SHORT WAVE RADIO

February
1934

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Edited by
Robert Hertzberg and Louis Martin

IN THIS ISSUE:

A Novel Unit Panel Idea for Experimenters

The A. C. Operated Find-All Globe Trotter

Selecting the Proper R. F. Choke

Best S. W. Station Lists in Print

Capt. Hall's Data on Foreign Stations

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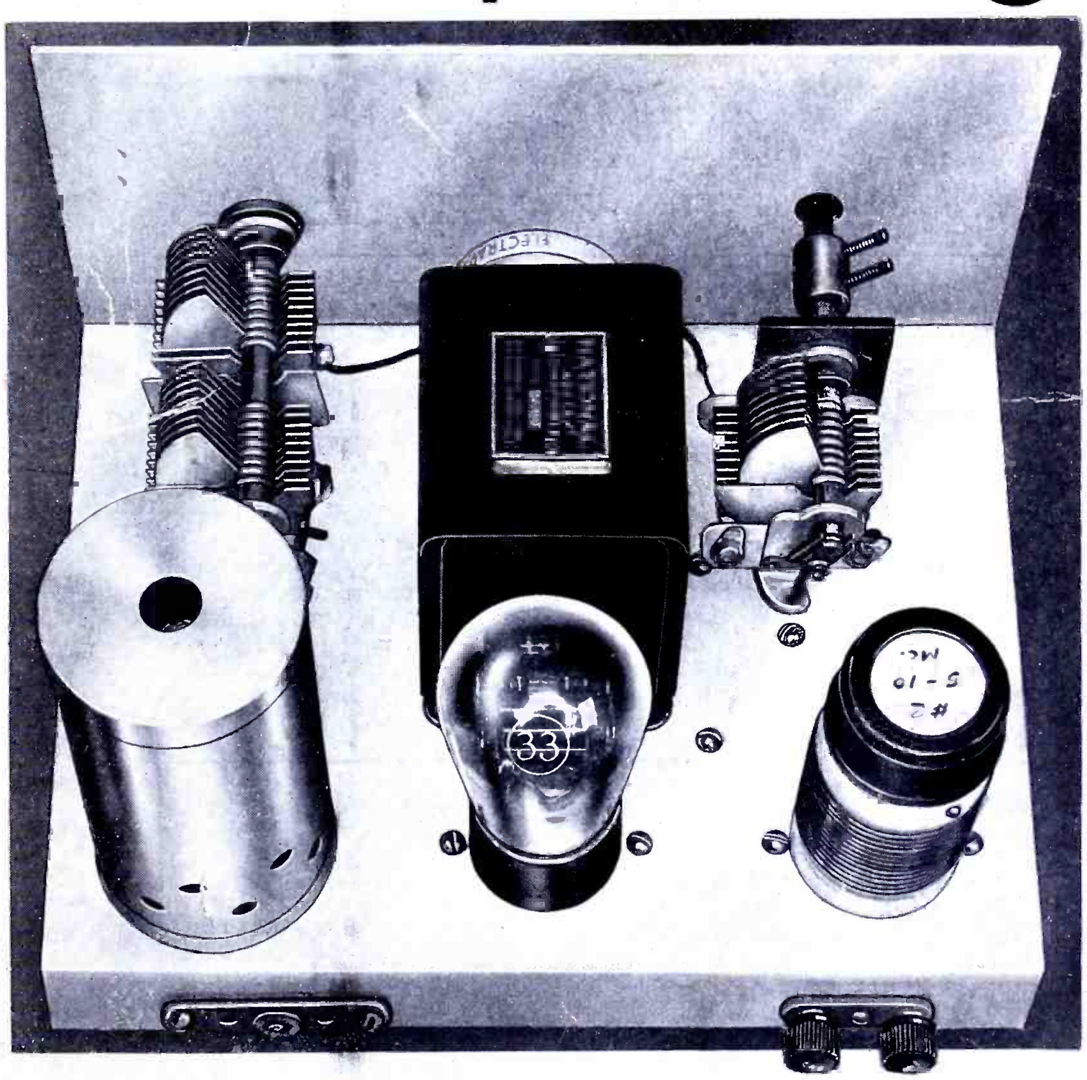

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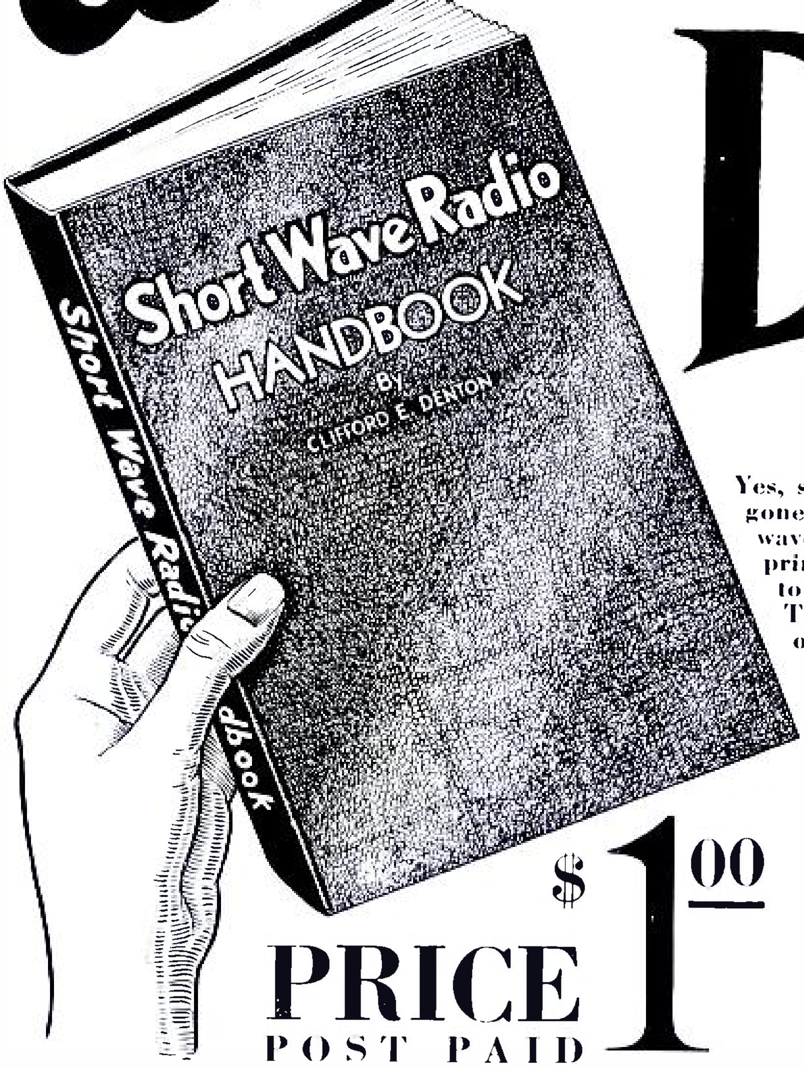

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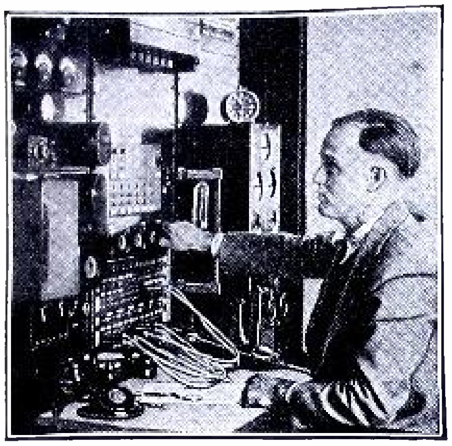

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SHORT WAVE RADIO

February, 1934
Vol. 1, No. 4

devoted to short-wave transmission and reception in all their phases

Robert Hertzberg, *Editor*

Louis Martin, B.S., *Technical Director*

General Advertising and Editorial Offices, 1123 Broadway, New York, N. Y.

IN THIS ISSUE:

IN FUTURE ISSUES:

EVERY S. W. SET A SUPER—Many owners of the popular t.r.f.-regenerative short-wave receivers would like to increase the sensitivity and selectivity of their outfits by converting them, whenever possible, into superheterodynes. A new intermediate frequency unit, recently developed by a prominent manufacturer, makes this conversion easy and economical. We will have complete "dope" on the subject soon.

MORE ON THE UNIT PANEL IDEA—The restless experimenter who finds great joy in constantly building and rebuilding will undoubtedly accept the unit panel idea described in this issue with great acclaim. We will show some further applications of the idea, built around the representative receiver illustrated on page 4 of the current number.

NEW ALL-WAVE SUPERS—The radio industry this year is going in strongly for all-wave receivers, in recognition of the thrilling reception that such sets offer. We will run technical "dope" on some of the outstanding sets of this type.

NEW ULTRA HIGH FREQUENCY RECEIVERS—Mr. J. A. Worcester, Jr., well known to readers of SHORT WAVE RADIO, is working on some new and extremely interesting five-meter receivers. These embody novel ideas and circuit arrangements that will be well worth trying. The simplicity of five-meter receivers makes this field a very inviting one for both new and old short-wave fans.

THE ARMY AMATEUR NET—The Signal Corps of the U. S. Army is sponsoring an amateur organization that is remarkable because of its purely voluntary and patriotic aspects. Capt. G. C. Black, in charge of the system, explains the organization of this net and how it functions. An article of interest to all readers!

CHARLES H. FARRELL, Advertising Manager

SHORT WAVE RADIO—Monthly. Entered as second-class matter September 15, 1933, at the post office at Chicago, Illinois, under the Act of March 3, 1879.

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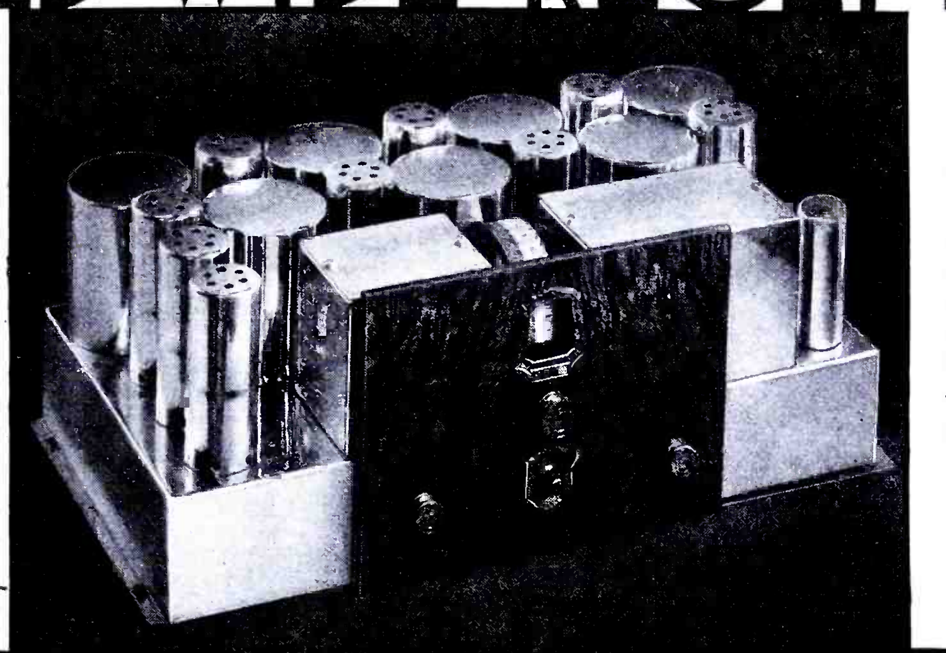

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ITALY

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GERMANY

Conn. "Best radio I have ever owned—price very reasonable for what it is and will do—have logged Rome, England, France, Spain, Brazil, Germany, Australia," OSJ, Conn. "VK3ME,

INDO-CHINA

Australia, every time they are on the air—clarity of tone and volume like local," CGB, Conn. "European stations as much 'at my finger tips' as locals," TPB, D. C. "England so that it can be heard all over house —

AUSTRALIA

also Paris and Rome—on grounded 25-foot aerial," WCD, N. J. "Congratulations on a receiver of such extreme sensitivity. Marvelous tone quality." JES, Ill.,—commercial manager of a great broadcasting station—Reception and recording on phonograph records of *every* program from VK2ME and VK3ME for an entire year accomplished by Mr. Scott under home reception conditions in Chicago.

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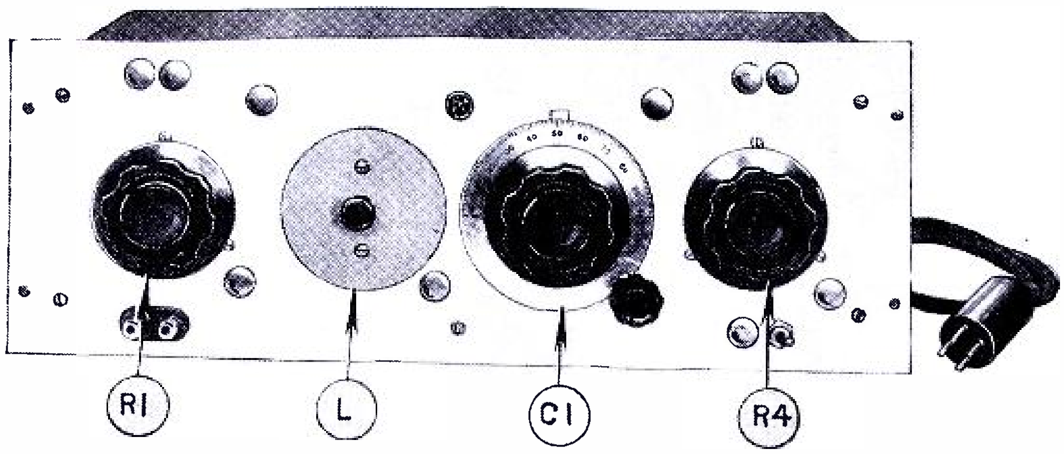


Front view of the completed receiver with the dust cover in place. L is the shielded plug-in coil; R1, the antenna volume control; C1, the tuning condenser; and R4, the regeneration control. The phone-tip jacks are directly under R1, the off-on switch under R4; the power-unit plug may be seen to the right.

A Unit Panel Idea for Constructors

By Robert Hertzberg

IN modern experimental work and receiver construction, the bread-board style of assembly is rapidly disappearing, especially where high-frequency, multi-tube circuits are involved. The use of metallic panels, bases, and shields is always desirable, and, in many cases absolutely imperative. However, many experimenters have been slow to adopt the metallic chassis idea, for the simple reason that they lack machine-shop facilities and are unable to perform the mechanical work of cutting, drilling, and finishing such things as panels, chassis decks, dust covers, shields, and other parts.

To facilitate the fabrication of experimental and semi-permanent assemblies, a New England radio manufacturer, long famous for his laboratory products, has recently developed some new unit panel equipment which will be enthusiastically welcomed by radio experimenters and constructors who have neither the money nor the place for power drills, lathes, etc.

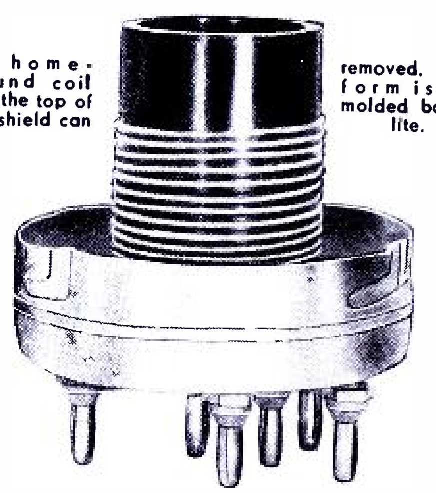
Parts Are Interchangeable

The advantage of the unit panel idea is that all parts are interchangeable. The complete assembly is mechanically rugged and neat in appearance; in fact, it bears the professional look that many short-wave fans strive for in their apparatus, but rarely attain. The equipment is equally suited to relay rack or table mounting in a number of convenient positions. Circuit changes can be made at any time without disfiguring the panel, and a whole unit is easily disassembled for conversion into an entirely different instrument.

The whole idea of this unit panel equipment has been very thoughtfully worked out, the designers showing a very fine appreciation of short-wave fans' problems.

The parts required for a complete individual metal box are a base, two ends plates, a sliding dust cover, a panel, and incidental accessories supplied with the latter. All the principal parts are made of a new material called "Eraydo," a non-magnetic, non-corrosive alloy of copper, silver and zinc, which is much heavier and stronger than aluminum. Holes can be cut in this material with an ordinary hand-drill, and come out clean. One side of the panel is satin finished and coated with clear lacquer as a protection against finger marks.

Three standard one-eighth-inch thick panels are available: one nineteen by twelve-inch panel, and two nineteen by seven-inch panels. Each panel has several 2⅞-inch diameter holes, symmetrically placed. Around each of these holes, three small mounting holes are provided, the combination being suitable for mounting standard bakelite - case meters or for fastening various mounting and adapter discs to the panel. Other half-inch holes are machined in each panel along the top and bottom edges and between the larger holes. These latter are intended for single-hole mounting parts such as rheostats, neutralizing condensers, telephone jacks, switches, pilot lights, potentiometers, dial verniers, etc. Bushings for reducing the hole diameters to 7/16-inch and ⅜-inch are available. The unused holes in any particular experimental set-up are plugged with snap buttons which match the panels in finish and are easily removable.



A home-wound coil with the top of the shield can removed. The form is of molded bakelite.

SUMMARY: *One of the grievances of most constructors is that they are required to cut new panels, drill new holes, and mess up the entire shop every time a new receiver or transmitter is built.*

This condition does not exist with the new unit panels now available to everyone. The holes are already drilled in all locations in which they are likely to be required, and the coil forms have interchangeable pins; in fact, every worth-while desire has been anticipated. This article outlines the whole idea.

Large Holes and Small Holes

One of the seven by nineteen-inch panels has four 2⅞-inch holes, and is most suitable for experimental receivers. The other seven by nineteen-inch panel is furnished with a five-inch permanent magnet dynamic loudspeaker, the input impedance of which is 3000 ohms. It also has two 2⅞-inch holes in addition to an assortment of half-inch holes. This unit lends itself nicely for use as a power and audio amplifier box.

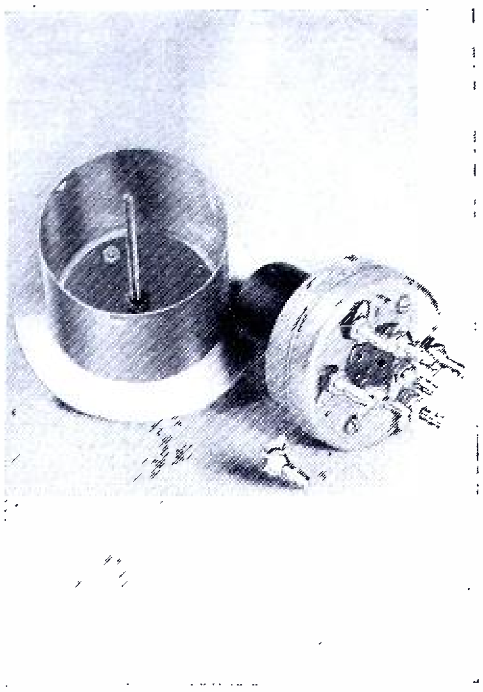
The large twelve by nineteen-inch panel has six of the large holes and is especially suitable for amateur short-wave transmitters or small public-address amplifiers. The depth of all units is 9⅛ inches.

All the parts fasten together accurately by means of ordinary nuts and bolts. Two seven-inch panels and one twelve-inch panel can be mounted one above the other in a special frame supplied for the purpose. A combination of this kind is ideal for the transmitting amateur whose table space is very limited.

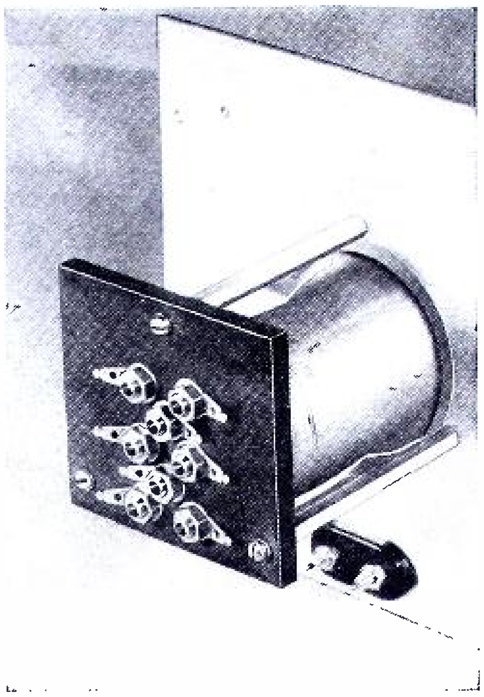
Four types of mounting discs to fit over the 2⅞-inch holes are available. The first is merely a blank disc which is used to cover the large panel holes not in use or to mount special parts that don't fit the other discs. The second disc is drilled with an assortment of twelve No. 6 holes and a single half-inch center hole. This is the most useful of all the mounting discs. The third disc is a special adaptor for Weston type 506 meters, which are only 2 1/16 inches in diameter. The fourth disc is a cover plate to fit the coil shields illustrated in this article.

The metal base supplied with all panels is fastened to the lower flange of the end plates by means of spacers and machine screws. One edge is bent at right-angles to form a flange which provides a terminal mounting strip at the back. It is not necessary, however, to have the flange at the back, for it can be mounted just as easily next to the panel. The base mounts in any of four positions, *i.e.*, flange up, flange down, either to the back or to the front. Small holes for mounting sockets, by-pass condensers, resistors, transformers, etc., are easily drilled and tapped in the base.

The dust covers are simply "L" shaped members that slide on from the rear. They fit tightly and provide excellent shielding in addition to protection against dust.



Details of the shielded plug-in coils. The shield can is securely locked to the shield base by three bayonet catches to make a single unit. In the center is a threaded rod which engages an insert in the jack base and holds the coil firmly in place.



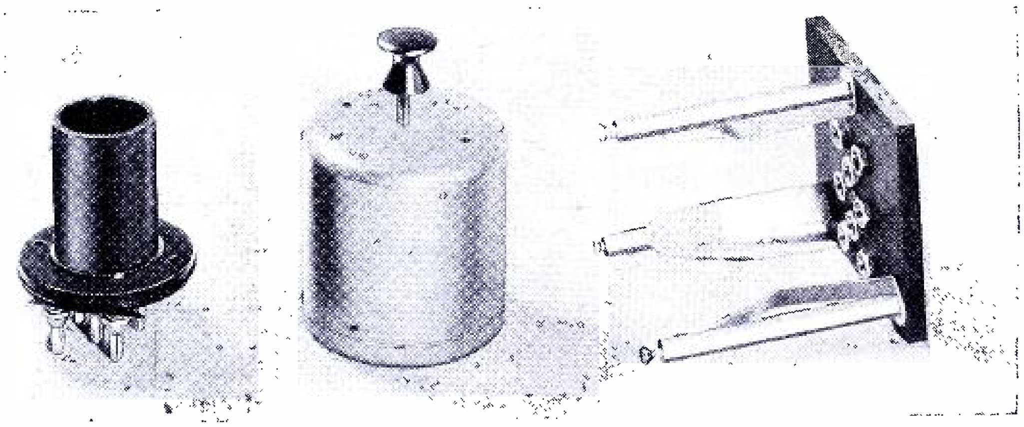
The complete shielded inductor mounts in this manner behind the panel. Three springs press against the sides of the shield can and guide it into place. All eight contact jacks are shown here; only seven are used in the receiver described.

Front Panel Coils

One of the best features of this new unit panel equipment, from the standpoint of the receiving experimenter, is that it permits the use of shielded plug-in coils that enter from the *front of the panel*, a convenience hitherto found only in a number of expensive factory-built superheterodynes. Accessories to fit the 2⅞-inch holes make coil winding and assembly a simple job. There are three basic components: a molded bakelite coil form which is fitted with eight quickly removable spring-type plugs, a two piece coil shield which fits over the coil form, and a bakelite jack base which accommodates the coils. With the coil base mounted behind the panel as shown, the coils slide in and out from the front in a manner long desired by set-constructors.

The spring-type plugs and jacks provide positive, noise-free connection. As a further protection against noise, the coil shield is provided with a long threaded rod, the end of which engages a threaded insert in the base plate. A turn of the knob on the outside of the coil shield draws the whole coil unit firmly into place. The coils themselves are fully protected against mechanical injury by the shield covers.

It is a pleasure to make up a homemade set of coils with these coil forms and accessories. It is not necessary to snake the wire through the usual fixed base pins, which become clogged with solder after they are used the first time. Instead, the ends of the wire are drawn through individual little holes in the base of the bakelite form and then they may be soldered conveniently to the lugs that fasten under the screw-in contact plugs. The eight terminals permit all sorts of tricky coil and circuit combinations. The coil forms themselves have a winding length of 1⅞ inches and are 1¼ inches in diameter. However, the base flares out to a diameter of two inches to accommodate the eight contact plugs. The coil shield is 2¾ inches high and 2½ inches in diameter.

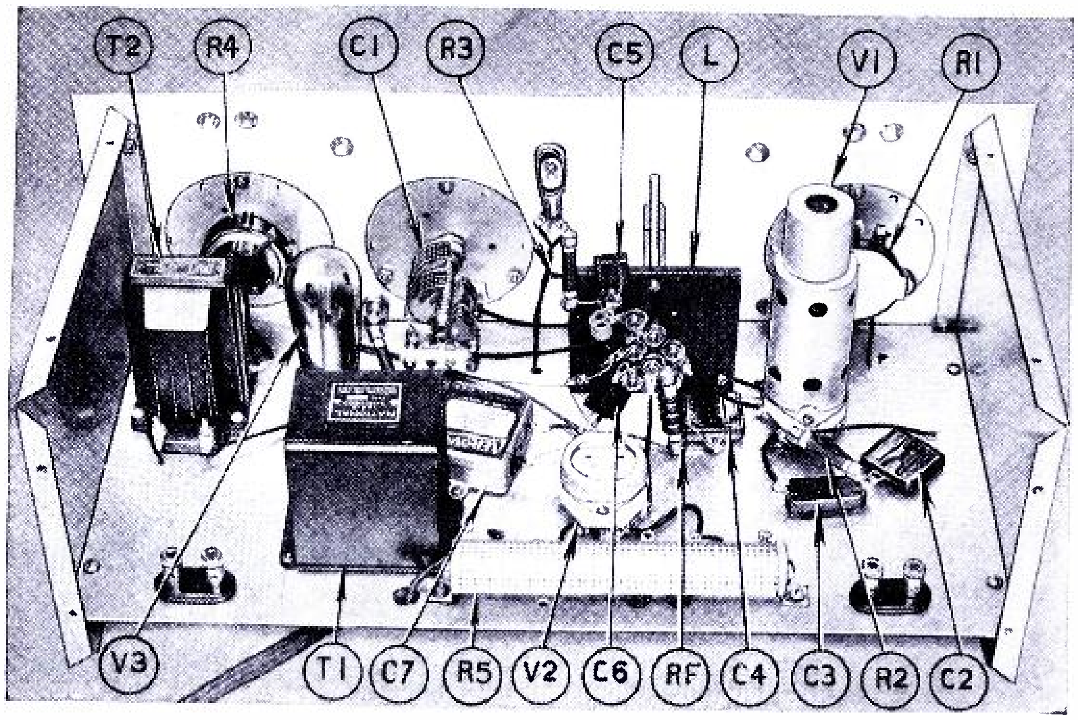


Left: the bare bakelite coil form. Center: the two-piece shield can which fits over the latter. Right: the coil base.

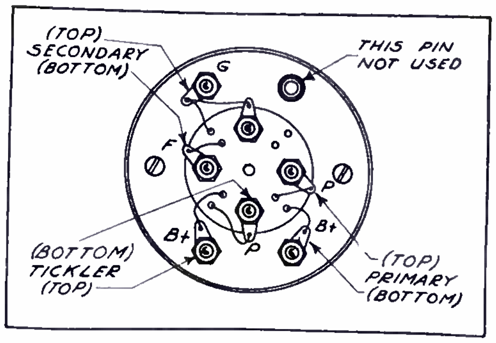
A Sample Receiver

To show what could be done with this new unit panel equipment, the editors of SHORT WAVE RADIO obtained one of the four-hole, seven by nineteen-inch panels, complete with its base, sides, cover plate, and incidental hardware. This was made into a representative three-tube, a.c. operated short-wave receiver. While the circuit is more or less conventional, the coil changing feature, the overall operating effectiveness, and the very stunning appearance of the set elicit highly complimentary remarks from all the people to whom the outfit is shown. Some experimenters refuse to believe that the set was home-built with no tools other than a hand-drill, a soldering iron, a screw-driver, and a pair of pliers.

The accompanying illustrations show the electrical and mechanical details of the outfit. Dozens of other circuit combinations and mechanical layouts will suggest themselves to the experimenter. For instance, it would be a simple matter to build up a t.r.f. set using two plug-in coils at a time. The first and third holes would accommodate the coils, the center hole the double tuning condenser, and the fourth hole the regeneration control. A switch, a pilot light, an r.f. volume control, and various other parts can readily be distributed among the half-inch holes. A really marvelous superheterodyne could be made with two of the seven by nineteen-inch panels, mounted one above the other: the lower panel could accommodate three plug-in coils and one three-gang condenser to form the r.f. end of the set, *i.e.*, the r.f. pre-selector, first detector, and oscillator circuits; the other panel could then accommodate



Inside view of the completed sample receiver with the sides in place, but with the dust cover removed. The numbered parts may be checked with the diagram below.



Coil base connections. The lettering refers to their respective destinations.

Above: view of bottom of coil form, showing method of connecting primary, secondary, and tickler. All coils are wound in same direction.

Winding data for two typical coils:

17 to 29 meters (with one section only of C1): secondary, 11 turns No. 22 s.c.c.; primary, 6 turns No. 26 s.s.c., interwound with bottom section of secondary; tickler, 2 turns No. 26 s.s.c., at very bottom of form.

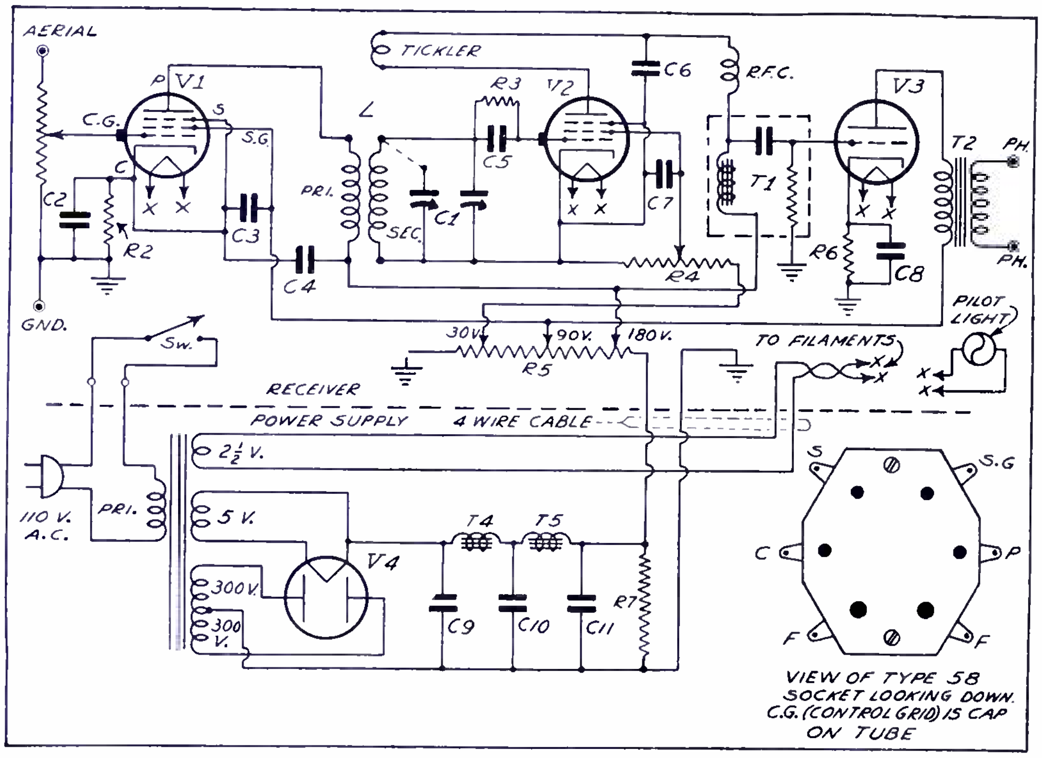
29 to 55 meters (with both sections of C1): secondary, 19 turns; primary, 14 turns; tickler, 2 turns.

the i.f. amplifier, the second detector, and the audio system. The power pack and the loudspeaker may be built separately, or a third seven by nineteen-inch panel added for the purpose. With a number of these unit panels and a supply of accessories, the restless experimenter can keep himself busy for many months! The receiver illustrated is a three-tube affair comprising an untuned r.f. amplifier, V1, which is a type 58 tube; a regenerative detector, V2, which is another 58; and a single audio output tube, V3, which, in this case, is a 56. If a type 2A5 pentode is used in the V3 position with a suitable output coupling transformer, T2, the set will produce excellent loudspeaker results. Even with the 56, as the set now stands, many short-wave broadcasting stations, including Berlin and London, can be heard in New York on a small magnetic speaker—not with great volume, of course, but, nevertheless, quite understandable.

As a matter of fact, many amateur phone stations come in so strongly that they have a tendency to block the detector tube, and it therefore became necessary to provide an r.f. volume control in the form of potentiometer, R1, which is connected between the aerial and the grid circuit of the untuned r.f. amplifier, V1.

Parts List for Receiver

L—plug-in coils wound as specified, using General Radio type 177-B forms, 177-K shields and type 661-P11 cover plate, with type 661-P10 jack base.
C1—Two-section midget variable condenser 50 mmf. per section (National type STD-50).
C2, C3, C4—.01 mf. mica bypass condensers (Aerovox).
C5—.0001 mf. mica grid condenser (Aerovox).
C6—.00025 mf. mica fixed condenser (Aerovox).
C7, C8—1 mf. paper bypass condensers (Aerovox).
R1—25,000-ohm potentiometer (Electrad).
R2—300-ohm bias resistor (Lynch).
R3—3 megohm grid leak (Lynch).
R4—50,000-ohm potentiometer with switch (Electrad).
R5—25,000-ohm divider resistor, with sliding taps (Electrad Truvolt).
R6—3000-ohm bias resistor (Lynch).
T1—impedance coupling unit, containing choke coil, coupling condenser and grid leak (National type S-101).
T2—1 to 1 ratio output transformer (Pilot No. 394 or similar unit).
2—six-prong Isolantite sockets (Hammarlund).
1—Five-prong Isolantite socket (Hammarlund).
1—Pilot light assembly with 2½-volt lamp.
RFC—2½ mh. radio-frequency choke (National).
4—wire cable with four-prong plug.
2—screen-grid connector clips (National Grid-grips).
2—type 58 tube shields (Trutest).
2—type 58 tubes.
1—type 56 tube.
1—unit panel (General Radio type 661-B).
1—end- and base-plate assembly (General Radio type 661-L).
1—dust cover (General Radio type 661-S).
3—three-hole mounting discs (General Radio type 661-P2).
3—double binding post assemblies with bakelite insulators (General Radio).
1—4" diameter friction drive dial (General Radio type 703-A).
2—bakelite knobs for R1 and R4 (General Radio type 637-R).



Complete schematic diagram. The potentiometer from aerial to ground is R1.

Parts List for Power Pack

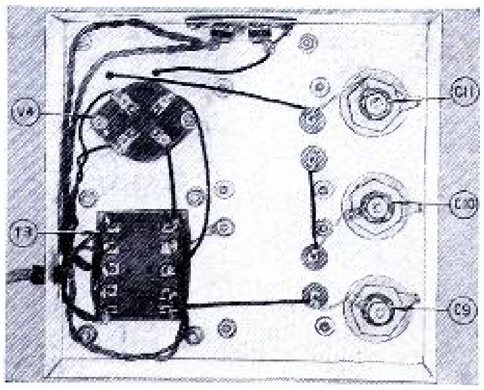
T3—power transformer with center tapped high voltage winding, one 5-volt winding, one 2½-volt winding (Trutest type 1-1494).
T4, T5—type 30-henry filter chokes (Trutest 2C-1752).
C9, C10, C11—4 mf. electrolytic filter condensers (Trutest D-3324).
2—four-prong wafer sockets, for rectifier tube V4 and output connections (Central Radio Corp.).
Flexible cord and plug for 110-volt circuit.
R7—15,000-ohm bleeder resistor, optional (Electrad Truvolt).
V4—type 80 rectifier tube.
Aluminum chassis as per specifications (Blan the Radio Man).

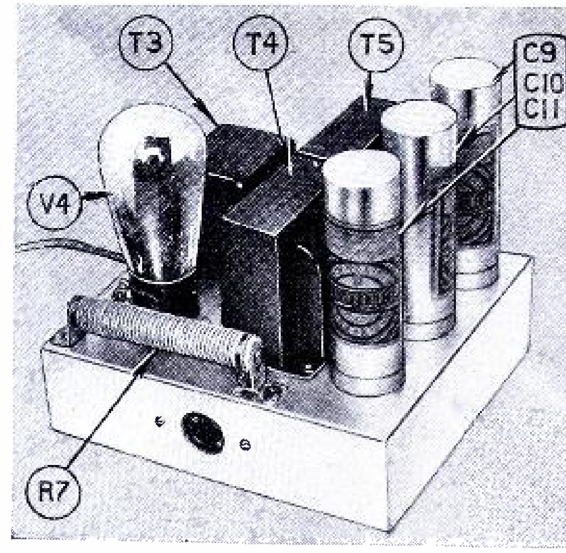
With eight connections available on the coil forms, it was a simple matter to make up three-winding coils, containing a secondary, an interwound primary, and a tickler. Tuning is accomplished by means of a double section National condenser, each section having a capacity of 50 mmf. Here is where the extra coil pins came in very handy. For the "medium" short waves, up to about 50 meters, only one section of this condenser was used, as this gave better dial spread than the full 100 mmf. combination. The two stator sections of the condenser are connected to individual contacts on the coil receptacle. Above 50 meters, the extra section is thrown in simply by bridging a seventh prong on coil form to the top end of the secondary winding, as indicated by the short dotted line in the schematic diagram.

