

The TCS Transmitter-Receiver Assembly

NOTES ON DESIGN AND CONSTRUCTION
AND AMATEUR BAND APPLICATIONS

B. M. JOHNSON (G3LOX)

This article discusses a useful and interesting item of ex-U.S.N. equipment, which has been available on the "surplus" market for some time. Our contributor gives much factual information on the circuitry and operation of the TCS apparatus, which covers the 160-80-40 metre amateur bands on both transmitter and receiver.— Editor.

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This article discusses a useful and interesting item of ex-U.S.N. equipment, which has been available on the "surplus" market for some time. Our contributor gives much factual information on the circuitry and operation of the TCS apparatus, which covers the 160-80-40 metre amateur bands on both transmitter and receiver.—Editor.

ONE of the best buys on the "surplus" market today is undoubtedly the TCS series of transmitters and receivers; they were designed and originally built for the U.S. Navy by the American Collins Company, though later several other contractors also made them. As far as the writer can ascertain, the series was numbered consecutively from TCS-1 to TCS-13. The U.S. Navy numbers were: 52245 for the transmitter, and 46159 for the receiver. The letters prefixing the Navy number is a code denoting the manufacturer, e.g. COL-52245 is a Collins-built transmitter, CHI-46159 a Hamilton receiver. Although minor differences may be noted in the construction and layout, as between one manufacturer and another, all the units with the above Navy numbers are basically the same and interchangeable, irrespective of the TCS number.

The TCS series was supplied to the U.S. Navy for duties similar to the British W/S19, e.g. /P and /M from tanks, trucks and similar vehicles. The TCS was also used as emergency radio aboard merchant ships. Although intended to work as a single inter-connected unit, the transmitter and receiver are in fact physically separate, and it is proposed in this article to deal with them individually.

TRANSMITTER TYPE 52245

The transmitter consists of a VFO/Buffer-Doubler/PA with an integral push-pull modulator; there is provision for four switched crystals as an alternative to the VFO. The frequency coverage is in three switched bands, as follows: Band 1, 1.5 to 3.0 mc; Band 2, 3 to 6.0 mc; Band 3, 6 to 12.0 mc.

When used in conjunction with its receiver, the TCS transmitter has full "push-to-talk" or CW "break-in" facilities. In its unmodified form the transmitter will run to about 35 watts input on Phone and 80 watts or so on CW. The power requirements for the standard transmitter are as follows: HT (1) 400 volts DC at 200 mA; HT (2) 220 volts DC at 40 mA; LT 12 volts AC/DC at 2½ amps.; Relay supply 12 volts DC at 1 amp.

Exciter Circuit

Reference to Fig. 1 will show the circuit of the VFO, crystal oscillator, and the buffer/doubler stages that form the RF exciter section. All the valves in this stage, V101, 102, 103, are 12A6's. (The designation of valves and components in this article follows that which will be found used in the actual units, many of the components being marked.) V101 is the oscillator, the familiar Hartley type; it is continuously tunable from 1,500 to 3,000 kc, the tuning being effected by C101. Being designed for mobile work under active service conditions, the mechanical and electrical stability of this VFO is outstanding; it will take considerable vibration with no appreciable change in note and will accept up to a 10% variation above or below the normal line voltage for a frequency shift of as little as .01%. Referring again to Fig. 1, it will be seen that the oscillator function is controlled by a six-position switch, S104. When this switch (Oscillator Selector) is turned to the "MO Test" position, HT is applied to the anode and screen of the VFO and buffer/doubler stage (V101, V103); this permits netting. With the switch in the "MO" position, the stages will only operate via the relay K103, which is part of the push-to-talk arrangements. The remaining four positions on the switch select the crystals (up to four) which, used in conjunction with a 12A6 (V102), form the crystal oscillator, available as an alternative to the VFO. The switch, S104, removes the HT from the oscillator not in use. The crystals are ground to be in the same range as the VFO, i.e., 1.5 to 3.0 mc; they are the 3-pin TCS Type 249.

