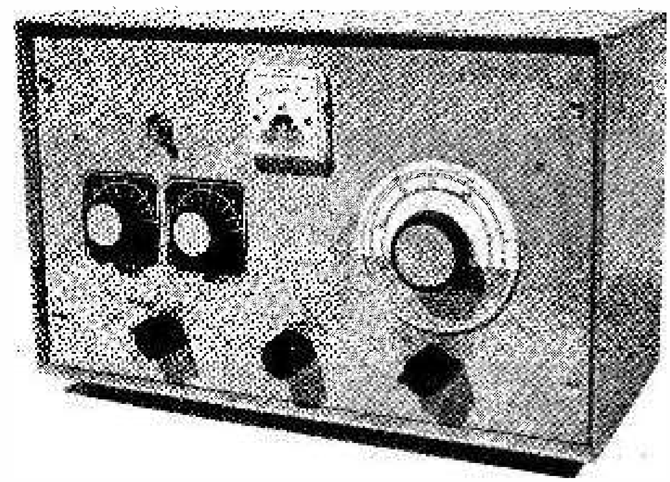
IT is apparent that there is a good deal of interest in small transmitters for the low frequency bands. There are several reasons for this. Such equipment can be constructed at small cost, with easily obtained components, and only a modest power pack is needed to reach the maximum allowed power input of 10 watts in the case of the 160m band. Many newly licensed amateurs start with such equipment, and when using this power on the low frequency bands the chances of interference to TV are minimal.

The transmitter described here is primarily for 160m working, but will be found to be a very practical piece of equipment on 80m also, coverage of this second band being easily arranged. In addition, an end-fed aerial is often used for 160m, which will also generally perform well on 80m. The 80m band also offers greatly improved range over 160m and contacts during daylight, so it is well worth having.

QRP TRANSMITTER for the LF BANDS

F. G. RAYER G3OGR



CIRCUIT

In Fig. 1, V1 (6C4) is the variable frequency oscillator, followed by V2 (6AM6) which is a buffer/doubler. V3 (6BW6) is the power amplifier, and runs at about 10 watts input, anode current being shown by the meter. This is a straightforward arrangement which gives good results with a minimum of difficulty.

VC1 tunes the v.f.o. from 1·75-2·0MHz and, for the 160m band, the 1·8-2·0MHz sector is used, transmitter output being on the same frequency as the v.f.o. For 80m, the v.f.o. is tuned over the range 1·75-1·9MHz, and V2 acts as doubler, so that the output frequency is from 3·5-3·8MHz. V6 provides a regulated supply for the v.f.o.

L2 and L3 are broadly resonant coils for 160m and 80m. When first testing the equipment, grid current in the p.a. stage can be checked by clipping a test-meter across R8. L4 is the pi-network tank coil, tapped for 80m.

The audio section has V4 (12AX7) as a high gain amplifier, followed by V5 (6BW6) which choke modulates V3. This arrangement has been found to give good modulation and quality when using a crystal microphone and it requires relatively few components.

With any set of transmitting/receiving equipment the problem arises of providing "Transmit" and "Receive" change-over facilities. A relay is often used to switch the aerial from receiver to transmitter, to switch on the transmitter and to mute the receiver or speaker.

No external items of this kind are necessary with this transmitter, as the required switching is incorporated. This gives complete change-over from "Receive" to "Transmit" with single switch control.

The switch has four poles, section S1 switching the aerial to the tank coil L4 at T (Transmit), but transferring the aerial to the receiver at R (Receive). Section S2 short-circuits the aerial feed to the receiver during transmission, to minimise r.f. leaking through to the receiver. S3 is in series with one speaker lead, and so silences the speaker during transmission.

The transmitter power circuit is controlled by S4, which applies h.t. to all stages on transmit. S5 is a separate two-way switch, which allows h.t. to be put on V1 and V2 only. This allows the v.f.o. to be tuned to any wanted frequency, and be "netted" with the receiver, either to answer a CQ, or to begin transmission on a selected channel.

