Single Package Transmitter for 160 and 2

Developed by D. W. FURBY, G3EOH *

THE design of the dual band transmitter to be described takes full advantage of the newly introduced power pentode type 7558. This valve, with an anode dissipation of 10 watts up to a maximum frequency of 175 Mc/s, may, from an amateur point of view, be considered as an improved version of the popular 5763.

By an ingenious arrangement of the tuned circuits, no actual switching of the tuned circuits takes place when changing bands. As a result, not only is the efficiency of the various stages improved, especially at v.h.f., but in addition, construction is simplified.

The transmitter will run an input of 15 watts on 2m, but on 160m the input to the p.a. is restricted to 10 watts to meet the official power limitation.

Only the r.f. assembly is dealt with here since there are many published circuits of suitable modulators. An output of 8 watts will be adequate to modulate the carrier fully on 2m and have plenty of power in reserve for 160m.

Circuit

Prior to examining the circuit (Fig. 1) in detail, it may be as well to review the functions of the individual valves in relation to the final frequencies. When operating on 1·8 Mc/s, V1 is not used, V2 functions as a Clapp variable frequency oscillator, V3 as a buffer amplifier, and V4 as the p.a. When operating on 144 Mc/s, V1 becomes a Colpitts crystal oscillator, V2 a frequency tripler, V3 a frequency doubler; V4 is of course the p.a.

As already mentioned, V1 only comes into operation when the transmitter is set for 144 Mc/s. The valve, a 6BW7, is used in a familiar Colpitts configuration in which the crystal oscillates on its fundamental frequency in the grid/cathode circuit with the screen grid forming the " anode " bypassed to r.f. The true anode of the valve is tuned to one of the harmonics of the crystal, in this case the third, which, with an 8 Mc/s crystal, provides drive to the following stage at 24 Mc/s.

It will be noted that the cathode of V1 is returned to the centre of a capacity divider between grid and earth, the values of which depart from those usually associated with this circuit. In addition, the d.c. return of the cathode of the valve is via a resistor which replaces the r.f. choke normally fitted.

Experience with this type of oscillator used to drive v.h.f. transmitters is that it has a natural tendency to make the final frequency lower than that which would be expected from the simple arithmetic of multiplying the crystal frequency by the frequency multiplication factor. In practice this means that the parallel capacity across the crystal, whether intentional or stray, must be kept well within the normal 30pF limit.

The foregoing observations are pertinent to this design since the effective capacity across the crystal given by C1 and C2 in series amounts to 60pF. This will be further increased by circuit stray capacities. The effect will be to cause the final frequency to be substantially lower than that expected from simple calculations. If specific final frequencies are required, crystals will have to be ordered to operate with a parallel capacity of 70pF. Alternatively, C1 should be reduced to the usual value of 30pF and C2 to 100pF. If the circuit then fails to oscillate with a resistive cathode load, R2 will have to be replaced with an r.f. choke.

The output from V1 is, for 144 Mc/s operation, coupled via S1 to V2. The entire bandchanging operation is accomplished by S1, no other switching being required.

When V2 is operating as a tripler, drive is applied to its grid via S1. It should be noted that the grid leak, R3, is not returned to earth in the usual manner, but is connected to the cathode of V2, and that the resistor in the cathode of V2 (R4) is not a bias resistor, but is associated with the function of this valve when it operates as a Clapp v.f.o. on 1·8 Mc/s. This resistor, R4, does not have any degenerative effect when the valve operates as a multiplier since it is bypassed by C10 which forms part of the capacity divider of the v.f.o. circuit. Since R4 contributes no bias voltage to the valve, all the bias for the tripling operation is developed by the grid current through R3. If the drive fails, therefore, there could be a danger of the anode current of V2 running up to destruction levels. Since R4 in the cathode circuit is fairly large in value, the consequent voltage drop across this resistor under such conditions would automatically reduce the h.t. appearing across the valve and so limit the current. Nevertheless, V2 should not be operated without drive when switched to the 144 Mc/s position.

The anode circuit of V2 when operating as a frequency multiplier is tuned to 72 Mc/s. The tuned circuit is unusual in that it is a pi-coupler, the shunt capacities of which are the output capacity of V2, and the input capacity of V3. Since the coil is resonated by these two capacities in series, the net capacity will be very small. This permits the use of a relatively large inductance, which, in itself, achieves broadband coverage so dispensing with the need for direct tuning. At this juncture it should be particularly noted that this coil L3 has a point of zero r.f. potential—nominally the physical centre of the coil—and use is made of this as will be seen.

