Mobile *with the* ARC-5/SCR-274

LT. PAUL H. LEE, W4RXO*

As the result of many requests for the conversion of war surplus gear. —Editor.

The writer has had the urge to "go mobile" for several years. However, lack of time for construction of homebuilt equipment, plus an unwillingness to spend the amount necessary for commercial gear have combined to prevent such action. However, the "bug" finally bit us very hard and we determined to work out a reasonable compromise. Conversion of the ARC-5/SCR274N series equipments offered an easy, extremely inexpensive, and neat looking installation.

In order to make the installation worthwhile from both the peacetime amateur and the Civilian Defense standpoint, an "all or nothing" approach was adopted, with phone operation on 3.9, 14, and 28 mc, by means of interchangeable units, as the goal. The purchase of three SCR-274N transmitters, three SCR-274N receivers, an MD7/ARC-5 plate modulator, a receiver rack, and a transmitter rack, gave us a good start. Included in the lot were one transmitter and receiver covering the 3.5-4.0 megacycle band, giving us the 3.9-mc phone band without the necessity of modifying the r.f. portions of these units. For the 14 and 28-mc bands, we used 4-5.3 mc transmitters, and 3-6 mc receivers. The latter were chosen because their i.f. frequency of 1415 kc offers a good amount of image rejection without sacrificing too much selectivity. The 4-5.3 mc transmitters were selected because of their lower cost.

The differences between the ARC-5 and SCR-274N transmitters should be noted here. The ARC-5's use shunt plate feed in the p.a. with an r.f. choke, while the SCR-274N's use series feed and no r.f. choke. This makes no difference in actual operation. Also, the size of the original power plugs at the rear of the chassis is different, as are the connections. Most racks on the surplus market fit the SCR-274N's, so if you happen to get an ARC-5 transmitter, it will be necessary to replace the larger power socket with a smaller one from an SCR-274N. These sockets are available on the surplus market. Of course, the best way is to get all ARC-5 equipment, or all SCR-274N equipment and racks to fit, and not attempt to mix the two.

Acquisition of circuit diagrams for these units is a necessity. Readily available sources of such information are the two volumes of the *Surplus Conversion Manuals,* and no attempt will be made to reproduce original circuit diagrams here. In all of the conversions we used as many of the original parts, and left as much of the original wiring undisturbed, as possible.

The author's Chevvy contains a three band installation using only war surplus materials. The antenna is the usual center loaded 75 meter whip.

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Power Source

The next matter for consideration was the source of power. After much careful thought it was decided to use 12 volts for several good reasons. First, the units are already equipped with 12 volt tubes, and require only the paralleling of filaments. Second, the low cost of 12 volt dynamotors outweighs the cost of an extra storage battery, and 12 volt dynamotors are easily obtainable from surplus. Third, use of an extra battery in series with the car battery places only half the drain on the car battery that would result from 6 volt operation. The extra battery can be located up under the hood in many cars. The writer obtained a battery mounting from a junkyard and installed it under the hood of his 1949 Chevrolet, on the left hand side, near the generator. Use of two extra batteries, with one out on charge while the other is in use, provides a reliable power source, and changing batteries has been reduced to a matter of but three or four minutes' time. Someone is sure to suggest the use of a 12 volt automobile generator at this point, but we did not wish to carry matters that far!

Basic Receiver Modifications

Now that the preliminaries are out of the way, let's get down to the actual conversion work. First of all, discard all the 28 volt receiver dynamotors, but save the mounting plates with attached snap fasteners. Mount DM-35 12 volt dynamotors on them, and replace them on the receivers. Then, make a short sleeve, slotted on both ends, out of 1/4" i.d. copper tubing, and use it as a coupling between the splined tuning shaft and a piece of 1/4" shafting to which a tuning knob may be attached. A spinner-type knob is very handy for this purpose. Fill the sleeve with some type of adhesive which dries hard, such as Duco cement, before fitting it snugly over the receiver tuning shaft. It will withstand rough usage without coming loose.

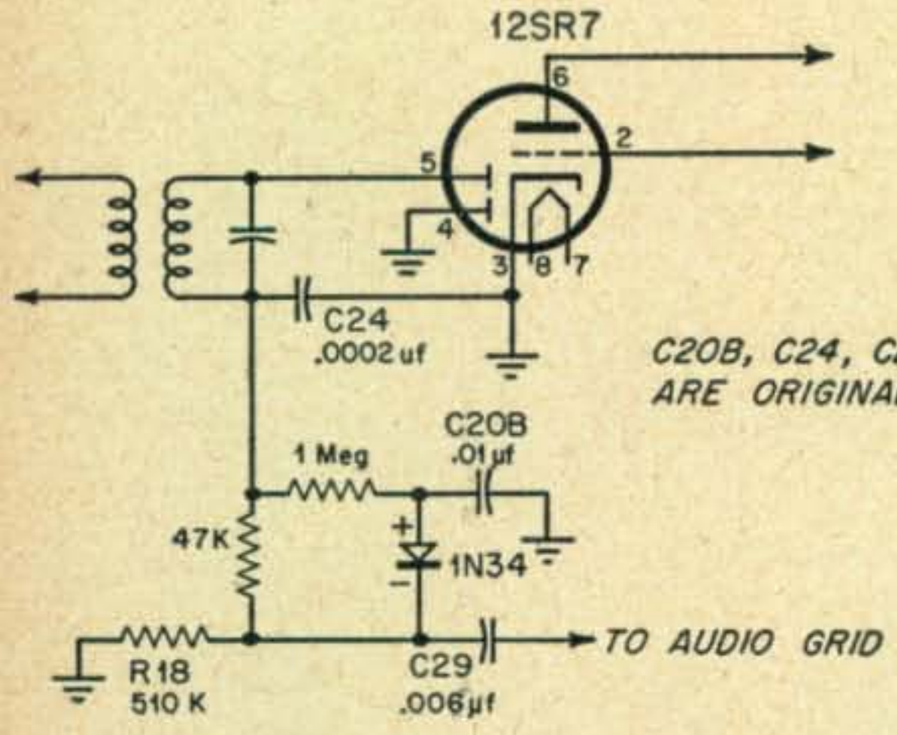


Fig. 1. The noise limiter circuit.

Remove the bottom shield and the front plug-in cover plate from each receiver. The latter may be thrown away, and a new cover plate made of scrap aluminum, for mounting the r.f. gain control and the BFO on-off switch. The r.f. gain control is a 50,000 ohm variable resistor. These two items may be connected to the proper pins of the recessed plug by merely soldering leads to the plug pins. The r.f. gain control should be connected between *pin 1* and *ground*, and the BFO switch between *pin 5* and *ground*. It will also be necessary to solder a jumper between *pins 6* and *7* to complete the filament circuit, as this was formerly accomplished through the plug-in cover that we threw away. Next, using care, clip all the leads from the power socket at the rear of the chassis except the following: *common ground*, *filament*, and *audio*. The red wires which formerly connected to *pin 4* of the old socket and which are the BFO "shut off" circuit, should be tied together and taped up. The remaining wires should be traced back to their origin and clipped out, as they will not be used. Next, trace the filament wiring, and connect the filaments of all tubes in parallel for 12 volt operation. Remove the bottom of r.f. stage grid resistor *R2* from the AVC circuit, and connect it to ground, to permit this stage to run wide open for increased gain. There are certain i.f. circuit differences between the ARC-5 and SCR-274N receivers, but they are of little consequence. In the ARC-5, the 2nd i.f. and a.v.c. tube is a 12SF7 instead of a 12SK7.

