An R. F. Short-Wave Broadcast Receiver*

(Awarded $100.00 Monthly Prize—See page 1119)

Incorporating an Optional R. F. Stage, Interchangeable Coils for the 10-725-meter Bands, and Push-Pull Amplification

By W. Francis Goodreau

WAVELENGTHS below 200 meters are rapidly becoming established as channels for the broadcasting of radio entertainment. The recent announcements of the decision of a number of popular broadcast stations to operate special transmitters on these waves proves that the industry's growing faith in transmission on high frequencies is beginning to be manifest in a concrete form. On the other hand, the interest of the general public in the construction of short-wave receivers shows that the special programs which are being transmitted on waves outside the broadcast band are being appreciated.

Short waves have many advantages, from the viewpoints of both the broadcaster and the listener. In the first place, they seem to be more efficient, as the programs of low-power stations are frequently heard half-way around the world. Secondly, there is less congestion, as more individual channels are available; and, as a result, a listener may often receive the program from the short-wave transmitter of a station with less interference than would be experienced in receiving the same program broadcast on the regular waves.

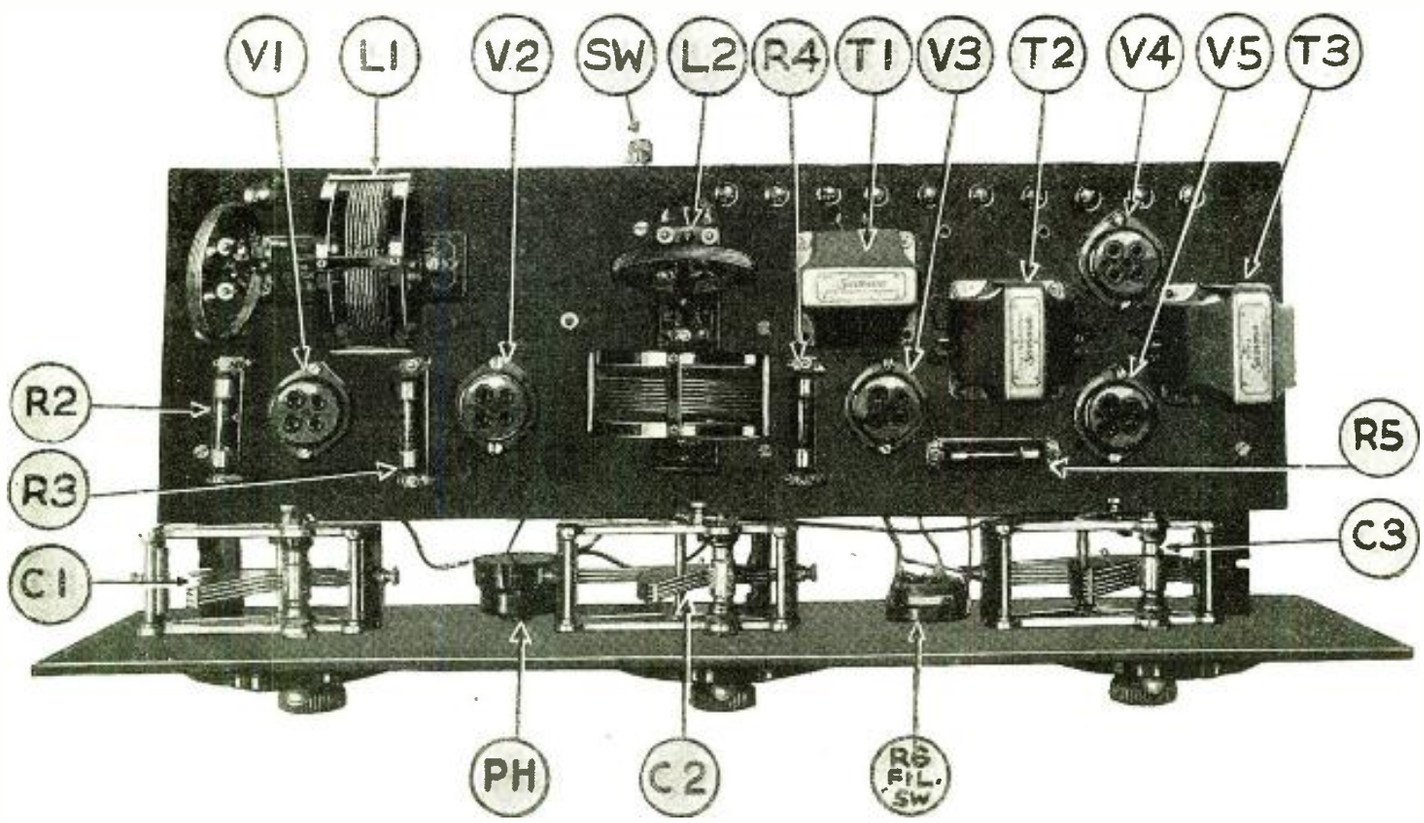
ENORMOUSLY GREATER RANGE

Not only in the United States, but in a number of other countries (including England, France, Germany, Holland, etc.) many stations are broadcasting on waves between 30 and 200 meters. A majority of these programs, even those originating on the other side of the Atlantic, are available to the owner of an efficient short-wave receiver. A number of these stations are broadcasting on regular schedules, while a great number are "on the air" quite frequently, especially when unusual programs are being offered. Practically all of the short-wave stations in this country broadcast the same program simultaneously on their broadcast and short-wave transmitters.