The aerial, or matching device, if used, is plugged into the aerial co-axial socket. A co-axial lead of convenient length is made up, and plugged into the "Rx" outlet of the transmitter. This lead runs to the aerial and earth terminals of the receiver. Communications type receivers normally have a separate speaker, one lead of which is cut, and extended if necessary, so that plugs can be inserted into the "Mute" transmitter sockets.

The two switches on the transmitter then give complete control, for tuning the v.f.o. netting on a signal, and changing from reception to transmission.

CONSTRUCTION

VFO

By using a ready-made inductor and accurate capacitor values, experiments to obtain suitable band coverage are avoided. It is only necessary to adjust the core of L1, and trimmer TC1, to set the band so that VC1 tunes 1·75-2·0MHz, with a little to spare at each end of the dial.

The v.f.o. is assembled in a box 3×2×2in. which screens it completely and also helps isolate components from sources of heat. This box is readily made from "universal chassis" strips. One strip is 7×2in., with flanges which are cut 2in. from each end, so that the strip can be bent into an open U-form 2in. high and 3in. wide, with flanges all round. An accurate bend is most easily obtained by holding the strip on a block of wood.

The second strip is 3×4in. and also has flanges. It is cut through centrally to obtain two pieces 3×2in. One of these is bolted to the front of the box as in Fig. 2 and carries VC1. After wiring is complete and the box is fixed to the chassis the second 3×2in. flanged piece is secured with self-tapping screws to close the back.

The v.f.o. is completely wired as in Fig. 2 before it is mounted. Trimmer TC1 is fixed just clear of the box top with a bracket or by bolts with spacers. A small hole is drilled in the box to permit adjustment of TC1. All connections are direct and rigid and points MC are joined with wire and also to tags bolted to the chassis.

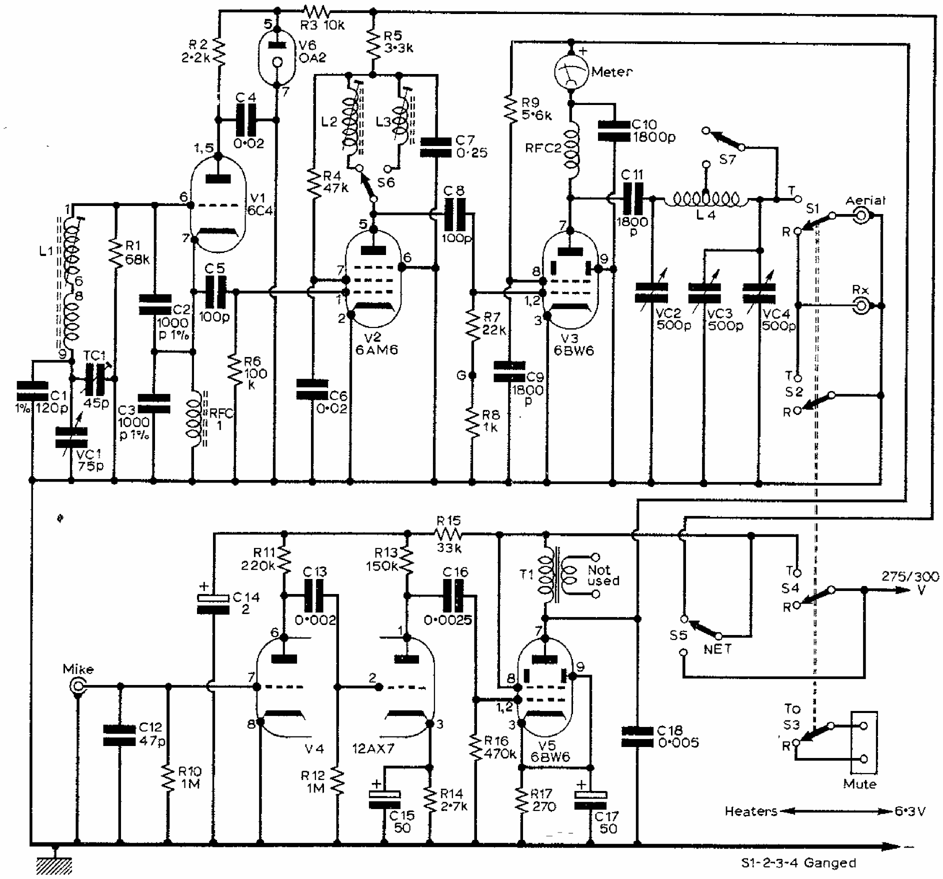


Fig. 1: Complete circuit of the QRP transmitter.

