mechanical design, otherwise the final results may not be satisfactory. Coil winding specifications should also be carefully followed. Some slight "pruning" of the coils will usually be necessary; this is accomplished by slightly compressing or expanding the coils until they cover the correct frequency range. All ground leads should connect to a common bus-bar.

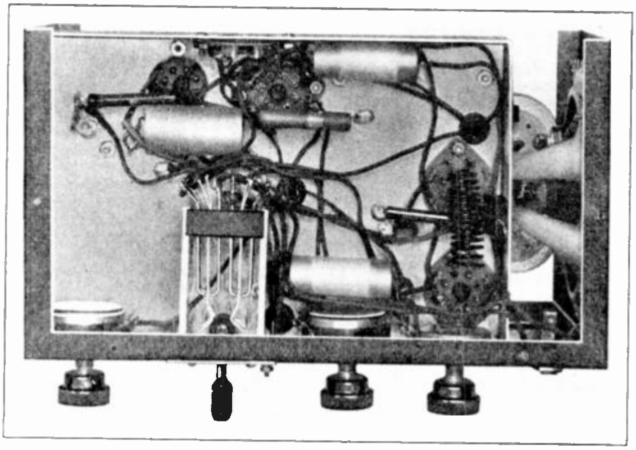


FIG. 45—Under-Chassis View of Transmitter-Receiver.

2½-5-Meter Metal Tube Transceiver

● Metal tubes fit readily into the design of a very compact and powerful transceiver for 5- and 2½-meter operation. This unit here illustrated transmits more power than most transceivers because heavy antenna loading is permissible for both transmitting and receiving. It is quite sensitive and the hiss level is low. The radiated interference is much less than from most transceivers while receiving, due to the separate interruption frequency coil circuit.

The set is built into a 5½ in. x 5½ in. x 4¼ in. steel can formed into two U-shapes with lips along the top and bottom edges of one of the U-shaped pieces. The chassis is 4 in. x 5⅜ in. x 1¾ in., thus making it somewhat difficult to wire-up the 4-pole-double-throw switch, but this job can be accomplished with a little patience. The tuning condenser, plug-in-coil and 6C5 tube are mounted on a vertical bakelite subpanel, 3⅜ in. high, 2¼ in. wide and 3/16 in. thick. The RF chokes are made both 5 and 2½ meters must be wound to the correct size of inductance so that no resonant absorption dips occur in either band. About 75 turns of No. 34DSC wire, closewound on a piece of ⅜-in. bakelite rod, serves the purpose. The terminals of these RF chokes are made by drilling small holes thru the ends of the bakelite rod and then soldering the fine wire to a piece of No. 22 wire twisted thru and around the ends of the rod.

The interruption frequency coil provides super-regeneration in the 6C5 tube when receiving, thus heavy antenna loading and low plate voltage can be used on 5 meters. On 2½ meters, the plate voltage should be 200 volts, preferably 250, if available. The transmitter output with 135 volts supply on 5 meters will be approximately ⅓ watt, and 1¼ watts at 200 volts, which is greater than the output obtainable from most other transceivers. A 6F6 power pentode acts as modulator when transmitting and as an audio amplifier when receiving. The output in the latter condition is sufficient to drive a small magnetic loudspeaker to moderate volume. The detector regeneration control can be set to a point of very low hiss level and high sensitivity.

A separate 4½ volt microphone battery allows the use of either AC or DC supply for the heaters of the two tubes. Either an AC power supply or batteries can be used for home or portable operation. Variable antenna coupling capacity will permit the use of any type of 5 or 2½ meter antenna. The coupling condenser can be adjusted through a hole in the front panel by means of a bakelite screw driver. The shield of the 6C5 tube should "float," i.e., it is not connected to ground, as is the usual practice.

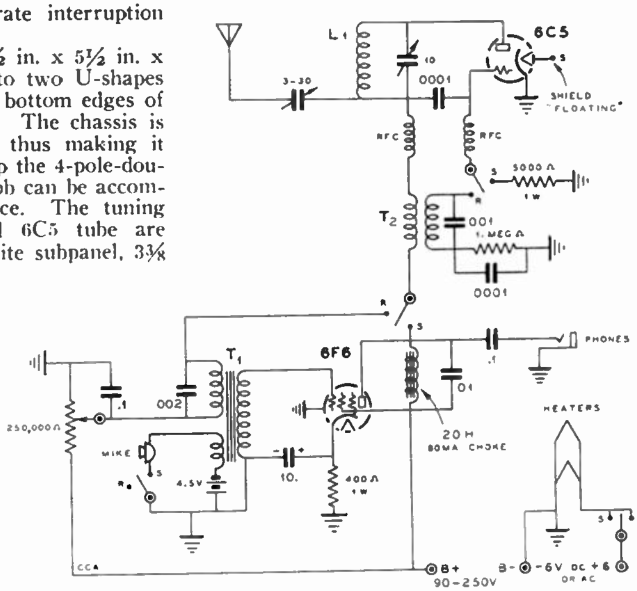


FIG. 46—Metal Tube 2½-5-Meter Circuit Diagram.

The 5-meter coil consists of 9 turns No. 14 wire, ½-in. diameter and 1½ in. long. The 2½-meter coil has 3 turns, ½-in. diameter, wound to a length of between 1 in. and 1½ in., depending upon the length of RF leads in the RF tuning assembly. Pin jacks serve as terminal plug receptacles for the little plug-in coils. The send-receive switch in its center position opens the heater supply circuit, but does not disconnect the B battery; consequently if dry cells are used, the regeneration control will absorb a small amount of current, even when the set is turned off.

This transceiver can be built on a larger chassis, if space requirements permit. The 6C5G and 6F6G large glass tube equivalents of the little 6C5 and 6F6 metal tubes can be substituted without change in circuit constants. Operation on 2½ meters should be slightly more efficient when using the glass 6C5G tube. These glass tubes have octal bases, but they require more space.

The same arrangement of horizontal RF tube mounting, very close to the tuning con-

FIG. 47.
Front View of Metal Tube Transceiver.

denser and coil, is recommended if 2½-meter operation is desired. The tuning condenser has two plates. An insulated shaft connects the condenser rotor to the dial.

The three-winding midget audio transformer is manufactured by several concerns.

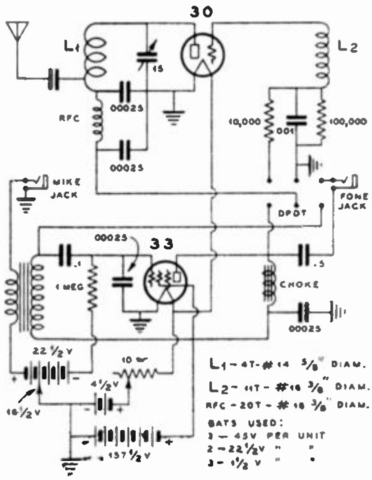
FIG. 48.
Interior View, Showing Coil and Condenser Support. Also Horizontal Mounting of 6C5.

Any small 20 or 30 henry, 50 ma. filter choke is suitable for the modulation choke.

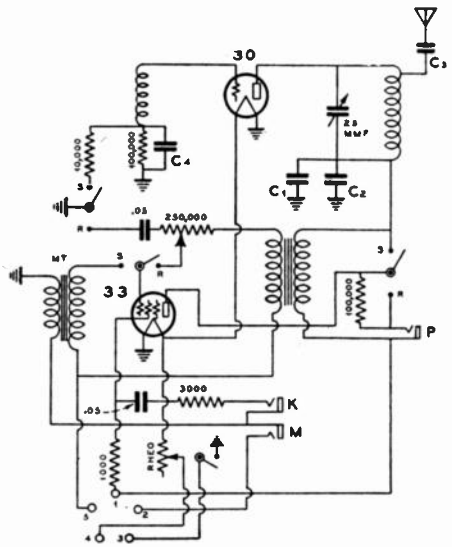
The performance of this unit is so superior to most other transceivers that it is highly recommended for the amateur.

Two-Tube Commercial Transceiver Circuits

● Those who wish to design two-tube transceivers after the circuits adopted by manufacturers will find the following schematic diagrams of practical interest. In general, constructors are advised to follow the details as close as possible to those given if good results are to be expected.



Haigis Portophone Model PF-1.



Haigis "A-M" DeLuxe Transceiver.

High-Output 6A6 5 Meter Transmitter-Receiver

● It was previously stated that 5-meter transceivers have many disadvantages, including excessive receiver radiation, low output when transmitting, poor sensitivity, high receiver hiss level, and variation of transmitter frequency with receiver frequency shift. The unit here shown has a separate transmitting RF circuit, a common audio system, and separate receiver RF circuits. This permits the use of a RF stage which increases sensitivity and prevents receiver radiation. The transmitter frequency can be set to some fixed value, and the output is several times as high as that from a transceiver.

This transmitter-receiver is not much larger than a transceiver, in spite of its being a separate receiver and transmitter for 5-meter operation. The receiver has a separate quench frequency tube and associated controls, thus the hiss level can be set at such a low value that it is no higher than the external interference noise in most locations. Regenerative RF amplification with regeneration control gives extremely high sensitivity when needed. A Class B 6A6 modulator supplies sufficient audio output to modulate the 5-meter oscillator at approximately 5 watts carrier output when a 300 volt plate supply is available. Either an AC power supply, or B batteries and a 6-volt storage battery, can be used for portable or fixed station operation. The B supply can be of any value from 150 to 325 volts, much better results being secured with the higher values around 280 to 300 volts.

A small magnetic loudspeaker is built into a cabinet only 14 in. x 7 in. x 7½ in. This set has all of the best features of mobile or medium power station units built into one, and it can be highly recommended for general 5 meter operation.

Technical Notes

● The transmitter has a TNT push-pull oscillator with a 6A6 tube in a cathode bias arrangement. A Class B 6A6 modulator is driven by a 6A6 speech amplifier which delivers 8 to 10 watts output at 300 volts. The microphone is an ordinary single-button type.

The same two 6A6 audio tubes serve as an audio amplifier for the receiver when the 4-P-D-T. switch is thrown to the receive position. The latter also switches the antenna from transmit to receive. The 76 super-regenerative detector is not self-quenching, but uses a separate 76 interruption frequency oscillator. The latter permits a setting of the detector plate voltage to such a value that the tube continues to super-regenerate, but with a very low hiss level. This means that a great portion of the troublesome loud hiss or roar can be eliminated, even when no station is tuned-in on the 5-meter band.

The regenerative RF stage has a 6K7 metal tube, requiring less space and shorter leads. A slight amount of regeneration actually gives some RF gain on 5 meters and very weak signals can be received which would otherwise be inaudible. A 954 acorn RF tube will give more gain, but at a considerable increase in cost, thus a compromise was made in the form of the 6K7 tube.

The interruption frequency oscillator has two small universal-wound coils in a small shield can beneath the chassis. This oscillator functions at about 100KC and causes a variation at 100 KC per second of the plate voltage on the 76 detector. This variation causes super-regeneration, with a gain of several thousand times on weak signals.

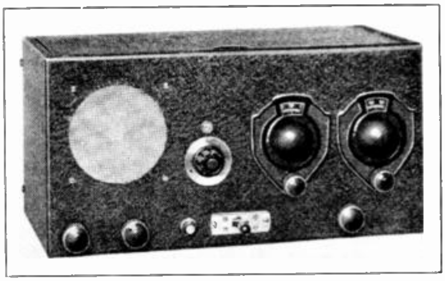


FIG. 49.

Front View of High-Output 6A6 Transmitter-Receiver.

Audio volume is controlled, in the receiver only, by shunting a tapered 50,000 ohm control across the grid circuit of the first audio stage. The microphone-to-grid transformer carries the detector plate current through its secondary when receiving; it should therefore be wound with sufficiently heavy wire in order to carry approximately 5 ma. A push-pull pentode to dynamic loudspeaker voice coil transformer can be substituted for the "mike" transformer. The voice coil winding then becomes the microphone winding, and the detector lead can be connected through the switch to the center-tap, or to the grid ends of the secondary. The loudspeaker connects from one of the Class B plates through a ½-mfd. condenser back to a switch contact which disconnects it when transmitting. This send-receive switch also connects the B supply voltage to either the transmitting 6A6 oscillator or to the detector and RF stages.

The 6A6 oscillator draws from 30 to 60 ma., depending upon plate voltage and antenna loading. The plate impedance is some value between 5,000 and 10,000 ohms and the Class B output transformer should therefore have a total primary-to-secondary turns-ratio of between 1.4-to-1 and 1-to-1. The transformer shown was rated for a 5,000 ohm load out of a 6A6 Class B tube, which would indicate a 1.4-to-1 ratio. The class B input transformer can be any type designed for a 6A6 or 53 driver into a 6A6 or 53 class B amplifier.

Construction

● The sheet-iron can is 14 in. long, 7 in. high and 7½ in. deep, a standard size available from many radio supply houses. A 1¾ in. chassis depth is ample for the 4-P-D-T switch, variable and fixed resistors and fixed condensers.

The 4-prong wafer socket for the power cable and the insulated microphone jack are insulators. The two corresponding vernier tuning dials are of bakelite, thus a one-inch front panel hole insulates the tuning condensers from ground. Other types of dials would require an insulated coupling on the tuning condenser shafts in order to prevent RF noise, in one case, and a short circuit in the other.

The 6K7 RF tube mounts horizontally on a 4 in. x 5 in. No. 12 aluminum shield. The latter has a ½-in. lip bent at right angles along the bottom so that a pair of 6/32 machine screws will hold it rigidly in place. Shakeproof lock-washers should be placed under all machine screw nuts if the set is operated in mobile service. The RF stage by-pass condensers, RF choke and plate coupling condenser mount directly at the 6A7 tube socket, with short leads to the aluminum sheet for a ground connection. All ground points are bonded together with

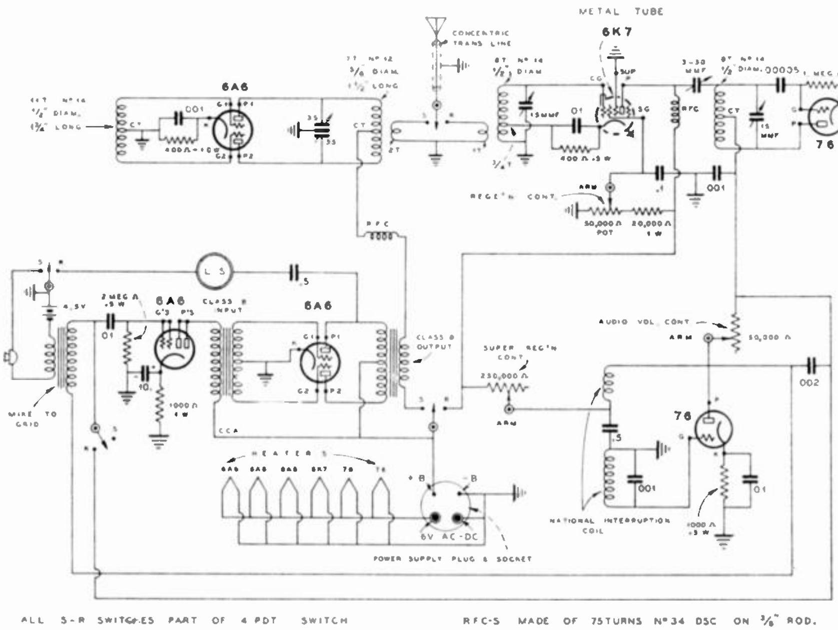


FIG. 50—Complete Circuit Diagram of High-Output 6A6 Transmitter-Receiver.

mounted in the rear. The class B transformers are placed in such a manner that space is available for a 4½ volt C battery for microphone supply. The separate mike battery makes possible the use of either DC or AC for the heaters without wiring changes. The 5-inch magnetic speaker is covered with a metal screen grill behind a 4-inch diameter hole in the front panel.

The two receiving 15 mmfd. tuning condensers mount on small porcelain stand-off hook-up wire and connected to the minus *B* power socket terminal.

The RF chokes are made by winding about 75 turns of No. 34 DSC wire on a ⅜-in. diameter bakelite rod. The detector coil has 8 turns, ½-in. inside diameter, tapped near the center, and the turns are spaced approximately the diameter of the No. 14 wire. The RF coil is similar in construction, except for the cathode tap, which is taken at about ¾-turn. The plate coil of the 6A6 oscillator has 7 turns, ⅝-in. diameter, 1½-in. long. The wire for the coils should be No. 12, or preferably No. 10 copper. The 6A6 grid coil has 11 turns of No. 14 wire, ½-in. diameter, with a center-tap. This coil mounts on small stand-off insulators beneath the chassis and the two grid leads extend through the insulators directly to the grid terminals on the isolantite socket of the 6A6. This arrangement gives equal and very short grid and plate leads to the 6A6 RF tube. The 6A6 RF tube and 76 detector both mount on isolantite sockets above the chassis in order to reduce the length of the RF leads.

All coils are soldered to their terminals so as to prevent loose connections, losses and noise. The two antenna coils are made of No. 18 insulated hook-up wire and the coupling can thus be varied for best results with different antennas.

Operating Notes

● When first testing the receiver, the RF regeneration control should be set so that the value of screen voltage is approximately zero. The super-regeneration control should be decreased in resistance until a super-regenerative hiss is audible in the loud-speaker. The RF control can then be rotated until RF oscillation takes place (without antenna), as indicated by a sudden cessation in hiss output when tuning the RF dial across its scale. When actually operating the receiver with an antenna, the RF regeneration control should never be set to the point of RF oscillation. A check on the operation of the RF stage and its tracking qualities with the detector tuning dial can be secured with the oscillation test just described.

