Modern Transmitter For 160 Metres

INCORPORATING CRT MONITOR — PHONE/CW/MCW OPERATION — SELF-CONTAINED FOR POWER

D. Pratt (G3KEP) and D. Noble (G3MAW)

With the trend of activity towards the LF bands, this design will be of great interest to those who like to build their own gear. Though intended to include the monitoring and MCW facilities, these may of course be omitted if preferred by suitable modification of the switching circuits. Indeed, the design as a whole incorporates sound basic circuitry for a Top Band transmitter to operate CW only, CW/Phone, or Phone only, with or without power supply built in.—Editor.

THE transmitter described in this article was designed to fulfil the requirements for a self-contained rig suitable for efficient working on the 160-metre amateur band. It was decided to replace the original installation with a more modern design, and to eliminate "external attachments."

The brief specification of the transmitter is as follows:

(1) Clapp VFO — untuned buffer amplifier —RF amplifier with pi-tank circuit;
(2) High quality anode-and-screen modulation with provision for "mixing" a second input of high level;
(3) Internal 1000 c/s sinusoidal MCW oscillator for slow Morse transmissions and test purposes;
(4) Internal 1in. cathode ray tube for modulation monitoring;
(5) Built-in power supply.

It was also aimed to build the transmitter into as small a space as possible; it is in fact built into a cabinet identical in size to the popular TU unit outer case.

Due to the small size of the instrument and the consequent restricted space on the front panel, the number of controls is kept to a minimum. This is achieved by incorporating rather complicated transmit/receive switching. In this way it is possible, for example, to eliminate special controls for the MCW oscillator, using one key jack only (non-shorting type) switched to the PA cathode on CW, and to the phase-shift oscillator on MCW/Phone.

RF Circuitry

The first two stages on the RF section are built into an Eddystone diecast box with an internal screen fitted as shown in the illustration.

The VFO stage is fed from a stabilised HT supply of 150 volts. It uses a triode-connected EF91 in a Clapp oscillator circuit with the anode at zero RF potential. The output is taken from the cathode *via* a low-value condenser C10 in order to eliminate "pulling." A trimmer condenser, C2, is provided across the main tuning, C1, so as to enable the VFO to be set up initially.

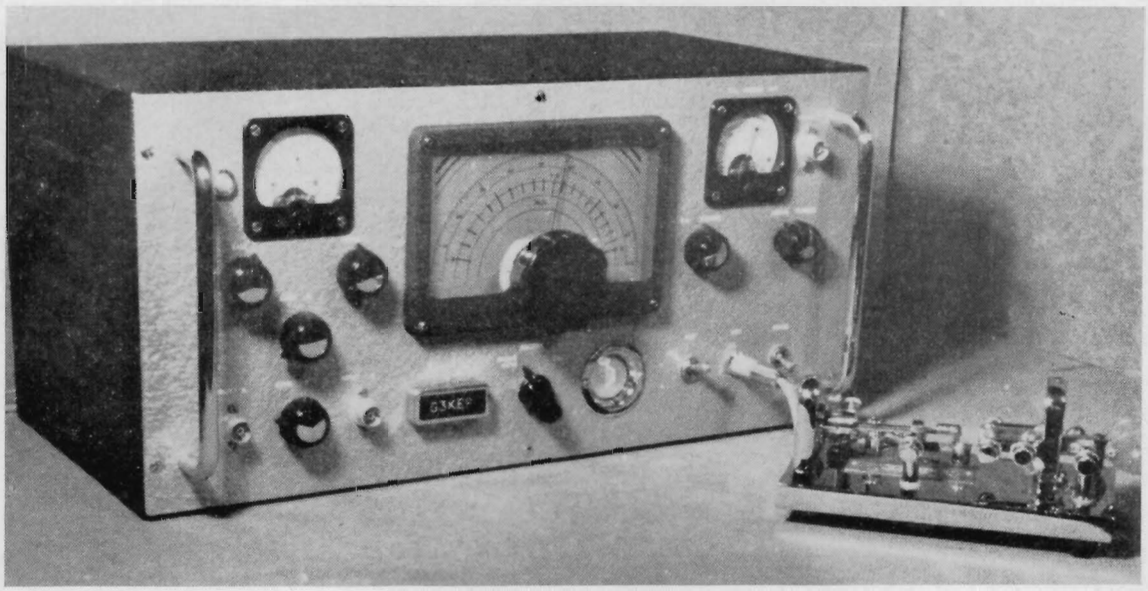
V3 is a conventional buffer amplifier which requires little comment. It is run at a fairly high power in order that a low value of coupling condenser may be used while still obtaining sufficient grid current to the PA valve.