The tag-strip in Fig. 2 is secured inside the box and supports the r.f. choke, C2, and C3. Coloured leads identify the wires which pass through the chassis—brown for h.t. (150V), blue for 6·3V, and yellow for the lead from C5.

The box is fixed to the chassis by bolts through the flanges which turn inwards (omitted in Fig. 2, for clarity) and through the front and back plates. It is placed so that the ball drive can be arranged as in Fig. 3.

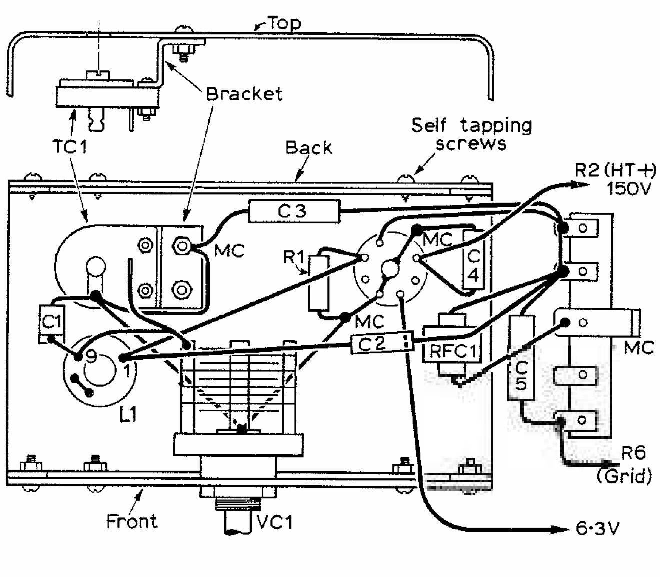


Fig. 2: Constructional details of the VFO assembly.

Top of Chassis

Fig. 3 shows the position of the major components. Capacitor VC2 is of a type fixed to the chassis with small feet. Capacitor VC3/4 has three holes in the front plate and is bolted to a small bracket to bring the spindle level with that of VC2. These spindles pass through ½in. clearance holes.

Panel and chassis are fixed together by the switches and panel brackets. The lower edge of the panel must project about ¼in. beyond the chassis, to clear the mounting flange of the case.

Buffer Stage

Components are placed around V2 as in Fig. 4, with grid and anode circuits separated and heater leads close against the chassis. The MC connection to the central spigot of the valveholder passes across the holder, as shown.

The coupling winding provided on L2 and L3 is not required, and must be completely removed. The outer end of the larger winding of L3 is then unsoldered from its pin and 28 turns removed. The end of the wire is cleaned and re-soldered to the pin.

PA Stage

Grid circuit components are under the chassis, and are placed around V3 approximately as in Fig. 4. A hole is drilled in the chassis adjacent to the anode, pin 7, a lead passing directly through to the r.f.c. Anode circuit items are above the chassis.