BECAUSE of the demands of readers for the constructional article on a short-wave receiver which it contained, the issue of RADIO NEWS *for October, 1927 has been completely exhausted. To satisfy the many people who want to get into the short-wave "game," we are presenting herewith a second article describing another short-wave receiver of excellent design. We earnestly recommend it to our readers who wish something new.*—EDITOR.

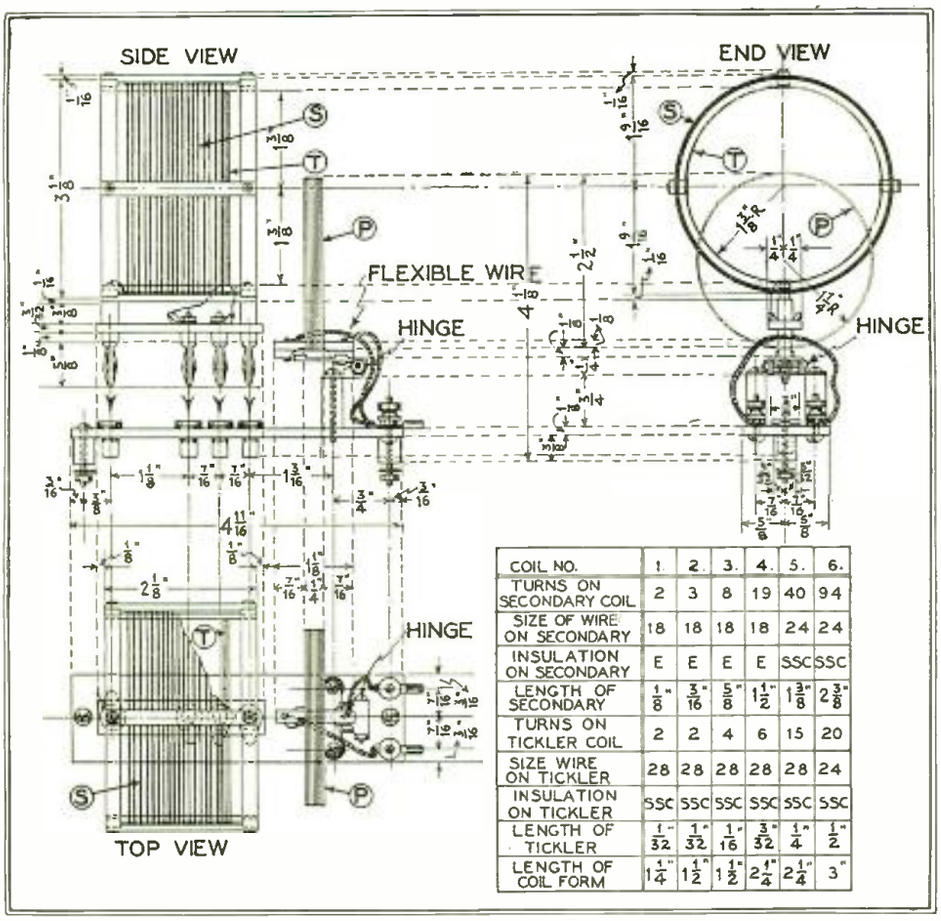
Because of their musical excellence, these programs are interesting to every listener, and especially to the DX fan who, having received practically all of the American and Canadian stations, is looking for new worlds to conquer. Unfortunately, until recently it was not possible to hear the short-wave broadcasts with any degree of satisfaction, because of the lack of suitable receivers. The sets that were used were mostly designed for code reception and, although they were very efficient, they were not designed to give the quality of reception demanded of broadcast receivers to-day.

Recently, however, articles have appeared in a number of radio magazines describing the construction of sets designed for quality of tone reception on short waves. Most strictly-short-wave receivers use condensers of very small maximum capacity in order to tune to the short wavelengths. When receivers of this type are used for the reception of waves above 200 meters, it is



This picture shows the location of practically all parts used in the construction of this short-wave receiver; the symbols correspond to those used in the wiring diagrams and the list of parts. L1 and L2, R.F. coils; T1, T2 and T3, audio transformers; V1, V2, V3, V4 and V5, tube sockets; C1, C2, tuning condensers; C3, regeneration condenser: R2, R3, R4 and R5, filament ballasts; R6, volume control; PH, oscillation control, Sw, switch controlling R.F. amplifier stage.

* RADIO NEWS *Blueprint Article No.* 52.