A word of caution is here in order. In any of the receivers, do not disturb the wiring between the 12K8 tube and the oscillator coil. In most sets these leads are fastened down with glyptal, and for a very good reason. Shifting these leads will greatly affect the oscillator frequency and stability. Hours of careful work can be ruined by movement of these leads.

A coaxial jack should be installed on the front panel in the place formerly occupied by the old antenna binding post. Merely drill a series of small holes around the circumference of a 5/8" diameter circle, and knock out the center. Use self-tapping screws to secure the jack to the panel.

Replace the 12SK7 r.f. and i.f. tubes with 12SG7's, to give greater sensitivity and gain. If you have an ARC-5, there is no replacement for the 12SF7 2nd i.f. tube, and you will have to be content with it.

At this point, we have completed the basic modifications for all receivers, and they are capable of operation from a d.c. power supply delivering 10-12 volts. Such a source of test voltage is a necessity for testing the receivers and transmitters on the work bench. The 3.9 megacycle receiver should now be tested and put aside.

Use of the station receiver during the conversion of the remaining receiver units is necessary, as it is a very simple matter to listen to the mobile receiver's h.f. oscillator in the station receiver and check its frequency as we make changes. Subtract 1415 from the h.f. oscillator frequency, and you will have the mobile receiver's operating frequency. To bandspread the 14 mc-band, the h.f. oscillator will have limits of 15,415 and 15,815 kc. For the 28 mc band, the limits will be 29,415 and 31,115 kc.

14 MC Receiver Conversion

Let's start on the 14 mc receiver. We have already performed the basic modifications. Remove

the top cover and the shield can over the variable condenser. The receiver may operate without these shields for rough frequency calibration. With a pair of long-nose pliers, carefully remove rotor plates from the variable condenser until only one rotor plate is left in each section. This should be the slotted plate, for tracking adjustment. Now turn on the power, and locate the receiver's h.f. oscillator by listening on the station receiver. The frequency will be much higher than it was originally, but we will have to go still further. Remove the plug-in coil unit from the bottom of the receiver, noting that it is polarized by the pin arrangement of the three coil plugs. Remove the oscillator coil from its shield can, and carefully remove the core from the coil. This should be replaced after rewinding, and its position is not too critical. Remove only the large winding of the oscillator coil, and rewind it with about 10 turns as a start, spacewound. The wire size is not critical. We used number 24 enamelled wire. Put the coil back in its shield, replace the coil unit in the set, and turn on the power. The h.f. oscillator should now be somewhere around 15 mc on the station receiver. Check the bandspread for approximately the correct limits. If you are very "foxy", you can use the original dial markings, with new figures, for the new frequency calibration. Slight adjustment of the number of turns, and the oscillator trimmers and padder, will give proper bandspread.

Tracking may be improved if necessary by bending the slotted sections of the tuning condenser rotor plate. Remember our limits of 15,415 kc (14 mc) and 15,815 kc (14.4 mc). Rewind the mixer and r.f. coils, using about 11 turns on each, spacewound. Rewind the mixer coil primary, using 18 turns of number 30 d.s.c., interwinding part of it with the secondary, to give increased gain. With the coils back in the receiver, and power on, adjustment of the trimmers should now bring in signals, using a short wire antenna. Slight changes in turns may be necessary, and adjustment of the slotted sections of the tuning condenser rotor plates may have to be made, to secure tracking of these two stages. Now replace the shield over the condenser, and fasten the coil unit securely in place.

Install the noise limiter circuit as shown in *Fig. 1*, in the ground return of the 2nd detector diode circuit. Replace the bottom cover. Use the station v.f.o. or frequency meter for final receiver calibration with the shield in place. The top cover may now be replaced, and the 14 mc receiver is ready for use. It is an excellent six-tube superheterodyne, capable of pulling in even weak signals with ease.

28 Mc Receiver Conversion

The conversion of the remaining receiver for 28 mc is performed in a like manner, but with several additional improvements. First, remove the octal r.f. socket, and replace it with a 7 pin miniature socket, for a 6AG5. Replace the 620-ohm cathode resistor *R1* with a 220 ohm resistor. Remove *C6* and connect the small ceramic bypass condensers (as shown in *Fig. 2*) with as short leads as possible. From the coaxial antenna jack on the front panel, run a short length of small coaxial cable to *terminals 1* and *6* of the oscillator coil socket, using *terminal 6* for the shield. Tie *terminal 6* to *terminal 3* to ground the shield. Connect the 6AG5 filament and the mixer stage filament in series and use a 6K8 as the mixer tube. Each tube draws 0.3 amps. filament current.

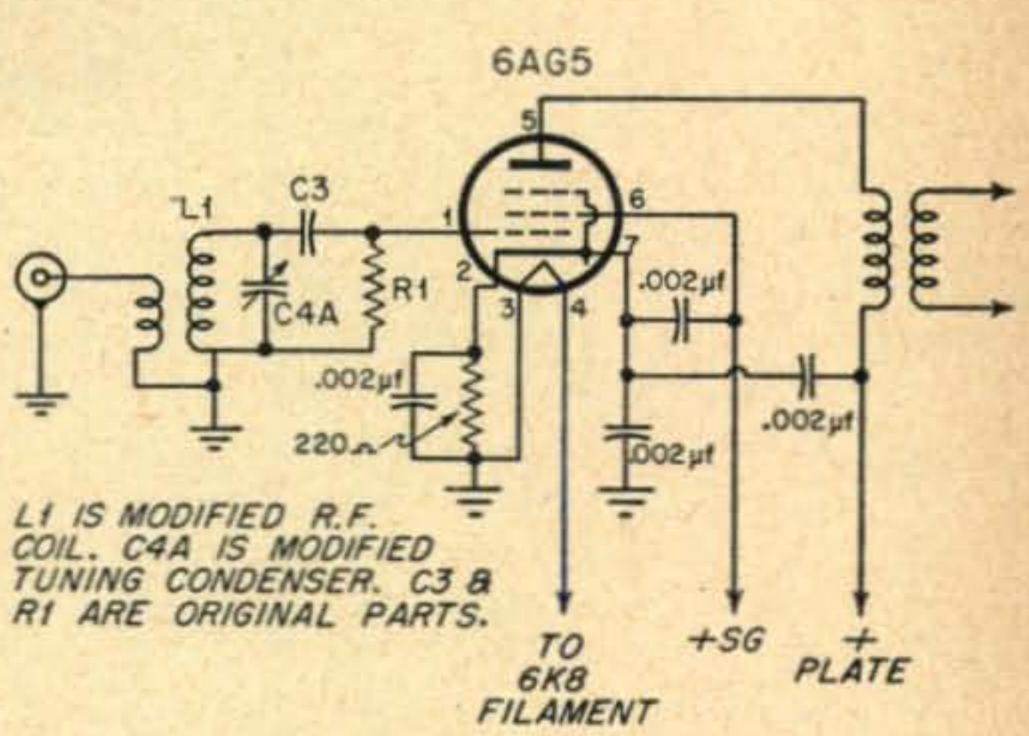


Fig. 2. The new r.f. stage.