C10 is anchored to a tag strip (Fig. 3) which also supports r.f.c.2, the top of the choke being held by C11. The 1800pF 1kV disc ceramic capacitors used in these positions are easily obtainable, but 2000pF

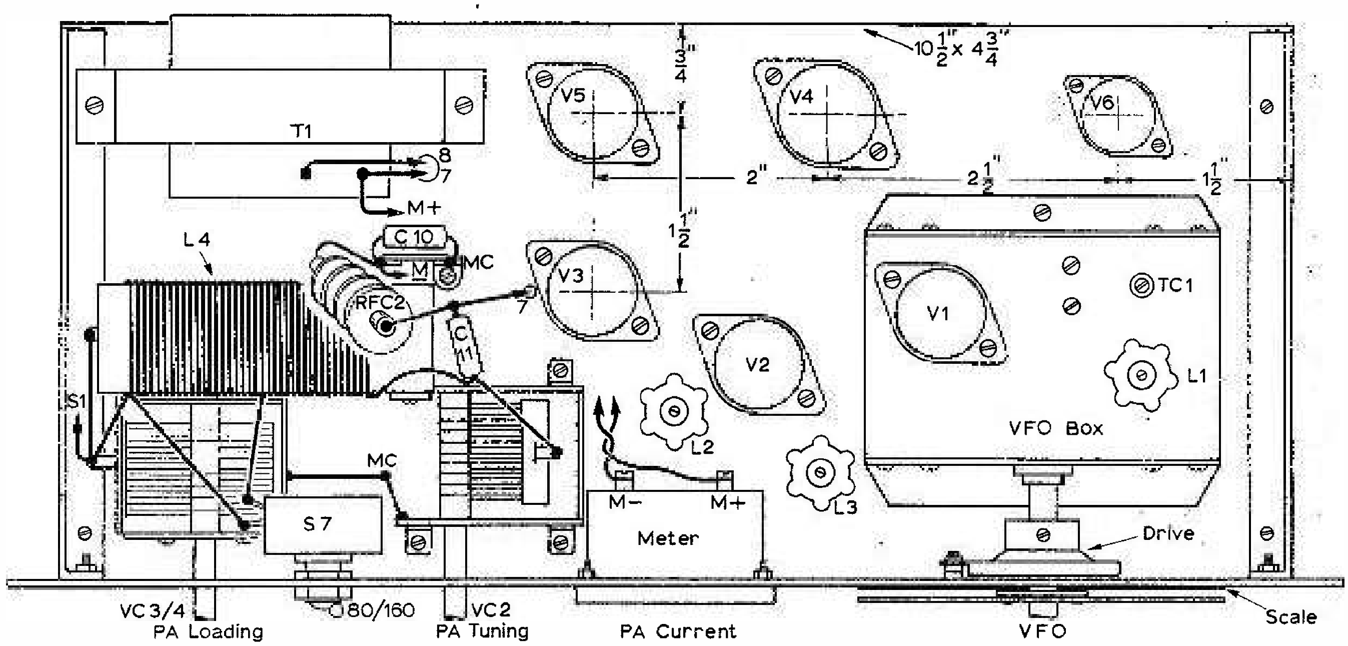


Fig. 3: Plan view of chassis showing disposition of major components.

mica capacitors of 750V rating could be used instead.

The p.a. coil has 63 turns of 22 s.w.g. enamelled wire, close-wound on a 1in. diameter paxolin tube about 2¾in long. During winding, a loop is made at 33 turns for the switch S7 connection. This leaves 30 turns in circuit from VC2 to the switch.

The coil is mounted by bolting a 1in. long strip of paxolin to it and attaching this to the frame of VC2 with a second bolt. The coil is well clear of metal parts and the cabinet top.

Audio Section

Grid leads and components should be against the chassis especially connections to pin 7 of V4 otherwise there is some danger of instability or picking up of hum or r.f.

No gain control was included because it was found that speaking normally with a hand-held crystal microphone gave just about the required audio level. Gain can be reduced by removing C15 or by substituting a 1 megohm potentiometer for R12 connecting the slider to pin 2 of V4. It should be mounted on the back runner near V4 or be connected with screened leads.

The modulation choke T1 is the primary of a mains pentode type speaker matching transformer and should be able to carry 70-80mA, and of low d.c. resistance, to avoid excessive voltage drop.

A test of the a.f. section can be made by connecting a speaker to the secondary of the transformer. The speaker must be well clear of the microphone, to avoid audio feedback. Speech should be reproduced at ample volume with good quality. Causes of distortion could be low emission valves, wrong resistor values, or slight leakage in C13 or C16 upsetting the bias of the following stage.