Output from the BA is taken through C16 to a nylon feed-through in the side of the diecast box. Another feed-through is fitted on the main chassis in a position near the PA control grid pin; between these feed-throughs comes C17. This is in an accessible position and can be adjusted in order to obtain the correct drive conditions to the PA stage. It was found in the prototype that correct drive was obtained with 27 $\mu\mu$F, but this may require slight alteration for stray capacity and component tolerances. This is probably the most convenient place to state that the maker's recommended control grid conditions for the 5763 are 60 volts across a 22,000-ohm grid resistor. This corresponds to a grid current of about 2·7 mA.

The rest of the PA stage is conventional save for the keying and switching arrangements which are dealt with later under the appropriate headings.

The PA output circuit is a *pi*-network designed to match the transmitter into a $\frac{1}{2}$-wave end-fed aerial. A co-axial socket is provided on the front panel, connected *via* a 1 $\mu\mu$F condenser to the output for monitoring and harmonic check purposes.

The tank tuning condenser, C28, is a good quality ceramic insulated single gang 500 $\mu\mu$F broadcast type, whereas the aerial loading condenser, C29, is a similar 2-gang with its sections connected in parallel so as to give a



Front-panel view of the 160-metre transmitter described in the article, with a typical display visible on the screen of the 1-in. modulation monitor tube. The circuitry provides for CW, Phone and MCW operation, and the unit is self-contained for power. The main circuit diagram is shown in Fig. 1 and the power supply section in Fig. 1B.

total maximum capacity of ·001 μF. Meters are provided to indicate the grid current and anode current of the PA stage.

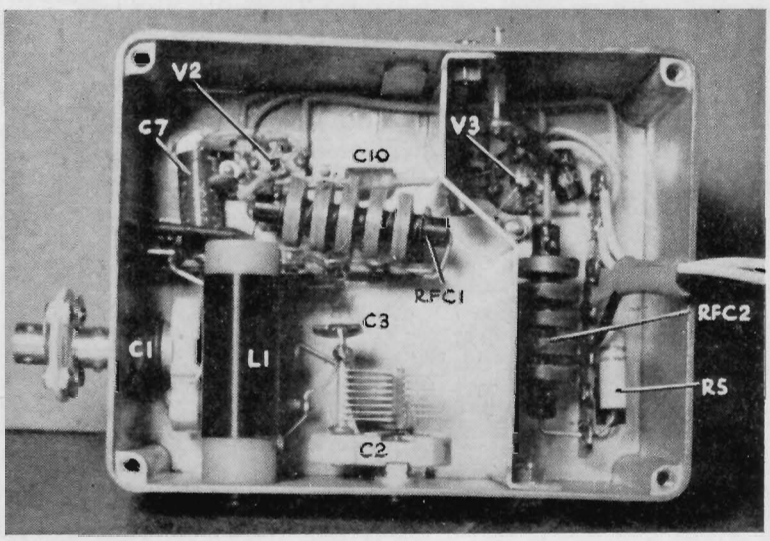
TVI precautions include a parasitic stopper resistor, soldered directly to the anode tag of the PA valveholder, and heater decoupling condensers on all the RF valves.

Audio Circuitry

The modulator circuit is based upon the well-known Mullard " 5-10 " design, but negative feedback has been omitted. In addition, an ECC83 double triode is added. One triode of this provides the necessary microphone pre-amplification and the other acts as a low-level input stage feeding into the grid of the phase splitter. The tone control circuit is thus inoperative when the " B-input " is being used, and a separate gain control, VR2, is necessary.

For MCW purposes an internal 1000 c/s sine wave oscillator V5 is provided. This is coupled *via* a high value resistor, R24, to the "B-input," and does not, therefore, have any adverse effects on any other input sources. VR1 enables the output of the oscillator to be adjusted to give the required modulation level with the external control (Gain B), VR2, at about half-track.

The 1000 c/s signal is obtainable at the " B-input " socket when the transmitter is switched to " receive," but this is of constant amplitude



Inside view of the VFO compartment, an Eddystone diecast box, with the major items keyed — see circuit diagram Fig. 1. The screws which hold the lid also secure the unit to the main chassis.

