Command Transmitters on the Amateur Bands

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THE Command series of transmitters, built for the U.S. Services, can be easily modified for use on the amateur bands. Units are readily available covering 3.5 and 7 Mc/s bands, while some covering other frequencies may come to light occasionally. Although outwardly identical, these units have various circuit arrangements, and anyone attempting to use them should tread carefully until the circuit, and particularly the power connections at the rear of the chassis, have been ascertained.

Circuit

Fig. 1 shows the original circuit of an ex-U.S. Navy unit T19/ARC-5, covering 3-4 Mc/s. This is more or less the basic arrangement of all these units, but a BC-459-A unit, ex-U.S. Army Signal Corps, covering 7-9 Mc/s, showed variations to the p.a. circuit (Fig. 2). Most of these circuit variations make little or no difference to the modifications described here, but a major difference between the two units is the connections to the power input socket. These are shown in Fig. 3(a) and (b) for the T19/ARC-5 and the BC-459-A respectively. Intending users would be well advised to trace out the wiring to this socket before applying power to the unit, because it is quite possible that other variations may exist, e.g., in units (if any) built for the U.S. Air Force!

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Modifications

One very attractive feature is that the transmitter can be put on the air (and with a very clean signal) with practically no alteration, or it may be subjected to extensive modification, as pleases the individual. For anyone who is without mains, and uses 24 volt accumulators as a power source, these units are made to measure. For the majority, however, some modification is necessary.

The first consideration is the valve heaters, which are wired in series-parallel to run direct off 24 volts (or 28 volts, as the Americans prefer). The 1625 bases are easily accessible, and it is a simple matter to change the heaters from series to parallel, but the 1626 and 1629 bases are rather difficult to reach; the simplest way to get the transmitter going is to short out R6, which is the wire wound resistor mounted on the back drop of the chassis, on the same side as the 1629. This resistor, marked 70.10, is in parallel with the 1629 heater. The 1629 takes 0.15A at 12.6V and the 1626 takes 0.25A at 12.6V, therefore this resistor, R6, carries the difference of 0.1A (value of R6 must be 126 ohms). By shorting out R6, the 1629 is put out of action, and if, at some future date, it is required, then the heaters will have to be re-wired in parallel.

Some qualms were felt about running a.c. through the oscillator coil, but the note is T9. No attempt should be made to change the 1626 heater and cathode wiring

