Carrier-Current Communication

WARTIME restrictions on radio communication have led many amateurs into the experimental investigation of non-radio methods of communication. A number of such methods have been explored — including induction-field, ground-current, light-beam and supersonic transmission — but the only one to achieve widespread use is carrier-current (wired-wireless) transmission. Hundreds of individuals in various sections of the country now are engaged in experimental communication using this method.

Although carrier-current communication systems have been in use for many years by telephone and power companies, the subject is a relatively new one to radio amateurs. For this reason, it seems appropriate to preface this chapter with a brief résumé of the principles involved, the results which may be reasonably expected, and the difficulties which may be encountered.

Carrier-Current Fundamentals

Essentially, carrier-current communication is similar to radio communication. The process is one of impressing modulation, either in the form of voice or the telegraph code, on a radio-frequency carrier (§ 4-1; § 5-1) and then demodulating the carrier at the receiving end. The only difference is in the medium by which the r.f. carrier wave is transported.

Since most amateurs are familiar with the feeders or transmission lines commonly used to feed antennas, the basic principles of the carrier-current system can be explained by saying simply that it is communication by means of feeder wires or transmission lines. R.f. energy is fed into the transmission line by a transmitter at the sending station, and is delivered to a receiver (instead of an antenna) coupled to the distant end of the line. For communication by this method the transmission line is, therefore, a prerequisite.

While telephone companies, which use the carrier system to carry several conversations simultaneously over a single conductor for long-distance circuits, employ lines especially designed for the purpose, the electric power companies have very successful systems operating over the same high-tension lines by which power is distributed from central generating plants. This leads to the thought of using the same lines which supply electric power to our homes as the transmission lines required for carrier-current communication, since all homes within a wide area usually are coupled to the same power system in one way or another.

Frequencies — A balanced feeder system radiates very little energy compared with the radiation from an antenna at the high frequencies normally assigned for amateur use in peacetime. Nevertheless, even a well-balanced two-wire line will radiate more energy at these frequencies than is permitted under wartime restrictions. Since radiation from a given conductor decreases as the frequency is lowered, most carrier-current systems operate at frequencies lower than 200 kc.

From the private experimenter's point of view, there is an even more important reason for using low frequencies. Power lines feeding the average home ordinarily are extremely poor transmission lines for high-frequency currents. Not only are these lines shunted by very low impedances in the house itself — lamps, heaters, b.c. receivers, motors and other appliances which consume r.f. energy — but the lines, once outside the house, are interrupted by transformers whose high capacities shunt much of the remaining energy to ground. For these reasons it may be said that, in general, the lower the frequency the better the performance for carrier-current work.

There are other considerations which limit the advisable extent to which the frequency may be lowered for purposes of private communication, however. It happens that the public utilities operating carrier circuits make use of the frequencies below 160 kc. Since individuals will not want to run the risk of creating interference with vital services, the very low frequencies are to be avoided. Another reason for giving preference to somewhat higher frequencies is that their use reduces, to a certain extent, the very real problem of supplying the large values of inductance and capacity required for oscillator tank circuits. Frequencies of 160 to 200 kc. are sufficiently low for reasonably successful work and avoid the range commonly used by public-utilities systems.

Operating restrictions — Although no Federal license is required for the operation of carrier-current equipment, there are two restrictions which must be observed. The first of these is the FCC regulation (Sec. 2.102) which limits the *radiation* field strength to a value of 15 microvolts per meter at a distance in feet of $157{,}000/f_{kc.}$, where $f_{kc.}$ is the frequency in kilocycles. At a frequency of 150 kc., for example, the radiation field strength should not exceed 15 microvolts at a distance of 157,000/150 or 1046 feet from any power line which may be carrying r.f. from the transmitter.

The second restriction is one imposed in certain regions by military authorities, in the form of public proclamations prohibiting the use of *any* equipment capable of being employed for communication within specified restricted zones. These zones are designated by notices posted at every local selective service board office, post office, court house or town hall within each restricted zone. Where such a military order is in effect, it means that carrier-current communication (as well as any other kind) is specifically prohibited in the area.

As might be expected, the noise level of most domestic power lines is rather high. To overcome this difficulty, the use of high transmitter power might seem desirable. However, because of the legal limitation on radiation field strength previously mentioned and the fact that harmonic output must be kept low to prevent interference with broadcast reception, the use of transmitter power inputs exceeding 50 watts or so is seldom advisable.

Ranges — Since performance depends so largely upon line conditions, it is impossible to predict with any degree of accuracy the distance range which may be expected with amateur carrier-current installations. In general, greater distances can be covered in rural districts, where open-wire lines are more often employed, distribution transformers are less frequent, and loading is less along the line. In the cities ranges usually will be less, because much of the wiring is carried in grounded conduit and the distances between loading points are short. However, the city dweller has an advantage in that usually he does not need to cover as great a distance to find someone with whom to communicate, because of the greater density of population. With transmitter power inputs of 25 watts or less, distances up to five miles often are reported in metropolitan areas. Rural stations frequently are able to increase their ranges to ten miles or more. It should be remembered that, to cover an air-line distance of three or four miles between transmitting and receiving stations, the signal may have to travel a considerably greater distance in following the power lines.

The fact that two stations may receive power from different distribution systems does not necessarily mean that communication is impossible, since there is evidence that the signal may be transferred from one line to another by induction provided the two lines run close together at some point.

The useful range usually is greater in the daytime than at night because line loading is less during the day. For the same reason, the noise level is lower in the daytime and during the late hours at night than it is in the middle of the evening.