Table of Values

Fig. 1. Circuit of the complete 160-metre Transmitter (*See opposite*)

C1 = 60 $\mu\mu$F variable
C2 = 60 $\mu\mu$F preset variable
C3 = 120 $\mu\mu$F, 10%, silvered-mica
C4, C5, C21, C26 = 1,000 $\mu\mu$F, 10%, silvered-mica
C6, C16 = 100 $\mu\mu$F, 10%, silvered-mica
C7, C11, C12, C15, C31, C39, C46, C51 = 0.01 μF, 400v. wkg. paper
C8, C9, C13, C14, C18, C19, C23, C24, C25 = 1,000 $\mu\mu$F, disc ceramic
C10 = 12 $\mu\mu$F, 10%, silvered-mica
C17 = 27 $\mu\mu$F, 10%, silvered-mica
C20 = 16 μF, 450v. wkg. electrolytic
C22 = 1 μF, 500v. wkg. electrolytic
C27 = 0.002 μF, 1,000v. silvered-mica
C28 = 500 $\mu\mu$F variable
C29 = 2-gang, 500 $\mu\mu$F, broadcast type variable. (Both sections in parallel)
C30 = 1 $\mu\mu$F ceramic
C32, C57, C58, C59 = 0.1 μF, 400v. wkg. paper
C33, C43, C44 = 25 μF, 25v. wkg. electrolytic
C34, C35, C36, C37 = 500 $\mu\mu$F, 300v. wkg. paper
C38, C54 = 0.05 μF, 500v. wkg. paper
C40 = 12.5 $\mu\mu$F ceramic — see text
C41 = 1 μF, 300v. wkg. paper
C42, C45, C52, C56 = 8 μF, 350v. wkg. electrolytic
C47 = 560 $\mu\mu$F, 5%, silvered-mica
C48 = 8,200 $\mu\mu$F, 5%, silvered-mica
C49 = 2,200 $\mu\mu$F, 5%, silvered-mica
C50 = 0.02 μF, 150v. wkg. paper
C53 = 330 $\mu\mu$F, 10%, silvered-mica
C55 = 100 μF, 12v. wkg. electrolytic
C60, C61 = 50 μF, 25v. wkg. electrolytic
C62 — C63 = 32 + 32 μF, 500v. wkg. electrolytic
R1, R15, R16, R17 = 100,000 ohms, ½ watt, 10%
R2 = 7,500 ohms, 5 watts, 5% wire-wound
R3, R26, R31 = 47,000 ohms, ½ watt, 10%
R4 = 150 ohms, ½ watt, 10%
R5 = 4,700 ohms, 2 watts, 10%
R6 = 22,000 ohms, 1 watt, 10%
R7 = 22,000 ohms, ½ watt, 10%
R8 = 10,000 ohms, 2 watts, 10%
R9 = 270 ohms, ½ watt, 10%
R10, R51, R52 = 47 ohms, ½ watt, 20%
R11, R12 = 1,000 ohms, ½ watt, 20%
R13 = 18,000 ohms, ½ watt, 10%
R14, R32 = 39,000 ohms, ½ watt, 10%
R18 = 820,000 ohms, ½ watt, 10%
R19 = 56,000 ohms, ½ watt, 10%
R20, R21 = 3.3 megohms, ½ watt, 10%
R22 = 470,000 ohms, ½ watt, 10%
R23 = 120,000 ohms, ½ watt, 10%
R24, R30 = 2.2 megohms, ½ watt, 10%
R25, R29 = 2,700 ohms, ½ watt, 10%
R27, R28 = 220,000 ohms, ½ watt, 10%
R33 = 6,800 ohms, ½ watt, 10%
R34, R41 = 68,000 ohms, ½ watt, 10%
R35 = 10,000 ohms, ½ watt, 10%
R36 = 1,800 ohms, ½ watt, 10%
R37 = 120,000 ohms, ½ watt, 10%*
R38 = 470,000 ohms, ½ watt, 10%*
R39 = 150,000 ohms, ½ watt, 10%
R40 = 33,000 ohms, ½ watt, 10%
R42 = 1 megohm, ½ watt, 10%
R43, R44 = 100,000 ohms, ½ watt, 10%**
R45, R46 = 820,000 ohms, ½ watt, 10%**
R49, R50 = 270 ohms, 3 watts, 5%
R47, R48 = 4,700 ohms, ½ watt, 20%
VR1 = 300,000 ohms linear preset pot.
VR2 = 500,000 ohms log. pot.
VR3, VR4 VR5 = 250,000 ohms log. pot.
S1 = 3-way, 9-pole rotary switch (3 banks, 3 poles per bank)
S2 = SPDT toggle switch (biased — see text) (N.S.F. type 8373/B4)
S3 = DPDT toggle switch (N.S.F. type 8370/K7)
M1 = 0-5mA, 2in. meter
M2 = 0-50mA, 2in.
RFC1, RFC2, RFC3, RFC4 = 1.5 mH RF chokes (Eddystone 1022)
CH1 = 2H, 300mA choke (T.V. smoothing choke)
CH2 = 10H, 60mA choke
T1 = Woden Modulation transformer Type UM-0
T2 = Mains transformer 300-0-300v. 150mA; 6.3v., 5A; 6.3v. 1A. (Gilson type W074B)
L1 = 90 turns, 30 swg close-wound on a ¾in. diam. former
L2 = 60 turns, 24 swg close-wound on a 1⅛in. dia. former
V1 = 150B2
V2 = EF91
V3 = EL91
V4 = 5763
V5 = EF184
V6, V8 = ECC83
V7 = EF86
V9, V10 = EL84
V11 = EZ81
CRT1 = DH3-91 (1CP1)
PL1 = Panel lamp — 6.5v., 0.3A (Bulgin type (D180)
PL2 = Indicator lamp — two 6.5v., 0.3A bulbs in series. (Bulgin type D720/Green/legend)
J1 = Open circuit key jack (Bulgin type J2)
P1 = Mains input plug (Bulgin type P360)