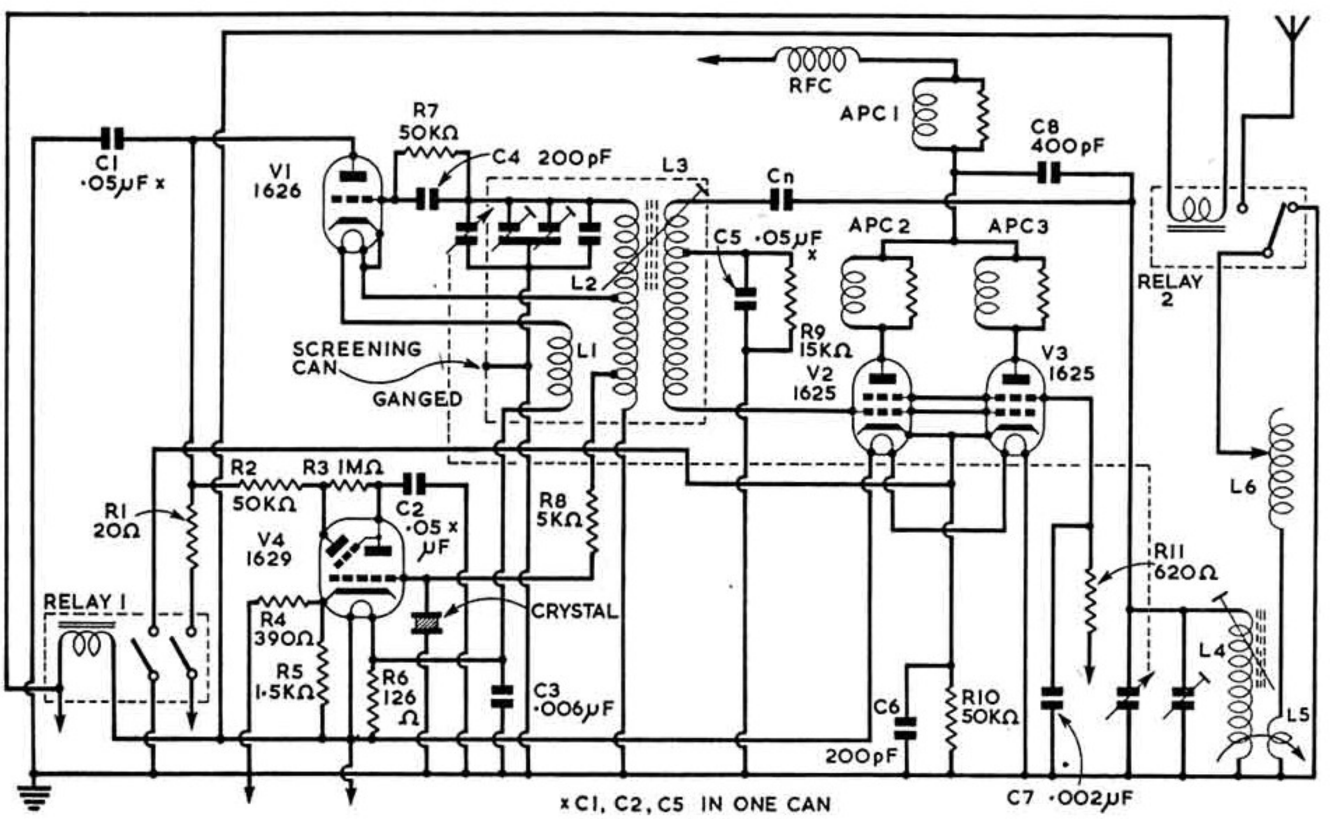

Fig. 1. Original circuit diagram of a T19/ARC-5 "Command" transmitter unit covering 3-4 Mc/s. L1, oscillator heater "choke" coil; L2, oscillator grid coil; L3, p.a. grid coil; L4, p.a. tank coil; L5, variable coupling link coil; L6, aerial loading coil. L1, L2 and L3 are all wound on the same former and mounted inside a screening can.

to eliminate the a.c. from the coil, or the r.f. feedback from the cathode will be lost to earth through the cathode/heater capacity, and the oscillator will cease to function.

Keying

Arranging the oscillator and p.a. valves to work off a 12 volt heater supply is satisfactory, but, unfortunately the relays, which originally worked from the l.t. supply, will not operate below about 17 volts and require d.c. As a.c. is to be used for the heaters some other source of d.c. is necessary. All that is required is 18-20 volts at about 150-200mA. Two 9-volt grid bias batteries in series will operate the relays for quite a long time.

The relay energising supply should be connected between the " hot " side of the l.t., and one side of the key, and the other side of the key to the relay return socket. It will be appreciated that the relay energizing supply, and the key, must be isolated from earth. Should this be inconvenient, then a little further modification is necessary.

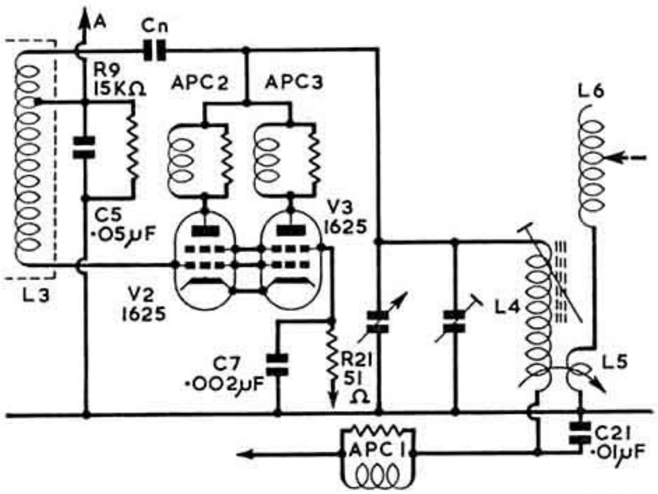

Fig. 2. Variations from Fig. 1 in the circuit of a BC-459-A transmitter unit covering 7-9 Mc/s.

Trace out the positive (white) leads from both relays to pin 1 on the 1625 base furthest from the keying relay, and disconnect them both at the valve base, then connect them both to earth. (Pin 7 on the same valve base is now an earth point.) The key should be connected between the relay return socket and the live side of the relay energizing supply, the other side of which is earthed. Using this method, only the key contacts must be isolated, but since the voltage being keyed is low, " operator protection " is unnecessary, so long as accidental contact with earthed objects is avoided, as this puts a direct short on the relay supply.