Fig. 4: The wiring underneath the chassis.

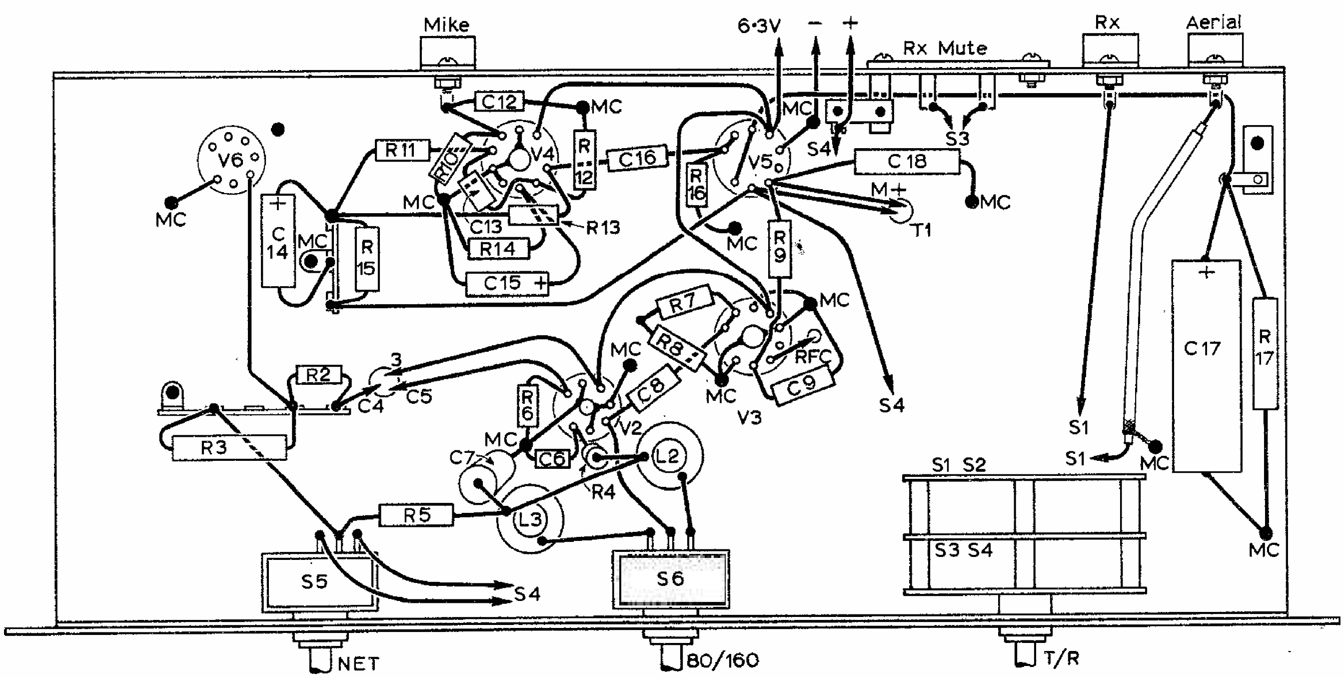
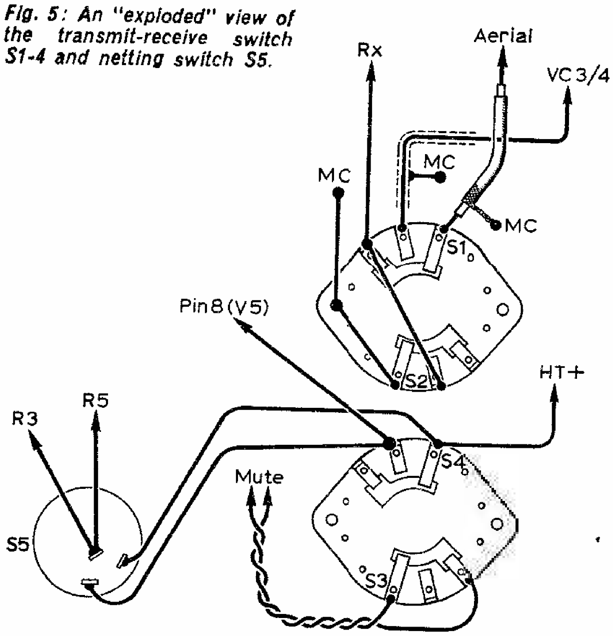