When the bandswitch, S101, is in position 1 or 2 (1.5 to 3 mc), the anode of the oscillator—VFO or crystal—is untuned and is directly resistance-capacity coupled to the buffer/doubler, V103; in these two positions the output of the oscillator is in the range 1.5 to 3.0 mc, which is the fundamental frequency of the VFO. When the switch is turned to Band 3 (6 to 12.0 mc), a tuned circuit consisting of L103, C101 and C107 is coupled to the anode

of the oscillator. This circuit resonates at the second harmonic of the VFO; on Band 3, therefore, the output of the stage is doubled to the range 3 to 6.0 mc. V103 is the buffer/doubler. On Band 1 the stage operates as a straight amplifier and as a doubler on Bands 2 and 3. The appropriate inductance for the frequency doubler, L104, L105 or L106 is selected by the switch S101, which is ganged to the bandswitch in the oscillator section.

The PA

Referring to Fig. 2, it will be seen that the PA consists of two tetrodes in parallel; the valves used are 1625's which, with the exception of the heater voltage and the base, are the same as 807's. (1625's require 12.6 volts at .45 amps. for their heaters.) The PA valves only work in parallel when the system switch on the front panel is set to the "CW" condition. In the "Voice" position the switch S105 disconnects the heater voltage from one of the PA valves (V105). Therefore on Phone the PA consists of a single 1625. It should be noted, however,

that the anode and screen HT remains on the unused valve. These considerations apart, the PA stage of the TCS transmitter is quite conventional. Auto-bias is obtained from the resistance R107 and R112. The PA tank circuit is formed by L107 and C116. S106 is ganged to the bandswitch in the exciter and doubler, and it selects the appropriate taps and padding

Table of Values

Fig. 1. RF Exciter and Buffer-Doubler, TCS Tx.

C101A = 360 μ F	R103 = 100,000 ohms
C101B = 280 μ F	R104 = 1,500 ohms
C101C = 75 μ F	R106 = 6,800 ohms
C102 = 30 μ F	R114 = 47,000 ohms
C103 = 30 μ F	R116 = 47 ohms
C104 = 40 μ F	R125 = 1.5-3.0 mc
C105 = .001 μ F	L101 = 1 mH RF choke
C106 = .002 μ F	L102 = 3.0-6.0 mc
C107 = 25 μ F	L103 = 6.0-12.0 mc
C108 = .006 μ F	L104 = 3.0-6.0 mc
C109 = 50 μ F	L105 = 1.5-3.0 mc
C124 = 250 μ F	V101 = 12A6
C122 = 1 megohm	V102 = 12A6
C123 = 22,000 ohms	V103 = 12A6

(Note: Circuit element numbering is in accordance with original.)