The action of the relays should be checked to ensure that they go right over, since they make an appreciable noise when activated by too low a voltage. Once heard, however, there is no mistaking the healthy " clang " as they both go over together. Apart from the necessity for an extra power supply for the relays, the noise is rather a nuisance, so the next step is their removal.

The aerial change over facility can be dispensed with altogether, and a permanent connection made to the aerial terminal. If the keying relay is removed by disconnecting the black lead from the relay bobbin, this lead can be connected to the p.a. cathode, and thus effect the keying. This long cathode lead causes instability, but a 0.01μF condenser from the cathode to earth (C31 in Fig. 5) will cure it.

Above-chassis view of a modified unit, showing the co-axial cable from the coupling link to the output socket on the front panel. Note that the vertical wire on the side of the p.a. tank coil is at high r.f. potential, and great care should be taken that the co-axial cable outer braiding does not touch it.

The oscillator h.t., which was originally keyed simultaneously with the p.a. cathode (by the keying relay) can be wired direct from the power input socket, through R1 to the anode pin of the 1626, so that the oscillator has to be switched externally. Leaving the oscillator running during transmission improves the quality of the radiated signal, and the spacer wave is only very slight, even locally.

Aerial

With the existing coupler, various lengths of wire will be found to load quite efficiently, though a good earth is essential. Theoretically, the best arrangement is a quarter wave (at the highest frequency used) or any *odd* number of quarter waves. An alternative method is to remove the aerial tuning coil, L6, and run the link output to a co-axial socket on the front panel, in place of the existing " Antenna Post." The output is then fed through co-axial line to a separate aerial tuning unit.

Power Supplies

The 12 volt heaters are a great drawback to these units, but since it is advisable to use separate power packs for the oscillator and the p.a., especially for high power working, two 6 volt heater supplies may be connected in series, *and phased correctly*, to give 12 volts. The current required is only 1.15A or 1.3A if the 1629 is used.

The oscillator will work down to about 50 volts h.t., but is designed for 150 volt operation; in practice 210 volts has been found to give the best results. The oscillator h.t. supply should be stabilized, or a chirpy signal will result.

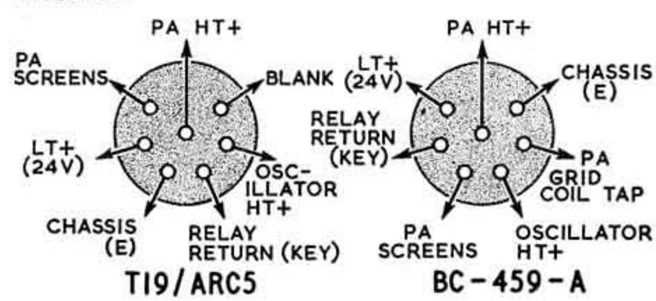

Fig. 3. (a) Power input socket connections of the T19/ARC-5 unit. (b) Power input socket connections of the BC-459-A unit.

The p.a. voltages depend upon the power input desired, and on the power supplies available. With 600 volts on the anodes and 300 volts on the screens, the transmitter runs an efficient 100 watts. A good arrangement was found to be an STV280/40 stabilizer providing 280 volts for the p.a. screens, and 210 volts for the oscillator. A slight chirp which was reported on first trials was cleared by stabilizing the p.a. screen voltage. It must be appreciated that these transmitters are v.f.o./p.a. only, and consequently require careful handling if the quality of the radiated signal is to be good.

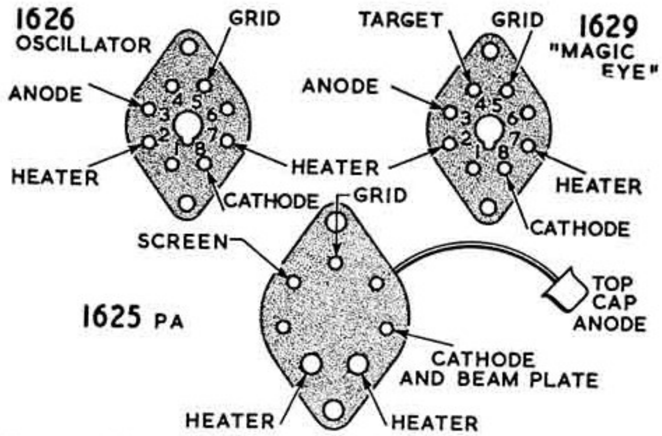

Fig. 4. Valve base connections of the valves used in "Command" transmitters

The "Magic Eye"