* High Stability
** Matched to within 5%

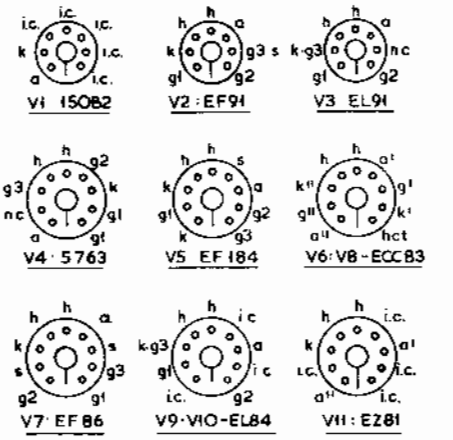


Fig. 1A, Base diagrams for the valves used in the 160-metre transmitter by G3KEP/G3MAW.

and is not affected by the position of the external control. This output is very useful as an auxiliary source for providing a pure sine wave when required.

On "receive," HT is applied to the pre-amplifier stages in order that there shall be no delay when switching on the transmitter to telephony due to the finite charging time of the modulator decoupling circuits. However, the push-pull output stage supply is only applied when the transmitter is switched to telephony, as this delay effect does not occur, and modulation can thus be obtained instantaneously upon switching on.

The modulation transformer is a Woden UMØ and the figures in the circuit diagram

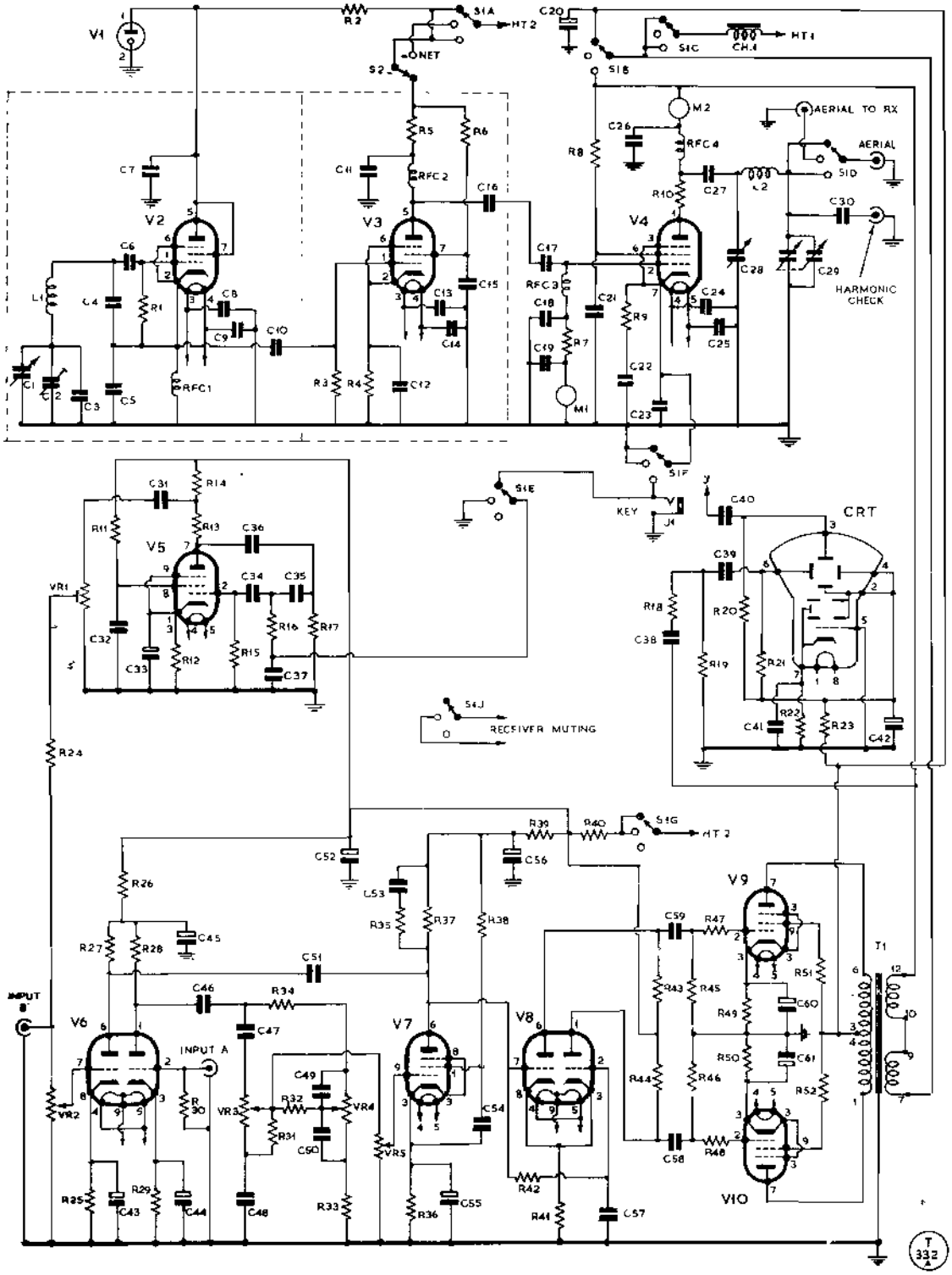


Fig. 1. Circuit diagram of the Top Band transmitter, fully described in the accompanying article. The power unit, integral with the transmitter in the model as illustrated, is at Fig. 1B, p.630.

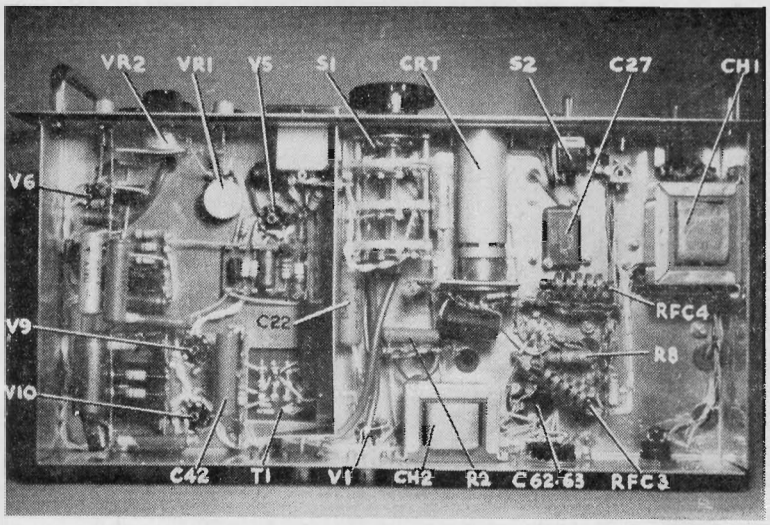
correspond to the tag connections recommended to obtain efficient matching in the transmitter circuit described.

"Input-A" is intended for use with a high-impedance crystal microphone. It can, however, be used with a good quality dynamic microphone.