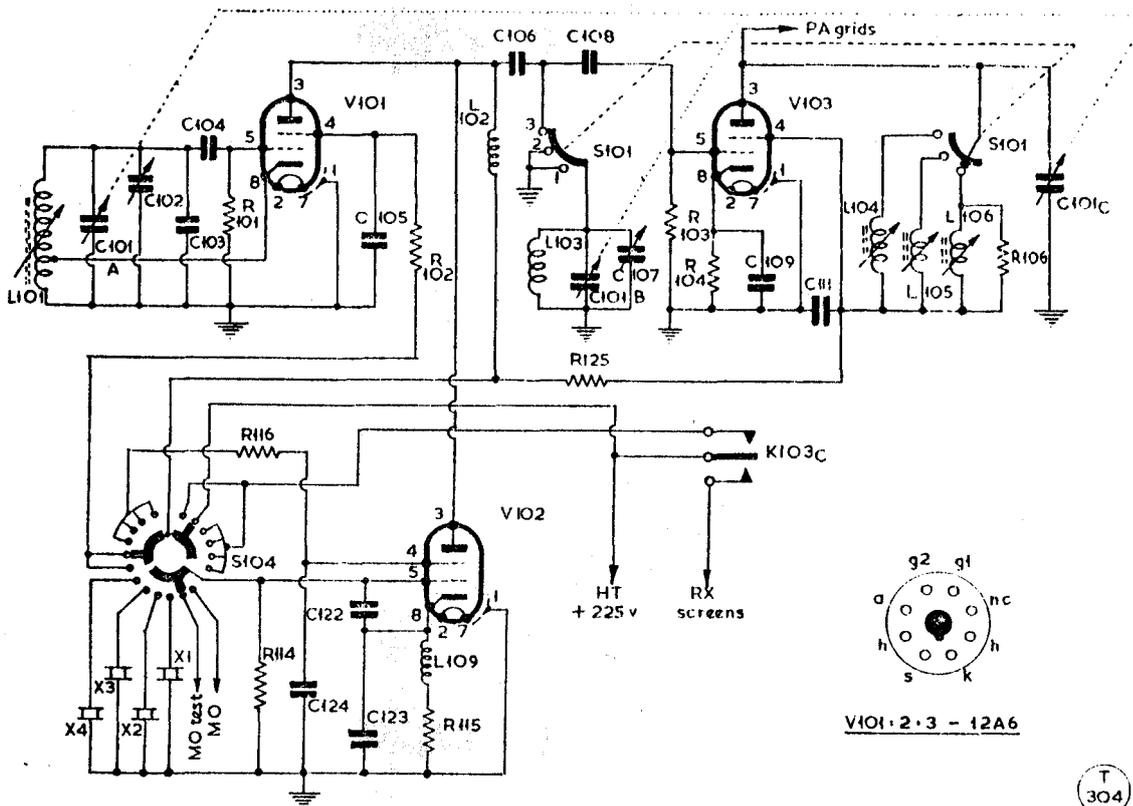


Fig. 1. RF exciter and buffer-doubler section of the TCS transmitter unit, which uses 12A6's in all three positions. Either crystal or VFO operation can be selected by switch S104, and the output frequency by S101. The PA section is shown in Fig. 2, and the whole transmitter is inter-switched with a corresponding receiver unit, to make the complete assembly.