Mention was made earlier of the possibility of getting the 1629 tuning indicator working; this is quite simple. First, the 1629 and 1626 heaters must be wired in parallel, then R4 and R5 (Fig. 1) removed, and R31 (Fig. 5), 4,700 ohms, wired from the 1629 cathode to earth. In the original circuit R4 and R5 formed a voltage divider across the 24 volt l.t. supply, so that about 8 volts positive bias was applied to the 1629 cathode, but by changing the l.t. supply to 12 volts a.c., this bias becomes 4 volts a.c., which causes the 1629 target to blur over about 15 degrees on either side of a 90 degree shadow. The removal of R4 and R5 and the substitution of R31 as a conventional cathode bias resistor provides the necessary bias to close the "eye." Tuning the oscillator to the crystal frequency causes the shadow angle to increase; the point of maximum shadow is the point at which the v.f.o. is tuned to the crystal frequency. A note on the lid of the unit says that if several responses are obtained, the lowest in frequency, and greatest in amplitude, is the correct one.

A small mirror is fitted under the hinged lid which covers the two valves and the crystal at the back of the chassis; if this lid is placed at an angle of about 45 degrees the reflection of the 1629 target can be observed from the front of the unit simultaneously with the tuning dial.

The crystals in these units are not usually within the amateur bands, and to make best use of this calibration check, a band edge crystal would be the most useful. It need not necessarily be an octal based one, but could be mounted on an octal plug (or old valve base) with the crystal connected between pins 3 and 7. The octal based crystals are so connected, with the outer metal shell connected to pin 1.

Calibration

The dial is calibrated in frequency, and the spacing is such that quite accurate frequency setting can be achieved, but of course, for this to be done, the readings must be accurate. The long storage and not always gentle handling of these units makes the possibility of accurate calibration being retained extremely remote. Any modifications carried out can also be expected to cause slight changes in calibration. Add to this the fact that the oscillator valve is a triode (so changes in h.t. voltage cause changes in frequency) and the need for re-alignment will be apparent.

