

THE COMMAND SET ROUNDUP

THE SURPLUS BONANZA

In spite of the many articles published about "Command Sets" in the past several years there remains an insatiable appetite among new amateurs for conversion data on the *BC-274N* and *ARC-5* equipments.

Information on the following points is in demand:

1. Basic conversion data.
2. Power supply requirements.
3. Simple modification to crystal control for Novice use.
4. Modifying 4-5.3 Mc. (*BC-457*) and 5.3-7 Mc. (*BC-458*) units to cover amateur frequencies.
5. Transmitter de-TV'I'ing information.
6. Receiver data.

This "final-final" article will attempt to assemble the above information in one place for the benefit of all concerned.

The Basic Transmitter Circuit

Although they have different nomenclatures and cover different frequency ranges, all "Command" transmitters utilize the basic circuit shown in *Fig. 1*. A 1626 variable-frequency oscillator drives an amplifier, consisting of a pair of 1625's in parallel. A 1629 "magic eye" tube, in conjunction with a quartz crystal, serves as a frequency calibrator.

A roller-type antenna coil, adjusted by means of a thumb wheel through the front panel permits using almost any *non-resonant* length of wire as a *Marconi* antenna. Antenna coupling is varied, also from the front panel, by a pivoted link coil inside the amplifier coil.

Rated transmitter input is about 90 watts on CW and half that on 'phone. All tubes have 12.6-volt filaments wired in series-parallel and operated from a 25-volt (nominal) d.c. source.

The two important differences between the

BC- and *ARC-5* model transmitters are in the method of plate feed to the 1625's and the power sockets on the rear. In the *ARC-5*'s, an r-f choke feeds the voltage directly to the plates, and a 0.0004- μ fd. blocking condenser keeps the d-c voltage off of the tank coil. In the *BC*-models, the plate voltage is fed through the 1625 tank coil. This difference has no practical effect on the operation of the transmitters.

Of more immediate importance are the differences in the power sockets, which are noted in *Fig. 1*.

Adapting The Transmitters

Few amateurs have 25 volts of d.c. available; therefore it is necessary to modify the filament circuit of the transmitters for a-c operation. Either 12.6 or 25 volts may be used. For 25-volt operation, the modification entails three steps:

1. Remove the two resistors (*R70* and *R77*) connected to *pin 8* of the 1629 tube socket. Replace them with a single 2500-ohm, $\frac{1}{2}$ -watt resistor connected between *pin 8* and the chassis (ground).

2. Jam both relays (*K53* and *K54*) closed.

3. Mount a key jack in the lower right-hand corner of the front panel. Disconnect the 1625 cathodes from relay *K53* and the 51,000-ohm resistor (*R75*) across it. Connect the cathodes to the jack through a 50-ohm, two-watt resistor. Bypass the cathode of each 1625 tube (*pin 6*) to the metal shell of the tube socket with .005- μ fd., 600-volt, disc ceramic condensers (*Centralab DD-502*). The 50-ohm resistor eliminates the effect of having the "dots" on a slightly different frequency than the "dashes," as sometimes happens when a "bug" key is used.

Operating the filaments on twelve volts requires one additional step:

4. Ground *pin 7* of the remaining 1625 socket (one is already grounded). Tie *pin 1* of the two sockets together and to *pin 2* of the 1629 socket. Remove the 126-ohm resistor (*R71*), which is connected across *pins 2* and *7* of the 1629 socket and mounted on the rear chassis wall. Transfer the wire connecting *pin 7* of the 1629 socket and the oscillator coil terminal strip to *pin 2* of the socket. Ground *pin 7* of the socket, and connect *pin 2* to the filament terminal on the power socket (*pin 6* on *BC*-models and *pin 5* on *ARC-5*'s.)

This completes the basic conversion.

Power Supply

The power supply shown in *Fig. 2* will furnish all power for 75-watt operation of the "Command" transmitters. This level probably represents the best compromise between power output, signal quality, and power supply cost.