Winding the Coils

In winding the coils, it is first necessary to drill small holes in the bakelite form to pass the ends of the wire. The tickler is wound first, at the very bottom of the form; then comes the secondary, about 1/8" away, with the turns spaced about the diameter of the wire. It is then an easy matter to interwind the primary between the bottom turns of the secondary.

Wind the coils without the base pins or shield in place. After pulling the wires through the holes in the bottom, slip on the bottom section of the shield can and then screw in the base plugs with their lock washers and soldering lugs.





Right: the separate power pack built for the unit-panel receiver. The resistor R7 is optional, and is not used as long as R5 is used in the set proper. Above: under view of pack.

Short Connections Possible

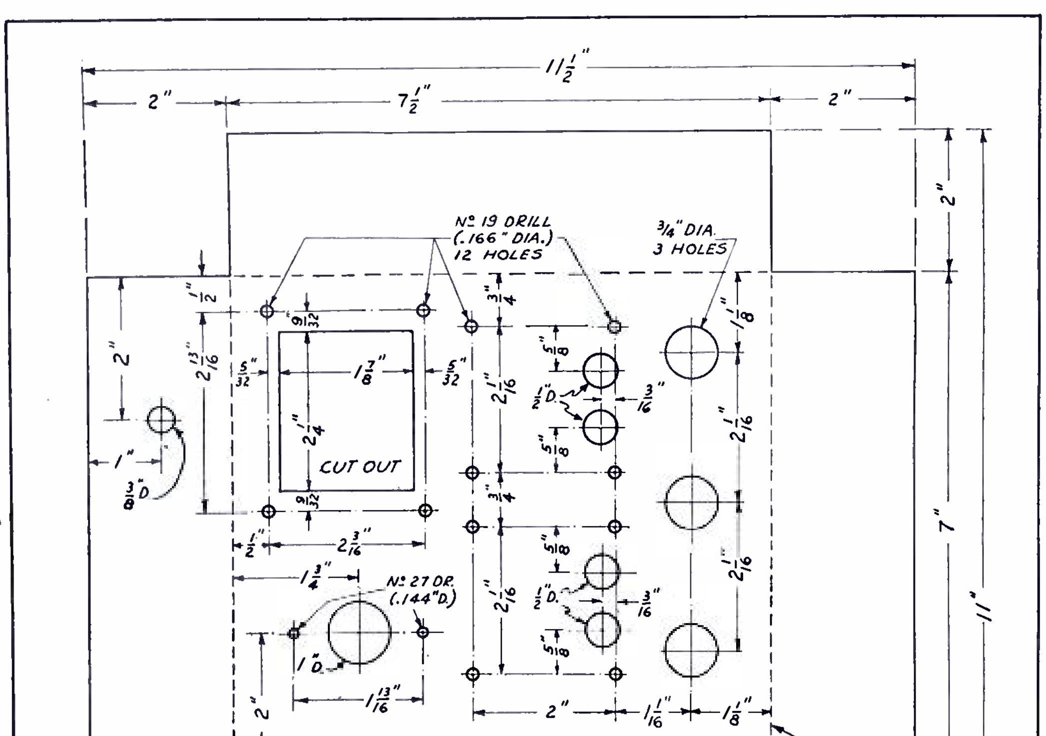
The manner in which the coil base mounts behind the panel permits exceedingly short and convenient connections. In this set, for instance, all the r.f. grounds of the detector circuit are brought to a single point, which happens to be one of the screws holding the bottom of the tube shield on the detector socket. In the r.f. stage, all the r.f. ground returns are similarly made. The grid condenser and the grid leak, C5 and R3, are mounted on the top edge of the square coil base, and, in this position, the grid leads are only about an inch and a half long.

The benefits of arranging the r.f. circuits in this fashion are reflected in the beautifully smooth action of the receiver. The detector slides into regeneration smoothly and slowly, permitting the operator to build up a voice or music signal to enormous strength before the tube actually spills into oscillation. The regeneration control is a 50,000-ohm potentiometer, R4, which is combined with a 110-volt switch, SW. The leads from this switch are brought out to the two binding posts shown in the lower left section of the rear view of the set, and are continued externally so as to connect into the primary line of the power transformer in the power pack. When the regeneration control is turned initially, the switch snaps on. The pilot light mounted between the tuning condenser and the coil receptacle lights up, thus indicating to the operator that the juice is on. This pilot light fits conveniently into one of the half-inch holes in the panel and is very useful in indicating to the operator whether the set is on or off. The light is a small 2½-volt flash-light bulb, wired directly in parallel with the tube filaments.

A separate power pack, as illustrated, supplies filament and plate voltage. The set is fitted with a four-wire cable, terminating in a four-prong plug that fits into a socket on the side of the pack. The voltage divider, R5, which is a 25,000-ohm affair, is mounted on the set chassis, rather than on the power pack, to simplify the wiring and to facilitate voltage adjustments. The various taps are adjusted to give 180 volts for the plates of V1 and V2, 90 volts for the screen of V1 and the plate of V3, and 30 volts for the potentiometer, R4. As much as 250 volts can be used on the plates of V1 and V2, but the lower voltage seems to make the set quieter, at the same time providing plenty of "hop."

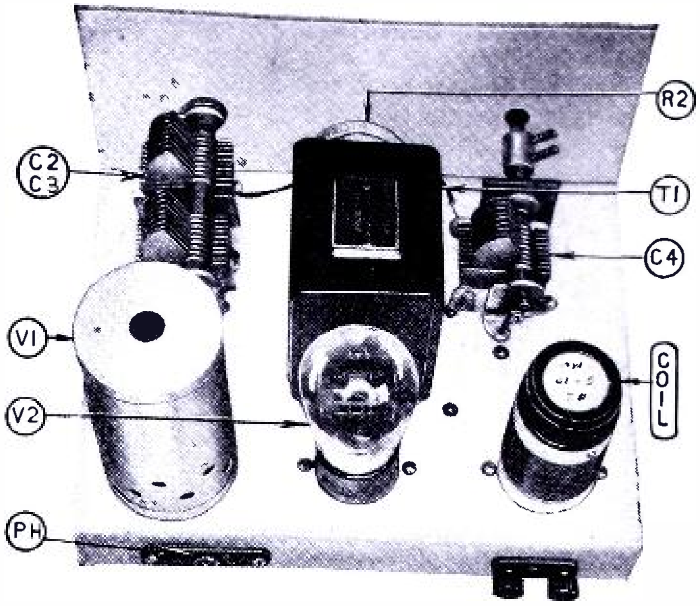
No drilling details are given for the sub-panel of the set, as the placement of the various parts is quite obvious from the photograph. However, a complete layout is given for the power pack, as this little unit is extremely useful for all sorts of experimental work.

The output transformer, T2, which has a 1 to 1 ratio, is not absolutely necessary, but is very desirable because it completely removes plate voltage from the earphones or the loudspeaker. Of course, it is a simple matter to feed the output of this set to an existing audio amplifier.



Drilling details of the power pack chassis.

The Constant Band-Spread Receiver



Deck view of the two-tube receiver.

SUMMARY: *Here is an article describing a brand new method of band spreading. In the older methods, the band-spread condenser is connected across either part or all of the tuning coil; the result is unequal frequency spreading over the dial for every coil and for each setting of the tank condenser.*

The new method, described in detail by the author and used in a two-tube receiver which he also describes, has constant band spreading, regardless of the coil used.

By J. A. Worcester, Jr.

IT has been almost universally recognized that some form of band spreading must be applied to short-wave receivers if this form of reception is to be received favorably by the average broadcast listener. At the same time, it is equally well recognized that present forms of band spreading have certain inherent objections which make them an unsatisfactory solution to the problem. Before considering in detail the specific defects of present band-spreading systems and the manner in which these defects have been eliminated in the system to be described, it might be advisable to review briefly the present methods of covering the short-wave bands.

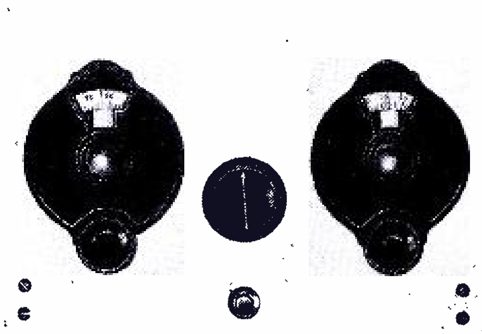
As is well known, the usual frequency range to be covered by a short-wave receiver extends from 1.5 to 20 megacycles, corresponding to a wavelength spread of 15 to 200 meters. In order to cover such a wide range of frequencies and still maintain a sufficiently high ratio of inductance to capacity in the tuned circuit, it is customary to employ a series of plug-in coils of fixed inductance. The actual tuning operation is then performed by a variable condenser shunted across the coil in use.

Fundamental Ideas

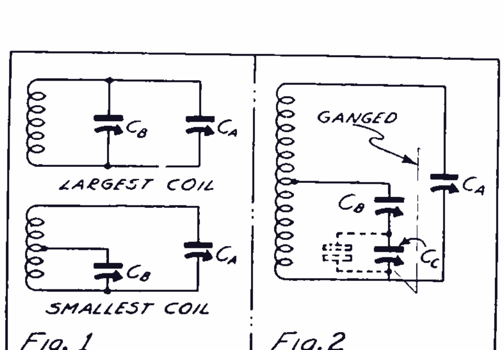
It is found that, with a variable condenser having any given value of maximum capacity, the ratio of the maximum to the minimum frequency covered is substantially constant, regardless of the coil employed. Hence, for a variable condenser having a maximum capacity of 140 mmf., it is found that a frequency range of approximately 2 to 1 can be covered with each coil. Consequently, if 20 megacycles is the maximum frequency to be received, the first coil will cover the frequency range of 10 to 20 megacycles, the second from 5 to 10 megacycles, the third from 2.5 to 5 megacycles, and the fourth from 1.25 to 2.5 megacycles.

From the above, it can be seen that the first coil covers a frequency range of 10,000 kilocycles, which is approximately ten times as large as the band covered by an ordinary broadcast receiver. Obviously, this results in extreme congestion, and makes tuning very difficult, especially for an operator who is accustomed to the station separation existing in the broadcast band. This fault, of course, exists in varying degrees with the other coil ranges as well.

To obviate this difficulty, several forms of band spreading have found limited use. The simplest method consists in shunting a small capacity variable condenser across the main condenser. The small condenser then becomes the main tuning control and the large condenser becomes the "tank" capacity, which is adjusted so that the band spreader covers a frequency band containing the desired stations. The obvious objection to this arrangement is that if the spread capacity is small enough to provide sufficient separation when using the smallest coil, the variation when using the largest coil will be so small that it will be hardly sufficient to tune a station in and out with complete rotation of the dial. On the other hand, if the spread capacity is made large enough for proper separation with the largest coil, the tuning will be so congested with the smallest coil that the purpose of the band spread will be entirely defeated.



Panel view of the constant band-spread receiver.

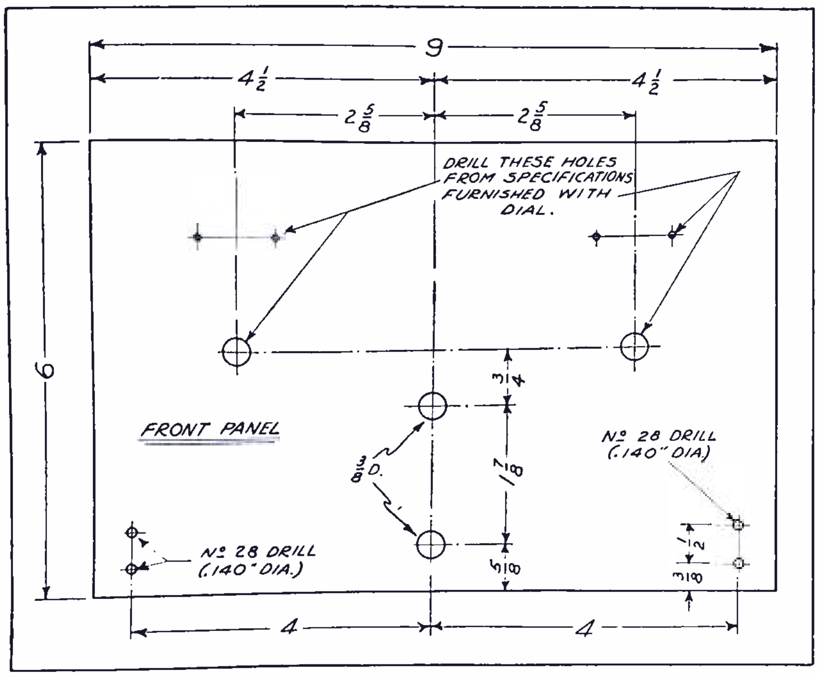


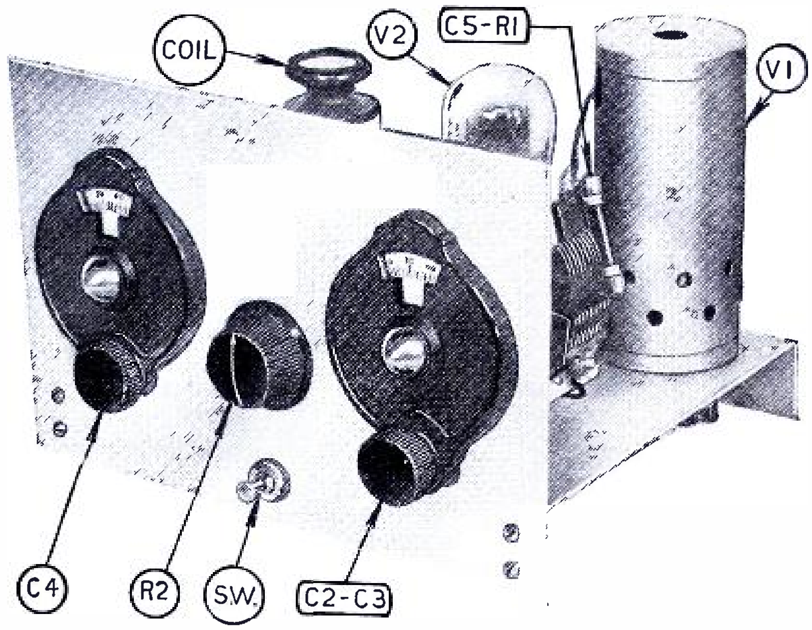
Left, the usual methods of obtaining band spreading; right, the constant band-spread method.

Some Solutions

There are various methods of alleviating this difficulty, the one most commonly employed being indicated in Fig. 1. Here the spread capacity is made large enough to provide sufficient band spread with the largest coil, while its effective maximum capacity is decreased to the desired values for the smaller coil ranges by connecting it across only a portion of the inductance as shown.

There is, however, an inherent objection to this arrangement also—unequal band spread over the range of the tank condenser. The reason for this is apparent when it is realized that the spread capacity produces a much greater change in the total capacity ratio when the tank capacity is a minimum than when it is a maximum. The result is that if the spread capacity is given an effective value sufficient to provide 500-kilocycle band spread when the tank condenser is a maximum, the band spread when the tank capacity is a minimum would be about 2500 kilocycles. Conversely, if the 500-kilocycle band spread were provided when the tank capacity was a minimum, the band spread would only be 100 kilocycles for maximum tank capacity. In the first instance, tuning would be too congested at one extreme of the tank capacity, while in the latter case tuning would be too slow, necessitating frequent adjustments of the tank capacity.





Panel and deck view of the constant band-spread set. The panel layout is shown to the left.

To obviate these difficulties, the system described in this article was developed. *This system provides substantially constant band spread regardless of the coil employed or setting of the tank condenser.*

The fundamental circuit is shown in Fig. 2. C_A is the tank capacity and C_B the spread capacity. In the receiver to be described, the equivalent value of C_B is sufficient to provide 500-kilocycle band spread for each coil when the tank capacity, C_A, is a maximum. The purpose of C_C, which is in series with C_B and ganged with C_A, *is to maintain the band spread at 500 kilocycles as the tank capacity is varied.*

The Receiver

The representative receiver described in this article, employing this principle, consists of a conventional regenerative detector and one-stage audio amplifier. The tubes employed are of the dry-cell variety, the detector being a type 32 and the audio amplifier a type 33. Regeneration is controlled by varying the screen-grid voltage by means of a 50,000-ohm potentiometer across a 22½-volt supply. The audio amplifier is impedance coupled, which provides greater volume and smoother regeneration control than is normally possible with resistance coupling.

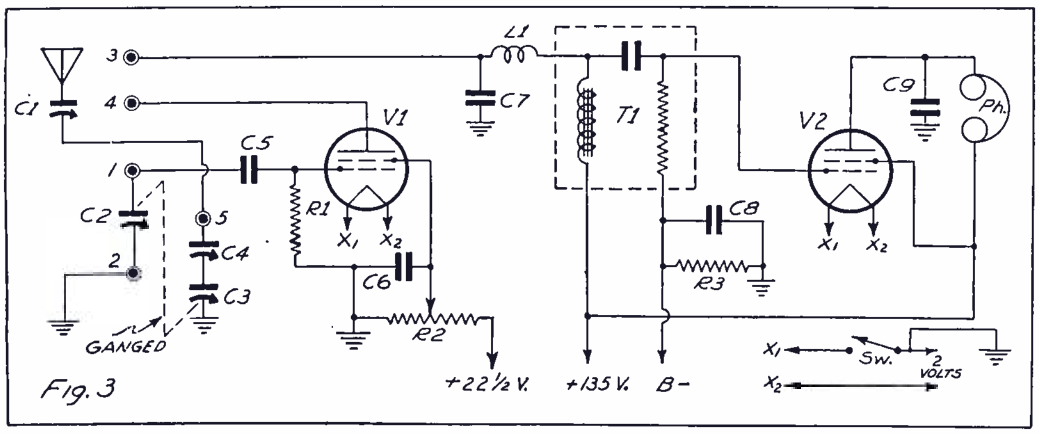
When constructing the receiver, the first step is to make, or procure ready made, the chassis. This consists of an aluminum front panel 6" x 9" and a subpanel, also of aluminum, 6" x 6¾" x 1⅜".

The location of the various parts can be noted from the photographs. On the front panel are mounted the dual variable condenser, the 50,000-ohm potentiometer, the filament switch, and the two vernier dials. On top of the subpanel are mounted the National impedance unit and the band-spread condenser, C4. This condenser is mounted about 1½" behind the panel by means of a small bakelite strip, and is connected to the dial with an insulated shaft to eliminate body-capacity effects. At the rear, the twin binding post and speaker jack assemblies are mounted. Battery connections are made directly to a five-conductor battery cable as indicated. Underneath the chassis are mounted the coil and tube sockets, the r.f. choke, and the antenna condenser, which

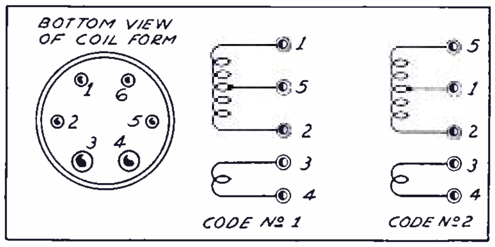
TABLE I

Frequency Range	*Coil No.*	*Code No.*	*No. Turns*	*Secondary Winding* Wire Size*	*Pitch*	*Tap At*	*Tickler Winding* N.Tr.*	*Wire Size*
10–20 mc.	1	1	7.3	No. 22 en.	5 t.p.i.	3	5	No. 30 d.s.c.
5–10 mc.	2	1	14	No. 22 en.	10 t.p.i.	9	7	No. 30 d.s.c.
2.5– 5 mc.	3	2	27	No. 22 en.	18 t.p.i.	25.5	9	No. 30 d.s.c.
1.5–2.5 mc.	4	2	54.5	No. 24 d.s.c.	no spacing	33.0	10	No. 30 d.s.c.

*Secondary and tickler windings wound in same direction.
Coil forms: Hammarlund Isolantite six-prong 1½" diam.



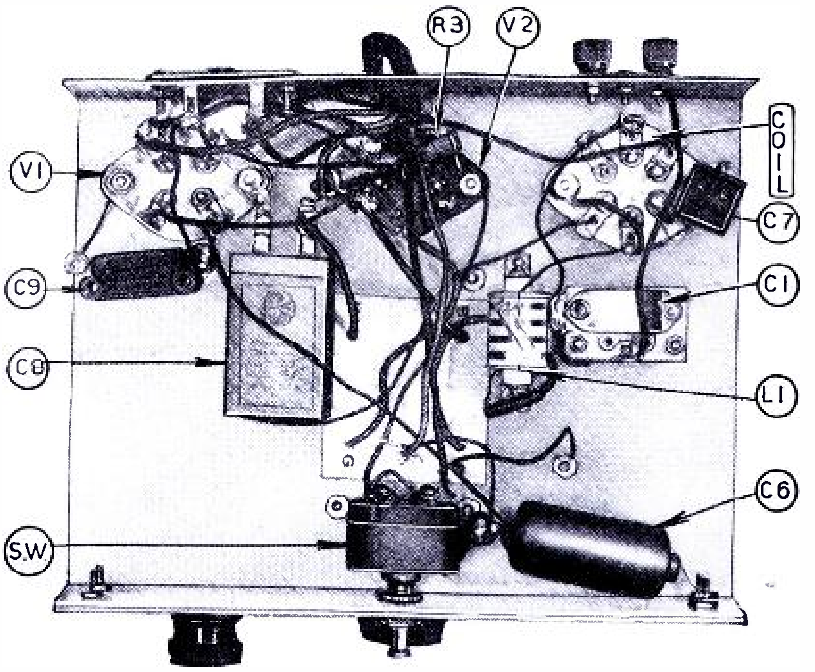
Schematic circuit of the receiver. The coil connections are shown to the right.



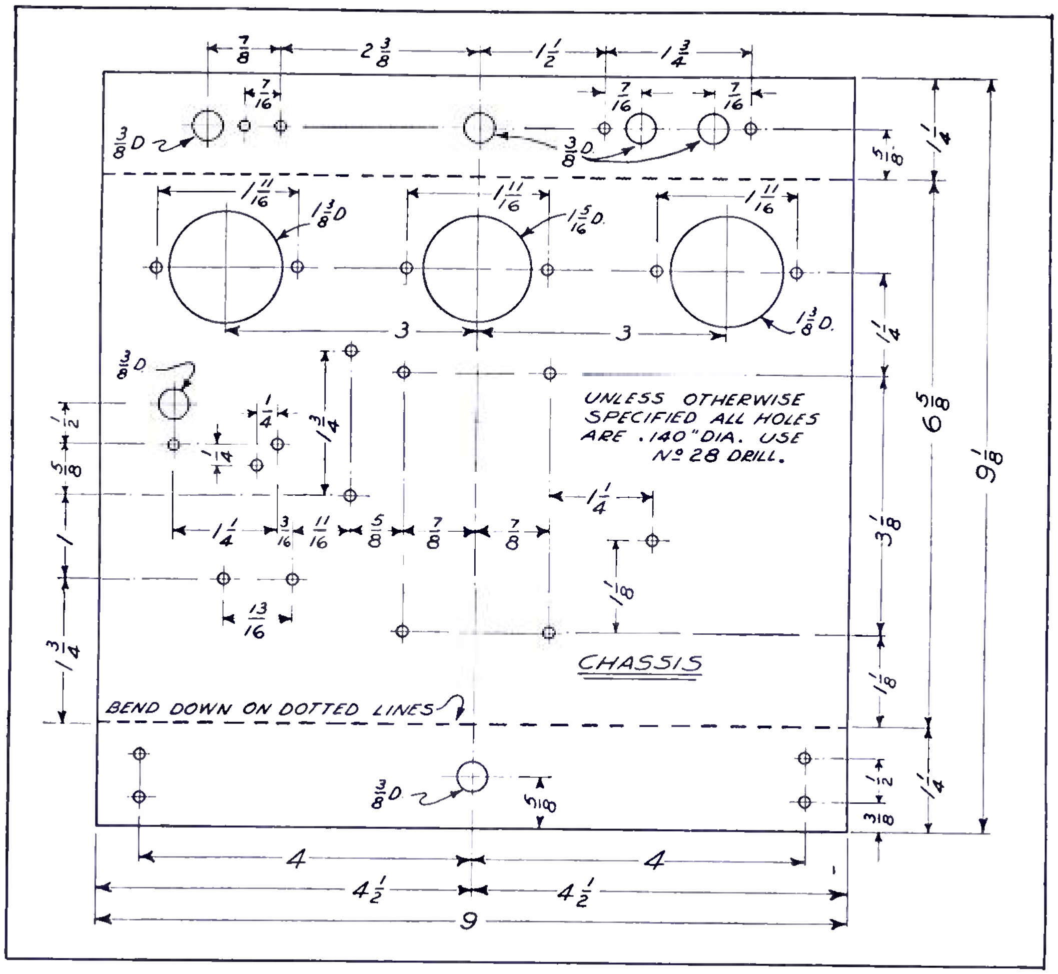
Coil connections of the set. See Table I.

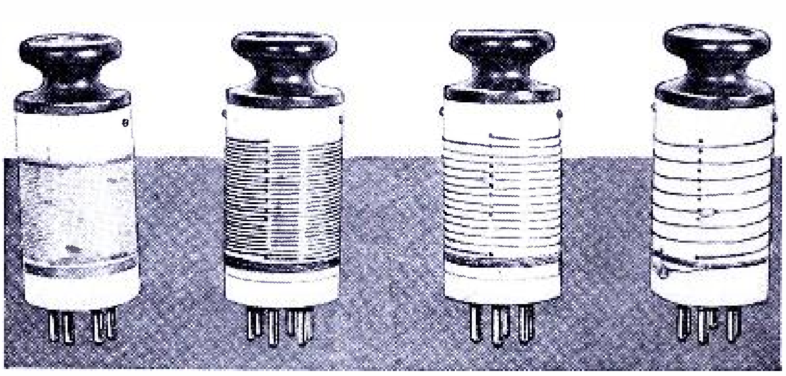
Parts Required

1—set of plug-in coils (see text).
C1—Hammarlund padding condenser, 10-70 mmf., type MICS-70.
C2, C3—Hammarlund dual midget condenser, 140 mmf. per section, type MCD-140 M.
C4—Hammarlund midget condenser, 140 mmf., type, MC-140-M.
C5—.0001 mf. mica condenser (Polymet).
C6—Cornell .5 mf. by-pass condenser.
C7—.0005 mf. mica condenser (Polymet).
C8—25 mf. bypass condenser, 25-volt (Polymet).
C9—.004 mf. fixed condenser.
R1—Lynch metallized resistor, 3 meg.
R2—Yaxley 50,000-ohm potentiometer.
R3—Lynch metallized resistor, 500 ohms.
L1—Hammarlund r.f. choke, 8 mh. type CH-8.
T1—National impedance coupler type S-101.
1—Blan chassis, as described.
1—type 32 tube.
1—type 33 tube.
2—National 3" vernier dials.
1—Eby twin binding post (laminated).
1—Eby twin speaker jack (laminated).
3 ft. 5 conductor battery cable.
1—battery switch.
1—4-prong Isolantite socket (Eby).
1—6-prong Isolantite socket (Eby).
1—5-prong wafer socket (Alden).
1—National type T5 tube shield.
Miscellaneous hardware and wire.



Under view of the unusual constant band-spread receiver. The labeling on this and other photographs corresponds with that given in the List of Parts and in the schematic diagram. The set is so simple, however, that the parts may easily be wired without any difficulties. The drawing below is that of the chassis. Once the holes are drilled, the photographs may be referred to when placing the large items.





Photographs of the coils constructed by the author for use with the constant band-spread receiver. The wire was wound on Hammarlund coil forms in accordance with the instructions given in Table I. The coils, from right to left, cover the bands of 10—20 mc., 5—10 mc., 2.5—5 mc., and 1.5—2.5 mc. These frequencies correspond to 15—30, 30—60, 60—120, and 120—200 meters.

is made accessible from the top by drilling a hole over the adjusting screw. The various resistors and fixed condensers are mounted by their pigtails as shown. The wiring diagram is shown in Fig. 3. Ordinary pushback hook-up wire is used for this purpose.

Coil Data

Complete information for winding the coils is given in Table I. The numbers assigned to the tube prongs agree with those indicated on the wiring diagram. Although no particular difficulty should be encountered in winding these coils, provided proper winding and spacing facilities are avalable, it is suggested that, lacking the facilities, it might be advisable for the constructor to obtain these coils ready wound.

To put the set into operation, the various external connections should be made. It is assumed that a 2-volt d.c. filament source is available; otherwise it will be necessary to insert a 30-ohm rheostat in series with one lead of a 3-volt source (2 dry cells in series) and adjust same until the voltage across the filaments is two volts. It is entirely feasible to substitute a well-filtered B eliminator for B batteries if desired.

When tuning the set, the actual tuning process is, of course, accomplished by the spread condenser, C4. The dual condenser is initially adjusted so that C4 covers the desired 500-kilocycle band.

Standard Frequencies

SHORT-WAVE set owners with a knowledge of the code can calibrate their receivers very easily and accurately by logging some of the commercial high-frequency telegraph stations. We were fortunate in being able to obtain a list of the stations operated by the Mackay Radio & Telegraph Company, and are publishing it herewith for the benefit of interested readers. It is a good idea to cut this out and to paste it in the log book or inside the cover of the receiver.

Transmitter Location	Frequencies (k.c.)	Call Letters
Clearwater, Calif.	4,405	KNR
	7,752.5	
Hillsboro, Oreg.	4,670	KGH
	7,655	
	8,980	
Kailua, Hawaii	17,420	KNN
do.	6,815	KQA
do.	7,662.5	KQB
do.	8,970	KQE
do.	14,680	KQF
do.	14,755	KQI
do.	10,820	KQN
do.	4,660	KQU
do.	19,600	KQY
Palo Alto, Calif.	4,395	KNA
	4,400	
do.	5,975	KNA
	5,985	
do.	17,140	KNG

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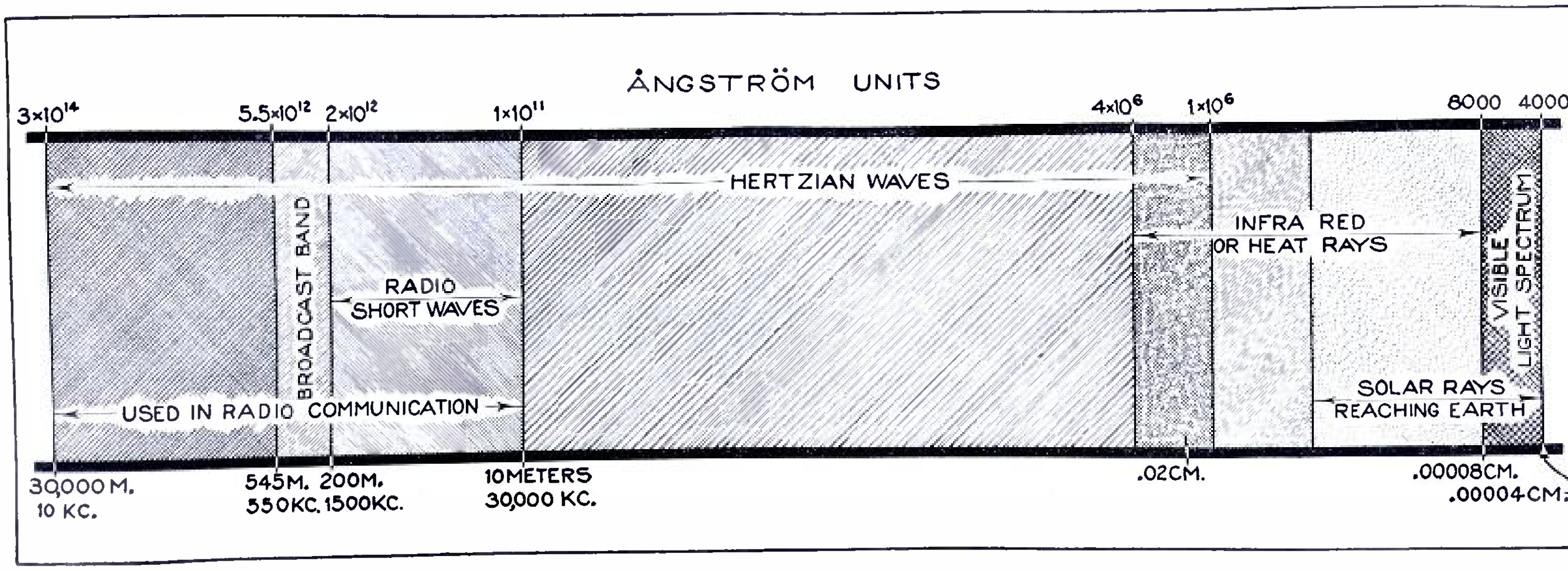

And Now, the Angström Unit?

SUMMARY: *The question of wavelength vs. frequency was settled a long time ago; now the question is, "Shall we use kilocycles, megacycles, centimeters, or Angstrom Units?" Our opinion is that the answer depends entirely upon what part of the spectrum you are talking about. For instance, we recommend that Angstrom units be used for wavelengths below 1 cm. However, the whole story is told below. What do you say?*

HOW many of you readers remember the old spark days when everything above 200 meters was "hot stuff" and only the saps with the fear of the radio inspector in their heart clung close to 199.99 meters? In those romantic days the "long waves" included everything above 1,000 meters, and the time signals from NAA's old spark and the press from POZ were the standards by which receiver performance was measured. Everything was either in the short- or long-wave bands.

And now? People whose only enjoyment lies in listening, not experimenting, are continually forced to oil their brains in order to mentally convert meters to kilocycles, kilocycles to megacycles, and megacycles to Angstrom Units. Experimenters with a mathematical turn of mind relish the thought of these conversions, for it enables them to display their brilliancy before less fortunate—or is it unfortunate?—brethren. Ah! But how many of these would-be sages actually know what it is all about? That, dear readers, is what we propose to find out.

The Meter and the Cycle

The meter is a measure of length, just as the inch or the foot is a measure of length. It seems that quite a number of years ago several different people had different ideas as to how to measure length; one group would measure it according to one standard, and another would measure it according to another standard. Furthermore, they couldn't agree as to the which was correct. The problem was—and still is, for that matter—a weighty one. If you want to measure length, the important thing is to have the standard stay the same, regardless of what other variations take place. The French, in inaugurating their c.g.s. (centimeter, gram, second) system of units, decided that the meter was to be their standard of length; furthermore, the meter was defined, at the close of the 18th century, as the one ten-millionth part of the distance, measured on a meridian, of the earth from the equator to the pole.

Remember, now, that no one took a tape measure and measured the distance from the equator to the pole and then divided that distance by 10,000,000. The distance was calculated, so that the value of the meter given here is only approximate—although much more accurate than you, dear readers, are accustomed to using. In any event, the derivation of the meter is quite scientific. Incidentally, the meter (and the whole Metric System) is legal here in the U. S.

The derivation of the foot, on the other hand is based on the length of the average human foot, and, as is quite obvious, is not a very consistent standard of length. Most everyone has had experimental evidence of this fact when buying a new pair of shoes!

And so the meter is universally regarded as the "real" measure of length, or, more technically, a *unit of length*. To deviate from the immediate problem for a moment, every numerical answer must consist of two parts: a unit, and a number designating the number of units. Thus, a coil has an inductance of 150 henries. The word "henries" is the unit, and the number 150 is the number of units—in this case there are 150 of them. If you see a number without any designation as to the unit—as, for instance, 18964—then the number is *dimensionless*.

Now, how does all this affect radio? Radio waves travel at the same speed as light—300,000,000 meters per second (approximately); and they alternate a certain number of times per second. So, if we divide 300,000,000 (the speed) by the number of alternations per second (the frequency), we get the *distance* the wave travels during the time it takes to complete *one* complete alternation (a cycle). This distance is known as the *wavelength* of the particular radio wave. Since the wavelength is the *distance* the radio wave travels in one cycle, it must be measured in meters, and the meter, as we all know, is equal to 39.37 inches—in

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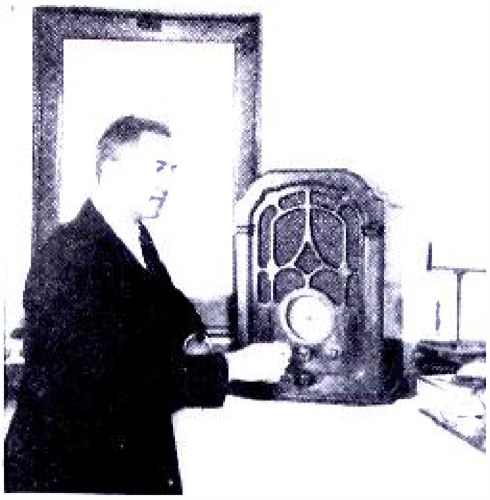
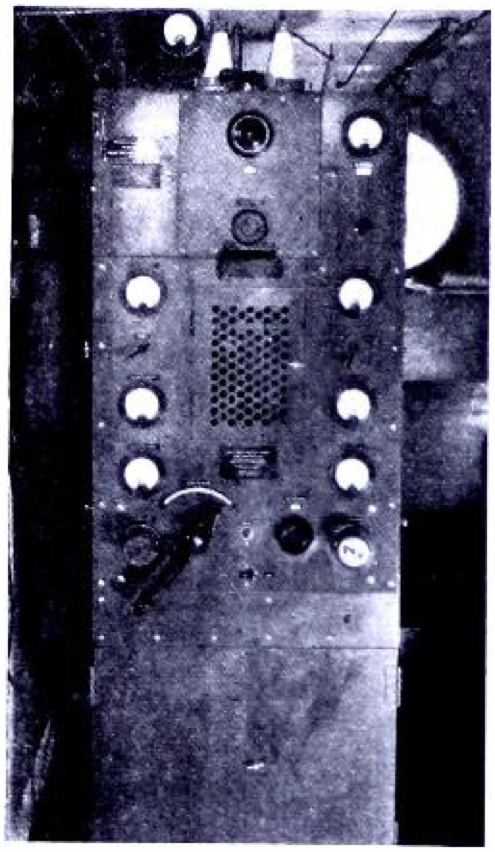


Rear Admiral Richard E. Byrd tuning the General Electric receiver which is used in his personal cabin on the "Jacob Ruppert."



The radio telegraph transmitter on the "Jacob Ruppert."