When the transmitter is switched for Top Band operation, S1 converts V2 into a Clapp variable frequency oscillator by connecting the grid to the tuned circuit, L2, C5, C6, C7, and the capacity divider C9, C10. In addition, the voltage regulator V5 is switched into circuit, and the screen supply for V2 connected to this instead of directly to the h.t. line. This stabilizes the operation of the v.f.o. and reduces the effect of variations in h.t. on the operation of the oscillator.

Mention has been made of the point of zero r.f. potential on L3. It is at this point that the h.t. is fed to V2 when it operates as a frequency multiplier, and the same point to

COIL DETAILS

L1, 16 turns, 26 s.w.g. enam., wound on Aladdin former 5961, with dust iron core.
L2, 95 turns, 38 s.w.g. enam., close wound on ¼ in. former.
L3, 21 turns tapped 10 turns from anode end, 26 s.w.g. enam., wound on Aladdin former 5961, with brass core.
L4, 6½ turns, tapped 3¾ turns from anode end, 20 s.w.g. enam., wound on Aladdin former 5961, with brass core.
L5, 5 turns, tapped 2½ turns from anode end, 20 s.w.g. enam., ¼ in. diam., ¼ in. long, self supporting.
L6, 36 turns, 18 s.w.g. enam., 1¼ diam., 2 in. long.
RFC1,2, 220 mH, Cambion type 2082-10.
RFC3, 2·5 mH.
RFC4, 40 turns, 30 s.w.g. e.s.s., wound on Aladdin former 5961, no core.

* Thorn AEI Radio Valves and Tubes Ltd.

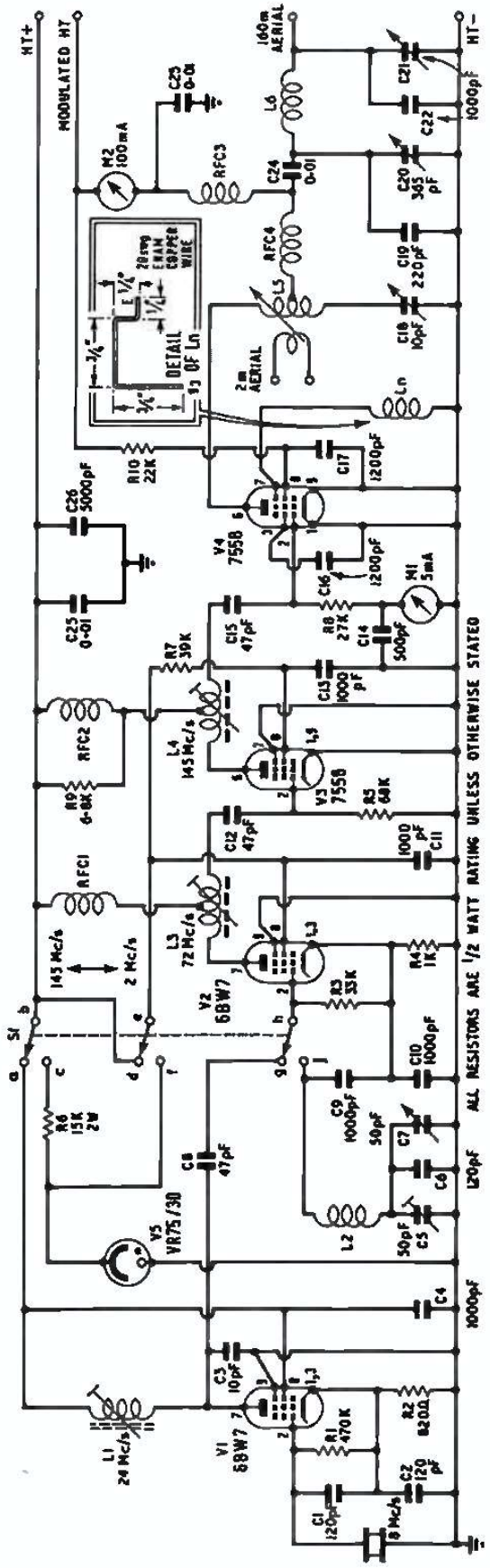


Fig. 1. The circuit of the transmitter for operation on 160m and 2m.

which the load for the output of the v.f.o. is connected. The output load for the v.f.o. is RFC1. To the output frequencies of the v.f.o. L3 is just another piece of wire, and it has no effect upon the operation of the circuit. Thus the coupling capacitor C12 is effective for both frequencies.