COIL NO.	1.	2.	3.	4.	5.	6.
TURNS ON SECONDARY COIL	2	3	8	19	40	94
SIZE OF WIRE ON SECONDARY	18	18	18	18	24	24
INSULATION ON SECONDARY	E	E	E	E	SSC	SSC
LENGTH OF SECONDARY	1/8"	3/16"	5/8"	1 1/2"	1 3/8"	2 3/8"
TURNS ON TICKLER COIL	2	2	4	6	15	20
SIZE WIRE ON TICKLER	28	28	28	28	28	24
INSULATION ON TICKLER	SSC	SSC	SSC	SSC	SSC	SSC
LENGTH OF TICKLER	1/32"	1/32"	1/16"	3/32"	1/4"	1/2"
LENGTH OF COIL FORM	1 1/4"	1 1/2"	1 1/2"	2 1/4"	2 1/4"	3"

Diagram gives complete details for building the six sets of coils required in order to give this set a wavelength range from 10 to 725 meters. The primary coil consists of 10 turns of No. 24 S.S.C. wire wound on a form 2½ inches in diameter, with whichever set of coils it is used.

necessary to use coils having a large number of turns of wire, in order to get an inductance value high enough to cover the waveband between 200 and 500 meters. While it is true that a tuned circuit having a large inductance and a small capacity will usually give louder signals from any given station than a smaller inductance and large capacity tuned to the same station, it is also true that the *selectivity* of the circuit using the small condenser and large inductance will not be as great as that of the other combination.

FAULTS OF EARLY DESIGN

It seems to have been the idea of the designers, of most short-wave receivers, that these were to be used entirely for reception of short waves; and that a separate receiver would be used for the regular broadcast band. While the use of plug-in coils will enable the operator of a short-wave receiver to cover the different bands, it will result in a receiver that is not very selective above 200 meters. The design of most of these short-wave receivers is rather a step backward, when compared with the usual set used for broadcast reception; since practically all of the sets designed for short-wave work are of the plain regenerative type.

It must be admitted that the use of two receivers has some advantages; but it must also be pointed out that the cost of two receivers is beyond the means of many. Besides this, there is the requirement of additional space, not only for the receivers but for the separate sets of batteries that would probably be used.

The special short-wave receiver described in this article was designed to be a flexible receiver, suitable for use on any wavelength band merely by plugging in the proper coils. By referring to the schematic diagram of this set, you will see that a stage of tuned radio frequency has been placed before the usual regenerative circuit. Because of this additional tuned circuit, the receiver is very selective on wavelengths above 200 meters, even though small tuning condensers are utilized. The audio-frequency amplifier has been designed for quality reception; it includes one stage of straight transformer-coupled and one of push-pull amplification. Thus, it will be seen that this set combines the advantages of both the broadcast and short-wave receivers in one flexible all-wave circuit.

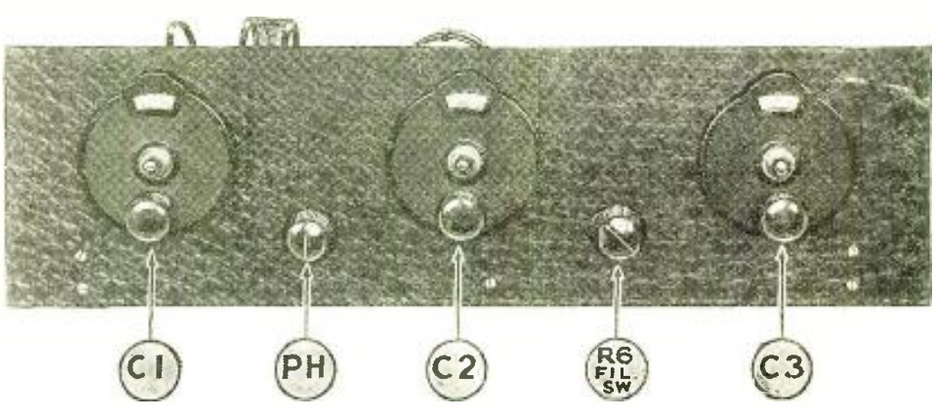
CONSTRUCTION

The set is so designed that the experimenter will find it easy to construct according to his personal desires, since a wide number of types of tubes can be used in the set. If it is not so desired, the audio-frequency end of the circuit need not be of the push-pull type; although the quality of reception will probably be somewhat better if this type of amplifier is used. Another point in favor of this receiver is that, although a complete equipment of coils to cover all the wavebands over which the set is capable of operating would be rather expensive, the constructor may purchase the coil mountings and two coils for the short-wave band at which the receiver is to be operated most frequently, and add the other coils later when finances permit. This feature alone is a good indication of the flexibility of this receiver.