A little practice is needed to operate the receiver for maximum sensitivity, because it has two tuning dials and two regeneration controls. For normal operation the RF stage tunes very broadly, and the RF gain control need not be set to its critical position. The detector super-regeneration control should always be set to a position where it will maintain a low degree of hiss level when no signal is received. The RF stage prevents radiation of super-regeneration squeals from the detector circuit and therefore serves a good purpose; careful tuning of the RF stage will give a decided gain in receiver sensitivity on weak signals.

The transmitter should be tuned to some frequency within the 5-meter band between 56 and 60 megacycles by means of a wavemeter or by checking it against another receiver. A diode tube field strength meter-monitor should be available for checking modulation. A single turn of wire in series with a 6 volt pilot lamp makes a good tuning indicator, in addition to the field strength meter. The lamp, when coupled to the 6A6 plate coil, should light up more brilliantly when the microphone is spoken into or energized by a whistle. Fairly heavy antenna coupling is essential for best results. The modulation percentage is greatest at a point where the RF current in the antenna begins to drop slightly on steady carrier, due to close coupling to the antenna feeder. The lamp indicator will also show a greater variation in RF current when modulating with a heavy antenna load. The spacing of the grid coil turns, and the value of the cathode resistor, both affect the degree of modulation for a given degree of antenna coupling.

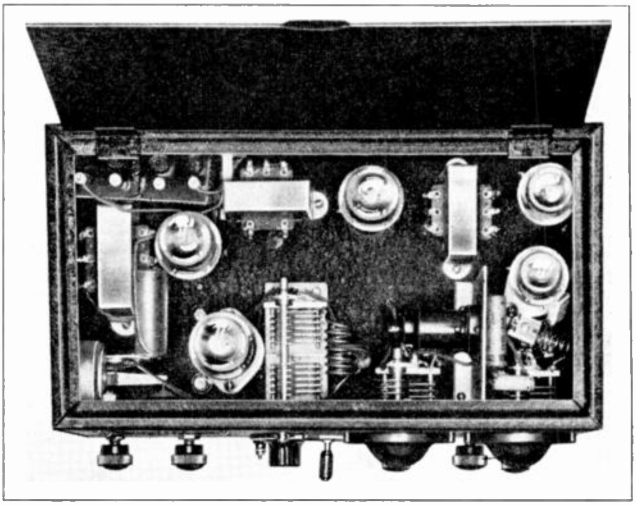


FIG. 51—Looking Into the High-Output Transmitter-Receiver.

The antenna coupling system is suitable for a spaced two-wire RF feeder, a single-wire feeder, or to a concentric feed line. The latter is of especial benefit for automobile installations, and is also best from a standpoint of minimum noise pick-up at fixed stations. The antenna can be a vertical half wave Y-fed wire or rod, about 8 feet long, or a "J" type. A directional array will give better performance than a single element half wave antenna. For automobile installations the antenna can be 4 feet long, with the inner conductor of a concentric line feeding the lower end of the 4-foot insulated rod.

Resistance-Coupled 5-Meter Super-Heterodyne

● One of the most widely imitated Jones developments is the simple 5-meter resistance-coupled super-heterodyne shown in Figs. 52 and 53. The receiver has four tubes; a 6C6 autodyne detector, two stages of resistance-coupled IF amplification with 6D6 tubes, and a 76 triode second detector. The values of resistors and condensers in the IF amplifier are correct to bypass the intermediate frequencies only; the coupling condensers and resistors are too small in value to pass audio frequencies. The response curve of the amplifier is quite broad in order to receive 5-meter phone signals.

All of the .0001 mfd. condensers should be of the mica "postage-stamp" variety. The resistors can all be ½ watt in rating. The 500,000 ohm screen control potentiometer in the 6C6 detector stage should be advanced only to the point where the detector oscillates weakly, and never to the point of howling or super-regeneration.

The coupling between the antenna coil and the first detector should be adjusted for best weak-signal reception. Too much coupling to a resonant antenna will prevent detector oscillation and proper super-heterodyne action. In tuning the receiver dial, it will be found that all 5-meter signals will have two points on the dial, very close to each other, because the detector functions in a simple autodyne circuit.

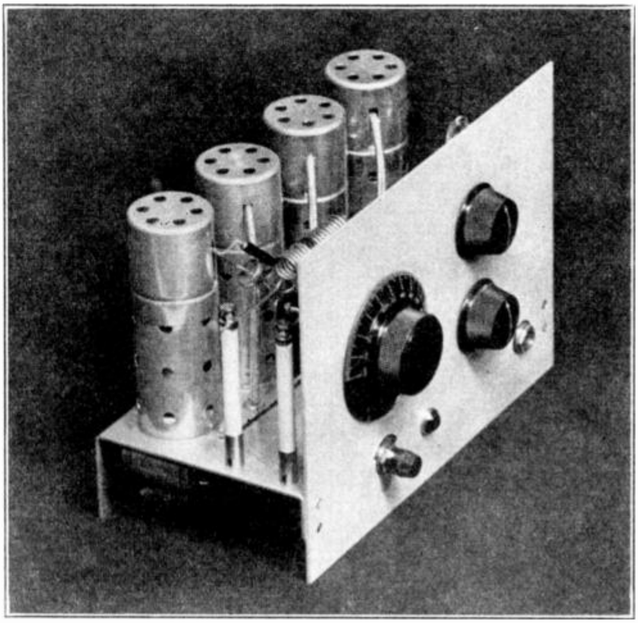


FIG. 52—The Complete 5-Meter Super-Heterodyne.

7-Tube Resistance Coupled Super

● When loudspeaker reception is demanded, together with somewhat better sensitivity, the larger receiver illustrated in Figs. 54 and 55 will give adequate satisfaction. A resistance-coupled IF amplifier simplifies the construction of the set. A semi-tuned RF stage isolates the autodyne first detector from the antenna circuit. This RF stage resonates at the low-frequency end of the 5-meter band

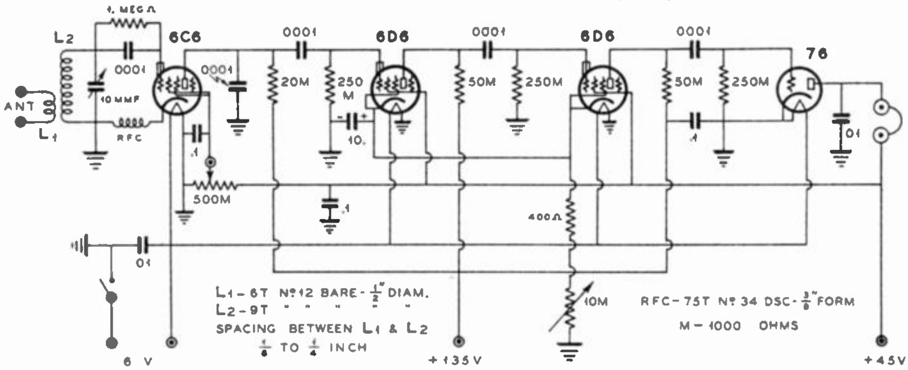


FIG. 53—The Extremely Simple Circuit Diagram of the 5-Meter Super.

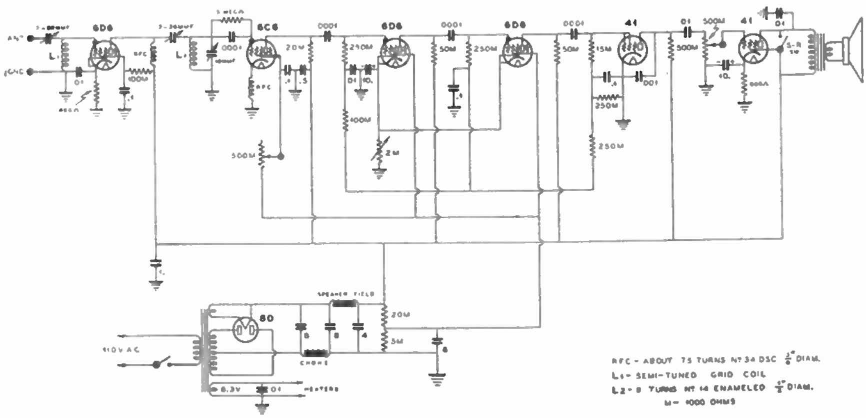


FIG. 54—Frank Jones' 7-Tube 5-Meter Superheterodyne Circuit.

by means of a variable antenna coupling condenser and resonant grid coil. This coil, L1 in the circuit diagram, is made of 16 turns of No. 16 enameled wire, ⅜-in. diameter self-supported. The length of the coil is varied until greatest sensitivity is obtained at approximately 55 megacycles for a medium capacity setting of the antenna coupling condenser. The RF plate-to-first-detector coupling condenser should be adjusted to a point which does not prevent oscillation in the first detector. The semi-tuned RF amplifier simplifies the receiver and prevents interlock between the oscillating first detector and RF grid circuit. Interlock can be defined as the action which takes place when the two tuning circuits react upon each other, making it difficult to align the circuits.

The second detector functions somewhat like a Class B tube, in that grid current starts to flow as soon as a signal is impressed. Detection is obtained in this tube and amplified by another type 41 tube connected as a pentode audio amplifier. The rectified grid current provides semi-AVC action, the voltage of which is fed back to the grids of the IF amplifiers.

The set is built on an 18 in. x 17 in. x 1½ in. chassis, made of 12-gauge aluminum. A standard 7 in. x 19 in. relay-rack is the front panel. All resistors are of the 1-watt size, except the power supply bleeder resistor, which should be rated at 35 watts. The .0001 mfd. condensers are of the small mica type, the other condensers are of the 600-volt paper variety.

The power supply rectifier circuit includes a 700 volt center-tapped transformer, a 20 henry 80 ma. filter choke, and a 2500 ohm loudspeaker field.

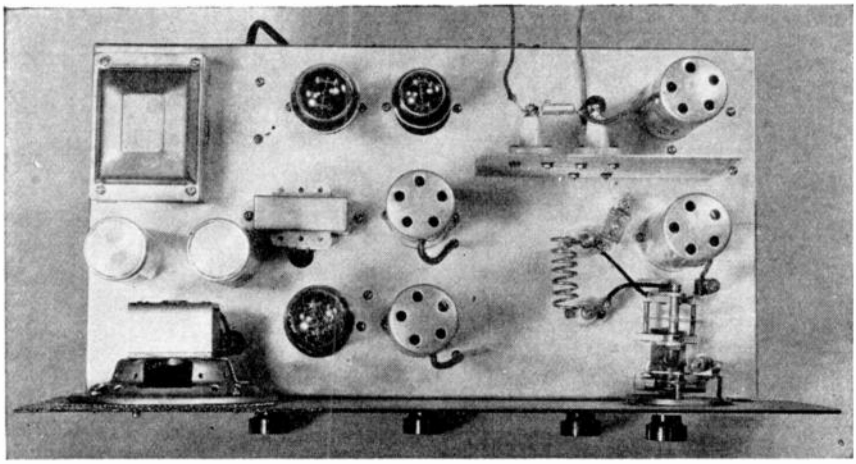


FIG. 55—The 7-Tube 5-Meter Super Should Be Laid Out as Shown in the Illustration Above.

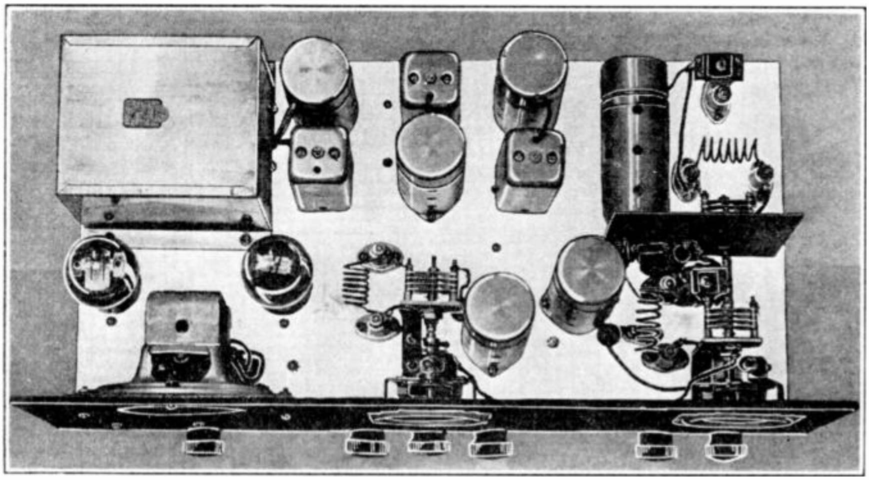


FIG. 56—Looking Down Into the 5-Meter Super. The RF Coil Is Mounted Horizontally to Permit Use of Very Short Leads. An Aluminum Shield Isolates the RF Stage From the Detector.

8-Tube 5-Meter Superheterodyne

● By incorporating regeneration in either the RF or first detector stage of a superheterodyne, the sensitivity can be increased from 5 to 50 times. A regenerative first detector is used in preference to a regenerative RF stage in order to eliminate antenna tuning dead-spots.

The choice of a suitable intermediate frequency and the degree of coupling in the IF transformers depends upon the received band width. If modulated oscillator type phone reception is desired, the IF amplifier should pass a band at least 50 kilocycles wide. The IF transformers in this receiver were designed with this purpose in mind. They are made by winding 120 turns of No. 34 DSC wire, jumble-fashion, on ⅜-inch diameter

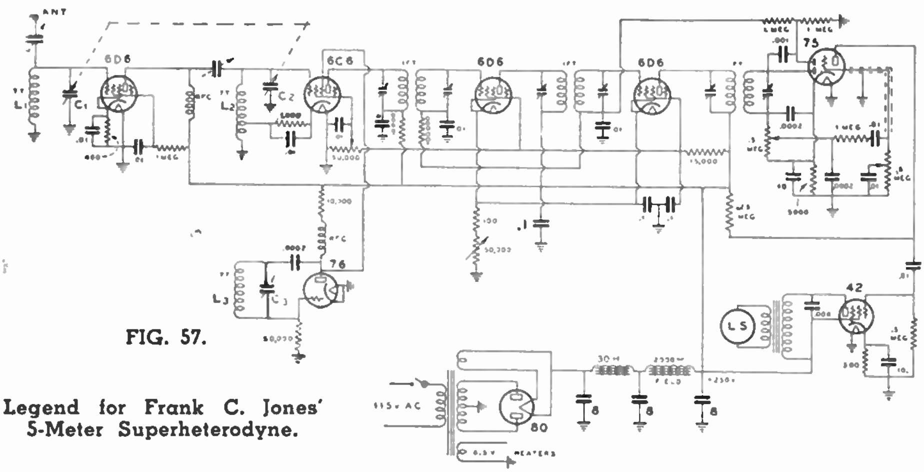


FIG. 57.

Legend for Frank C. Jones' 5-Meter Superheterodyne.

L1 and L2—Each 1½ in. Long, 7 Turns, No. 14 Enameled Wire, ½ in. Dia. L3—1 in. Long, 7 Turns, No. 14 Enameled Wire, ½ in. Dia. C1, C2, C3—100 uufd. Double-Spaced Variable Condensers, With Only 7 of the Original Plates Remaining. Maximum Capacity of These Re-built Condensers to Be About 18 uufd. I.F. Transformers Tuned to Approximately 2,000 KC.

tubes, two of these windings being required. Each winding is ⅜-inch long, and there is a space of ⅛ inch between the two coils. The coils are tuned with mica trimmers which are an integral part of the original 465 KC transformers. The 465 KC windings are removed, and the new windings put on the form. The IF amplifier is aligned to 2.7 megacycles by means of an all-wave test oscillator.

All 5-meter coils are supported on small stand-off insulators, close to the tuning condensers. The RF tube is mounted in a horizontal position in order to provide a short plate lead to the detector tuned circuit. The RF chokes in the oscillator and RF stage are made by winding 75 turns of No. 34 DSC wire on a ⅜-inch diameter bakelite rod. A type 75 tube serves as a diode detector, AVC tube, and first stage audio amplifier. Loudspeaker operation is from a type 42 pentode audio amplifier.

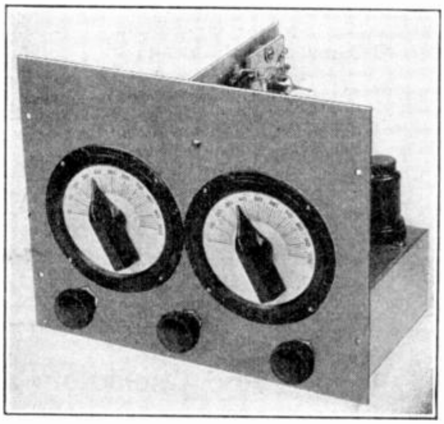
The chassis is No. 14 gauge aluminum, 9 in. x 17 in. x 1¾ in., mounted behind a standard 7 in. x 19 in. relay-rack panel. A separate dial tunes the oscillator, although it is possible to gang all three tuning condensers to one dial by using a wider chassis. Either capacitive coupling to the antenna, as shown, or the same condenser connected to ground as a padder and inductively coupled to the antenna, will give satisfactory results. Inductive coupling will reduce ignition interference if a twisted-pair lead-in is connected to a half wave antenna.

5-Meter Regenerative RF Receiver

● Extremely high sensitivity is obtained when a 954 Acorn regenerative RF stage is connected ahead of a super-regenerative detector. A separate interruption frequency oscillator, a 6C5 tube, provides a type of super-regeneration in the 955 detector which can be adjusted to operate with very low hiss level. A 6F6 serves as an ordinary pentode amplifier of conventional design.