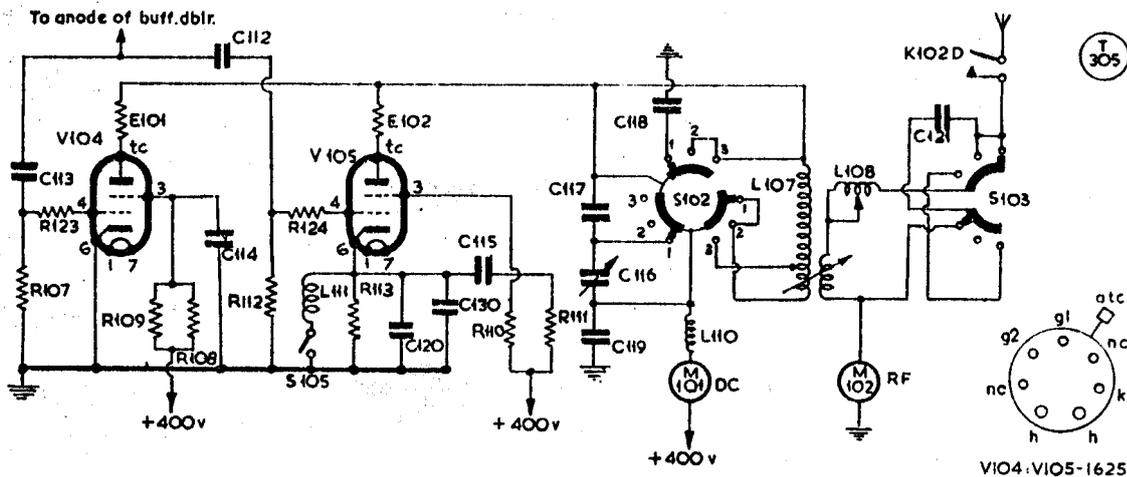


Fig. 2. The RF power amplifier section of the TCS "surplus" transmitter. The valves, V104/V105, are a pair of 1625's in parallel; these are 807's with 12v. heaters. On CW both valves are driven, but for phone one is switched out, the PA circuit then being as shown in Fig. 3. All values are given in the table, and it should be noted that circuit element numbering is in accordance with the original; many of the circuit references are given on the transmitter chassis. The TCS is not self-powered, so that a separate HT/LT supply must be provided; the connections are shown in Fig. 4.

condensers on L107. This tapped coil (L107) covers the entire frequency range of the transmitter, 1.5 to 12.0 mc.

Aerial Coupling

The tank coil L107 is coupled to the aerial by a variometer which controls the degree of coupling between the aerial and the PA tank. The "Antenna Loading" inductance, L108, is in series with the aerial. The switch S103 is the "Antenna Condition" switch and it connects the padding condenser C121 either in series or parallel with the aerial. The meter M102 is an RF ammeter; some of the TCS transmitters have this meter in the aerial lead and not, as shown in Fig. 2, in series with the earth. The relay contact shown, K102D, is part of the aerial send/receive change-over.

The TCS aerial coupling and loading circuits enable almost any aerial to be matched and loaded.

The Modulator

The TCS transmitters are among the few on the "surplus" market to have an incorporated modulator. The circuit of the audio stage is given in Fig. 3. It consists of a pair of 1625's operating in Class-B push-pull, modulating the PA (V104) on plate and screen via the transformer T102. There is no pre-amplifier, the 1625's being driven direct from the microphone transformer T101, which is designed to work with a carbon-button microphone of about 100 ohms. Auto-bias and the energising voltage for the microphone develops across the resistor

Table of Values

Fig. 2. Circuit of the PA section, TCS Tx.

C112,	R108,
C113 = .001 μ F	R109,
C114,	R110 = 47,000 ohms
C115 = .002 μ F	R111,
C116 = 425 μ F	R112,
C117 = 630 μ F	R123,
C118 = 50 μ F	R124 = 47,000 ohms
C119 = .01 μ F	L108 = 0.30 μ H, var.
C120,	L110 = 1.0 mH RFC
C130 = .008 μ F	M101 = 0.200 mA DC
C121 = 500 μ F	M102 = 0.3 amps., RF
R107,	E101,
R112 = 22,000 ohms	E102 = Anti-parasitic chokes
	V104,
	V105 = 1625

(Note: Circuit element numbering is in accordance with original.)

R118. The "Emission Selector" switch, S105 (Fig. 2), which, as has been mentioned, cuts the heater volts from the parallel PA valve when placed in the "Voice" position, also switches on the heaters of the two modulator valves, V106 and V107. It also places the modulator valves on the HT rail via the relay contacts K101B, though no HT will be available until the push-to-talk switch is closed and the relay K102 applies the HT. When the transmitter is switched to the "CW" condition, the modulator valves have neither HT nor heater volts applied; it follows, therefore, that when changing from one function to another, time must be allowed for the heaters to warm up.

All the supplies to the transmitter are fed through a 16-pin Cannon plug, Type SK-C16-23 1/2 AC. The connections will be found in Fig. 4.