While both telegraphic and voice communication have been carried on successfully, telegraphy will carry better through noise and more advantage may be taken of the noise-reducing properties of a selective receiver. A high percentage of modulation is advisable for 'phone work.

Getting started — The best first step for anyone interested in getting started in carrier-current work is to find someone not too distant from his location to work with him. Watch the pages of *QST's* "Experimenter's Section" for the names of other interested persons in the community. Having located another enthusiast, one can build the transmitter while the other takes on the job of making the receiver or converter. If the receiver is so designed that it may be operated in a car, so much the better, since it will then be possible to form a good idea of where and how far the signal is traveling by following power lines. Tests also can be made at a distance to determine the effects of experimental adjustments at the transmitter. Such tests eliminate much of the guesswork ordinarily connected with an experimental carrier-current system.

Station Equipment

Except for the antenna, the apparatus required for carrier current consists of the same units as used in radio communication — transmitter, receiver, power supplies, modulator (if used) and microphone or key. The apparatus may consist of anything from a simple self-excited oscillator for the transmitter and

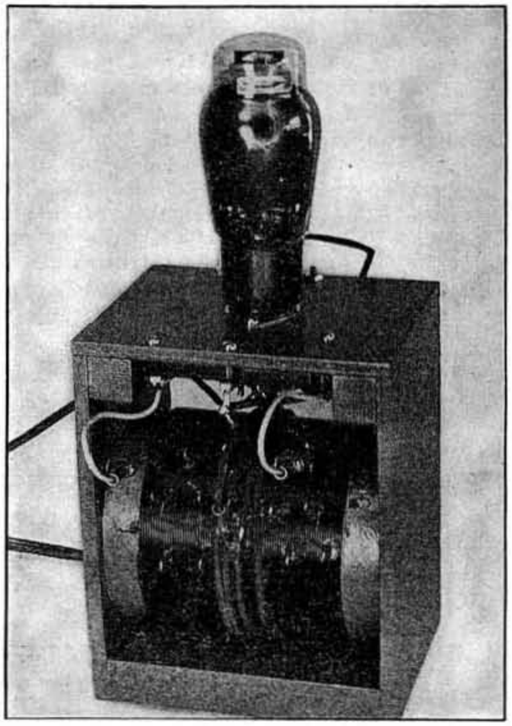


Fig. 1801 — A 25-watt 6L6 transmitter for wired wireless. Since variable condensers large enough to give sufficient frequency change are difficult to secure unless paralleled b.c. receiver gangs are used, a tapped coil is used for tuning. Circuit diagram is shown in Fig. 1804.

a regenerative receiver (if c.w. alone is used) to a modulated m.o.p.a.-type rig with a superheterodyne receiver or a converter working into a communications or broadcast receiver which is used as the i.f. and a.f. amplifier. Representative examples of the kinds of equipment commonly used are shown in the photographs and diagrams which appear throughout this chapter.

Checking frequency — The frequency of the transmitter may be checked by picking up harmonics on a near-by broadcast receiver. For example, when the transmitter is tuned to 150 kc. the fourth harmonic will be heard at 600 kc., the fifth harmonic at 750 kc., the sixth harmonic at 900 kc., etc. The number of kilocycles between any consecutive pair of harmonics will give the transmitter frequency. If harmonics are separated more than 200 kc. the transmitter frequency is too high, while a separation of less than 150 kc. will indicate that the transmitter frequency is too low. Frequencies of 150 kc. and 200 kc. are most suitable for checking in this manner, since their harmonics fall in broadcasting-station channels where the beats with the broadcast signals are easily spotted.

It is advisable to move the transmitter frequency to a setting such that the harmonics fall between broadcast channels and, in particular, well away from the frequencies used by local stations, to avoid interference with neighboring listeners.

Coupling to line — Various methods of coupling the output of the transmitter to the power line may be used, as shown in Fig. 1802. In these circuits, C_1 serves a dual purpose as both blocking and tuning condenser for the line circuit. The value to be used depends to a considerable extent on the line constants, and should be determined experimentally. In practice, it has been found that the capacity required varies from about 0.01 μfd. to as much as 0.05 μfd. The condenser used must be capable of withstanding the line voltage. The coupling coil, L_1, should be of sufficient size to provide the necessary coupling to the final tank circuit. It is advisable to start out with a fairly large coil, wound over the final tank coil and tapped every few turns so that the loading can be adjusted.

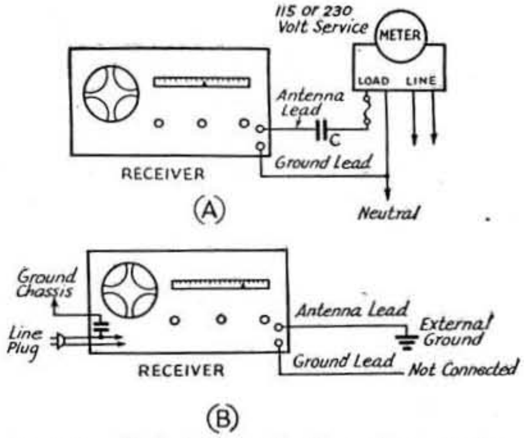


Fig. 1803 — Methods of coupling the receiver to the line.

While it is possible to work without the use of load-isolating filters if the necessary material is not available for their construction, a considerable improvement in over-all efficiency can be obtained by their use, since a large percentage of the total power loss may be attributed to the house load. It can be seen from diagrams C and D, Fig. 1802, that the purpose of the filters is to prevent the radio-frequency power from being expended in the shunt load normally connected to the house side of the meter.