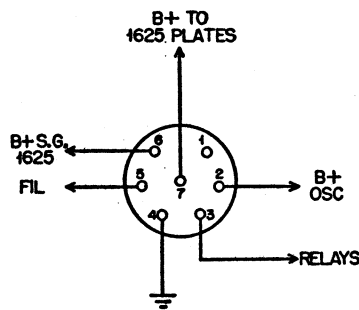
Oscillator plate voltage is relatively critical for best results. Approximately 200 volts gives essentially "zero-drift" operation. Either higher or lower voltage causes a frequency drift in one direction or the other. Actually, optimum voltage varies from transmitter to transmitter, but is usually quite close to 200 volts. Fortunately, a deviation of ten or fifteen volts does not degrade performance appreciably. Regulation of the oscillator plate voltage is highly recommended. Two *VR-105* tubes in series may be used, between *B+* and ground, as shown.

Six hundred volts a-c on the plates slightly exceeds the 550-volt maximum rating of the

5U4G rectifier tube, but such operation does not apparently reduce tube life, especially if the maximum current drawn does not exceed 200 milliamperes. Because the 5U4G is being slightly overloaded, fusing the primary circuit of the transformers is a wise precaution so that, should the tube arc over at the end of its useful life, the fuse and not the transformer will blow.

The transformer, *T1*, in the parts list is one of the very few available stock items that delivers sufficient plate voltage for our purpose and has two 6.3-volt filament windings that may be connected in series to provide 12.6 volts to light the tubes in the transmitter. Transformers with only a single 6.3-volt winding may be used in conjunction with an additional 6.3-volt, two-ampere filament transformer. Connect its primary in parallel with the primary of the plate transformer, and connect the two 6.3-volt windings in series.

The most desirable filter condenser for the power supply is an oil-filled, 1,000-volt unit,



ARC-5 Power Plug Connections.

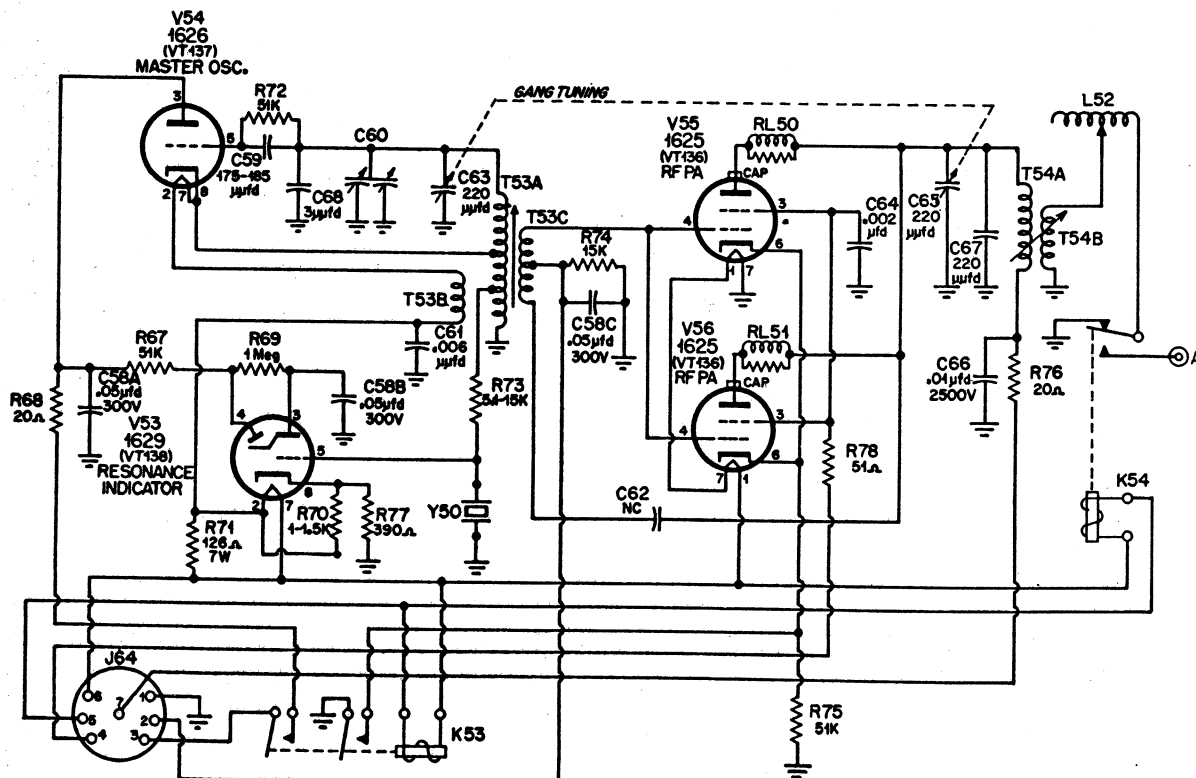
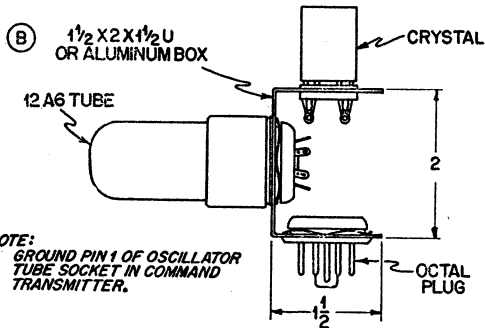
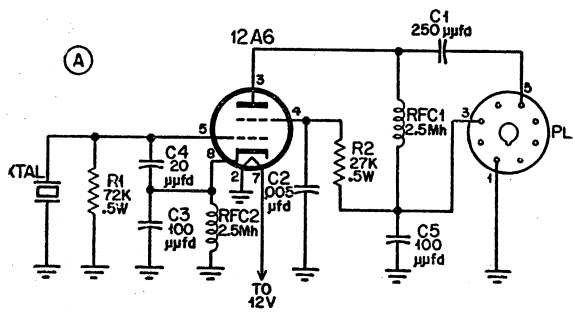