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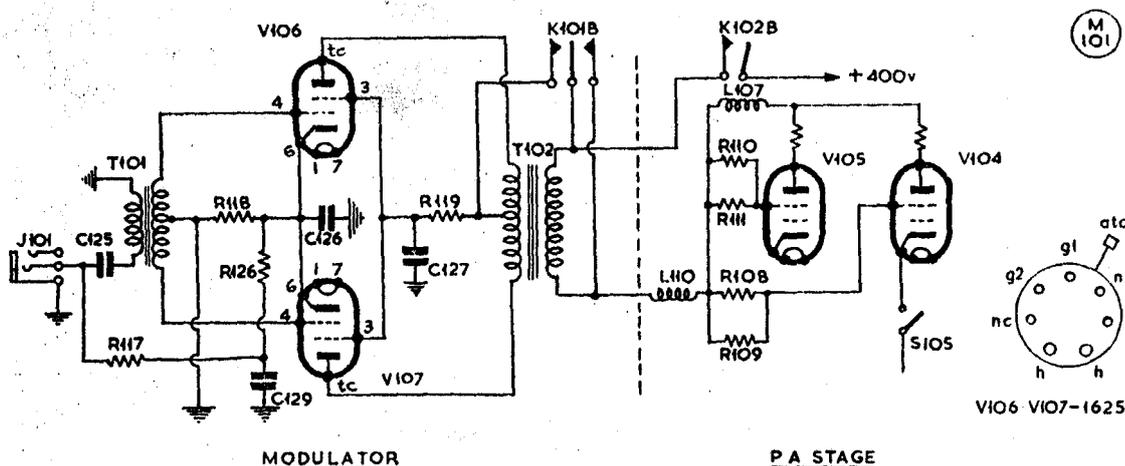


Fig. 3. Modulator arrangement in the TCS transmitter, using a pair of 1625's, V106/V107. As explained in the article, the speech output with a carbon microphone and the circuit as shown here leaves something to be desired, and it is better to drive the 1625's with a separate high-gain speech amplifier suitable for a crystal microphone.
 (Note: In this diagram, V104 should be shown in the V105 position, S105 being as given under V105 in Fig. 2.)

TCS RECEIVER TYPE 46159

The TCS transmitter has a companion receiver, U.S. Navy number 46159. The size, panel lay-out and construction are very similar to the transmitter. The frequency range is identical. As the receiver is a conventional seven-valve superhet it is not proposed to deal with it in any detail here, but merely to give the valve line up and the plug connections. The valve run is as follows: RF, 12SK7; Mixer, 12SA7; Osc., 12A6; 1st IF, 12SK7; 2nd IF, 12SK7; Det/BFO, 12SQ7; Audio, 12A6. The IF is 455 kc.

It will be seen from this that the receiver has a separate oscillator valve (12A6). On the front panel will be found a switch marked "Oscillator Selector," and one of four crystals can be used as an alternative to the IF oscillator. The crystals are ground to be 455 kc above the signal frequency. It is doubtful whether in the ordinary way this facility will be required (it spot-tunes the receiver), so the switch will be left in the "MO" (IF Osc.) position. Other controls on the front panel are: HT on/off, BFO on/off, CW pitch, RF gain/AVC on/off, LF gain, Bandswitch, and the main tuning control. When the BFO is on, the AVC is inoperative. The power and control circuits from the transmitter arrive via a twelve-pin Cannon plug, Type GK-12-23½AC.

Though designed to work in conjunction with the TCS transmitter, the receiver, with the exception of the power supply, is self-contained. The receiver is muted during transmission by cutting off the HT to the screens of the RF and

Table of Values

Fig. 3. TCS Tx Modulator section

C125	T101 = 100 ohms, push-pull to grids, mic. xformer
C126 = 4 μF	T102 = 6000/6000 ohms mod. xformer, 20w.
C127 = 0.25 μF	J101 = Mic jack
C129 = 2 μF	V106,
R117,	V107 = 1625
R126 = 470 ohms	
R118 = 330 ohms	
R119 = 20,000 ohms	

(Note: Circuit element numbering is in accordance with original.)

IF valves. The relay K103 in the transmitter switches the HT from the exciter to the receiver screens when the push-to-talk switch, or the CW key, is open. The relay rests in the receive position.