It should be borne in mind that the inductance coils in the isolating filters must have sufficient current-carrying capacity for the total connected load without causing any serious loss of voltage at the line frequency. C_2 does not have to withstand any considerable voltage but must have the proper capacity to tune the coil, L_2, to the operating frequency. As in the case of the tank circuit, a wide range of values may be used. If a 0.005-μfd. mica condenser is used for C_2, a coil which will resonate at approximately 150 kc. may be wound with 70 turns of No. 14 enameled wire on a 3½-inch form. The voltage drop in such a coil should be negligible under normal house-wiring loads.

Where the street side of the meter is accessible the transmitter

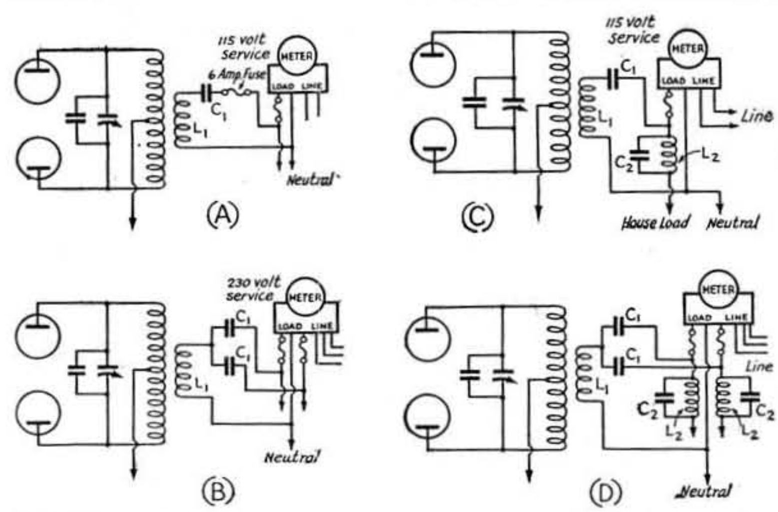


Fig. 1802 — Methods of coupling the carrier-current transmitter to the power line.

may be coupled to the line on that side, thereby avoiding the necessity for feeding r.f. through the meter.

Suggested methods for coupling the receiver to the power line are shown in Fig. 1803.

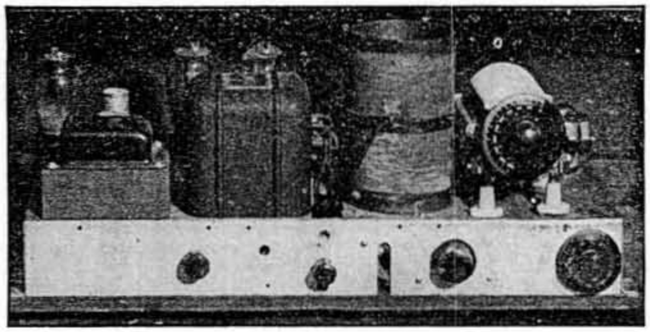


Fig. 1805 — **M.o.p.a.-type carrier-current transmitter. Transmitter, modulator and power supply are on one chassis, arranged for remote control from the operating position. The final tank coil and tuning condenser are at right. Circuit diagrams are shown in Figs. 1806 and 1807.**

Transmitter Construction

Hartley 6L6 transmitter — A carrier-current transmitter of the simplest type is pictured in Fig. 1801. The circuit, shown in Fig. 1804, is the conventional series-fed Hartley. The tank condenser, C_1C_2, consists of two 0.006-μfd. mica condensers connected in series (to decrease the possibility of breakdown). Frequency and excitation are adjusted by selection of the proper taps on the coil. The output or "antenna" coupling is adjusted by the proper selection of the condensers in series with the coupling coil, L_2.

The inductance is wound on a Quaker Oats carton, which is a convenient source for 3½-inch diameter cardboard tubing. After the contents have been removed and the box cut down to a length of about 4¾ inches, the cardboard should be given a coat or two of shellac. Then 80 turns of No. 18 enameled wire must be wound on, as tightly as possible. Taps are made at every 5th turn, making a 1-inch loop of wire at each tap and twisting it tightly for several turns so that the loop will not pull apart as the rest of the coil is wound. When the coil is finished the loops should be scraped bare of insulation, using a knife or fine sandpaper. As a finishing touch, spots of Duco cement may be applied to secure the twisted portions in place.

The framework used to support the coil and other components is made of ¼-inch plywood, except for the two corner strips at the top, which are of ½-inch square stock, and the two 1 × 2-inch bottom strips. The whole assembly is held together by brads and glue. The box is made just wide enough to allow the coil to be forced in, the pressure of the sides then serving to hold the coil firmly in place. The box measures 6⅞ inches high, 5¼ inches long, and 4¼ inches deep.

The tube socket is submounted in a hole in the center of the top of the framework. The tank condensers, C_1 and C_2, are fastened underneath by screws. The grid choke, *RFC*, is supported on a ½-inch pillar attached to the rear screw holding the socket. The coupling condensers, C_5, C_6 and C_7, are supported on lugs under the heads of screws which serve also for coupling taps at the rear of the box. Flexible leads from the coil are fastened to the terminals of the tank condensers.