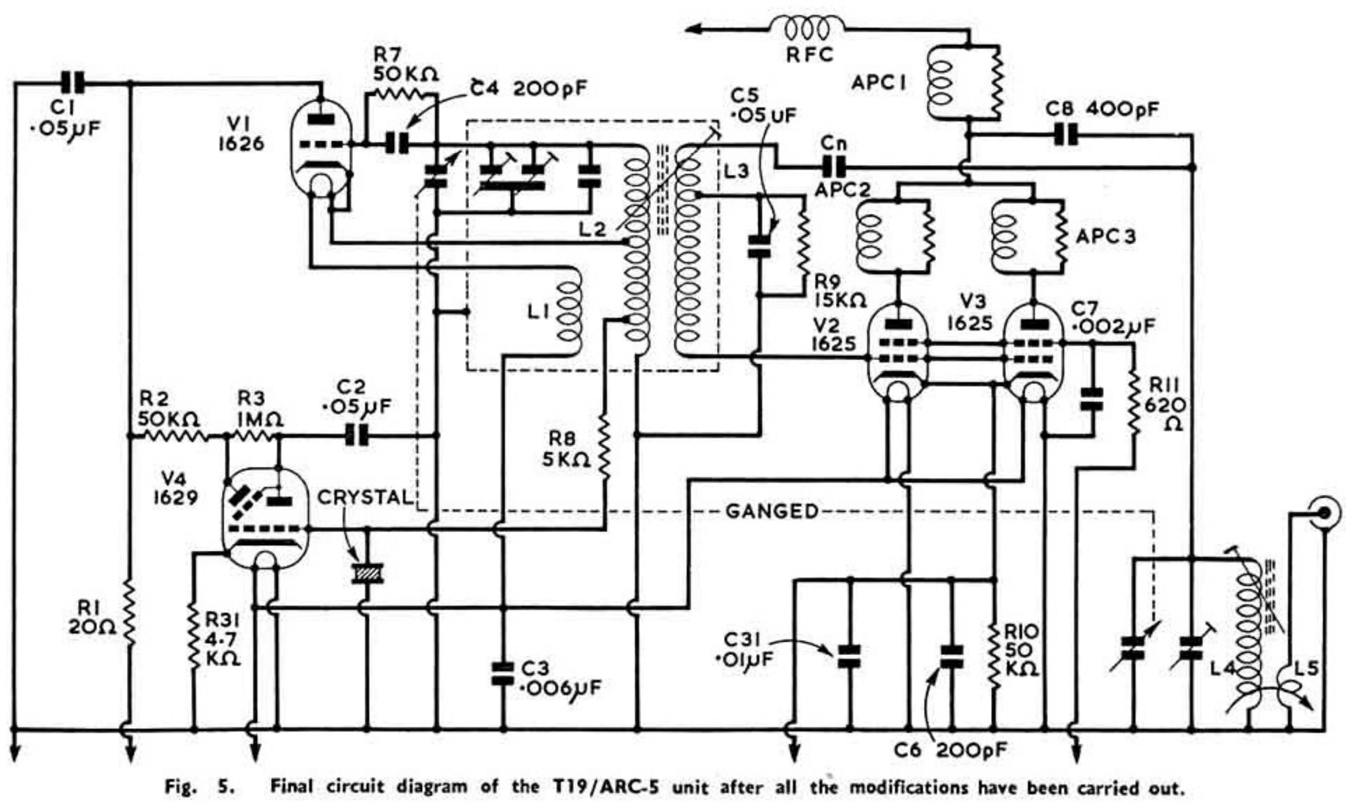

Fig. 5. Final circuit diagram of the T19/ARC-5 unit after all the modifications have been carried out.

The oscillator grid circuit consists of a coil (L2), tuned by the ganged variable, a small fixed capacitor and two trimmers. The fixed and the two trimming capacitors are inside the oscillator screening can which is mounted between the 1626/1629 valves and the 1625s. The trimmers consist of a fairly large capacity screwdriver adjustable variable with a locking arm and screw, and a single vane varied against the same stator, which is accessible through the top of the can. The inductance of L2 can be varied by means of a screw adjusted core, which is also accessible from the top of the can. It is, in fact, one of the "screws with the blue heads," whose settings, according to a warning printed on the top of the can, must not be changed without reference to the instruction book. It should hardly be necessary to do more than adjust the calibration over the portion of the dial covering the amateur band, so little difficulty should be experienced.

About the best source of reference for calibration is a 100 kc/s crystal oscillator, and with the aid of a receiver covering the required band, the v.f.o. signal can be beaten against the harmonics of the 100 kc/s oscillator to give spot checks as required.

First, with the b.f.o. on, set the receiver to the low frequency end of the band (i.e., 3.5 Mc/s for the 80m transmitter) then swing the v.f.o. about 3.5 Mc/s on the dial until the signal is heard. Switch off the b.f.o. and adjust the core of L2 until the oscillator of the transmitter is zero beat with the 3.5 Mc/s harmonic of the 100 kc/s crystal oscillator, when the dial is set exactly on 3.5 Mc/s. Next move to 3.8 Mc/s and adjust the trimmer through the top of the screening can for zero beat when the dial is set exactly on 3.8 Mc/s. Move back to 3.5 Mc/s and re-trim the coil, then back to 3.8 Mc/s and adjust the trimmer again. Repeat this process until the two readings are obtained simultaneously.

Should it be found that the small trimmer will not adjust sufficiently to achieve this, it becomes necessary to adjust the large trimmer, the locking screw of which can be seen through a hole in the side of the can. The easiest way is to remove the can, carefully measure the distance from the locking screw to the spindle on the side of the trimmer, and mark off and drill a $\frac{3}{16}$in. hole in the can, so that when it is replaced the large trimmer can be adjusted through this new hole. The small amount of movement permitted by the locking arm should be quite sufficient to allow the calibration to be adjusted. All adjustments should be made with the screening can in place.

Once the band edges are calibrated, and providing the unit was in good condition to start with, the setting of the dial at 3.6 and 3.7 Mc/s may be accurate also. However, in units so far modified it has been found that with 3.5 and 3.8 Mc/s accurately aligned, the intermediate 100 kc/s points showed varying errors up to 5 kc/s. Correcting this proved slightly more difficult.