So much for the two major units of the TCS equipment. Apart from the Rx/Tx as described, there were several power supplies made for the series; these are rather rare (particularly the 230 AC mains unit) and inclined to be expensive; however, a list is appended for those who may be interested.

TCS AUXILIARY EQUIPMENT

Item		US Navy No.
416T-3 Dynamotor	12v. DC input	21770
416T-4 Dynamotor	12v. DC input	211035
416T-4 Dynamotor	12v. DC input	21881
Motor Generator	24v. DC input	21826
Motor Generator	32v. DC input	21775
Motor Generator	115v. DC input	21776
Motor Generator	115v. AC input	21777
Motor Generator	230v. DC input	21827
Rectifier Unit	115v. AC input	20218
Rectifier Unit	230v. AC input	20242

THE TCS ON THE LF AMATEUR BANDS

The TCS equipment can be used "as is" on the three LF bands; all that is required is a suitable power supply—the requirements will be found in the foregoing notes. The pin connections for both the transmitter and the receiver plugs are given in Fig. 4. Unless you are very lucky, the units will not have plugs when purchased, so they will have to be modified. The correct plugs can be obtained new from Films & Equipment, Wardour St., London (but not at "surplus" prices!). The types to specify are: Transmitter, Cannon SK-23c- $\frac{1}{2}$; Receiver, Cannon GK-12-23 $\frac{1}{2}$ AC.

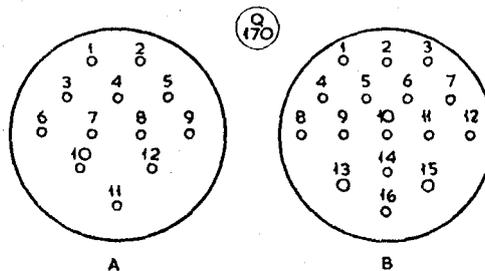
Modulation

A carbon button microphone will modulate the transmitter to about 80%, but the system is a little marginal, to say the least. A vast improvement in both the quality and depth of modulation can be achieved by the addition of a pre-amplifier. The writer removed the mic. transformer, T101, and disconnected J101, —see Fig. 3. R118 in this circuit was returned directly to earth. The leads from the 1625 grids, taken from tags 3 and 5 on T101, were then connected to the tip and ring of the jack J101 (this jack requires the small GPO "sleeve, tip and ring" plug). The tip and ring of the jack are insulated from earth.

An external pre-amplifier consisting of two EF37A's and a 6SN7 phase inverter was found to work very well, with ample gain, using either a ribbon or moving coil microphone.

Having disconnected J101, the push-to-talk and CW key will now have to be taken to pin 4 on the supply plug (Fig. 4b), and earthing this pin will put the transmitter on to transmit. No additional wiring is needed as this pin was originally in parallel with the mic. switch.

So much for Phone operation. CW can be worked with full "break in" (BK) if desired, but there are snags in this; the relays are rather noisy, and if the rig is used in a living-room this can be very irritating to the other occupants. If the keying speed goes much above 15 w.p.m. the sending sounds a bit ragged, as the relays do not follow well. Careful ad-



Receiver plug from the front. Transmitter plug from the front
Fig. 4. Connector layout for the TCS units; the key is given in the table.

TCS UNIT CONNECTION SEQUENCE

See Fig. 4.