When completed, the transmitter should be hooked up to a power supply delivering 350 or 400 volts at 100 ma. A meter and key should be connected in the positive high-voltage lead, as shown in Fig. 1804. While there may be some objection to placing the key in the positive lead, there is a measure of safety in the fact that, as long as the operator's hand is off the key (as it would be when making adjustments) there is no chance for shock when adjusting the coil taps. Care must be exercised, of course, and it is recommended that all tuning adjustments be made with one hand in the pocket.

Initial tuning-up should be done without the oscillator coupled to the line. Set the clips so that there are 60 turns between grid and plate, and attach the cathode tap at 25 turns from the grid end. Press the key and read the plate current; then try again with the cathode tap on either side of the first position. The setting of the cathode tap which gives the lowest plate-current reading is the one to use. With a 350-volt supply, the no-load plate current should run around 25 or 30 ma.

The next step is to connect the output circuit to the line. Set the coupling clip so that neither C_6 nor C_7 is being shorted (the condition of loosest coupling). The plate current under load should increase to 30 or 40 ma., depending upon the frequency of the transmitter.

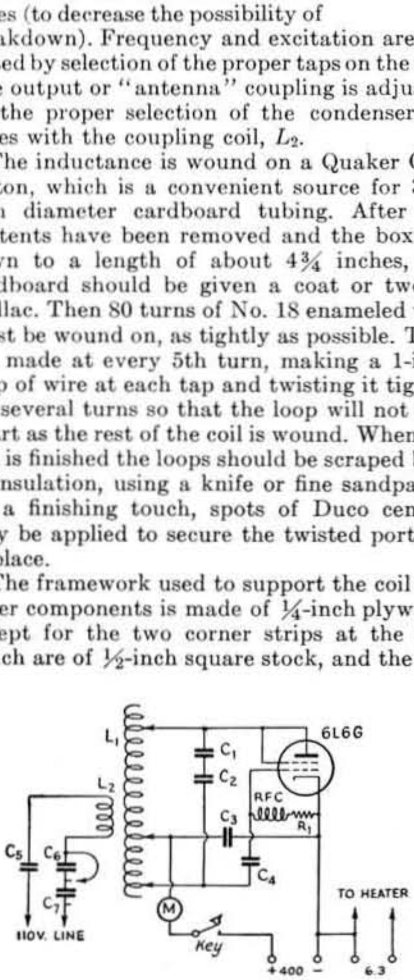


Fig. 1804 — **Circuit of the 25-watt 6L6 transmitter.**

C_1, C_2 — 0.006-μfd. mica, 2500 volts.
C_3, C_5 — 0.1-μfd. paper, 600 volts.
C_4 — 100-$\mu\mu$fd. mica.
C_6, C_7 — 0.05-μfd. paper, 600 volts.
R_1 — 50,000-ohm wire-wound, 10-watt.
RFC — 80-mh. r.f. choke (Meissner 19-2709).
L_1 — 80 turns No. 18 e., close-wound on 3½-inch diameter form, tapped every 5th turn.
L_2 — 4 turns No. 18 rubber-covered wire, wound over the center of L_1.

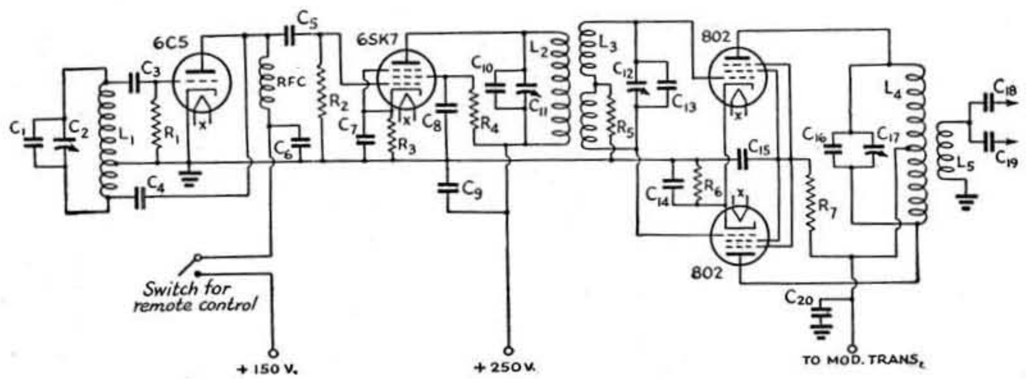


Fig. 1806 — Circuit diagram of the master-oscillator power-amplifier wired-wireless transmitter.

C_1 — 0.002-μfd. mica.
C_2 — 350-μfd. variable.
C_3 — 500-μμfd. mica.
C_4 to C_9, inc. — 0.1-μfd. paper, 600 volts.
C_{10} — 0.002-μfd. mica, 2500 volts.
C_{11}, C_{12} — 350-μμfd. variable.
C_{13} — 0.002-μfd. mica, 2500 volts.
C_{14} — 0.1-μfd. paper, 600 volts.
C_{15} — 0.002-μfd. mica, 1000 volts.
C_{16} — 0.002-μfd. mica, 5000 volts.
C_{17} — 350-μμfd. variable.
C_{18}, C_{19} — These condensers correspond to C_1 in Fig. 1802.
C_{20} — 0.002-μfd. mica, 1000 volts.
R_1 — 0.1 megohm, 1-watt.
R_2 — 50,000 ohms, 1-watt.
R_3 — 300 ohms, 1-watt.
R_4 — 50,000 ohms, 1-watt.
R_5 — 20,000 ohms, 1-watt.
R_6 — 300 ohms, 10-watt.
R_7 — 15,000 ohms, 10-watt.
L_1 — 160 turns No. 28 e. on 1½-inch form, tapped 50th turn from bottom.
L_2 — 90 turns No. 22 e. on 3-inch form.
L_3 — 90 turns No. 22 e. on same form as L_2, half each side of L_2.
L_4 — 80 turns No. 18 e. on 3½-inch form, tapped at center.
L_5 — See section on coupling.
RFC — 30-mh. choke.