Insert a 10,000 ohm 10 watt resistor between *R22* and *R23*, to increase the screen voltage to approximately 140 volts. Connect the filaments of the two i.f. tubes in series, and use two 6AC7's in place of the 12SK7's in these sockets. If you have an ARC-5, you will have to use the existing 12SF7 2nd i.f. with a 12SG7 1st i.f. The gain will be a bit lower than with 2 6AC7's. Install the noise limiter circuit as shown in *Fig. 1* in the ground return of the second detector diode circuit. Now, remove all but one rotor plate in each section of the tuning condenser, and use 6 turns on the r.f. coil, 5 turns on the mixer coil secondary, 9 turns on the interwound mixer primary, and 5 turns on the oscillator coil grid winding, all spacewound. Wind a one-turn link of insulated wire over the ground end of the r.f. coil, and connect it to *terminals 1* and *6* of the coil plug.

Using the station receiver, VFO and frequency meter as before, align the receiver for 28 - 29.7 mc coverage. In this case it will be easier to make a new dial plate than to attempt to make the receiver track to the old markings. As before, the final adjustment should be made with the condenser shield cover, and bottom cover, in place. The preceding paragraphs cover in a few words many hours of work, but the results are well worth the effort. We now have a receiver that is hard to beat for sensitivity and good signal-to-noise ratio on 28 mc.

3.9 Mc Transmitter Conversion

Conversion of the 3-4 mc transmitter for 3.9 mc phone is quite easy. This portion of the work is also the basic conversion for the other two units and it should be done simultaneously in all units.

Remove the top and bottom shield covers, and the oscillator cover. The common ground, filament, p.a. plate, oscillator plate, p.a. screen and antenna relay leads should be connected to the power socket at the rear of the chassis as shown in the diagram, *Fig. 3*.

Remove the old antenna relay, and the feed-thru insulator associated with it, and install two coaxial chassis-type connectors for the antenna connections. From the bottom of the unit, remove the ceramic-insulated keying relay, and by rearrangement and bending of the contacts, make it over into a new s.p.d.t. antenna relay, and mount it in the holes on the front panel where the old one was mounted. Rewinding is not necessary, as it will operate on 12 volts. Now, go back under the chassis and install a closed circuit jack for p.a. plate current measurement in the lower left corner of the front panel. Connect the ungrounded side of this jack to the cathodes of the 1625's, and bypass *both* ends of this lead to ground with 0.001 μf mica condensers. Rewire all tube filaments in parallel, and remove and discard the 126-ohm resistor mounted in clips on the rear of the chassis. The 20-ohm resistor may be removed from the oscillator plate voltage lead. The circuit diagram of the completed 3.9 mc. unit is shown in *Fig. 3*.

One word of caution is in order. Before replacing the oscillator shield in any of the transmitters, take a piece of transformer cloth or other suitable, good, insulating material, and pass it down between the secondary and primary windings of the oscillator coil. Occasionally, one of the primary leads, as it comes thru the coil form and passes down to the terminal block, may rest against the secondary winding and may break down intermittently after the unit heats up. This fault may be recognized by a very rough, off-frequency signal, and it caused the writer much consternation until the trouble was located after several hours of work.

The 3.9 mc unit may now be tested, after replacing the oscillator shield cover and the top and bottom shields. Use a source of 10-12 volts d.c. for the filaments and 250 volts for the plates, with a 5000 ohm dropping resistor for the p.a. screen voltage. If you are lucky enough to have a unit with the calibrating crystal still in it, you may use it and the magic eye tube for calibration. Without the crystal, the station receiver and frequency meter may be used.

The rotating antenna loading coil is left in the circuit, to permit use of the unit with a wire antenna should the occasion ever arise. However, it should be set at *zero* for operation into coaxial feedline.

14 Mc Transmitter Conversion

The conversion of the 4-5.3 mc transmitter for 14 mc is based upon retaining single dial control, using as many of the original parts as possible, and the use of only one doubler stage. The circuit shown in *Fig. 4* is the result.

First, perform all the basic modifications as described under the 3.9 mc portion of the conversion. Then, change the oscillator of this transmitter to bring it to 7 mc, with bandspread, using the existing dial calibration markings with new figures. The outside winding of the oscillator coil should be reduced to 12 turns by removing turns from the top only. The oscillator tuning condenser located under the chassis should have all but 2 rotor plates removed. One of these remaining plates should be the slotted one for tracking adjustment. Now, at the coil terminals under the chassis, move the grid leak tap from the center of the secondary to the bottom end. Disconnect and discard the p.a. neutralizing condenser. Strip out all wiring and small resistors associated with the crystal and 1629 magic eye tube sockets, and remove the 1629 socket.

The doubler coil is wound of 11 turns of number 24 enamelled wire, spaced to occupy ½" length, on a 5/8" diameter slug tuned form. The crystal

