# An SSB Transceiver for Twenty

## GENERAL DESIGN, CIRCUITRY, CONSTRUCTIONAL DETAILS

PART I

**J. D. HEYS (G3BDQ)**

*The more sophisticated commercial approach to Sideband operation is a combined Transmitter/Receiver, or Transceiver, designed to cover all amateur bands 10-80 metres, with certain sections of the circuit operating on both "transmit" and "receive," an exceptionally stable VFO for accurate SSB working, and the power supply built in. These features can be combined in a single cabinet, so making an extremely compact and portable one-knob single-switch controlled transmit-receive unit, with the "transmit" side always on the "receive" frequency, because the VFO is common to both. Our contributor has adapted these general principles to a single-band (20-metre) SSB Transceiver, with the advantages, on this one band, of the modern commercial trend in amateur Sideband equipment. As this Transceiver can be home-constructed, it is dealt with in some detail. The discussion will be of great interest to many readers.—Editor.*

DURING the winter of 1959-60 the writer was tempted to try his hand at Single Sideband, which to a dyed-in-the-wool CW and VHF man seemed then to be rather a bold and rash undertaking. However, after a few months on 80 and 20 metres using his version of the G2NH Exciter[1] (which, incidentally, forms the basis of the excellent "K.W. Viceroy" transmitter), the superiority of SSB over AM—and at times even of CW—left him in no doubt that previously an awful lot had been missed. A mere 50 watts input to a 6146 linear hooked on to the faithful end-fed "wet string" aerial gave solid contacts with all sorts of exotic DX.

Of course there was a big snag—there always is! The station was cluttered with power packs, VFO, exciter, PA, ATU, relays, and inevitably the receiver, a vintage HRO with BC453 out-rigger. Change-over, netting, and tuning-up became a work of art and a source of wonderment to the XYL and visiting amateurs. Something neater and more compact was needed, so then began the long search through all the technical literature that could be obtained on the subject.

Reading of the Collins KWM Transceivers and also an excellent *QST* article on a Mobile SSB Transceiver for 15m.[2] finally decided the course of future construction. It had to be a transceiver! W1DX in a report on the KWM-1[3] said: "Once you get used to it (two or three QSO's), you are likely to think anything else is old-fashioned." This referred to the ease of operation when using a VFO common to receiver and transmitter. Accurate netting, so important on SSB, is simplicity with a transceiver. Tune to a station — push a switch — then call, right on frequency.

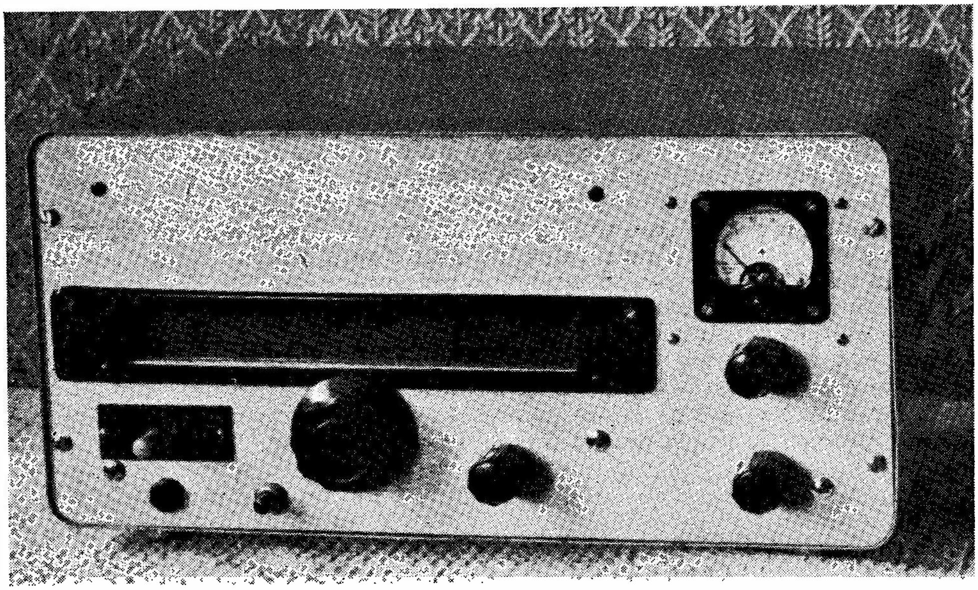
As the design took shape on paper a major decision was taken. The transceiver was to be for just one band, 20m. being the obvious choice as it carries most of the DX traffic and is likely to be disturbed least by the rapidly approaching sun-spot minimum. By building for one band there is great simplification, there being no need for coil switching and the associated lining-up problems. Provision was made for CW operation, and by using a high-frequency filter, reception and transmission could be achieved with a single-conversion design.

It is suggested that newcomers to the art of SSB first gain some experience with a simple half-lattice design for the LF bands (like the G2NH Exciter) before embarking upon a more complex transceiver such as this. However, there are many sections of the circuit, *e.g.* the VFO, the filter, the balanced modulator or the crystal calibrator, which can easily be "Chinese copied" and incorporated into the reader's own home-brew equipment.

The Transceiver described here involves 14 valves and 7 germanium diodes. It tunes from 13995 kc to 14355 kc and can transmit and receive CW and upper sideband SSB over this frequency range. The PA valve, a Mullard QQVO6-40, can be run at inputs up to 120 watts, but 65 to 70 watts is a more realistic figure with only 500 volts HT. No provision has been made for loudspeaker operation, so VOX and anti-trip circuits were not needed; the Transmit/Receive functions are rapidly achieved with a manually-operated keyswitch.