Authorized Call Letters and Operating Frequencies of the Byrd Expedition

THE Federal Radio Commission has authorized the following stations to be used by the Byrd Antarctic Expedition for establishing communication with the outside world and for conducting experiments in radio and geophysical fields.

Ship Stations

"Bear of Oakland"—Frequencies: 3105*, 3115, 4140*, 4145, 4150, 4160, 4165, 5515, 5520*, 5525, 5530, 6170, 6180, 6190, 6200, 6210*, 6220, 6230, 8240, 8250, 8260, 8280*, 8290, 8300, 8320, 8330, 11025, 11040*, 11055, 11070, 11085, 12360, 12375, 12390, 12420*, 12435, 12450, 16460, 16480, 16500, 16520, 16560*, 16580, 16660, 16680, 22025, 22050, 22080*, 22100, 22125, 22150 kc. Call Signal, WHEW; Emission, A1, A2; Power, 350 watts; Communication, primarily with coastal and maritime mobile stations, and secondarily with amateur stations, provided no pecuniary interest is involved nor interference is caused with commercial stations.

"Jacob Ruppert"—KJTY—Frequencies: Same as for *"Bear of Oakland,"* and in addition: 6650, 6660, 6670, 8820, 8840, 13185, 13200, 13230, 13245, 13260, 17600, 17620, 21575, 21600, 21625 kc. Emission, A3; Power, 500 watts and 1000 watts; Communication, same as for the *"Bear of Oakland."*

Point-to-Point Stations

The construction of two point-to-point stations has been authorized. One station, KFY, is to be located at the forward base, the other, KFZ, is to be located at the main base. The frequencies and emission are the same as authorized for the *"Jacob Ruppert."* Communication is authorized primarily with New York, Boston, Buenos Aires, stations KJTY and WHEW and stations in Little America; secondarily with amateur stations, provided no pecuniary interest is involved, nor interference is caused with commercial communications. KFY is authorized to use 75 watts power and KFZ 1000 watts.

*Primarily for calling.

Special Experimental Stations (Portable)

The Commission has authorized the construction of two special experimental stations, W10XCA and W10XCB, to operate on 1602, 1628, 1652, 1676, 1700, 30,000 kc. and above with A1, A2 and A3 emission and .5 watt power. These stations are to be used for geophysical and experimental work.

General Experimental Stations (Portable)

Construction permits for four general experimental stations have been granted. The call letters assigned are W10XCC, W10XCD, W10XCE and W10XCF. These stations are to operate on the frequencies 1652, 2398, 3492.5, 4797.5, 6425 and 8655 kc. with A1, A2 and A3 emission and 5 watts power. They are to be used for experimental communication in Little America and Antarctica to various points where dog sledges are located.

Book Review

KRUSE'S RADIOPHONE GUIDE, by Robert S. Kruse, copyrighted and published by the author at Guilford, Conn., 7 by 10 inches, 38 pages, paper covers, numerous diagrams and photographs. Price, 35c.

This meaty little book will provide much interesting material for the transmitting amateur interested in phone work. We doubt if there is anybody in the United States who knows as much and has had as much experience with "ham" radio in all its ramifications as Kruse. A graduate engineer and for many years technical editor of QST, Kruse's standing as an honest-to-goodness expert is unquestioned.

In addition to material written by Kruse himself, the book contains excellent contributions by Boyd Phelps on "Modern Grid Modulation;" Raymond Morehouse, "Economical Tuning Condensers;" E. E. Griffin, "Microphone and Amplifier Levels Simplified;" McMurdo Silver, "Class A Prime Radio Modulators;" R. F. Shea, "A Simple But Good Converter" and F. S. Dellenbaugh, Jr., "The Design of R.A.C. Power Supplies."

Other subjects that are treated in detail are leak bias for the modulated tube, modulator mistakes, a new type of frequency measuring service, antenna feeders, modulating tetrodes and single signal reception without a crystal.

Every amateur interested in installing a good radiophone transmitter or in improving his present outfit cannot possibly invest 35c in better fashion.

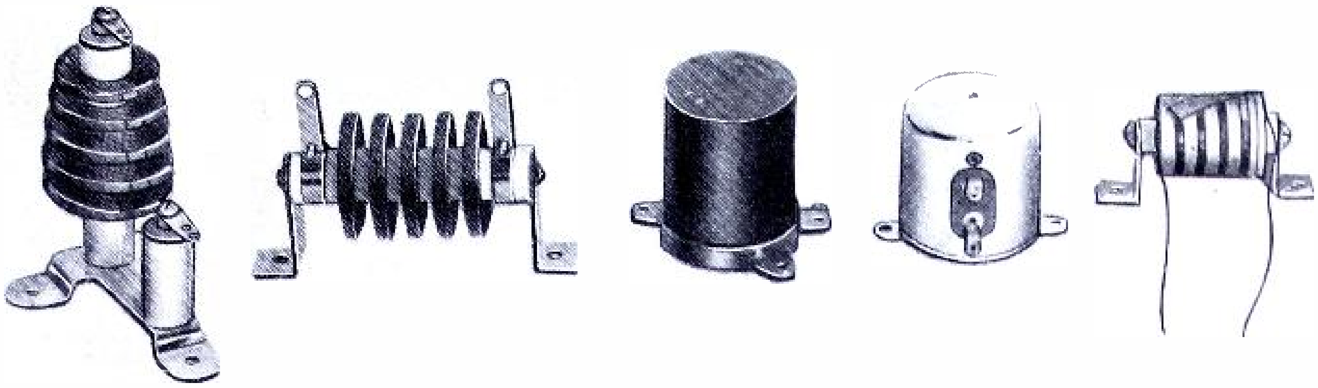
Correction Note

IN the article appearing on page 6 of the January, 1934, issue, the statement was made that a Hammarlund broadcast receiver was taken on the *Jacob Ruppert*, Rear Admiral R. E. Byrd's main supply vessel. This was an inadvertent error. The Hammarlund Manufacturing Company does not make broadcast receivers at all, the set in question being the well-known Hammarlund "Pro" short-wave superheterodyne with crystal filter. This set is being used with excellent results by the operators of the expedition.

TWO errors unavoidably crept into the Naval Time Signal Schedule published on page 30 of the November, 1933, issue of SHORT WAVE RADIO. Readers who cut this list out and are saving it for reference purposes can easily mark the corrections on it.

The third listing in the extreme left column now reads: 0425 to 0430 (11.25 to 11.30 A.M. E. S. T.). This should read: 0425 to 0430 (11.25 to 11.30 P.M. E. S. T.). The fourth listing now reads: 0455 to 0500 (11.55 to 12 Noon E. S. T.). This should read: 0455 to 0500 (11.55 P.M. to 12 Midnight E. S. T.).

The list otherwise is correct in all respects.



Some samples of well-designed r.f. chokes suitable for short-wave use.

Selecting the Proper R. F. Choke

By Louis Martin

ONE thing that the experienced broadcast-set constructor cannot understand when he attempts to build or design a short-wave receiver is the use of extensive filtering in the plate and grid circuits. Even a well-designed broadcast set will have plate chokes with their attendant bypass condensers; although the more usual receiver—of fairly good design, though—may employ but one choke and condenser in the common plate return.

The word "choke" is fairly indicative of its function. The non-technical man usually likes to visualize the action of a choke in somewhat the same light as he does the action of a dam: the water piles up at one end, leaving only a relatively small overflow drip over the other side. In a choke, however, he has visions of alternating current reaching the choke at one end, and a very much smaller amount passing through. A point to remember, though, is that this picture portrays the *result* of choking action rather than what actually takes place.

Why the Choke Chokes

Any coil of wire having inductance is a choke—sometimes in name only. Whether or not it actually performs the function of a choke depends almost entirely upon the nature of the circuit in which it is connected. The reason for this fact becomes apparent when it is realized that, when used *alone*, a choke "chokes" simply because of the counter e.m.f. which it builds up by virtue of its inductance. Any coil through which a varying current is passed generates a voltage, and the amount of this voltage depends upon the rate of variation of the current and the inductance of the coil. Now, you say, "If the current *through* the coil *must* vary in order to generate the required e.m.f. in order to have choking action, how is the a.c. prevented from coming out the other end in order that the choke 'choke'?" The answer to this question is simple *and is the basis for our entire discussion of chokes.*

As the frequency of the current through a coil—a choke, in our case—increases, the amount of current required through it in order to generate the necessary e.m.f. decreases; it decreases in direct proportion to the increase in the frequency of the current through the coil.

So, if a coil is connected in series with the plate circuit of a tube in which an alternating current that is to be suppressed is present, and if the inductance of the coil and the frequency of the current to be suppressed are high enough, the amount of current through the choke is small; furthermore, since the coil is in *series* with the remaining circuit, the current to be suppressed in the remaining circuit must also be small, because in a series circuit, *one* and only *one* current can flow. Hence, the choke "chokes."

The more usual use of a choke is in a circuit which has both low- and high-frequency currents, such as a detector-tube plate circuit; in such a circuit it is usually desired to suppress only the high-frequency current. Does the choke choke both currents? If not, which one? And why? For the answer to this one, see Fig. 1.

SUMMARY: *This is one of the few articles that has appeared during the past few years which tells how to select the proper r.f. choke for a given purpose. An r.f. choke made by a reputable firm will have its inductance, resistance, and distributed capacity clearly marked; what to do with these constants is the purpose of this informative article.*

It is found that the lowest frequency at which a choke can be used is determined by its low-frequency inductance, while the highest frequency is determined by its inductance, distributed capacity, and the values of bypass condensers used with it.

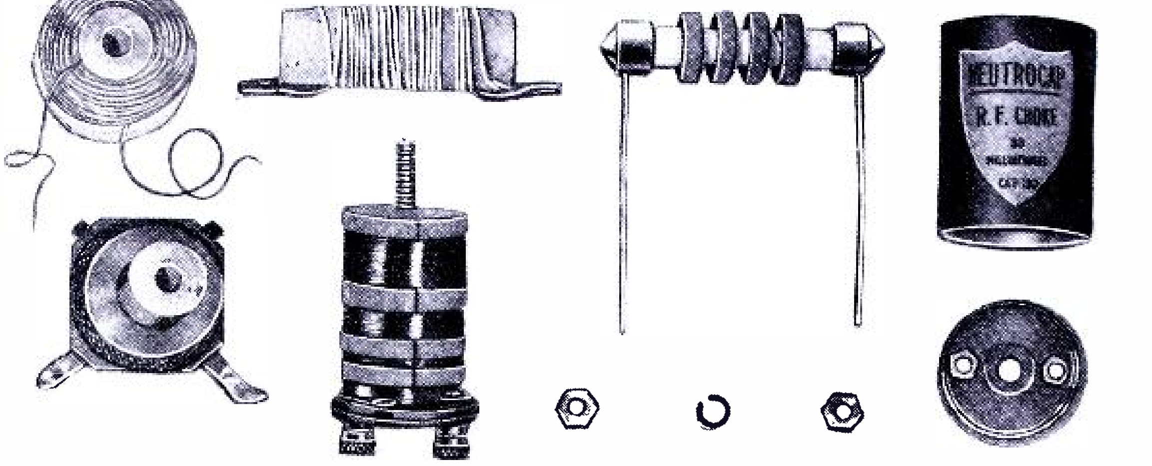
The frequency that can be suppressed depends upon the size of the choke and the frequency of the currents involved. If the choke were made of many turns of fine wire wound over an iron core, it would suppress both the audio and the r.f. signal, *provided the distributed capacity of the choke were not so large as to bypass the r.f.* The effect of distributed capacity will be considered a little later, so that if we assume, in our case, that the choke has a large inductance and a small capacity, then it will effectively block both the a.f. and the r.f. currents.

If the choke inserted in the plate circuit of Fig. 1 were composed of a few turns of wire wound on an insulated form, then in all probability its inductance would be too small for the a.c., although it might be high enough for the r.f. Our next problem is to be found in the question, "When does a choke start to choke, and when does it finish choking?"

When a Choke Starts to Choke

A coil having inductance starts to act when its reactance—which is equal to the voltage generated when the current passing through it is varying at the rate of 1 ampere per second—is large enough to reduce the current through it appreciably. Practically speaking, the current to be suppressed must be reduced to about 10% of the value it would have if the choke were not there, before any choking action results. Now, with a choke of given inductance, there is a particular frequency at which the current is reduced to 10% of its initial value, and what this frequency is depends upon the impedance of the circuit connected in series with the choke. Look at Fig. 1 again.

Suppose the tube has an impedance of 10,000 ohms and is connected in series—as far as the signal is concerned—with an audio transformer and a B battery. Now, almost every audio transformer primary has such a high distributed capacity at radio frequencies that its impedance may be considered



Some additional samples of r.f. chokes. The first and second from the left in the upper row were home made; whether or not they really do any effective choking is a matter of speculation. The third from the left in the upper row is one of the most modern available, and is shown here for comparative purposes. The left choke, in the lower row is fairly common, while the one immediately to its right, while somewhat old, is wound according to modern engineering principles. It's cover and mounting facilities are shown to the right in the lower row and at the extreme right in the upper row.

zero; furthermore every B battery *should* be bypassed sufficiently so that the resistance of the battery is negligible. Our problem then resolves itself down to that of a 10,000-ohm tube impedance connected in series with an r.f. choke. Two things must be determined: (1) with a choke of given inductance, what must be the frequency at which choking action starts? and (2) with a given frequency, what must be the inductance of the choke in order that choking action start? The second query is the more important and will be worked out in detail.

An Example

If the tube develops, say, 25 volts, and if the choke were not connected, the current flowing (high frequency) would be 25/10,000, or 2.5 milliamperes. For our choking action to be effective, this current must be reduced to .25 ma. Our circuit to be solved is shown in Fig. 2, in which the tube impedance is shown as a resistance. Since the current through the circuit must be .25 ma., the *impedance* of the circuit must be 25/.00025, or 100,000 ohms.

Since the tube resistance is 10,000 ohms, it *might* be concluded that the reactance of the coil must be 90,000 ohms, but such is not the case. The reactance of the coil must be:

$$X_L = \sqrt{Z^2 - R^2} = \sqrt{100{,}000^2 - 10{,}000^2}$$

$X_L = 95{,}000$ ohms (nearly).

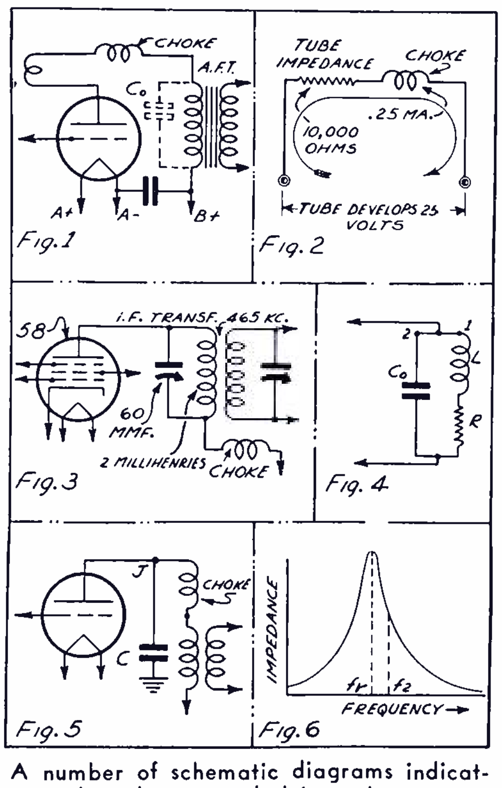
The inductance required for a reactance of 95,000 ohms depends upon the frequency. If the frequency at which the receiver is to be worked is from 15,000 kc. (20 meters) to 1500 kc. (200 meters), then the inductance of the choke should be such as to have a reactance at the lowest frequency of 95,000 ohms. The reactance, $X_L = 6.28 \times f \times L$; therefore, since f is 1,500,000 (1500 kc.), the inductance is L = 10 millihenries. The same choke is good at 15,000 kc. simply because its reactance is greater—ten times greater—so that the current to be suppressed is reduced to much less than 10% of its initial value—better choking action.

It does not require much calculation to note that as the frequency at which the choke is to be used decreases, the required inductance of the choke must increase.

Another thing: the choke calculated is to be used with a tube whose impedance is 10,000 ohms, such as the 27, 01A, 56, etc. For higher impedance tubes, a greater value of inductance must be used in order to obtain the same choking action.

Another type of problem may arise: the choke may be connected in series with an i.f. amplifier plate lead, and the impedance of the primary of the i.f. transformer may not be negligible at the lowest frequency the set can tune to—the set may tune to 1500 kc. and the i.f. may be 465 kc. Can the impedance of the primary of the i.f. transformer be neglected by virtue of its tuning and distributed capacities? This problem is perhaps more important than the one cited before.

Consider a typical i.f. transformer, as shown in Fig. 3. The primary of this transformer has an inductance of 2 millihenries and is shunted by an adjusting condenser of 60 mmf., resonating at 465 kc. If the set is a short-wave superhet and the lowest frequency to which it can tune is 1500 kc., will the capacity of 60 mmf.—which also includes the distributed capacity of the coil—be large enough to neglect? If not, how is it taken into consideration when designing or choosing the correct choke?



A number of schematic diagrams indicating the theory underlying the proper choice of r.f. chokes.

The reactance of the primary coil of the i.f. transformer at 1500 kc. is 18,840 ohms; the reactance of the 60 mmf. capacity at the same frequency is 1770 ohms. This means that the shunting effect of the coil may be neglected because the capacity reactance is about 10% of the inductive reactance. But even the capacitative reactance may be neglected because it is in series with a type 58 tube, whose plate impedance is 800,000 ohms. Our previous method of choke design, then, holds good.

But suppose the tube impedance were 10,000 ohms, then we could not neglect the transformer impedance because it is nearly 1800 ohms. What then? The answer is that a tube with a plate impedance of 10,000 ohms would not use such a transformer for the simple reason that with a reasonably efficient coil—with a "Q" of about 100—it would present an impedance of close to 170,000 ohms at 465 kc., the resonant frequency. Such an impedance is out of the question with a tube having a plate impedance of 10,000 ohms!

Distributed Capacity Effects

All the facts and figures given previously were based on the assumption that the choke had no distributed capacity itself—something which is hardly realizable in practice. Whenever two wires are laid side by side, a capacity exists between them. The effect of this capacity is—or, rather, should be—small at low frequencies; but, as the frequency increases, it becomes more and more important. Finally, at a certain frequency, the effect of the distributed capacity is the same as the effect of the coil, and the choke is in resonance. At frequencies higher than this critical frequency, *the choke is no longer a choke—it is a condenser.*

Look at Fig. 4, which shows the schematic circuit of a choke coil as it actually is in practice. The "pure" inductance is represented by L, the r.f. resistance of the coil by r, and the distributed capacity of the coil by C. When this is connected in a circuit, the current divides between the two branches, 1 and 2. That portion passing through branch 1 receives choking action; and that portion passing through branch 2 goes right through. Any increase in frequency results in more current going through the condenser and less through the coil branch, because the reactance of the condenser decreases with increasing frequency, and the reactance of the coil increases with frequency.

At low frequencies the current through the distributed capacity is very small, so that the whole unit acts as a choke; but, as the frequency increases and increases, a point is reached where more current flows through the distributed capacity than through the coil—and the choke is not a choke!

When is a choke a choke? A choke becomes a choke when the frequency through it is high enough so that an appreciable counter e.m.f. is generated, and stops being a choke when the frequency of the current through it is so high that the choke acts as a condenser.

For all practical purposes, the highest frequency that may be choked successfully is equal to the natural frequency of the choke, which is determined by a low-frequency inductance measurement and its distributed capacity. One other factor must be taken into consideration when choosing a choke: the current carrying capacity must be sufficient to handle the current through it.

How do commercially available chokes measure up to the specifications outlined here? Illustrated in the photographs are a number of manufactured types, some of which are new and some of which are not so new; also, there are shown some of rather unknown vintage having equally unknown characteristics. The danger of using these chokes is quite evident. Of course, the cut-and-try method may be used, but the results are seldom satisfactory.

The long, narrow photograph shows, to the left, the type R-152 National transmitting choke. It has an inductance of 4 millihenries and a distributed capacity of 1 mmf. Its resistance is small and will be neglected, as has coil resistance in all previous considerations. Now, as stated, a choke may be used up to such a frequency where the ratio of the inductive reactance to the capacitative reactance is unity. Under these circumstances, this choke, alone, may be used up to 2527 kc., corresponding to a wavelength of about 120 meters.

The choke immediately to the right of the National is a Hammarlund type CH-500. This choke has an inductance of 5.3 millihenries and a distributed capacity of 1.5 mmf. The "critical frequency" in this case is 1770 kc., which corresponds to a wavelength of about 170 meters.

To the right of this choke is the Hammarlund type RFC-250, which has an inductance of 250 millihenries and a distributed capacity of 2 mmf. The limit in this case is 227 kc., which corresponds to a wavelength of 1300 meters.

Then, again to the right, is the Hammarlund type CH-10-S, which has an inductance of 10 millihenries and a distributed capacity of 2 mmf. Here, the limiting frequency is 1130 kc., which corresponds to a wavelength of about 265.5 meters.

The Hammarlund type CH-8, the last in this row, has an inductance of 8 millihenries and a distributed capacity of 3 mmf. Our calculated limiting frequency here is 1030 kc., corresponding to a wavelength of about 291.3 meters.

The upper third from the left (page 14) is a National type 100 and has an inductance of 2.5 millihenries and a distributed capacity of 1 mmf. The limiting frequency here is very high, 3184 kc., corresponding to a wavelength of 94 meters.

The remaining chokes, as stated before, are relics of days gone by, and the inductance and distributed capacity are unknown. The values computed for these manufacturers' chokes, however, may be relied upon.

How to Use a Choke Properly

The natural conclusion to be drawn from these figures is that the manufactured chokes are not suitable for short-wave use. *Such is the case if the choke were used without any attendant bypass condensers.* The more usual—and correct—arrangement in which chokes are used makes use of at least one bypass condenser associated with the choke. See Fig. 5.

If the circuit were used *without* condenser C, then, as far as the frequency to be suppressed is concerned, the plate load of the tube is high, and is determined by the impedance of the choke. In fact, if the frequency to be suppressed is equal to the natural frequency of the choke, the circuit is equivalent to a tuned-plate—tuned-grid oscillator, *and the circuit will oscillate at the very frequency that is to be suppressed!*

(*Continued on page* 41)

Have You Your Certificate?

THE Before Breakfast Short Wave Club, which was first described in the November, 1933, issue of SHORT WAVE RADIO, is a unique organization open to all short-wave listeners. There are no dues, meetings, minutes or other parliamentary nuisances. It is merely a friendly, fraternal and not too serious organization of early birds who believe in the old adage about catching the worm. The only requirement for membership is two verifications from short-wave phone stations one thousand miles or more from the applicant's location, received any time after 5:00 a.m. and before 9:00 a.m. any day of the week.

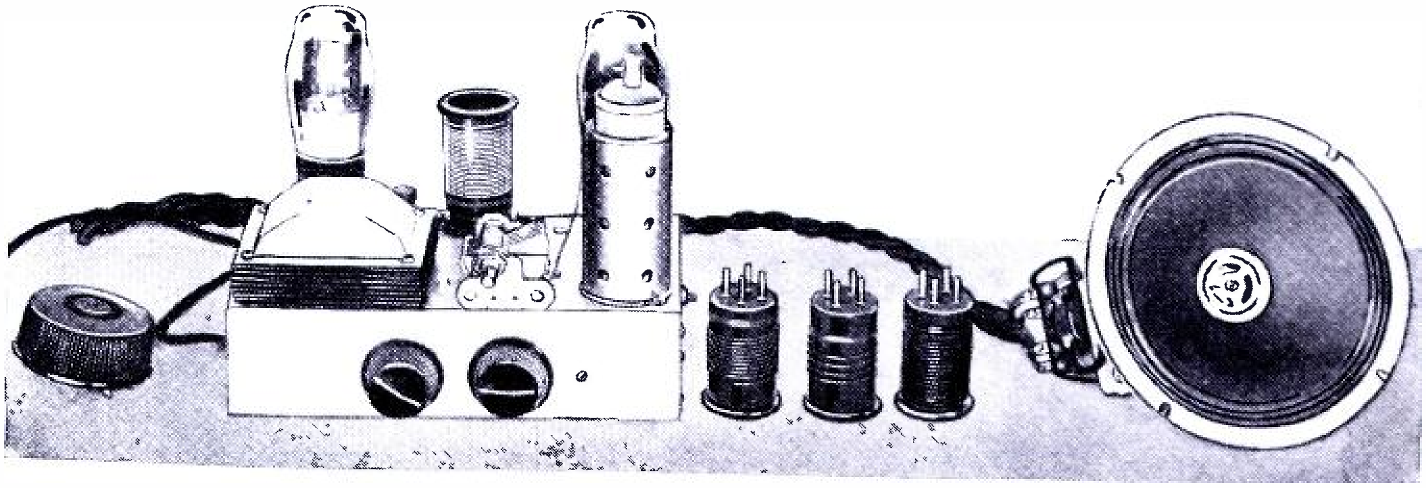
Verifications sent in to the B. B. S. W. C., are returned promptly to their senders along with a certificate of membership suitable for framing. This certificate measures 8½ in. by 11½ in. and is printed on high grade paper.

We do not make any distinction between short-wave relay broadcasting stations, commercial radiophones, amateur phones, experimental stations, and ship stations. Any station that operates below 200 meters and uses voice transmission is a legitimate catch for the short-wave listener, who is interested only in the feat of reception itself and not in the musical programs, political propaganda and private conversations that fill the air. It is really much more of an accomplishment to bring in an amateur station using perhaps only ten or fifteen watts of power than a powerful broadcasting station using ten or fifteen kw.

Your letters and cards will undoubtedly contain valuable "dope" on wavelengths and operating hours of elusive stations, which we will publish for the benefit of less fortunate listeners.

Address your verifications and applications for membership to the Before Breakfast S. W. Club, care of SHORT WAVE RADIO, 1123 Broadway, New York, N. Y., and be sure to enclose a large stamped and addressed envelope for their safe return.

A reduced reproduction of the diploma issued, free of all charges, to all those who can qualify. See text.



Photograph of the dial, "Globe Trotter," coils, and loudspeaker, all part of the receiving equipment.

The A. C. Operated Find-All Globe Trotter

SUMMARY: *A complete description of a simple little two-tube receiver designed strictly for a.c. operation. The author makes no extravagant claims for it, but it can be relied upon to deliver good, reliable service for domestic stations and for foreign reception on many other stations.*

This receiver was designed with the main idea of producing a simple receiver that could be constructed by those experimenters who are not engineers, but who have a good, practical working knowledge of radio.

H. G. Cisin, M. E.

THE A.C. Operated Find-All Globe-Trotter is an excellent beginners' set from many standpoints: first of all, it is very simple, using only two tubes and a rectifier; second, it is inexpensive; third, it gives splendid results, operates a dynamic speaker and covers a wave band of from 15 to 550 meters. While designed primarily for short-wave work, it will also bring in standard broadcast programs by using the plug-in coil provided for this purpose.

Brings in Distance

When operated as a short-wave receiver, the Globe-Trotter will bring in plenty of domestic distant stations and under suitable conditions it should also bring in foreign stations. Although the circuit employed is a standard one, which has met with the approval of thousands of radio fans, it has been modernized and improved through the use of the newest tubes and up-to-date components. The type 57 high gain r.f. pentode serves as a regenerative detector. Regeneration is controlled by means of the potentiometer R4, which varies the voltage applied to the screen grid of the 57 tube, V1. This takes the set into and out of regeneration with extreme smoothness.

The small condenser C1, which controls the antenna circuit capacity, makes an excellent vernier for the fine adjustments required when tuning in distant stations. The r.f. coil used at L1 is of the plug-in type. A set of five coils permits one to cover a range from 15 to 550 meters. A midget variable condenser, C2, is used to tune the coil. Resistance coupling is used between the 57 detector tube and the power output tube, V2. The latter is a 2A5 tube, which has an undistorted power output rating of 3 watts. This is the reason the set has sufficient power to operate a loudspeaker even on many distant stations. The tone quality is good. Provision is made for using earphones by plugging into jack J. The standard type 80 full-wave rectifier, V3, is employed.

The short-wave r.f. choke, L2, bypassed by the .00025 mf. mica condenser, C5, keeps r.f. current out of the audio portion of the circuit.

The power transformer PT supplies the necessary voltages for the plates and filaments. Ample filtering is obtained using the speaker field as an audio choke and bypassing this on either side with 8 mf. dry electrolytic condensers, C8, C9.

Good Aerial Necessary

In attempting to tune in distant stations, it is imperative that the antenna system be as nearly perfect as possible. First of all, the antenna itself should be located as far above the roof as possible or stretched out in the clear, well away from the building.

The chassis is available with holes drilled for the sockets and the power transformer. These parts should be mounted first. The variable condenser C2 is mounted next. Do not permit the stator terminals to touch the metal chassis. The rotor may be grounded to the chassis. Binding posts A and G are then mounted. Post A *must* be insulated from the chassis; the other is fastened directly to the chassis. The antenna condenser C1 is then mounted on the front chassis wall at the right. An insulating washer must be used to prevent the rotor from grounding on the chassis. The potentiometer-switch is mounted on the left front chassis wall.

Parts Under Chassis

The double section electrolytic condenser, C8-C9, is fastened to the bottom of the chassis by means of thin brass or copper bands. Then the jack J is mounted on the rear chassis wall as shown in the bottom view. This must also be insulated, by means of an insulating washer, from the metal chassis. Condenser C4 is fastened to the rear chassis wall. The r.f. choke L2 is fastened to the underside of the chassis, using a long screw to keep it as far from the metal as possible.

The remaining fixed condensers and resistors are soldered in place while the set is being wired. First wire in the filament circuits of tubes V1 and V2. The various grid circuits are wired in next. The chassis should not be depended upon as a return circuit for the tuning circuit. Instead, wires should be run to all points in the r.f. circuit.

After wiring the grid circuits, plate circuits are wired, then cathodes, negative returns, bypass condensers, filter condensers, etc. Finally, the rectifier tube V3 is wired in, and then the primary of the power-supply transformer.

After checking over the wiring, the three tubes are placed in their respective sockets, the dynamic speaker is plugged into the socket on the back of the chassis, the antenna and ground are connected to posts A and G respectively, the primary of the transformer is connected to a 110-volt a.c. source, and the green (80-200 meter) coil is plugged into the socket behind the tuning condenser C2. Switch SW is closed by turning. Condenser C2 is tuned to a signal and then condenser C1 is turned until maximum volume is obtained. The proper setting for this condenser must be determined by experiment. The regeneration control R4 is advanced until the set goes into oscillation. If the set goes into oscillation too quickly, it may be necessary to reduce the value of the grid leak R1 from 2 megohms to 1 megohm or less, so that satisfactory smoothness of regeneration control may be obtained.

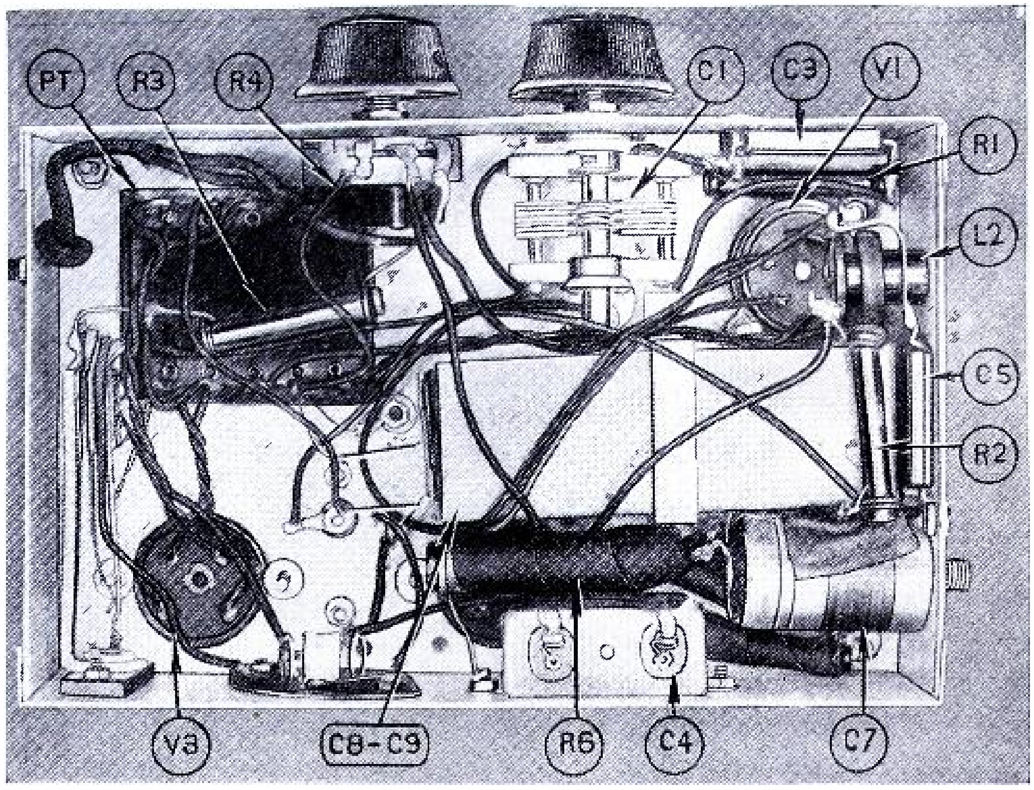
The tuning condenser should be turned slowly, advancing the regeneration control at the same time towards the right. Stop turning the regeneration control as soon as the set goes into oscillation. As the tuning condenser is turned, stations will be heard. At first the signals will be indistinct but by turning the regeneration control back, they will clear up. To obtain desired regeneration control, correct adjustment is necessary throughout the receiver. About 22½ volts on the screen grid of tube V1 will give maximum sensitivity. The set should next be tested in the same way with all the other plug-in coils.

Concluding Notes

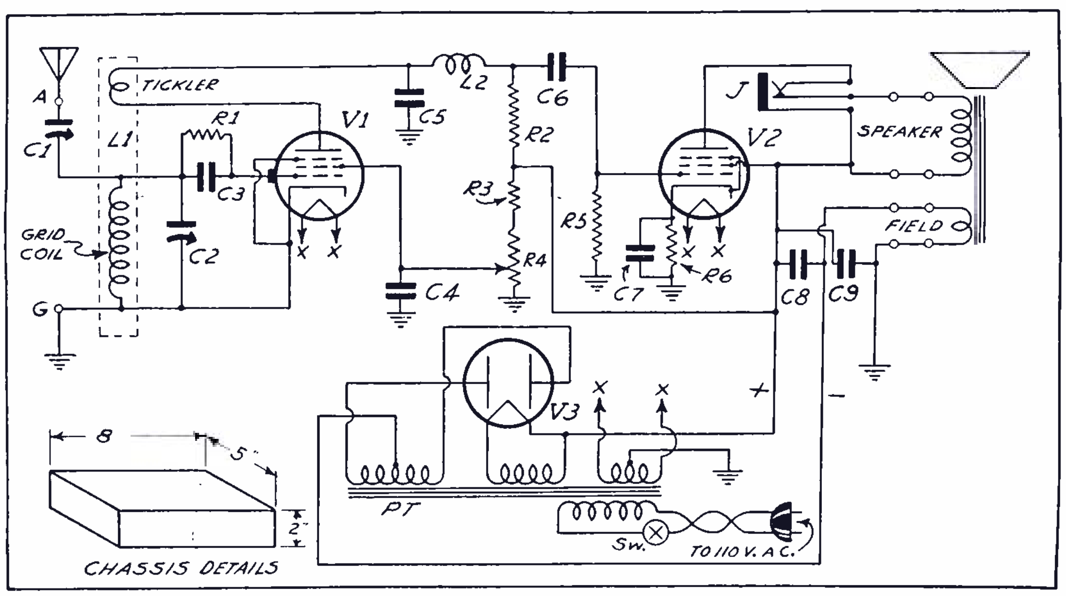
There are a few points to take into consideration when tuning any regenerative receiver: as the regeneration control is advanced or retarded, the actual tuning of the dial must be changed in order to bring in a station at maximum volume. This apparent change in tuning is brought about by the action of the feedback: it tends to change the inductance of the circuit, necessitating changes in the attendant capacity.

Another thing that should be watched is the innocent tendency to blow filter condensers whenever tubes are removed from their sockets with the power on. When this is done, the voltage from the power unit may increase to such high values as to exceed the safe value for some of the condensers. *Warning*—always turn the set off when changing tubes.

Do not use an antenna that is too long. A horizontal wire about 50 feet long will enable the condenser C1 to tune the antenna circuit to resonance on many signals, greatly increasing the signal strength.



Under view of the "Globe Trotter," with all values labeled for convenience. See the diagram of connections below and the list of parts for the actual values. Only the location of the larger units are fixed; the positions of the smaller ones are not fixed, as they may be placed as close to their destination as possible.



Schematic circuit and list of parts for the "Globe Trotter."

1—Hammarlund .00005 mf. variable condenser type MC-50-S, C1.
1—Hammarlund variable condenser, .00014 mf. capacity, type MC-140-M, C2.
1—set of Alden short-wave coils, plug-in type, covering the following bands: green, 80 to 200 meters; yellow, 40 to 80 meters; red, 20 to 40 meters; blue, 15 to 20 meters; extra coil for broadcast band, orange, 220 to 550 meters, L1.
1—Electrad 75,000-ohm potentiometer, type R1-202-P R4, with switch SW.
1—Electrad 400-ohm wire wound, 10-watt vitreous resistor, type H-897, R6.
1—Aerovox mica condenser, 0001 mf., type 1460, C3.
1—Aerovox mica condenser, .00025 mf., type 1460, C5.
1—Aerovox cartridge condenser, .01 mf., 400 volts type 481, C6.
1—Aerovox metal case condenser, .5 mf., 200 volts, type 260, C4.
1—Aerovox 10 mf., 50-volt can type bypass condenser, type SM50, C7.
2—Aerovox 8 mf. electrolytic condensers, cardboard container, type P5-8, C8, C9.
2—I.R.C. ¼ meg., 1-watt metallized resistors, type F-1, R2, R5.
1—I.R.C. 150,000-ohm, ½-watt metallized resistor, type F-½, R3.
1—I.R.C. 2 meg., ½-watt metallized resistor, type F-½, R1.
1—Find-All short-wave r.f. choke, L2.
1—Trutest closed circuit jack, J.
2—Alden six-prong moulded sockets, type 436, for V1, V2.
3—Alden four-prong moulded sockets, type 424, for L1, V3 and speaker plug.
1—type 57 r.f. amplifier pentode tube, V1.
1—type 2A5 power output pentode, V2.
1—type 80 full-wave rectifier tube, V3.
1—Lafayette dynamic speaker for single 2A5 tube, with 1800 to 2500-ohm field, type W19166.
1—Trutest power supply transformer, type C1490, PT.
2—Eby binding posts, A.G.
1—Acratest four-prong plug, type K11666, for loud-speaker connection.
1—roll of solid core Corwice Braidite hook-up wire.
1—Metal chassis 8" x 5" x 2" high.