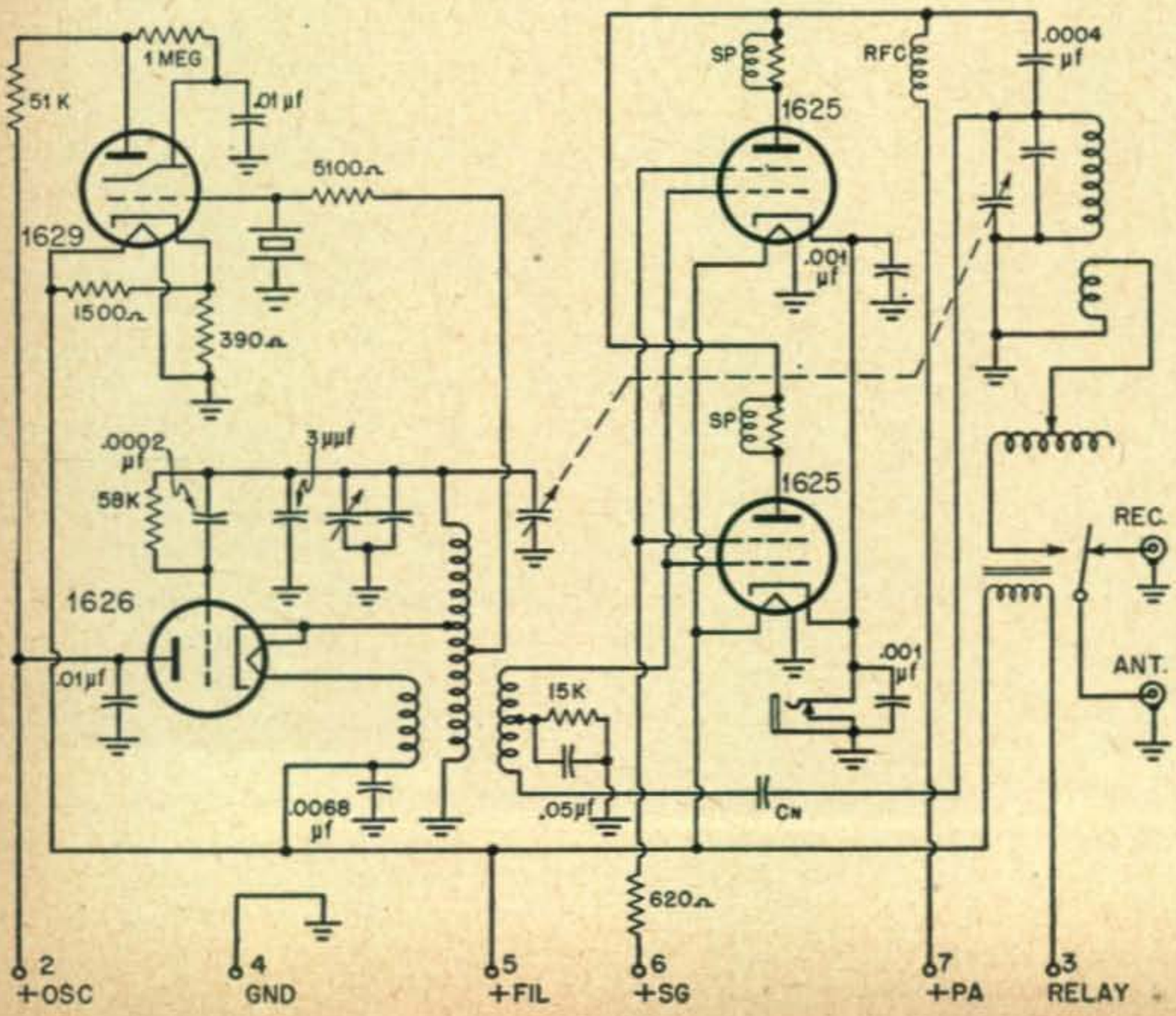


Fig. 3. The 3-4 mc ARC-5 Conversion. This particular transmitter is used on 75 meter phone with considerable success.

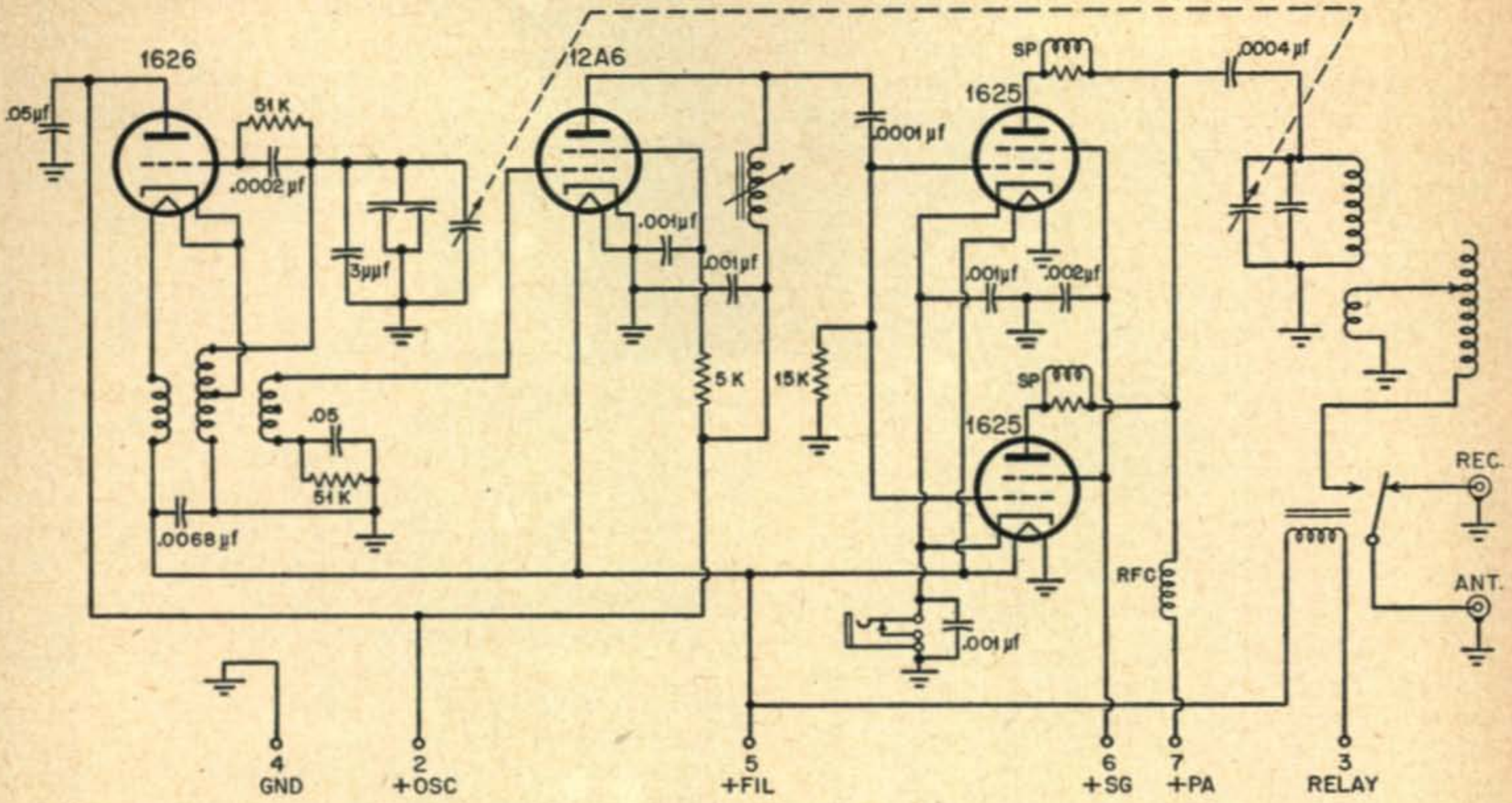


Fig. 4. The circuit of the 14 mc transmitter. The plan here was to use as many of the original parts as possible from a 4-5.3 mc unit.

socket is used for the 12A6 doubler, and the doubler coil is mounted by means of an "L" bracket under the chassis with its adjustment screw sticking up through the vacant socket hole. Wire the doubler stage as shown in the diagram. Now attack the p.a. plate tank circuit, and rewind the coil with its own wire, using only 5½ turns, double-spacing them in the existing grooves. Carefully pull out rotor plates from the p.a. variable tuning condenser until only two are left. Loosen the set screws holding the rotor of the fixed tank condenser, and remove all but two rotor plates. Now the p.a. plate tank on 14 mc will track with the oscillator on 7 mc, giving us our single dial control. The rotary antenna coil may be left in, for use with a wire antenna, or removed, as desired. It should be set at *zero* for coaxial feed, if it is retained.