Fig. 1. Typical Command Set transmitter wiring schematic with power plug connections for the "BC-" series.

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- C1—250 μ fd. 600v. ceramic.
 C2—.005 μ d. 600v. ceramic.
 C3, C5—100 μ fd. 600v. ceramic.
 C4—20 μ fd. 600v. ceramic.
 R1—72,000 ohm $\frac{1}{2}$ w.
 R2—27,000 ohm $\frac{1}{2}$ w.
 RFC1, RFC2—2.5 mh. r-f chokes
 PL—Octal plug, male

- (base of metal tube or Amphenol CP8).
 VT—12A6 or 1626 (see text).
 Xtal—3.5 or 7 Mc. crystal.
 Built-in U bracket bent of aluminum or aluminum box approx. $1\frac{1}{2} \times 1\frac{1}{2} \times 2$ ".
 To use adapter, ground pin 1 of 1626 tube in transmitter.

Fig. 3. This adapter may be used with any Command transmitter by following the instructions given in the text on the previous page. A partial structural view is shown in "B" and a schematic (parts list above) is shown in "A."

Without plate or screen voltage on the 1625's, adjust the main transmitter dial until the oscillator functions smoothly. Then apply voltage to the 1625's and resonate the 1625 tank circuit by adjusting C65. Antenna tuning and loading are described previously.

Utilizing the BC-457 and BC-458

So far, it has been assumed that 3-4 Mc. or 7-9.1 Mc. transmitters, which cover the 3.5 and 7-Mc., amateur bands, respectively, are available. However, 4-5.3 Mc. and 5.3-7 Mc. units are more plentiful and can be modified to cover these and other bands quite easily.

To cover the 3.5-Mc. band with a 4-5.3 Mc. BC-457 unit, set the oscillator padding condenser C60 (under the oscillator coil shield) to maximum capacity and re-resonate the 1625 stage with C65. The oscillator coil shield must be in place while this is being done.

The easiest way to cover the 7-Mc. band with a 5.3-7 Mc., BC-458 unit is to decrease the capacity of both padding condensers just enough to permit covering the entire band. A better way is to short out three turns from the top of each coil, before adjusting the padders.

By shorting out the top turn on each coil,

removing two rotor plates from each of the ganged condensers, and judiciously juggling the setting of the coil slugs and padders, it is possible to make the 7-Mc. band start at 6.0 on the dial and end at 6.3, giving direct frequency calibration by mentally adding 1 to the dial reading.

Covering Other Bands

Modifying the frequency range of "Command" transmitters to cover other bands requires changes ranging from working on the coils to completely rebuilding the unit. Some of the more-successful methods will be described briefly in the following few paragraphs, with full details to be found in the reference articles.