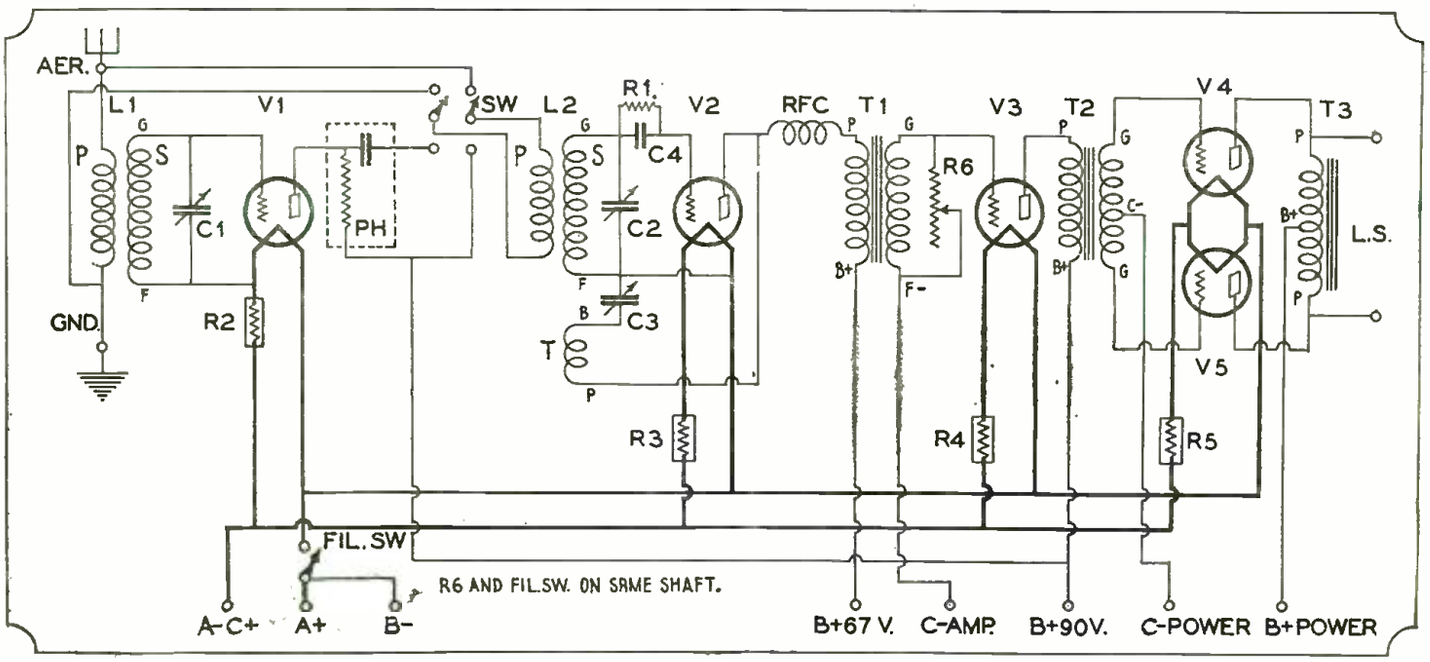
With the panel and sub-panel drilling layouts shown here, it will be a simple matter to place the various parts in their proper positions. It will be noted that, although the front panel measures only 24 inches long, the spacing from center to center of the variable condensers is 8 inches; more than the usual spacing of such instruments. Because of the short wavelengths to which this set can be tuned, this spacing was deemed desirable to prevent interaction between units and eliminate any need for shielding. The coils are placed at right angles to each other and sufficient space is left between them to assure correct operation.

In assembling the set, the sub-panel should be drilled first and the apparatus mounted on it. After this, the front panel should be drilled and the condensers (C1, C2 and C3) volume control (R6) and oscillation control (PH) mounted. Care should be taken in laying out the panel and sub-panel, in order to get the holes at the right points; as otherwise considerable difficulty will be encountered when mounting the apparatus. After all of the parts have been mounted on the panel and sub-panel, the brackets should be screwed into place and the set is ready for wiring. The oscillation control has been mounted on the front panel because of the need of readjusting it with the different coils and tubes that will possibly be used.

It will be noticed that a double-pole, double-throw, jack switch (Sw) has been incorporated in the set between the radio-frequency and detector tubes. This switch is for the purpose of comparing results obtained with the set when the radio-frequency stage is used and when the set is operated as a simple regenerative receiver. It is also helpful in adjusting the receiver when it is first tried out.



This shows the arrangement of controls on the front panel of the set. C1 and C2, wavelength tuning dials; C3, regeneration control; PH, oscillation control; R6-Fil. SW, volume control and filament switch. The plug-in coils are partly visible.



This schematic wiring diagram gives complete details of all electrical connections in the receiver; and the symbols which are used to identify them correspond with those in the other illustrations, as well as the text.