The transmitter is now ready for test. With plate power applied to the oscillator and doubler only, set the transmitter dial to the desired frequency, say 14 mc, and adjust the fixed oscillator tank condenser under the shield can (it will be necessary to loosen the set screws holding the rotor, and then replace the shield) until the signal is heard in the station receiver on 7 mc. Its harmonic may be heard on 14 mc. Next, check the bandspread, and adjust the slotted rotor plate in the variable condenser under the chassis until proper dial tracking is secured. In the W4RXO transmitter, the new dial markings correspond to the old as follows: 14-4.0, 14.1-4.2, 14.2-4.4, 14.3-4.6, 14.4-4.8. A little painstaking work here will make it possible for you to read frequency directly, and may save you a "pink ticket" from the FCC later on. Slight adjustment of the tuning slug in the oscillator coil may be necessary for proper bandspread or tracking. Once the adjustments have been made, the oscillator should be perfectly stable and should give no trouble.

Now the p.a. may be adjusted. With 250 volts applied to the p.a. plates and the 5000-ohm series dropping resistor supplying the screen voltage, tune the p.a. to resonance by adjustment of the fixed tank condenser under the chassis. Some slight adjustment of the slug in the p.a. coil may be necessary for perfect tracking. Once this condenser is adjusted it may be locked and forgotten, and the p.a. will track with the oscillator over the whole band. Replace the top and bottom shield covers, peak up the doubler coil for maximum drive to the final, and make final frequency adjustments through the holes provided for that purpose. The job is now finished.

28 Mc Transmitter Conversion

This conversion is very similar to the 14 mc job, as may be seen from the diagram, *Fig. 5*. In this case, we bring the oscillator to 14 mc and use one doubler stage to go to 28 mc. For those who may have their doubts, let us state that the oscillator is as stable on 14 mc as it ever was, and also the p.a. operates perfectly on 28 mc, although unneutralized.

Make all the basic modifications as in the 3.9 mc unit. Then remove the 1629 socket, and all parts associated with the crystal calibrating circuit, as in the 14 mc set. The doubler coil in this case consists of 6 turns, spaced to ½" length, on a ⅝" slug tuned form. The doubler coil is mounted as in the 14 mc set, with its adjustment screw sticking up through the vacant socket hole. The oscillator coil is cut down as follows. Remove turns from the top of the coil, leaving 1⅔ turns above the cathode

tap. Then remove turns from the bottom of the coil, leaving 4 turns below the cathode tap. Be careful not to damage the fine-wire filament winding which is interwound. Remove turns from the bottom of this winding, until 4 turns are left. This latter operation should be done by cutting a turn, removing turns, and splicing the wire ends together again, rather than by attempting to pass the wire through the hole in the form and down to the terminal block. It is impossible to take the coil apart without ruining it, so we do it the easy way. Next remove all but 3 plates from the oscillator tuning condenser rotor under the chassis, and all but 7 rotor plates from the fixed oscillator tuning condenser above the chassis.

Remove and discard the p.a. neutralizing condenser and leave the bottom of the oscillator coil secondary winding floating. Wire in the doubler circuit. Note that an r.f. choke is necessary in the p.a. grid leak lead. The p.a. circuit modifications are next. We made no attempt to make the p.a. tuning track with the oscillator, as the p.a. tuning under load is broad enough to give good results within several hundred kilocycles of the operating frequency. If it becomes necessary to retune, this is easily done with a screwdriver. With a little cussing and some carefully applied brute force, remove the gear from the p.a. tuning condenser shaft. Yes, it *can* be done! Remove both rotor and stator plates from the p.a. tuning condenser until a total of 11 plates are left. Then drill a ¼" hole in the side of the chassis so that the shaft may be turned with a screwdriver. The old p.a. fixed tank condenser is left unchanged, and is used as the antenna loading condenser, in series with the link. The small parasitic suppressors should be removed from the old tank coil and reused in the 1625 plate leads.

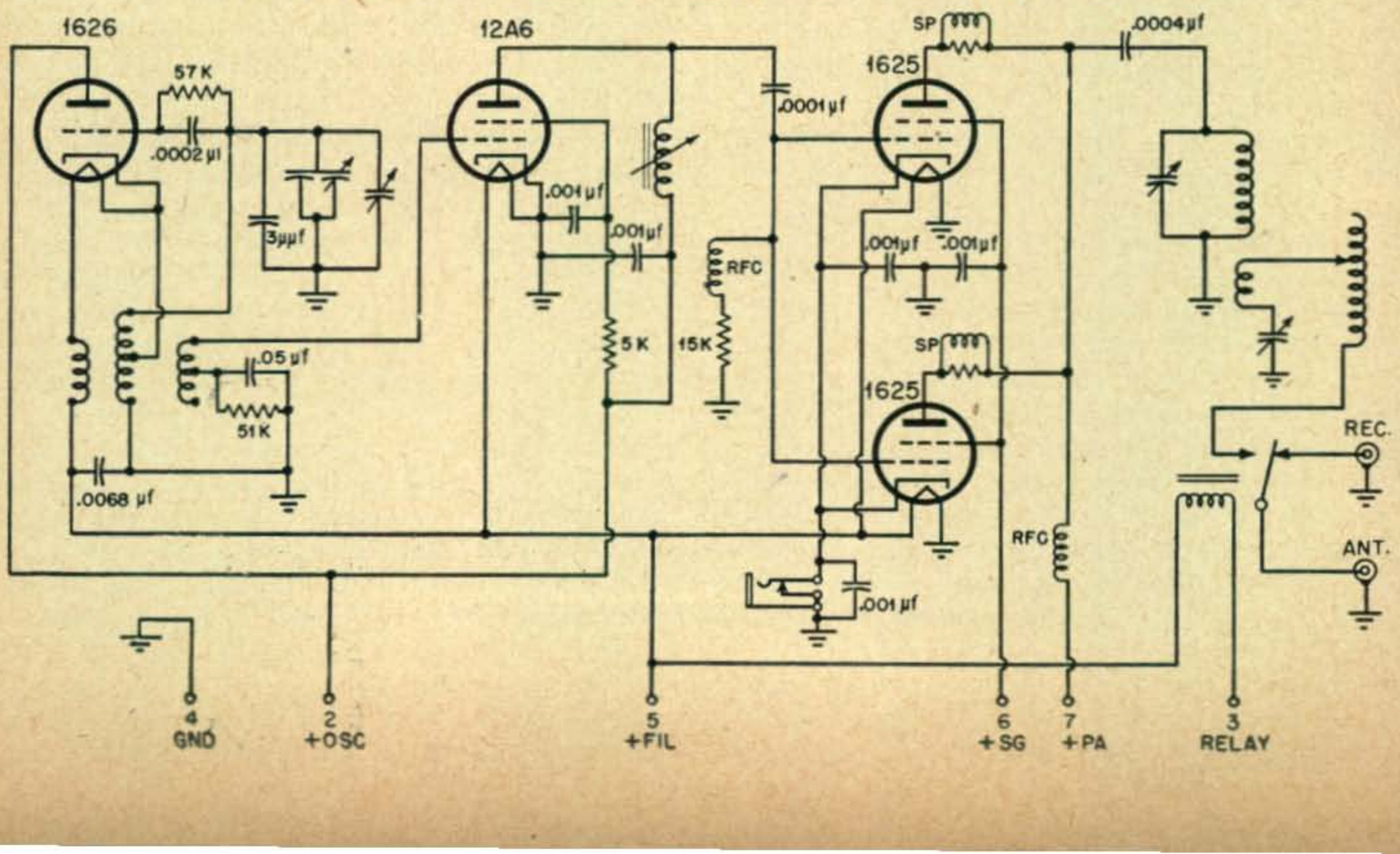
The new tank coil is airwound, consisting of five turns of #12, 1" long, and 1" diameter. The hot end of the coil connects to the tuning condenser stator thru a small feed-thru insulator on which it is mounted. The link consists of 3 turns of #12, ⅞" diameter, and should be mounted on another feed-thru insulator, near the ground end of the tank coil. Once adjusted for proper loading, it may be fixed in position and left alone. Note that shunt plate voltage feed is used.