### The Receiver Circuit

V1 is the receiver RF amplifier (refer Figs. 1 and 2) and is an ECC85 double-triode working in the series cascode manner. The ECC85 is a low-noise, high-gain valve designed to work satisfactorily at VHF and so gives good performance at 14 mc. A small variable con-



**General view of the 20-metre SSB Transceiver, which is housed in a wrap-round style cabinet. The controls, from left to right, are : Send-receive keyswitch and phone jack, calibrator push-button, main tuning, RF gain and PA tuning controls, the upper of these two being the PA tank condenser C73 and the lower the grid condenser C72 (see Fig. 2). The dial mechanism is the Eddystone type 898, with a home-made escutcheon.**

denser, C1 (Fig. 2) is provided to peak up the RF stage when tuning across the whole band. The tuning is quite flat and adjustment of C1 is not needed over a range of 100 kc or so ; this control is located at the rear of the transceiver, and in practice it is rarely touched. A potentiometer R2 controls RF gain, R4 ensuring that V1 is never without bias regardless of the gain control setting. A negative AGC voltage (audio derived) is applied to the grid of V1 by strong signals. The time constant of the AGC circuit is of a type suitable for SSB working. The tuned circuit at V1A anode is pre-set to mid-band.

V2 is the receiver mixer and is arranged in the conventional manner, apart from its anode circuit which has an RF choke as load. A tuned circuit at the IF (8·4 mc) and also a 1000-ohm resistor were tried in this position, but the receiver performance was unchanged ; this is because of the low input impedance of the filter which follows.

Two half-lattice sections back-to-back using four inexpensive surplus-type crystals make up the filter. The filter circuit is given in Fig. 3, together with the crystal frequencies. (The toroid coupling coil LT, will be fully described in the section on filter construction.) The use of a filter of this type with a steep cut-off characteristic (*see* Fig. 5) in the receiver obviates the need for high-Q IF transformers.

V3 is a 6AK5 pentode and is the first IF amplifier. A 6AK5 can be a " fiery " valve owing to its high mutual conductance, but as used in the transceiver with a 560-ohm resistor (R14) between control grid and earth no instability is experienced. The second IF stage V4 is a 6BA6. The coils L3 and L4 are unscreened, but by careful positioning at right angles to each other there should be no feedback problems. However, if this is not the case, neutralisation can easily be effected by making a small condenser, NC1, from a pair of suitably-insulated wires twisted together and adjusted for correct capacity. Originally a second 6AK5 was used as V4 and the high gain made neutralisation necessary, and no re-arranging of the IF coils would overcome this ; IF gain level is fixed because both stages are also used when transmitting.

In the " Receive " position the IF output goes *via* the IF relay to the grid of V8A ; V8 and V8A make up a cathode-coupled mixer or product detector. V10 provides BFO voltage to the detector as well as supplying the carrier to the balanced modulator when transmitting. The audio output from this type of product detector is small and both sections of a 12AX7 (V7 and V7A) in cascade amplify the signals to a comfortable level.

Further simplification is achieved by omitting the usual AF gain control. In practice the writer never uses a loudspeaker, and as a result the AF gain is always left right up and signal levels are adjusted with the RF gain control. This is the correct procedure when receiving SSB. Much has been said and written upon the merits and disadvantages of audio-derived AGC systems, but they certainly work very effectively on SSB. D3 (a high back resistance type germanium diode) is back-biassed through R37 and R38 to prevent AGC action taking place on normal background noise and weak signals. Audio voltages appear across the small LF choke Ch.1 and any of greater amplitude than the back bias are rectified by D3 and appear as negative voltages at V1 grid. C42 and R36 set the time constant to ensure the fast attack and slow decay action needed for SSB reception.

## The Transmitter Circuit

The carrier generator V10 (Figs. 1 and 2) is a 6BA6 with an 8400 kc crystal between its screen and control grids, in a Pierce oscillator circuit. V10 anode is tuned to the same frequency by L7 and C64. A "swamping" resistor of 3900 ohms (R62) was found to simplify the initial setting up and also reduced the output to the correct level. L7A is a link coil which couples to the balanced modulator at the correct low impedance. To prevent stray carrier voltages finding their way around the balanced modulator and the filter, L7 and L7A must be enclosed in a suitable screening can. The twin leads from L7A must also be screened along their length. A 3/30 $\mu\mu$F Philips trimmer (C62) can be used to set the oscillator frequency to its correct position on the response curve of the filter (*see* Fig. 5).

The output from a crystal microphone is amplified by V9A and V9, two sections of a 12AX7 high-gain double triode, and is coupled at medium impedance *via* T1 to the balanced modulator. Any small output transformer with a secondary impedance in the 300 to 500 ohms range is suitable for T1; output transformers from the SCR-522 equipment or the "Command" receivers are suitable. R53 is the amplifier gain control which can be pre-set and forgotten about once the correct audio level has been found. When SW1 is in the CW position, the microphone input is removed and V9A functions as a phase-shift audio oscillator with a frequency of about 1000 c/s. As the output from this kind of oscillator is almost pure sine-wave, the single tone produced enables the transmission of a CW signal. Keying takes place in the cathode lead to V9A, the jack self-shorting when the key plug is removed.