First remove the base plate from the chassis, and set the dial to 3.8 Mc/s. On the end vanes of the oscillator ganged variable capacitor are segments about a quarter of an inch wide. Determine which segment is the next one to be meshed with the stator as the dial is turned to *decrease* frequency, and bend it slightly *towards* the stator if the dial reads low on 3.7 Mc/s, and *away* from the stator if the reading is high. Re-adjust the trimmer through the top of the can for zero beat on 3.8 Mc/s, then swing to 3.7 Mc/s and check the error. Repeat if necessary until satisfactory calibration is achieved. Similarly adjust the next segment which becomes meshed on tuning to 3.6 Mc/s, and check the settings at 3.6, 3.7 and 3.8 Mc/s. The trimmer should need little or no adjustment when setting 3.6 Mc/s, since, when tuned to 3.8 Mc/s, the segment which is adjusted to trim 3.6 Mc/s is not in close proximity to the stator, and therefore has no effect on the capacity.

When 3.6 Mc/s is correct the 3.5 Mc/s calibration must be re-set. This is done by means of the next segment of the rotor vane. A final check on the four spot frequencies, and perhaps a touch on the coil slug and the trimmer, and the job is done. Any slight frequency shift caused by replacing the top cover can be eliminated by adjusting the trimmer, which is accessible through the slide covered hole in the top of the cover. This process sounds very complicated, but actually it is remarkably easy to achieve calibration to within less than 1 kc/s of the dial markings.

The above process should be carried out with voltage applied to the oscillator of the value which it is intended to use, as a change of 50 volts in h.t. can cause a frequency shift of 4 or 5 kc/s.

P.A. Trimming

The p.a. tank circuit tuning is ganged to the oscillator tuning, and may require trimming up after the oscillator has been calibrated. This is done by means of the large screwdriver - adjustable capacitor immediately behind the p.a. tuning capacitor under the chassis, and also by the adjustable core in the tank coil. (The other "screw with the blue head" mentioned in the warning on the oscillator screening can.)

Front view of the transmitter after modification. Note the aluminium panel covering the "window" above the tuning dial.

The trimmer is accessible through the side of the chassis, there being two holes corresponding with the spindle of the trimmer and the locking screw. The plugs in these holes are only a spring fit, and can easily be removed with a screwdriver. The locking arm on the spindle permits only a degree or two of movement, but this should be quite sufficient.

To trim the p.a., first set the dial to the h.f. end of the band, and the "antenna coupling" control at zero. Apply power to all inputs (reduced h.t. to the p.a. anodes safeguards against damage to the valves during the process of tuning up), press the key and adjust the trimmer for minimum anode current. Lock the trimmer. Do not leave the key pressed for long periods, because in this "dipped" condition the screen current is higher than normal, and damage to the valves may result.

Next, set the dial to the l.f. end of the band, and adjust the coil core for minimum p.a. anode current. Check that the anode current does not rise much above the lowest dip obtained at any setting of the dial within the band; if it appears to rise at the h.f. end, repeat the trimming procedure until the p.a. remains dipped over the whole band.

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In operation the coupling coil is advanced until the p.a. draws the required current, or until the maximum r.f. output is obtained. Over coupling will give a greater d.c. input, but efficiency falls off rapidly, and any harmonics which are present in the p.a. tank circuit are more easily radiated.

Telephony

To use telephony with these transmitters the simplest method is that for which they were originally intended, i.e., screen modulation. For this it becomes necessary to reduce the screen voltage to 150 volts maximum so that the standing input obtainable is correspondingly lower. The screen is fed through the secondary of a modulation transformer. A few watts of audio will fully modulate 50 watts input.

When setting up on 'phone, the coupling and aerial tuning must be adjusted until the p.a. anode current kicks upwards when modulation is applied, otherwise the radiated signal will be badly distorted, and probably unintelligible. It will be found that slightly more coupling than the optimum for maximum r.f. output is necessary to achieve good modulation.

TVI

Lacking a television receiver, the author can make no claims about the TVI aspect of the Command transmitter, but *Television Interference*, Third Edition (Remington Rand Laboratory of Advanced Research) carries on page 75 a short note on this subject, which broadly speaking, advocates the removal of the aerial tuning coil, as mentioned earlier, complete screening of the unit, with an aluminium plate over the front window, and copper mesh over the inside of the louvres, and the by-passing of all the supply and keying leads with 0.01μF disc ceramic capacitors at the power socket.

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The 3.5 Mc/s unit has been on the air under the call-sign G3HTI for several months, with very satisfactory results from a poor aerial.

The Command Set Receivers

Continued from page 354

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