Fig. 5: An "exploded" view of the transmit-receive switch S1-4 and netting switch S5.



Switching

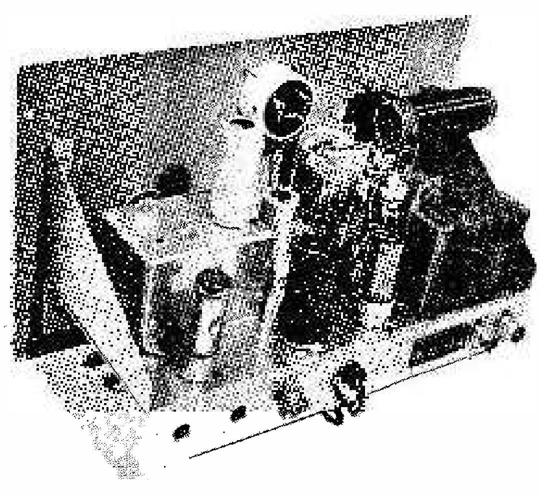
Fig. 5 shows switch connections. A co-axial lead is used for the aerial, taken to chassis at the socket, and at VC3/4. S5 is switched to the "Tune" position only when adjusting the v.f.o. frequency, and so S4 normally switches on all transmitter h.t. circuits.

VFO Dial

A pointer, cursor or disc of transparent material such as perspex can be mounted on the flange of the ball drive by two short 8BA screws. A disc with a line marked on it was used. A piece of thin card of larger diameter than needed was temporarily fixed to the panel, and calibration marks made around the edge of the disc. The card was removed, markings transferred to scales of suitable diameter, and the card cut down to size and cemented in place, finally checking that the calibration was still correct.

CW

V3 can be keyed by disconnecting pin 3 from the chassis, connecting a 5000pF capacitor directly from this tag to chassis and wiring a lead from pin 3 to a jack, normally closed to complete the circuit.



This places the key between cathode and chassis when the plug is in. It is also necessary to take T1 out of circuit, which can be done by fitting a two-way switch to the back runner, so that on c.w. h.t. reaches the r.f. section only. The lamp load mentioned later for a.m. tests is not suitable on c.w. Connect a 470 ohm resistor in series with a 5000pF capacitor across the key jack.

VFO CALIBRATION

Calibration is most easily done with a 100kHz crystal marker used in conjunction with a communications type receiver. First adjust the core of L1, and trimmer TC1, for suitable coverage. As TC1 is increased in value, the range of frequencies covered by VC1 will be reduced. TC1 and L1 also allow the band edges to be adjusted. It is best to arrange that almost the whole swing of VC1 is needed to tune from 1·75-2·0MHz, but to avoid the extreme positions.

★ components list

Resistors:

R1	68kΩ	R10	1MΩ
R2	2·2kΩ	R11	220kΩ
R3	10kΩ 3W	R12	1MΩ
R4	47kΩ	R13	150kΩ
R5	3·3kΩ 1W	R14	2·7kΩ
R6	100kΩ	R15	33kΩ 1W
R7	22kΩ	R16	470kΩ
R8	1kΩ	R17	270Ω 2W
R9	5·6kΩ 2W		

All ½W 10% unless indicated otherwise.