Regeneration in the RF stage makes the receiver more sensitive to weak signals and also improves the selectivity. A cathode tap on the RF tuned circuit coil provides regeneration which is controlled by means of a 25,000 ohm potentiometer. The degree of super-regeneration in the detector is controlled by means of another 25,000 ohm potentiometer. Audio volume is controlled by a 500,000 ohm potentiometer in the 6F6 audio amplifier, and either headphone or loudspeaker operation can be had at will.

The chassis is 6 in. x 9 in. x 2 in., with a shield partition in the center which supports the two Acorn tubes and shields the RF from the detector stage. The RF tube extends through this partition. Separate tuning controls permit exact tuning of the RF stage at the peak of regeneration. Small tip jacks are mounted in hard rubber panels for plugging-in the coils. The disadvantage of two separate tuning controls is more than offset by the great sensitivity which can be obtained by careful adjustment of RF regeneration and tuning.



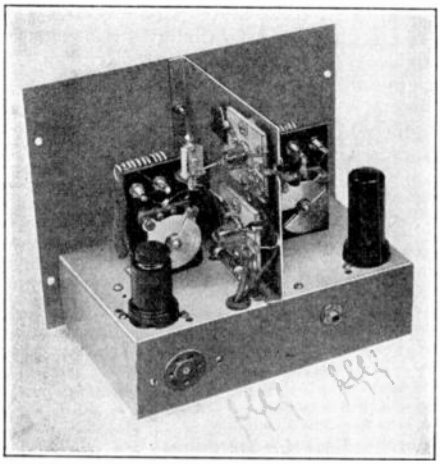


FIG. 58—Front and Rear Views of U.H.F. Receiver With Metal Tubes and Regenerative RF Stage.

The correct value of the fixed condenser in shunt with the interruption frequency grid coil (labeled .0005 and connected across the *I.F. OSC. COILS* in the circuit) depends upon the particular make of coils. Standard interruption frequency coil units are available from radio dealers, and it is desirable to purchase these coils ready-made because they consist of many turns of fine wire, honeycomb wound.

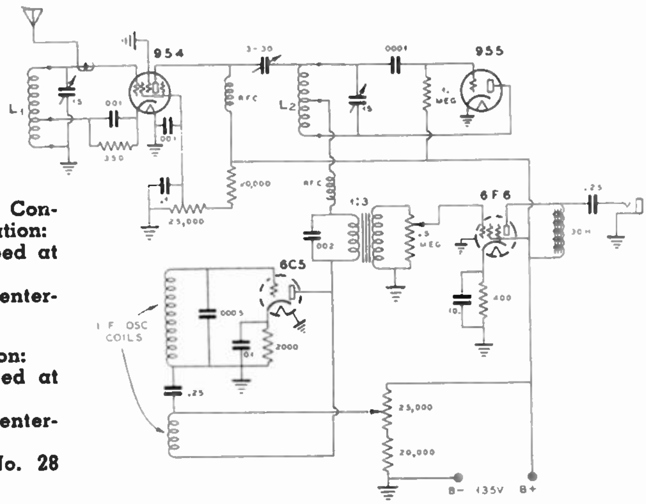


FIG. 59.

Complete Circuit Diagram. Constants for 5-Meter Operation:
L1—10 Turns, No. 12 Tapped at 1 Turn.
L2—10 Turns, No. 12, Center-Tapped.

For 2½-Meter Operation:
L1—4 Turns, No. 12, Tapped at 1 Turn.
L2—4 Turns, No. 12, Center-Tapped.
R-F Chokes: 75 Turns, No. 28 DSC, ¼" Dia.

Parallel Rod Oscillators

● Push-pull oscillators of the type shown in Figs. 60, 61 and 62 give good frequency stability in ultra-high-frequency transmitter circuits. The parallel grid rods act as a high "Q" circuit for frequency control. The plate parallel rods are tuned to resonance by sliding a shorting-bar along the rods to a point which gives lowest plate current. For 5-meter operation, the grid rods are 4½ feet long and the grids connect to each rod ⅕ to ⅓ of the way up from the shorted end. Since the shorted end has no RF voltage, these rods can be supported in holes bored into a wood block.

A parallel rod oscillator can be plate-modulated without excessive frequency modulation, as shown in Fig. 62.

High Power M.O.P.A. Transmitter

● Power output of 250 watts can be secured on 5-meters with the M.O.P.A. transmitter shown in Fig. 63. A stabilized 50-T oscillator is link coupled to a neutralized push-pull 50-T amplifier. Tubes with low inter-electrode capacities function satisfactorily in this circuit. Frequency stability in the oscillator is obtained by a critical value of RF

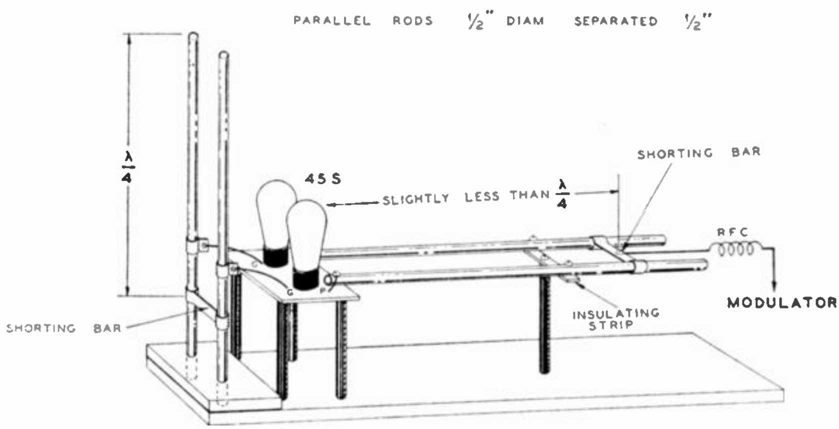


FIG. 60.

feedback to the grid circuit. Mechanical rigidity is also necessary. Correct ratio of condenser plate spacing in the oscillator will provide a circuit having good frequency stability over a fairly wide range of plate voltage. Somewhat better frequency stability can be obtained in the oscillator portion by means of concentric pipe oscillators, similar to the one described elsewhere for 2½ meter operation.

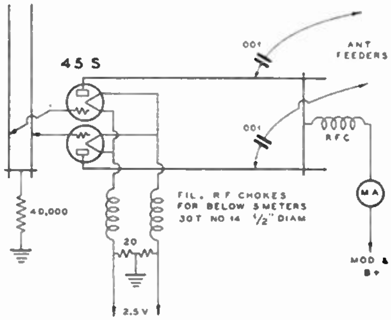


FIG. 61—Parallel-Rod Oscillator Circuit.

Crystal control can be applied by means of the *Jones* 4-6A6 *Exciter,* operating in conjunction with a 35-T doubler and 35-T buffer. Type 50-T tubes can be crystal controlled on 3 meters in this manner, if an additional 35-T doubler is added to the circuit.

For 5-meter operation, the amplifier plate tuning condenser consists of two aluminum plates, No. 12 gauge, 3 in. square, mounted 1 in. apart. A grounded plate is placed midway between the two other plates. The neutralizing plates are 1 in. x 1½ in. pieces of No. 12 gauge aluminum, separated nearly ½ in. Fig. 63.

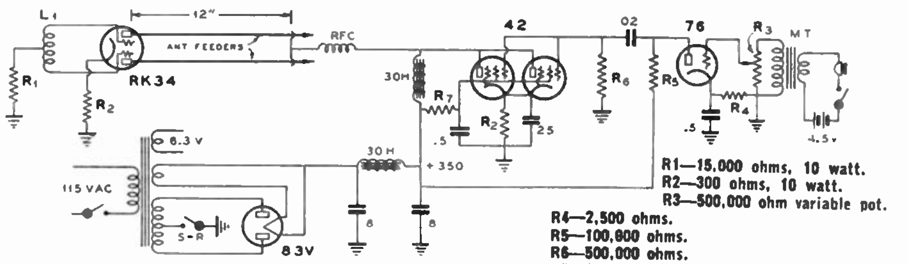
The oscillator condenser is made of three parallel plates of No. 12 gauge aluminum, also mounted rigidly on stand-off insulators. The two plates across the coil are 4 in. x 4 in., and the grid coupling plate is 3 in x 4 in. Tuning is accomplished by varying the length of the coils and the plate spacing of the tuning condensers. These adjustments are not easily made, therefore operation should always be on a fixed frequency.

Low P. F. Line Oscillator

● Large diameter pipes, a quarter wave long, are a practical means for stabilizing the frequency of u.h.f. oscillators. RCA has been using these "pipe lines" for frequency control in preference to a quartz crystal oscillator over the range of from 7 to 500 megacycles. Castings and heavy pipes are utilized in commercially-built lines, and temperature compensation is secured by means of a semi-flexible metal bellows and invar-rod within the inner pipe.

The construction can be greatly simplified for amateur operation below 10 meters. The complete copper concentric line for a 2½-meter oscillator can be built in a sheet metal shop for less than $5.00. This is only a fraction of the cost of a crystal control unit, yet comparable results can be obtained.

Crystal oscillators provide good frequency stability because of their relative "stiffness" of circuit constants. The circuit "Q" is much higher than can be obtained with a variable condenser and coil. Similarly, the effective $Q = \frac{VA}{W}$, proving that oscillatory-energy-to-power-loss is very high in a concentric line of the proper size. The "Q" is inversely proportional to the square-root of the pipe material resistivity, therefore the use of copper is desirable. The "Q" is proportional to the square-root of the frequency, consequently the lines become more effective at 2½ meters than at 5 meters. The "Q" is proportional to the diameter of the pipes



R1—15,000 ohms, 10 watt.
R2—300 ohms, 10 watt.
R3—500,000 ohm variable pot.
R4—2,500 ohms.
R5—100,000 ohms.
R6—500,000 ohms.
R7—10,000 ohms, 10 watt.
L1—5 turns, No. 18, 1" long, 7/16" dia.
RFC—30 turns, No. 22, ¼" dia., self-supporting.

FIG. 62—Circuit Diagram for the Complete 2½-Meter Transmitter.

for a given ratio of diameters. The outer pipe is often made 2 ft. in diameter, the inner about 6 inches for 5 meter oscillators. The length of the inner pipe should be ¼ wavelength and the outer pipe should connect to the inner at one end by means of a copper plate or casting, and the open end extends a few inches beyond the inner pipe.

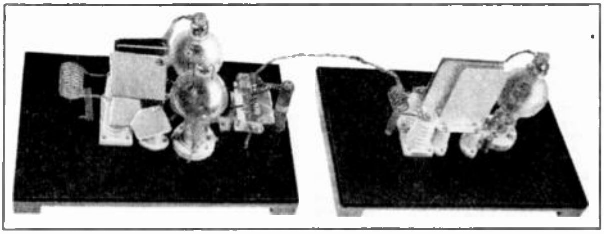


FIG. 63—High Power M-O-P-A Transmitter.

The pipe or line oscillator illustrated in Figs. 64, 65 and 66 should have a "Q" of nearly 8,000 at 2½ meters, which is high enough to give excellent frequency stability. The inner pipe is made of 1½-in. diameter copper tubing, about 27 in. long. Two-inch diameter tubing would be even more satisfactory. The outer pipe is made of 16-oz. sheet copper, from a piece 30 in. x 24 in. The diameter of the finished pipe is 7⅛ in. The average sheet metal roller equipment will handle lengths up to 30 in.

One end of the pipe is soldered to an 8 in. x 12 in. x 18 ga. piece of sheet copper. A 1¼-in. diameter hole is punched in the center in order to pass the inner pipe; the hole is then carefully reamed to a diameter of 1½ in. in order to give a tight sliding fit of good contact to the inner pipe. Waxed linen cords are wrapped around the free end of the smaller pipe, which is then centered in the larger pipe by three small holes in the outer pipe (not shown in the photographs) through which the waxed cord is passed and knotted.

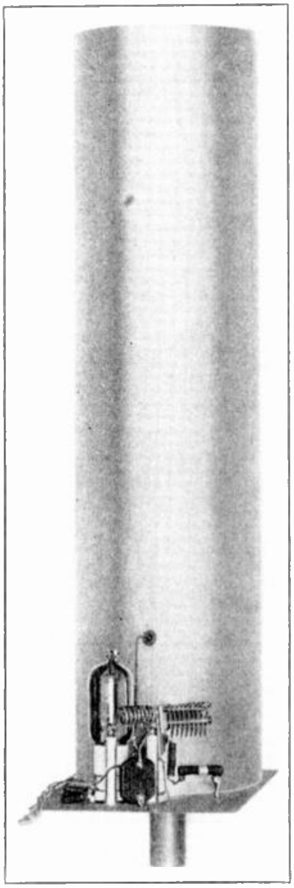


FIG. 64.
Low Power-Factor Line Oscillator.

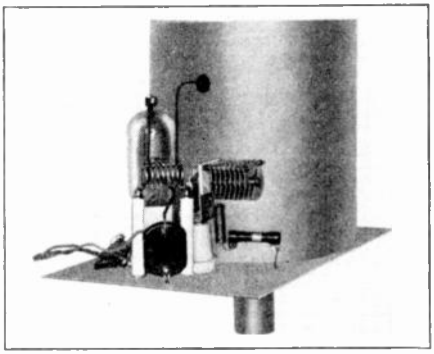
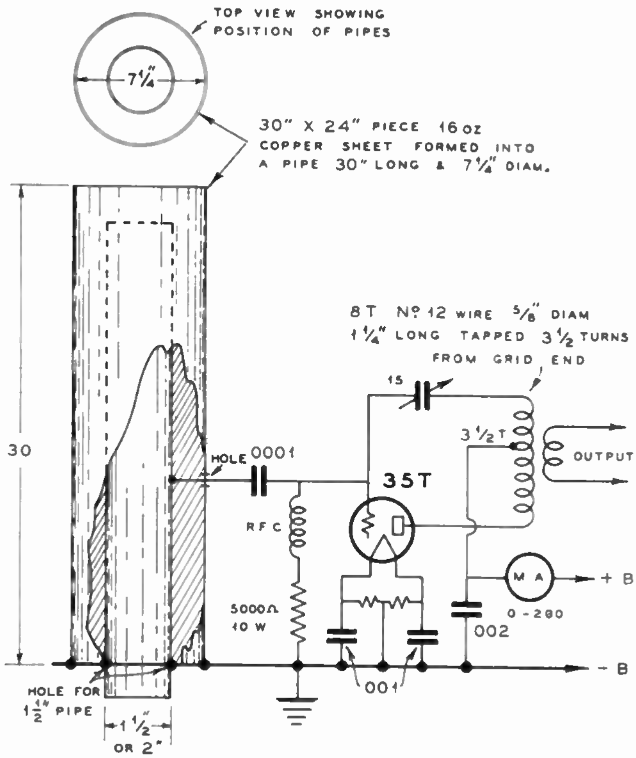


FIG. 65.
Close-Up of Line Oscillator Components.

A wire connection to the inner tube is made at 5 in. to 6 in. from the closed end, which in this case is 8 in. from the actual end of the 27-in. tube. 24 in. to 25 in. of actual inner pipe length (inside the large pipe) is approximately correct for the 2½-meter band.

A 35T is used as a regenerative Hartley oscillator in a low C plate-tuned circuit, shown in Fig. 66. A small variable condenser could be connected across the plate coil for convenience in tuning, but with a reduction in the L-to-C ratio. Frequency control is due entirely to the large low-power factor line which connects across the grid and filament of the oscillator tube. Regeneration (and plate tuning, to some extent) is varied by means of a 15 mmfd. grid excitation condenser. The capacity of this condenser should be varied until the tube oscillates (under load) over a range of pipe lengths. The plate current is relatively low when the proper adjustment is found. When the adjustments are not correct, the plate current is two or three times as high, and the heterodyne note against a stable oscillator's harmonics will vary greatly with changes in plate voltage. The plate voltage can be varied 50%, up or down, with hardly a perceptible change of beat note when the circuit is properly adjusted. The entire transmitter should be suspended on a shock-absorbing system in order to prevent vibration, otherwise the frequency stability will be impaired. Without temperature control, the frequency drifts quite rapidly out of the range of audibility in the harmonic monitor for a few minutes during "warm-up" time. The 35-T can be plate-modulated without appreciable frequency modulation, as could be determined on a fairly-selective super-heterodyne receiver.

The plate coil consists of 8 turns of No. 12 wire, 5/8 in. average diameter, and wound to cover a length of 1¼ in. The tap is made at 3½ turns from the grid end. An absorption wavemeter can be used to tune the oscillator to 2½ meters as a preliminary adjustment with the concentric line disconnected.



2½ METER STABILIZED OSCILLATOR

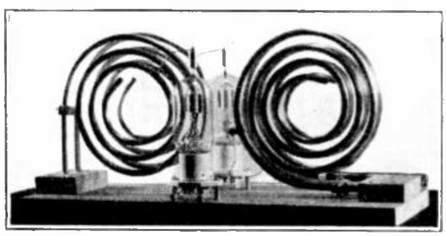
FIG. 66.

The efficiency apparently runs quite high: values of 50% can be obtained. At a plate potential of 500 volts, plate current was 25 ma.; at 700 volts, 35 to 40 ma.; at 1000 volts, from 75 to 90 ma. under load, in laboratory tests.

This type of frequency control line is superior to a parallel-rod oscillator with small pipes.