Oscillators — And Their Characteristics

SUMMARY: *Because of the importance of oscillators in radio work, an intimate knowledge of their characteristics is of vital importance. This first of a series of articles treats in some detail the theory and operation of the tickler type of oscillator circuit. In issues to follow, all of the other types will be considered.*

The article is divided into two parts: the first treats the subject qualitatively, and the second tackles it from a more quantitative standpoint.

By Louis Martin

IN receiving as well as in transmitting circuits, the question of what type of oscillator circuit to use has always been a tough one. Is the Hartley as good as the Colpitts? Is the simple tickler feedback as efficient as the tuned-grid—tuned-plate. Regardless of what the answers to these questions may be, the fact remains that all of these circuits will oscillate, all with about the same efficiency; it is only a question of whether or not the characteristics of the individual circuits suit the requirements of the set-up.

For instance, in a receiver, the primary question is not whether or not the circuit will oscillate with the greatest efficiency, but whether or not the tube will slide into oscillation easily and smoothly. In a receiver, it is not a question of plate dissipation so much as it is a question of stability. Let us consider the more common types of oscillator circuits and study their actions and reactions.

Tickler Feedback Circuit

A simple circuit used extensively in low-powered transmitters and in receivers is the familiar tickler feedback circuit of Fig. 1A. The coil L is the usual tuned secondary, and the coil L1 is the tickler. The load, Z, may be the primary of an audio transformer, the plate resistor of a resistance-coupled amplifier, or a choke in an impedance-coupled amplifier. The coupling, or mutual inductance, between the tickler and the secondary, is represented in the diagram by *M*. The mutual inductance may be increased by increasing the number of turns on L1, by placing L and L1 closer together, or by placing L and L1 parallel to each other.

The diagrammatic circuit may be shown in a little different manner to facilitate analysis, and is so shown at B. In this analysis, the tube capacitances have been neglected to simplify the work; but if it is found that they are necessary at any time, their effect will be considered. The batteries have been eliminated, as they have no effect upon the circuit as far as a.c. is concerned. Also, the internal a.c. resistance of the tube, *rp*, is considered. To sum up, the load, Z, the tube impedance, *rp*, and the tickler, L1, are connected in series; furthermore, the coupling between the plate circuit and the grid circuit takes place through *M*. It is this coupling that causes the tube to oscillate, because it is only through this coupling, in this type of circuit, that energy is fed from the plate to the grid circuit.

The simple theory of an oscillating or regenerative circuit is that by virtue of the fact that energy is fed from the plate to the grid circuit of a tube, the losses in the grid circuit are supplied; and any excess of energy existing in the grid circuit is amplified by the tube in the usual manner. This amplified energy is again fed to the grid circuit, and the process continues so long as circuit conditions are kept constant. When oscillating or regenerating, therefore, the circuit reacts as though the resistance of the circuit has been reduced to zero, because all of the power necessary to supply the losses comes from the plate circuit. This point, perhaps, requires a little more discussion.

In any electrical circuit the power lost in heat is directly proportional to the resistance of the circuit and the square of the current flowing. If we double the resistance, keeping the current constant, then the power lost in heat doubles. In fact, the actual effective resistance of a.c. circuits is frequently measured by determining the power lost by means of a wattmeter, and then, with the current known, calculating the resistance. If we had an oscillating circuit, therefore, which was supplying all the losses in the grid circuit, —in our case also the oscillating circuit—then any other signal applied to the grid would get tremendous amplification, because that signal would not have to supply any losses at all!

Coming back to the equivalent circuit of Fig. 1B, then, it is seen that all the losses in the grid circuit are supplied by the plate circuit—which eventually comes from the B battery; furthermore, if the energy fed back is just about sufficient to supply the losses, then the circuit regenerates; if it is more than sufficient, the circuit oscillates.

At the same time that the resistance of the circuit is reduced, the reactance (inductive) is increased, so that if the circuit is to be tuned to a given frequency, the capacity of the tuning condenser, C, must be reduced to compensate for the increase in inductance caused by regeneration—an important point in tuning short-wave receivers that have regenerative detectors.

Suppose, now, that *M* is small and is increased gradually either by bringing L and L1 closer together or making them more parallel. When this happens, the current *I* in the tank circuit and the current *Ip* in the plate circuit increases with in-

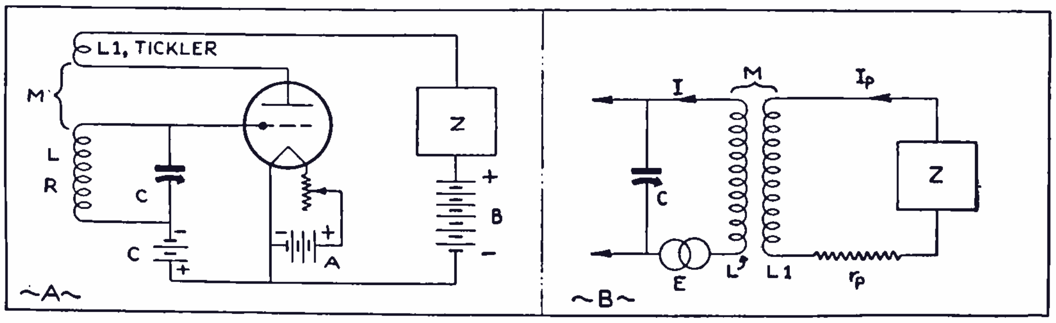


FIG. 1: SCHEMATIC AND DIAGRAMMATIC CIRCUITS OF A TICKLER CIRCUIT

creasing M, reaching a maximum when the resistance of the grid circuit becomes nearly zero. The current I never actually reaches infinity, because when Ip becomes very large, the amplification factor of the tube drops, and the plate resistance changes, limiting the maximum gain obtainable. However, as M is increased, the tank current and the plate current (by plate current is meant the a.c. plate current) increases, the limit being determined by the constants of the tube. At the same time, the inductive reactance of the circuit increases, so that it becomes necessary to continually decrease C in order to maintain the circuit resonant at a fixed frequency.

The extent to which the resistance of the tuned circuit may be reduced is best given by an example cited by Chaffee. The resistance of a certain coil was 300 ohms, but the effective resistance could be reduced to .001 ohm by careful manipulation of the tickler. Furthermore, it was found that the resistance of .001 ohm was raised to 1.2 ohms by increasing the temperature of the coil 1 degree centigrade. Hence, a thousandth of a degree just about doubles the effective resistance of the tuned circuit.

Conditions of the Tickler Circuit When Oscillating

Suppose, now, that M is increased sufficiently to cause the tube to oscillate. When this condition obtains, the frequency of oscillation is different from that when it is not oscillating. It is less by a very small amount, as pointed out previously, so that if the tuning of the circuit were not touched during the time oscillations were building up, the circuit, if it were part of a receiver, would *not* be in exact resonance with a signal to which it was tuned previously. The circuit oscillates at the lower frequency, and the difference between the signal frequency and the actual circuit frequency gives rise to the familiar "beat," or whistle, known to every tuner of a regenerative circuit. In practice, the whole thing works as follows: the set is not oscillating, and a signal is tuned in. The tickler is advanced until oscillations start, and a squeal is heard. This squeal is the beat note between the signal and the oscillations. The reason why the circuit does not oscillate at the same frequency to which it was originally tuned is that the oscillations actually changes the inductance of the coil, shifting the frequency of oscillation, although the station frequency remains the same, it being determined by the transmitter.

The usual practice, now, is to retune in order to keep the set tuned to the signal, and when this is done, the pitch of the beat note drops for the simple reason that the frequency of oscillation of the tube has come closer to that of the signal, lowering the frequency of the beat note. If

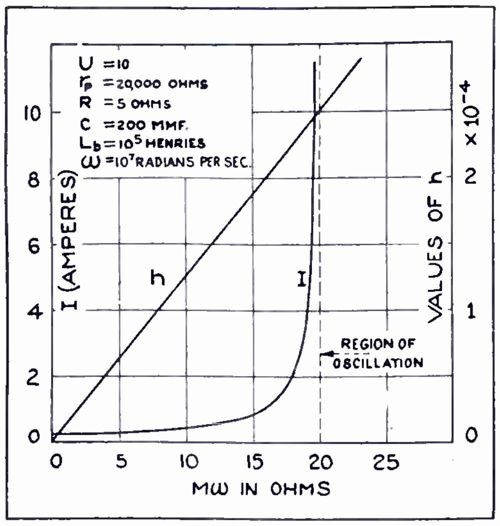


FIG. 2: TANK CURRENT VARIATION

The current curve is interesting because it shows the rapidity with which the oscillation point in this circuit is reached.

the capacity of the tuning condenser is further reduced, the frequency of oscillation and that of the signal become the same, giving what is termed "zero beat."

A More Technical Analysis

For those versed in the mysteries of algebra, a more quantitative analysis of regeneration may be given. Referring to Fig. 1B, assume that a signal voltage E, is applied to the circuit in series with the coil L and its tuning condenser C. Such a voltage would react upon the circuit exactly as would a signal fed to the circuit by a conventional coupling system. The tank current circulating between the coil and condenser, I, is then given by the expression:

$$I = \frac{E}{Z_t}$$

where Z_t is the impedance of the tuned circuit (grid circuit). The impedance of the tuned circuit is purely resistive if the circuit is tuned to resonance with the signal, so that the current is given by $I=E/Re$, where Re is the effective resistance of the tuned circuit—the actual resistance against which the signal must work. From this expression, it is clear that as the effective resistance of the circuit is lowered because of regeneration or oscillation, the tank current, I, increases, and would reach infinity were it not for the fact that the amplification factor and the plate resistance of the tube limit the amplification at large values of I.

Now, if, as Re is reduced, the signal voltage E is also reduced *in the same proportion*, the tank current would remain constant; in the extreme, when Re approaches zero, the signal voltage necessary to maintain I constant also approaches zero. Finally, when Re *is* zero, no signal at all is needed in order to maintain I constant; in plain English, the circuit is oscillating and the tank current is I amperes.

The value of Re is given by the equation:

$$Re = R - hrp, \quad\quad (1)$$

in which R is the actual, r.f. resistance of the coil and h represents what is technically called the *coefficient of regeneration*. This coefficient is a complicated mess having a value

$$h = \frac{\dfrac{uM}{C} - M^2\omega^2}{Z^2} \quad\quad (2)$$

Now that all our equations are down on paper, let us examine them in a little more detail. As the value of M is increased from a very small value, h increases to a maximum; then as M is further increased, h decreases because of the negative term $M^2\omega^2$. Usually, however, $M^2\omega^2$ is negligible in comparison with

$$\frac{uM}{C}$$

so that the point of oscillation is approached slowly at first, and then more and more rapidly as the oscillation point is reached.

Chaffee has plotted a curve which shows the relation between the tank current I and the signal voltage E; this curve is shown in Fig. 2. The curve is shown plotted as I vs. $M\omega$, assuming that E is constant at 2.5 microvolts. The interpretation is the same, however. The constants of the circuit for which the curve was drawn are listed in the figure.

The final figures show that when the oscillation point is just about reached, the amplification of the tank current is about forty times as great as when no regeneration is used at all. Also, since $M^2\omega^2$ is neglected, h has the value

$$h = \frac{uM/C}{Z^2} \quad\quad (3)$$

and since u, the amplification factor of the tube, and Z, the plate circuit impedance are constant, h, is a linear function of M, and is shown as a straight line in the diagram.

For those who wish to use the data here for numerical substitutions, the complete equation for the tank current I is given as:

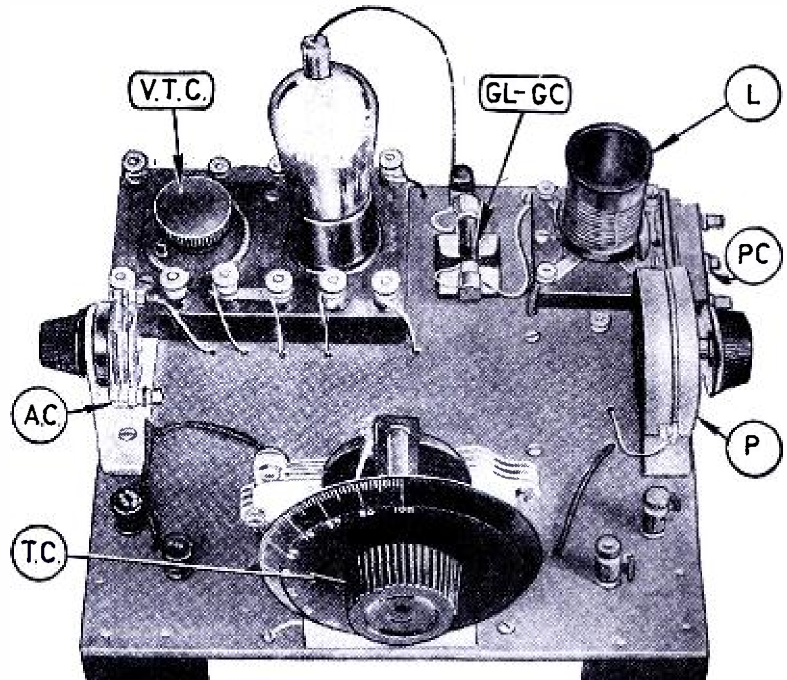
$$I = \frac{E}{R - \dfrac{uM\ rp}{CZ^2}} \quad\quad (4)$$

This equation is based on several assumptions: (1) the circuit is tuned to resonance with the signal; (2) the load impedance Z has negligible resistance compared to the internal resistance of the tube; (3) the effect of tube capacitances are nil; and (4) the amplification factor and plate resistance of the tube re-

(*Continued on page* 39)

Fundamental Radio Experiments

SUMMARY: *This is the second, and final, installment of articles by the author on this interesting subject, the first of which appeared in the December issue. Here, a combination receiver and transmitter is described.*



Top view of the set-up.

By Sol Prensky*

THIS article, the second of a series, covers the building of a unit to be used for experiments in radio receiving and transmitting. This unit is complete in itself and does not necessarily depend on the experiments or apparatus described in the first article, which appeared in the December, 1933 issue of this magazine. However, we will employ the same scheme here as before, namely that of putting together *a unit that can be adapted for more than one experiment*, and using only those ideas for our work that will result in *working models* of practical applications of radio principles.

The unit presented here is called the Radio Frequency Unit, and it is adaptable for *comparing broadcast- and short-wave reception*, so that we will be in a position to know what to expect from the new "extended-wave," or "all-wave," tendency in commercial receivers. It is also adaptable for *comparing receiving circuits with transmitting circuits* in a simple manner. This unit covers the following experiments:

(1) The Unit as a Receiver
  a. for broadcast waves,
  b. for short-waves,
  c. for amplification (using an a.f. unit).

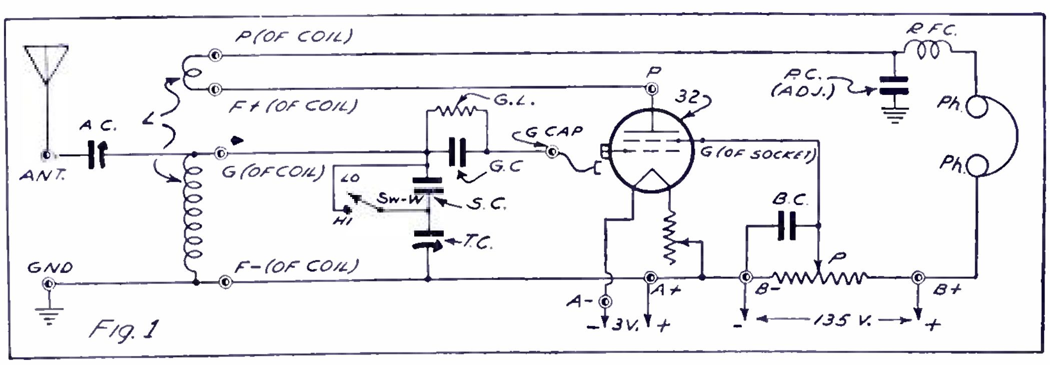
(2) The Unit as a Generator of Radio Waves
  a. radio-frequency oscillator
  b. radiophone transmission (over room distance, with an a.f. unit).

It will be noted that opportunity is offered to those who have constructed the first unit (the Audio-Frequency Unit, which covered experiments in producing audible effects) to use that unit as an audio amplifier for receiving and transmitting work. Thus, the two units *in combination*—aside from their independent uses—form *a widely useful radio laboratory outfit*.

* Instructor in Physics and Radio, Thomas Jefferson High School, New York, N. Y.

The Unit As a Receiver

For our basic arrangement, we use the familiar regenerative detector, a simple and highly sensitive circuit, to tune and defect the incoming radio waves. In our first experiment (Exp. 1A) we receive broadcast stations, so that we may proceed from the known to the unknown in our observations. When we have adjusted this circuit and obtained results from some broadcast stations, which will be found to be a simple and straightforward task, we will be ready, at the flip of a switch, to delve into short-wave mysteries.



Schematic circuit of the apparatus used in these experiments.

A.C.—Antenna condenser, 5-plate midget variable.
B.C.—Bypass condenser, 1/2 mf. 200 v.
G.C.—Grid condenser, 150 mmf.
G.L.—Grid leak, 1 megohm.
G cap—Grid cap with lead connected to binding post.
P—Potentiometer, 20,000 ohms, 10 watt (Carter).
P.C.—Plate condenser, adjustable 100 to 500 mmf. (X-L, G5).
R.F.C.—Radio-frequency choke, 2 1/2 mh. (National).
S.C.—Series condenser, fixed 100 mmf. (Aerovox).
Sw-W—Switch (on-off).
TC—Variable tuning condenser .00025 mf.
VTC—Leeds vacuum tube control, consisting of the following parts mounted on a bakelite base; 4-prong tube socket; 6-ohm rheostat; 10-ohm fixed resistor; 8 binding posts.
L—Coil Socket, 4-prong (Air-Gap).
Three Universal mounting brackets.
Set of four short-wave coils (Na-ald).
Type 32 tube
*Phones.
*3-volt A battery (General No. 2 PX).
*B supply (anywhere from 90-250 volts, B eliminator preferable).
*Leeds A.F. Unit.

*Starred accessories may be the same as were used for experiments in previous article in December, 1933, issue.

Exp. 1A—Broadcast Wave Reception

Object: To determine the best operating conditions for broadcast reception.

Method: The assembly of the unit is simplified by following the symbols of the diagram (Fig. 1) and referring to them in the photos. The Vacuum Tube Control Unit is the same as was used in the first series of experiments. We connect the antenna (Ant.) and ground (Gnd), the A battery (small dry cell), the B supply (which may have any value from 90 to 250 volts in the form of B batteries or a B eliminator, with the latter preferable), and the plug-in coil (L) having the most turns (coil D). After these connections, the following adjustments are made:

The rheostat is turned on half way.

Antenna Condenser (A.C.) is rotated so that the plates are about half in mesh.

Plate Condenser (P.C.) is adjusted so that the capacity is maximum (by turning the screw all the way in, to the right) and then turning back one-half turn.

The Wave Switch (Sw-W) is turned to Hi, which is the *on* position of the switch. (This position can be found by testing with a battery and phones.)

We are now ready to operate the *two controls*, tuning condenser (T.C.) and the regeneration control potentiometer (P). The arm of P is advanced about three quarters towards the post connected to the positive side of the battery. When the tuning dial is rotated towards the high numbers, whistles or "squeals" will be heard, indicating the presence of stations. None of the adjustments given up to this point are at all critical. If no regeneration is obtained (as evidenced by the absence of whistles), the wiring must be rechecked. In particular, the tickler connections should be reversed. Having located a whistle, the actual bringing in of the station is a proposition calling for the use of the two hands. With one hand rocking the tuning dial back and forth, the regeneration control is backed up very slowly, with its arm moving toward the negative post, until the squeal disappears; a slight movement of the tuning dial will then give the position for the best reception.

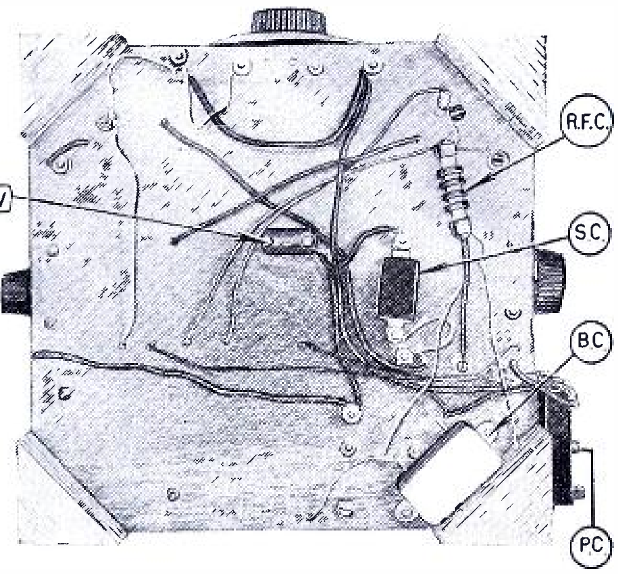
Warning! The whistles emitted by the set when you are tuning for a particular station can be heard by other people in the neighborhood listening to that station, and so may cause interference. Therefore, the set must be allowed to remain in the whistling (oscillating) condition no longer than is barely necessary to locate the station. As soon as the station is located, the regeneration control must be set at the position for best results by the procedure given previously.

Observations: We then proceed to log, that is get the dial reading for some stations like WMBQ or WEVD, and compare the settings with the dial curve given in curve A. This gives a very convenient reference point. (See Fig. 6.)

Instructions for Short-Wave Operation

Before attempting the next experiment, in short-wave reception, we must add to the information already gained from the broadcast waves. This topic of short-wave radio is one that lends itself to wide experimentation and is full of surprises and thrills. This is amply illustrated by the title and material of this publication; we must not expect to become short-wave experts simply by the doing of this one experiment. We will confine ourselves, therefore, to the purpose of producing a workable result within the limits of our experiments.

The result aimed at is to extend our distance range by working below 200 meters (1500 kc.) and to explore these waves for types of communication other than those heard on broadcast waves, such as, for example, police, aviation, and amateur communications. The tuning-in of foreign stations like GSA in London will be the final test of the care with which we have worked. To insure this care, we will outline here briefly three characteristics of short-wave reception, the details of which can be read elsewhere in this publication.



Under view of the set-up. It is to be noted that the wiring is very simple, nearly all of which appears above the deck. The knob on the left is the antenna condenser, that on top is the main tuning condenser, and the one to the right is the regeneration control. Only three small parts are mounted on the lower side of the baseboard. Practically the same mechanical arrangement is used when the apparatus is used as a transmitter; although the legal difficulties must be overcome, as outlined by the author. See the text for a discussion of this important point.

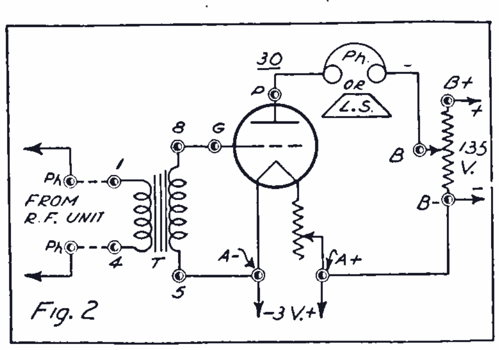
1. *Tuning of stations is exceeding sharp*, therefore, tune slowly and with great care.

2. *Stations are not uniformly distributed over the tuning dial*, since various types of communication operate within limited wavelength bands; the location of these on the dial must be known at least approximately. For this purpose, we use a calibration curve, similar to curve B, in connection with a short-wave station list such as is given elsewhere in this publication. We pay particular note to the following bands:

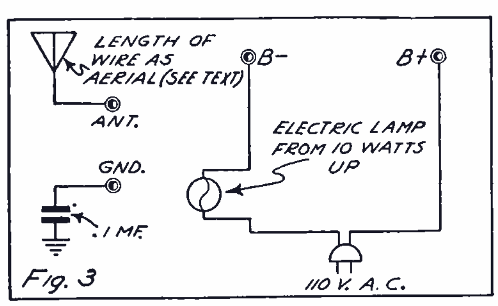
Police waves about 120 m. (2500 kc.).

Amateur waves about 80 m. (3750 kc.) and 160 m. (1875 kc.).

Powerful short-wave stations about 31 m. (9700 kc.) and 50 m. (6000 kc.).



Using the a.f. unit as described in the December issue.



Changes to be made in the r.f. when used as a transmitter.

3. *Stations will not be received continuously throughout the day.*

a. To allow for these discontinuous time schedules, we must visit and revisit the bands on which we wish to receive.

b. We must expect daylight to affect the band. In a general way, we have a good chance for favorable conditions after darkness above 40 m. (7500 kc.); below 40 m. we must look for daylight conditions as best for reception.

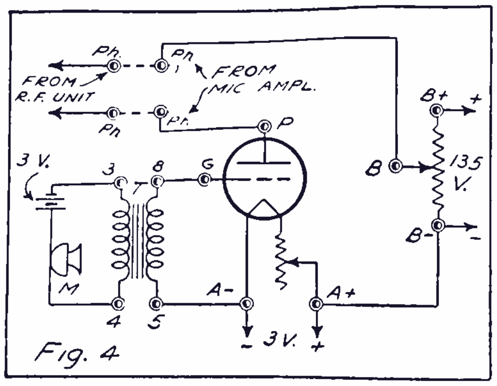
c. Fading of the signal (due to atmospheric conditions) is often encountered. Do not try to make any adjustments while the signal is weak, since the signal will swing back to its original loudness at intervals without any adjustment.

Do not read the foregoing to mean that the difficulties in the way of the listener are extremely great. Common sense, care, and patience will overcome every one of them, and any odds against the listener make the hunt all the more exciting.

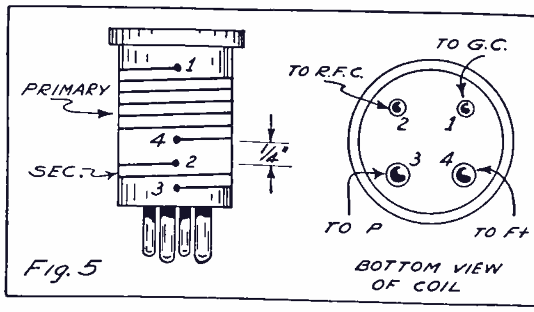
Exp. 1B—Short-Wave Receiver

Object: To determine the best operating conditions for short-wave reception.

Method: Starting with the unit as a broadcast receiver, throw the wave switch to the Lo position. (This removes the short circuit from the fixed series condenser (SC) and puts it in series with the main tuning condenser (TC), which has the effect of reducing the resulting capacity and tuning to a lower wavelength (or higher frequency). See Curve B. The police band (120 meters, or 2500 kc.) will be encountered around 30 on the dial; near the center of the dial, the presence of many squeals will signalize the amateur phone band. Tune one of these stations in by reducing regeneration, as explained before, and explore the amateur phone band around 160 m. (1875 kc.), Here, in particular, good use can be made of the instructions for short-wave oper-



Schematic circuit of the microphone amplifier.



ALL COILS WOUND WITH No. 26 D.S.C. WIRE

COIL FORM 1¼" DIA. AND 2" LONG

COIL No.	PRI.	SEC.	COIL No.	PRI.	SEC.
COIL D	52 t.	16 t.	COIL B	11 t.	6 t.
COIL C	23 t.	8 t.	COIL A	5 t.	4 t.

Coil data for the calibration curves of Fig. 6.

ation given before. Select a fairly good amateur station for trying out the best adjustments.

(a) Investigate the effect of the setting of the antenna condenser (A.C.). It will be found that using too high a capacity here will prevent regeneration. Set this adjustment for the smoothest regeneration. The smallest capacity used for this adjustment will also be found to improve selectivity.

(b) Investigate the effect of the setting of the plate condenser (P.C.). It will be found that too small a capacity here (obtained by turning the screw out) will require that a higher screen voltage be applied by the regeneration control (P). Also set this adjustment for smoothest regeneration. Do not try to be too critical with these settings, since the two main controls have ample leeway for bringing the stations in.

Observations—(a) Make your own calibration curve by comparing your dial readings with those given in curves A and B.

Note: The plan of using a fixed condenser (S.C.) in series with the main tuning condenser gives a band spread effect, that is for a given movement of the tuning condenser dial, there is a smaller frequency change, and so there will be fewer stations to be covered by that given movement of the dial. This means less crowding of stations. This advantage is obtained by the use of the wave switch in addition to the obvious one of extending the frequencies covered by a single coil, as compared to the condition where only a low capacity tuning condenser is used. A recommended set of coils is given in the list of parts. For those who wish to wind their own, the wiring data are given in Fig. 5.

(b) Repeat explorations with the coil having the next lower number of turns (Coil C). In addition to hearing aviation reports and the 80 m. amateur phone band, concentrate on this coil to answer the challenge of *distant short-wave stations*. Become familiar with powerful stations around 25 on the dial like W3XAL, New Jersey, W8XK, Pittsburgh, and W9XF, Chicago—all around 50 m. (6000 kc.)—and then be ready for *foreign reception* like GSA in London around the same settings. Results will be more effective when working with one stage of audio amplification, as given in the next experiment.

Exp. 1C—Adding An Audio Amplifier

Object: To amplify the output of the receiver by adding one stage of audio amplification.

Method: The method of using the A. F. Unit (described in the December issue, to act as one stage of audio amplification for the receiver is given in Fig. 2.

Observation: The simple connection of the two wires shown causes the output of the receiver to actuate the grid of the amplifier, and we get amplified reception in the phones of the amplifier. This allows us to hear more clearly and thus identify many distant stations that may escape recognition when the receiver only is used. Thus, although the sensitivity to the signal has not been changed, the effective result is to make the set capable of getting better reception on all stations, and will add to the list of stations received.

Second Experiment—Generating Radio Waves

The simplest way of understanding the production of radio waves is to go back to the regenerative receiver and recall the effect of too much regeneration. The signal becomes distorted and the set squeals. What has happened is that the tube has broken into oscillation. When the tube oscillates, the attached coil-condenser circuit produces radio waves. The explanation for this is that when enough energy is fed from the plate circuit, through regeneration, back to the grid circuit, the tube is able to sustain the production of waves—in this case at radio frequency. This oscillation—ordinarily beyond our range of hearing—is made audible in the present case by mixing with the incoming signal wave to produce a heterodyne or beat note which we recognize as a "whistle" or "squeal." When the regeneration control is turned back to give less feed-back, the tube cannot keep up its oscillations and reverts again to its action as a regenerative detector.

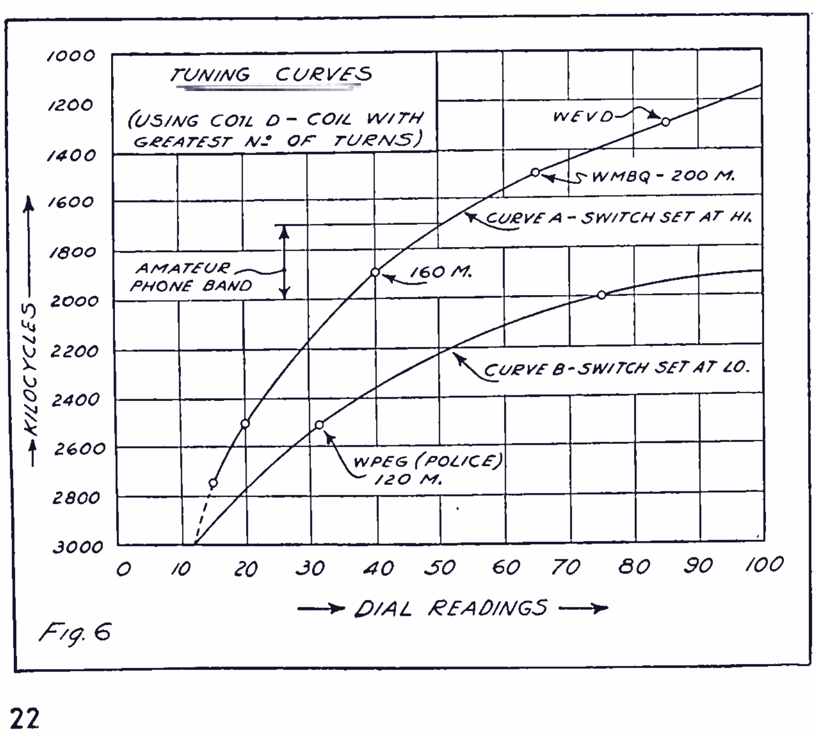
We will make use of this simple idea to generate radio waves for the experiment *by no other change* than increasing the amount of regeneration by its control. But here it becomes very important to heed the following *WARNING: The radio waves produced by the oscillator must not be allowed to interfere with other receivers which can pick up this wave.* Therefore, we will take the following precautions to avoid the appearance of transmitting without a license:

1. Choose a portion of the dial on which no station can be heard (while the tube is acting as a detector), since this will be the wavelength produced when the tube is allowed to oscillate.

2. Disconnect the regular aerial when using the oscillator.

With these precautions, the experiment will cause less trouble to other receivers than the interference ordinarily caused by a regenerative set in the process of listening-in. This

(*Continued on page* 40)



Calibration curves for two of the coils used in the experiments. Note that these curves are only approximate for your apparatus, but serve as a good guide. Your curves would coincide with these only if the apparatus and wiring of your receiver are exactly the same as those used by the author. For convenience, the location of the amateur and police bands are labeled.

Short Wave Short Cuts

PRIZE WINNER

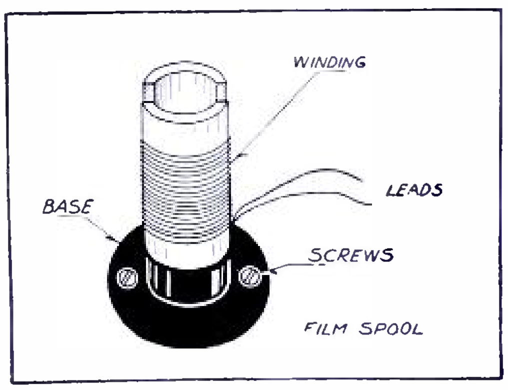
Film Spool as Choke Holder

By Horace E. Eddy

THE ordinary spool used to carry the roll film of an ordinary camera may be used as a form on which r.f. chokes may be wound. A distinct advantage of such a spool is that it is easier to mount than the usual half-inch dowel.

One of the metal flanges on the end of the spool should be removed. Two holes should be drilled through the other flange in order to mount the coil in an upright position. The spool should be treated with varnish to prevent the accumulation of moisture, resulting in increased efficiency.

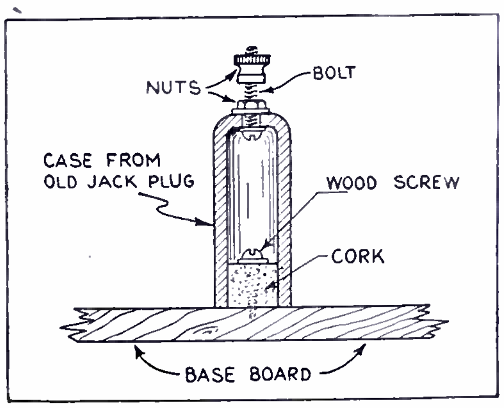
The coil may then be wound over the spool in several layers; each layer should be insulated from the adjacent ones by means of collodion. The ends of the winding may be secured by threading them through the slot which runs axially through the spool. This construction is illustrated in diagram herewith.



Insulators From Phone Plugs

By William Riemann, Jr.

VERY good stand-off insulators may be made from the bakelite cases of old or discarded jack plugs. The first step in constructing such an insulator is to drill a hole through a piece of cork, the diameter of which is equal to or just slightly greater than the inside diameter of the phone-plug case. Next, mount a bolt and nut through the hole in the bakelite case through which the phone cord ordinarily protrudes; a binding post cap on this bolt serves to act as a connector for anything which the insulator supports. Finally, slip the bakelite case over the cork.



It might seem that the insulator will not be rigid; but if the cork is about three-quarters of an inch high, the insulator will be surprisingly strong.

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The BC Set on 160 Meters

By T. F. Dixon

MANY short-wave fans want to listen to the amateurs on 160 meters and to police calls between 160 and 200 meters with their present broadcast receivers. Usually, a broadcast receiver, if it is not too old a model, will tune to a band close to the low frequency end of the amateur band. All that is necessary, therefore, is to remove a few turns from certain coils in the receiver, and police and amateur phones may be heard.

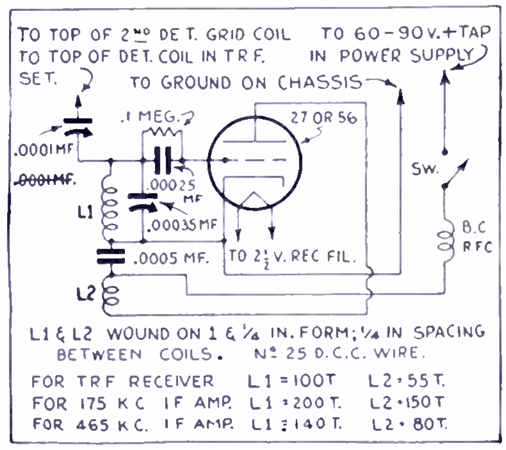
If the receiver is a super, five turns are removed from the secondaries of the band-pass coils, the r.f. coils, and of the first-detector coil. Three and one-half turns are removed from the grid coil of the oscillator. All of these turns are removed from that end of the secondary farthest from the primary. The r.f. stages are then rebalanced, the oscillator checked for tracking, and the set is ready for use.