V3 operates either as a frequency doubler, or as an untuned buffer.

For 144 Mc/s operation, the output of V2 is coupled to V3 by a pi-network and C12, and V3 operates as a frequency doubler from 72 Mc/s to 144 Mc/s. Like V2, V3 relies on grid current through its grid leak, R5, to give it the correct operating bias. The anode circuit of V3 consists of another pi-network similar to that in the anode of V2 except that it is tuned to 144 Mc/s.

When switched to Top Band operation, the screen grid of V3, which now operates as an untuned buffer amplifier, is connected to the stabilized supply instead of directly to the main h.t. Its output is thus reduced. Even with this procedure the drive to the p.a. is still too high, and so a damping resistor is fitted across the r.f. choke anode load RFC2.

The p.a., V4, follows the practices established in the preceding stages. Grid current through the grid leak R8 provides the correct operating condition and a pi-network is used for the v.h.f. output, while the output circuit for Top Band is connected to the point of zero r.f. potential on this pi-network.

There are one or two points which require special note in relation to the p.a.

First, since the valve is operated as a straight amplifier at v.h.f., it will require neutralizing. In this circuit suppressor grid neutralization is employed. This simply consists of an inductance connected in the suppressor earth return lead, and is shown in Fig. 1. While it would be possible to employ capacity neutralization from the top of C18 back to the grid, the method shown is far easier to adjust and is more stable over a wider range of frequencies.

It must be particularly noted that two decoupling points are used on the screen grid of the p.a. valve. It is essential, if degeneration is to be avoided, that the screen grid has a low r.f. impedance to earth. To assist in this, both of the pins of the valve to which the screen grid is connected are bypassed individually.

The v.h.f. tank circuit is a pi-network tuned in this case at its " far end " by a 10pF variable capacitor C18. To this coil is fitted a variable link from which the 144 Mc/s output is taken.

To the centre of the v.h.f. pi-network is connected a v.h.f. choke, RFC4. Note that the point to which this choke is connected to the coil is not bypassed. This is correct and not an omission. It is bad practice to bypass this point in any v.h.f. tank circuit, and in this case it would be disastrous, as it would " drain off" the Top Band output.

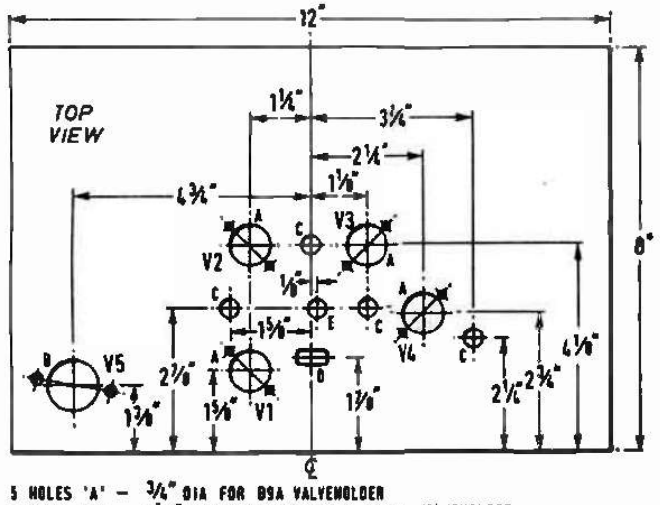
The Top Band output circuit is a familiar pi-network connected to the centre of the v.h.f tank circuit via the blocking capacitor C24 and the v.h.f. choke RFC4.

Metering in the transmitter is limited to measuring the p.a. grid and anode currents, and this is quite adequate. Indeed, a single meter could be used suitably shunted and switched.

Heater Wiring

The power rating and power requirements of this transmitter make it particularly suitable for mobile operation, in addition to fixed station usage. For this reason, heater wiring is not shown. When operated on 6·3V, the heaters of the valves should all be in parallel.