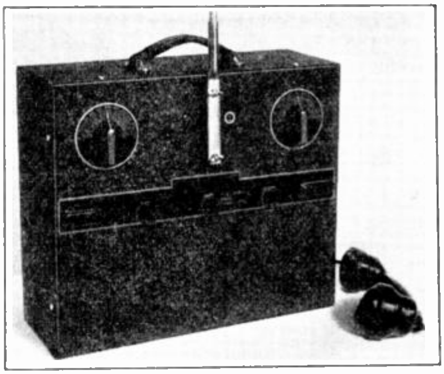
Spiral Rod Oscillator

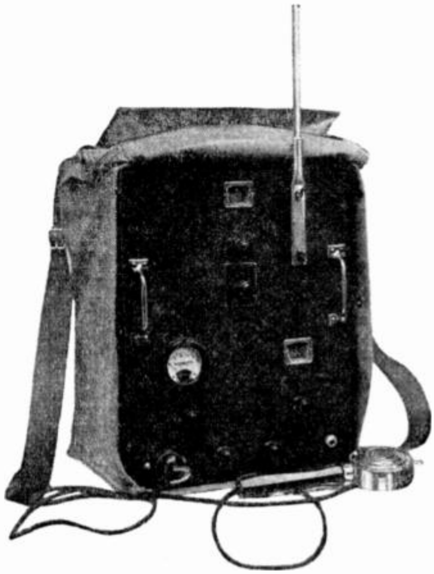
● A standard push-pull parallel rod oscillator can be coiled into a spiral, as shown in the illustration to the right, in order to conserve space. The spirals should be rigidly supported with high-grade insulation so as to prevent mechanical vibration. Adjustments are the same as for a conventional parallel rod oscillator. 400 watts input can be supplied to the 35T spiral rod oscillator here shown.

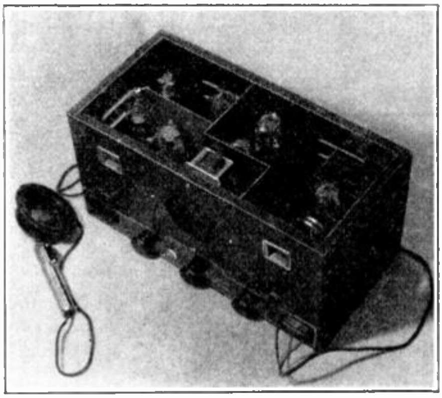


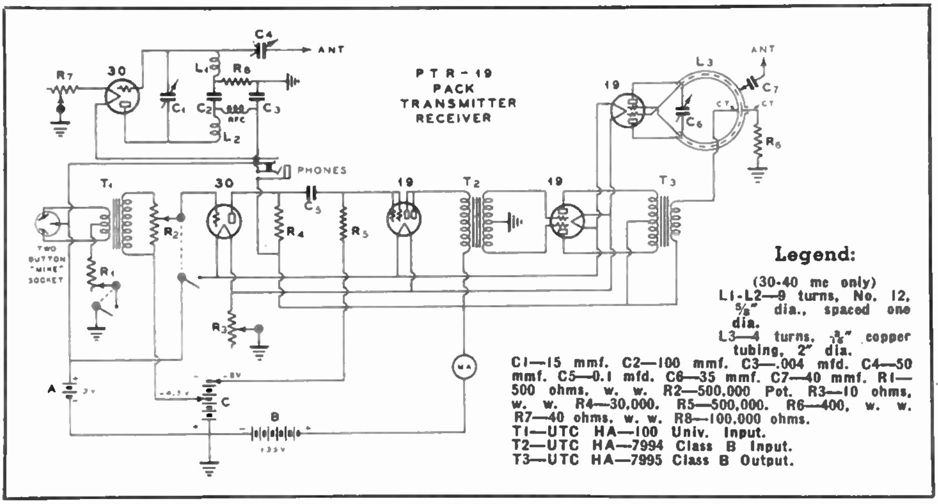
Factory-Built U.H.F. Sets

● There is nothing very unusual in the design of factory-built 5-meter sets because they conform to standard practice and the circuits are almost identical with those so widely used by amateur constructors. Only those who have long engaged in u-h-f manufacture have been successful in marketing their products because the engineering of a 5-meter set calls for more than ordinary experience and knowledge. On the several pages that follow, a number of the better-known factory products are shown. Those on this and the facing page are manufactured by *Radio Transceiver Laboratories* of Richmond Hill, New York. The photographs to the right show the *RTL—"Compact"* (top), and (below) the *PTR-19 Pack Transmitter Receiver.* The photo to the left, at the top of the circuit diagram, shows the *TR-53-6.46 Duplex Transmitter-Receiver.*





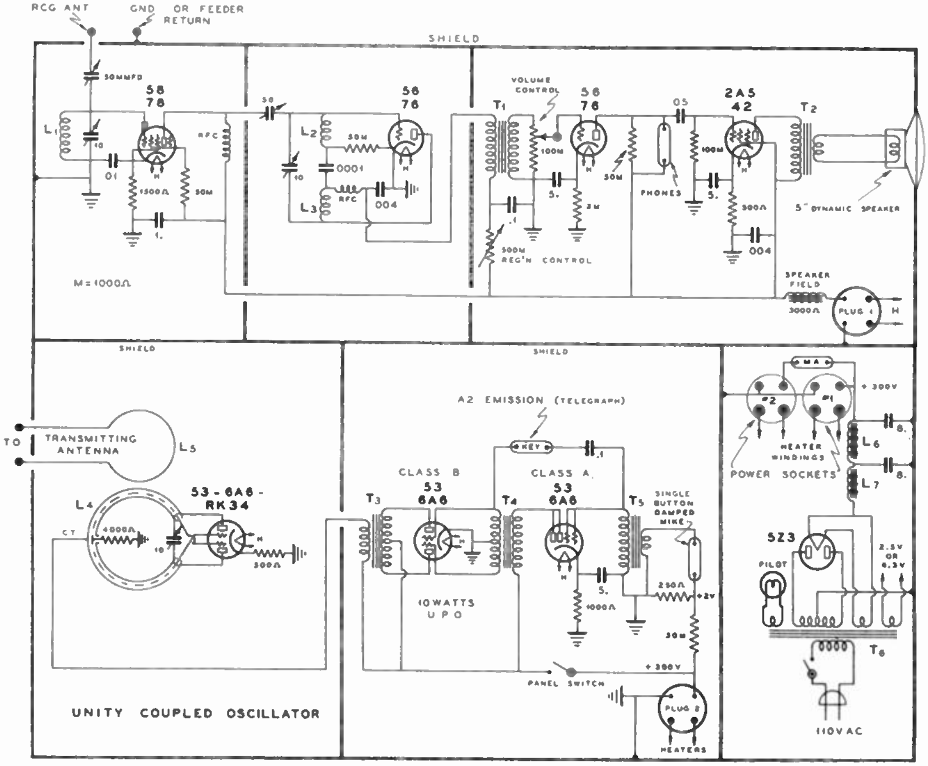




Legend:

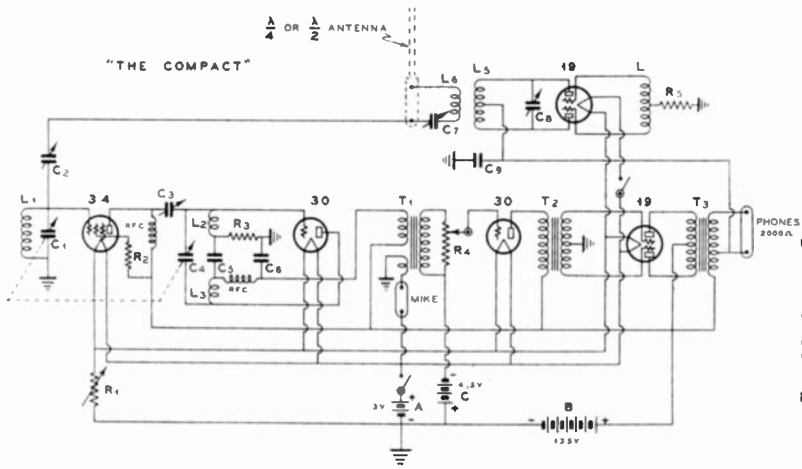
(30-40 mc only)
L1-L2—9 turns, No. 12, 5/8" dia., spaced one dia.
L3—4 turns, 3/16" copper tubing, 2" dia.
C1—15 mmf. C2—100 mmf. C3—.004 mfd. C4—50 mmf. C5—0.1 mfd. C6—35 mmf. C7—40 mmf. R1—500 ohms, w. w. R2—500,000 Pot. R3—10 ohms, w. w. R4—30,000. R5—500,000. R6—400, w. w. R7—40 ohms, w. w. R8—100,000 ohms.
T1—UTC HA—100 Univ. Input.
T2—UTC HA—7994 Class B Input.
T3—UTC HA—7995 Class B Output.

Circuit Diagrams of Factory-Built 5-Meter Sets



Radio Transceiver Laboratories TR53—6A6 Transmitter-Receiver.

L1, L2, L3—7 turns No. 14, ⅜" dia., spaced one diameter. L4—2 turns, $\frac{3}{16}$" tubing, 2" dia.

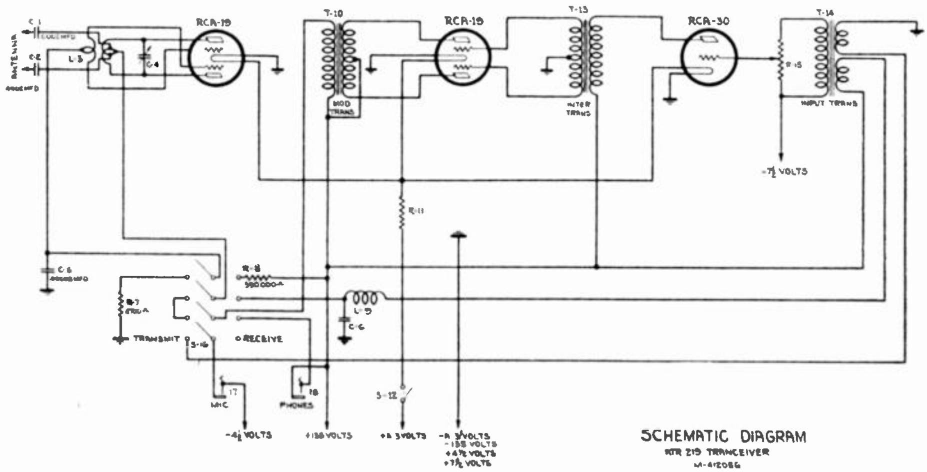


Legend:

L—15 T. No. 14, ⅜" dia., spaced one dia.
L1-L2-L3 — 7 T. No. 14, ⅜" dia., spaced one dia.
L5—6 T. No. 12, ⅝" dia., spaced one dia.
L6—2 T. No. 20 CORLAC, ⅝" dia.
C1—10 mmfd.
C2—50 mmfd.
C3—50 mmfd.
C4—10 mmfd.
C5—100 mmfd.
C6—.004 mfd.
C7—50 mmfd.
C8—20 mmfd.
R1—10 ohms, wire wound.
R2—30,000, ½ w.
R3—100,000, ½ w.
R4—500,000 pot.

Radio Transceiver Laboratories "Compact."

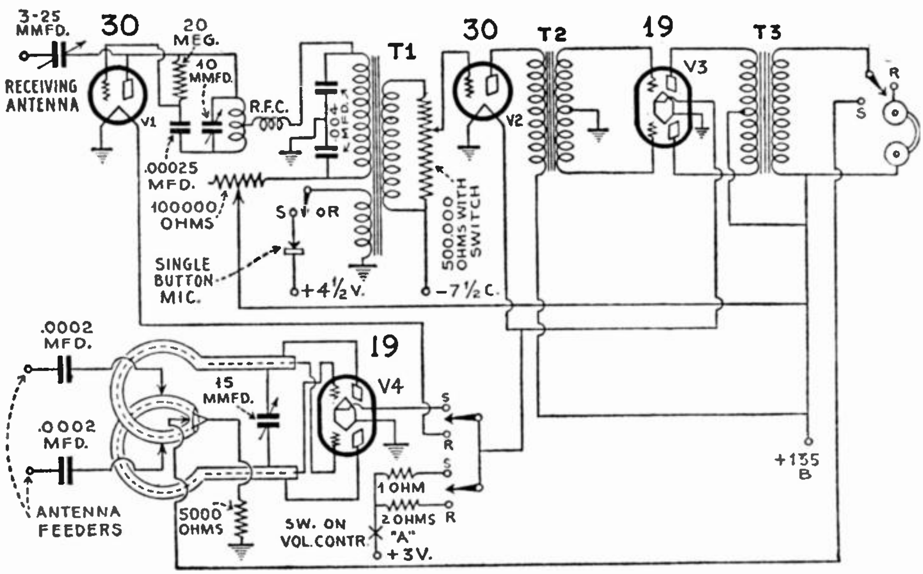
Factory-Built U.H.F. Transceivers



RCA ATR—219 Transceiver.

● The tube complement for this transceiver consists of two RCA-19 twin-triodes and one RCA-30 triode, connected as shown in the circuit diagram above. The transceiver is housed in a small case, equipped with a handle, so that it can easily be carried from place to place.

● Another transceiver circuit is shown below. It is the Wholesale Radio Company's "*Transceptor*," designed by Frank Lester, W2AMJ. In the transmit position, the type 19 tube in the lower portion of the circuit acts as a unity-coupled push-pull RF oscillator. For receiving, a separate antenna is connected to the first type 30 tube which functions as a self-quenching super-regenerative detector.

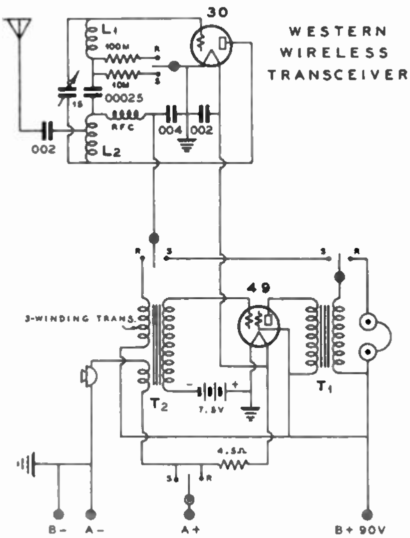


"Transceptor"—Wholesale Radio Service Co., Inc., New York City.

Forest Service Transceiver

● Built into a compact carrying case, 6 inches wide, 9 inches long and 7 inches deep, the *Forest Service Transceiver*, pictured to the right, is one of the smallest factory-made portable units for u.h.f. service. Miniature dry batteries are housed in the carrying case, and in spite of their small size they will give approximately 8 hours continuous service. A 4-P-D-T anti-capacity switch changes the circuit from send to receive.

Two-volt tubes are used, a type 30 and a 49. The circuit diagram shows the values of condensers, resistors, etc. Coils L1 and L2 are the same as those for home-built transceivers shown elsewhere in these pages. The coils are "air supported" and wound with heavy enameled wire. A 15 mmfd. midget variable condenser is mounted directly below the coils. The antenna is ca-

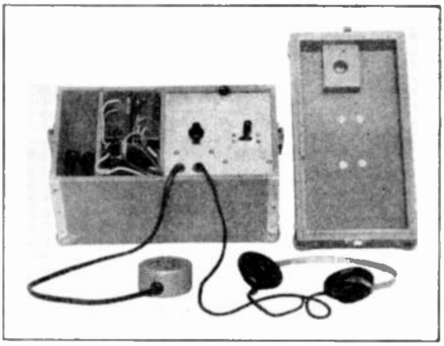


Circuit for Forest Service Transceiver.

pacitively coupled through a .002 mfd. mica fixed condenser, mounted above the coil.

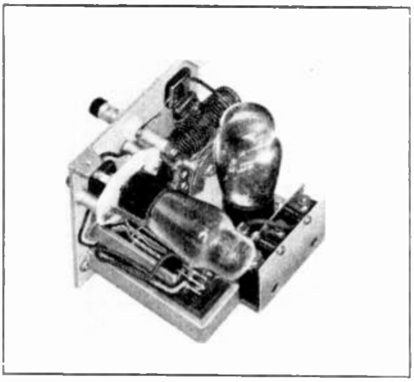
The front panel of this transceiver is of cast aluminum. A through-panel porcelain insulator carriers the antenna lead through the panel and to the coil. The antenna is connected to a binding post which can be seen in the photograph of the complete transceiver. The other controls on the front panel are the condenser tuning knob and the 4-P-D-T switch handle. A small carbon microphone and a pair of headphones fit into the compartment to the far right of the carrying case.

From the circuit diagram it is seen that the type 30 tube acts as a super-regenerative detector in the receive position, or a modu-



Carrying Case, Showing Compartments for "A" and "B" Batteries, "Mike" and Phones.

lated oscillator for transmitting; the 49 tube serves as a tetrode audio amplifier for receiving, and a modulator tube for transmitting. Transformer T1 serves the dual pur-



The Chassis. A 7½-Volt Miniature Battery Is Mounted Behind the 49 Tube.

pose of a modulation transformer for transmitting, or an output choke for receiving. The RF choke is a conventional 5-meter type.

High Power 10 and 5 Meter Power Amplifier

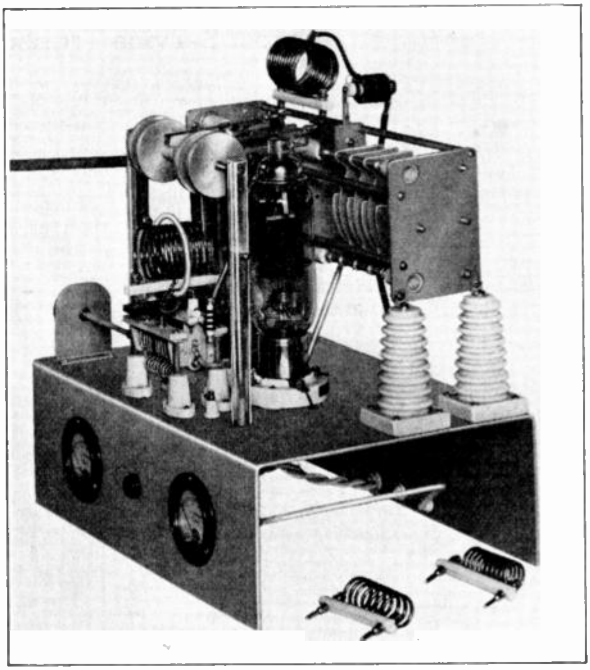


FIG. 69—High Power 10 and 5 Meter Amplifier with HF-200 Tubes in Push-Pull.