Apply plate voltage to the oscillator and doubler only, and adjust the oscillator to 14.5 mc in conjunction with the station receiver. Its harmonic should be found on 29 mc. It is simpler in this case to disregard old dial markings and either paint them out, or make a new dial plate and calibrate it, than to attempt to align the oscillator to any of the old markings. Replace the oscillator shield can and again adjust the oscillator to 14.5 mc. Apply plate and screen voltage to the p.a., and tune the p.a. tank to resonance. The antenna loading condenser shaft should be left unlocked so that it may be adjusted in the final installation. Replace the top and bottom shields on the unit, peak up the doubler circuit, and again adjust the oscillator to frequency, and calibrate the tuning dial from 28 to 29.7 mc. The conversion is now complete.

Power Supply and Modulator

The original ARC-5 modulator also has the 575 volt dynamotor mounted on it. This is a 28 volt machine; it is useless to us and may be discarded. Save the mounting plate, however, and mount a DM-34-D 12 volt machine on it. The output of this dynamotor is 625 volts, which is just fine for our purpose. Strip out the tone oscillator, and install a VR-105 in the old 12J5 socket. Replace the two large 15,000-ohm resistors with two 5000-ohm resistors of the same size, and connect these in parallel. Remove all cable sockets except the one with 12 contacts. Cover the vacant holes, and mount a

Fig. 5. The 28 mc conversion is somewhat similar to the 14 mc transmitter.



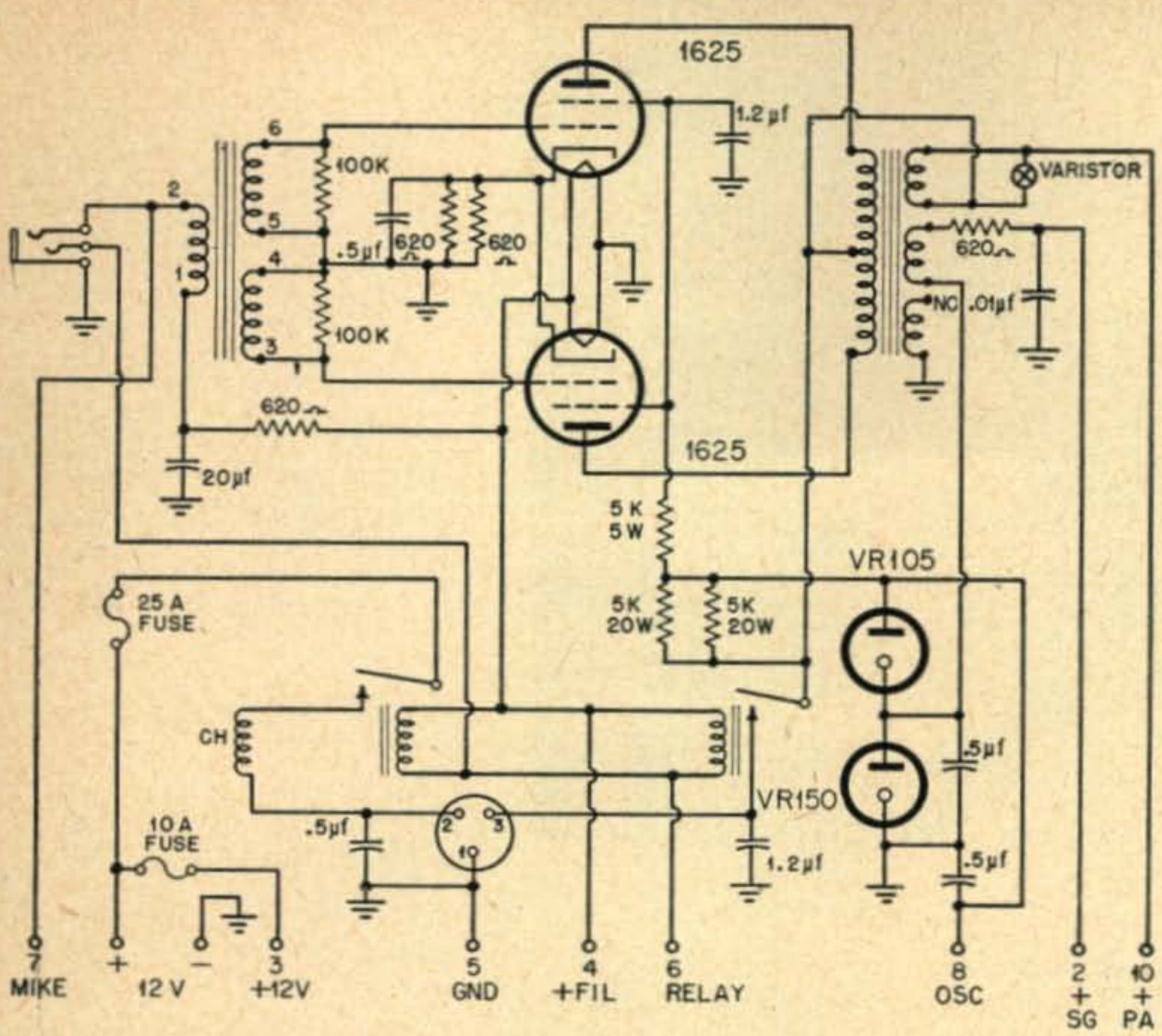


Fig. 6. The final modulator schematic. Note that this unit now supplies the power to the oscillator through the voltage regulator tubes.

heavy terminal block for the 12 volt leads from the battery. Rewire the 12 volt lines to the dynamotor plug with #12 wire. The relays will operate on 12 volts with slight adjustment of the contact springs. The final circuit of the modulator unit is shown in *Fig. 6*. Note that this unit supplies both plate and screen modulated voltage to the power amplifier, as well as unmodulated, regulated voltage to the oscillator. We chose plate and screen modulation rather than simple screen or clamp-tube modulation because we wanted to get the most out of our transmitter. With only 60 watts input, every watt of modulated output counts, especially in mobile operation.