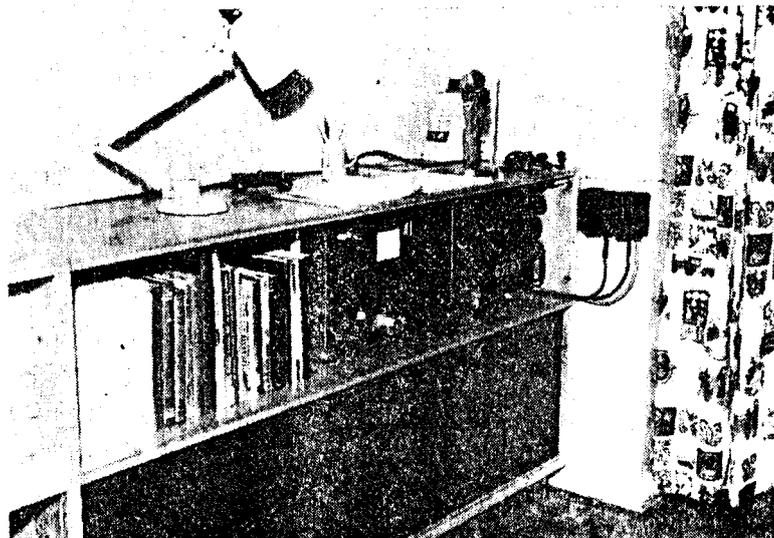
(A) Rx Plug from Front

- 1, Not used
- 2, 225v. DC
- 3, RF screens
- 4, Not used
- 5, 12v. heaters
- 6, Earth
- 7, Not used
- 8, Joined 12
- 9, Speaker
- 10, Joined 11
- 11, On/Off, remote control
- 12, On/Off other side, joined 8

(B) Tx Plug from Front

- 2, 400v. HT
- 4, Key, or send switch
- 5, Test grid mA
- 7, To 12 via interlock
- 8, Mic. across J101
- 9, Earthed on send
- 11, HT to Rx screens
- 12, As 7
- 13, 12v. AC, heaters
- 14, 225v. HT
- 15, Common earth, and heaters
- 16, 12v. DC for relays (Pins 1, 3, 6, 10 not used)

justment might cure this, but after fiddling fruitlessly with these relays, the writer abandoned BK and simply keyed the cathode of the PA. As it was not intended in the interest of TVI to run more than about 40 watts



As this photograph shows, the TCS equipment makes quite a neat living-room installation. G3LOX has a BC-453 run as a "Q5'er" to improve the receiver side, as explained in his article, which gives a lot of practical information on the TCS assembly. The power supply and auxiliary audio amplifier (see Fig. 3) are in the lower cupboard. In effect, G3LOX has his whole station fitted in a book-shelf, the top of which serves as an operating table.

or so on CW, the parallel PA valve, V105, was removed and the cathode of V104 keyed. A small shorting jack was fitted next to the microphone plug on the front panel. The jack is in the PA cathode, and when Phone is required the plug is removed. (If a break-jack cannot be found, a shorted plug can be used in place of the key, or the key can be locked down.)

For Top Band the input must be reduced; the writer uses a separate low power HT supply as the most convenient solution.

The Receiver

The receiver requires no modification, with the exception of the plug. The output is about 500 ohms and will, with a suitable transformer, drive a speaker with ample gain. The sensitivity is very good; the selectivity, however, is not all it might be, but a BC-453 as a "Q5'er" takes care of this. An insulated lead is twisted round pin 4 (diode anode) of V206 (detector) and taken, well screened, to the aerial of the BC-453. (For further details of the "Q5'er" application see page 465 of the November 1956 issue of *Short Wave Magazine*.)

If an S-meter is considered essential a suitable design will be found on page 39 of March 1957 issue of the *Magazine*.

Conclusion

The TCS units offer a compact amateur station for our LF bands, with all the facilities one requires for efficient working on either phone or CW. It can be arranged as a neat living-room rig, either as an alternative to a main station, or as a starting point for a newly-licensed operator who wants to get on the air quickly.

The writer has been using TCS units for about two years and so far no TVI has been reported; however, two apparently identical transmitters may differ one from the other in this respect.

No rare DX has been raised (or sought), but many fine QSO's have been enjoyed, invariably with good reports both for the signal strength and the phone quality; CW reports have always been T9.

The construction of the units is of the highest class, and for the price of a second-hand DX receiver you can have a complete station.