Capacitors:

C1	120pF SM 1%	C10	1800pF 1kV
C2	1000pF SM 1%	C11	1800pF 1kV
C3	1000pF SM 1%	C12	47pF SM
C4	0·02μF 350V	C13	0·002μF 350V
C5	100pF SM	C14	2μF 350V
C6	0·02μF 350V	C15	50μF 6V
C7	0·25μF 350V	C16	0·0025μF 350V
C8	100pF SM	C17	50μF 50V
C9	1800pF 1kV	C18	0·005μF 1kV

TC1 45pF trimmer, ceramic.
VC1 75pF miniature, air.
VC2 500pF variable, air.
VC3–4 500+500pF ganged variable, air.

Valves:

V1	6C4 (EC90)	V4	12AX7 (ECC83)
V2	6AM6 (EF91)	V5	6BW6
V3	6BW6	V6	OA2

Inductors:

L1 "Yellow", Range 3 (Denco)
L3 "Red", Range 2 (Denco)
L2 "Blue", Range 2 (Denco)
L4 See text
RFC1 2·5mH miniature iron-cored choke
RFC2 2·5mH 60mA sectionalised choke

Miscellaneous:

Valveholders, B7G with skirt (3) B9A with skirt (3). B7G screens (2) B9A screens (1). Co-axial sockets (3). Switches, 4 pole 2 way rotary (1) 1 pole 2 way rotary (1) on/off toggle (1). Miniature meter, 50mA f.s.d. T1, see text. Flanged ball drive. Knobs etc. Cabinet No. BX5 with chassis 10½ x 4¾ x 1½ in. (Home Radio). VFO box made from flanged chassis strips CU136 and CU144 (Home Radio).

With S5 at the "Tune" position and a lead from the receiver lying near the transmitter, tune the receiver to 3·5MHz using the crystal marker, tune VC1 to zero beat, and mark the scale for 3·5MHz repeating for 3·6, 3·7 and 3·8MHz. Also mark 3·6 as 1·8, 3·7 as 1·85, and 3·8 as 1·9MHz. Continue with the 3·9 and 4·0MHz marker pips, but marking the v.f.o. for 1·95 and 2·0MHz only. If the extreme settings of VC1 have been avoided the 10kHz points can be filled in linearly between the 100kHz points.

A 10mA or multi-range meter is connected from "G" Fig. 1 to chassis, the latter being positive. The v.f.o. is set to 1·9MHz, S6 to 160m, and the core of L2 is adjusted for maximum grid current, which should be around 3mA. Then adjust the v.f.o. to about 3·7 MHz, switch to 80m adjusting L3 core for maximum grid current which will be around 2mA.

TESTING

It is simplest and best to test the whole equipment by feeding the transmitter output into an artificial aerial load. This can be a 15 watt or 25 watt 240V or similar household lamp. Clip it across VC3/4 and chassis, or fit a holder, lead and co-axial plug so that it may always be employed for tests.

P.A. tuning procedure is that generally employed with a pi-network. Check that S7 is closed for 80m, or open for 160m, to match the position of S6. Fully close VC3/4 and also VC2 (to prevent the possibility of doubling in the p.a.). Switch to "Transmit" and open VC2 to obtain a dip in anode current, as shown by the panel meter. Current will be low but loading is increased by opening VC3/4, meanwhile adjusting VC2 for minimum current. As this is done, the minimum current rises, and the 15 watt lamp should light with fair brilliance when the input reaches about 10W.

The d.c. input to V3 anode is anode volts×anode current, thus 33mA at 300V will be 9·9 watts. A supply voltage of less than 275V is not recommended.

If the transmitter is loaded into the lamp, and a receiver is tuned to the signal, speech should sound clear and well modulated. The receiver should have its aerial disconnected and r.f. gain turned well back, or overloading may cause distortion.

POWER SUPPLY

Fig. 6 is the circuit of a suitable power supply. The mains transformer actually used was a Parmeko P.2931, 250/0/250V 150mA, with SE-05 rectifiers D1 and D2, and Parmeko P.3141 120mA choke. This provided 280V with a load of 120mA. BY100 rectifiers would also be suitable. The voltage obtained when using semi-conductor rectifiers is somewhat higher than with a valve rectifier. Many transformers have winding for valve rectifiers so a 5U4G is a suitable rectifier for a 5V 3A winding, or an EZ81 for a 6·3V 1A winding.