In the case of a t.r.f. receiver, five turns are taken from the secondaries of all the r.f. coils and from the detector coil. Here, too, the turns are taken from that end of the secondary farthest from the primary.

Of course, these changes will alter the dial readings for the usual stations; furthermore, those broadcast stations at the extreme low frequency end, about 550 kilocycles, will not be heard, due to the reduced size of the coils.

In case the operator desires to receive c.w. signals, a beat oscillator may be constructed according to the diagram herewith. This oscillator is designed to beat against the signal in the detector of a t.r.f. receiver or in the second detector of superheterodynes. The tuning condenser may be used for adjusting the beat frequency.

This oscillator should be carefully shielded and placed as close as possible to the receiver. Either a type 27 or a type 56 tube will operate satisfactorily.



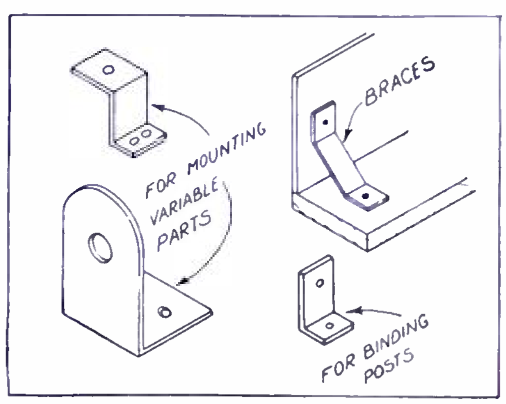
"Molding" Hard Rubber

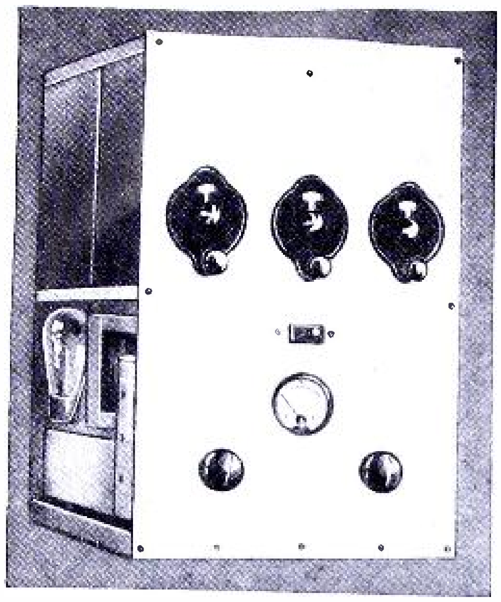
By Ernest Harper

HARD rubber may be bent with the fingers into any desired shape by simply heating it in boiling water. For best results, the piece of rubber to be bent should be placed in some sort of a cooking utensil, completely covered with water, and allowed to boil just long enough for the rubber to soften. Then, with a sharp knife heated to the same temperature as the rubber, cut the rubber to the desired length and bend it into any shape you want.

After the rubber has been shaped, plunge it into cold water. You will find that it will retain this shape and return to its usual hardness.

The illustrations herewith show several brackets that were made by the writer using the method outlined above.





Replacing Obsolete 5-Meter Modulated Oscillators

SUMMARY: *The third and final of a series of articles by Kruse on replacing obsolete 5-meter modulated oscillators. The first of the series treated the general ills that accompany the usual 5-meter phone circuit, such as frequency drift, instability, and modulation difficulties; the second of the series stressed the importance of proper tube selection and what can be done with various combinations; and this, the final article, describes the construction of an actual transmitter, pictured to the left. A schematic circuit with all constants enables anyone to construct this excellent transmitter.*

By Robert S. Kruse, E. E.*

IN the past two installments we have talked about assorted experiments, showing that there is nothing to prevent one from working an oscillator - amplifier transmitter of the usual sort at 5 or 10 meters. Some tube combinations have been suggested, and the honest-to-goodness experimenter will need nothing more.

However we have no objection to showing a specific example of a set of this type, in fact the front view of the rig was shown on page 24 of the January issue, and we hope that the Editor will here show it again so that we can describe the affair.

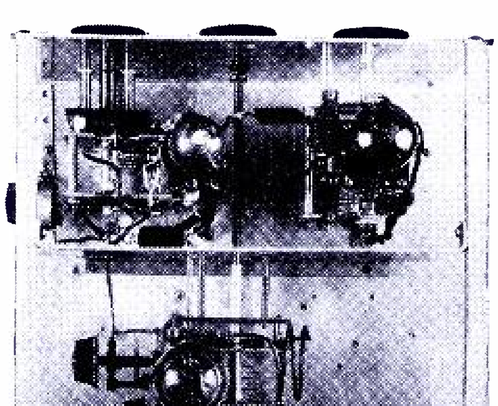
Looking at the panel you see, upstairs, three of the familiar National dials. The one at the left tunes the oscillator, the next one drives an insulating shaft which extends through into the rear compartment to tune the output stage (which is the modulated tube, of course), while the right-hand dial tunes the buffer tank.

The switch amidships is a send-receive switch. Because of the low power level, an ordinary cam switch can be used. Many connections are possible, but about the best one is that which cuts the primary of the plate-supply transformers of transmitter and receiver respectively. If the same antenna is used for sending and receiving, it is also run through the switch—there are plenty of contacts. The filaments in both sender and receiver burn whenever the switch is on either side, but not when it is amidships. The changeover goes through this neutral position but is too quick to cool the filaments off.

The two knobs below belong to the receiver, which is not super-regenerative because we don't seem to care much for the noises of such receivers. The construction is shown clearly by the photographs, and it remains only to show circuits and to comment on amplifier and buffer construction, the proper construction of the oscillator having been covered in the January issue.

Circuits

In Fig. 7 we have the now familiar balanced Colpitts oscillator driving a tetrode buffer which, in turn, drives a triode final amplifier that is not neutralized. The constants are given under the diagram. The reason for omitting neutralization is that we intend to modulate by the grid-bias method; therefore, the grid of the final amplifier will be so loosely coupled to the preceeding tube circuit as to be virtually untuned. Its tendency to oscillate is then negligible. The best combination of tubes now available is a 112A oscillator, running at 180 volts with a grid-leak of about 15,000 ohms, driving an 865 buffer with a plate voltage (B+) of 500 and a screen voltage (+D) of 125 with a grid leak, R4, of about 15,000 ohms. Since this tube is directly heated, the cathode resistor R5 with its bypass disappear, and are replaced by a center tap resistor of 50 to 100 ohms, which is connected across the filament and has its midpoint grounded as in the case of any ordinary transmitter. Use bypasses around it if you feel like it. The resistor R3 limits the feed to the buffer grid and is not ordinarily necessary in this tube combination. Our final amplifier, which we intend to modulate, will in this case be a 210 running with a plate voltage of 700 and a bias of −135.



Top view of the transmitter pictured above. See text for a description of the apparatus pictured.

In this particular rig the oscillator is first started up with the buffer feed lead clipped on at random. Adjust oscillator to proper frequency by wavemeter; then resonate circuit C5L3 with the feed clip of the final tube set about ¼ of the way up on L3. A neon lamp and a milliammeter (later plugged into J1) facilitate resonance. The buffer should be fed considerably less r.f. than is necessary to produce normal output. If it draws 15 milliamperes, that's enough. Don't be afraid to move the clip down on L2.

Having rechecked and readjusted the frequency of oscillator and buffer, we move on to the amplifier, which will almost surely be drawing much more than its proper plate current of 15 milliamperes. Set C7 for resonance with the assistance of the meter plugged into J3, the neon lamp held as far down L4 as possible and perhaps also a thermo galvanometer with a 2″ turn of wire connected across it and coupled loosely to L4. This is an excellent way to blow thermo galvanometers.

Next, move the clip on L3 downward or else increase R6 until the final tube draws exactly 15 milliamperes. You are now already to modulate, and a 1 milliampere meter, or better, a microammeter, plugged into J2, is necessary, as explained in the January issue. Any movement of this meter shows overmodulation. The 135-volt bias is connected to the "C" terminals in series with the secondary of an ordinary audio transformer whose primary is in the plate circuit of a 56 audio amplifier, this tube in turn being driven by a microphone and a 58.

Let us now consider what other combinations may be used, and see if we can arrive at some definite conclusions regarding the best, practical amplifier to use.

* Consulting Engineer.

Other Combinations

The obvious objection to the foregoing is that it requires 700 volts to produce a six-watt carrier, and if one is going in for power, it seems more sensible to discard the 210 and use an 825 running with 110 volts of bias at 700 volts plate, or better, with 150 volts bias at 1000 volts plate. The new type 800 tube might also be considered, and in any case the r.f. input is adjusted to produce 10% of the plate current which would exist if zero bias were used at the same voltage. If you love the tube, don't get that information by test, but by extension of the manufacturer's curves.

Weird as it may sound, this same oscillator and buffer could drive a 204A with a plate voltage of 4000 and a bias of 240 volts, though this would admittedly be a full day's work and might necessitate raising the buffer plate voltage a little, though it has been done with the adjustments named. Modulation for that combination can be obtained from the same two small tubes mentioned before.

The price of the 865 being an objection, one can use the 57 or 58-tube to drive a 59 as final amplifier, connecting the 59 as a triode. This combination has one very pleasant advantage in that the buffer can now be controlled as to gain, just as if it were in a broadcast receiver, which is to say, by means of a variable cathode resistor. To do this, the lower end of R4 is disconnected from the chassis and the circuit is again completed through a 5000 ohm volume control, of which the slider is grounded to chassis and the free end joined to R4. The junction of the volume control and R4 is connected to a 10,000 ohm resistor whose other end goes to some convenient source at a potential of +90 or +100 volts. The adjustments are as before, but in this case the voltages can be 180 for the oscillator, 250 and 100 for the buffer and 400 for the 59, whose bias is minus 125 volts. The r.f. input is adjusted for 20 milliamperes plate current, using the cathode control of the buffer, the position of the clipper on L3 and just possibly the addition of the resistor R6.

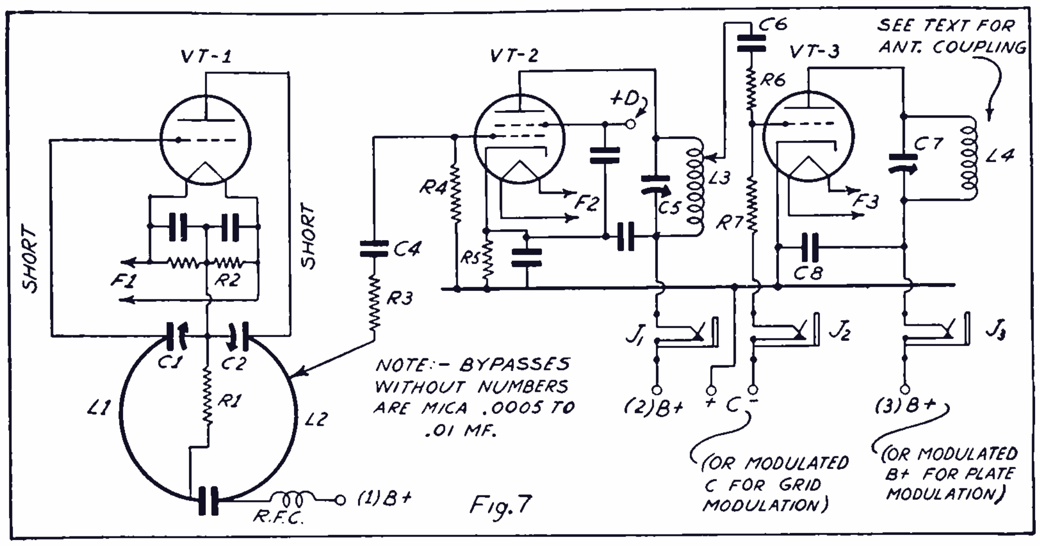
Adjustment Hints

Since it has been said several times that the final amplifier is to be grid modulated and is not to draw grid current, one may wonder at R7. Its purpose is simply to provide a path for such electrons as accumulate on the grid accidentally, especially during unintentional overswings. Somewhat regardless of the tube type, it may have a value between 100,000 and 500,000 ohms. It has the healthy effect that one can't do much overmodulating without getting the plate meter of this stage all out of gee and giving the error away.

If a tetrode buffer is used it can easily be overswung, especially if it is a 57 or the like, for that reason the variable mu 58 was suggested and a prayer added for the missing tube between it and the 865. It certainly is needed but until it arrives we will get on very nicely at 5 and 10 meters with such rigs as here described.

(For a more comprehensive treatment of tube selection, refer to the January 1933 issue of SHORT WAVE RADIO, in which Kruse treats the subject in greater detail.—*Tech. Dir.*)

This article concludes a series of three contributions by Robert S. Kruse, formerly Technical Editor of QST, and one of the world's leading authorities on high-frequency radio communication. The previous installments appeared in the December, 1933 and January, 1934 issues. Every transmitting amateur interested in keeping abreast with technical developments in the high-frequency field will find these articles of great interest and value.



Schematic circuit and list of parts for the 5-meter transmitter.

Type diagram for which variations are given in the text.
R1—grid leak, 5000 to 20,000 ohms depending on tube.
R2—50- to 100-ohm center tap resistor.
R3 and R6—limiting resistors, see text.
R5—cathode resistor proper for tube use, see text.
C1 and C2 two-gang tuning condenser, each section .00035 or more.
C3—mica .001.
C4—mica .0001 to .001.
C5—.000015, maximum may be larger.
C6—see C4.
C7—see C5.
C8—mica .0005 to .01.
L4 and L3 each 1½" diameter 3 turns spaced ¼" center to center using No. 12 wire or quite small, soft copper tubing.
R4, R7—see text.

ELECTRON TUBES AND THEIR OPERATION by John H. Morecroft, Sc. D., published by John Wiley & Sons, New York, N. Y., 6 by 9 inches, 460 pages, cloth cover, profusely illustrated. Price, $4.50.

The theoretical aspects of vacuum-tube operation have been published in detail in many new books and in the literature. These treatments, in general, discuss the industrial use of the vacuum-tube only incidentally, relying upon the experience of the reader to adapt the tubes for special purposes.

This book by Morecroft represents a departure from this form of treatment. Although any book on vacuum-tubes must necessarily be preceded by some theoretical discussion, Morecroft has wisely minimized the amount of theory, since the express purpose of the text is to stress the industrial applications.

Chapters I to VII, inclusive, are semi-theoretical in nature. The fundamental theory of operation of all vacuum-tubes and of photoelectric cells is discussed, various constants entering into the choice of materials are given, and suitable curves indicating the characteristics of different substances used in photoelectric-cell work are discussed. These discussions, though, as stated previously, are practical in nature and serve to illustrate the application of vacuum-tube theory, rather than to explain their actions theoretically.

Chapter VIII is a very compact and precise treatment of the uses of electronic tubes. The use of the diode as a voltage regulator, the operating characteristics of mercury-arc rectifiers, an excellent resume of the use of the phototube in picture transmission and television, the treatment of phototubes itself, and several examples of the application of these devices in industry constitute this chapter in the main.

Chapter IX treats the triode as a power converter. Although much of the work reproduced in this chapter is treated in Morecroft's "Radio Communication," it is, nevertheless, of such fundamental importance that it is well worth reproducing again in this book. Some very excellent oscillograms depicting the action of the tube as a power converter and a series of actual curves really do justice to this subject.

Chapter X and XI treat the vacuum tube as an audio- and radio-frequency amplifier, respectively. There seems to be nothing radically new in this treatment, although some representative curves of audio transformers are very illuminating. Here again, much of the illustrations have been borrowed from his larger work.

L. M.

Some Notes on Super-regeneration

SUMMARY: *The principles of operation of the super-regenerative receiver has received much general discussion; but there are a number of fine points that have received little or no public notice. It is these points that the author discusses.*

Both the rate of increase to the point of oscillation and the rate of decrease from the point of oscillation have an important bearing on the successful operation of super-regenerative receivers; the rate of increase depends to some extent on the feedback, while the rate of decrease depends upon the damping of the tuned circuit. These factors are discussed in detail by the author.

By J. A. Worcester, Jr.

THE super-regenerative circuit has recently experienced a marked revival in public appeal due to its almost universal application to ultra short-wave receivers operating in the five-meter band. In spite of its popularity at this time, however, very little has been done to improve the circuit, and present designs do not vary materially from the circuit introduced by Armstrong more than a decade ago. The main reason for this situation can be traced to the almost total absence of fundamental information dealing with the operation of the circuit. This is a particularly regrettable state of affairs, especially since the super-regenerative circuit is one of the most interesting circuits we have from an analytical standpoint and one which is capable, in theory, at least, of tremendous amplification. It is the writer's opinion that a thorough analysis of the circuit, together with the *application* of the knowledge obtained by the analysis to existing circuit designs, would result in a substantial increase in the amplification obtainable and would make possible a realization of the theoretical possibilities of the circuit.

As the readers of this magazine are aware, super-regenerative action consists of periodically rendering inoperative a normally oscillating detector circuit by means of a locally generated quenching frequency. This enables the degree of regeneration to be carried much further than is possible with an ordinary regenerative circuit, with a consequent increase in sensitivity.

The mechanics of operation of the super-regenerative circuit can be better understood by considering the simple oscillating detector shown in Fig. 1. If this oscillating circuit is turned on by means of switch S1, oscillations will build up logarithmically as shown in Fig. 2 until a maximum value is reached after a period TA, and sustained oscillations will be produced, as shown. If the oscillator is turned off after a period TB, the oscillations will die out logarithmically, as shown.

Fundamental Theory

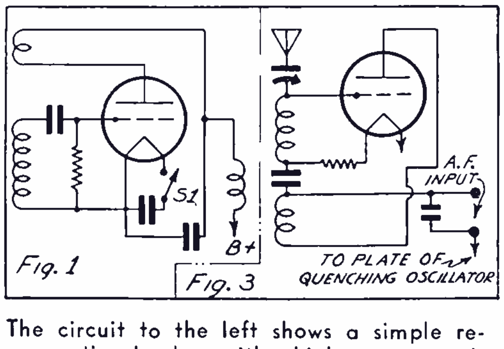
The initial amplitude of the oscillations, E1, represents the intensity of the disturbance present on the grid when the oscillation is just starting. If this disturbance has a greater amplitude, say, equal to E2, it is obvious from inspection of Fig. 2 that, during a given time interval T, measured from E2, the oscillation builds up to a proportionately higher value than if the oscillations started from E1. Hence, if the circuit is periodically rendered inoperative after a period T, measured from any point to the left of TA, a modulated signal will be faithfully amplified *as long as operation is confined to the transient period existing prior to the establishment of sustained oscillations.* From the standpoint of amplification, the period T should be as long as possible so that the maximum amplitude of the modulated signal, when added to the oscillations, just fails to produce *sustained* oscillations. However, it cannot be made too long, or else the quenching action will become audible and result in a steady high-pitched whistle. Hence, this period T is something of a fixed quantity, and generally is about .000025 second, if we are able to assume a quenching frequency of 20 kilocycles per second.

Since the time interval T is a fixed quantity, determined by the quenching frequency, we may control the amplification of the signal by varying the rate at which the signal builds up by varying the feedback, since this is the most flexible factor involving the rate of oscillation increase.

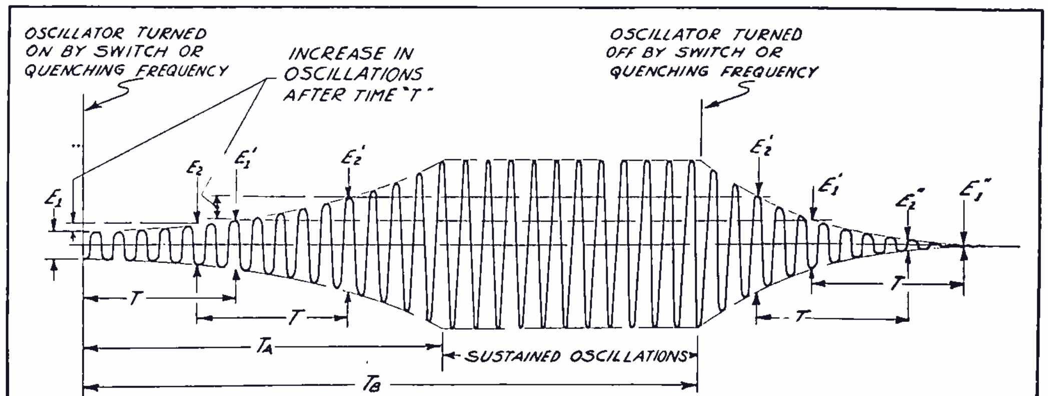
The Decay

Having gone thus far in our discussion of the super-regenerative circuit, we now arrive at the most important single consideration of all—the behavior of the circuit during the period that the oscillating detector is rendered inoperative by the quenching frequency. A corresponding situation occurs in our simple oscillating detector circuit shown in Fig. 1 when it is turned off after a time interval TB, as indicated in Fig. 2.

The rate at which the signal decreases depends on the values of inductance and resistance of the tuned circuit. These two factors have opposing effects, however, as an increase of the resistance causes an *increase in the rate of signal decrease,* while an increase of the inductance causes a decrease in the rate at which the signal decreases.



The circuit to the left shows a simple regenerative hookup with which most experimenters are familiar and which forms the basis of the theory underlying super-regeneration.
A typical antenna circuit is shown to the right, Fig. 3. In this circuit energy remaining in the antenna may be re-impressed on the grid, causing distortion.



DEPICTING THE RISE AND DECAY OF OSCILLATIONS IN A SUPER-REGENERATIVE RECEIVER

Reverting to the super-regenerative circuit, if the oscillation $E1$ builds up to a value of E'_1 during the operative period, it can be seen from inspection of Fig. 2 that this signal will die down to a value E''_1 during the inoperative period. Likewise, an oscillation of intensity E_2 increases to a value E'_2, and decreases to a value E''_2 during a complete cycle of the quenching frequency.

It becomes fairly obvious that it is necessary for the oscillation to decrease to a value substantially smaller than the initial value E, *if the next cycle of oscillation is to build up from the intensity of the signal applied to the grid by the antenna rather than from the amplitude of the signal left over from the previous cycle.* In other words, supposing E_2 and E_1 represent the maximum and minimum values of a modulated signal. For faithful amplification of this wave, it is essential that the damping be sufficient to make E''_2 smaller than E_1. If the damping is insufficient for this purpose, the signal present on the grid will increase with each successive cycle of the quenching frequency until oscillations of a semi-sustained nature are produced. In order to make the circuit suitable for faithful amplification of the desired signal, the operator would have to decrease the feedback to a point where the signal just builds up enough so that the damping is sufficient to enable it to die out to a value smaller than the minimum value of the modulated wave being received.

Hence, it can be seen that if the theoretical amplification of the super-regenerative circuit is to be realized, it is essential that the rate of decrease, or damping, of the signal during the inoperative period be sufficiently high.

It will be recalled that the damping is directly proportional to the resistance and inversely proportional to the inductance of the tuned circuit. For the relatively high values of inductance required for broadcast reception, the damping of the tuned circuit is far too low for satisfactory super-regenerative action. As a matter of fact, the addition of a series resistance of about 250 ohms in the tuned circuit would be necessary for sufficient damping. This, of course, would be impractical because the tickler would have to assume such proportions for oscillation production that the plate load would become capacitative and oscillation would be impossible.

Short-Wave Coils

In the case of the small inductances required for ultra short-wave reception, however, a series resistance of less than one ohm would produce sufficient damping for satisfactory super-regenerative action. As the circuit losses are normally several times this value, no difficulty should be experienced from the tuned circuit itself if fairly small wire is used.

There is the possibility, however, that the damping in some adjacent coupled circuits may be insufficient to damp out the induced currents during the inactive period. When the quenching frequency swings to the opposite extreme, and again makes the tube favorable for oscillation production, such a circuit will induce a signal on the grid and the result will be similar to insufficient damping in the oscillatory circuit itself, as discussed previously.

One of the most probable sources of difficulty from this source is the antenna itself, which generally presents a very low resistance to the currents generated by the oscillating detector. As the antenna is generally connected directly to the grid of the detector through an antenna condenser, as in Fig. 3, any oscillations remaining in the antenna from the preceding cycle will be re-impressed on the grid, and it follows, naturally, that faithful amplification of the original signal will not result.

A Solution

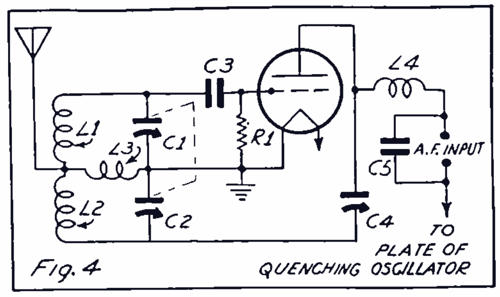
A theoretical solution to this problem is indicated in Fig. 4, where the bridge arrangement is employed. The antenna and ground are connected across two points of zero potential, and, hence, oscillating currents flowing in the detector circuit are not induced into the antenna. However, due to the connection employed, only one-half of the voltage on the antenna is impressed across the grid. This circuit is purely theoretical and would probably require considerable research work before it could be made practicable.

Another arrangement which is employed by the Bell Telephone Laboratories in their ultra short-wave receivers is shown in Fig. 5. The antenna, which is one-half a wave-length long, is connected directly to the midpoint of the plate coil. This circuit is also unusual in that a screen-grid tube is employed as the oscillating detector. The quenching frequency is applied through the screen-grid circuit.

In order to minimize the possibility of other low resistance, ultra high-frequency paths, it is advisable to use resistance wire wherever possible for wiring and to avoid closed loops when laying out and wiring the apparatus.

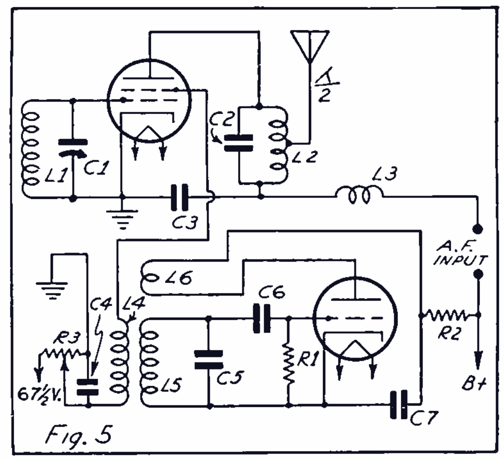
In conclusion, it might be advisable to consider briefly another form of short-wave detection introduced by the writer as the *Oscillodyne* and often referred to as a "squegging" detector when applied to ultra short-wave reception. The operation of this type of oscillating detector, as shown in Fig. 6, depends on grid blocking. In other words, the detector produces irregular oscillations, the production of which can be briefly explained as follows: the feedback is increased to a point where the negative charge accumulating on the grid cannot leak off fast enough for the

(*Continued on page* 43)



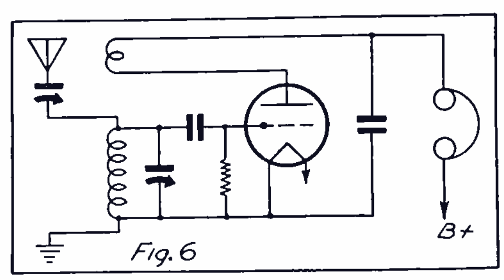
A simple circuit—entirely theoretical—which illustrates a method which may be employed to balance out any oscillations remaining in the antenna at the end of the oscillation decay. Note that this circuit is a Wheatstone bridge and that a balance is obtained when the oscillation voltage across L3 is zero. Suitable construction data are given below.

L1, L2—4 turns No. 20 d.s.c., spaced on 1/2" dia. form.
L3, L4—20 turns No. 30 d.s.c., spaced on 1/2" dia. form.
C1, C2—dual variable, 50 mmf. per section.
C3—.0001 mf.
C4—50 mmf.
C5—.002 mf.
R1—1 meg.



A super-regenerative circuit developed by the Bell Telephone Laboratories which effectively eliminates the oscillations in the antenna circuit. Complete construction data are given below.

L1—6 turns No. 20 d.s.c., spaced on 1/2" dia. form.
L2—6 turns No. 20 d.s.c., center tapped, spaced on 1/2" dia. form.
L3—20 turns No. 30 d.s.c. spaced on 1/2" dia. form.
L4—1000 turns No. 35 d.s.c., slot wound, 3/8" inside dia., 1/4" wide, windings separated 1/8".
L5—1200 turns No. 35 d.s.c., slot wound.
L6—750 turns No. 35 d.s.c., slot wound.
C1—variable 50 mmf. condenser.
C2—50 mmf. condenser.
C3—.001 mf. condenser.
C4—1 mf. condenser.
C5—.0025 mf. condenser.
C6—.001 mf. condenser.
C7—.1 mf. condenser.
R1—100,000-ohm. resistor.
R2—20,000-ohm resistor.
R3—50,000-ohm potentiometer.



Fundamental circuit of the "Oscillodyne," developed by the author.

Using Pentagrid Converter Tubes in Multi-range Receivers

THE pentagrid converter tubes 2A7, 6A7, and 1A6, frequently used as combination mixer (first detector) and oscillator in broadcast receivers, have application in short-wave or multi-range receivers.

This application note is devoted to a discussion of the conditions under which the pentagrid converter may be used in multi-range receivers, of the proper circuit conditions for best operation, and of the specifications and constants for the inductances and capacitances suitable for various frequency bands.

The 2A7, 6A7, and 1A6 are suitable for operation in any frequency band in which they can be made to oscillate. All of the advantages which these tubes have for applications at broadcast frequencies are retained at the higher frequencies. The fundamental circuits for the higher frequencies are found to be almost identical with those used for the broadcast band. Also, operating voltages are the same as those recommended for broadcast frequencies.

In a multi-range receiver, it is generally desirable to use the same tuning condenser for each frequency band, a convenient capacity range being approximately 40 to 350 mmf.

In a multi-range receiver typical frequency bands are:

550 to 1,500 kilocycles—4 to 10 megacycles
1.5 to 4 megacycles—10 to 25 megacycles

A low frequency band of 150 to 400 kilocycles is sometimes included.

An intermediate frequency of approximately 450 kilocycles is suitable for use with all of these bands. The 2A7 and 6A7 will operate satisfactorily in all the bands to provide gain comparable with that obtained at broadcast frequencies. The 1A6 may be used in all except the 10 to 25 megacycle band. Although the 1A6 can be made to oscillate at frequencies higher than 25 mc., it is difficult to cover the 10 to 25 mc. band. To cover this and higher frequency bands, the 1A6 can be used in combination with a triode in a circuit to be described.

The table below gives for the frequency ranges considered the approximate values of inductances for r.f. and oscillator coils and of series condensers. The constants assumed are:

R.F. tuning condenser, 40 to 350 mmf.

Intermediate frequency, 450 kc.

The minimum capacity assumed will be somewhat higher for the high-frequency ranges, due to the close coupling between circuits necessary at high frequencies.

The design of the high-frequency oscillator coils requires care. The principle requirements are:

1. Low resistance in the grid coil.
2. High mutual inductance between grid and plate coils.
3. Low capacitance between grid and plate coils.
4. Low self-inductance in plate coil.

Since these requirements are to some extent contradictory, compromises are indicated. Other considerations such as restrictions on overall dimensions and wire size should be taken into account.

The details of coil design are illustrated in Fig. 1. Grid and plate coils are made short in comparison with their diameters to facilitate proper coupling. The plate coil is wound at the end of the grid coil rather than inside of it in order to keep their inter-capacitance at a low value. The inductance of the plate

(*Continued on page* 39)

Frequency Band Megacycles	.15 to .40	.55 to 1.5	1.5 to 4.0	4 to 10	10 to 25	
R.F. coil inductance (L_1)	3248	241.6	32.5	4.43	.709	microhenries
Oscillator grid coil inductance (L_2)	699	131.2	25.0	3.60	.648	microhenries
Tracking condenser (C_1)	120	385	1000	*	*	mmf.
Additional minimum capacity required in oscillator circuit	22	9.5	4.3	11.3	4.2	mmf.
Ratio of oscillator grid coil inductance to r.f. inductance	.21	.54	.77	.81	.92	mmf.

* Not required for the 4 to 10 and 10 to 25 megacycle bands.

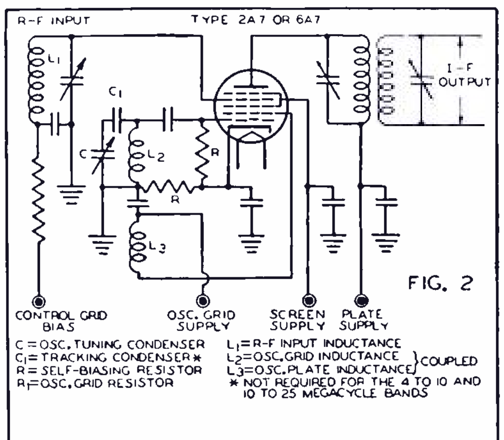


FIG. 2

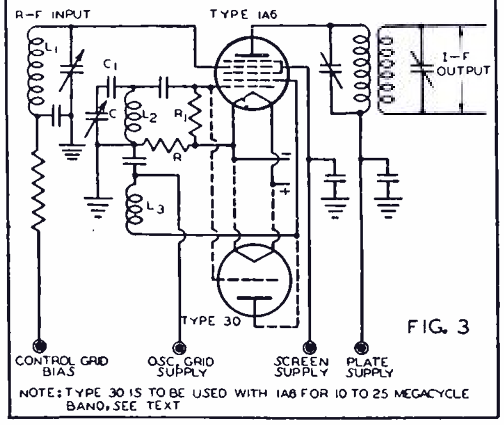


FIG. 3

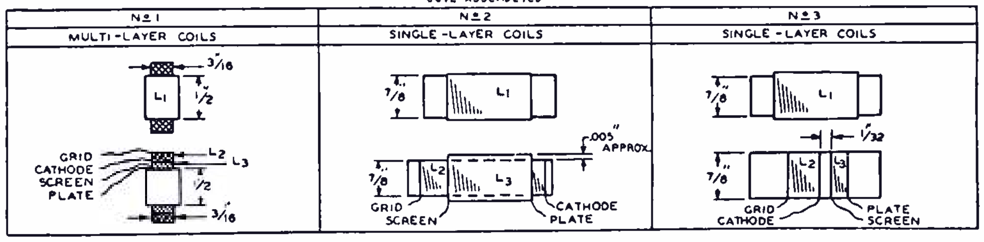
COIL DATA

FREQUENCY BAND Megacycles		0.15 to 0.40	0.55 to 1.5		1.5 to 4.0	4.0 to 10	10 to 25
ASSEMBLY NO.		1	1	2	2	3	3
R-F COIL L_1	Turns	442	121	147	36 8	10 4	4.2
	Wire	#36 sse	#30 sse	#32 enam	#30 enam	#30 enam	#20 enam
OSC. GRID COIL L_2	Turns	194	83	91	33.4	9.1	4.0 *
	Wire	#36 sse	#30 sse	#32 enam	#30 enam	#30 enam	#20 enam
OSC. PLATE COIL L_3	Turns	90	45	30	12	12	6
	Wire	#36 sse	#30 sse	#32 enam	#30 enam	#36 enam	#36 enam

* This coil is not suitable for use with the 1A6 unless a type 30 tube is used in parallel

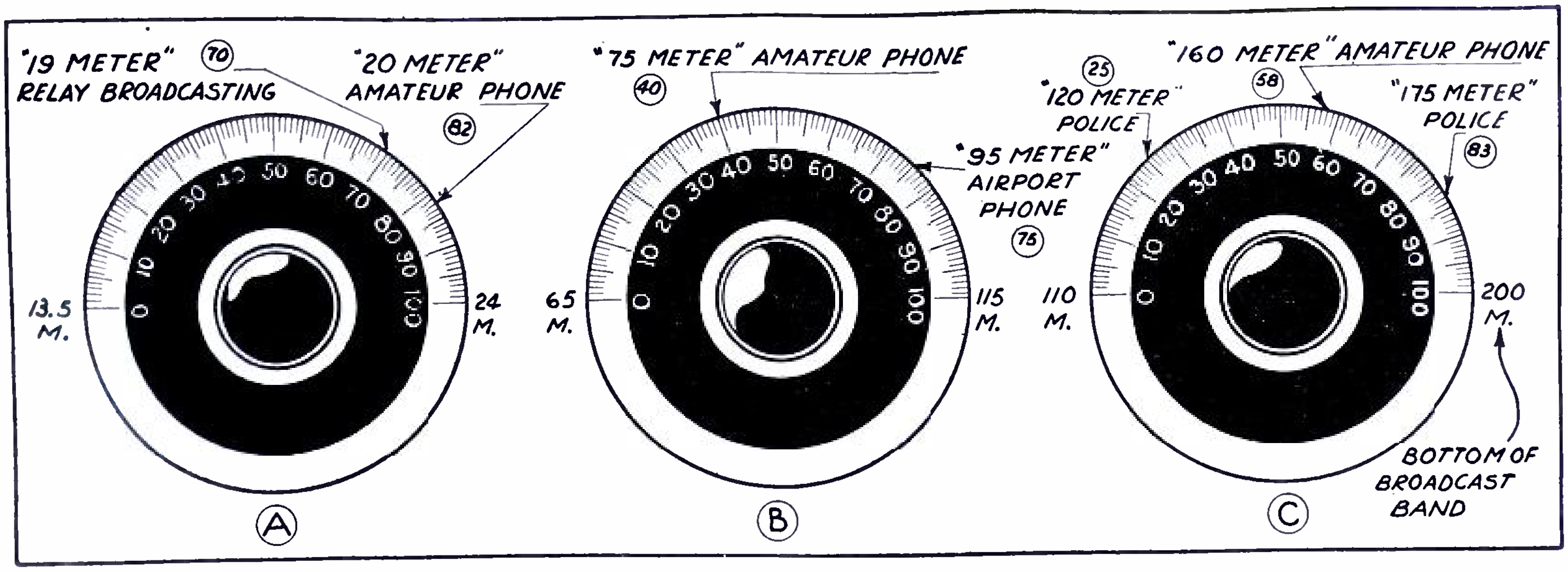
FIG. 1

COIL ASSEMBLIES



COIL AND CIRCUIT DATA FOR USE WITH THE 6A7 AND 1A6 TUBES

Figure 1, above, gives construction data for the grid and plate coils for use with pentagrid converter tubes. Grid and plate coils are made short in comparison with their diameters in order to obtain the proper coupling. The schematic circuit of Fig. 2, upper left, shows the connections necessary for the 2A7—or 6A7—and the circuit of Fig. 3 that for the 1A6—a 2-volt pentagrid converter. Note the use of an extra tube for the 1A6 at high frequencies in order to obtain sufficient oscillator voltage. This extra tube is not required in the 2A7 or 6A7 tubes unless the frequency is above about 25 megacycles.