160 Meters: If the scarce 2.1-3 Mc. BC-456 transmitter is available, set the padding condensers to approximately maximum capacity. Otherwise, the coils of one of the higher-frequency units may be rewound. A new oscillator coil contains 36 turns of #20 enameled wire, with the cathode of the 1626 connected to the eighteenth turn. The 1626 filament wires (pins 2 and 7) are cut completely free of the oscillator coil. Disconnect the neutralizing condenser from the oscillator coil and move R74 and C58C to that terminal. Set oscillator padder to maximum capacity. Rewind the amplifier coil with $34\frac{1}{2}$ turns #18, enameled wire. Tune to resonance with C65.

20 Meters: The simplest method of covering 14 Mc. with a "Command" transmitter is to use a 7-9.1 Mc. BC-459 unit. Disconnect tuning condenser C67, and use C65 to tune the 1625 stage as a 14-Mc. doubler. Disconnect neutralizing condenser from the oscillator coil. Move R74 to that terminal. Replace C58C with an 0.002- μ d. mica condenser. A much better method is to insert a frequency multiplier between oscillator and revamp the amplifier.

15 Meters: With a 7-9.1 Mc. BC-459 unit, add a frequency multiplier between the oscillator and amplifier. Rewind the amplifier coil to have 5 turns, double spaced.

The conversions using an added multiplier stage may have it installed in the space originally occupied by the 1629 calibrator tube socket.

10 and 6 Meters: Operation on these bands requires practically a complete rebuilding job. The process has been described fully in several articles.

Adding Another Stage

To The Command Transmitter

Installing an untuned stage between the oscillator and the amplifier of a "Command" transmitter reduces reaction, resulting in better keying, which is discussed a bit later, and eliminates the possibility of frequency modulation when the 1625's are amplitude modulated for 'phone work. Also, as mentioned above, an extra frequency multiplier is usually required to operate the amateur bands above 7.3 Mc. Figure 4 is a suitable circuit for either application.

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A 2.5 mh. r-f choke acts as the plate load impedance when the stage is to be used as an isolating stage, and a slug-tuned coil is substituted for the choke when a frequency multiplier is required. The switch and coil shown in the dashed lines permits using the stage for either purpose. Of course, for this feature to be of any value, a similar switch must be added to the 1625 tank circuit. Then one transmitter may be used on two adjacent bands.

Rewire the crystal socket for the tube, mount the coil on a scrap of metal in place of the 1629 tube socket, and mount the switch on the rear or side lip of the chassis.

The simplest modification of the 1625 tank circuit for two-band operation is to mount another switch on the side of the chassis behind C65 and C67 (See Fig. 1 and bottom photograph) and wire it so that when it is open, C67 is out of the circuit. Resonance is obtained on the new frequency near minimum capacity of C65. It is convenient to add an external shaft and dial to C65 for adjustment.

Alternatively, the switch may be mounted above the chassis and used to short out the top half of the turns on the amplifier coil T54. Resonance on either band will then occur at approximately the same setting of C65, depending upon how accurately the tap is placed. Ganged tuning of the oscillator and amplifier is retained. Also a more favorable L/C ratio in the tank circuit for harmonic discrimination is obtained.

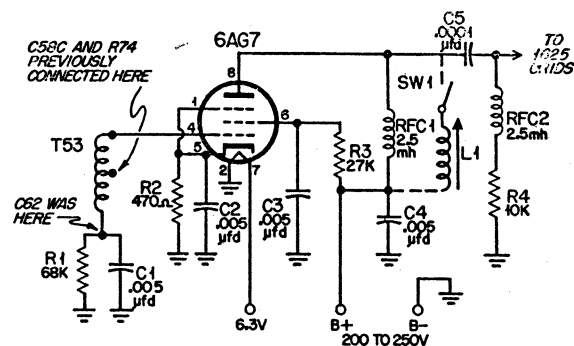
De-TVI'ing The Command Set Transmitter

"Command" set transmitters are notorious TVI producers. However, there are tremendous differences in the TVI produced by apparently identical units. Some are very nearly "clean," and others are just the contrary. Also, the oscillator of one may be full of TVI, with the amplifier relatively clean, or vice versa, or both stages may contribute their share to the overall confusion.