The circuit of the remote control box is shown in *Fig. 7*. It contains the *receiver on-off* switch, which turns on all filaments and the receiver dynamotor, a transmitter *plate on-off* switch, a *phone-speaker* switch, a *volume control*, and a *loudspeaker*. All this is mounted in a metal box about 7" x 5" x 3" deep. The handset plugs into the two jacks. The handset has both microphone and receiver in it, together with a push-button for transmitter control. A loudspeaker silencing relay is also included in the control box, and it is connected so that it silences only the speaker. Thus the handset receiver may be used to monitor one's own signal if desired.

The control circuits are shown in *Fig. 8*. Terminal numbers are shown. It is best to purchase the plugs which fit the various cable sockets on the racks and modulator unit. They are listed here for those who do not have instruction manuals which give this information.

ARC-5 Modulator ——— 9589
SCR-274N Receiver Rack — PL-152, PL-151
SCR-274N Transmitter Rack — PL-154, PL-156

If you are not able to find these plugs, the sockets may be removed and standard octal fittings substituted.

Installation

The W4RXO mobile instalation is in a 1949 Chevrolet sedan, with the modulator unit in the right rear fender cavity in the trunk. This saves most of the usable trunk space. The cables go through a hole behind the rear seat, which is thus concealed, and run under the front edge of the rear seat, under the floor mats alongside the hump in the floor, and up to the front bulkhead under the dashboard. The receiver and transmitter racks are bolted together and are mounted under the dashboard. This makes a very neat mounting and enables a quick change of units when changing bands. The control box mounts under the dashboard, on the driver's side. The handset is hung on the dashboard in a mounting bracket made of copper tubing. The transmitter plate current meter is plug-in, and is used only in tuning up and testing.

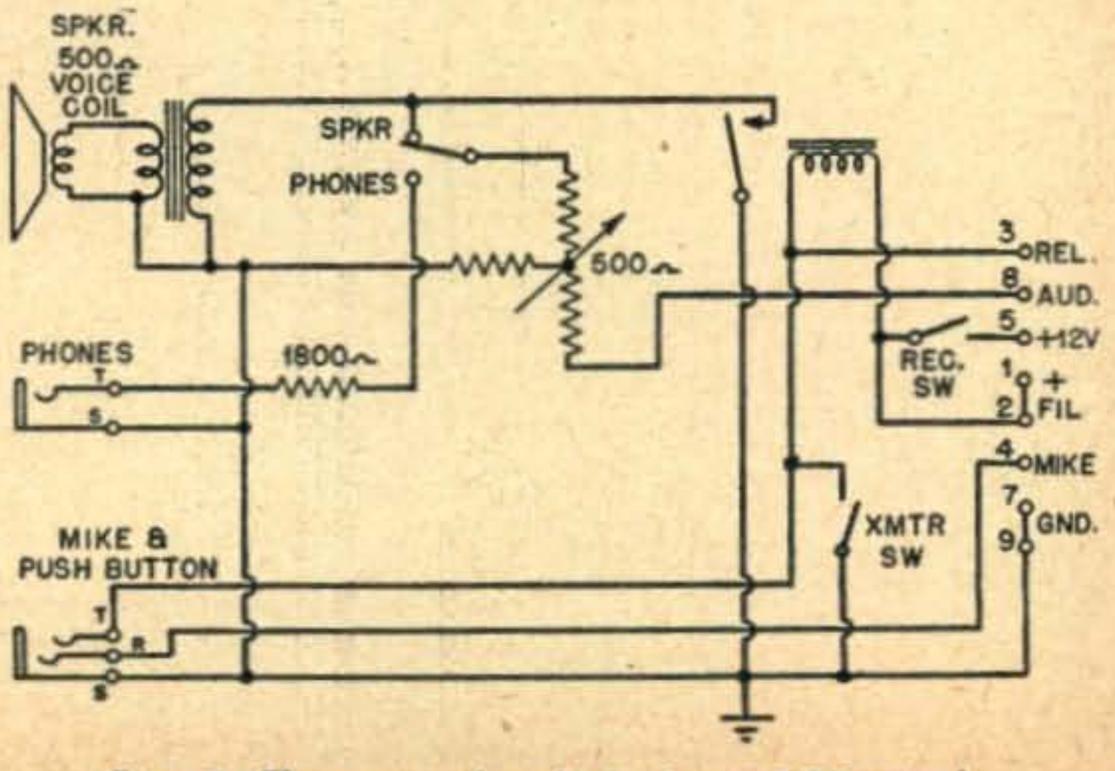
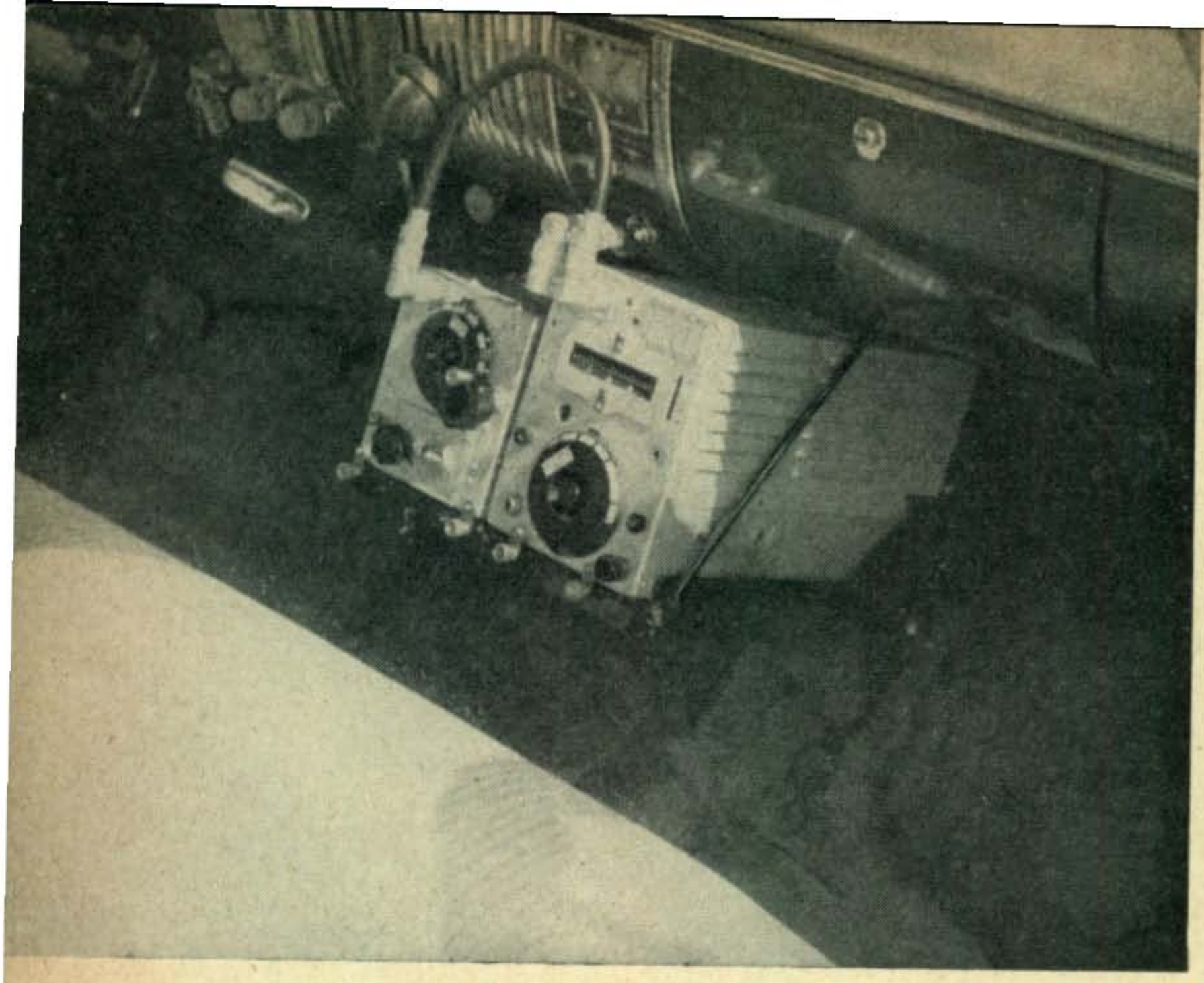