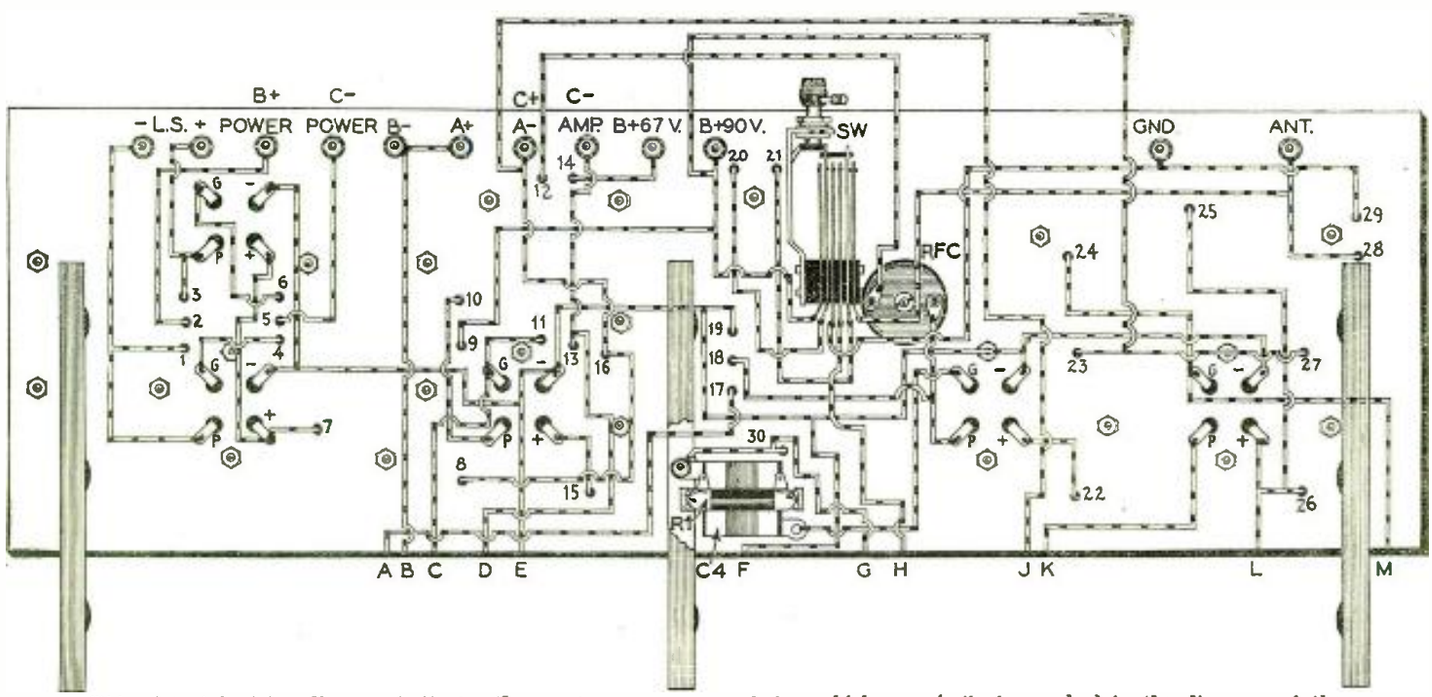
Care should be taken in placing the grid leak R1 and grid condenser C4, to keep them away from the plate wires leading to the radio-frequency tube (V1) and also from the radio-frequency choke (RFC) in the detector plate circuit. The sub-panel mounting brackets are placed as indicated; one slightly off center to provide additional support for the weight of the audio-frequency transformers (T1 and T2).

TESTING AND OPERATING

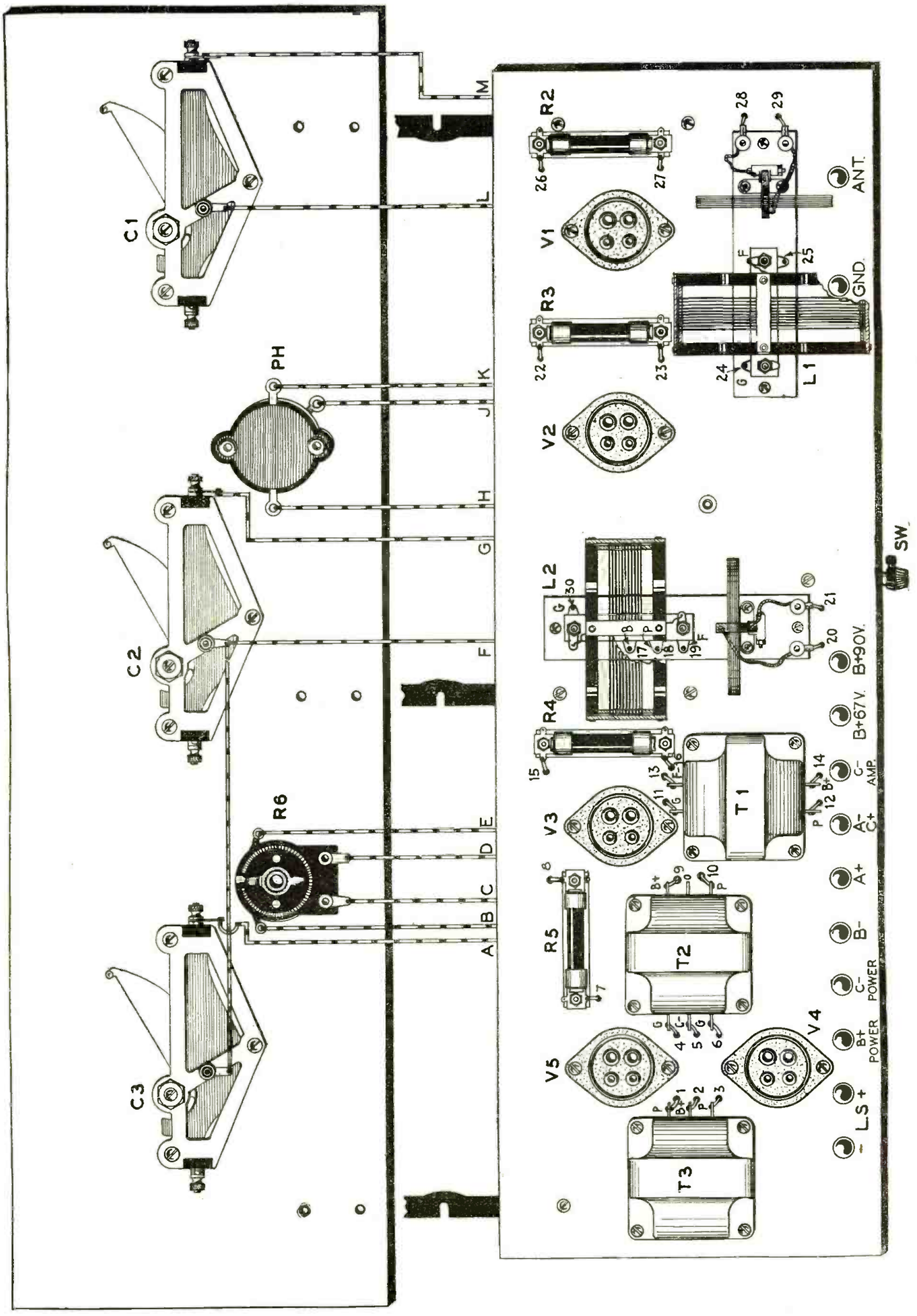
After the wiring is completed the set may be tested. It is best to throw the double-pole switch so that the aerial and ground are connected to the primary of the second tuning unit, in order to get accustomed to tuning the regenerative part of the receiver. It will be noticed that the set is very selective on the short waves; but, the nearer you come to the band between 200 and 500 meters, the more interference will be experienced. However, when the radio-frequency stage is connected in the circuit, the selectivity is very good, on both broadcast and short waves.