The balanced modulator is of the ring type similar to that used in the Collins KWM-1 and KWS-1 equipments, with four semi-conductor diodes, D1, D1A, D2 and D2A; these consist of two matched pairs of Mullard OA79's. R24 is the balance potentiometer used in conjunction with C25 and C28 to reduce the carrier

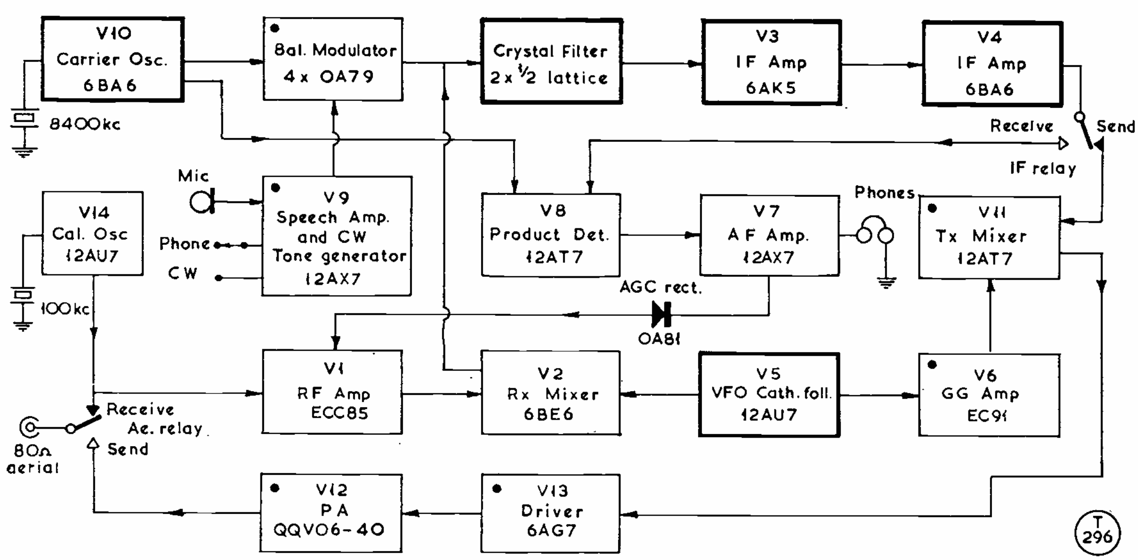
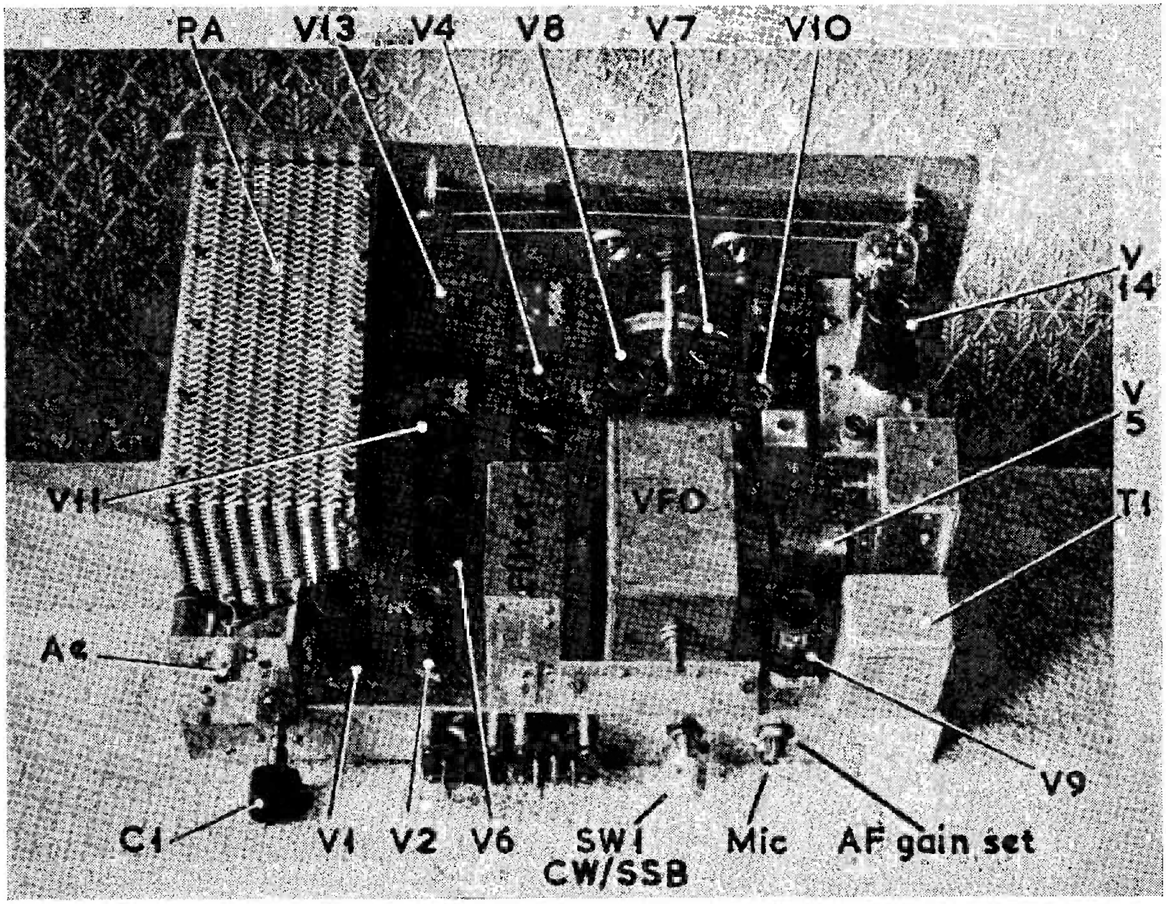



**Fig. 1. Block diagram of the 20-metre Transceiver designed by G3BDQ, and fully described in the article. The units in heavy line are common to both "transmit" and "receive" positions, and those with a dot in the top left-hand corner operate when transmitting. V1, V2, V7, V8 and V14 are only in use when receiving. The send-receive switch, SW3 in Fig. 6, is not shown on this diagram.**




**Rear view of the 20-metre SSB Transceiver out of its cabinet, with main items identified. The aerial relay is between the PA box and C1, and to the left of the VFO box are the IF stages and IF relay. The balanced modulator box and the crystal calibrator unit are behind the transformer T1 ; the 100 kc (calibrator) crystal is hidden by V14.**

output to a very low level.