The quality of the note can be checked by listening to a harmonic with the communications receiver set to its lowest frequency range. As the coupling is increased the note will become rough or "yoopy", indicating that the coupling is too tight or that the cathode tap needs adjustment. The note will roughen up before it chirps; the roughness can be tolerated, but the chirp makes copying difficult.

Be careful when making adjustments — you will have deliberately hooked onto the 115-volt line, and you can get a good shock from it!

M.o.p.a. transmitter — The photograph of Fig. 1805 illustrates a typical transmitter of the m.o.p.a. type. The circuit diagram appears in Fig. 1806. The tube line-up consists of a 6C5 Hartley oscillator, 6SK7 buffer, and push-pull 802 final amplifier. In addition to the r.f. circuits, the chassis also includes a plate-and-screen modulator for 'phone work, and a power supply. The wiring diagram of the modulator unit is shown in Fig. 1807.

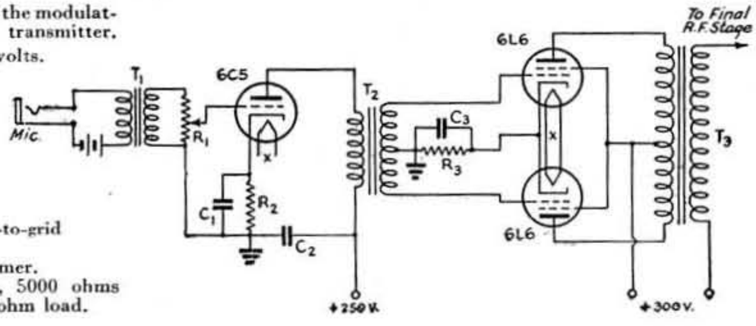
This transmitter operates at an input of about 20 watts, with a final plate current of 70 ma. and screen current of 30 ma. It is, however, capable of handling higher power with increased final-amplifier plate and screen voltages.

Almost any combination of tubes could be used in a similar arrangement. Triodes will require neutralizing circuits, of course.

Combination transmitter-receiver — In Fig. 1808 is shown the circuit diagram of a c.c. transmitter-receiver. The receiver consists of a 6SJ7 regenerative detector and a single-stage audio amplifier with a 6C5, preceded by an untuned stage of r.f. using a second 6SJ7 with the hot side of the power line tied directly to the grid. The detector is quite conventional. R_7 is the regeneration control. The receiver coils, L_1, L_2 and L_3, are scramble-wound with No. 32 enameled wire, on a piece of cardboard tubing about one and one-half inches in diameter. The secondary, L_2, should be wound on first and covered with a layer of friction tape. The primary, L_1, is then wound close to the grid end of L_2, and the tickler, L_3, close to the ground end. Finally, the entire coil should be given another covering of friction tape.

Fig. 1807 — Circuit diagram of the modulator used with the m.o.p.a. c.c. transmitter.

C_1 — 10-μfd. electrolytic, 25 volts.
C_2 — 8-μfd. electrolytic, 450 volts.
C_3 — 10-μfd. electrolytic, 50 volts.
R_1 — 0.5-megohm volume control.
R_2 — 1000 ohms, 1-watt.
R_3 — 125 ohms, 10-watt.
T_1 — Single-button microphone-to-grid transformer.
T_2 — Interstage audio transformer.
T_3 — Modulation transformer, 5000 ohms plate-to-plate to 3000-ohm load.



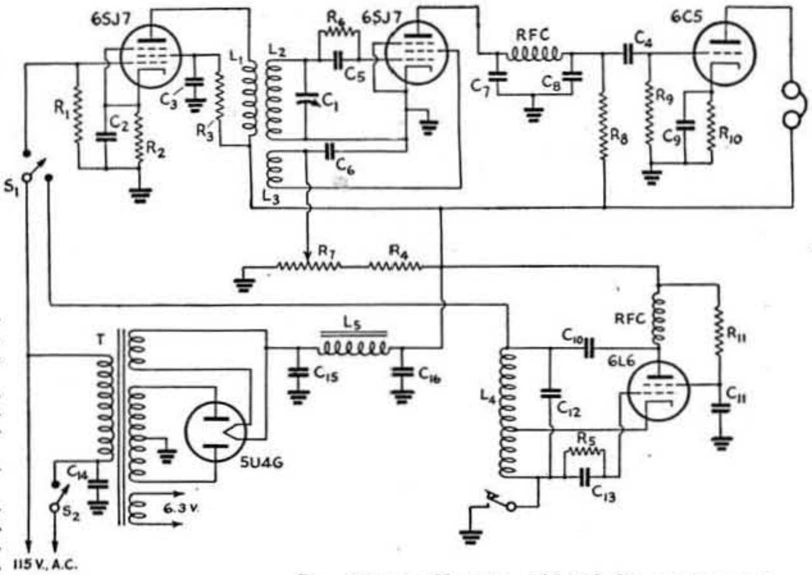


Fig. 1808 — Circuit diagram for a combined transmitter-receiver for carrier-current communication.