● A good mechanical layout for a high-frequency final amplifier with a standard neutralized push-pull circuit is shown in the photograph, Fig. 69.

The grid and plate leads are very short and direct, with the result that the amplifier can be used effectively on 5 meters, as well as 10 and 20 meters. The tubes are type HF-200, with the plates at the top and the grids at the side, making for short RF connections throughout. The 10 meter coils consist of 10 turns of No. 8 copper wire, 2 in. diameter, wound to cover a length of approximately 4 inches. The 5 meter coils have 7 turns of No. 8 wire, 1-inch diameter, 4 inches long. These coils are mounted on standard Johnson 4-inch glazed porcelain antenna spreaders. Coil plugs are secured to these spreaders by means of 6/32 machine screws. Center-tap connections to all coils are made with flexible leads and clips. A one-turn coupling link, 2½ inches in diameter, is wound around the center of grid coil and this link is fed with a twisted line of No. 8 rubber covered wire. This amplifier can be driven by a HF-100 RF stage.

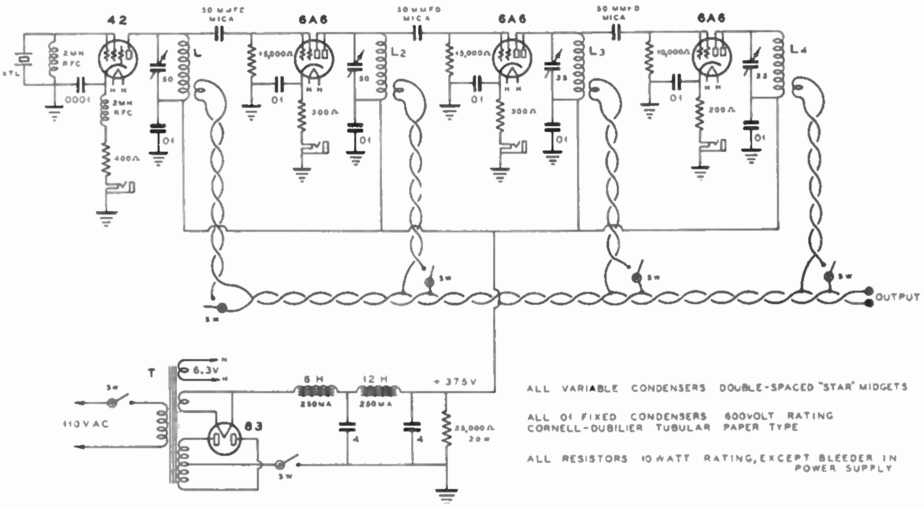
The final plate tuning condenser is an Audio Products Type WS-1502035, having a maximum capacity of 35 mmfd. per section. The grid tuning condenser is the new high-frequency Cardwell split-stator type. The neutralizing condensers consist of two machined aluminum plates, ¼-inch thick, 2½ inches in diameter, with an adjustable gap which is varied by means of a machine-screw threaded rod.

Practical 6-Band Exciter 5 to 160 Meter Operation

● One of the greatest difficulties encountered by the experimenter is the design of a crystal-controlled exciter from which several watts of output can be secured in the 5-meter band without resorting to costly and special tubes. Outputs of from 3 to 5 watts are obtained on 5 meters, and from 5 to 7 watts on 10, 20, 40, 80 and 160 meters from the simple exciter illustrated here for the first time. It was designed by Jones and first demonstrated to the radio amateurs at the 1936 Amateur Convention in Oakland, California. Its presentation aroused more interest than any exciter previously shown, because it operates on four bands from a single crystal. For example, the unit shown in the photograph operates on 40, 20, 10 and 5 meters from a 40 meter crystal. There are no neutralizing problems to cope with, inexpensive receiving tubes are used mere throw of a toggle switch. All four stages are first tuned to resonance for maximum output, after which no major retuning of any stage is necessary. Normally, the tuning dials can be left in one position at all times.

The exciter is a completely self-contained unit and it will serve as a driver for any phone or c-w transmitter because the plate supply has a two-section filter with negligible hum in the output. Furthermore, it occupies only as much space as is available for a standard 19 in. x 7 in. relay rack panel, with a chassis pan 17 in. x 11 in. x 1¾ in.

The coil design is extremely simple because each coil consists of only a single winding in the plate tuning circuit, with a two turn coupling loop wound on the same form slightly below the bottom turn of the



JONES 6 BAND EXCITER
DELIVERS 2 TO 5 WATTS OUTPUT ON 5 METERS

FIG. 70

throughout, a pair of terminals for connecting the coupling link to the exciter and single-pole toggle switches connect or disconnect the output from any stage without appreciable detuning effects. Thus it can be seen that operation on 40, 20, 10 or 5 meters can be secured without change in the coupling to the buffer stage, and the chosen frequency of operation is determined by the plate winding. The coupling to the buffer stage can be easily varied by moving the coupling turn (or turns) closer to, or farther away from, the node of the grid coil. The node of the plate coils in the exciter is at the positive B ends of the tuned plate circuits (bottom of plate coil windings). The small mica .00005 (50 mmfd.) fixed coupling condensers connected between plate coils and grids of the doubler stages are mounted above chassis between socket terminals or lugs. All tube and coil sockets are supported about ¾ in. above chassis. A large hole is punched directly under each coil and tube socket in order to facilitate wiring connections. All of the plate tuning condensers are insulated from the metal panel with fibre washers of the type that have protruding collars, so that the condenser shaft will not short-circuit the plate supply to the chassis. The rotor of each tuning condenser should connect to the positive B side of each circuit.

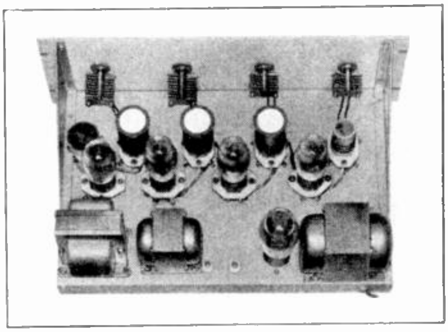


FIG. 71
Top View of 6-Band Exciter

Each stage is individually bypassed to ground, directly at the coil or tube socket, resulting in greater stability and efficiency, especially on 5 and 10 meters. These by-pass condensers are 600 volt paper tubulars, mounted under the chassis. The metering

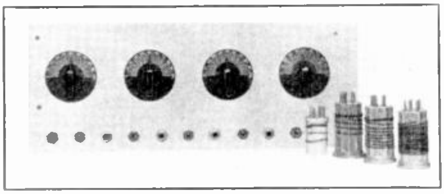


FIG. 72
Front View of Exciter and Coils

jacks are not insulated from the metal panel because the sleeves connect to ground.

An analysis of the circuit diagram shows that the doublers are straight-forward high-mu circuits with the grids and plates of the 6A6 tubes connected in parallel. Parallel operation results in approximately twice as much output as can be obtained with a single section of a 6A6, and this method of connection has proven satisfactory even on 5 meters. The grid drive from each succeeding doubler stage is sufficient to bias each stage to several times cut-off, resulting in high doubler efficiency. A combination of grid-leak and cathode bias is provided.

In order to simplify the design of the crystal oscillator, a 42 tube was selected. This tube can be used as a high-mu triode in a regenerative crystal oscillator circuit. A 6A6 with grids and plates in parallel would give more oscillator output, but the crystal RF current is excessive when the plate potential is more than 300 volts. A push-pull 6A6 crystal oscillator would also require a split plate coil, and such a coil cannot be easily coupled into a single grid circuit.

Regeneration in the crystal oscillator increases the output, and with less crystal current than in any other standard circuit

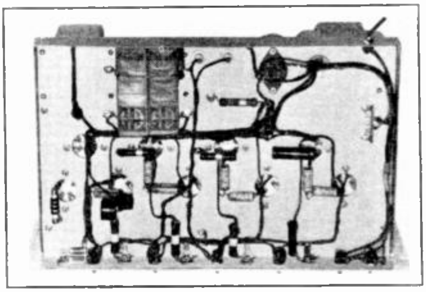
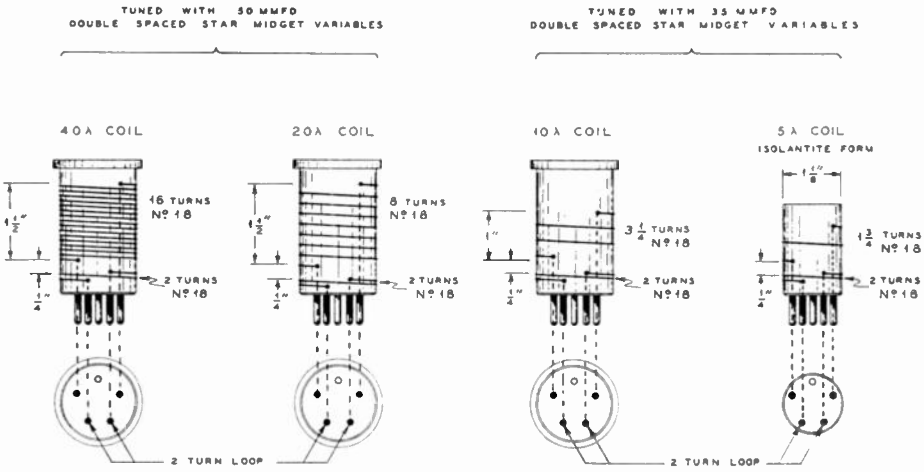


FIG. 73
Under-chassis View, Showing Placement of Resistors, Condensers, Coupling Link Line and Switches.

with the same tube. Regeneration is produced by means of a non-critical RF choke in the cathode circuit, by-passed to ground with a .0001 mfd. mica fixed condenser of the postage-stamp variety. The RF choke can be any standard small receiving type with an inductance of approximately 2 mh. The size of the cathode by-pass condenser depends upon the type of tube in the crystal oscillator circuit; for this particular circuit a .0001 mfd. mica condenser is correct. Other tubes may require a condenser as large as .00025 mfd. The tuning of the regenerative oscillator circuit is not critical and there is no self-oscillation when the crystal is removed. The circuit is tuned for maximum output. It can be loaded more heavily than a non-regenerative oscillator without loss of oscillation. The output of the crystal oscillator can be increased at least 50% with the regenerative circuit here shown.

The cathode of the crystal oscillator can be keyed for c-w or break-in operation.

Link coupling terminals are at the rear



COILS FOR 40, 20, 10 AND 5 METER OPERATION
(40 λ CRYSTAL IN OSCILLATOR)

FIG. 74

of the chassis deck between the rectifier tube and swinging choke. The power supply requires a power transformer that will supply approximately 400 volts output at 250 milliamperes. A 1000 volt center-tap winding rated at 150 milliamperes RMS is satisfactory. This transformer should also have a 5 volt rectifier filament winding and a 6.3 volt heater supply for the RF tubes. Swing-ing-choke input gives good voltage regulation when keying the oscillator, or when one or more stages are cut out of operation by means of an open-circuit plug in the cathode jack.

The constructor is advised to build the entire unit at one time, then plug each succeeding coil into its proper place after the preceding stage has first been tuned to resonance and functions properly. The oscillator cathode current will be between 40 and 60 milliamperes, depending upon the external load and plate supply voltage. Each doubler circuit will draw between 55 and 75 milliamperes, depending upon the external load. These values should not be exceeded.

A flashlight globe and single turn of wire provides a convenient method for tuning each doubler circuit to resonance.

The band selector toggle-switching arrangement effectively places the link circuits in parallel when more than one switch is thrown to the "*ON*" position at one time. The idling stages should not be detuned. Each coupling link connects through a twisted-pair with a switch in one side, thus completing the circuit to the output standoff insulator connectors. All of these link circuit wires are run either parallel or

Coil Winding Specifications

All coils, except the 5 meter coil, are wound on standard five prong 1½ in. diameter low-loss plug-in coil forms. The 5 meter coil is wound on a 1⅛ in. diameter ceramic 5-prong plug-in form. Coils for 160, 80, 40, 20 and 10 meter operation have a 2-turn winding at the bottom of the form. This 2-turn winding is the coupling loop, and the ends of the loop are connected to two of the prongs on the coil form. The pictorial drafting (Fig. 74) shows a complete group of coils for 40, 20, 10 and 5 meter operation with a 40 meter crystal in the oscillator stage.

160 Meter Coil: 60 turns, No. 24 DSC, close-wound.

80 Meter Coil: 30 turns, No. 18 DSC, close-wound.

40 Meter Coil: 16 turns, No. 18 DSC, space-wound over a winding length of 1½ inches.

20 Meter Coil: 8 turns, No. 18 DSC, space-wound over a winding length of 1½ inches.

10 Meter Coil: 3¼ turns, No. 18 DSC, space-wound over a winding length of 1 inch.

5 Meter Coil: 1¾ to 2½ turns, No. 18 DSC, spaced approximately ⅜ in. between turns. Some readjustment of this spacing may be necessary in order to permit the plate tuning condenser to resonate the circuit.

twisted together throughout the system in order to prevent absorption losses or coupling into other circuits.

The cathode resistors are soldered to the metering jacks. The grid resistors are of the wire-wound type, thus there is no need for RF chokes in the doubler circuits. The grid resistors are mounted under the chassis, below the tube sockets, as the photograph shows. The two 8 mfd. filter condensers are also below chassis. Either a type 83 or 83V rectifier can be used in the power supply. A switch is connected in the center-tap lead of the high voltage winding and plate voltage is not applied until the heaters of the tubes have first reached their normal operating temperatures. A 6-volt pilot light is at the extreme right, bottom end, of the panel; it denotes whether the main power switch is on or off.

If the band selector switching arrangement seems too complicated to the novice, merely couple a two-turn loop of push-back wire over the positive *B* end of the stage from which the output is to be taken. All doubler stages should be tuned to resonance as indicated by *minimum* cathode current, no matter from which stage the power is being drawn. If any one of the stages is detuned (with RF grid excitation applied), its plate current will be excessive, resulting in damage to the tube.

The output on 5 meters from this exciter should be sufficient to drive a pair of 6L6G tubes in push-pull, or a single 801, 802, RK25, or a 35T as a medium-power buffer. More output is secured on the other bands, and the same buffer tubes can be driven to somewhat higher efficiency. At longer wave lengths, a type 10, 45s, or 2A3s can be used for buffers. Screen-grid pentodes, such as the RCA-803 and 804, or Raytheon RK-20 and RK-28 can be driven by this exciter.

Antennas for Ultra High Frequency Operation

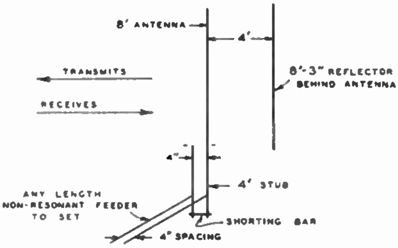
● The fundamental principles of antennas for wavelengths below 10 meters are no different than those discussed elsewhere for short-wave operation. The physical size of these antennas is such that they are economical to construct and they can easily be made portable. In the ultra-high-frequency field of communication the direct, or ground wave is used; for this reason the transmitting and receiving antennas are generally in visual range of each other. It is therefore necessary that the antennas be located as high above ground as possible. Low angle radiation is necessary and antennas which are particularly effective for this purpose should always be used. The earth reflects the ground wave upward, somewhat like the effect which is created by a body of salt water which pushes the somewhat longer wave in an upward direction. The ground acts like a mirror in reflecting light waves. Vertically polarized waves have less tendency for an upward bending, and thus vertical antennas are generally employed.

The simple non-directional antenna for u.h.f. operation consists of a half wave vertical wire or rod, fed with a two-wire matched impedance feeder (Fig. 77), or by means of a quarter wave matching stub and two-wire non-resonant line, Figs. 75 and 78.

Zepp. feeders are seldom employed, because the antenna in most cases is located several wavelengths away from the transmitter or receiver in order to secure ample height above the ground.

A *Concentric Feeder* (Fig. 79) is very effective for feeding either a half wave antenna or a quarter wave Marconi antenna, such as those used for mobile 5-meter work.

Directive antennas often prove of great value in the ultra-high-frequency region because the high power gain which is obtainable gives the same result as a great increase in transmitter power. The cost of increasing power is far more than that of a simple antenna array. Any of the directional antenna systems previously discussed can be used for u.h.f. communication, although those



SIMPLE 5 METER DIRECTIONAL ANTENNA WITH REFLECTOR WHICH DOUBLES OUTPUT & SENSITIVITY

FIG. 75

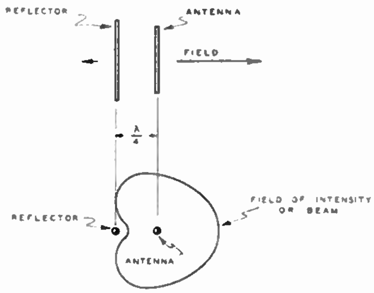


FIG. 76
Directivity Pattern of Antenna Shown in FIG. 75

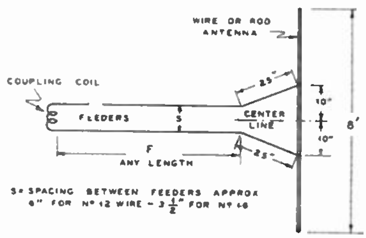


FIG. 77
5-Meter Matched Impedance Antenna.

which give vertical polarization, such as the Stacked Diploe, Yagi, Vertical Franklin, or Bruce are best.