From the balanced modulator the double sideband suppressed carrier signal at 8400 kc passes through the filter and the resultant upper sideband signal is amplified by the two IF stages before appearing at the grid of V11A. V11A and V11 are arranged as a cathode coupled mixer. The USB at 8400 kc is mixed with the VFO frequency and a 14 mc upper sideband is developed at V11A anode. There is no change of sideband because the mixing process is one of addition. L8 is slug tuned to 14 mc, the only capacity across it being interelectrode capacities and strays. This makes the coil effective across the whole band without re-adjustment of the slug.

A 6AG7 operating in Class-A (V13) behaves as a high-gain driver to the PA and requires no neutralisation if its input and output circuits are properly shielded. The 47-ohm anode stopper R75 is also important in this direction.

The PA valve V12 is a Mullard QQVO6-40 VHF twin tetrode with both sections in parallel. It is a small, extremely efficient valve very suitable for SSB applications. In Class-AB1 it has an efficiency of 67·5% with a total distortion product of only 2·4%. (Prospective users of this valve are advised to obtain the most informative *Data and Application Notes* from Mullard.) In Class-AB1 only 40 volts RF is required between control grid and cathode when both sections of the valve are in parallel. This is easily obtainable from the 6AG7 driver stage, and R71 is a 22000-ohm resistor shunted across L10 and C72 to damp the circuit and help linearity. The correct value of R71 can be found by experiment, depending upon the available drive. The common screen grid of V12 is tied to the 250-volt HT line on " transmit " and does not need stabilising as the load-

## Table of Values

**Fig. 2. Circuit of the SSB Transceiver**

| | |
|---|---|
| C1 | 20 μμF variable |
| C2, C8, C12, C24 | 120 μμF silver mica |
| C3, C7, C10, C18, C21, C40, C44, C65, C66, C76, C82, C83, C84, C90 | .01 μF disc ceramic |
| C4, C6, C9, C11, C15, C23, C26, C27, C39, C45, C48, C49, C54, C56, C61, C70, C80, C87, C91, C92 | .001 μF disc ceramic |
| C5, C17, C22, C25, C28, C62 | 3/30 μμF Philips trimmers |
| C13, C14, C19, C20, C43, C69, C88 | 005 μF disc ceramic |
| C16, C29, C30, C37, C50, C51, C85 | 200 μμF silver mica |
| C31, C72 | 50 μμF variable |
| C32 | 10 μμF variable |
| C33 | approx. 200 μμF silver mica (*see text*) |
| C34, C63 | 15 μμF silver mica |
| C35, C38 | .003 μF mica |
| C36 | 10 μμF silver mica |
| C41, C93 | 50 μμF silver mica |
| C42 | 0.5 μF paper |
| C46, C52, C55 | 8 μF 450v. wkng. elect. |
| C47 | 0.1 μF paper |
| C53 | 500 μμF mica |
| C57, C58, C59 | 470 μμF tubular ceramic |
| C60 | 10 μF 25v. wkng. elect. |
| C64 | 65 μμF silver mica |
| C67 | 40 μμF silver mica |
| C68 | .05 μF paper |
| C71 | 300 μμF mica |
| C73 | 150 μμF var. txm. type |
| C74, C79 | .001 μF mica, 2500 volts wkng. |
| C75 | 450 μμF mica compression |
| C77, C81 | .006 μF mica |
| C78 | 50 μμF mica, 2500 volts working |
| C86 | 5 μμF tubular ceramic |
| C89 | 10 μμF tubular ceramic |
| NC1, NC2 | Neutralising condensers (*see text*) |
| R1, R43 | 220,000 ohms |
| R2 | 10,000 ohms w/wound pot. |
| R3 | 85,000 ohms |
| R4, R31 | 100 ohms |
| R5, R13, R70, R72, R75 | 47 ohms |
| R6, R15, R17, R19, R20, R27, R30 | 220 ohms |
| R7, R50 | 68,000 ohms |
| R8, R47, R82 | 47,000 ohms |
| R9, R34, R74 | 150 ohms |
| R10, R48 | 820 ohms |
| R11, R42, R46, R57, R58, R59, R67, R79 | 100,000 ohms |
| R12 | 27,000 ohms |
| R14 | 560 ohms |
| R16, R29, R71, R73, R76 | 22,000 ohms |
| R18, R61 | 330,000 ohms |
| R21 | 15,000 ohms |
| R22 | 4,700 ohms 2-watt |
| R23, R25, R66 | 470 ohms |
| R24 | 100ohms w/wound pot. |
| R26 | 1,300 ohms |
| R28 | 330 ohms |
| R32, R37, R52, R56 | 10,000 ohms |
| R33, R84 | 180,000 ohms |
| R35 | 5,000 ohms, 1-watt |
| R36, R45, R60 | 1 megohm |
| R38 | 270,000 ohms |
| R39, R64 | 18,000 ohms |
| R40, R77, R83, R55 | 470,000 ohms |
| R41, R44, R51, R54 | 2,200 ohms, 1-watt |
| R49 | 25,000 ohms |
| R53 | 500,000 ohms, carbon track pot. |
| R62 | 3,900 ohms |
| R63, R78, R81 | 1,000 ohms |
| R65 | 6,000 ohms |
| R68 | 1,600 ohms |
| R69 | 12,000 ohms |
| R80, R85 | 12,000 ohms, 1-watt |
| RFC1, RFC8, RFC10, RFC11 | 100 μH single pi-section (*ex*-R1355 receiver) |
| RFC2, RFC3, RFC4, RFC5, RFC6, RFC9 | 2.5 mH, 100mA |
| RFC7 | 2.5 mH, 300mA |
| Aerial Relay | 27 volt surplus (coils in parallel for 12 volt working) |
| IF Relay | 12 volt 180 ohms enclosed. (G.E.C. type M1485) |
| M1 | 150 mA moving coil |
| SW1 | Single pole, 2-way |
| SW2 | On/Off, push-button |
| CH1 | 20 mA, 4 Hy. or similar |
| T1 | SCR-522 receiver output transformer or similar. (15,000 ohms to 300 ohm load) |
| PC1, PC2 | Anti-parasitic chokes: 9 turns 20g. enam. on 1-watt 47 ohm resistors |
| D1, D1A, D2, D2A | Two matched pairs Mullard OA79 germanium diodes |
| D3 | Germanium diode, high back-resistance type, Mullard OA81 |
| D4, D5 | Germanium diodes, Mullard OA70 |
| V1 | ECC85 Mullard |
| V2 | 6BE6 Brimar |
| V3 | 6AK5 |
| V4, V10 | 6BA6 Brimar |
| V5, V14 | 12AU7 Brimar |
| V6 | EC91 Mullard |
| V7, V9 | 12AX7 Brimar |
| V8, V11 | 12AT7 Brimar |
| V13 | 6AG7 |
| V12 | QQV06-40 Mullard |