Fig. 7. The control unit is from TCS surplus.



The finished product — a sensitive receiver and a stable moderate power transmitter. Provisions for working on three bands by switching units.

Antenna

The writer decided to use a standard, manufactured, center-loaded whip, with replaceable loading coils, for quick band-change. It is mounted on the left rear fender, as high as possible, and is fed through RG8/U coaxial line with the shield grounded to the car body at the base of the antenna. Once the loading coils are cut to size with the aid of a grid-dip meter, no further adjustment is necessary. We found that removing the coil shield gave a stronger signal on 75 meters. If this is done it will be necessary to rewind the coil with smaller wire, because more turns will be required. Also, on 75 meters, cut the loading coil for maximum transmitter loading at 3970 kc. The drop-off in loading as you QSY to 3800 can be made up by running in about 5 or 6 turns of the variable loading coil in the transmitter. If you cut your antenna coil for 3900 kc, there is no way to make up the large drop in loading which occurs as you QSY to 4000 kc.

That completes our mobile installation. One final word of caution—use a heavy lead between the batteries, and from the batteries to the modulator unit, and a short heavy jumper from the modulator unit to the car frame, in order to keep voltage drop in the 12 volt circuit to a minimum. The loss should be no more than a fraction of a volt under full load, and this can be accomplished with sturdy, heavy, leads, plugs, and connectors. Suitable battery cable and connectors may be obtained at any automobile supply store. In our car, the negative terminal of the battery is grounded to the frame. Should your car have the positive grounded, it will merely be necessary to reverse the dynamotor's low-voltage leads. To make the connection to the car battery from the extra battery, drill and tap the positive (or negative, as the case may be) battery post to take a ¼-20 screw, about ½" long. The lug on the jumper cable may thus be securely bolted to the top of the battery post, without disturbing the car wiring in any way.

With the antenna described, each of the transmitters may be easily loaded up to 100 milliamperes plate current, at about 575 volts. A husky, well-modulated signal is put out by this installation, and results are limited only by band conditions and the amount of high-powered QRM that piles up on our frequency. We have worked 1000 miles on 75, and all U. S. districts and several foreign countries on 20 and 10 at the present writing.

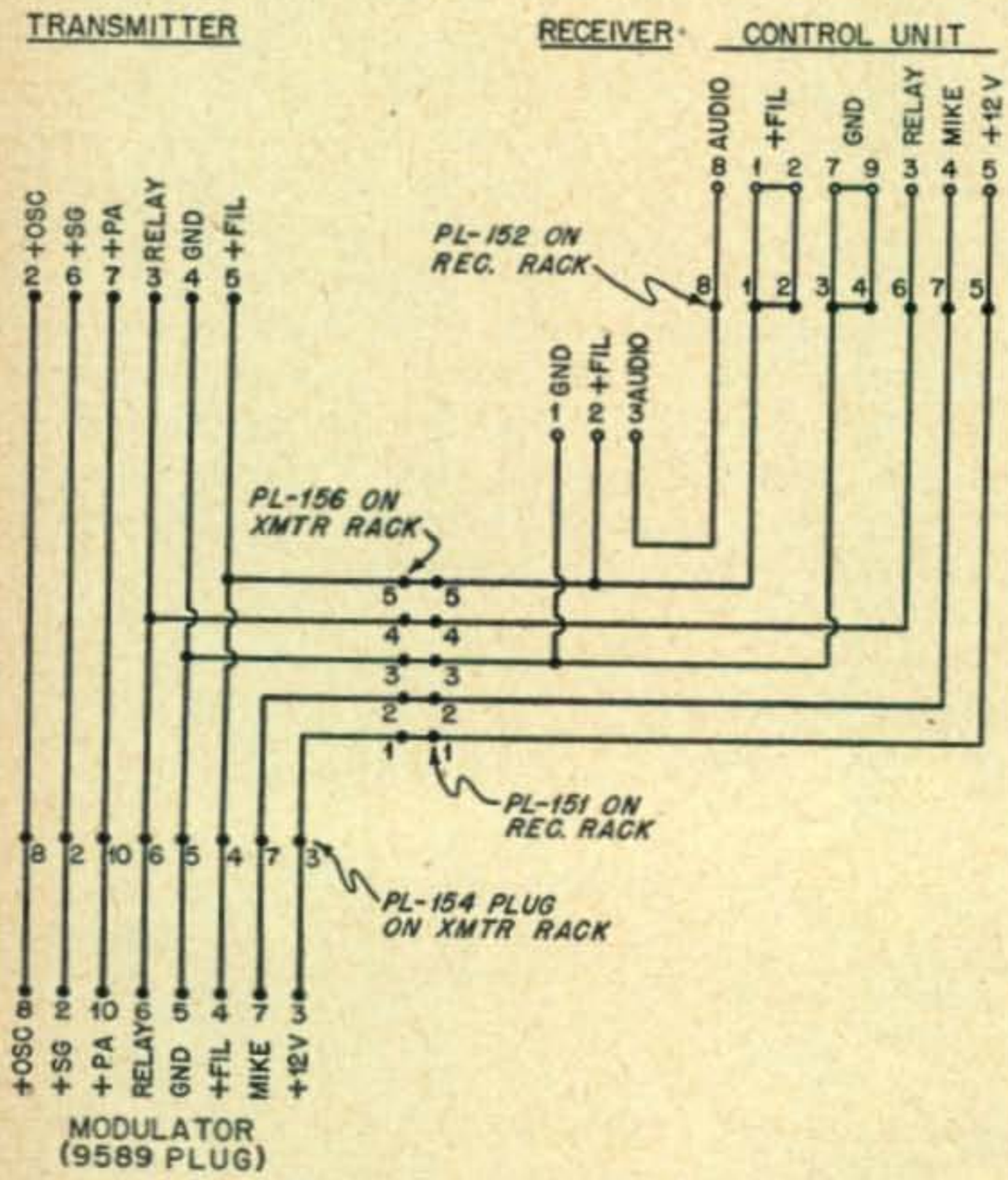


Fig. 8. The control circuits