When operated from a 12V nominal source, such as a car battery, V1 and V2 should be wired in series, with pin 4 of V1 earthed, and pin 5 of V2 connected to the 12V supply. Similarly, V3 and V4 should be wired in series with pin 5 of V4 earthed, and pin 4 of V3 to the supply. Pin 4 of V4 should be decoupled with a 5000pF capacitor using very short leads. The two live leads from V2 and V4 are terminated on a



5 HOLES 'A' – ¾" DIA FOR B9A VALVEHOLDER
1 HOLE 'B' – 1 1/8" DIA FOR INTERNATIONAL OCTAL VALVEHOLDER
4 HOLES 'C' – 11/32" DIA HOLE FOR ALADDIN COIL FORMER TYPE S961
1 HOLE 'D' – SUITABLE FOR CRYSTAL SOCKET
5 HOLE 'E' – ⅜" DIA FOR PRE-SET AIR-SPACED TRIMMER
MATERIAL: 20 SWG TINNED STEEL SHEET

Fig. 2 (a). Top view of chassis plate.

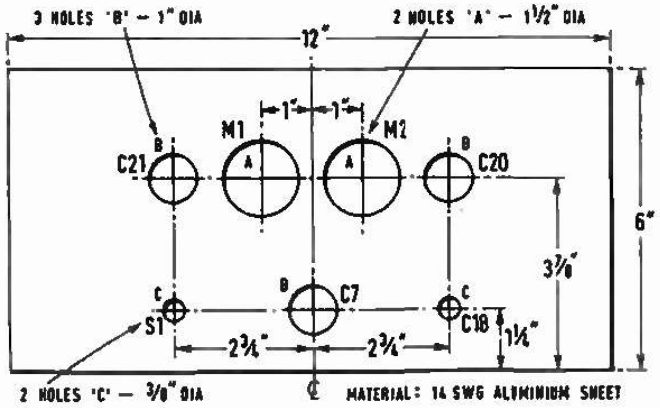


Fig. 2 (b). Front panel. The two holes M1 and M2 were cut for use with Shinohara meters, which are 1¾ in. diameter.

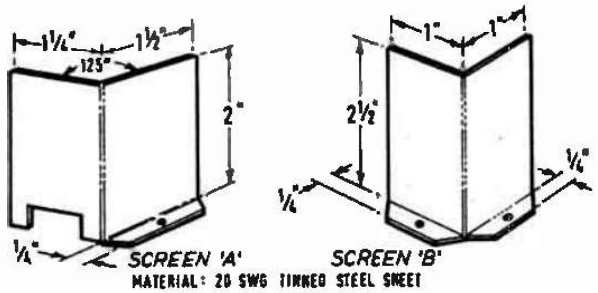


Fig. 2 (c). Screens A and B.

1000pF feed-through capacitor, the far side of which provides an anchor point for the incoming heater supply.

Construction

The transmitter is laid out on a chassis measuring 12 in. × 8 in. × 2¼ in. deep. In view of the difficulty of obtaining satisfactory earth connections to aluminium, this material should be avoided. Tinned steel or cadmium plated steel is far more satisfactory, or even sheet brass if one does not mind the somewhat higher cost. In actual fact the size of the chassis specified is quite a bit larger than that needed for just

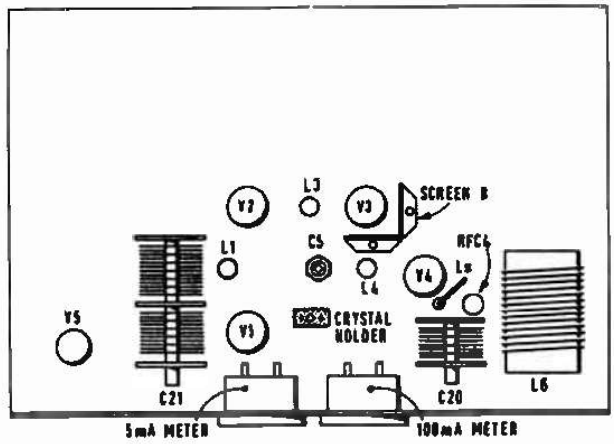


Fig. 3. Layout of the principal components above the chassis.

the r.f. section, and sufficient room has been allowed to accommodate both a modulator and power supply.

Fig. 2(*a*) shows the drilling layout of the chassis, while Fig. 2(*b*) details the panel layout and the two screens needed in the construction. It should be noted that these diagrams do not make provision for power supply or modulator components.