### COIL VALUES FOR THE SSB TRANSCEIVER

| | |
|---|---|
| L1 | ⅝-ins. 26g. enam. close wound on 13/32-ins. diam. former, slug-tuned, to tune 14 mc. |
| L1A | 2 turns 24g. PVC covered, at earthy end of L1. |
| L2 | ⅝-ins. 26g. enam. close wound on 0 4-ins diam. former, to tune 14 mc. |
| L3, L4 | 26g. enam. scramble wound on ¼-ins. diam. slug-tuned former to tune to 8.4 mc in parallel with 20 μμF. |
| L5 | 15 turns 20g. over 1½-ins. on 1-in. diam. ceramic ribbed former; tap 4 turns from earthy end. |
| L6 | 26g. enam. close wound for ⅞-ins. on 13/32-ins. slug-tuned former, to tune to about 6 mc with V9 anode/ground capacity in parallel. |
| L7 | 30g. enam. scramble wound on 0.3-ins. Aladdin slug-tuned former, to tune 8.4 mc with 65 μμF in parallel (in screening can). |
| L7A | 8 turns of 30g. enam. at earthy end of L7. |
| L8 | 26g. enam. close wound on 0.3-ins. Aladdin slug-tuned former, to tune 14 mc with circuit capacities in parallel. (V11A anode/ground, plus V13 grid/ground capacities), in screening can. |
| L9 | 1.47 μH approximately; 11 turns of 16g. enam., self-supporting, 1¼-ins. long, 1-in. diameter. |
| L10 | 12 turns 22g. enam. over ¾-ins. on ¾-ins. diameter ceramic former. |

ing on the power pack is sufficient to hold the voltage reasonably constant through undriven to driven conditions.

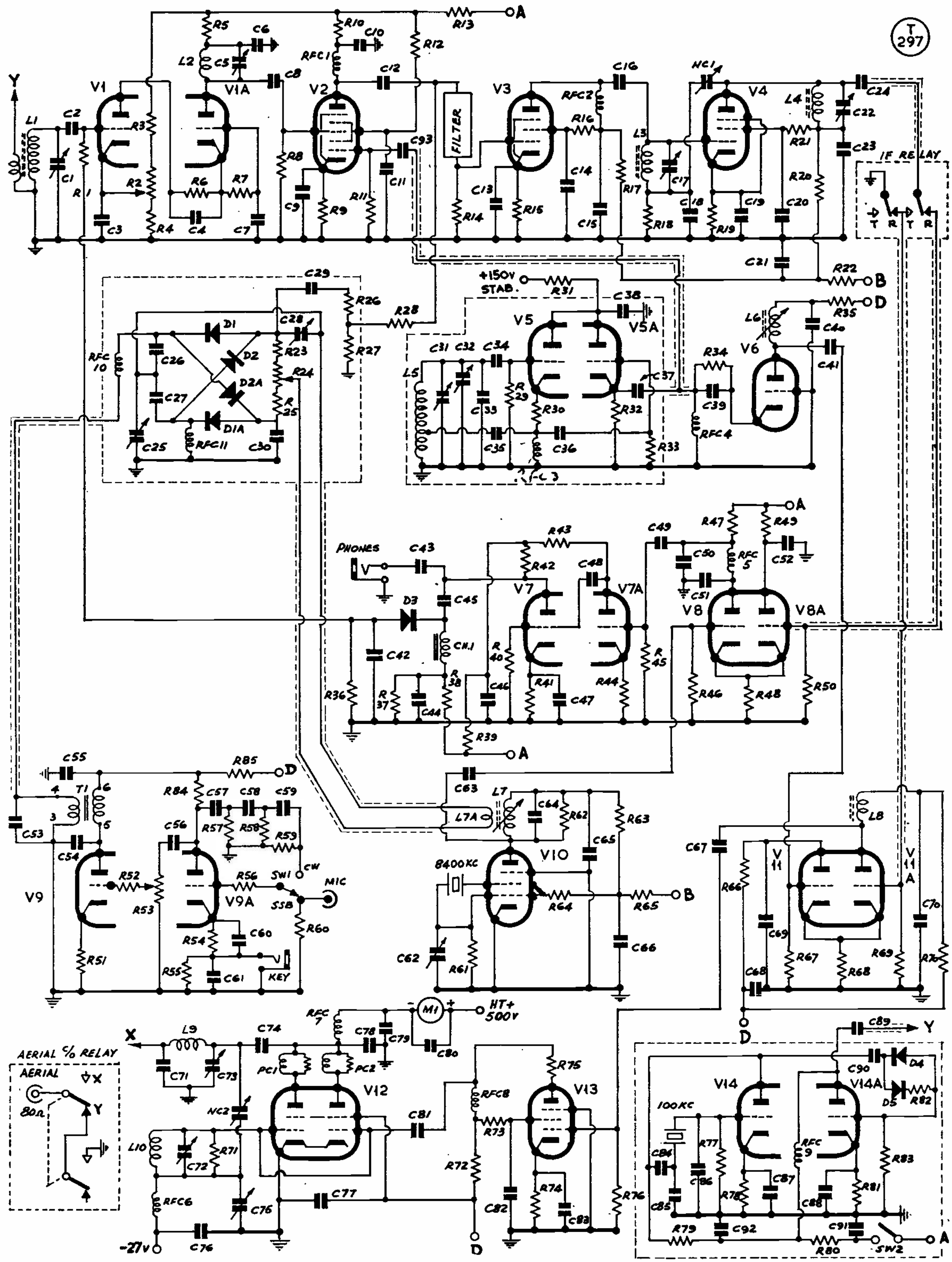
An orthodox pi-tank circuit is employed with a ·003 μF mica condenser C71 on the output side to match the PA to an 80-ohm load. Part of the tank capacity on the anode side is made up by C78, a 50 μμF high-voltage mica condenser; this is a useful anti-harmonic device and also makes it possible to use a physically smaller tuning condenser, C73.