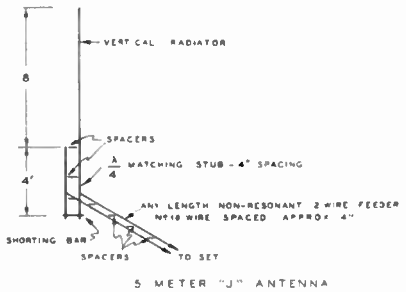


FIG. 78

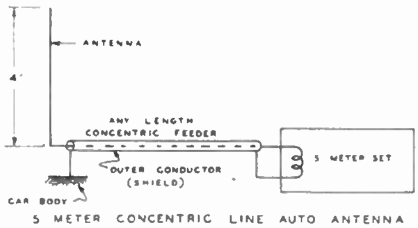


FIG. 79

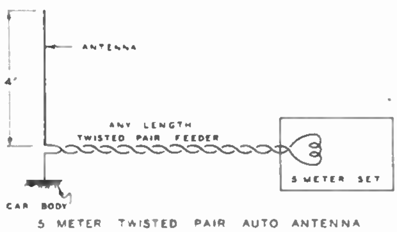


FIG. 80

Types of Mobile U. H. F. Antennas

● A quarter wave vertical Marconi antenna (Fig. 81) is very convenient for automobile installations. A 4-foot rod with the bottom end grounded to the car body can be fed with a single wire feeder several feet long; this feeder connects to the 5-meter set in the car.

Another 5-meter antenna consists of an insulated 4-foot rod, fed by either a twisted pair (solid conductors), or by a concentric transmission line, Figs. 79 and 80. In the case of twisted pair feeders, the impedance match is not very good, but this effect can be overcome to some extent by cutting the twisted pair to some particular length. This can best be determined by experiment, because a few inches more or less of feeder will provide a tuning effect and allow more efficient operation.

Quarter wave rods can be mounted on the roof of an automobile, if some means of flexible coupling is built into the base of the rod so that the antenna can be swung down

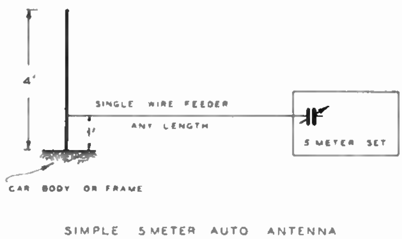


FIG. 81

when it strikes an overhead obstacle, such as a garage entrance, etc. Sometimes the rod is mounted on the front or rear bumper of the car, on the radiator, running board or fender. In many cases the antenna rod is mounted directly on a transmitter housed in the rear trunk of the automobile.

Mobile antenna installations for police radio work differ from the 5-meter types in that the antennas are somewhat longer because the frequency of operation is lower. The length can be calculated from the formula:

$$L_1 = \frac{492{,}000 \times 0.485}{f}$$

where L_1 = The quarter wave antenna length in feet.

f = The transmitter frequency in kilocycles.

The length of a half wave antenna is twice that of a quarter wave antenna.

Fixed Station 5-Meter Antennas

● These antennas can be constructed from copper or aluminum rod, or wire. When a wire antenna is used, the wire can be supported on stand-off insulators attached to a vertical 2"x3" wood pole. The pole should be guyed, preferably with ropes, in order to keep metallic conductors away from the field of the antenna. The antenna should be as high as possible and well remote from surrounding objects.

These same types of antennas can be used for television reception by making the half wave antenna resonant to the frequency of the television transmitter. In this case a twisted-pair feeder of solid wire, such as the *EO1 Cable,* can be used in order to reduce automobile ignition interference. The loss in a twisted-pair feeder at these frequencies is rather high and transposition blocks can be used at intervals along the two-wire feeder line.

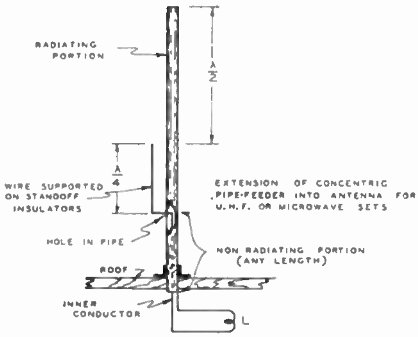


FIG. 82

Long wire antennas can be used on 5 meters providing the directional effects are taken into consideration. For example, a 20 or 40 meter single wire fed or Zepp. antenna can be operated on 5 meters with fairly satisfactory results for both transmitting and receiving.

2½-Meter Antennas

● Any of the antennas previously described, and which provide vertical polarization, are suitable for 2½ meter operation. Those shown in Fig. 83-A on Page 50 are ideally suitable for use with a 2½ meter transceiver. The figures are self-explanatory, in that all dimensions are clearly shown. The Table showing *Antenna Array Dimensions* lists all of the data for the ultra high-frequency bands, down to 1¼ meters. The Table, *Reflector and Director Dimensions,* shows the data for any form of Yagi or Parabolic Reflector system for wavelengths down to 1¼ meters.

Micro-Wave Antennas

● Antennas for operation in the vicinity of one meter, or less, are classified as *Micro-Wave Antennas.* Half wave vertical rods are suitable for portable operation and in most cases they can be capacitively coupled at one end to the micro-wave transmitter or receiver. Directive arrays, especially those of the Yagi type, are easily constructed; they greatly improve the performance of micro-wave sets.

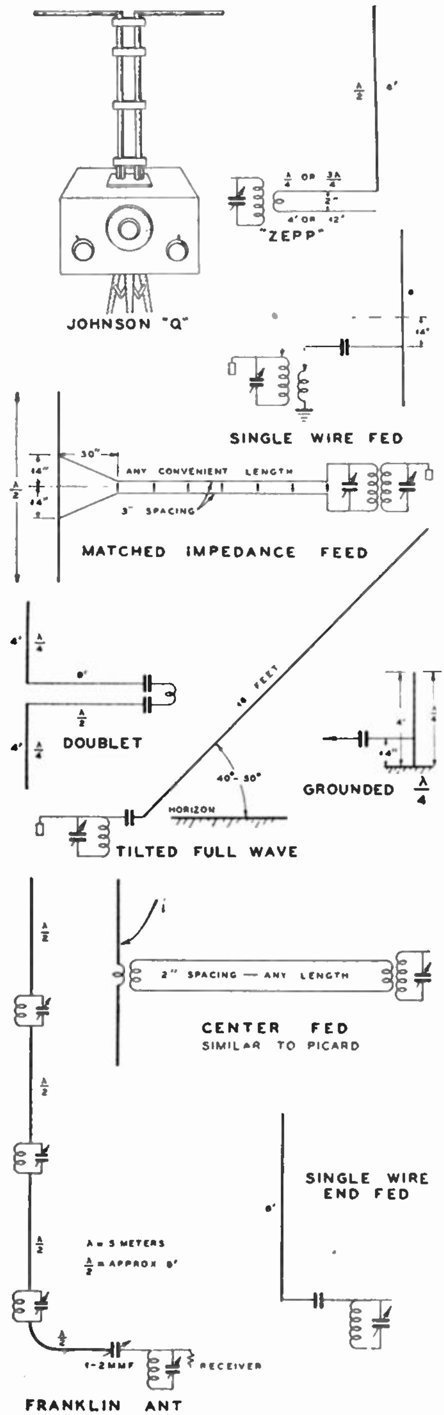


Fig. 83. Typical 5-Meter Antennas.

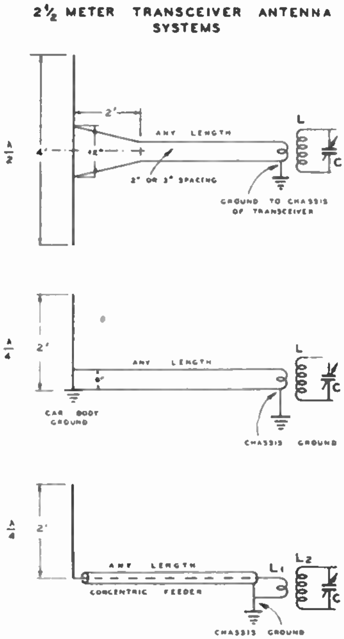


FIG. 83-A

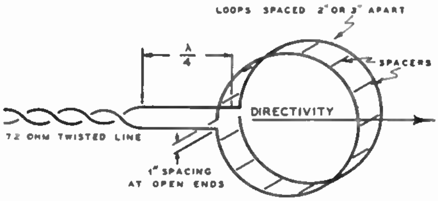


FIG. 84

Reinartz Rotary Beam with Twisted-Pair Feeder and Stub.

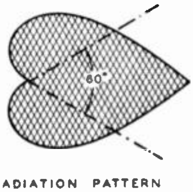


FIG. 85

Directivity of the Reinartz Rotary Beam.

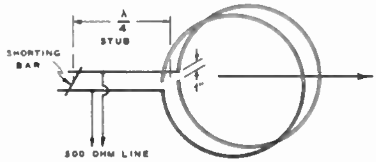


FIG. 86

Reinartz Rotary Beam Antenna with Spaced Feeder and Stub.

Reinartz Rotary Beam Antenna

● The John L. Reinartz compact directive antenna, Figs. 84 and 86, has relatively high efficiency on the short and ultra-short wavelengths. It is suitable for 5-meter transmission and reception and its field pattern is similar to that of a half wave vertical antenna with single reflector, Fig. 85.

It consists of two 8-foot lengths of tubing, bent into a circle, with 2 in. to 3 in. spacing between the tubes. The circles are not closed; an opening of one inch remains, as shown in the diagram.

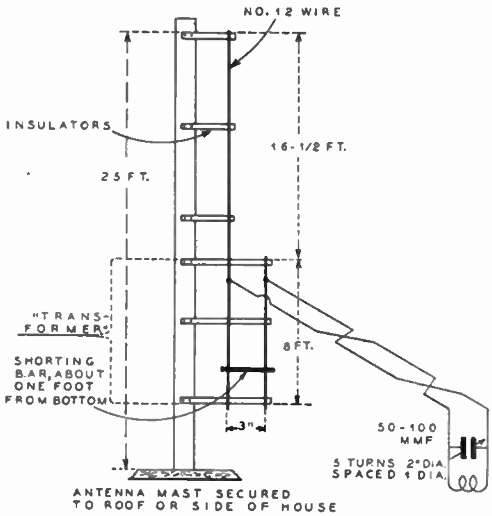
The diameter of the circle is a little over 30 inches. The most efficient method of feeder connection to a 5-meter set is by means of a quarter wave matching stub connected to either a twisted pair feeder or two wire 500 ohm line. This type of antenna can be placed in either a horizontal or vertical plane, depending upon whether horizontal or vertical polarization is desired. The actual power gain over that of a vertical half wave antenna in the desired direction is approximately 15%. The power directivity is nearly 6-to-1 in a forward direction away from the open ends.

16½ ft. rods can be used for 10 meter operation, 33 ft. rods for 20 meters. The spacing between the rods, or circles, need not be increased when the antenna is built for operation on the longer wavelengths.

The antenna should be arranged for 360° rotation.

10 Meter Vertical Antenna With Matching Stub

● A very effective antenna system for non-directional 10 meter operation is shown in Fig. 87. It consists of a 25 foot pole, supported on the roof or to one side of a building or other structure, a 16½ foot vertical antenna wire run up along the pole and insulated from it with small insulating strips or rods. At the bottom of the 16½ foot section is another section of two wires, called the matching stub. These wires are 8 feet long, one of them being a portion of the antenna proper. A shorting bar, connected across the bottom of the two wires, is moved upward or downward for antenna tuning; likewise, the feed line tapped across the two wires at a point about ⅓rd the way down from where the two wire portion begins, is also later adjusted and readjusted in tuning up the system.



10-METER VERTICAL ANTENNA WITH QUARTER WAVE MATCHING TRANS.

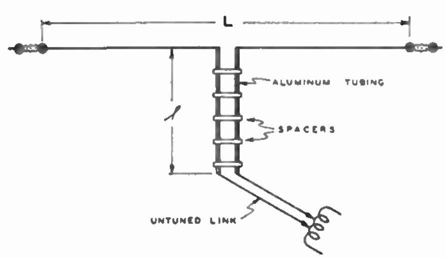
FIG. 87

Tuning Procedure

(1) Place transmission line ⅓rd the way down from the point where the two wires begin, that is, ⅓rd the way down from the top of the "matching transformer."
(2) Adjust the shorting bar by placing it approximately 1 foot or 18 inches from the bottom of the "matching transformer."
(3) Turn "on" transmitter, and loosely couple the antenna coil to the final amplifier plate coil.
(4) Place a "field strength meter" somewhere where it can be seen from the roof, or let someone else watch the reading of the meter.
(5) Never re-adjust the field strength meter once it is set, while the antenna is being tuned.
(6) Take readings on the field strength meter and adjust the antenna coupling to the instrument so that half scale readings are obtained.
(7) Return to the roof, put on a pair of gloves, and adjust the shorting-bar until the field strength meter denotes maximum reading.
(8) Next, adjust the position of the feed-line to a point, where maximum indication is again had on the field strength meter.
(9) Lastly, re-adjust the shorting-bar so that a more accurate position can be found, as again denoted by still greater reading of the field strength milliammeter.

The Johnson "Q" Antenna

● Another type of single band half wave antenna is the Johnson "Q," which uses a special quarter wave matching transformer to couple a more or less conventional 400 to 600 ohm two-wire line to the 73 ohm impedance which exists at the center of a half wave antenna. This matching transformer consists of two parallel aluminum tubes, each a quarter wave in length, suspended from the center of the antenna. See Fig. 88.



JOHNSON "Q" ANTENNA

FIG. 88

The surge impedance is made fairly low by using half-inch diameter tubing, spaced 1.6 inches apart. This spacing results in an impedance of slightly over 200 ohms, which is the geometric mean between the antenna center impedance of 73 ohms and the impedance of a two-wire line of 600 ohms. The matching section should be approximately a quarter wave in length for the particular frequency used.

Directive Antennas

● All antennas have directional properties and these can be increased by properly combining the antenna elements. The various forms of half wave antennas already described have maximum radiation out at right angles to the direction of the wire, but the directional effect is not very great. If this radiation can be confined to a narrow beam, the signal intensity can be increased a great many times in the desired direction of transmission. This is equivalent to increasing the power output of the transmitter. It is more economical to use a directive antenna than to increase transmitter power if general coverage is not desired.

Directive antennas can be designed to give as high as 23 DB gain over that of a single half wave antenna. However, this high gain (nearly 200 times as much power) is confined to such a narrow beam that it can be used only for commercial applications in point-to-point communication. The increase in radiated power in the desired direction is obtained with a corresponding loss in all other directions. Gains of 3 to 10 DB seem to be of more practical value for amateur communication because the angle covered by the beam is wide enough to sweep a fairly large area. 3 to 10 DB means the equivalent of increasing power from 2 to 10 times. For example, an amateur living in the center of the United States would want his beam to be wide enough to cover all of Europe in one direction, and New Zealand in the opposite direction. His beam should be centered about 45° north-of-east, and about 35° wide. Similarly, a 20° beam width, 50° south-of-east, would cover South America and the Orient. Another 35° beam pointing east and west would cover Australia and South Africa. In San Francisco, two beam antennas could be made to cover all DX sections fairly well; a 30° beam, 35° south-of-east for South America and the Orient, and another 35° to 40° beam, 45° north-of-east for Europe, New Zealand and Australia.

In this discussion all antenna arrays are assumed to have two main lobes of radiation in opposite directions (no reflector system). Angles in which the antennas could be pointed can be figured as the Great Circle shortest distance direction with the aid of a globe of the world. Day and night directions in some cases are different, due to the skip distance effects of some of the high-frequency bands, because the signals may go around the world in one direction in the morning, and in the other direction at night, to points near the opposite sides of the world.

Four to six half wave antennas or their equivalent are apparently about all that can be used without securing too much directivity, unless the operator is aiming at one locality of relatively small area. With ultra-short wavelengths below 10 meters, the problem of rotating the beam antenna is simplified and more directional effects with greater power are desirable. Reflector systems can be set up for increasing the beam in one direction and preventing radiation in the opposite direction.

Tables of wire lengths for several arrays and directional types of antennas are given. Local conditions of surroundings will modify these values, but for most purposes the wires can be cut to the values listed, and satisfactory results obtained.

The most simple method of feeding many types of directional antennas (if near the transmitter) is by means of Zepp feeders which are generally some old multiple of quarter waves in length. In all cases where the system is much more than a wavelength from the transmitter to the feed point, a non-resonant two-wire feeder and quarter wave matching stub should be employed. The problem is greatly simplified in most cases by the use of Zepp feeders, since the feeders can be tuned at the transmitter just as with any Zepp half wave antenna. In some instances the feeders should be electrically an even multiple of quarter waves in length. A simple field strength meter coupled to the antenna system will readily indicate correct feeder tuning.

All directional resonant antenna systems, other than a single long wire system, operate on the one frequency for which they are designed. The "*V*" beam can be operated on two bands with fair satisfaction, although the correct angle δ between the arms of the "V" can only be made for one frequency. A type is generally chosen from a consideration of available space. The "V" beams are less critical in mechanical design; if space is available for pointing the open or closed end of the "V" in the desired direction, this type is excellent.