DIAL CHARTS SHOWING THE LOCATION OF AMATEUR PHONES ON A TYPICAL RECEIVER

How to Find the "Ham" Phone Stations

NEWCOMERS in the short-wave receiving field too frequently concentrate their early listening efforts exclusively on the relay broadcasting channels, which are located roughly around 49, 31, 25 and 19 meters. If they are without previous experience in radio, they are likely to overlook completely the hundreds of many interesting amateur radiophone stations on other channels. These amateur stations are continually chatting back and forth, often over great distances, and the fact that they talk in understandable English makes their identification easy. The lingo of the operators may sound a bit queer at first, but eventually the listener will get the hang of it.

Amateur radio telephony is permitted on six different channels. Three of these, the three-quarter meter, five-meter and ten-meter bands, are inaccessible on most ordinary short-wave broadcast receivers, although recently special ten-meter coils have been made available for some of the more popular factory built sets. The three channels that can be tuned in quite readily are as follows: 14,150 to 14,250 kc. (21.05 to 21.2 meters); 3,900 to 4,000 kc. (75 to 76.9 meters); and 1,800 to 2,000 kc. (150 to 166.7 meters).

When to Use the Bands

Practically all transmission on the highest of these three frequencies is done during daylight. It is not at all uncommon to hear amateurs on the East and West coasts conversing with each other very freely in this band. As this channel is limited in extent, and is represented by only a few degrees of dial movement on most receivers, it is sometimes quite easy to pick up both sides of a conversation. This is quite thrilling under some circumstances.

The intermediate channel, 3,900 to 4,000 kc., is the most popular of the amateur phone bands and is busy both day and night. In fact, conditions approaching bedlam prevail here, as there are so many hundreds, if not thousands, of stations all jammed into this narrow 100 kilocycle-wide band. If a listener sets his receiver to approximately the middle of this band and leaves it there all night, he will hear dozens upon dozens of stations. They operate on such closely overlapping frequencies that heterodyne interference must be expected. This interference manifests itself in the receiver in the form of strong, high-pitched whistles. It is useless to attempt to tune out this sort of interference, as it is created by the transmitted waves themselves and is in no way affected by the receiver proper.

The 1800 to 2000 K.C. Band

The 1,800 to 2,000 kilocycle band is popular for local "rag-chewing." This particular amateur channel is located between two police channels and seems to be more or less overlooked by short-wave listeners in search of a thrill. One of the main troubles here is that in some parts of the country harmonic interference from local broadcasting stations is likely to be annoying.

Short-wave listeners accustomed to waiting hours for announcements from foreign broadcasting stations will greatly approve of the amateur habit of announcing call letters and the station location at the slightest provocation. Incidentally, all American amateur call letters consist of the letter "W" followed by a number from 1 to 9, to indicate the geographical district, and either two or three letters. To make their station announcements clear, many amateurs use names of cities or common objects to make the initials unmistakable. For instance, W2BJU may say, "This is W2 Boston Jersey Union." Reports of reception addressed to amateur stations invariably bring back "QSL" (acknowledgement) cards, many of which are worth framing.

When writing to amateurs, always state how he was received—whether he was loud or weak—the quality of the voice—the amount of fading if any. You might enclose a stamp, too.

Reducing Noise Level

ONE of the main reasons why many short-wave fans find the noise level of their receivers so objectionable is that they insist on keeping their loudspeakers close to the receivers and to themselves. Reception will be much more enjoyable if the speaker is removed a distance from the operating position. Background noise and "soup," which previously sounded very bad, will apparently drop to a much lower level. A separation of at least six or eight feet is desirable. A greater distance should be allowed if the available space permits.

This idea of separating the speaker from the set is by no means a new one, but many radio fans of the present generation do not seem to be familiar with it. For many years one of the industry's best known broadcast set manufacturers even refused to put the loudspeaker in the same cabinet with the tuner!

If the speaker is of the dynamic type, and its field winding is part of the filter system of the power pack, do not be afraid to extend the connecting wires six, eight, or even ten feet. The current flowing in the field circuit is comparatively light, and if ordinary flexible lamp cord is used, the voltage loss through a line of this length will be negligible.

Capt. Hall's Report on Foreign Stations

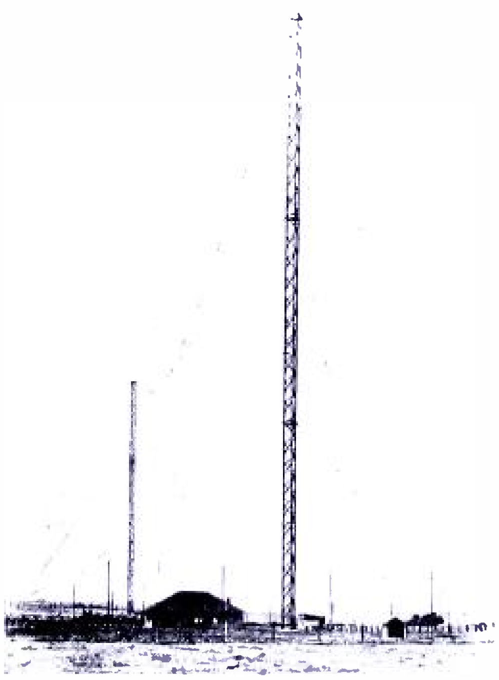
SUMMARY: *This is the Captain's fourth installment in which he explains what should be known about short-wave reception. In this issue he tells about G. M. T., calculating distances, and his personal reactions about code reception.*

The Captain has moved, and we reproduce photos of his new quarters. That on the right shows one section of his new radio room. In the far corner, on the left, may be seen two National SW5 sets. On the wall, above the stove, are some of his war mementos: his honorable discharge from the U. S. Navy with the rank of Lieutenant Commander, a picture of former officers of the U. S. S. Santa Rosa, and the Captain's Master's License.

Capt. H. L. Hall

NEARLY every day I get a letter from some short-wave fan who expresses a desire to know the meaning of the three letters G.M.T. These letters stand for Greenwich Meridian Time, which is the basis for time the world over. For the benefit of those who would like to know more about the history of this time center and its method of operation, I add the following notes.

Many years ago, upon international agreement, it was decided to select the town of Greenwich, near London, England, as the starting point for time, principally because in Greenwich was located one of the world's finest observatories. Incidentally, I might add that in order to tell the Londoners the time of day, scientists evolved the scheme of dropping a red ball at high noon.



Aerial system of the Amalgamated Wireless' short-wave station, VK3ME, Braybrook, Melbourne, Victoria.

Greenwich Meridian Time

Now for an explanation of the time in terms of G.M.T.

We will start from the meridian at Greenwich and travel west. For every fifteen degrees from Greenwich there is an hour difference in time. Greenwich is on the zero meridian, or double 0. For example, when it is high noon at Greenwich, going west, it is 11 a.m. in Iceland, which is on the fifteenth meridian; 10 a.m. in the Azores, which is on the thirtieth meridian; 9 a.m. in east Brazil, which is on the forty-fifth meridian; 8 a.m. in the Virgin Islands, which lie on the sixtieth meridian; and 7 a.m. in New York, which is on the seventy-fifth meridian time. So on to the 180th meridian.

When going east from Greenwich, the time in Central Europe, which lies on the fifteenth meridian, is 1 p.m.; South Africa, on the thirtieth meridian, the time is 2 p.m.; on the forty-fifth meridian, where Madagascar lies, it is 3 p.m.; in Persia, on the sixtieth meridian, the time is 4 p.m.; and on the seventy-fifth meridian, still going east, it is 5 p.m.; and so on until the 180th meridian was reached.

When crossing the 180th meridian, a day is either lost or gained, depending upon the direction in which you are travelling. If you were going from San Francisco to Australia you would gain one day when your ship crossed the 180th meridian. Homeward bound from Australia, you would lose a day when you recrossed the 180th meridian, which is also known as the International Date Line.

One of the purposes of transmitting time signals is that it is possible for seamen to know the correct Greenwich time so as to enable them to find their longitude at sea. The longitude of a place is the difference between the time at that place and the time at the identical instant at Greenwich. Local time can be found by observation, but Greenwich time is always carried by the ship's chronometer. Before time signals were broadcast, there always lurked the fear that the chronometer would be wrong, and so give the wrong Greenwich time, sometimes with disastrous results for the seamen. However, since time signals have been transmitted, the chronometer can be checked daily.

NAA, at Arlington, Va., is one American station which sends out time signals; it uses several wavelengths. When they operate either on 33.81 or 74.72 meters, the time signals start at 9.57 p.m., and the last signals at 10 p.m., Eastern Standard Time. NAA also transmits time signals from 11.57 a.m. to 12 o'clock noon, using the 18.68- and 24.89-meter wavelengths.

France radiates time signals over FLJ on 31.50 meters and over FL on 49.02 meters. These signals are broadcast from the Eiffel Tower, in Paris.

All short-wave fans hear time signals whenever they listen to Daventry, England. Even when a program is in progress, they can hear the signals. "Big Ben" is, as we all know, a time checker, and is accurate to within half a second, the time being indicated by the first-hour stroke of any hour or the first chime stroke of any quarter hour.

Distance Calculations

Many fans have asked me to compute the distance between their home city and Morocco, or Rome, or some other station they have heard on their short-wave receivers. They are not interested in the approximate mileage; they want it exactly. Almost all of these inquirers have maps of their own, but they are unable to find a suitable scale of distances to use with the maps. The whole idea can be worked out very simply.

Suppose, for example, you have heard HVJ. Take a map of the world and draw a straight line from New York City, or the town in which you live, to Vatican City. Get a pair of sharp-pointed dividers, which can be purchased for a few cents at any stationery store. Now, look at the left- or right-hand margin of your map, where there are numbers that start at zero, at the Equator, and increase to 10, 20, 30, 40, etc. These numbers are degrees of latitude. The space between each two numbers represents 600 miles. Next, open the dividers until its points span the 40 to 50 latitude lines between Vatican City and your location. It is best, now, to draw a line whose length is equal to the distance between the points and start laying out the 600-mile lengths along the line you have drawn. You will find the total distance to be 3,945 miles.

These are nautical, or sea, miles. A nautical mile is 6,080 feet, or slightly more than the land mile with which we are more familiar. To convert your measurements into statute miles, multiply the nautical miles by 1.1515, and you will have the distance in statute miles.

The new verification card from VK3ME, Melbourne, Australia, gives distances from this station to many parts of the world.

Thrills in S. W. Reception

There are more surprises in short-wave radio than in any other hobby I can think of. I know that this is so, through personal experience with one of the best known stations, HVJ. For over a year I have been setting my alarm clock to wake me in time

A typical New Zealand artist.

Captain Hall in his new "shack." Note some of his verifications and his new Postal International set.

to tune in the Vatican City station, which, according to my informants, was on the air only between the hours of 5 and 5.15 a.m. daily and from 5 to 5.30 a.m. on Sunday, working on 19.84 meters. Repeatedly, I tuned in on that wave at those hours, but to no avail. If HVJ had been active, I certainly would have heard them, but no such luck.

One morning, about 10 a.m., I happened to be "fishing" on the 19-meter band, and heard a man shouting, *"Pronto, pronto, Radio Vaticano,"* followed by more *"prontos."* He was addressing the Catholics of Central America. Here, it seemed, was HVJ, and on his rightful place, 19.84 meters. For three days in succession I heard him at the same time (10 to 10.30 a.m. E.S.T.); but, in general, it appears that his schedule is irregular, and depends on the messages which he is given to transmit to foreign missionaries.

I sent the Vatican my report of their program, and, very promptly, I received a verification in the form of a beautiful postcard of Vatican City, signed by the station engineer.

I advise listeners to try for this station; the card is well worth the trouble. With this verification, you can easily prove to your skeptical friends that you have heard HVJ.

The station also operates on 50.26 meters, but to date, I have never heard it at that point on my dial.

Code Stations

Personally, I am not vastly interested in phone or code stations. It has always been my impression that to listen to either was similar to peeking through a keyhole or listening to a party-line conversation on the telephone; but all scruples are cast aside when short-wave tuning gets the upper hand. And now, without a blush, I must confess listening to many and many a phone conversation. These circuits have, as the average short-wave fan knows, the advantage of being very powerful, and when in communication with the United States, they have their beam pointed in our direction, or towards the country they are calling. These "secret" conversations also have a little mystery attached to them, because of the fact that they are one-sided. The listener, to tune in both sides of the conversation, requires either two receivers, a change of coils, or some other arrangement. Needless to say, short-wave fans are often satisfied to hear one side and await the happy day when they will run into the other circuit.

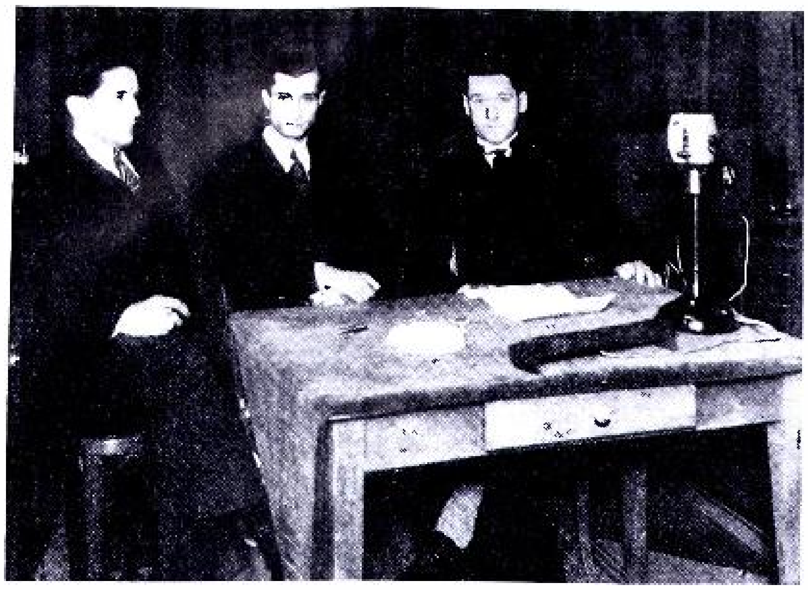
Not always are these phone circuits busy with commercial traffic.

WHO IS CAPT. HALL?

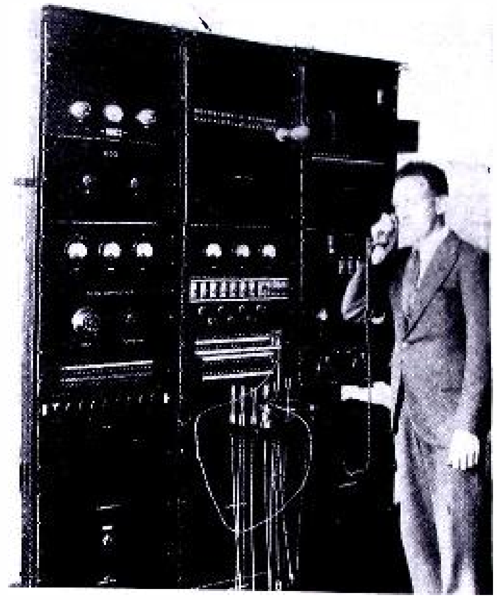
WHO is this man, Hall, who is able to tune in so many foreign stations and obtain so many marvelous verifications?" This question has been asked by many readers of SHORT WAVE RADIO.

Capt. Horace L. Hall is a retired sea captain who has found short-wave radio the ideal hobby. He is not a "radio expert" and frankly admits that his main interest is tuning-in stations and helping other listeners. His home is a regular rendezvous for short-wave fans of all ages. Many of his visitors are openly skeptical of his claims, but a demonstration of his reception dispels their doubts.

A sea-faring man for most of his life, Capt. Hall is a particularly enthusiastic short-wave tuner because he has actually been in most of the places from which he picks up short-wave programs. There is hardly a port of call in the world the Captain has not entered. During the war, Capt. Hall had the rank of Lieutenant Commander in the U. S. Navy and fulfilled many important missions.



Left, studio of the League of Nations' station with three of the announcers present. This is a rare photograph of the station heard so often by many listeners. Right, the technical operator's position located in the Wellington Telephone Exchange. The equipment shown, which is under the control of the technical operator, includes the voice-operated equipment of VODAS, which enables the four-wire telephone circuit (two wires to transmitting and two to the receiving station) to be connected.



Many of them send test, or sponsored, programs having entertainment value. One New York City short-wave fan was extremely fortunate in picking up and having verified a rare catch in South Africa. He heard OPM, on 29.58 meters, located in Leopoldville, Belgian Congo, sending a musical program to Belgium. Hardly ever had this circuit been heard transmitting this type of program.

VRT An Easy Catch

OPM is a rather difficult station to pull in; one of the easiest is VRT, on 29.8 meters, at Hamilton, Bermuda, which lies practically off the shores of the United States. Verifications from this station are rare, and thereby lies a tale. If you hear this station in communication with the ships, the *Monarch of Bermuda* or the *Queen of Bermuda*, they may verify your reception; but if you hear them talking to the United States, you will receive a letter known as a "threatener" among short-wave fans. This letter informs you that you have violated penal code number such and such, section so and so. To put the thing mildly, you have committed a criminal act in listening to this station when it is engaged in commercial traffic. As to what follows if one listens and writes again, I have no idea, nor am I interested in knowing. After receiving this "warm" letter the short-wave fan generally turns his attention to colder climates.

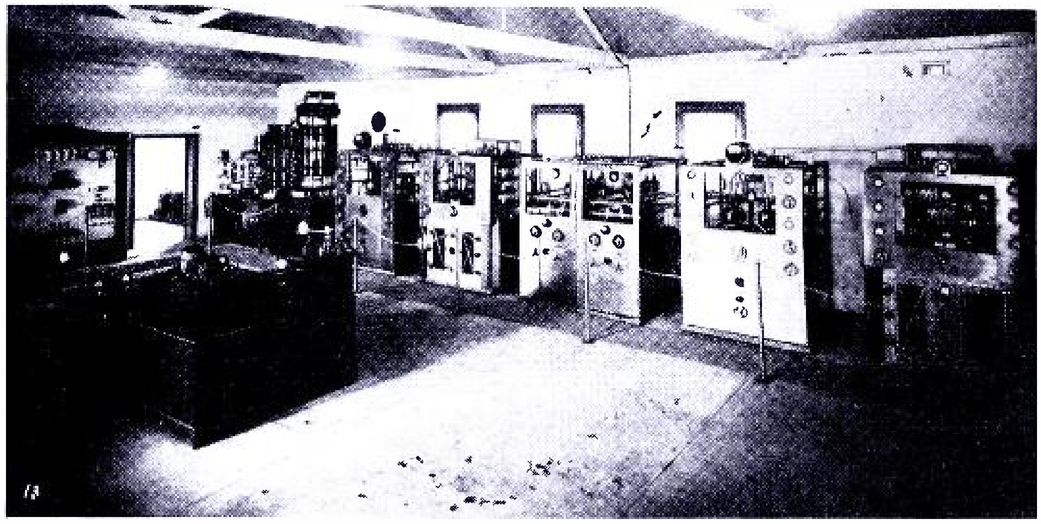
Perhaps it is just as well, because the European countries are thanking listeners for sending reports on reception. Such countries are Holland, which "scrambles" the speech to insure privacy and ignores the fan who writes for a verification, and Germany, who answers, but informs the listener that they know their phone circuit is coming over in fine style and that they are interested only in the reception of their short-wave broadcasting station, are not among the commercial stations to whom to write. Many interesting experiences have happened to the writer when phone circuits were heard and verifications sent for.

Up near the Arctic Circle is another catch, and LGN-LGB is the station. Although it has been heard on voice, it is considered a code station. The transmitter is situated on the mountain Dundemanden, 2000 feet above sea level, near Bergen, Norway. Five miles away is the receiving central. The wavelengths used are 23.8, 32.5, and 35.93 meters. The power is 2 k.w. They transmit from 10 a.m. to 3 p.m., E.S.T.

Less than a year ago "Bergen Radio" started corresponding with ships by telephony, and from a financial point of view has been highly successful. As we all know, Norway is one of the countries which has six months of day and six months of night. Therefore, the heaviest traffic is during the winter months, when over ten thousand Norwegians are working in the Arctic on whaling ships, commonly known as floating factories.

A record traffic for "Bergen Radio" was 29,700 telegrams cleared during the month of December, 1929. "Bergen Radio" was in regular communication with "Little America, Antarctica." Also, when Sir Hubert Wilkins tried to cross the North Pole in the submarine *Nautilus*, this station kept in touch with him. "Port Stanley Radio" sends all European traffic via LGN.

LGB is also built for working on 53.8 meters. Except for dead zones in the Pacific Ocean, they reach all places using a wave suitable for the time of night and day.



Transmitters of the Amalgamated Wireless' station, VK3ME.

A neat good-wish card from the New Zealand Short Wave Club.

Short Wave "Best-Bets"

The list of stations below has been compiled directly from the log of Capt. Hall. The column to the left is the wavelength, the letter to the right indicates the type of transmission, and the location and operating time follow. The operating time is liable to change from day to day, so that those listed may only be used as a guide.

World wide stations that send programs, B, Broadcast; E, Experimental; P, Telephone stations.

Europe

16.30, P, PCK, Kootwijk, Holland, about 6.30 a.m.
16.86, B, GSG, Daventry, England, 7 to 9 a.m.
16.88, B, PHI, Huizen, Holland, 7 to 9 a.m., irregular.
19.55, B, CTIAA, Lisbon, Portugal, Tuesday and Friday, 4.30 to 7 p.m.
19.68, B, Pontoise, France, 8 to 11 a.m.
19.73, B, DJB, Zeesen, Germany, 7 to 10 a.m.
19.82, B, GSF, Daventry, England, 4.30 to 8 a.m.
19.84, B, HVJ, Vatican City, Italy, 10 to 10.30 a.m.
25.20, B, Pontoise, France, 11 to 12 a.m.
25.28, B, GSE, Daventry, England, 7 to 9 a.m.
25.40, B, 2RO, Rome, Italy, 2 to 6 p.m.
25.51, B, DJD, Zeesen, Germany, 2 to 6 p.m.
25.53, B, GSD, Daventry, England, 2 to 6 p.m.
25.57, B, PHI, Huizen, Holland, 8 to 10 a.m.
25.63, B, Pontoise, France, 3 to 5 and 6 to 8 p.m.
30.00, B, EAQ, Madrid, Spain, 5.30 to 7 p.m.
31.27, B, HBL, Geneva, Switzerland, Sat. 5.30 to 6 p.m.
31.30, B, GSC, Daventry, England, 2 to 6 p.m.
31.38, B, DJA, Zeesen, Germany, 2 to 6 p.m.
31.55, B, GSB, Daventry, England, 11 to 1 p.m.
45.38, B, REN, Moscow, Russia, 2 to 6 p.m.
49.50, B, OXY, Skamleback, Denmark, 2 to 6 p.m.
49.59, B, GSA, Daventry, England, 11 to 1 p.m.
49.83, B, DJC, Zeesen, Germany, 7 to 9.30 p.m.
50.00, B, RV59, Moscow, Russia, 4 to 6 p.m.
50.26, B, HVJ, Vatican City, Italy, very irregular.
60.30, E, G6RX, Rugby, England, 8 to 10 p.m., irregular.
69.44, E, G6RX, Rugby, England, 9 to 11 p.m., irregular.

Asia

16.50, P, PMC, Bandoeng, Java, 3 to 5 p.m., irregular.
19.03, E, JIAA, Kemikawa, Japan, 4.30 a.m., irregular.
20.03, P, KAY, Manila, Phillippine Isl., 5 to 8 a.m.
28.80, P, UIG, Medan, Sumatra, 4 to 5 a.m.
30.40, E, JIAA, Kemikawa, Japan, 5 to 7 a.m.
48.90, B, ZGE, Zula Lumper, Malayan States, Sun., Tues., Fri., 6.30 to 8.30 p.m.
49.10, B, VUC, Calcutta, India, 9.12 a.m. and 2 p.m. to 3 a.m.
71.00, B, RV15, Khabarovsk, Russia, 3 to 9 a.m.

Africa

23.38, B, CNR, Rabat, Morocco, Sun., 7.30 to 9 a.m.
29.58, P, OPM, Leopoldville, Belgian Congo, 9 to 10 a.m.
37.33, B, CNR, Rabat, Morocco, Sun., 2.30 to 5 p.m.
41.60, B, EAR58, Tenerffe, Canary Isl., 5 to 6 p.m.
48.99, B, Johannesburg, South Africa, 4 to 5 a.m., 12 to 3 p.m., and 8 to 10 a.m.
49.50, B, VQ7LO, Nairobi, Kenya, 11 a.m. to 2 p.m.

North America

16.87, B, W3XAL, Bound Brook, N. J., 10 a.m. to 4 p.m., irregular.
19.56, B, W2XAD, Schenectady, N. Y., Mon., Wed., Fri. and Sun., 4 to 5 p.m.
19.64, B, W2XE, Wayne, N. J., 11 a.m. to 1 p.m.
19.67, B, W1XAL, Boston, Mass., 11 a.m. to 3 p.m., Sun.
19.72, B, W8XK, Pittsburgh, Pa., 10 a.m. to 4 p.m., irregular.
25.27, B, W8XK, Pittsburgh, Pa., 4 to 10 p.m., irregular.
25.36, B, W2XE, Wayne, N. J., 5 to 6 p.m. and 6 to 10 p.m.
25.45, B, W1XAL, Boston, Mass., Sat., 5 to 11 p.m., and Sun. 6 to 8 p.m.
31.28, B, W3XAU, Philadelphia, Pa., 1 to 6 p.m.
31.36, B, W1XAZ, Springfield, Mass., 8 a.m. to mid.
31.48, B, W2XAF, Schenectady, N. Y., 8 to 11 p.m.
46.69, B, W3XL, Bound Brook, N. J., irregular.
48.86, B, W8XK, Pittsburgh, Pa., 4 p.m. to 1 a.m.
49.02, B, W2XE, Wayne, N. J., 6 to 11 p.m.
49.19, B, W3XAL, Bound Brook, N. J., Sat. 4.30 to 12 p.m.
49.18, B, W9XF, Chicago, Ill., 8 to 9.30 p.m.
49.34, B, W9ZAA, Chicago, Ill., 3 to 6 p.m.
49.50, B, W3XAU, Philadelphia, Pa., 8 to 12 p.m.
49.50, B, W8XAL, Cincinnati, Ohio, 9 to 10 p.m.

South America

19.19, P, OCJ, Lima, Peru, 2 p.m. irregular.
25.73, E, PPQ, Rio de Janeiro, Brazil, 7 p.m., irregular.
27.35, P, OCI, Lima, Peru, 10 p.m., irregular.
28.98, E, LSX, Buenos Aires, Argentina, 8 to 9.30 p.m., irregular.
30.03, E, LSN, Buenos Aires, Argentina, 9 to 10 p.m., irregular.
32.00, B, Ti4NRH, Costa-Rica, 8 to 10 p.m.
31.56, B, YV3BC, Caracas, Venezuela, 9.30 to 10.30 p.m.
36.65, E, PSK, Rio de Janeiro, Brazil, 8 p.m., irregular.
40.55, E, HJ3ABD, Bogota, Colombia, 9 to 11 p.m.
41.55, B, HKE, Bogota, Colombia, Mon. 6 to 7 p.m. and Tues. 8 to 9 p.m.
41.60, B, HJ4ABB, Manizales, Colombia, 9 to 10 p.m.
45.00, B, HC2RL, Quito, Ecuador, Sun. 5 to 7 and Tues. 9 to 11 p.m.
45.31, B, PRADO, Riobamba, Ecuador, Thurs. 9 to 11 p.m.
45.60, B, HJ1ABB, Barranquilla, Colombia, 6 to 10 p.m.
47.00, B, HJ5ABD, Colombia, Thurs., Sat. and Sun., 7 to 9.30 p.m.
48.00, B, HJ3ABF, Bogota, Colombia, 7 to 10.30 p.m.
48.50, B, TGW Guatemala, 6-12 p.m.
48.78, B, YV3BC, Caracas, Venezuela, 6.30 to 10 p.m.
48.95, B, YV11BMO, Maracaibo, Venezuela, 8 to 11 p.m.
50.20, B, YV1BC, Caracas, Venezuela, 5 to 10 p.m., irregular.
50.20, B, HJ4ABE, Tunga, Colombia, 9 to 10.30 p.m.
73.00, B, HCJB, Quito, Ecuador, 7.30 to 9.45 p.m.

Mexico, West Indies, and Yucatan

25.50, P, XDM, Mexico City, Mexico, 8 to 9 p.m., irregular.
26.00, E, XAM, Merida, Yucatan, 6 to 7 p.m. irregular.
32.09, E, XDC, Mexico City, Mexico, 5 to 7 p.m., irregular.
47.50, B, HIZ, Santo Domimgo, 5 to 6 p.m.
47.80, B, HI1A, Dominican Republic, Mon., Wed. and Fri. 12 to 1.30 p.m. Tues., Thurs. and Sat. 7.30 to 9.30 p.m.
50.40, B, HIX, Santo Domingo, Tues. 8 to 10 p.m., and Sun. 2.30 to 4.30 p.m.

Oceanic

31.28, B, VK2ME, Sydney, Australia, Sun. 1 to 3 a.m., 5 to 8.30 a.m., and 9 to 11 a.m.
31.55, B, VK3ME, Melbourne, Australia Wed. 5 to 6.30, Sat. 5 to 7 a.m.

Canada

25.60, B, VE9JR, Winnipeg, Canada, 6 to 10 p.m., irregular.
49.10, B, VE9HX, Halifax, N.S., 8 to 11 p.m., 5 to 10 p.m.
49.22, B, VE9GW, Bowmanville, Canada, 3 to 6 p.m., irregular.
49.29, B, VE9BJ, St. Johns, N. B., 5 to 10 p.m.
49.42, B, VE9CS, Vancouver, B.C., Fri. 12 to 1.30 p.m.
49.96, B, VE9DR, Montreal, Canada, 8 to 10 a.m., Sun 1 to 10 p.m.

NOTE: All times given are approximate and subject to change.

SHORT WAVE RADIO'S

Short-Wave Station List

The following list, conveniently arranged alphabetically according to call letters, represents practically all the short-wave stations of the world, except amateur, that use voice transmission and are therefore recognizable by listeners who do not know the code. In most cases the frequency in kilocycles, the corresponding wavelength in meters, and the location by city are given; the country of origin, where it is not obvious, may quickly be determined from the preliminary list of international call letter assignments. Amateur and some special experimental calls consist of the assigned prefix, followed by a number and two or three letters.

Stations listed as "experimental" change around a great deal and may use code or voice; definite frequencies cannot be given for them.

No attempt has been made to include operating schedules in this list, as a great majority of the stations are experimental in nature, and have the habit of changing announced programs without warning. Up-to-the-minute information on the best stations of the month is contained in another department in this issue.

For the sake of brevity, a number of abbreviations of operating company names are used. These are RCA, Radio Corporation of America; GPO, General Post Office; BBC, British Broadcasting Corporation; CBS, Columbia Broadcasting System; NBC, National Broadcasting Company; GE, General Electric Company; ATT, American Telegraph & Telephone Co.; MRT, Mackay Radio Telegraph Co; MIT, Mass. Institute of Technology.

List of International Call Assignments

Block of Calls	Country	Amateur Prefix
CAA-CEZ	Chile	CE
CFA-CKZ	Canada	VE
CLA-CMZ	Cuba	CM
CNA-CNZ	Morocco	CN
CPA-CPZ	Bolivia	CP
CQA-CRZ	Portuguese colonies:	
	Cape Verde Ids.	CR4
	Portuguese Guinea	CR5
	Angola	CR6
	Mozambique	CR7
	Portuguese India	CR8
	Macao	CR9
	Timor	CR10
CSA-CUZ	Portugal:	
	Portugal proper	CT1
	Azores	CT2
	Madeira	CT3
CA-CVZ	Rumania	CV
CWA-CXZ	Uruguay	CX
CZA-CZZ	Monaco	CZ
D	Germany	D
EAA-EHZ	Spain	EAR
EIA-EIZ	Irish Free State	EI
ELA-ELZ	Liberia	EL
ESA-ESZ	Esthonia	ES
ETA-ETZ	Ethiopia (Abyssinia)	ET
F	France (including colonies):	
	France proper	F
	French Indo-China	F1
	Tunis	FM4
	Algeria	FM8
G	United Kingdom:	
	Great Britain except Ireland	G
	Northern Ireland	GI
HAA-HAZ	Hungary	HA
HBA-HBZ	Switzerland	HB
HCA-HCZ	Ecuador	HC
HHA-HHZ	Haiti	HH
HIA-HIZ	Dominican Republic	HI
HJA-HKZ	Colombia	HJ
HRA-HRZ	Honduras	HR
HSA-HSZ	Siam	HS
I	Italy and colonies	I
J	Japan	J
K	United States of America:	
	Continental United States	W
	Philippine Ids.	KA
	Porto Rico and Virgin Ids.	K4
	Territory of Hawaii	K6
	Territory of Alaska	K7
LAA-LNZ	Norway	LA
LOA-LVZ	Argentine Republic	LU
LZA-LZZ	Bulgaria	LZ
M	Great Britain	G
N	United States of America	W
OAA-OCZ	Peru	OA
OFA-OHZ	Finland	OH
OKA-OKZ	Czechoslovakia	OK
ONA-OTZ	Belgium and colonies	ON
OUA-OZZ	Denmark	OZ
PAA-PIZ	The Netherlands	PA
PJA-PJZ	Curacao	PJ
PKA-POZ	Dutch East Indies	PK
PPA-PYZ	Brazil	PY
PZA-PZZ	Surinam	PZ
RAA-RQZ	U. S. S. R. ("Russia")	RA
RVA-RVZ	Persia	RV
RXA-RXZ	Republic of Panama	RX
RYA-RYZ	Lithuania	RY
SAA-SMZ	Sweden	SM
SPA-SRZ	Poland	SP
STA-SUZ	Egypt:	
	Sudan	ST
	Egypt proper	SU
SVA-SZZ	Greece	SV
TAA-TCZ	Turkey	TA
TFA-TFZ	Iceland	TF
TGA-TGZ	Guatemala	TG
TIA-TIZ	Costa Rica	TI
TSA-TSZ	Territory of the Saar Basin	TS
UHA-UHZ	Hedjaz	UH
UIA-UKZ	Dutch East Indies	PK
ULA-ULZ	Luxemburg	UL
UNA-UNZ	Yugoslavia	UN
UOA-UOZ	Austria	UO
UWA-VGZ	Canada	VE
VHA-VMZ	Australia	VK
VOA-VOZ	Newfoundland	VO
VPA-VSZ	British colonies and protectorates	
	British Guiana	VP
	Fiji, Ellice Ids., Zanzibar	VPI
	Bahamas, Barbados, Jamaica	VP2
	Bermuda	VP9
	Fanning Id.	VQ1
	Northern Rhodesia	VQ2
	Tanganyika	VQ3
	Kenya Colony	VQ4
	Uganda	VQ5
	Malaya (including Straits Settlements)	VS1-2-3
	Hongkong	VS6
	Ceylon	VS7
VTA-VWZ	British India	VU
W	United States of America:	
	Continental United States	W
	(for others, see under K.)	
XAA-XFZ	Mexico	X
XGA-XUZ	China	AC
YAA-YAZ	Afghanistan	YA
YHA-YHZ	New Hebrides	YH
YIA-YIZ	Iraq	YI
YLA-YLZ	Latvia	YL
YMA-YMZ	Danzig	YM
YNA-YNZ	Nicaragua	YN
YSA-YSZ	Republic of El Salvador	YS
YVA-YVZ	Venezuela	YV
ZAA-ZAZ	Albania	ZA
ZBA-ZHZ	British colonies and protectorates	
	Transjordania	ZC1
	Palestine	ZC6
	Nigeria	ZD
	Southern Rhodesia	ZE1
ZKA-ZMZ	New Zealand:	
	Cook Ids.	ZK
	New Zealand proper	ZL
	British Samoa	ZM
ZPA-ZPZ	Paraguay	ZP
		ZS
ZSA-ZUZ	Union of South Africa	ZT
		ZU

STATIONS ALPHABETICALLY BY CALL LETTERS

—C—

CEC 10,670 kc., 28.12 m.
15,860 kc., 18.91 m.
19,690 kc., 15.24 m.
Santiago, Chile

CFA 6,840 kc., 43.8 m.
Drummondville, Quebec, Canada

CGA 4,780 kc., 62.7 m.
13,340 kc., 22.55 m.
13,750 kc., 21.82 m.
9,330 kc., 32.15 m.
18,170 kc., 16.5 m.
Quebec, Canada

CM6XJ 15,000 kc., 19.99 m.
Central Tuinucu, Cuba

CMCI 6,060 kc., 49.5 m.
Havana, Cuba

CN8MC 6,250 kc., 48 m.
Casablanca, Morocco

CNR 8,050 kc., 37.33 m.
9,300 kc., 32.26 m.
12,880 kc., 23.38 m.
Rabat, Morocco, Africa

CT1AA 6,990 kc., 42.9 m.
9,600 kc., 31.25 m.
Lisbon, Portugal

CT3AQ 11,181 kc., 26.33 m.
Funchal, Madeira

—D—

DAF 8,470 kc., 35.42 m.
12,400 kc., 24.19 m.
17,270 kc., 17.37 m.
Norden, Germany

DAN 11,340 kc., 26.44 m.
Nordeich, Germany

DFA 4,400 kc., 68.17 m.
19,240 kc., 15.58 m.