Monitoring Facilities

A 1-in. cathode ray tube is provided for modulation level monitoring. It operates with a very low final anode voltage which may be readily obtained from the normal HT rail to the modulator output stage. The modulation monitor is thus only operative when using telephony or MCW. A trapezoidal display is obtained by feeding a small audio voltage to the X-plates and RF to the Y-plates, in the normal way.

The RF deflection voltage is obtained by wrapping the connection from C40 round the PA anode lead to form a very small capacity. This may then be adjusted to give a suitable Y-amplitude. It is advisable that this adjustment be carried out with the transmitter connected to an aerial and tuned up. This is because the RF voltage present at the anode, and hence the deflection voltage, will vary considerably with load conditions. The X-deflection amplitude should be suitable with the circuit values given but, if necessary, may be adjusted by altering the ratio of R18 and R19 which are in a potential divider circuit.



View under-chassis of the 160-metre transmitter described in the article, with key to layout (see circuit Fig. 1). The main control switch is at centre, with the speech circuitry to the left, and the PA and power supply sections at right, behind the modulation indicator.

So as to eliminate distortion of the display by stray pick up from heater wiring etc., an M.E.A. mumetal shield type ST.39 was used. (A suitable shield may readily be made from the screen from an ex-Govt. unit using a VCR97, for example.) Care should be exercised in working with the material in order not to disturb its excellent screening properties.

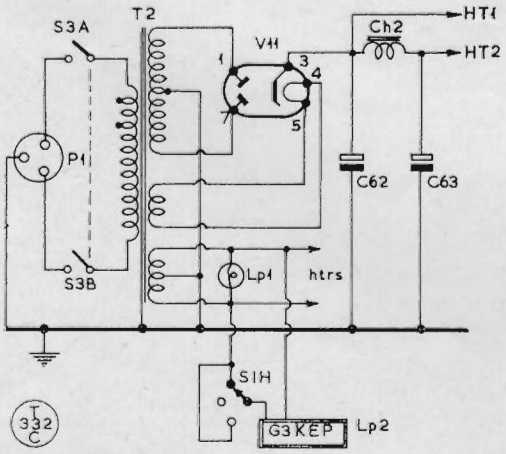


Fig. 1B. Power supply circuit for the transmitter, and included on the same chassis. Values given on p.628.

Switching

There are three switches in the unit:—(i) Mains supply switch; (ii) the netting switch; and (iii) the main transmit/receive switch, S1.

The transmit/receive switch has three positions. The central position is "receive" and the other two are for CW and Phone CW. Section "*a*" of this switch is used to switch the power to the VFO and buffer stages. A spring-loaded toggle switch is used for netting purposes, so that the VFO only comes up on "net." If the "net" switch is inadvertently left on when the transmitter is switched to "transmit," the buffer stage would not operate and the consequent lack of grid drive would result in the PA stage drawing excessive anode current which would cause damage. It is for this reason that a spring biased switch is used for netting.

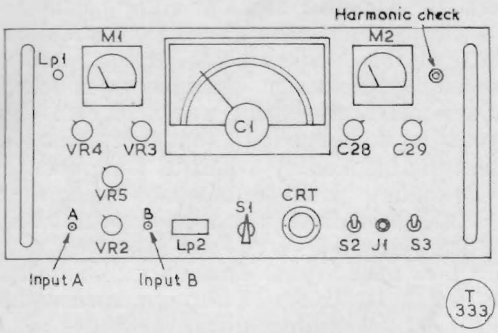


Fig. 2. Sketch showing front-panel layout in the model as illustrated.

Sections "*b*" and "*c*" of the transmit/receive switch are used on CW to feed the PA *via* the key click filter choke, CH1, from the main HT line. (The unorthodox position of CH1 will be explained later.) On telephony, these switches connect a 16 μF condenser, C20, which gives additional smoothing together with CH1; they also feed the PA *via* the modulation transformer secondary and supply power to the modulator output stage and cathode ray tube.

S1d is the aerial change-over switch, while S1e and S1f are for keying; the modulator pre-amplifier stages and MCW oscillator HT is switched by S1g. S1j is for receiver muting and its connections are brought out through the octal socket at the rear of the chassis.

A panel light, PL2 (which in the case of the model reveals the call-sign of the station), is fitted, and is switched to the heater supply *via* S1h when the transmitter is operating.

Keying

As mentioned earlier, there is only one key jack for both CW and MCW. When using CW, S1f open-circuits the cathode of the PA valve and connects it to the key jack; S1e performs a similar function for the keying point of the MCW oscillator. The grid of V5 is keyed for MCW and as this is a low-current point, only a small condenser, C37, is required for click elimination. It is advisable that the key lead be kept as short as possible because of the AF present under key-up conditions.