Horizontal and Vertical Directivity

● The horizontal directivity of any antenna system is that shape of the radiated beam or beams shown looking down at the earth from a point above the antenna system. For example, a beam having a width of 30° horizontally would spread out enough to cover a whole continent, such as Europe, from points in the United States. *Vertical Directivity* is the expression for defining the angle above the horizon at which the major portion of the radiation goes out from the antenna. Directional antenna systems are generally made to have a very low angle of radiation, so that the vertical directivity is outward toward the horizon, rather than upward.

Polarization

● Radio waves are *Polarized* in that they will induce a greater signal in the receiving antenna when the plane of that antenna is parallel to the plane of polarization. For example, a vertical transmitting antenna will produce a vertically-polarized wave which can best be received by a vertical receiving antenna over relatively short distances, such as in the ultra-high-frequency region. Wave-lengths between 10 and 100 meters can be transmitted with either vertical or horizontal antennas, resulting in the wave starting out with a *vertical* or *horizontal* polarization, and by the time it reaches the distant receiving antenna it is apt to be mainly *horizontally* polarized. Reflection and refraction effects in the Heaviside Layer tend to twist the wave polarization so that in most cases a horizontal receiving antenna will give best results.

For ultra-short wavelengths, vertically polarized waves are not reflected upward by the surface of the earth as easily as those of horizontally polarized nature and only the ground wave is useful on wavelengths below 10 meters. Vertical transmitting and receiving antennas have thus proven most satisfactory at these frequencies.

Wavelengths above 100 meters are not as easily twisted as those below 100 meters. With ultra-short wavelengths the plane of polarization may be twisted by such objects as hills or buildings, so that occasionally a horizontal antenna will very efficiently receive signals transmitted by a vertical antenna.

Directive Factors

● Directional antenna systems operate on the principle that the radiation fields add or subtract in space. When several radiating elements, such as half wave antenna, are in close proximity to one another, the radiated fields may aid or oppose each other in different directions. In those directions in which opposition or cancellation occur, the signal is attenuated; similarly in those directions in which the fields aid each other, or add, the signal is increased. All directive antennas depend upon this phenomena. The fields are said to be *in phase* when they are additive, and *out of phase* when they cancel each other. Antenna directivity results from phasing the radiation from adjacent antenna elements so as to neutralize the radiation in the undesired directions, and to reinforce the radiation in the desired direction. Directivity can be obtained in either horizontal or vertical planes. In transmission, directive antennas concentrate energy much like reflectors and lenses concentrate light rays. For receiving, the signal is proportional to the amount of antenna wire exposed to the radio waves when the half wave sections are properly phased.

Reflectors

● A simple reflector consists of a wire approximately a half wave long, either excited directly by the transmitter so as to be out of phase with the antenna, or it can be of the *parasitic* type, A Parasitic Reflector one quarter wave away from the antenna must be slightly longer than the antenna in order to have an inductive reactance. The radiated field from the antenna is re-radiated by the reflector wire so that the radiation in line with the two is reinforced back toward the antenna and cancelled in the opposite direction. If the reflector wire is spaced a half wavelength distant from the antenna the radiated field will be increased in two directions, or tend to cancel in a direction at right angles. The increase is in a plane at right angles to the plane of the antenna and reflector, as shown in Fig. 89.

Two reflector wires spaced a half wave each side of an antenna, and an additional reflector spaced a quarter wave behind the

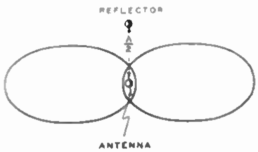


FIG. 89

antenna, will combine to increase the field intensity in a forward direction, and tend to cancel the field in all other directions.

Reflector curtains, a combination of several reflector wires in proper phase relation, are normally used in commercial applications in order to confine a beam to one direction. Without such a reflector curtain, which is usually similar to the antenna array, the beam would be transmitted with less intensity in both a forward and backward direction. The reflector in such cases *doubles* the field in the forward direction.

Parasitic reflectors have no direct connection to the antenna or feeders. Their length can be calculated from the formulas:

$$L = 1.60 \times \lambda$$

where L is the reflector length in feet.
λ is the transmitter wavelength in meters.

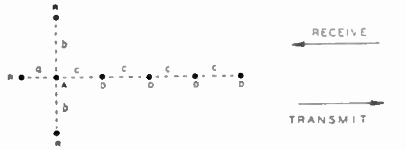
$$L = \frac{492{,}000 \times 0.97}{f}$$

where f is the transmitter frequency in kilocycles.

These formulas can be used for determining the length of single half wave reflector wires, such as those used in a parabolic reflector or in a *Yagi* antenna.

Directors

● If a wire is placed in front of an antenna and if it has a capacitive reactance, it will aid the radiation in a *forward* direction. More than one wire may be placed in line of the desired direction, such as shown in the Yagi antenna in Fig. 90 in order to greatly increase the directivity and field intensity in that direction. These are called *director wires* and they are shorter than those used for reflectors. A capacitive reactance is obtained by making the wire less than an electrical half wave in length. A straight wire loses both inductance and distributed capacitance as it is decreased in length. At a given frequency the inductive reactance will predominate if the wire (less its end effects) is over a half wave in length. Similarly, if it is less than a half wave in length the capacitive reactance will be greater than the inductance reactance. The antenna should always be resonant, in which case the inductive reactance is equal to the capacitive reactance and the two will then cancel each other.



TOP VIEW OF VERTICAL ANTENNA, REFLECTOR AND DIRECTOR SYSTEM.

R-REFLECTOR WIRES; D-DIRECTOR WIRES; A-ANTENNA WIRE.

FIG. 90
Yagi Antenna.

Director wires should be spaced at intervals of ⅜ths wavelength in the desired direction from the transmitting antenna. These lengths can be calculated as follows:

$$L = 1.425 \times \lambda$$

where L is the director length in feet.
λ is the transmitter wavelength in meters

$$L = \frac{492{,}000 \times 0.87}{f}$$

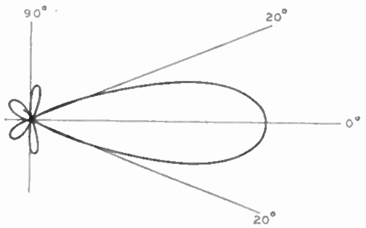
where f is the transmitter frequency in kilocycles.

Directional Antenna Types

The Yagi Antenna

● The Yagi Antenna is useful on the ultra-short and micro-wave bands. It consists of several reflector and director wires grouped around a half wave antenna, such as that shown in Fig. 90, which is a top view of a vertical array. The rear reflector wire *R* is placed a quarter wave behind the antenna wire *A*, two other reflector wires are placed a half wave from the antenna, on each side. The director wires *D* are spaced a distance of ⅜ths of a wave apart. The distances *A*, *B*, and *C* are a quarter, half and ⅜ths of a wave respectively in Fig. 90. In the table (page 56), dimensions are listed for the design of this type of directive antenna for wavelengths of from 1¼ meters to 20 meters (224 to 14.4 mc.).

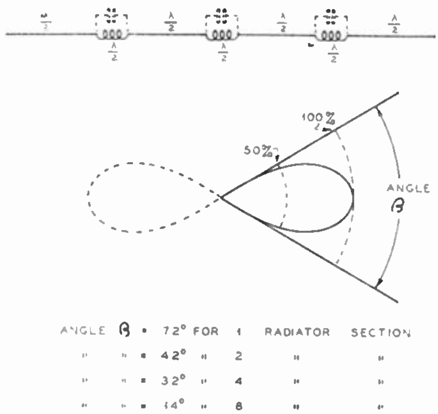
The reflector and director wires are all parasitically excited. The antenna can be



HORIZONTAL DIRECTIVITY OF A SIMPLE YAGI ANTENNA

FIG. 91

fed with any type of RF feeder, such as a two-wire matched impedance feed, Zepp feeders or by a quarter wave matching stub and non-resonant line.



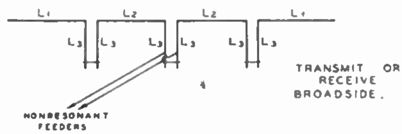
FRANKLIN ANTENNA

FIG. 92

The Franklin Antenna

● A directive antenna array which is quite practical for amateur application is shown in Fig. 92. It consists of two or more half wave sections in phase, so that the radiation field is broadside to the antenna. More than four sections will provide too sharp a beam for most amateur purposes. The half wave sections may be phased with quarter wave sections, as shown in Fig. 93, or by means of phasing coils, as shown in Fig. 94. In either case the phasing coil, or quarter wave section, is equivalent to a half wave antenna which does not radiate, but only serves the purpose of phasing the antenna current in the same direction in adjacent sections of the radiating antenna. The two end sections L_1 should be cut for end effects, thus making these sections slightly shorter physically than the intermediate section L_2.

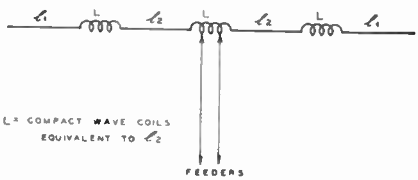
The dimensions listed in the Table for Antenna Arrays are theoretical values which may have to be slightly modified in actual practice, due to the proximity of surrounding objects. Ordinarily, this antenna can be tuned to resonance by varying the lengths of the quarter wave stubs L_3.



BROADSIDE DIRECTOR ANTENNA

FIG. 93

Non-resonant feeders in the form of a 600 ohm line should preferably be tapped across the middle quarter wave section in order to secure a balanced antenna system. If one of these quarter wave sections is near the transmitter, it can be used as a Zepp. feeder of either one-quarter or three-quarters of a wave in length. It can be tuned with series condensers and coils, as discussed under Zepp. Antennas.



TYPE OF FRANKLIN ANTENNA

FIG. 94

A 20 meter directional antenna of this type is easily constructed because the required space is only about 135 feet, and the height above ground about 40 feet. A single 6-inch strain insulator can be used to support the L_1 and L_2 sections. The L_3 sections can hang toward the ground, held in position with a small weight. The L_3 quarter wave sections can be spaced with 6-inch ceramic Zepp. feeder separators. Standing waves along the non-resonant feed line can be located by means of a milliammeter, carborundum detector, and coil arrangement. The standing waves are indicated by variations of the milliammeter reading as the feeder test set is moved along the feed line at a constant distance from the line. The standing waves can be eliminated or minimized by changing the position of the feeder taps on the quarter wave section, also by a variation of the quarter wave section lengths. In some cases the values of L_1 and

L_2 may have to be shortened slightly, and the various sections may sometimes differ from the lengths shown in the Table because of the proximity of some object near one of the sections. In most cases the values shown in the Table can be used without variation, unless the utmost in efficiency is desired. The values of L_1, L_2, L_3 and L_4 are correct for nearly all forms of antenna arrays. This Table greatly simplifies directional antenna array design for amateur operation.

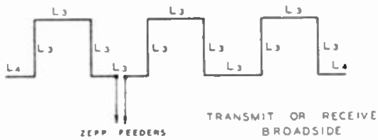
Antenna Array Dimensions

For Franklin, Bruce, Chireix-Mesny, Barrage and Stacked Dipole Arrays.

BAND	Frequency in Megacycles	L_1	L_2	L_3	L_4
40 Meter	7.02	68′2″	70′	35′	17′1″
	7.10	67′6″	69′2″	34′7″	16′11″
	7.20	66′7″	68′4″	34′2″	16′8″
	7.28	65′10″	67′6″	33′9″	16′5″
20 Meter	14.05	34′1″	35′	17′6″	8′6″
	15.15	33′10″	34′8″	17′4″	8′5″
	14.25	33′7″	34′6″	17′3″	8′5″
	14.35	33′5″	34′3″	17′1″	8′4″
10 Meter	28.0	17′1″	17′7″	8′9″	4′3″
	29.0	16′6″	17′	8′6″	4′1½″
	30.0	16′	16′5″	8′2″	4′
5 Meter	56	8′7″	8′9″	4′5″	2′2″
	58	8′3″	8′6″	4′3″	2′1″
	60	8′	8′2″	4′1″	2′
2.5 Meter	112	4′3″	4′5″	26″	13″
	116	4′1½″	4′3″	25″	12½″
	120	4′	4′1″	24½″	12″
1.25 Meter	224	25½″	26½″	13″	6½″
	232	25″	25½″	12½″	6¼″
	240	24″	24½″	12″	6″

The Bruce Antenna

● One of the simplest antenna arrays is shown in Fig. 95. It is not critical as to the length of its elements, and it can be used over a wider frequency range than most other antenna arrays. The antenna is made up of ⅛ and ¼ wave sections, resulting in good horizontal directivity if the overall length is at least five wavelengths long; however, it possesses very little vertical directivity because of its lack of height. The currents in each half of a horizontal section are out of phase and thus these sections tend to cancel their radiation field. The vertical sections are in phase, resulting in broadside radiation or reception, because this antenna is normally used for receiving. A similar bent wire, placed a quarter wave behind the antenna, will act as a reflector and make the system unidirectional.



BRUCE BROADSIDE DIRECTIVE ANTENNA

FIG. 95

This antenna is occasionally used for 5-meter transmission and reception, due to its small size. The dimensions for different amateur bands are listed in the Table showing *Antenna Array Dimensions.*

Reflector and Director Dimensions

Freq.	A	R	D	a	b	c
224	25″	26″	23″	13″	26½″	20″
232	24″	25″	22″	12½″	25½″	19″
240	23½″	24″	21″	12″	24½″	18½″
112	4′2″	4′3″	45½″	26″	4′5″	39″
116	4′	4′1½″	44″	25″	4′3″	38″
120	3′10″	4′	43″	24½″	4′1″	37″
56	8′4″	8′7″	7′½″	4′5″	8′9″	6′7″
58	8′1″	8′3″	7′4½″	4′3″	8′6″	6′4″
60	7′10″	8′	7′1½″	4′1″	8′2″	6′2″
28	16′8″	17′2″	15′3″	8′9″	17′7″	13′2″
29	16′1″	16′6″	14′9″	8′6″	17′	12′8″
30	15′6½″	16′	14′3″	8′2″	16′5″	12′4″
14.05	33′4″	34′1″	30′5″	17′6″	35′	26′3″
14.15	33′1″	33′11″	30′2″	17′4″	34′8″	26′1″
14.25	32′10″	33′8″	30′	17′3″	34′6″	25′11″
14.35	32′8″	33′5″	29′10″	17′1″	34′3″	25′8″

Stacked Dipole Antennas

● A *dipole* is simply another name for a half wave antenna. Several dipoles can be arranged in stacks to form a highly directive antenna system. When an entire "curtain" of these dipoles is used, together with a similar reflector curtain spaced one-quarter wave behind it, the beam becomes very sharp and of great intensity. Actual power gains of 100 to 200 are secured in commercial practice. Both horizontal and vertical directivity can be very great because several elements, such as shown in Fig. 96 (four radiating dipoles), can be built into a curtain with one row on top of the other. For amateur purposes the single unit will provide sufficient directivity in most cases.

The radiating sections L_1 may be either horizontal or vertical, depending on whether horizontal or vertical polarization is desired. The currents in the L_2 and L_3 sections produce fields which neutralize each other, with the result that radiation occurs only from the L_1 sections which are a half wave in length, electrically. The actual physical length is approximately 0.975 of a half wavelength. The L_2 sections are made a half wave in length in order to provide the proper phase in the L_1 sections. In Fig. 95 the radiation is broadside to the antenna, as shown, and end-wise if the two sections L_2 do not cross.

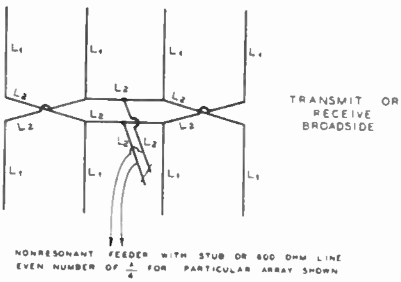


FIG. 96

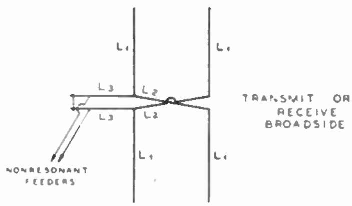


FIG. 97

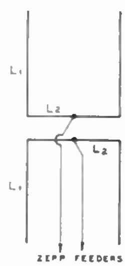


FIG. 98

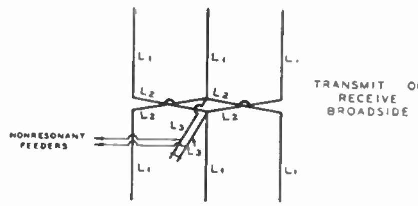


FIG. 99

In the four forms of this antenna shown in Figs. 96 and 99, quarter or half wave matching stubs provide a means of connection to a two-wire non-resonant feeder. In some cases a 600 ohm line can be connected directly into the array when the impedance at the chosen point is 600 ohms. Zepp. feeders are satisfactory if they are not over 5 quarter wavelengths long. These arrays are fairly popular for the ultra-short wavelengths for amateur operation, although commercial application is widespread for wavelengths above 10 meters. These systems must be adjusted for the exact frequency of transmission, and quite rigidly supported.

The arrays shown in Figs. 97 and 98 are similar in performance, even though the L_2 sections do not cross or reverse in one case. The phase of the current in the L_1 sections is maintained by connection of a resonant feeder or quarter wave matching stub at the ends of L_2 in one case, and at the center in the other case.

Figure 100 shows the construction of a framework for an ultra high frequency directional antenna with parasitic reflectors spaced a quarter wave behind the "H"-section antenna. If desired, the reflector wires *D* can be cross-connected at their adjacent ends. The antenna sections *A* are listed in the Table for *Antenna Array Dimensions* as L_1. The reflector wires *D* are listed in the Table for *Reflector and Director Dimensions* as *D*, which in this case is equivalent to L_1. The Zepp. feeders should be an even number of quarter wavelengths, the same as in a center-fed Zepp. antenna.