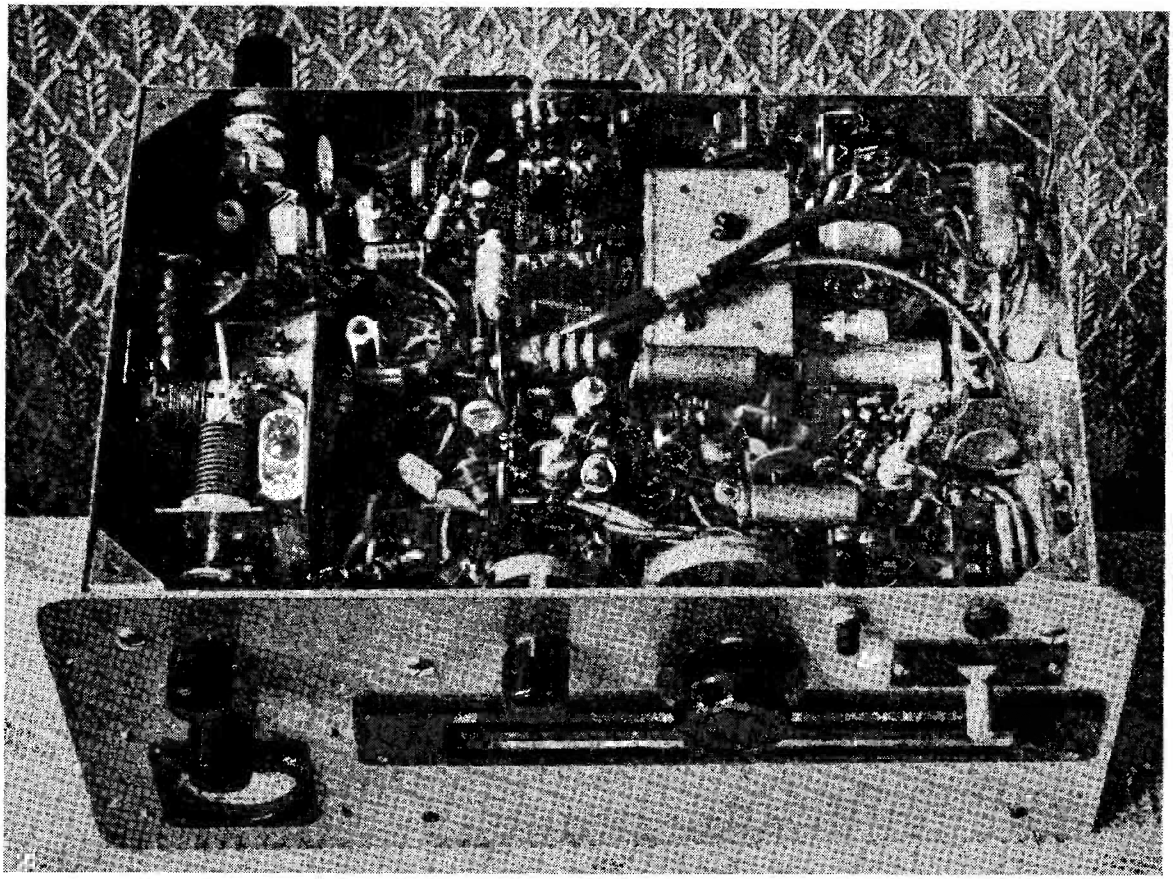
When used as a conventional push-pull amplifier the QQVO6-40 does not need external neutralisation, but when its elements are paralleled it is of course necessary. The capacitive bridge method is employed using C75 (a 450 μμF mica compression condenser) and NC2. To calculate the capacity of NC2 the following formula is used *(see p.630)*:

**Fig. 2. At right is the circuit of the 20-metre SSB Transceiver complete. For the HT and other switching, see Fig. 6. The balanced modulator, VFO, filter unit and crystal calibrator were built and tested as separate items before incorporation in the main assembly. All crystals are surplus types, at a few shillings each. Although the receiver section is only single-conversion, the high IF of 8.4 mc eliminates second-channel and the two half-lattice sections in the crystal filter give ideal selectivity for SSB reception.** (*Note: In this circuit, the winding in the cathode of V5 should be marked RFC3.*)

R64 should be connected to the screen of V10, the carrier oscillator, and not as shown







**Underside view of the SSB Transceiver designed and built by G3BDQ.**

$$NC2 = \frac{C75 \times Cga}{Cgk}$$

All values of C are in $\mu\mu$F.