All components associated with the operation of the transmitter on 144 Mc/s should have leads as short as possible. The position of components associated with operation on 1·8 Mc/s is, on the other hand, relatively unimportant.

In view of the comprehensive nature of the layout diagrams, Fig. 3, which shows the positions of the components mounted on the top of the chassis, and Fig. 4, the layout of the underside of the chassis, a wire by wire commentary should not be required. However, in relation to these two diagrams, it should be noted that not every single wire is shown, and when wires not illustrated are fitted, they should be routed according to the remarks made in the preceeding paragraph.

Tuning Procedure

Since self-bias is used throughout this transmitter, the unit must be tuned stage by stage. Apart from an absorption wavemeter to verify the frequency to which the respective stages are tuned, the most convenient method of ensuring correct tuning is by measuring the grid current to the succeeding stage. To assist in this, the earthy ends of the grid resistors of V2 and V3 should be temporarily disconnected.

Switch the transmitter for 144 Mc/s operation and insert V1 and V2 into their sockets. Fit a suitable 8 Mc/s crystal to the crystal socket. Switch on heater supply and apply h.t. to V1 only. With a meter set to its 2mA range connected from the earthy end of R3 to the cathode of V2, adjust the core of L1 for maximum current indication on the meter. This should be about 1·2mA occurring when the core of L1 just starts to enter the winding.

Disconnect the h.t., re-connect R3 to the cathode of V2, and restore the h.t. supply connections to V2. Insert V3 and temporarily break the connections taking h.t. to the anode circuit and screen grid of this valve.

Connect the meter between the earthy end of R5 and chassis. Apply power to V1 and V2. Tune the brass slug of L3 for maximum grid current to V3. This should be of the order of 1mA. Check that the frequency to which L3 is tuned is 72 Mc/s.

Remove the power, re-connect R5, and restore the h.t. supplies to V3. Insert V4 and disconnect the lead marked MODULATED H.T. in Fig. 1 from the modulation transformer or the h.t. supply.