In practical applications of curtains, the reflector wires should be tuned for maximum current. Usually the lengths will be between 2% and 5% greater than a half wave in length. The antenna elements are sometimes as much as 10% shorter than a half wave in length. The reflector curtain has a reactive effect upon the antenna and thus it is generally tuned-up first, then the antenna wires are cut to length experimentally in order to provide exact resonance under operating conditions. In these curtains, which consist of horizontal rows of half wave elements and often two or three tiers one above the other, RF power is fed in the proper phase relation to several points.

A reflector placed a quarter wave behind an antenna, and properly tuned, will provide a gain of 3 DB, which is a power gain of two. Two half wave antennas spaced a half wave apart and properly excited, will also provide a 3 DB gain over that obtained from a simple half wave antenna. Three and four half wave sections in a line a half

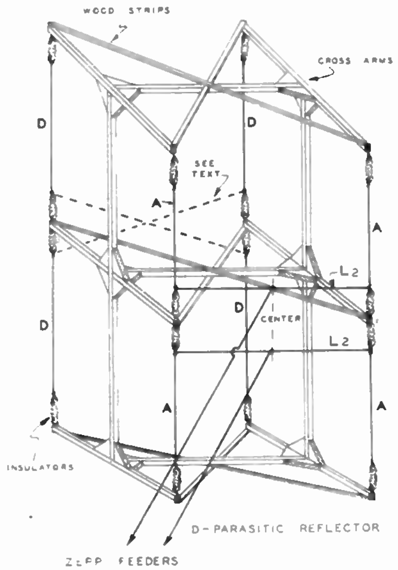


FIG. 100

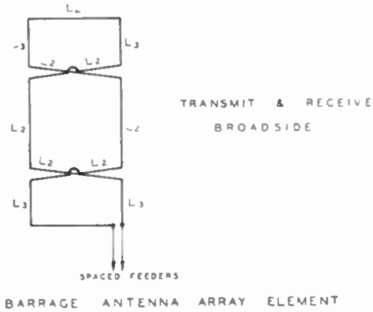


FIG. 101

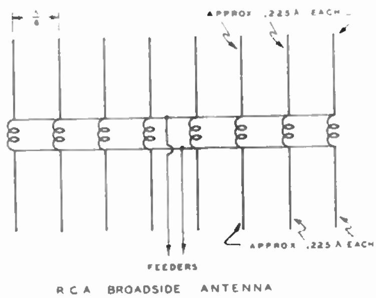


FIG. 102

wave apart will provide gains of 5 DB and 6½ DB, respectively, over that of a single half wave antenna. The simple "H" type of stacked dipole, Fig. 97, which consists of four half wave sections, will give a gain of approximately 6½ DB. The antenna shown in Fig. 99 which has six half wave radiating sections will give a gain of approximately 8½ DB. The one shown in Fig. 96 which has eight sections will give a gain of 10 DB. Adding a reflector section similar to the antenna array, and spaced one-quarter wave behind it, will provide 3 DB additional gain to any of these arrays.

The Barrage Antenna

● Another of the many types of directive arrays is shown in Fig. 101, a broadside radiator of vertically polarized waves.

The horizontally polarized waves which would be radiated by the top and bottom horizontal wires are negligible because of the opposition of current flow in the two halves of each of these members. This is obtained by making the vertical sections at the top and bottom of L_3 a quarter wave long. The middle sections L_2 are half wave in length. The dimensions for this antenna are listed in the Table of *Antenna Array Dimensions* for amateur bands.

RCA Broadside Antenna

● In this array, Fig. 102, all parts of the parallel transmission line connecting the L sections are kept in phase by means of shunt inductances.

The waves are vertically polarized and the beam is broadside to the antenna. A reflector system spaced a quarter wave behind the antenna can be used to make it unidirectional.

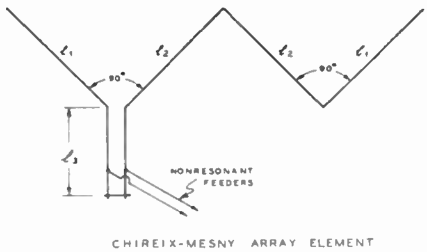


FIG. 103

Chireix-Mesny Antenna

● Numerous elements of the type shown in Fig. 103 are connected to form an antenna and reflector curtain for operation in many French commercial stations. In this case, the feeder system is different from that shown.

For amateur application a Zepp. type feeder is recommended. The dimensions for L_1 and L_2 are approximately a half wave in length, and for the amateur bands the lengths can be found in the Table of *Antenna Array Dimensions.*

"V" Antennas

● The horizontal "V" antenna shown in Fig. 104 is suitable for amateur as well as commercial work. The long wires *L* can be made several waves in length in order to obtain good directivity.

By choosing the proper angle δ, the lobes of radiation from the two long wire antennas aid each other to form a bi-directional beam. The back end radiation can be re-directed forward by a reflecting antenna similar to the radiating antenna, located an odd number of quarter wavelengths behind, and faced so that the two antennas are supplied with current 90° out of phase. Each wire *L* by itself would have a radiation pattern similar to that shown for antennas operated at harmonics. Design data for the 10, 20 and 40 meter bands is listed in the Table, together with the proper angle δ.

This type of antenna can be made into a Vertical "V" as shown in Fig. 105, which is particularly adaptable for receiving, because only one antenna mast is required.

The angle δ for different lengths of *L* is shown in the chart for *Diamond Antennas.* A good ground connection is necessary.

Horizontal V antennas are easily constructed and have proven very effective. For amateur operation *L* can be two or four wavelengths long. Commercial antennas are usually made eight waves in length in order to secure a sharper beam with a correspondingly greater power gain.

Diamond Antennas

● A very effective directional antenna having a low angle of radiation of horizontally polarized waves is shown in Fig. 106 (A). This non-resonant *Diamond* antenna consists

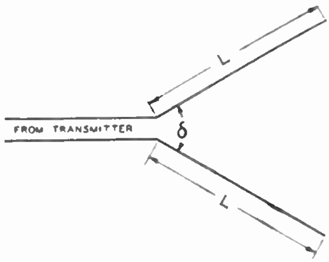


FIG. 104

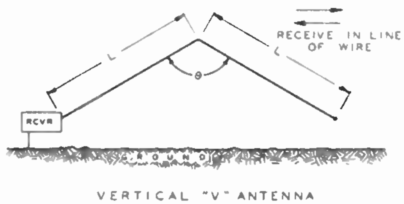


FIG. 105

"V" Antenna Design Table

Frequency in Kilocycles	"Half Wave" Dipole	"Full Wave" $L = \frac{\lambda}{2}$ $\delta = 180°$	$L = \lambda$ $\delta = 104°$	$L = 2\lambda$ $\delta = 75°$	$L = 4\lambda$ $\delta = 52°$	$L = 8\lambda$ $\delta = 39°$
28000	16′ 8″	17′ 1″	34′ 8″	69′ 8″	140′	280′
28500	16′ 4″	16′ 9″	34′ 1″	68′ 6″	137′ 6″	275′
29000	16′ 1″	16′ 6″	33′ 6″	67′ 3″	135′	271′
29500	15′ 8″	16′ 2″	33′	66′ 2″	133′	266′
30000	15′ 6½″	15′ 11″	32′ 5″	65′	131′	262′
14050	33′ 4″	34′	69′	139′	279′	558′
14150	33′ 1″	33′ 10″	68′ 6″	138′	277′	555′
14250	32′ 10″	33′ 7″	68′ 2″	137′	275′	552′
14350	32′ 8″	33′ 5″	67′ 7″	136′	273′	548′
7020	66′ 7″	68′ 2″	138′ 2″	278′	558′	1120′
7100	65′ 9″	67′ 4″	136′ 8″	275′	552′	1106′
7200	64′ 11″	66′ 5″	134′ 10″	271′	545′	1090′
7280	64′	65′ 8″	133′ 4″	268′	538′	1078′

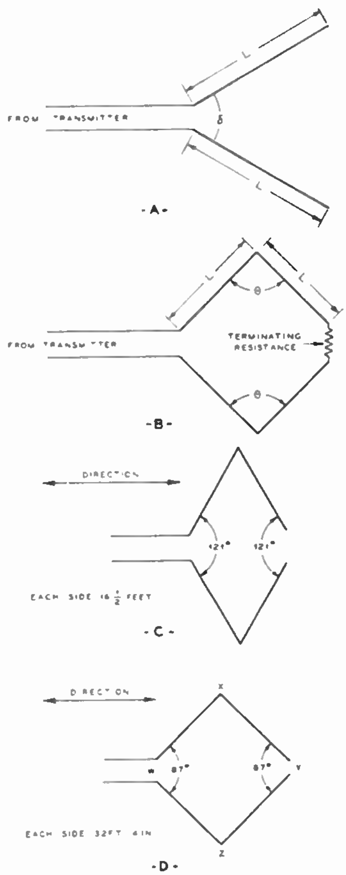
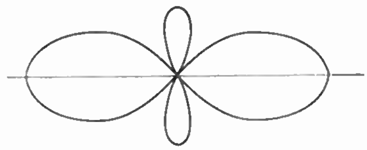


FIG. 106
Diamond and "V" Antennas.

of two "V" antennas. The current distribution 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. It can be used without any change or adjustment over a frequency range of at least two-to-one. Furthermore, it is unidirectional, since the terminating resistance eliminates the radiation which would otherwise take place in the backward direction. These properties make the Diamond antenna desirable in many ways. It can, for example, be used for 20 meters in the daytime and 40 meters at night, without any change. The terminating resistance should be about 800 ohms, capable of dissipating half of the power supplied by the transmitter. The antenna offers a resistance load of about 800 ohms to the transmission line. Design data is shown in the *Diamond Antenna Charts* and the dimensions *L* are listed in the Table for *"V" Antenna Design.*

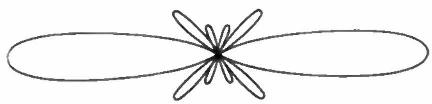
"V" Antenna Design

If the terminating resistance is not used, the Diamond antenna is bi-directional and becomes of the resonant type. Diamond antennas will radiate in an exactly horizontal direction, provided the angle of radia-



HORIZONTAL DIRECTIVITY OF A "V" ANTENNA
4 λ LONG ON EACH SIDE

FIG. 107



HORIZONTAL DIRECTIVITY OF A "V" ANTENNA
8 λ LONG ON EACH SIDE

FIG. 108

tion in degrees and the height of the antenna in wavelengths is correctly calculated. These calculations have been simplified, and the Chart will enable the quick determination of the necessary dimensions. For example, slanting the antenna 6° will cause the energy to be radiated in an exactly horizontal plane.

The Diamond antenna is much more economical in construction than the various forms of antenna arrays employing vertical curtains of wires. It is just as effective in its directivity and power gain, and is not critical with respect to frequency of operation.

Beverage Antenna

● A very long wire terminated in a resistance equal to its characteristic impedance is called a *Beverage*, or *Wave Antenna*.

The antenna should be several wavelengths long and it can be of any convenient height, from 10 to 20 feet above earth. It is quite satisfactory for long-wave reception and is sufficiently directive to materially reduce static disturbances. It is non-resonant and can be considered as a one-wire transmission line with ground return. It should be pointed toward the station whose signals

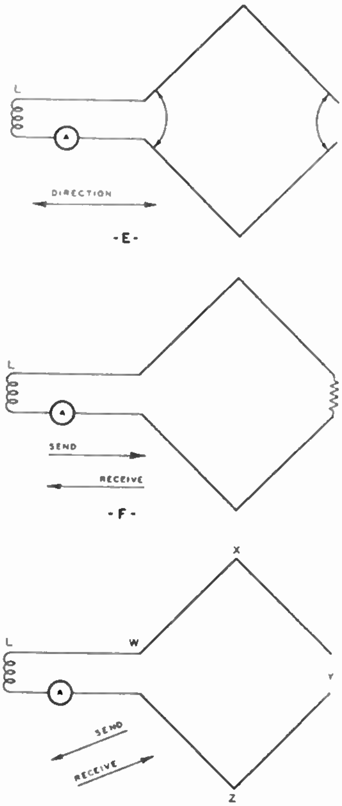


FIG. 109
Diamond Antennas.

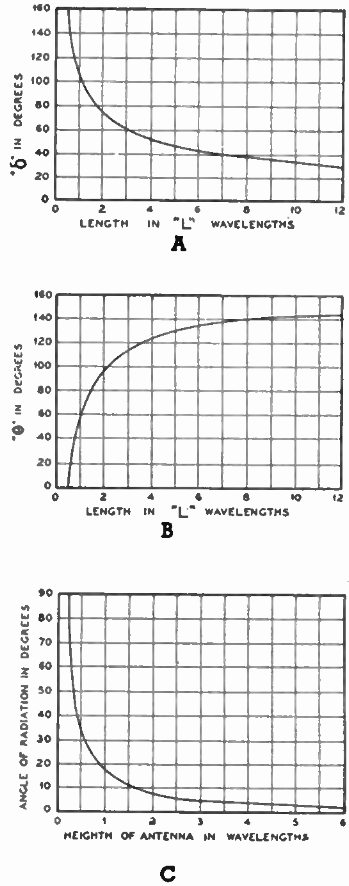
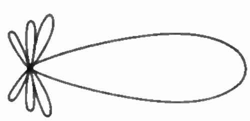


FIG. 111
Diamond and "V" Antenna Design Curves.

VERTICAL DIRECTIVITY OF A 2λ DIAMOND ANTENNA

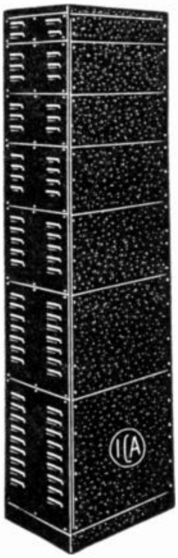
FIG. 110

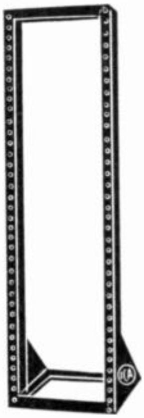


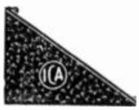
HORIZONTAL DIRECTIVITY OF A 2λ DIAMOND ANTENNA

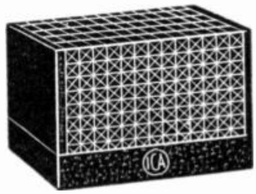
FIG. 112

are to be received. This antenna operates most effectively when located over poorly conducting earth, since in this case the wave front of the received signal is tilted more than when the wave travels over water or moist earth. This form of Beverage Antenna is not suitable for short-wave reception.

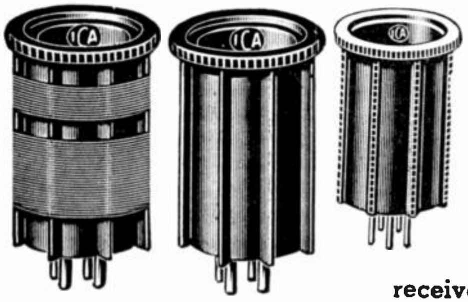








loss of EFFICIENCY



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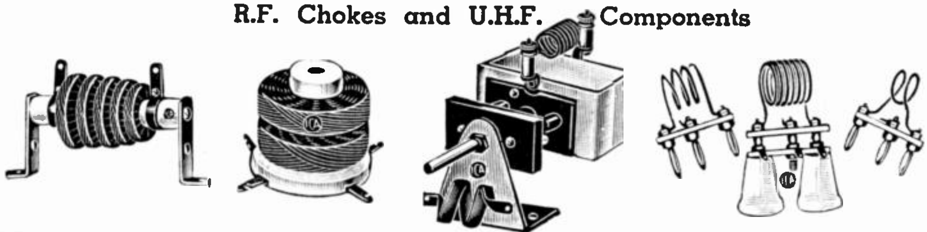

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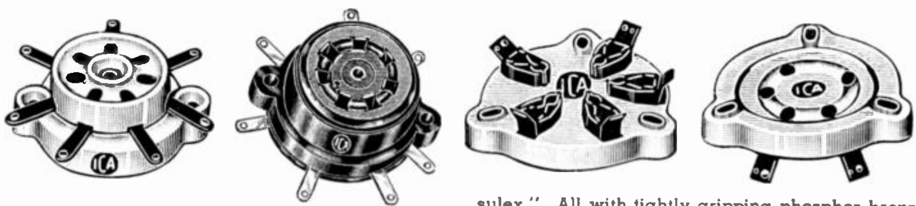

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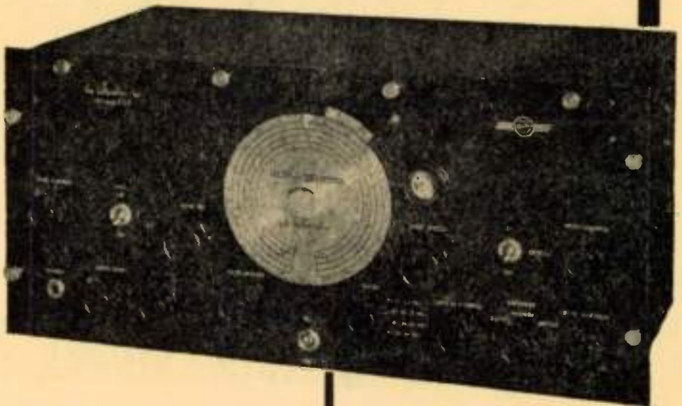

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