C_1 — 700-μμfd. variable.
C_2, C_3, C_4 — 0.01 μfd.
C_5 — 250-μμfd. mica.
C_6 — 0.25 μfd.
C_7, C_8 — 500-μμfd. mica.
C_9 — 0.1 μfd.
C_{10}, C_{11} — 0.002 μfd.
C_{12} — 0.006 μfd.
C_{13} — 250-μμfd. mica.
C_{14} — 0.1 μfd.
C_{15}, C_{16} — 8 μfd., 450 volts.
R_2 — 1000 ohms, 1-watt.
R_3, R_4, R_5 — 50,000 ohms, 1-watt.
R_6 — 2 megohms, ½-watt.
R_7 — 50,000-ohm variable.
R_8 — 0.25 megohm, ½-watt.
R_9 — 0.1 megohm, ½-watt.
R_{10} — 2500 ohms, 1-watt.
R_{11} — 15,000 ohms, 1-watt.
RFC — 25 mh. to 80 mh.
S_1 — S.p.d.t. toggle switch.
S_2 — S.p.s.t. toggle switch.
T — Power transformer: 350-0-350, 5 and 6.3 volts.
L_1 — 100 turns No. 32 e., 1½-inch diameter; see text.
L_2 — 300 turns Bo. 32 e., 1½-inch diameter; see text.
L_3 — 75 turns No. 32 e., 1½-inch diameter; see text.
L_4 — 150 turns No. 18 e., 2¼-inch diameter, tapped at 50 turns from grid end.
L_5 — 15- to 30-henry filter choke.

The ground connections which are shown in the diagram indicate connections to the chassis and not to actual earth.

The transmitter is a regulation Hartley oscillator using a 6L6G. With the plate voltage available the input runs about 12 watts. The note should be crystal d.c.

The power supply is common to both the receiver and transmitter, the receiver acting as a bleeder for the supply.

All condensers are of the tubular type except the transmitter tank condenser, the grid condensers, and the variable used for detector tuning. The latter is a two-section gang condenser of 365 μμfd. capacity per section, with both sections in parallel. If the system shown in the circuit diagram is used, all ground connections shown must be made to the chassis and not to actual ground; otherwise, the key will short-circuit the line. The chassis must not be grounded. If it is desired to ground the chassis for safety, place C_{14} between the arm of S_1 and the ungrounded side of the line. The chassis may then be grounded and the danger of shock or short-circuit removed. A 25-mh. to 80-mh. r.f. choke inserted between the key and L_4 will improve the keying. A 0.1-μfd. by-pass condenser should then be placed across the key.

Receiver Construction

Receivers for frequencies below 550 kc. are not readily available under wartime conditions. However, almost any superheterodyne receiver can be converted to operate on 150 kc. by making simple changes in the oscillator and tuned circuits.

While the circuits used in superheterodynes vary considerably from one model to another, a typical arrangement is that shown in Fig. 1809. The oscillator circuit, before necessary changes are made, is shown at A, while B is the revised circuit. C_2 is the series tracking condenser in the oscillator circuit; this condenser is removed and connected in parallel with C_1, the oscillator tuning condenser. Fig. 1809-B shows the radio-frequency circuit. L_1 and L_2 are removed and the coils shown in B are connected in place of those removed. The dimensions of the coils are given in the drawing. Coil L_2 has approximately 300 turns and L_1 approximately 25 turns. Both coils may be boiled in wax. After cooling, they should be wrapped with cotton tape so they will hold their form.

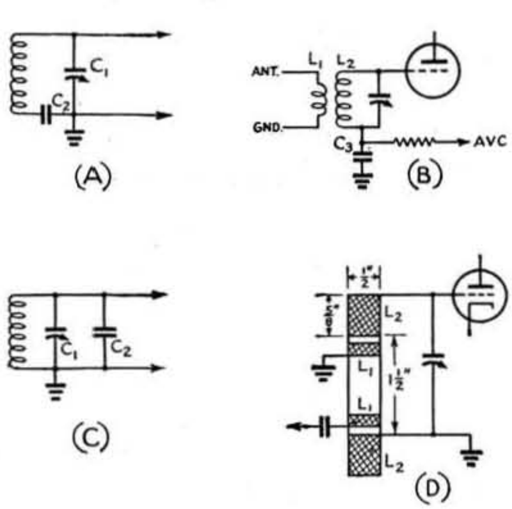


Fig. 1809 — Circuit changes required for converting a b.c. superheterodyne receiver for operation in the 150–160 kc. region. A, normal oscillator circuit; B, revised oscillator circuit; C, normal r.f. circuit (mixer input); D, revised r.f. circuit, showing cross-section of coil for tuning to 150 kc. See text for further description.

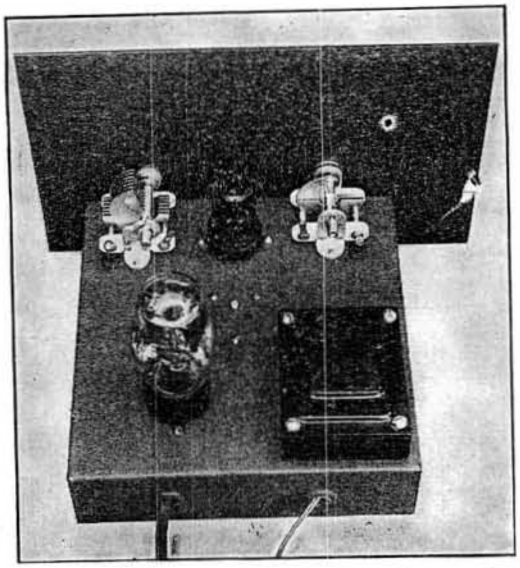


Fig. 1810 — Top view of the superheterodyne carrier-current converter. Note the adjusting screw for the output tank condenser, C_5, in front of the 6SA7 tube.