Apply power and tune L4 by means of the brass slug

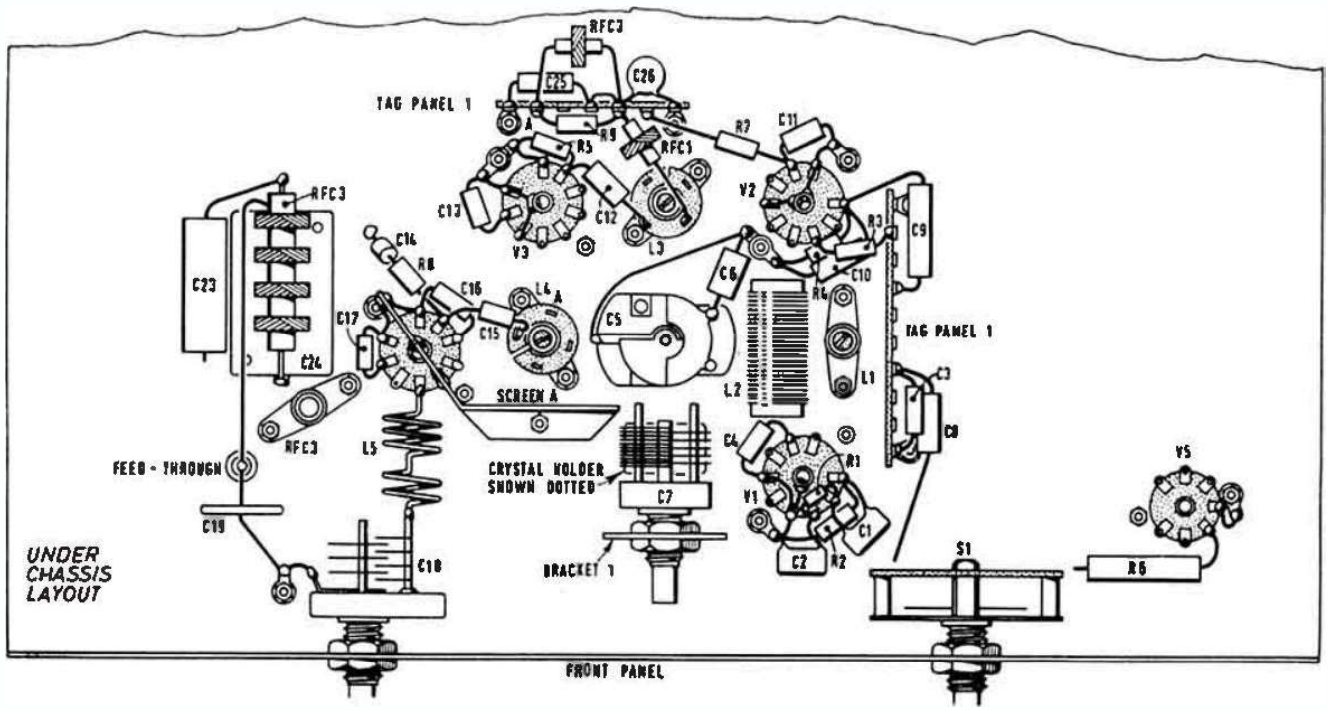


Fig. 4. Positions of the sub-chassis components. Ample space is left for the inclusion of a simple modulator.

until maximum current is indicated on the grid current meter of V4. This should be about 2mA. Check the frequency present in L4 by means of an absorption wavemeter.

Remove h.t. from the transmitter and restore the h.t. connection to the p.a. valve, V4.

Apply h.t. to the whole transmitter and rapidly tune C18 for maximum dip in the anode current to V4. Remove the h.t. Bring a wavemeter within reasonable distance of L5. apply power and quickly check that this circuit is tuned to 144 Mc/s.

With either an 80 ohm dummy load or a 144 Mc/s aerial connected to the link winding of L5, adjust the position of the link until the p.a. draws 60mA-65mA. Check the dip in anode current by tuning C18 slightly as the link is swung into position. If C18 has to be varied considerably from its initial setting as the link is progressively coupled to the p.a. tank circuit, look for a mismatch in either the dummy load or the aerial. In this respect an s.w.r. bridge will be found a useful adjunct. Once the p.a. is loaded, re-adjust L4 for maximum grid drive to V4.

To set up the transmitter for 1·8 Mc/s operation, the first adjustments relate to the v.f.o.

Switch off the power and set S1 for 1·8 Mc/s operation. Apply power via the stabiliser to the v.f.o. only. Set C7 to minimum capacity. Adjust C5 until the oscillator frequency is precisely 2 Mc/s. Set C7 to maximum capacity. Check the lower frequency to which the v.f.o. has now tuned. This will be below 1·8 Mc/s. Reduce the inductance of L2 by removing *one turn at a time* until the oscillator frequency is 1·8 Mc/s. Since removing turns from L2 will affect the highest frequency to which the v.f.o. will tune, after each adjustment to L2 check the highest frequency and adjust C5 so that this is 2 Mc/s. Repeat these adjustments in the order and manner given until the v.f.o. tunes 1·8-2 Mc/s.

Apply power to the driver stages, and the v.f.o. and check the grid current to the p.a. If the chokes specified have been fitted, then the 6·8 K ohm resistor across RFC2 will produce a grid current of 2mA to the p.a. If other chokes have been substituted, the value for the resistor to be fitted at R9 will have to be found by trial and error.

No special comments are required on the Top Band pi-network output circuit which functions in the normal manner.

Conclusion

As will be appreciated, this transmitter is of a very useful design in itself, but there would seem to be no reason why similar circuit configurations could not be successfully worked out for other powers and bands. The prime requirements are that the two frequencies involved should be fairly well divorced from each other.

Acknowledgements

The Society gratefully acknowledges the permission given by Thorn AEI Radio Valves and Tubes Ltd. to draw on their application report No L.87 in relation to the valve type 7558.

OLLERTON AMATEUR RADIO SYMPOSIUM
Saturday, September 11 to Sunday, September 12

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This weekend symposium has been arranged to acquaint youth leaders and young people with the hobby of amateur radio. The lectures and events on the Sunday have been given a broader scope, however, to appeal to radio amateurs as well.

Two separate lecture sessions will be run on Saturday afternoon, evening and Sunday morning, while on Sunday afternoon there will be a junk sale, aerial mast erection demonstration, radio controlled models, aircraft demonstration, and a display of Archery.

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Full details may be obtained from Mr. S. Denner, 68 Hawton Road, Newark, Notts. (Telephone Newark 3757).