A current of up to 50 mA is to be expected in the cathode circuit of the PA. Thus, when using CW a more elaborate key-click circuit is required; R9 and C22 form part of the filter, while the key-click filter choke is in the HT line to the PA. The effect of the choke is to delay the current increase when the key is depressed, so controlling the click on "make." It is immaterial whether this be placed in the positive or the negative supply line to the PA valve. However, the effect of its DC resistance if placed in the cathode circuit results in the stage running at lower efficiency. It is for this reason, therefore, that the choke is shown in the PA anode-and-screen feed.

over

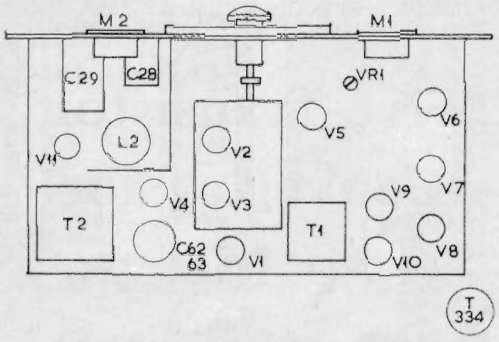
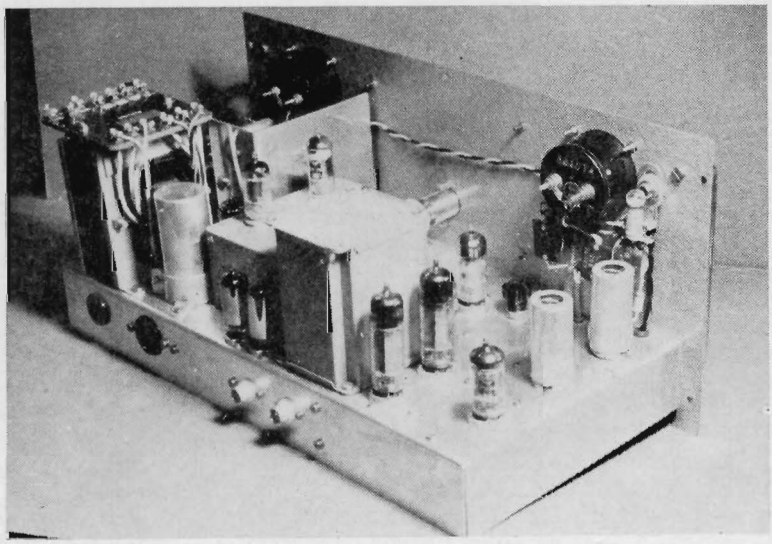


Fig. 3. Over-chassis layout for the major components — read with Fig. 2, and see photographs.



Three-quarter rear view of the Top Band transmitter, showing the AF section in the foreground. The screened-off PA compartment is at upper left. Along the rear chassis drop are the mains input, receiver muting, and aerial input and output connectors.

Power Supply

This is a conventional full wave HT circuit. The transformer used should be capable of giving 150 mA for HT, and 5 amps. for heaters, with an additional one-amp. winding for the rectifier valve V11. The HT smoothing consists of a dual 32 μF, 500v. electrolytic as reservoir and smoothing condensers; a smoothing choke is connected with these in the normal low-pass filter circuit. HT1, which supplies the modulator output stage and PA stage, is taken direct from the anode of the reservoir condenser, while the supplies for the remaining lower level stages are taken from the better smoothed voltage across C63.

Appearance Considerations

The appearance of the finished transmitter was intended to be up to the standard of commercially available amateur equipment.

A silver-hammered sprayed front panel contrasts with a black crackle cabinet, and by careful layout design a highly symmetrical front panel arrangement was achieved. The layout is dominated by an Eddystone full vision dial flanked by a pair of 2-in. meters.

Chromium plated fittings are used where possible, the cathode ray tube surround being a Bulgin type E.7 escutcheon intended for use with 1-in. magic eyes. The control knobs used are Bulgin type K.424/Chr. with chromium plated decorative inset discs.

Belling-Lee co-axial sockets serve as audio inlets; N.S.F. switches are used for mains and "net," with a Bulgin chromium plated jack socket for the key. The panel fittings are completed by two chrome handles so as to facilitate easy withdrawal from the cabinet.