The simpler regenerative-detector receivers have also been used successfully for carrier-current work. The basic circuit of the simple regenerative receiver described in Chapter Eleven (Figs. 1101–1105) may be used with the provision of suitable coils and tuning condensers. Using a broadcast-type 365-$\mu\mu$fd. variable condenser for C_1, L_1 may be 120 turns of No. 32 enameled wire wound on a 3-inch diameter form and L_2 about 20 turns on the same form as L_1.

The three-tube wide-range general-coverage and bandspread superheterodyne receiver described in the same chapter (Figs. 1111–1119) also is suitable for carrier-current use when the low-frequency coils (range A) are plugged in.

A Superhet Converter — A simple superheterodyne converter for carrier-current work is shown in Figs. 1810 and 1812.

The circuit of the converter, shown in Fig. 1811, is quite conventional. It consists of a 6SA7 mixer tube with the output on 1950 kc., so that it can be hooked into any communications receiver which will tune to 1950 kc. The grid circuit tunes the range 150 to 200 kc. and, in order to give the output frequency of 1950 kc., the oscillator tunes from 1800 to 1750 kc. The oscillator could also be made to tune from 2100 to 2150 kc., but by using the former range it can be checked on a communications receiver which covers only the amateur bands.

The converter is built on a 7 × 7 × 2-inch chassis. The tuning condensers, C_1 and C_3, are bolted to the chassis in a position such as to allow the panel to be supported by their panel bushings. The toggle switch and the screw

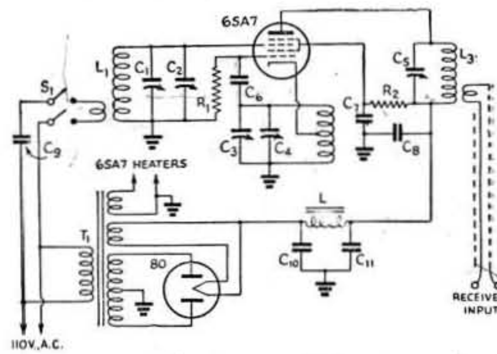


Fig. 1811 — Wiring diagram of the c.c. converter.

C_1 — 100-$\mu\mu$fd. variable (Hammarlund MC-100-S).
C_2, C_5 — 260-$\mu\mu$fd. trimmer (Hammarlund CTS-160).
C_3 — 20-$\mu\mu$fd. variable (Hammarlund MC-20-S).
C_4 — 350-$\mu\mu$fd. mica trimmer (Hammarlund CTS-230).
C_6 — 50-$\mu\mu$fd. mica.
C_7 — 0.1 μfd. paper, 400 volts.
C_8 — 0.01 μfd. paper, 600 volts.
C_9 — 0.1-μfd. paper, 600 volts.
C_{10}, C_{11} — 8-μfd. electrolytic, 450 volts.
R_1 — 20,000 ohms, ½-watt.
R_2 — 20,000 ohms, 1-watt.
S_1 — D.p.s.t. toggle switch.
T_1 — Power transformer, 240-0-240 volts each side of center-tap, 6.3-and 5-volt filament windings (Thordarson T-13R19).
L — 8 henrys, 40 ma. (Thordarson T-13C26).
L_1 — 175-kc. i.f. transformer replacement winding (Carron S735). Antenna winding is 11 turns of No. 32 d.s.c. wire wound over L_1.
L_2 — 43 turns No. 32 d.s.c., close-wound on 1-inch diameter form. Cathode tap at 5th turn from ground end.
L_3 — 50 turns No. 32 d.s.c., close-wound on 1-inch diameter form. Output coil is 14 turns of No. 32 d.s.c., close-wound, ⅛-inch from L_3.

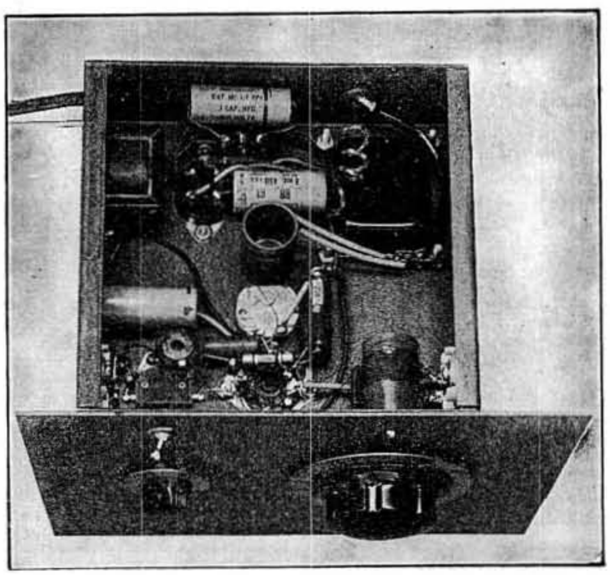
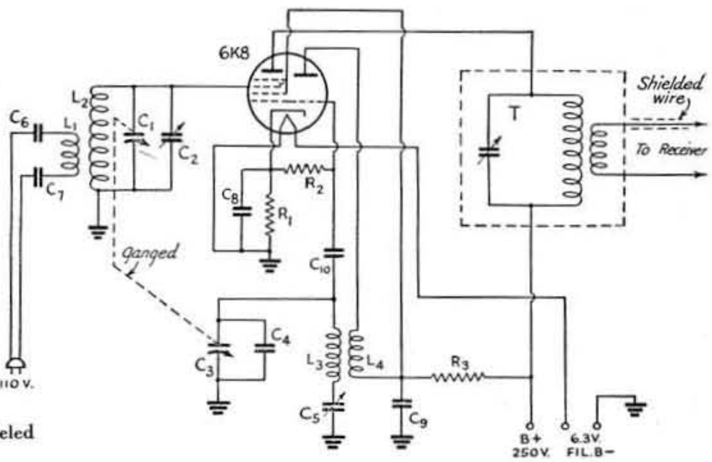