The first step in de-TVI'ing the transmitter is to improve the effectiveness of the bypassing under the chassis, and to cool off the power and key leads. The ingredients required are a handful of 0.005- μ fd. disc ceramic condensers and about five feet of shielded wire. Carry out as many of the following steps as are necessary to clean up your troubles:

1. Bypass to ground each of the following points: screen grid of each 1625 (pin 3), plate of 1626 (pin 3), target of 1629 (pin 3), the centertap of the 1625 grid coil, and the point where the filament voltage is fed into the oscillator coil. Disconnect and remove the three-section, 0.05- μ fd. condenser (C58) mounted on rear lip of the chassis.

2. Replace the leads from the power socket to the various points within the transmitter with shielded conductors, grounding the shield wherever possible throughout its length, especially at each end. At the same time, short-



- C1, C2, C3, C4—0.005 μ fd. 600 v. disc ceramics.
- C5—0.001 μ fd. mica or ceramic.
- L1—Wound on National XR-50 or equiv. slug-tuned forms 7 Mc. 20 T. #20, enam. close wound. 14 Mc. 10 T. #20, enam. spaced to occupy $\frac{1}{2}$ inch. 21 Mc. 7 T. #20, enam. spaced to occupy $\frac{1}{2}$ inch. (One only required.)
- R1—68 K, $\frac{1}{2}$ w.
- R2—470 ohms, 2w.
- R3—27 K, 1w. (May be varied to adjust excitation to 1625's).
- R4—10 K, $\frac{1}{2}$ w.
- RFC1, RFC2—2.5 mh. 50 ma. radio-frequency chokes.
- SW1—S.p.s.t rotary switch, preferably ceramic insulated (Centralab 2043 or equiv.) A similar switch is used in the 1625 stage, described in text.

Fig. 4: Diagram of an isolating stage or frequency multiplier which may be substituted in the frequency calibrator stage space of "Command" transmitters. Referring to Fig. 1, the wire between the oscillator coil (T53) and the 1625 grids is removed from the grids and connected to pin 4 of the 6AG7 socket, and the output of the 6AG7 connected to the 1625 grids. Other changes required are to remove the 1625 neutralizing condenser (C62) and disconnect C58C and R74 from the oscillator coil terminal strip. Connect R1 and C1 to the terminal to which C62 was previously connected. When only an isolating stage is required, L1 and SW1 are omitted, and when only a frequency multiplier is required, L1 is substituted for RFC1, SW1 again being omitted.

en all ground leads as much as possible and remove unused components and conductors. In low TV-signal areas, it is also desirable to bypass each terminal of the power socket with an 0.005- μ fd. disc ceramic condenser. The important point in installing these bypasses is to keep their lead length to an irreducible minimum.

3. With the bottom plate in place, the bottom of the transmitter is quite well shielded, even though there is a theoretical possibility of r-f leakage along the crack between the edges of the chassis and the plate. Use all screws and press the plate firmly into place while tightening them.

4. Another good method of improving the shielding is as follows: Remove the rotary antenna coil and cover the holes in the front panel with a piece of scrap aluminum. Next, bend a piece of bronze screening, 12 x 15 inches, into a trough to fit inside the cover. Then solder another piece across the open back of the trough. When the cover is screwed into place, the screen is clamped firmly between it and the chassis. Pay particular attention to the openings near the rear of the cover at the bottom. They may be sealed off by soldering the edge of the screening at this point.

5. Other methods of improving the shielding of the cover include backing up the ventilating louvres with perforated sheet metal and sealing the tube-access openings on the top with electronic weatherstripping.

6. Undoubtedly the most efficient way to keep harmonic energy out of the antenna circuit is to substitute a coaxial fitting for the original output terminal and feed the antenna through a low-pass filter, in conjunction with an antenna tuner if necessary. Any conventional link-coupled antenna tuner may be used. Also, by remounting the original rotary coil on a small metal base and link coupling it to the transmitter, it will function in much the same fashion as it did before being removed from the transmitter.

After the coil is remounted, close wind a three-turn link of stiff, well-insulated wire (about #16) of a diameter just sufficient to slip over the rotary coil. Slip the link coil over one end of the rotary coil, with the link fitting between the coil and the rod upon which the roller slides. Terminate the link winding in a coaxial cable chassis fitting mounted on the base on a small angle plate. The fitting serves the dual purpose of supporting the link winding and bringing r-f power from the transmitter to the tuner.

Ground the end of the rotary coil under the link winding and connect the roller to the antenna. Adjustment and limitations of the loading coil will be as already described, but with the possibility of inserting a low-pass filter in the link line for further attenuation of harmonic output from the transmitter.