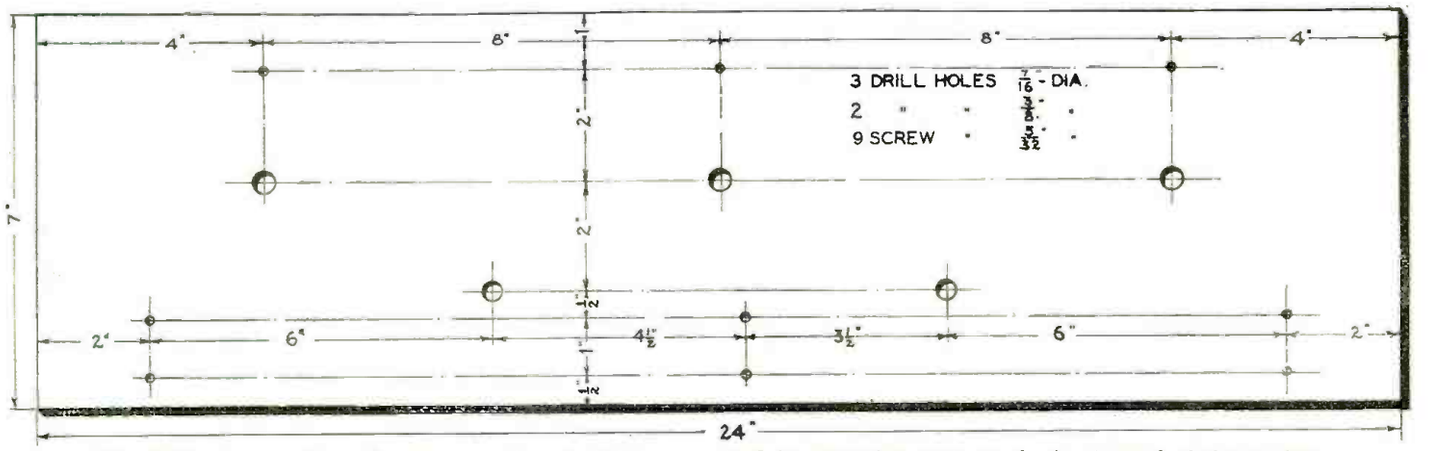
Having spent some time testing the receiver in this manner, the aerial and ground should be connected to the primary of the first tuning unit by throwing the switch (Sw) in the opposite direction. The adjustment of the oscillation control (PH) is not difficult. Tune in a station near the lower end of the condenser scale, turn back the dial of C3 and then slowly turn the dial on the oscillation control (PH) to the left. On retuning the dials C1 and C2 no squeals should be heard; if they are heard, turn the oscillation control still farther to the left. If it is found impossible to control the oscillation in this manner, move the primary of the second tuner further away from the secondary. The relation of the primaries on the tuning coils L1 and L2, to their respective secondaries, governs the selectivity of the set.

It was found in testing the receiver that different adjustments of the oscillation control (PH) were needed for some of the coils, although most of the coils could be operated without the adjustment. When experimenting with the set, a 199 tube was tried in the radio-frequency stage and was found to be easier to control than a 201A but, since it was not difficult to adjust the 201A and since the signals were louder with this tube, it was finally chosen. In changing the tubes, the automatic filament controls (R2, R3, R4 and R5) were found very convenient, since they are easily changed, permitting the use of any type of tube without changing the batteries.



This pictorial wiring diagram indicates the exact arrangement of all wiring under the sub-base panel. Letters and numbers in this drawing refer to corresponding wires and holes, which are similarly marked in the diagram of the wiring above the sub-base panel and the leads to panel apparatus, which appears on the opposite page.





This drilling layout shows the exact location of all holes required for mounting parts on the front panel of the receiver.

In the audio-frequency stages, care should be taken to secure the proper "C" and "B" battery voltages recommended by the manufacturer. This information will be found in the cartons in which the tubes are sold. When using two 171-type tubes in push-pull, it is possible to secure dance-hall volume. Using the 210-type tubes with 425 volts on the plate, terrific volume can be obtained.