DFB 18,520 kc., 17.12 m.
DGK 6,680 kc., 44.91 m.
DGU 9,620 kc., 31.2 m.
DHC 11,435 kc., 26.22 m.
DHO 20,040 kc., 14.97 m.
DIH 19,950 kc., 15.03 m.
DIQ 10,290 kc., 29.15 m.
DIS 10,150 kc., 29.54 m.
Nauen, Germany

DJA 9,560 kc., 31.38 m.
Konigswusterhausen, Germany

DJB 15,200 kc., 19.73 m.
DJC 6,020 kc., 49.83 m.
DJD 11,760 kc., 25.51 m.
Zeesen, Germany

DOA 7,230 kc., 41.46 m.
7,390 kc., 37.8 m.
4,430 kc., 67.5 m.
3,620 kc., 82.9 m.
Doeberitz, Germany

—E—

EAJ25 6,000 kc., 50 m.
Barcelona, Spain

EAR110 6,980 kc., 43.0 m.
Madrid, Spain

EAQ 19,700 kc., 15.23 m.
10,000 kc., 30 m.
Alcalda 43—Madrid, Spain

EHY 10,100 kc., 29.7 m.
Madrid, Spain

—F—

F8KR 3,750 kc., 80 m.
F8KR 6,660 kc., 45 m.
Constantine, Algeria

F8MC 6,875 kc., 43.6 m.
Casablanca, Morocco

FIGA 6,000 kc., 49.97 m.
Tananarive, Madagascar

FL 6,120 kc., 49.02 m.
FLJ 9,230 kc., 32.5 m.
Paris, France

FQE 12,150 kc., 24.68 m.
FQO 12,150 kc., 24.68 m.
FRE 18,240 kc., 16.44 m.
FRE 19,400 kc., 15.45 m.
FRO 18,240 kc., 16.44 m.
St. Assise, France

FSR 20,680 kc., 14.5 m.
Paris, France

FTA 11,950 kc., 25.12 m.
FTD 19,830 kc., 15.12 m.
FTF 7,770 kc., 38.6 m.
FTK 15,690 kc., 19.12 m.
FTK 15,860 kc., 18.9 m.
St. Assise, France

FYA 11,705 kc., 25. 6 m.
FYA 11,905 kc., 25.16 m.
FYA 15,240 kc., 19.68 m.
Pontoise (Paris) France

FZG 12,000 kc., 24.98 m.
FZR 16,200 kc., 18.5 m.
FZS 11,900 kc., 25.02 m.
FZS 18,310 kc., 16.38 m.
Saigon, Indo-China

—G—

GAA 20,380 kc., 14.72 m.
GAG 18,970 kc., 15.81 m.
GAS 18,410 kc., 16.38 m.
GAU 18,620 kc., 16.11 m.
GBB 13,580 kc., 22.09 m.
GBC 17,080 kc., 17.55 m.
GBC 12,780 kc., 23.46 m.
GBC 9,310 kc., 32.22 m.
GBC 8,680 kc., 34.56 m.
GBC 4,980 kc., 60.26 m.
Rugby, England

GBJ 18,620 kc., 16.1 m.
GBK 16,100 kc., 16.57 m.
9,250 kc., 32.4 m.
11,490 kc., 26.1 m.
Bodmin, England

GBP 10,770 kc., 28.04 m.
GBS 18,310 kc., 16.38 m
12,250 kc., 24.46 m.
12,150 kc., 24.68 m.

GBU 18,620 kc., 16.11 m.
22,300 kc., 13.45 m.
12,290 kc., 24.41 m.
9,950 kc., 30.15 m.

GBW 14,480 kc., 20.7 m.
9,790 kc., 30.64 m.
GPO, Rugby, Eng.

GBX 16,150 kc., 18.56 m.
10,390 kc., 28.86 m.

GCA 9,710 kc., 30.9 m.
GCB 9,280 kc., 32.33 m.
GCS 9,020 kc., 33.26 m.
GCU 9,950 kc., 30.15 m.
GCW 9,800 kc., 30.60 m.
GDS 6,900 kc., 43.45 m.
GDW 4,840 kc., 62.0 m.
Rugby, England

GSA 6,050 kc., 49.58 m.
GSB 9,510 kc., 31.55 m.
GSC 9,585 kc., 31.29 m.
GSD 11,750 kc., 25.53 m.
GSE 11,865 kc., 25.28 m.
GSF 15,140 kc., 19.81 m.
GSG 17,770 kc., 16.88 m.
GSH 21,470 kc., 13.97 m.
BBC, Daventry, Eng.

G6RX 4,320 kc., 69.44 m.
Rugby, England

—H—

HB9D 7,200 kc., 41.5 m.
Zurich, Switzerland

HBF 18,900 kc., 15.78 m.
HBJ 14,560 kc., 20.6 m.
Pragins, Switzerland

HBL 9,595 kc., 31.27 m.
HBP 7,800 kc., 38.47 m.
Geneva, Switzerland

HC1DR 6,382 kc., 47 m.
Quito, Ecuador

HC2JSB 8,000 kc., 37.5 m.
Guayaquil, Ecuador

HCJB 8,110 kc., 37.0 m.
5,714 kc., 52.5 m.
Quito, Ecuador, S. A.

HJ1ABB 5,800 kc., 51.75 m.
Barranquilla, Colombia

HJ2ABA 5,880 kc., 51.49 m.
Tunja, Colombia

HJ3ABD 7,400 kc., 40.55 m.
HJ3ABF 6,250 kc., 48.0 m.
Bogota, Colombia

HJ4ABB 7,150 kc., 41.6 m.
Manizales, Colombia

HJ4ABE 5,930 kc., 5.06 m.
Medellin, Colombia

HJ5ABD 6,380 kc., 47.0 m.
Cali, Colombia

HJB 7,470 kc., 40.16 m.
HJY 9,930 kc., 30.2 m.
18,460 kc., 16.25 m.

HKC 6,270 kc., 47.81 m.
Bogota, Colombia

HKF 7,612 kc., 39.14 m.
HKM 6,660 kc., 45 m.
Bogota, Colombia

HKO 5,900 kc., 50.8 m.
Medellin, Colombia

HKX 7,140 kc., 42.02 m.
Bogota, Colombia

HSP2 9,640 kc., 31.1 m.
HSP 17,750 kc., 16.92 m.
Bangkok, Siam

HVJ 5,970 kc., 50.26 m.
75,110 kc., 19.84 m.
15,120 kc., 19.83 m.
Vatican City, Rome, Italy

—I—

I2RO 11,810 kc., 25.4 m.
Rome, Italy

I3RO 3,750 kc., 80 m.
Rome, Italy

IAC 8,380 kc., 35.8 m.
6,650 kc., 45.1 m.
12,800 kc., 23.45 m.
Pisa, Italy

IBDK 11,470 kc., 26.15 m.
S. S. Elettra (Marconi's Yacht)

IRW 19,540 kc., 15.25 m.
Italy

J

JB 6,069 kc., 49.43 m.
Johannesburg, South Africa

J1AA 7,880 kc., 38.07 m.
13,090 kc., 22.93 m.
9,870 kc., 30.4 m.
15,490 kc., 19.36 m.
Tokio, Japan

—K—

K6XQ Experimental
S. S. Lake Miraflores

KAZ 9,970 kc., 30.09 m.
Manila, P. I.

KDK 7,520 kc., 39.89 m.
KEJ 9,020 kc., 33.27 m
Kauhuku, T. H.

KEL 6,860 kc., 43.7 m.
Bolinas, Cal.

KEQ 7,370 kc., 40.71 m.
Kauhuku, T. H.

KES 10,410 kc., 28.80 m.
KEZ 10,410 kc., 28.80 m.
Bolinas, Cal.

KGHO 1,534 kc., 191.1 m.
Des Moines, Iowa

KGJX 1,712 kc., 175.15 m.
Pasadena, Cal.

KGOZ 2,470 kc., 121.5 m.
Cedar Rapids, Iowa

KGPA 2,414 kc., 124.2 m.
Seattle, Wash.

KGPB 2,416 kc., 124.1 m.
Minneapolis, Minn.

KGPC 1,712 kc., 175.15 m.
St. Louis, Mo.

KGPD 2,470 kc., 121.5 m.
San Francisco, Cal.

KGPE 2,422 kc., 123.8 m.
Kansas City, Mo.

KGPG 2,422 kc., 123.8 m.
Vallejo, Cal.

KGPH 2,450 kc., 122.4 m.
Oklahoma City, Okla.

KGPI 2,470 kc., 121.5 m.
Omaha, Neb.

KGPJ 1,712 kc., 175.15 m.
Beaumont, Tex.

KGPL 1,712 kc., 175.15 m.
Los Angeles, Cal.

KGPM 2,470 kc., 121.5 m.
San Jose, Cal.

KGPN 2,470 kc., 121.5 m.
Davenport, Iowa

KGPO 2,450 kc., 122.4 m.
Tulsa, Okla.

KGPP 2,442 kc., 122.8 m.
Portland, Ore.

KGPQ 2,450 kc., 122.4 m.
Honolulu, T. H.

KGPS 2,414 kc., 124.2 m.
Bakersfield, Cal.

KGPW 2,470 kc., 121.5 m.
Salt Lake City, Utah

KGPX 2,442 kc., 122.8 m.
Denver, Colo.

KGPY 1,574 kc., 189.5 m.
Shreveport, La.

KGPZ 2,450 kc., 122.4 m.
Wichita, Kans.

KGTP Various aero frequencies

KGZB 1,712 kc., 175.15 m
Houston, Tex.

KGZD 2,430 kc., 123.4 m
San Diego, Cal.

KGZE 2,506 kc., 120 m
San Antonio, Tex.

KGZF 2,450 kc., 122.4 m
Chanute, Kans.

KGZH 2,442 kc., 122.8 m
Klamath Falls, Ore.

KGZI 1,712 kc., 175.15 m
Wichita Falls, Tex.

KGZL 1,712 kc., 175.15 m
Shreveport, La.

KGZM 2,414 kc., 124.2 m.
El Paso, Tex.

KGZN 2,414 kc., 124.2 m.
Tacoma, Wash.

KGZP 2,450 kc., 122.4 m
Coffeyville, Kans.

KGZQ 1,712 kc., 175.15 m
Waco, Tex.

KGZR 2,442 kc., 122.8 m.
Salem, Ore.

KGZU 2,470 kc., 121.5 m.
Lincoln, Neb.

KGZX 2,414 kc., 124.2 m.
Albuquerque, N. M.

KIO 11,670 kc., 25.68 m.
KKH 7,520 kc., 39.89 m.
KKP 16,040 kc., 18.71 m.
Kauhuku, T. H.

KKQ 11,945 kc., 25.1 m.
KKW 13,780 kc., 21.77 m.
KKZ 14,150 kc., 21.17 m.
KQJ 18,050 kc., 16.61 m.
Bolinas, Cal.

KSW 1,658 kc., 180.7 m.
Berkeley, Cal.

KVP 1,712 kc., 175.15 m.
Dallas, Tex.

KWN 21,060 kc., 14.24 m.
KWO 15,420 kc., 19.46 m.
KWU 15,350 kc., 19.54 m.
KWV 10,840 kc., 27.67 m.
KWX 7,610 kc., 39.42 m.
KWY 7,560 kc., 39.65 m.
KWZ 10,400 kc., 28.8 m.
Dixon, Cal.

—L—

LGN 9,600 kc., 31.23 m.
Bergen, Norway

LQA 9,600 kc., 31.25 m.
LSA 9,890 kc., 30.3 m.
LSA 14,530 kc., 20.65 m.
LSG 19,950 kc., 15.03 m.
LSG 19,906 kc., 15.07 m.
LSL 10,300 kc., 29.12 m.
LSL 21,160 kc., 14.17 m.
Buenos Aires

LSM 21,130 kc., 14.15 m.
Monte Grande, Argentina
(Buenos Aires)

LSN 14,530 kc., 20.65 m.
LSN 21,020 kc., 14.27 m.
LSN 20,680 kc., 14.5 m.
LSR 18,960 kc., 15.82 m.
LSX 10,350 kc., 28.98 m.
LSY 20,730 kc., 14.47 m.
LSY 10,410 kc., 28.8 m.
LSY 18,130 kc., 16.55 m.
Buenos Aires

—N—

NAA 16,060 kc., 18.68 m.
NAA 12,045 kc., 24.89 m.
NAA 4,105 kc., 74.72 m.
Arlington, Va. (time signals)

NPO 8,872 kc., 33.81 m.
Cavite, P. I. (time signals)

NSS 12.045 kc., 24.89 m.
Annapolis, Md. (time signals)

—O—

OCI 18,680 kc., 16.06 m.
OCJ 15,620 kc., 19.19 m.
Lima, Peru

OKI 21,000 kc., 14.28 m.
Podebrady, Czechoslovakia

OKIMPT 5,145 kc., 58.31 m.
OKIMPT 5,170 kc., 58 m.
Prague, Czechoslovakia

OPL 20,040 kc., 14.97 m
OPM 10,140 kc., 29.58 m
Leopoldsville, Belgian Congo

ORG 19,210 kc., 15.62 m

ORK 10,330 kc., 29.04 m.
Brussels, Belgium
OXY 15,300 kc., 19.6 m.
Lyngby, Denmark
OXY 6,075 kc., 49.4 m.
OXY 9,520 kc., 31.51 m.
Skamleback, Denmark
OZ7RL 3,560 kc., 84.24 m.
Copenhagen, Denmark

—P—

PCK 7,770 kc., 38.6 m.
18,400 kc., 16.3 m.
PCL 16,300 kc., 18.4 m.
PCV 17,830 kc., 16.82 m.
PDK 10,410 kc., 28.8 m.
PDU 7,830 kc., 38.3 m.
PDV 12,060 kc., 24.88 m.
Kootwijk, Holland
PHI 17,770 kc., 16.88 m.
11,730 kc., 25.57 m.
Huizen, Holland
PK2AG 3,156 kc., 95 m.
Samarang, Java
PK3AN 6,040 kc., 49.67 m.
Sourabaya, Java
PLE 18,200 kc., 15.94 m.
PLF 17,850 kc., 16.8 m.
PLG 15,950 kc., 18.8 m.
PLM 12,250 kc., 24.46 m.
PLR 10,630 kc., 28.2 m.
PLV 9,420 kc., 31.86 m.
PLW 8,120 kc., 36.92 m.
9,480 kc., 31.63 m.
PMB 20,620 kc., 14.54 m.
5,170 kc., 58 m.
PMC 18,370 kc., 16.33 m.
PMN 10,360 kc., 29.25 m.
PMY 5,170 kc., 58.0 m.
Bandoeng, Java
PPG 11,660 kc., 27.73 m.
PPU 19,270 kc., 15.57 m.
Rio de Janeiro
PRADO 6,620 kc., 45.31 m.
Riobamba, Ecuador
PRAG 8,450 kc., 35.5 m.
Porto Algero, Brazil
PSA 21,080 kc., 14.23 m.
PSH 10,220 kc., 29.35 m.
PSK 8,190 kc., 36.65 m.
Rio de Janeiro

—R—

RABAT 12,830 kc., 23.38 m.
8,035 kc., 37.33 m.
Morocco
RAU 15,100 kc., 19.85 m.
Tachkent, Turkestan
REN 6,610 kc., 45.38 m.
RIM 7,630 kc., 39.34 m.
RKI 7,500 kc., 39.97 m.
U. S. S. R.
RV15 4,273 kc., 70.2 m.
Khabarovsk, Siberia
RV59 6,000 kc., 50 m.
Radio Moscow, U.S.S.R.
RXF 14,500 kc., 20.69 m.
Panama City, Panama

—S—

SAJ 6,065 kc., 49.46 m.
Motola, Sweden
SRI 9,570 kc., 31.35 m.
Poznan, Poland
SUV 10,050 kc., 29.83 m.
Cairo, Egypt

—T—

TI4NRH 9,675 kc., 31 m.
Heredia, Costa Rica, C. A.
TIR 8,790 kc., 34.13 m.
14,500 kc., 20.69 m.
Cartago, Costa Rica
TGA 14,500 kc., 20.69 m.
TGW 6,660 kc., 45 m.
6,180 kc., 48.5 m.
TGX 5,940 kc., 50.5 m.
Guatemala City, C. A.

—U—

UIG 10,400 kc., 28.8 m.
Medan, Sumatra
UOR2 6,072 kc., 49.41 m.
Vienna, Austria

—V—

VE9AP 6,335 kc., 47.35 m.
Drummondville, Canada
VE9BJ 6,090 kc., 49.29 m.
St. John's, N. B., Canada
VE9BY 4,795 kc., 62.56 m.
6,425 kc., 46.7 m.
8,650 kc., 34.68 m.
London, Ontario, Canada
VE9CA 6,030 kc., 49.75 m.
Calgary, Alta., Canada
VE9CF 6,050 kc., 49.59 m.
6,100 kc., 49.15 m.
Halifax, N. S., Canada
VE9CG 6,110 kc., 49.1 m.
Calgary, Alta., Canada
VE9CL 5,710 kc., 52.5 m.
6,147 kc., 48.8 m.
Winnipeg, Canada
VE9CS 6,069 kc., 49.43 m.
Vancouver, B. C., Canada
VE9CU 6,005 kc., 49.99 m.
Calgary, Alta., Canada
VE9DR 11,780 kc., 25.47 m.
6,005 kc., 49.96 m.
Drummondville, Quebec, Canada
VE9GW 6,095 kc., 49.17 m.
11,800 kc., 25.42 m.
Bowmanville, Ontario, Canada
VE9HK 6,120 kc., 48.98 m.
VE9HX 6,125 kc., 48.98 m.
Halifax, N. S., Canada
VE9JR 11,720 kc., 25.6 m.
Winnipeg, Canada
VK2ME 9,760 kc., 30.75 m.
10,520 kc., 28.51 m.
Sydney, Australia
VK3LR 9,510 kc., 31.55 m.
5,680 kc., 52.8 m.
Melbourne, Australia
VLJ 9,980 kc., 37.59 m.
VLK 9,760 kc., 30.75 m.
10,520 kc., 28.51 m.
Sydney, Australia
VPD 7,890 kc., 38.0 m.
Suva, Fiji Islands
VPN 4,510 kc., 66.5 m.
Nassau, Bahamas
VQ7LO 6,000 kc., 49.5 m.
Nairobi, Kenya, Africa
VRT 5,050 kc., 59.42 m.
10,070 kc., 29.8 m.
Hamilton, Bermuda
VS1AB 7,195 kc., 41.67 m.
Singapore, S. S.
VUC 6,110 kc., 49.1 m.
Calcutta, India
VWY 18,540 kc., 17.1 m.
Poona, India

—W—

W1XAB 4,700 kc., 63.79 m.
Portland, Me.
W1XAG Experimental
Police, Providence, R. I.
W1XAI Experimental
Tufts College, Medford, Mass.
W1XAK Experimental
Westinghouse, Chicopee Falls, Mass.
W1XAL 11,790 kc., 25.45 m.
W1XAL 6,040 kc., 49.67 m.
W1XAL 15,250 kc., 19.67 m.
W1XAL 21,460 kc., 13.98 m.
Boston, Mass.
W1XAN Experimental
Round Hills, Mass.
W1XAU 1,560 kc., 199.35 m.
W1XAV 1,600 kc., 187.5 m.
Boston, Mass.
W1XAW Experimental
Tufts College, Medford, Mass.
W1XAZ 9,570 kc., 31.35 m.
Westinghouse, Springfield, Mass.
W1XG 43,000 kc., 6.52 m.
Boston, Mass.
W1XJ Experimental
Harvard U., Cambridge, Mass.
W1XK Experimental
Westinghouse, Port. & Mob.
W1XL 6,040 kc., 49.67 m.
Boston, Mass.
W1XM Experimental
M.I.T.
Cambridge, Mass.
W1XP Experimental
W1XV Experimental
M.I.T.
S. Dartmouth, Mass.
W1XW 41,000 kc., 7.32 m.
W1XW 51,400 kc., 5.83 m.
W1XW 60,000 kc., 5.00 m.
W1XW 400,000 kc., ¾ m.
A. F. Sise, Milton, Mass.
W2XAA Experimental
Bell Labs., Port. & Mob.
W2XAB 2,750 kc., 109.1 m.
CBS, New York, N. Y.
W2XAC 8,690 kc., 34.5 m.
W2XAD 15,330 kc., 19.56 m.
W2XAF 9,530 kc., 31.48 m.
GE, Schenectady, N. Y.
W2XAK 43,000 kc., 6.52 m.
W2XAK 48,500 kc., 6.18 m.
W2XAK 60,000 kc., 5.00 m.
CBS, New York, N. Y.
W2XAO 17,850 kc., 16.8 m.
W2XAR Experimental
Long Island City, N. Y.
W2XAV Experimental
Bell Labs., Port. & Mob.
W2XAW Experimental
GE, Schenectady, N. Y.
W2XBB Experimental
RCA, New York, N. Y.
W2XBC 25,700 kc., 11.67 m.
RCA, New Brunswick, N. J.
W2XBG Experimental
Radio Marine, New York, N. Y.
W2XBI Experimental
RCA, Rocky Point, N. Y.
W2XBJ 14,700 kc., 20.27 m.
Rocky Point, N. Y.
W2XBL Experimental
RCA, Port. & Mob.
W2XBS 2,100 kc., 136.4 m.
W2XBT 43,000 kc., 6.52 m.
W2XBT 48,500 kc., 6.18 m.
W2XBT 60,000 kc., 5.00 m.
NBC, Portable
W2XBW Experimental
Globe Wireless, Garden City, N. Y
W2XBX Plane, Experimental
Bell Labs.
W2XCJ Experimental
Police, Bayonne, N. J.
W2XCS Experimental
W2XCT Experimental
Police, Eastchester, N. Y.
W2XCU 12,850 kc., 23.35 m.
W2XCU 8,650 kc., 34.68 m.
Rocky Point, N. Y.
W2XDC Experimental
RCA, Portable & Mobile
W2XDJ 21,420 kc., 14. m.
ATT, Deal, N. J.
W2XDK Experimental
Polin, Inc., Port. & Mob.
W2XDO 17,110 kc., 17.52 m.
W2XDO 8,630 kc., 34.74 m.
ATT, Ocean Gate, N. J.
W2XDT Experimental
Press Wireless, Port. & Mob.
W2XDV Experimental
CBS, New York, N. Y.
W2XDY Experimental
W2XDZ Experimental
Central Hudson Gas & Electric Co.
Portable
W2XE 15,270 kc., 19.65 m.
W2XE 11,830 kc., 25.36 m.
W2XE 6,120 kc., 49.02 m.
CBS, Wayne, N. J.
W2XEA Experimental
W2XEB Experimental
W2XEC Experimental
W2XED Experimental
W2XEE Experimental
W2XEF Experimental
W2XEG Experimental
W2XEH Experimental
Police, Bayonne, N. J.
W2XEI Experimental
P. J. Golihofer, Port. & Mob.
W2XEJ Experimental
D. B. Whittemore, Yonkers, N. Y.
W2XEK Experimental
Knickerbocker Broad. Co., Port. & Mob.
W2XEL Experimental
Police, Eastchester, N. Y.
W2XER Experimental
D. B. Whittemore, Yonkers, N. Y.
W2XES 34,600 kc., 8.67 m.
Englewood, N. J.
W2XF 43,000 kc., 6.52 m.
W2XF 48,500 kc., 6.18 m.
W2XF 60,000 kc., 5.00 m.
NBC, New York
W2XG Experimental
Bell Labs., Ocean Township, N. J.
W2XGG Experimental
Police, Bayonne, N. J.
W2XJ Experimental
Bell Labs., Ocean Township, N. J.
W2XK Experimental
NBC, New York, N. Y.
W2XL Experimental
Bell Labs., Port & Mobile
W2XM Experimental
W2XN Experimenta
Bell Labs., Holmdel, N. J.
W2XO 12,850 kc., 23.35 m.
GE, Schenectady, N. Y.
W2XP Experimental
RCA, Riverhead, N. Y.
W2XR 1,600 kc., 176.5 m.
W2XR 43,000 kc., 6.97 m
W2XR 48,500 kc., 6.18 m.
W2XR 60,000 kc., 5.00 m.
W2XS Experimental
W2XT Experimental
RCA, Rocky Point, N. Y.
W2XU Experimental
Bell Labs., Portable
W2XV 8,650 kc., 34.68 m.
W2XV 4,975 kc., 60.30 m.
Long Island City, N. Y.
W2XW Experimental
W2XY Experimental
Bell Labs., Portable
W3XAB Experimental
RCA, Camden, N. J.
W3XAD 43,000 kc., 6.97 m.
W3XAD 48,500 kc., 6.18 m.
W3XAD 60,000 kc., 5.00 m.
RCA, Camden, N. J.
W3XAJ Experimental
RCA, Camden, N. J.
W3XAK 2,100 kc., 136.4 m.
NBC, Portable
W3XAL 17,780 kc., 16.87 m.
W3XAL 6,100 kc., 49.15 m.
NBC, Bound Brook, N. J
W3XAM Experimental
RCA, Port. & Mob.
W3XAN Experimental
Harrisburg, Pa.
W3XAR 34,600 kc., 8.67 m.
Haverford (Brookline), Pa.
W3XAU 9,580 kc., 31.32 m.
W3XAU 9,590 kc., 31.28 m.
W3XAU 6,060 kc., 49.5 m.
CBS, Philadelphia, Pa.
W3XAW Experimental
W3XAX Experimental
M. & H. Sporting Goods Co., Port.
W3XB Experimental
College Park, Md.
W3XE 9,580 kc., 31.32 m.
W3XE 43,000 kc., 6.52 m.
W3XE 48,500 kc., 6.00 m.
W3XE 60,000 kc., 3.75 m.
Philco, Philadelphia, Pa.
W3XE 8,650 kc., 34.68 m.
Baltimore, Md.
W3XL Experimental
NBC, Bound Brook, N. J.
W3XN Experimental
Bell Labs., Whippany, N. J.
W3XR Experimental
Bell Labs., Mendham Township, N. J.
W3XV Experimental
RCA, Arneys-Mount, N. J.
W3XW Experimental
Boonton, N. J.
W3XX 8,650 kc., 34.68 m.
W3XZ 4,795 kc., 62.56 m.
Washington, D. C.
W4XB 6,040 kc., 49.67 m.
Miami Beach, Fla.
W4XC Experimental
Portable
W4XD Experimental
Port. & Mob.
W4XG 8,650 kc., 34.68 m.
Miami, Fla.
W5XC Experimental
Shreveport, La.
W6XAC Experimental
Fred W. Christian, Jr., Portable
W6XAD Experimental
San Francisco, Calif.
W6XAH 2,000 kc., 150 m.
Bakersfield, Cal.
W6XAJ Experimental
Portable
W6XAO 43,000 kc., 6.97 m.
W6XAO 48,500 kc., 6.18 m.
W6XAO 60,000 kc., 5.00 m.
Los Angeles, Cal.
W6XAP Experimental
Port. & Mob.
W6XAR Experimental
W6XAS Experimental
Julius Brunton & Sons Co., Port. & Mob.
W6XBB Experimental
Port. in Calif.
W6XD 27,800 kc., 10.79 m.
MRT, Palo Alto, Cal.
W6XF Experimental
Port. in Calif.

W6XJ Experimental
Port. in Calif.
W6XP Experimental
Press Wireless, Portable and Mobile
W6XQ 24,000 kc., 12.48 m.
San Mateo, Cal.
W6XR Experimental
San Francisco, Calif.
W6XS 2,100 kc., 136.4 m.
Los Angeles, Calif.
W7XA Experimental
Globe Wireless, Ltd., Portable
W7XAW 2,342 kc., 128.09 m.
Seattle, Wash.
W7XC Experimental
Edmonds, Wash.
W7XK Experimental
Seattle, Wash.
W7XL Experimental
Northern Radio Co., Portable
W8XAG 8,650 kc., 34.68 m.
Dayton, Ohio
W8XAL 6,060 kc., 49.5 m.
Crosley, Cincinnati, O.
W8XAN 43,000 kc., 6.97 m.
W8XAN 48,500 kc., 6.18 m.
W8XAN 60,000 kc., 5.00 m.
W8XAN 1,600 kc., 176.5 m.
Jackson, Mich.
W8XF 43,000 kc., 6.97 m.
W8XF 48,500 kc., 6.18 m.
W8XF 60,000 kc., 5.00 m.
Pontiac, Mich.
W8XI 31,000 kc., 9.68 m.
W8XJ 5,550 kc., 54.02 m.
Columbus, O.
W8XK 21,540 kc., 13.93 m.
W8XK 17,780 kc., 16.87 m.
W8XK 15,210 kc., 19.72 m.
W8XK 11,870 kc., 25.26 m.
W8XK 9,570 kc., 31.35 m.
W8XK 6,140 kc., 48.86 m.
Westinghouse, E. Pittsburgh, Pa.
W8XL 17,300 kc., 17.34 m.
Dayton, O.
W8XL 43,000 kc., 6.97 m.
W8XL 48,500 kc., 6.18 m.
W8XL 60,000 kc., 5.00 m.
Cuyahoga Hts., Ohio
W8XN 1,600 kc., 176.5 m.
Jackson, Mich.
W9XAA 6,080 kc., 49.31 m.
W9XAA 11,830 kc., 25.36 m.
W9XAA 17,780 kc., 16.87 m.
Chicago, Ill.
W9XAI Experimental
W9XAJ Experimental
Milwaukee, Wis., Portable
W9XAK 2,100 kc., 142.9 m.
Manhattan, Kans.
W9XAL 2,200 kc., 136.4 m.
Kansas City, Mo.
W9XAM 4,795 kc., 62.56 m.
Elgin, Ill.
W9XAO 11,840 kc., 25.34 m.
W9XAO 2,000 kc., 150 m.
W9XAP 2,100 kc., 142.9 m.
Chicago, Ill.
W9XAR Experimental
Portable & Mobile
W9XAT 43,000 kc., 6.97 m.
W9XAT 48,500 kc., 6.18 m.
W9XAT 60,000 kc., 5.00 m.
Dr. G. W. Young, Portable
W9XAV Experimental
Press Wireless, Port. & Mob.
W9XD 43,000 kc., 6.97 m.
W9XD 48,500 kc., 6.18 m.
W9XD 60,000 kc., 5.00 m.
Milwaukee, Wis.
W9XE 43,000 kc., 6.97 m.
W9XE 48,500 kc., 6.18 m.
W9XE 60,000 kc., 5.00 m.
Marion, Ind.
W9XF 17,780 kc., 16.87 m.
W9XF 11,880 kc., 25.24 m.
W9XF 6,100 kc , 49.18 m.
NBC, Chicago, Ill.
W9XG 2,750 kc., 109.1 m.
W. Lafayette, Ind.
W9XK 2,000 kc., 150 m.
Iowa City, Iowa
W9XL 17,300 kc., 17.34 m.
W9XL 12,850 kc., 23.35 m.
W9XL 6,425 kc., 46.70 m.
Anoka, Minn.
W10XAA Plane, Experimental
Bell Labs.
W10XAC Experimental
Milwaukee, Wis., Port. & Mobile
W10XAF Experimental
Larry L. Smith, Portable
W10XAG Experimental
N. Y. Conservation Dept., Port. and Mobile
W10XAH Experimental
W10XAI Experimental
NBC, Portable and Mobile
W10XAJ Experimental
N. Y. Conservation Dept., Port. and Mobile
W10XAK Experimental
NBC, Portable and Mobile
W10XAL Experimental
CBS, Portable and Mobile
W10XAM Experimental
W10XAN Experimental
W10XAP Experimental
NBC, Portable and Mobile
W10XAQ Experimental
Westinghouse, Portable & Mobile
W10XAY Experimental
Polin, Inc., Portable and Mobile
W10XBA Plane, Experimental
W10XBB Plane, Experimental
W10XBC Plane, Experimental
Aeronautical Radio Inc.
W10XBE Experimental
N. Y. Conservation Dept., Port. and Mobile
W10XBF Experimental
W10XBG Experimental
W. G. H. Finch, Portable & Mob.
W10XBI Plane, Experimental
Roland Reed
W10XBK Experimental
W. G. H. Finch, Portable & Mob.
W10XE Experimental
RCA, Portable and Mobile
W10XI Plane, Experimental
Aircraft Radio Corp.
W10XJ Experimental
Bell Labs., Portable
W10XN Experimental
NBC, Portable and Mobile
W10XT Experimental
RCA, Portable and Mobile
W10XX 43,000 kc., 6.97 m.
W10XX 48,500 kc., 6.18 m.
W10XX 60,000 kc., 5.00 m.
RCA, Portable
W10XY Experimental
NBC, Portable and Mobile
W10XZ Experimental
CBS, Portable and Mobile
WAEQ Various aero frequencies
Elmira, N. Y.
WAJ 13,480 kc., 22.26 m.
Rocky Point, N. Y
WBA 257 kc., 1,123 m.
Harrisburg, Pa.
WBR 257 kc., 1,123 m.
Butler, Pa.
WCK 2,414 kc., 124.2 m.
Belle Island, Mich.
WCN 5,070 kc., 59.08 m.
Lawrenceville, N. J.
WDX 257 kc., 1,123 m.
Wyoming, Pa.
WEA 10,610 kc., 28.28 m.
WEB 6,940 kc., 43.23 m.
WEC 8,930 kc., 33.59 m.
WEF 9,590 kc., 31.6 m.
WEL' 8,950 kc., 33.52 m.
WEM 7,400 kc., 40.54 m.
WES 9,450 kc., 31.74 m.
WGN 5,260 kc., 57.03 m.
WIY 13,870 kc., 21.63 m.
Rocky Point, N. Y.
WJL 257 kc., 1,123 m.
Greensburg, Pa.
WKA 21,060 kc., 14.25 m.
Lawrenceville, N. J.
WKDU 1,712 kc., 175.15 m.
Cincinnati, Ohio
WKF 19,220 kc., 15.61 m.
WKF 4,750 kc., 63.21 m.
Lawrenceville, N. J.
WKJ 9,590 kc., 31.6 m.
Rocky Point, N. Y.
WKK 21,410 kc., 14.01 m.
WKN 19,830 kc., 15.13 m.
Lawrenceville, N. J.
WKU 14,700 kc., 20.27 m.
WKW 19,020 kc., 15.77 m.
Rocky Point, N. Y.
WLA 18,350 kc., 16.35 m.
WLK 16,330 kc., 18.44 m.
WLO 21,400 kc., 14.01 m.
WLO 16,300 kc., 18.4 m.
WLO 10,540 kc., 28.44 m.
ATT, Lawrence, N. J.
WMA 13,390 kc., 22.4 m.
Lawrenceville, N. J.
WMB 267 kc., 1,123 m.
West Reading, Pa.
WMDZ 2,442 kc., 122.8 m.
Indianapolis, Ind.
WMF 14,470 kc., 20.73 m.
Lawrenceville, N. J.
WMI 19,850 kc., 15.1 m.
WMI 9,700 kc., 30.9 m.
ATT, Deal, N. J.
WMJ 2,422 kc., 123.8 m.
Buffalo, N. J.
WMN 14,590 kc., 20.56 m
Lawrenceville, N. J.
WMO 2,414 kc., 124.2 m.
Highland Park, Mich.
WMP 1,574 kc., 189.5 m.
Framingham, Mass.
WNA 9,170 kc., 32.72 m.
WNB 10,680 kc., 28.09 m.
Lawrenceville, N. J.
WNC 19,200 kc., 15.6 m.
WNC 14,480 kc., 20.7 m.
WNC 9,750 kc., 30.75 m.
WND 18,350 kc., 16.35 m.
WND 13,400 kc., 22.38 m.
WND 6,753 kc., 44.4 m.
ATT, Deal, N. J.
WOA 6,750 kc., 44.41 m.
WOB 5,850 kc., 51.26 m.
WOF 9,750 kc., 30.77 m.
WOK 10,550 kc., 28.44 m.
WON 9,870 kc., 30.40 m.
Lawrenceville, N. J.
WOO 17,110 kc., 17.52 m.
WOO 8,550 kc., 35.09 m.
WOO 6,515 kc., 46.05 m.
WOO 8,630 kc., 34.74 m.
WOO 4,750 kc., 63.13 m.
WOO 4,116 kc., 72.87 m.
WOO 3,124 kc., 96.03 m.
WOP 19,380 kc., 15.48 m.
Ocean Gate, N. J.
WOU 2,590 kc., 115.8 m.
Green Harbor, Mass.
WOX 2,540 kc., 118.06 m.
New York, N. Y.
WPDA 2,414 kc., 124.2 m.
Tulare, Cal.
WPDB 1,712 kc., 175.15 m.
WPDC 1,712 kc., 175.15 m.
WPDD 1,712 kc., 175.15 m.
Chicago, Ill.
WPDE 2,442 kc., 122.8 m.
Louisville, Ky.
WPDF 2,442 kc., 122.8 m.
Flint, Mich.
WPDH 2,442 kc., 122.8 m.
Richmond, Ind.
WPDI 2,430 kc., 123.4 m.
Columbus, Ohio
WPDK 2,450 kc., 122.4 m.
Milwaukee, Wis.
WPDL 2,442 kc., 122.8 m.
Lansing, Mich.
WPDM 2,430 kc., 123.4 m.
Dayton, Ohio
WPDN 2,458 kc., 122. m.
Auburn, N. Y.
WPDO 2,458 kc., 122. m.
Akron, Ohio
WPDP 2,470 kc., 121.5 m.
Philadelphia, Pa.
WPDR 2,458 kc., 122. m.
Rochester, N. Y.
WPDS 2,416 kc., 124.1 m.
St. Paul, Minn.
WPDT 2,470 kc., 121.5 m.
Kokomo, Ind.
WPDU 1,712 kc., 175.15 m.
Pittsburgh, Pa.
WPDV 2,458 kc., 122. m.
Charlotte, N. C.
WPDW 2,422 kc., 123.8 m.
Washington, D. C.
WPDX 2,414 kc., 124.2 m.
Detroit, Mich.
WPDY 2,414 kc., 124.2 m.
Atlanta, Ga.
WPDZ 2,470 kc., 121.5 m.
Fort Wayne, Ind.
WPEA 2,458 kc., 122.8 m.
Syracuse, N. Y.
WPEB 2,442 kc., 122.8 m.
Grand Rapids, Mich.
WPEC 2,470 kc., 121.5 m.
Memphis, Tenn.
WPEE 2,450 kc., 122.4 m.
WPEF 2,450 kc., 122.4 m.
WPEG 2,450 kc., 122.4 m.
New York, N. Y.
WPEH 1,712 kc., 175.15 m.
Somerville, Mass.
WPEI 1,712 kc., 175.15 m.
E. Providence, R. I.
WPEK 2,422 kc., 123.8 m.
New Orleans, La.
WPEL 1,574 kc., 189.5 m.
W. Bridgewater, Mass.
WPEP 1,712 kc., 175.15 m.
Arlington, Mass.
WPET 1,712 kc., 175.15 m.
Lexington, Mass.
WPEV 1,574 kc., 189.5 m.
Portable, Mass.
WPEW 1,574 kc., 189.5 m.
Northampton, Mass.
WPEZ
Miami, Fla.
WPFA 1,712 kc., 175.15 m.
Newton, Mass.
WPFC 2,442 kc., 122.8 m.
Muskegon, Mich.
WPFD 2,430 kc., 123.4 m.
Highland Park, Ill.
WPFE 2,442 kc., 122.8 m.
Reading, Pa.
WPFG 2,442 kc., 122.8 m.
Jacksonville, Fla.
WPFH 2,414 kc., 124.2 m.
Baltimore, Md.
WPFI 2,414 kc., 124.2 m.
Columbus, Ga.
WPFJ 1,712 kc., 175.15 m.
Hammond, Ind.
WPFK 2,430 kc., 123.4 m.
Hackensack, N. J.
WPFL 2,470 kc., 121.5 m.
Gary, Ind.
WPFM 2,414 kc., 124.2 m.
Birmingham, Ala.
WPFN 1,712 kc., 175.15 m.
Fairhaven, Mass.
WPFO 2,470 kc., 121.5 m.
Knoxville, Tenn.
WPFP 2,414 kc., 124.2 m.
Clarksburg, W. Va.
WPFQ 2,470 kc., 121.5 m.
Swarthmore, Pa.
WPFR 2,470 kc., 121.5 m.
Johnson City, Tenn.
WPFU 2,422 kc., 123.8 m.
Portland, Me.
WPGD 2,458 kc., 122.8 m.
Rockford, Ill.
WPGG
Schenectady, N. Y.
WPGS 2,414 kc., 124.2 m.
Mineola, N. Y.
WRDH 2,458 kc., 122 m.
Cleveland, Ohio
WRDR 2,414 kc., 124.2 m.
Grosse Pt. Village, Mich.
WRDQ 2,470 kc., 121.5 m.
Toledo, Ohio.