Alternate Keying Methods

The problem of which is the best method of keying "Command" transmitters has caused more hair tearing than any other question. When operated conservatively, excellent keying can be obtained on 3.5 Mc., and good keying

on 7 Mc. On the higher frequency bands, however, keying is seldom better than passable, unless a frequency multiplier has been inserted between the oscillator and power amplifier in the course of the modification, and if only the 1625's are keyed.

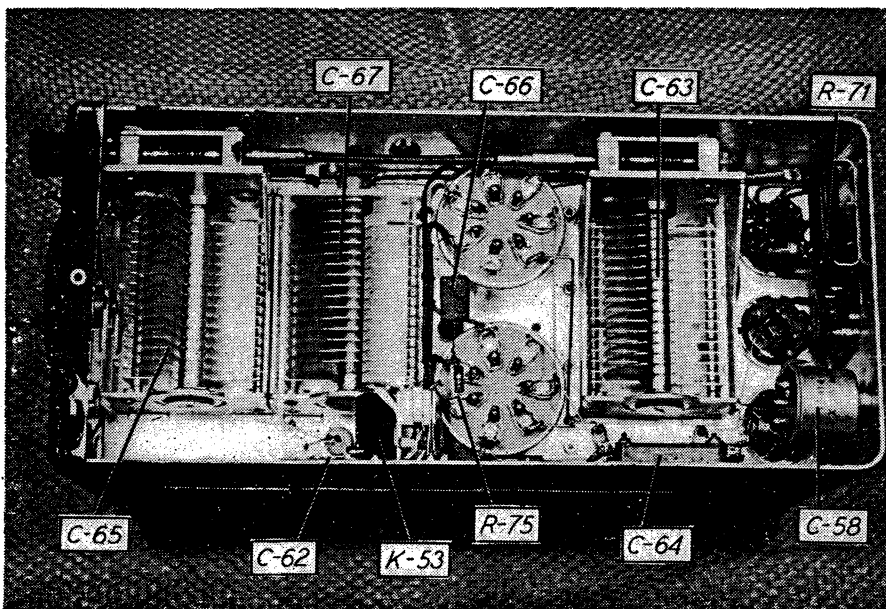
In our opinion, on 3.5 and 7 Mc., straight cathode keying of the 1625's is as good as any type, and better than some. It suffers the disadvantage of not permitting "break-in." Keying the oscillator permits "break-in" operation, but almost invariably accentuates chirps. Expedients used to permit oscillator keying include keying the B- lead of the power supply, keying oscillator B+ and amplifier screens simultaneously through a relay, and replacing the jumper between pins 7 and 8 on the 1626 socket with a 0.002- μ fd. condenser and connecting pin 8 to the key jack through a 2.5-mh. r-f choke.

Modulation

The transmitters work well on phone at inputs of approximately fifty to sixty watts. In fact, many amateurs run considerably higher power than this on phone, without too much trouble. For an input of fifty watts, any modulator capable of delivering twenty-five watts of audio power may be used. Assuming a 1625 tube plate voltage of 500 volts and a total current of 100 milliamperes, the modulation transformer should be capable of matching the plate load impedance of the modulator tubes to a 5000-ohm load. The screens of the 1625's should be modulated as well as the plates. This is most easily accomplished by feeding the screen voltage through a 10-henry, 50-milliamperere filter choke, which will allow them to be self-modulated.

Command Receivers

The most commonly available "Command" receivers are the BC-453, covering 190-550 kc; the BC-454, covering 3-6 Mc; and the BC-455,



Bottom view of the typical Command type transmitter.

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covering 6-9 Mc. They all use the same, basic, six-tube circuit, with the filaments of the 12.6-volt tubes wired in series-parallel for operation from twenty-five volts.

As in the case of the transmitters, there are both *BC-* and *ARC-5* models, but the only important difference between them is that the *ARC-5* receivers use a 12SG7 tube in the second i-f stage, while the *BC* models use a 12SK7 tube.

The receivers are quite sensitive and stable, but the two units that cover the amateur 3.5 and 7-Mc. bands leave much to be desired from the selectivity standpoint. Nevertheless, they make excellent "first" or standby receivers. The bibliography contains many references to articles describing how to cover these and other bands with "Command" receivers.