In the case of the QQVO6-40, NC2 should be about 4 $\mu\mu$F. Any small air-spaced condenser of around this value will suffice, the final adjustment being made with C75.

The anti-parasitic chokes PC1 and PC2 are needed in the anode leads, for without them alarming things are likely to happen!

### The VFO and G.G. Amplifier

The heart of the transceiver is the VFO, V5

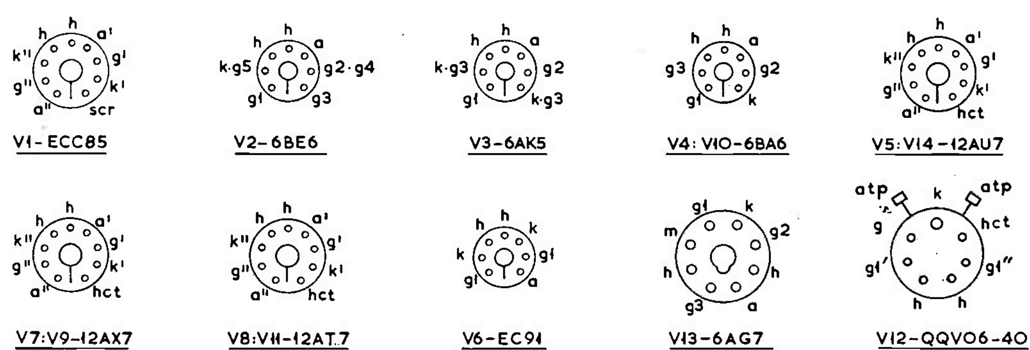



**Fig. 2A. Base connections for all the valves used in the G3BDQ 20-metre SSB Transceiver.** *(Note: In the V12 diagram, the grid connection at upper left should be marked G2, for screen).*

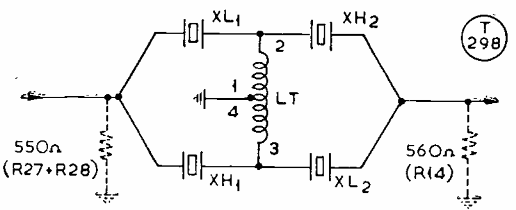



**Fig. 3. The crystal filter for the Transceiver; it comprises two half-lattice sections back-to-back, tightly coupled by the winding LT, a home-made toroidal bifilar coil. The crystals are two identical pairs, XH1/XH2 being etched 1.5 kc higher than XL1/XL2, which have a nominal frequency of 8,400 kc. The filter input and output leads are shunted by 550-ohm resistors, essential to achieve correct filter characteristics.**

in Figs. 1 and 2. It must be realised that no "second best" is likely to be good enough for any VFO used in SSB equipment; short-term stability of the order of 50 cycles must be the aim with a rapid settling-down time when switching on from cold.

After considerable deliberation a version of the earthed-anode Hartley oscillator was chosen, and the results exceeded all expectations. V5 is the oscillator and V5A is a cathode follower isolating stage, both being parts of the same 12AU7 valve. Output from V5A is very low but sufficient to operate V2, the receiver mixer, quite adequately. The transmitter mixer requires a greater voltage so V6, an EC91 grounded-grid amplifier, was added. The low impedance output from the cathode follower matches in beautifully to the cathode of V6. L6 is a slug-tuned coil adjusted to the centre VFO frequency (5775 kc) and is broad-banded enough not to need alteration when tuning.

The VFO is constructed around an Eddystone die-cast box, the usual precautions being taken to prevent mechanical movement of components by tying everything down very securely. A good quality coil form (ceramic ribbed) and tuning condenser having both front and back bearings are essential; high-grade silver-mica condensers should be used for C34 and C33; the latter is made up from a 150 $\mu\mu$F condenser with two smaller capacities in parallel to make up the required total; the exact value must be found by experiment. A virtue of the VFO design is that its output is almost pure sine wave and free from strong harmonics.

It should be possible to dunt the VFO box with a heavy screwdriver and *not hear any change of beat note on a monitor receiver.* After 5-10 minutes' running the drift is negligible, and one can short circuit the output lead without pulling the oscillator frequency by more than a few cycles.

## Making the Crystal Filter

This part of the transceiver was actually built and tested before any other constructional work began. If the filter would not work it was pointless to go ahead with anything else. Some little experience with filters had been gained from building the G2NH Exciter using FT241 LF crystals at 430 kc, but from all accounts a filter designed around HF crystals was rather more difficult. However, this proved not to be the case, for all the work had been done already by W3LTN. In his *QST* article "Surplus-Crystal High-Frequency Filters,"[4] W3LTN produced a sure-fire design with four crystals. Luckily, a large number of surplus 8400 kc crystals appeared on the market at 2s. 6d. each, and eight of them were purchased.

A BC-221 Frequency Meter was borrowed and a test oscillator (Pierce type) was knocked up. Two of the crystals were spot-on the same frequency and they were marked XL1 and XL2; these became the LF crystals for the filter.