—X—

X2GA 7,612 kc., 39.4 m.
Nuevo Laredo, Mexico
XAM 11,540 kc., 26.0 m.
Merida, Yucatan
XDA 5,857 kc., 51.22 m.
11,760 kc., 25.5 m.
14,620 kc., 20.5 m.
XDC 9,400 kc., 31.9 m.
XETE 9,600 kc., 31.25 m.
XEW 6,023 kc., 49.8 m.
XIF 6,167 kc., 48.65 m.
Mexico City, Mex.

—Y—

YNA 14,500 kc., 20.69 m.
Managua, Nicaragua
YV1BC 6,110 kc., 49.1 m.
YV11BMO 6,130 kc., 48.95 m.
YV1BC 6,120 kc., 49.02 m.
Caracas, Venezuela
YV2AM 14,110 kc., 21.26 m.
Maracaibo, Venezuela
YV3BC 6,130 kc., 48.9 m.
9,510 kc., 31.56 m.
Caracas, Venezuela
YVQ 11,690 kc., 25.65 m.
13,500 kc., 22.48 m.
YVR 18,300 kc., 16.39 m.
Maracay, Venezuela

—Z—

ZGE 6,000 kc., 50 m.
Kuala, Lumpur, Malay States
ZL2ZX 6,060 kc., 49.5 m.
ZLT 7,390 kc., 40.6 m.
10,990 kc., 27.3 m.
ZLW 12,300 kc., 24.4 m
18,340 kc., 16.35 m.
10,980 kc., 27.3 m

And Now—The Angstrom Unit

(*Continued from page 11*)

this country. A signal that has a wavelength of 1,000 meters travels 1,000 meters during the time it completes one cycle.

Thus, the use of the term wavelength grew and grew, and the most prolific users of the term probably knew less about what they were talking about than those who were in doubt. Soon scientists and engineers began the precise measurement of the wavelength of radio waves. It was found that the term "wavelength" had little significance. You cannot measure wavelength directly; you had to measure the number of cycles per second (frequency) first, and then convert it into wavelength by dividing it into 300,000,000. And since any indirect method of measurement is liable to yield results that are more innacurate than a direct method, the term "wavelength" disappeared from scientific use. But the good old public, difficult to convince and more difficult to "unconvince" once "taken in," persisted in using the word "wavelength" when referring to radio waves.

And another thing: you have to remember too many figures after the decimal point when talking wavelength. It's nice when a station is on 300 meters or 500 meters, but what about the boys in between? Furthermore, the Federal Radio Commission and the Bureau of Standards, who have probably done more work on the measurement of frequency than any other single organizations, use *frequency* in all their work; the word *wavelength* does not exist for them. Broadcast stations are separated 10,000 cycles (10 kilocycles); amateurs are alloted frequency bands in which to work; everything is frequency, frequency, and more frequency. Even now, most newspapers feature the frequency of the stations and the corresponding wavelength in parenthesis.

To facilitate printing and speaking, the frequency of a station is usually divided by 1,000 and given in *kilocycles*. Thus, 550,000 cycles is a rather awkward number to handle, so it is usually shortened to 550 kc. (kc. is the abbreviation for kilocycles).

When the 10,- 20,- 40,- 80- and 160-meter bands (there we go using meters again) were opened to hams, the statement of the frequency became more universal, and was regarded by all as the only way in which to designate the location of a station in a given band.

The Kilocycle and the Megacycle

Soon, the number of kilocycles necessary for expression became too large: a signal may have a wavelength of 20 meters, corresponding to a frequency of 15,000 kc. Now, the number 15,000 is a bit too difficult for the usual lightning calculator to handle without burning up his bearings, so the Final Authorities simply decided to divide by another thousand and call the result *megacycles*, the prefix *mega* being derived from the Greek meaning *great;* but in our parlance signifying a million. Thus, 15,000,000 cycles is the same as 15,000 kilocycles, which, in turn, is the same as 15 megacycles. It's simple, isn't it? Yeh, well try and get some of you birds to use it.

The use of the word megacycles has another distinct advantage. Because of the common units *microfarad* (the millionth part of the farad) and the *microhenry* (the millionth part of the henry), the *megacycle* fits very nicely into the scheme of things when it comes to figures. The only things that makes some calculations difficult is the term 2 pi. 2 x pi x f appears so often that many people prefer to express frequency in radians directly—the number of radians being 2 x pi x the frequency. However, from the looks of things, that's a long way off yet, although you *must* convert frequency in cycles to frequency in radians in about 90% of the formulas used in radio. Right now, though, many radio men do not know they are doing it. (What say, psychologist?)

The Megacycle and the Angstrom Unit

Below 10 meters we have the ultra-short-wave bands. In fact, the Federal Radio Commission has recently opened the 75 centimeter (.75 meter) band for the American amateur. It is strange, but in the ultra short-wave bands those versed in the use of the word frequency again revert to wavelength for purposes of specification. Why? Simply because megacycles fails in its purpose "down there." Let us see just how the whole thing works out.

A fellow wants to tell you that he is working .75 meter—only he does not want to use the term wavelength because of technical reasons. Now, .75 meter corresponds to a frequency of 400,000,000 cycles per second—truly, an imposing array of figures. But, 400,000,000 cycles is the same as 400,000 kilocycles, which is also the same as 400 megacycles. So far so good. But what about the 18 centimeter band? It's used commercially for phone work across the English channel. Note that as the wavelength gets smaller and smaller, the frequency gets bigger and bigger; finally, even the term megacycles does not permit us to ease up on the "brain oil."

The wavelengths below 1 meter are being used more and more, so that it becomes necessary to hunt for some unit that has a general significance and is easy to handle. Fortunately, we do not have to hunt very far, because our next door neighbor, the Light family, has been standardized for years, and they will be more than pleased to allow us to use their units. Hence, the *Angstrom*.

The very high-frequency radio waves and the low-frequency light waves act almost identically. They both can be reflected, refracted, modulated, etc. In fact, as far as frequency is concerned, there is no definite line of demarkation between them. (See the chart on the first page of this article.) The only thing is that energy represented by a radio wave is different from that represented by a light wave. We can see light, but nobody has as yet (to my knowledge) seen a radio wave.

The measurement of light has always been made, in general, in meters. The term frequency is not used because the light experts have not as yet found a convenient unit for the measurement of light frequencies; besides, there is some talk about throwing out the wavelength business in favor of the quantum idea, but that is another story. Right now, light measurements are made in meters as the fundamental units. The meter, however, is so darn large that the Angstrom is used; and the Angstrom is defined as the one ten-billionth part of the meter. Whew! Some numbers!

Things are not as bad as they look. All you have to remember is to move the decimal place ten places to the right when you have meters and you get Angstroms. For instance, looking at the illustration on the first page again, we see that a radio wave with a wavelength of 10 meters has a wavelength or 100,000,000,000 Angstrom units. This figure is larger than the number of meters, *but the point is that it should only be used when the wavelength is below 1 cm.*. The lower you go, the easier it becomes to use the Angstrom. Again, suppose you want to express the English Channel wave of 18 centimeters in Angstrom units, how do you go about it?

Simple. 18 cm. corresponds to .18 meter; and .18 meter corresponds to 18,000,000 A.

Conclusion

An analysis of the entire situation resolves itself down to a few simple rules: (1) don't use *meters* if you can help it; (2) above 100 meters use kilocycles; (3) from 100 down to 1 meter use megacycles; (4) from 1 meter down use the centimeter; (5) below 1 cm. use the Angstrom.

It sounds tough, I know; but buck up, for the worst is yet to come.

Using Pentagrid Converter Tubes

(*Continued from page* 28)

coil is about twice that of the grid coil for the 10 to 25 mc. coil. Increasing plate turns beyond the number given will increase the amplitude of oscillation at the low-frequency end of the range, but will also limit the high-frequency end to a value considerably less than 25 mc.

All except the 10 to 25 mc. coil may be used with the 1A6, although it may be desirable to increase the plate turns on the "4 to 10 mc." coil for use with this tube. All coils will operate with the 6A7 and 2A7 in the circuit of Fig. 2.

It is possible to use the 1A6 in the 10 to 25 megacycle band and the 2A7 and 6A7 at still higher frequencies by connecting a triode in parallel with the oscillator portion of the pentagrid converter, as shown in Fig. 3. This combination may be used in any variation of this circuit without change in connections or voltages. The function of an extra tube is to increase the voltage available for excitation of the oscillator circuit. This is necessary at high frequencies because of the very unfavorable L/C ratios and consequent low impedances obtained with tuned circuits operating at these frequencies. Combinations suitable for use in this circuit are:

Pentagrid Converter	Triode
2A7	56
6A7	37
1A6	30

When these converter-triode combinations are used, it is not necessary to disconnect the triode for low-frequency operation. However, with this combination, it will probably be found desirable to reduce the number of turns in the low-frequency oscillator plate coils in order to keep the voltage developed across the grid coils at the value best suited for operation of the converter.—*RCA Radiotron Company.*

Oscillator Characteristics

(*Continued from page* 19)

and plate resistance of the tube remain constant.

Conclusion

The characteristics of the tickler feedback arrangement show several inherent faults which may or may not be present in the same degree in other methods of feedback. To those familiar with radio receivers, the detuning and other effects are well known, although the quantitative data may be a bit simpler than others given in the past. To those not so familiar with regenerative receivers, it is recommended that the beginning of this article be read in detail.

Fundamental Radio Experiments

(*Continued from page 22*)

applies to the use of the oscillator in both the experiments which follow.

Experiment 2A—R.F. Oscillator

Object: To generate radio waves using an r.f. oscillator.

Method: The three changes to be made in the r.f. unit are shown in Fig. 3. The regular antenna is disconnected to prevent interference and instead a length of wire about 10 feet, stretched out where convenient, is used as an aerial. Increased effects can be obtained with lengths up to 30 feet and by having this wire run in the proximity of the set which is to pick up the oscillator. The set is grounded through a .1 mf. condenser to prevent a short circuit through the 110-volt system, which is grounded.

Tuning the receiver to a point at which no station is received (1600 kc. on curve A, for example), the regeneration control P is advanced to make the set oscillate. The B battery is then disconnected and the 110 v. alternating current plug and lamp connected in its place. (The plug may be inserted either way since A.C. has no steady polarity.) The point in using A.C. is to modulate the wave, that is, to impress an audible frequency on the r.f. oscillation, which by itself is far beyond the range of audibility. In this case, the 60-cycle hum is used as the audible part of the wave.

Observation: Any receiver in the home (a broadcast receiver will do) will pick up the wave and tune it in at a definite point on the dial. Be sure that the broadcast set can reach the frequency selected for the oscillator. The indication will be a strongly amplified 60-cycle hum which can be tuned in and out. The strong amplification is due to the fact that the signal from the oscillator is amplified by both the r.f. and a.f. sections of the receiver being used. Since the r.f. oscillator is calibrated by curves A and B, it can be used as a *frequency meter* to calibrate the receiver being used. Service-men use such an oscillator frequency as a signal generator with which to line up the condensers in a broadcast set and make adjustments for best operation.

Experiment 2B—Radiophone Work

In this experiment, we once more employ the flexible a.f. unit, which we used in Exp. 1C as a one-stage audio amplifier. Here we will use it as a microphone amplifier to modulate the r.f. waves produced by our oscillator, not with a 60-cycle hum as in Exp. 2A, by with speech or music delivered to the microphone. With the proper precautions for preventing interference, the use of this arrangement as a miniature radiophone allows some very interesting experimental work to be done by anyone.

Object: To impress speech on the radio waves generated by the r.f. oscillator.

Method: The output of the microphone amplifier is impressed on the output of the r.f. oscillator by the arrangement shown in Fig. 4. The same precautions as to the changes to be made in the antenna and ground system also apply here. It is more important here to use a good quality receiver to pick up the oscillations. With a commercial electric set, we take advantage of the full amplification power of the receiver, since we are not here using only the audio part of the set as is done with most microphone amplifiers.

Do not attempt to increase the length of wire connected to the oscillator antenna post in order to be received by any set other than one in the same house as the oscillator, since this would constitute transmitting without a license, which is illegal. If the oscillator and receiver are separated by more than two rooms in the same house, the reception of the signals will be aided by a wired-radio set-up. In this arrangement, a coil of a few turns, coupled to the oscillator coil, is connected to the 110 v. line through a 0.1 mf. condenser; the waves traveling along the power line are picked off by connecting the antenna post of the receiver to the 110-v. power line, again through a 0.1 mf. condenser. For the ordinary case, the 10-ft. length of wire used for the oscillator will give satisfactory results.

Observations: The experiments and stunts that can be tried with the microphone were covered in the previous article. When the radiophone is used by one who has learned the microphone technique, imitations of broadcasting may be given, which can be very realistic when tuned in, in another room, on a commercial receiver. As an experiment, it goes far to reveal the true nature of radio broadcasting.

—o—

Mounting Insulators

In mounting insulators or sockets made of ceramic materials, always use a fiber washer under the head of each screw. This will take up pressure and prevent cracking.

* * * * *

In drilling aluminum for panels or chassis decks, the best method of handling is to clamp the sheet between two flat boards and to drill through the entire "sandwich". The holes will come out round and clean and the surface of the metal will be protected against damage by slipping drills.

If a pair of tinner's snips is not available for cutting purposes, score the aluminum heavily on both sides and it will break off evenly.

Selecting the Proper R. F. Choke

(Continued from page 15)

By connecting a condenser from plate to ground, a low-impedance path is offered to the frequency to be eliminated. Thus, at the junction J, the current has two paths: the first through the choke, transformer primary, etc., to ground, and the second, from the plate to the ground through condenser C. If the impedance of the choke is large compared to the impedance of C, then the major portion of the current will go through C, regardless of whether the frequency is lower than, equal to, or less than the natural, frequency of the choke. Note particularly that this holds only provided that the impedance of the choke is large compared to C.

Fig. 6 shows the variation of impedance with frequency of a choke. The dotted line through the peak represents the resonant frequency of the choke. Now, at some frequency higher than resonance, say at f_2, the choke is a condenser—a small one, to be sure—but the impedance of the combination is so large compared to the reactance of bypass condenser C, that most of the current to be suppressed goes right through C; only a small portion actually passes through the plate load. This process continues until the frequency to be suppressed is so high that a goodly percentage of the current actually passes through it instead of through C. What the limiting frequency is depends upon the value of L and Co of the choke and the value of C. Therefore, a choke may be used at frequencies much higher than its resonant frequency *if at least one bypass candenser is used with the choke.*

Conclusions

From this last discussion two conclusions may be drawn: (1) a choke may be used successfully at frequencies much higher than its resonant frequency by the addition of bypass condensers; and (2) the theory of operation of the choke is different when used without bypasses than when using bypasses.

The higher the ratio of L to Co, the more the impedance decreases as the frequency departs from the resonant frequency, although the *actual value* of the impedance is greater at any time compared to another choke having the same resonant frequency, but a lower value of L/Co. This holds true only if the resistances of the two chokes are also the same, something not readily obtainable in practice.

To choose the best choke—with bypass condensers—for your purpose, then, determine the lowest frequency to be eliminated by the choke circuit and the largest value of bypass condenser C that may be used without a choke in order not to affect the frequencies that are to be passed on to the next tube.

Next, pick a choke with an inductance of such value that its reactance at the lowest frequency to be used is about ten times the reactance of the bypass condenser C. Last, but not least, the choke must, at the *highest* frequency in use, be such that its inductance and distributed capacity combined have an impedance equal to about ten times the reactance of the bypass condenser at the highest frequency. Under these conditions, effective choking action will result over the entire band covered by the apparatus.

Bear in mind that the theory of operation of a choke depends entirely upon its associated equipment, not upon its method of connection in the circuit. It was seen that without bypasses of any sort, choking action will be obtained, but at the expense of probable oscillation if the phase of voltages and the resistance of the tuned circuit will permit. This method is recommended only in cases where, because of circuit requirements, a bypass condenser cannot be connected. In all cases where circuit constants are such as to permit the use of at least one bypass condenser, by all means use it.

U.S. Station Schedules

W2XE, the short-wave transmitter associated with WABC, the key station of the Columbia Broadcasting System at Wayne, N. J., is rated at 1000 watts of power and operates according to the following schedule, E.S.T.:

15,270 kc. (19.646 meters) 11 a. m. to 1 p. m.

11,830 kc. (25.36 meters) 3 p. m. to 5 p. m.

6,120 kc. (49.02 meters) 6 p. m. to 11 p. m.

Station W1XAZ, one of the Westinghouse Radio stations in New England, located at Millis, Mass., (eighteen miles from Boston) is rated at 10 kw. It transmits from 7 a. m. to 1 a. m., E.S.T., on 9,570 kc. (31.3 meters).

Station W8XK, of the Westinghouse Electric & Mfg. Co., Pittsburgh, Pa., operates as follows:

6,140 kc. (48.86 meters) Daily 4:30 p. m. to Signoff.

11,870 kc. (25.27 meters) Daily 4:30 p. m. to 10:00 p. m.

15,210 kc. (19.72 meters) Daily 10:00 a. m. to 4:15 p. m.

21,540 kc. (13.93 meters) Daily 7:00 a. m. to 2:00 p. m.

(Times listed are Eastern Standard Time)

W8XK operates in conjunction with and relays the programs of KDKA. No advance programs of KDKA are mailed to listeners.

Quartz Crystals in S. W. Supers

THE article entitled "Quartz Crystals in S.W. Supers," which appeared on page 42 of the January 1934 issue of SHORT WAVE RADIO, seems to have aroused considerable interest. We are printing herewith letters received from Mr. James J. Lamb, Technical Editor of *QST*, who, as mentioned in the article, is responsible for present day single-signal receivers, and from Mr. Arthur H. Lynch, Vice-President of the Stenode Corporation of America and President of the Lynch Mfg. Co. These letters are self-explanatory.

"I have just looked over your very interesting issue for January and congratulate you upon the continued interest which obtains between the covers of your periodical.

"An unsigned article entitled 'Quartz Crystals in S.W. Supers' has been called to my attention and may cause some confusion of thought, but it is good to see that you are helping to overcome the erroneous impression which is growing among short wave broadcast listeners that the 'single signal' receiver is suitable for short-wave broadcast reception.

"Single signal receivers of the type developed by the National and Hammarlund Companies along the lines suggested by Mr. James Lamb of QST, in our opinion most certainly incorporate the Stenode principles developed by Dr. James Robinson and covered by American patents issued to this corporation:

Patents No.

1867958 1821033 1876163 1876162 1821032

1889293 1854066 1878891 1898895

in addition to numerous other patents pending.

"While these receivers have been designed for radio telegraphic rather than radio telephonic communications, it is possible to apply the same principles for the reception of short-wave broadcasting by adding a suitable audio amplifier. There is a real field for development along this line among the more serious short wave broadcast listeners.

"It is possible that the article appearing in your magazine can be misconstrued in some respects and clarification is desirable. The statement has been made that simpler circuit combinations for the securing of high selectivity have proved quite satisfactory and less costly than would be possible with crystals. While this statement may have been true at the time when super selectivity as a result of the use of crystals was first introduced, the modern application of crystals brings about the benefit of super selectivity in a most inexpensive and certainly most practical manner.

"The last paragraph of your article might also be very misinterpreted. While it is a fact that the original demonstrations of the models of the Stenode receiver first brought here from England and placed in operation before the Radio Club of America were looked upon with anything but favor by the engineering fraternity in general, it must be remembered that even at that time there were a few who recognized the potentiality of the Stenode's fundamental principles.

"Since that time the same principles were used by this corporation at its laboratory on Long Island in co-operation with the engineering departments of most of the leading broadcast receiver manufacturers, with the result that a Stenode receiver was developed which outperformed any other receiver then on the market in the matter of selectivity and it was generally agreed by those who witnessed its demonstration that the audio quality was equal to any receiver on the market and a great deal better than most.

"A very complete article, describing tests of these receivers observed by Messrs. W. W. MacDonald, Technical Editor and Ray Sutliffe, Managing Editor, of the McGraw-Hill publication *Radio Retailing* and published in the June 1931 issue of that magazine, indicates that the claims originally made for the Stenode by Dr. Robinson were very satisfactorily demonstrated in practise.

"I am sure it was not the intention of the article you published to minimize the importance of the Stenode and I trust that this explanation of our point of view in the matter will be of real interest.

Cordially yours,

STENODE CORP. OF AMERICA,
ARTHUR H. LYNCH,
Vice-President.

P. S. The National Co. of Malden, Mass., are licensees of this corporation and negotiations are now under way with the Hammerlund Mfg. Co."

* * *

"In connection with comments on quartz crystals in s. w. supers, your January issue, I believe that an important feature of filter operation in the crystal-type single-signal receiver, as developed by me, has been overlooked.

"As has been pointed out in my several articles on the development (the latest being in Nov., 1933, *QST*), the quartz filter selectivity is variable, the selectivity or equivalent band width obtainable (by variation of impedance in series with the crystal) ranging from approximately 18 cycles to over 100 cycles in a typical instance. Although the maximum selectivity of the crystal circuit (minimum band width) is unquestionably improper for 'phone or program reception, the lesser order of selectivity obtainable is decidedly useful, even where interference from other signals is not a concern. Since the reduction in equivalent noise is generally inversely as the square root of the equivalent band-width ratio. a considerable improvement in the *effective* sensitivity of the receiver is actually realized, while still maintaining surprisingly passable intelligibility, even in program reception. In a typical case the signal-noise ratio is 7 times that of the same receiver as a "straight" superhet, with filter selectivity such that program reproduction approximates that experienced in ordinary broadcast reception with audio tone control of the "bass" order. This, of course, increases the effective sensitivity of the receiver in the same proportion, permitting a corresponding increase in receiver gain.

"Noise being the limiting factor in high-frequency reception in many instances, it would seem that this type receiver would find use in locations where short-wave broadcast reception would be otherwise impracticable."

Sincerely yours,
JAMES J. LAMB,
Technical Editor, *QST*."

Some Notes on Super-regeneration

(*Continued from page* 27)

value of grid condenser and leak employed. The result is that the grid becomes increasingly negative until a point is reached where the grid is made so negative that the mutual conductance of the tube is no longer sufficient to maintain oscillations, and they consequently die out. After the negative charge has leaked off the grid, conditions are again favorable for oscillation, and the cycle is repeated.

The operation of this circuit differs from that of the normal super-regenerative mainly in that the signal always builds up to the same value before oscillation ceases. However, inspection of Fig. 2 will indicate that the time required for a signal to build up to any given value will depend on the initial value of that signal. Consequently, a weak signal will produce fewer dips in the plate current per unit of time than a strong one. Hence, the average plate current will be greater for a weak signal than for a strong one, and the incoming modulated signal will be faithfully amplified.

For proper operation of this circuit a grid condenser of .0001 mf. and a grid leak of 3 megohms will generally be satisfactory.

For the production of satisfactory inaudible irregular oscillations, it is imperative to employ as high an L/C ratio as possible. In other words, the inductance should be as high as possible and the capacity as small as possible. The number of tickler turns should be no more than necessary for the production of irregular oscillations.

Letters From Readers

THE instant and widespread popularity achieved by SHORT WAVE RADIO has been very gratifying to the publishers and justifies their opinion that a real need existed for a conservative, accurate magazine devoted to the interests of short-wave enthusiasts. Hundreds of congratulatory letters have poured in on the editors, who take pride in quoting from a few of them selected at random.

"I have purchased all three issues of SHORT WAVE RADIO. I am a 'green' amateur, and I can truthfully say that the different articles are surely explained clearly.

Harry B. Webber
513 No. Maple
Watertown, So. Dak."

"After seeing a copy of the November issue of SHORT WAVE RADIO at a recent meeting of the Newark News Radio Club, I decided to buy the next issue and did so. I like the magazine because of the way the short-wave field is dealt with. I don't care for publications which are dedicated to short waves just as a matter of course. I prefer one which gets right into the short-wave end and provides information which the reader really wants. I have the December issue and after difficulty in trying to get the magazine through our dealer, I decided to subscribe.

Clement Van Velsor
1033 Sanford Ave.
Irvington, N. J."

"Congratulations on your first issue and may you grow rapidly! I received an advertisement from you some time ago but thought it was only another magazine and disregarded it. Went into a news room to buy cigarettes and came out with SHORT WAVE RADIO and no cigs! I read the magazine from cover to cover and then ran down to some of the gang, and of course, had to loan it to some of them, but made sure I got it back. All proclaimed it a hit. Yes sir, hits the amateur, the short-wave listener and the experimenter; hits them right in the spot, and they want more dope like it.

Norman W. Smith, Secy.
Jamestown Amateur Radio Assn.
P. O. Box 273
Jamestown, N. Y."

"Please accept my congratulations on Vol. 1, No. 1. You have apparently succeeded in putting together a very readable collection of worthwhile material, at the same time keeping away from the rather insulting cheapness of tone which utterly ruins some of the other radio and pseudo-scientific publications. Do your best to steer clear of editorial comment, which, through highly colored claims and promises, tends to create in the uninformed reader extravagant expectations of performance from the circuits described. Conservative comment, phrased simply and with dignity, will attract a host of readers who have been a bit sickened by the other sort of thing.

H. P. Manly
698 Sixty-First St.
Oakland, Calif."

"Maybe you fellows don't know it—and maybe you do—but you are putting out a most interesting magazine, and you are appearing on the scene at a very psychological moment, by which I mean that right now the grand army of BCL's are getting quite a collection of 'all-wave' and even an occasional short-waver stuck right under their eyes in the 1933-1934 lines. They are, it seems clear to me, on the verge of spilling over into quite a wave (sic) of S.W. consciousness, and I should strongly imagine that a good percentage of these fellows—and YL's—are doomed to get almightily interested in following really interesting S.W. developments, in understanding what it is all about, in getting themselves more sensitive and more specialized strictly S.W. sets and in following and keeping up with the slightly unstable schedules of S.W. stations. You of SHORT WAVE RADIO are very much on the job, as one can observe very readily by reading the first two issues.

Donald M. Gildersleeve, M.D.
2518 Webb Ave., Kingsbridge
New York, N. Y."

"I have just purchased a copy of your new magazine and think it is a WOW. I have constructed many long-wave sets but am just getting interested in short waves again, principally on account of your magazine.

Edward Bernard Patten
Little Road
Morris Plains, N. J."

"Congratulations on your new magazine SHORT WAVE RADIO. May it prosper and live to a ripe old age. In my humble opinion it is 'just what the Doctor ordered' and is free from drivel. The printing is flawless and illustrations are numerous and clear.

John A. Haley
1450 Shannon Ave.
Indianapolis, Ind."

"Obtained Vol. 1, No. 1 and have enjoyed SHORT WAVE RADIO very much. It appears to promise a good future if its general make-up is continued and I am sure you will see to that.

"Your cover is a great improvement over the others that have come into the home during the past years. Most fans are considered 'nuts' enough without their magazine assuring everyone they are wherever it is seen. Some covers I am ashamed to display in public—so you can count on me for a steady SHORT WAVE RADIO reader.

L. H. Taylor
615 South Blvd.
Oak Park, Ill."

"Today, I bought the first copy of your magazine, and I will say that it has lots of good dope in it, and no doubt will improve with age, like other good things.

W. S. Armstrong
53 Dixon Ave.
Toronto, 8, Ontario, Canada"

"Allow me to offer my congratulations on the very interesting manner in which you have offered your first copy of SHORT WAVE RADIO. I have not only found it intensely interesting in every respect, but I have found one article which is very useful.

A. J. Manning
1252 Greenwich Ave., S. W.
Atlanta, Ga."

"I have just obtained a copy of the first issue of SHORT WAVE RADIO, and I am all for it. You have gotten off to a fine start and your method of presentation particularly appeals to me.

Wendell C. Miller
26 Oakview Ave
Maplewood, N. J."

"Let me be among the early birds to congratulate you on your new magazine SHORT WAVE RADIO. Have heard many very nice compliments and have seen at least six of the issue in the hands of real 'dyed-in-the wool' radio enthusiasts. Such men as Kruse, Denton and Lynch should be able to give us some real practical information—now let's not get it too technical either. Just completing a nice portable 'Convertible 5' and may send you a picture of it later. Good luck to you and best wishes.

T. J. Sadilek, W9APM
4600 University Ave.
Des Moines, Iowa."

"Either I have been negligent or delving in the wrong radio sector, but your SHORT WAVE RADIO issue of December, 1933, issue is splendid. I never saw it on the local newsstands before and regret I have missed previous issues.

"I wish to congratulate you on the excellent articles. My interest in radio dates back a long time, but only recently have I picked up where I ceased several years ago. Every article in the December issue is not only interesting to those in radio, but the average radio listener can obtain considerable knowledge from the articles it contains.

J. F. Schmieskors
Box TT
Boulder City, Nev."

"The November issue of SHORT WAVE RADIO, which I purchased at the corner drug store, was Providential. It contained articles I could understand and the description of and directions for building the 'Convertible Five' were so complete that I think I can tackle it. From the standpoint of a novice you are to be congratulated on the start you have made.

Parke K. Bryan
3229 E. Pine
Wichita, Kans."

"I have before me a copy of SHORT WAVE RADIO, which I purchased today on the newsstand and wish to say that I am very much pleased with same, the quality of the articles therein. Coupled with the fact that two such prominent men as Robert Hertzberg and Louis Martin are behind it is conclusive evidence that the future numbers will be interesting and instructive. This medium fills a long felt want, as my experience has been that short-wave magazines that I have subscribed to and have been able to get hold of heretofore were altogether too elementary, mostly for the novice and tyro. Your article 'A Compact Amateur Station W2FIU' was to me about the most interesting article that I have had the pleasure of reading along this line. Enclosed please find money order for one year's subscription. I do not want to run the risk of missing one single copy.

W. M. Horton
Box 462
Douglaston, Wyo.

Comfort in Tuning

The personal comfort of the operator is an important factor in the tuning of sensitive, ultra-selective short-wave receivers. Place the receiver far enough back from the front of the table to give your whole arm, up to the elbow, complete support. Use a chair that supports your back and permits you to relax thoroughly.

Most people can hear better in a dimly lighted room than in a brightly illuminated one.

Report on a Special Broadcast

by Our Short-Wave Reporter

ONE night in October, a score of men in New York stood listening to a program coming via short waves from the world known station HCJB, Quito, Ecuador.

Mr. Clarence W. Jones, the station's director, notified Capt. Horace L. Hall of New York that he intended to broadcast a program in his honor from 10 to 11 p.m. E.S.T., on October 28th, 1933. Captain Hall arranged one of his regular Saturday night DX parties.

As the hour of ten approached Captain Hall started to warm up his powerful superhet and tuned for the 73-meter channel for HCJB. To the consternation of all present there was such strong television signal interference that it was impossible to pull through any program. After waiting for this to go off the air, the 73-meter band was tuned in again and there were code signals. The guests were getting rather disgusted and wandered into the other room to DX the long-wave receiver with which Capt. Hall has pulled in every State in the Union (except one).

One short-wave fan and experimenter, Mr. Peter Curry of Yorktown Heights, N. Y., who made a special trip to the city to hear the program, started tuning with ear phones. Leaving the receiver he then went into the room where everyone was listening to KFI and quietly announced, "If anyone wants to hear that program I'm going to put it on the loud speaker." KFI was forgotten in a grand rush to be first in the short-wave "shack."

Mr. Curry threw the signals into the loud speaker and there with R-6 signal strength was Mr. Jones' voice saying, "Hello, Captain Hall! This is a special program broadcast in your honor, through HCJB. Capt. Hall sends greetings to his many short-wave fan friends." Then the "Star Spangled Banner" was played and another announcement along the same lines as the first.

The DX party ended up with a letter being written then and there and all present signed it. The following day it was sent via air mail to the man who made an event in the lives of all those present.

We questioned Capt. Hall on the details of this station and he told me this: The transmitter of HCJB is located 15 miles south of the line of the equator and at an altitude of nearly 10,000 feet. They broadcast each evening of the week except Mondays, beginning at 8 o'clock Quito time, which is 14 minutes behind E.S.T. The programs include national music, news items, etc.

The station sends out a very clever QSL which attracts the eye of everyone who sees it. The address is Mr. Clarence Jones, Casilla 691, Quito, Ecuador, S. A.

Some Notes on Soldering

THE surprisingly large number of inquiries received by the editors on the subject of soldering indicates that many people have not been properly instructed on this very important operation. Many radio constructors who are otherwise quite adept with tools seem to run into serious difficulties when they pick up an iron.

The entire trick of soldering can be summed up in one lonely, solitary word—*cleanliness*. It is important that both the "iron" and the work be absolutely bright and shiny. Some people have an idea that soldering flux is a cleansing agent, but this is not at all the case. The only function of the flux is to prevent the formation of a microscopically thin layer of oxide on the surface of the metal to be soldered. Oxides of this kind form on all solderable metals when heat is applied to them, and absolutely prevent the molten solder from flowing into the pores of the metal.

Many constructors who can solder successfully with the aid of paste fluxes find themselves stumped when they use rosin-core solder, which is unquestionably the best for radio work. (Rosin, unlike other fluxes, has no corrosive after effects.) The difficulty here does not lie with the solder or the flux, but invariably is due to the impatience of the constructor. Rosin melts more slowly than paste fluxes and its chemical action in dissolving the thin oxide film seems to be slightly slower. The trick is merely to use a hot iron and to keep it on the joint for an appreciable length of time, say six or eight seconds, until the rosin burns out thoroughly. While the rosin is melting, the molten solder will tend to assume a globular shape; as soon as the rosin is completely burned, the solder will flow on to the joint and stick there.

To facilitate set construction, it is advisable to use tinned wire, preferably of the push-back insulation type. The insulation keeps the tin coating bright and clean, and the wire itself therefore requires no preparation for the soldering operation. However, soldering lugs on various instruments very frequently accumulate films of dirt or oil from the fingers, and these must be wiped off with a dry rag. If the item to be soldered is not already tinned, the surface must be cleaned thoroughly. For flat surfaces, nothing equals fine emery cloth for effectiveness. For cleaning untinned wire, use the back edge of a knife, not the sharp edge, as the latter is likely to nick solid wire or to cut the fine strands of flexible wire.

The tip of the soldering iron itself must be kept bright and clean, and special attention must be paid to the elimination of pits.

Standard Frequencies

(Continued from page 10)

do.	6,875	KNK
do.	13,960	KNW
do.	7,655	KWA
do.	7,670	KWB
do.	8,850	KWC
do.	8,990	KWD
do.	10,890	KWI
do.	13,000	KWJ
do.	14,740	KWM
do.	15,535	KWP
do.	18,260	KWQ
do.	21,380	KWS
do.	13,750	KWT
Sayville, N. Y.	6,942.5	WIB
do.	7,737.5	WIC
do.	6,935	WID
do.	7,745	WIE
do.	7,752.5	WIF
do.	7,760	WIG
do.	6,927.5	WIH
do.	8,710	WIJ
do.	9,070	WIQ
do.	9,290	WIT
do.	10,170	WIU
do.	10,490	WIV
do.	10,810	WIW
do.	10,820	WIX
do.	13,030	WJJ
do.	13,960	WJV
do.	14,680	WJX
do.	14,710	WKI
do.	17,140	WKR
do.	16,285	WKS
do.	16,370	WKT
do.	8,990	WKV
do.	18,789	WMD
do.	19,560	WMG
do.	19,580	WMK
do.	14,740	WML
do.	19,620	WMM
do.	19,740	WMQ
do.	20,980	WMY
do.	4,660	WMZ

Kinks to Remember

IN using earphones or loud speakers of the magnetic type directly in the plate circuit of output tubes without benefit of coupling transformers, it is desirable to "pole" the connections so that the steady plate current, which is d.c., helps to increase the strength of the permanent magnets. With earphones, the correct connection can be determined quite easily by unscrewing one earcap and testing the steady attraction of the magnets by pulling on the diaphragm. With speakers having the driving unit covered, the better connection can be determined only by listening carefully to weak signals.

"B" batteries last longest if kept in a cool, dry place. Excessive cold will reduce their output temporarily, but they will recover when normal room temperature returns. Excessive heat, on the other hand, damages them permanently. Most batteries are sealed so thoroughly they are not affected to any extent by ordinary degrees of humidity.

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The best authors in the short-wave field are regular contributors. Among these are Clifford E. Denton, Robert S. Kruse, Arthur H. Lynch, Capt H. L. Hall, H. G. Cisin, Alfred A. Ghirardi, J. A. Worcester and John B. Brennan. Keep up with short-wave radio by reading SHORT WAVE RADIO!

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