AERIALS

The simplest possible aerial is an end-fed wire. Some lengths will offer such a load impedance that the transmitter can be worked directly into the aerial, on one or both bands. Other lengths present load impedances which are outside those which can be matched by the transmitter, and then proper tuning or loading will be impossible. One of the

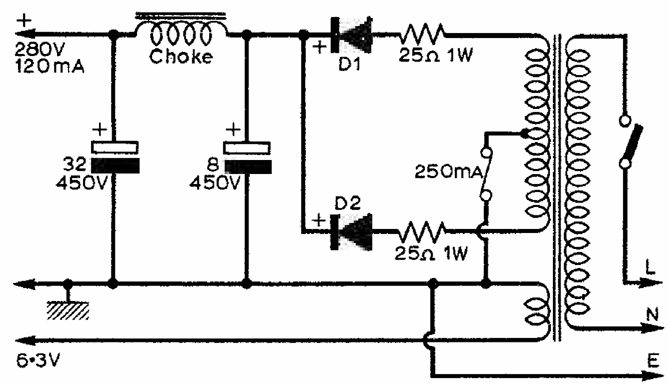


Fig. 6: Suggested power supply for the QRP transmitter.

matching circuits in Fig. 7 can then be used.

Fig. 7(a) is the simplest. L1 may be similar to the tank coil, or be a surplus tapped inductor, or may consist of a number of turns, found by trial and error, on a former 1in. to 3in. in diameter.

Fig. 7(b) is similar but has a capacitor VC1 added, of about 250pF, which allows more accurate adjustment and has fewer tappings on L2.

Fig. 7(c) is series tuning often used for quarter-wave aerials on l.f. bands. VC2 can be 500pF and again L3 resembles the tank coil. The tapping makes L3 into an auto-transformer and may be set about 10 turns from earth for 160m, or 4 or 5 turns from earth for 80m. For the latter band only L3 may have fewer turns.

Fig. 7(d) is parallel tuning suitable for a half-wave aerial on 80m. L4 is about 30 turns on a 1in. diameter former, with a 250pF capacitor for VC3 and L5 is about 4 turns of insulated wire over the earthed end of L4.

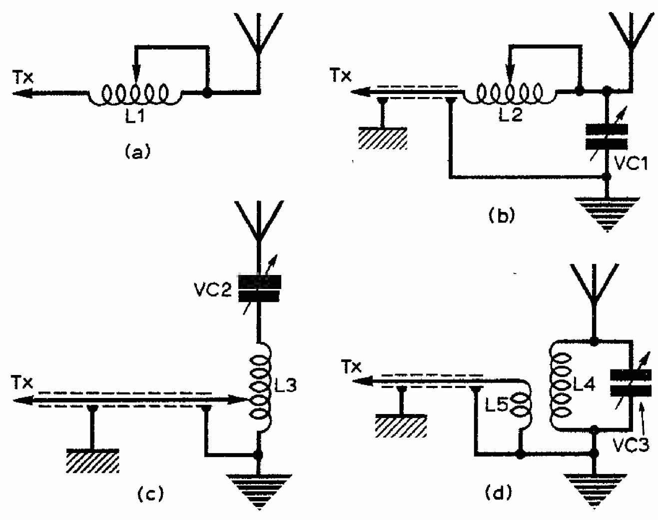


Fig. 7: Four circuits enabling almost any aerial to be matched to the transmitter.

A typical aerial of 126ft in length would be about a quarter-wave on 160m, and a half-wave on 80m, so Fig. 7(c) would be required for 160m, and Fig. 7(d) for 80m working. However, it is generally easier to make up a tuner with one of the circuits in Fig. 7 or a similar circuit and to experiment with tappings until the transmitter can be satisfactorily loaded by the aerial. Even very short wires (under 10ft.) may be used with these circuits but range is much reduced. ■