The grid condenser (C4) has a capacity of .00025-mf., and the grid leak (R1) has a resistance of 5 megohms. Grid leaks of different values should be tried, in order to determine which produces the best results. If the set has a tendency to howl, try a grid condenser of .0001-mf. capacity.

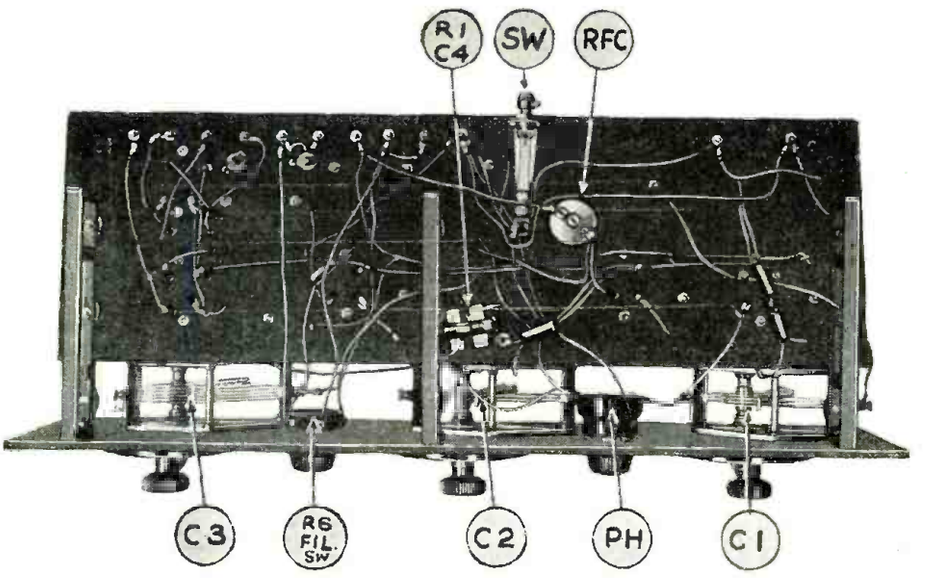
In testing the receiver in the Radio News Laboratories, coils covering all the wave-lengths from 10 to 550 meters were used. Amateur short-wave stations from great distances were tuned in, and some very interesting phone conversation between amateurs on the Pacific coast was heard on the Atlantic seaboard with sufficient volume to operate a loud speaker. On the regular broadcast band, it was not unusual to find a station at almost every degree on the tuning dials.

COIL DATA

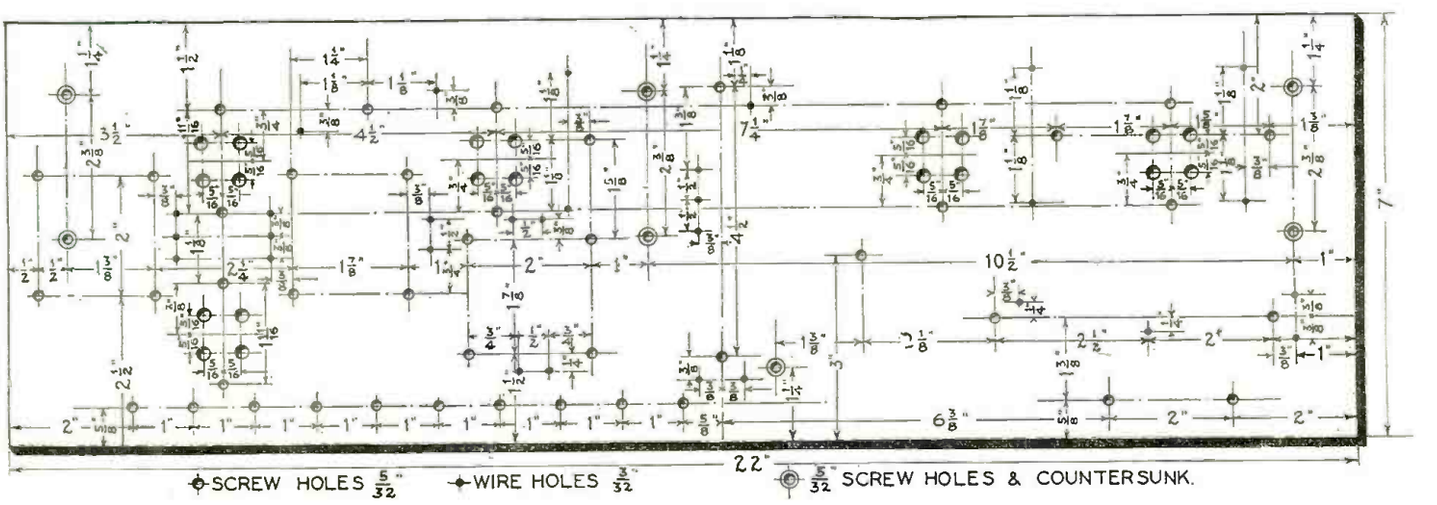
The illustrations of the receiver, which accompany this article, clearly show how various coils may be plugged in the coil sockets in order to receive stations on different wave bands. For receiving stations on any particular wave band two coils of identical construction are required. One coil (L1) is used as an antenna coupler, and the other (L2) as a radio-frequency transformer, Each coil consists of two windings, a secondary (S) and a tickler (T). The primary winding (P) has the same number of turns for all wave-lengths and is attached to the coil socket with a hinge, which makes it possible to adjust the coupling between the primary and secondary coils. The tickler windings of the coils for position L1 are not used. If manufactured inductors are purchased, the tickler connections may be disregarded. If the coils are made at home the tickler may be omitted altogether.