Fig. 1812 — This bottom view of the converter also shows the panel layout. The output tank coil, L_3, can be seen in the center of the chassis; L_2 is directly under the oscillator tuning dial, and the mixer grid coil, L_1, can be seen at the right, next to the toggle switch. Padding condensers C_4 and C_2 are mounted on the left- and right-hand sides of the chassis, beneath their respective tuning condensers.

Fig. 1813 — Circuit diagram of the low-frequency carrier-current converter. The oscillator range is 1710 to 1950 kc. for 1600-kc. i.f.

C_1 — 250-μμfd. variable.
C_2, C_4 — 3-30-μμfd. mica trimmer.
C_3 — 250-μμfd. variable with 9 rotor plates removed.
C_5 — 3-130-μμfd. mica trimmer.
C_6, C_7, C_8, C_9 — 0.1-μfd. paper.
C_{10} — 100-μμfd. mica.
R_1 — 300 ohms, ½-watt.
R_2 — 50,000 ohms, ½-watt.
R_3 — 50,000 ohms, ½-watt.
L_1 — 1 mh.
L_2 — 5 mh.
L_3 — 200 turns No. 28 e., ¾-inch diameter, close-wound.
L_4 — Oscillator tickler (approximately 20 turns).
T — 465-kc. i.f. transformer, remodeled to tune to 1600 kc.



holding the oscillator coil also help to hold the panel to the chassis. The mixer and oscillator padding condensers, C_2 and C_4, are fastened to the sides of the chassis, under their respective tuning condensers, and C_5, the output-circuit tuning condenser, is mounted on the chassis directly behind the 6SA7. The output coil, L_3, is fastened to the chassis near its tuning condenser. Both L_2 and L_3 are wound on one-inch bakelite forms. L_1 is a winding taken from a 175-kc. i.f. transformer.

The primary winding for L_1 is put on after two layers of cellophane tape have been wound over L_1 to serve as insulation. The primary then is wound on and cemented with coil dope or Duco cement.

The converter is put into service by connecting its output to the input of a communications receiver and plugging in the line cord of the converter. While both the converter and receiver are warming up, set the receiver to 1950 kc. Then adjust the output trimmer, C_5, for maximum noise from the receiver. Next, check the converter oscillator range by setting the oscillator tuning condenser, C_3, to minimum capacity and the receiver to 1800 kc. It should then be possible to tune in the converter oscillator signal by adjusting C_4 until the signal is heard. Check the range of the oscillator by setting C_3 at maximum; if it can be tuned in at 1750 kc. on the receiver, the range is right on the nose. If the range is too great (oscillator frequency lower than 1750 kc. at maximum capacity), it indicates that fewer turns are required on L_2, and vice versa. The range is not critical, of course, since the converter is not ganged.

The receiver can now be reset to 1950 kc. and C_1 and C_3 set to the middle of their ranges. After adjusting C_2 for maximum noise (with S_1 closed), the converter is lined up for action. It will be found that the mixer tuning control is not too sharp and will need attention only after the signal has been tuned in with the main tuning control, C_3. Remember that C_3 tunes backward to the usual way: i.e., the converter is tuned to 150 kc. when it is at minimum capacity and to 200 kc. when it is at maximum capacity, the reverse of the mixer condenser action.

The coupling switch, S_1, is included so that the converter will not receive r.f. during transmission periods. It should be used to disconnect the converter from the line whenever the transmitter is being keyed.

A 6K8 converter — The circuit diagram of another converter for low frequencies is shown in Fig. 1813. It is designed for an i.f. of 1060 kc. and the output circuit must be tuned to this frequency.

All of the coils used in the grid circuit of the mixer section are universal-wound r.f. chokes. The tuning range has been extended on either side of the 150- to 200-kc. band in order to permit listening to radio stations operating on neighboring frequencies.

Remote-control relay — The circuit diagram of a relay which may be operated from a carrier-current signal for the purpose of controlling remotely an external circuit is shown in Fig. 1814. The series circuit, LC, should be resonant at the frequency of the distant transmitter. When the signal is applied, the potential between the cathode and the starter anode is increased. If sufficient starter-anode current flows the discharge is transferred to the anode, which causes the relay to close until the signal is removed. The relay may be used to operate a lamp or bell, turn on a receiver, or to perform other similar remote-control operations.

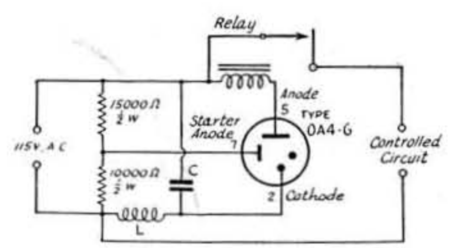


Fig. 1814 — Circuit of the c.c. remote-control relay.