The *BC-453*, 190-550 kc., receiver has proved to be an extremely useful gadget around many amateur shacks. It uses an 85-kc., i-f amplifier, which is very selective. By tuning the main dial to 455 kc., the standard intermediate frequency of most communications receivers, and using a wire connected to the antenna post of the *BC-453* with the other end wrapped loosely around the lead from the last i-f transformer to the second detector in the communications receiver, the combination becomes an extremely selective "dual-conversion" receiver.

Some amateurs however, just take the i-f transformers from the *BC-453* to build a selective i-f channel in less space.

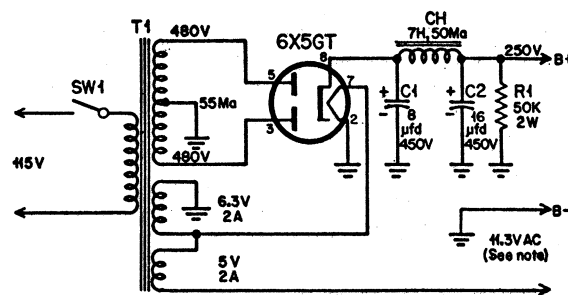
Modifying The Receivers

To use the receivers in amateur service entails adding a gain control, a beat-oscillator switch and a phone jack, and building a power supply.

Also, as it is easier to obtain 12.6 volts than twenty-five volts, it is usually necessary to rewire the filaments in parallel for twelve-volt operation. When this is done, the six-volt equivalents of the original tubes may be substituted and the receivers then operated from a six-volt filament source.

The logical place to mount the new gain control, phone jack, and beat-oscillator switch is on the front panel in the space occupied by the adapter box. Remove the screws holding the box in place. Unplug it and remove the aluminum box holding the socket into which the adapter plugged. Mark the wires that were connected to *pins 1, 4, and 5*. Remove the rest. Cover the hole in the panel with a flat piece of aluminum upon which is mounted a midget, 25,000-ohm wire-wound potentiometer, flanked by a s.p.d.t. toggle switch and a small phone jack.

Ground the middle terminal of the potentiometer



NOTE: REVERSE CONNECTIONS TO ONE FILAMENT WINDING, IF THIS VOLTAGE IS VERY LOW.

- T1—Power transformer. 480v., 55ma., c.t., 5v., 2amp.; 6.3v., 2amp. (Stancor PC-8402 or equiv.)
- CH—7 h., 50ma. filter choke. (Stancor C-1707 or equiv.)
- C1, C2—dual 8 µfd., 450v. electrolytic.
- R1—50,000 ohm, 2w.
- SW1—s.p.s.t. toggle.
- Octal tube socket
- 6X5GT tube
- 7 x 7 x 2" chassis
- Additional receiver conversion parts: 25,000-ohm, wire-wound pot. small size. S.p.s.t. toggle switch. Single-circuit phone jack

Fig. 5. Wiring schematic and parts list of a power supply unit suitable to operate the Command Set receivers.

meter and one terminal of the switch to the ground lug of the phone jack. Connect the *No. 1* wire to the *left-hand* terminal of the potentiometer (viewed from the back with terminals down), wire *No. 5* to the switch, and wire *No. 4* to the phone jack.

To rewire the filaments of tubes, ground one filament pin of each tube socket and connect the other filament pins of each socket together and to *Pin 2* of the three-terminal plug at the rear of the receiver. *Pins 2 and 7* are the filament terminals on all tubes, except the 12SR7 and 12SG7, on which they are *pins 7 and 8*.

Connect power to the three-terminal plug thusly: B— and one side of the filament circuit to *pin 1*; twelve volts, a.c., to *pin 2*; and 200 to 250 volts, d.c., at fifty milliamperes, to *pin 3*.

WARNING! Do not apply more than 250 volts to the receiver; otherwise there is danger of blowing some of the condensers in it.

Figure 5 is the diagram of a power supply suitable for use with "Command" receivers. It is conventional, except for the 6X5 rectifier tube and the use of two filament windings connected in series to operate the tubes in the receiver. The total of 11.3 volts is a little low, but it will satisfactorily operate the receiver.

Obviously, this article just scratches the surface of the vein of information available on the use of "Command" equipment, but we hope that, combined with the bibliography, it serves a useful purpose.