In one of the drawings complete details will be found for making the various coils which are required for receiving stations

(*Continued on page* 1174)



Above is shown the arrangement of parts and wiring under the sub-base panel. R1-C4, grid condenser and leak; RFC., R.F. choke coil; SW, D.P. D.T. switch.



The panel layout showing location of holes required for mounting parts on sub-base panel.

An R. F. Short-Wave Broadcast Receiver

(*Continued from page* 1130)

operating on wavelengths between 10 and 550 meters. Six different types of coils and two coils of each type (12 coils in all) are needed to cover this wide band. However, all the coils are not required if the builder wishes to limit the wavelength range of the set to a narrower band. The waveband which each of the six coils covers approximately is as follows: coil No. 1, 10 to 25 meters; coil No. 2, 15 to 33.5 meters; coil No. 3, 31.5 to 68 meters; coil No. 4, 57 to 133 meters; coil No. 5, 125 to 250 meters and coil No. 6, 235 to 550 meters. If it is desired to increase the wavelength range of the set to 725 meters it is possible to do so by connecting a .0001-mf. mica fixed condenser in shunt with each of the tuning condensers (C1 and C2) when coil No. 6 is being used.

In constructing the coils the secondary windings must be spaced. The chart in the drawing gives the number of turns, the size of wire and the length of each secondary winding; and with this data the builder can determine the proper spacing between turns by experiment. The tickler and primary coils are wound with insulated wire and are not spaced. The primary coil consists of 10 turns of No. 24 S.S.C. wire wound on a form 2½ inches in diameter. The tickler coils are merely glued inside the secondaries, or held in place with a few drops of sealing wax or paraffin from a candle.

The following is a complete list of the parts required for the construction of this short-wave receiving set:

LIST OF PARTS

L1, L2—Two sets of coils (see drawing for details);
C1, C2—Two S.L.F. variable condensers, .00014-mf.;
C3—One S.L.F. variable condenser, .00025-mf.;
C4—One mica fixed condenser, .00025-mf.;
T1—One A.F. transformer, 3:1 ratio;
T2—One A.F. transformer, push-pull input type;
T3—One A.F. choke coil, push-pull output type;
R1—One grid leak, 5-megohm;
R2, R3, R4—Three filament-ballast units, 5-volt, ¼-amp. type;
R5—One filament-ballast unit, 5-volt, ½-amp. type;
R6—One 500,000-ohm volume-control rheostat and filament switch;
RFC—One R.F. choke coil, 60-millihenry;
PH—One oscillation control, variable resistor-condenser type;
V1, V2, V3—Three vacuum tubes, 201A-type;
V4, V5—Two power tubes, 171A-type;
SW—One jack switch, D.P.D.T. type;
Three tuning dials, vernier type;
Five vacuum-tube sockets, UX-type;
One panel, 7 x 24 x 3/16 inches;
One sub-panel, 7 x 23 x 3/16 inches;
Three brackets, 3 inches high;
Twelve binding posts;
Two coil mountings (see drawing for details).

FREE BLUEPRINTS

A set of full-size blueprints, covering all the constructional details of the flexible short-wave receiver described in the foregoing article, may be obtained free of charge at the office of Radio News, 230 Fifth Avenue, New York City. Readers desiring to have these prints delivered by mail should send ten cents in stamps or coin to cover the cost of mailing.

Short-Wave Broadcast Information

By E. T. Somerset (England)

IN view of the difficulty experienced by most people in obtaining a comprehensive list of short-wave radio-telephone stations, and the fact that a large number of the readers of Radio News have constructed the short-wave broadcast receiver featured by this magazine, the writer has compiled the list of stations given below, grouped into three divisions, corresponding to the tuning coil which must be used with that waveband.

Of course it must be realized that the bands overlap; for instance, 2XAF may be found to come in at the extreme upper end of the scale with No. 1 coil, as well as at the lower end of No. 2. This is explained also by the fact that different tubes and detector voltages will cause an alteration in readings.

Should the reader be unfortunate enough to experience trouble with what is known as "Threshold Oscillation" (that is to say, the set bursts into oscillation after a station has been tuned in and the hands removed from the dials) this may almost certainly be cured by inserting an extra R.F. choke in series with that used already; and by-passing the second choke to "A—" with a .0005-mf. fixed condenser on each side.

If there is trouble with body-capacity effects, however slight, an improvement can always be obtained by taking a separate ground lead direct from the "A—" battery terminal to the ground binding post on the set, and also by grounding the filament end of the grid inductor.

The following list is, of course, subject to changes, as these transmissions are largely experimental; by the time it appears, WJZ will probably be operating on 22.207 and 18.715 meters. Likewise, Norway's and Denmark's short-wave transmitters will be on the air, and as well PCJJ, which has been removed from Eindhoven;