Some hydrofluoric acid was obtained and added to an equal volume of water, then one of the remaining crystals was etched up 1·5 kc higher than the LF pair. (Details of the acid-etching technique will be found in the July 1954 issue of SHORT WAVE MAGAZINE and elsewhere.)[5] Then another crystal was etched to exactly the same frequency, a process involving considerable care and patience. The two etched crystals were marked XH1 and XH2 respectively, and attention next turned to the coil LT (*see* Figs. 3 and 4).

For the correct operation of this type of filter, the coupling coil LT must be bifilar wound, and if maximum coupling is to be achieved, the windings must be on a ferrite toroidal core. Some cores were obtained from a surplus store but their characteristics remained a mystery. They were 2 ins. in diameter with a cross section of ½ in. and probably came from telephone equipment. Suitable 1-in. diameter cores can be obtained in Stanferite S.F.6 material from S.T.C. Ltd.,

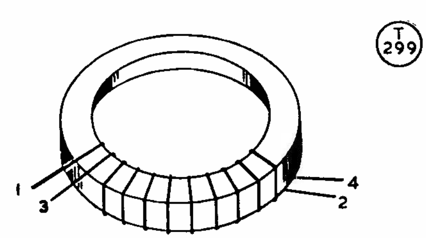



**Fig. 4. Winding the toroid coil LT; the leads marked 1, 4 are connected to earth.**

Magnetic Materials Dept. at 1s. 6d. net each (although the delivery time is from 8 to 10 weeks).

The exact inductance of LT is not critical, about 100 $\mu$H total being suggested by W3LTN. Not having an inductance bridge, the writer looked up his coil tables and discovered that 50 $\mu$H tuned by 120 $\mu\mu$F should resonate around 2 mc. A silver-mica condenser across half the winding on LT, a one turn link, and a grid-dip meter were all that was needed to wind the coil to approximate inductance. The winding details are given in Fig. 4. Wire gauge is not important, but owing to the large size of former used the writer put on about 20 bifilar (40 total) turns of 18g. enamelled copper. The coil was mounted in a rectangular screening can and connected up to the crystals.

The filter as described should give excellent results (*see* Fig. 5) but with the help of a BC-221, a couple of 560-ohm resistors, a small coupling condenser, and a communications receiver with an S-meter, the actual filter response curve can be plotted in under an hour.

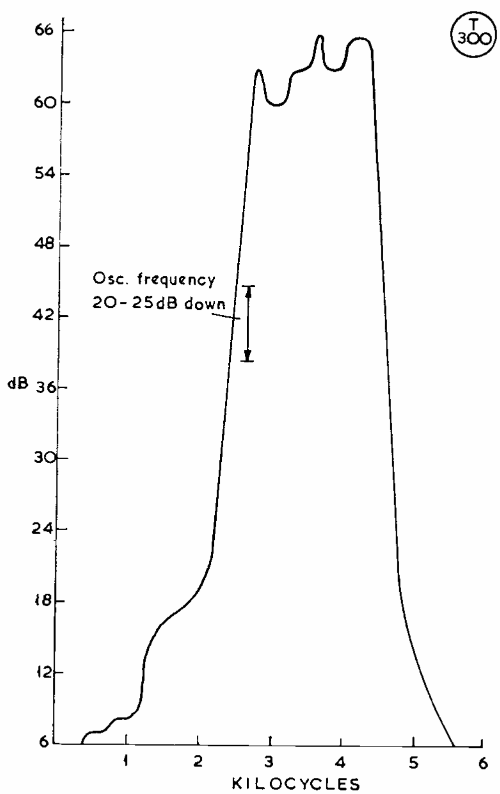



**Fig. 5. The filter response curve, obtained by using a BC-221 as an RF generator and a carefully adjusted S-meter on the station Rx at G3BDQ. The filter band-width is adequate for amateur phone working and it has a good cut-off characteristic. For USB generation, the carrier oscillator should be positioned as shown, about 20 dB down the LF slope. Exact carrier placing is achieved by pulling the oscillator frequency slightly with a small air-trimmer C62 — see Fig. 2.**

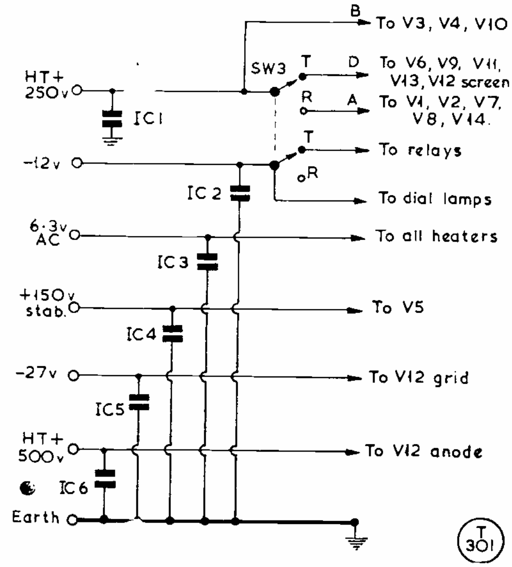



**Fig. 6. A GPO type key-switch is used for SW3, the transmit-receive selector switch on the front panel — see photograph. SW3 switches HT to the appropriate sections of the equipment and also operates the IF and aerial relays. IC1-IC5 are .01 $\mu$F disc ceramics at the input sockets; IC6 is a .0018 $\mu$F disc ceramic rated at 1,200v. The negative 27v. bias for the PA is obtained from three 9v. dry batteries.**

From the remaining 8400 kc crystals one was selected for use in the carrier oscillator circuit.

## The Calibrator Circuit

The transceiver is provided with a 100 kc crystal calibrator, V14, which gives strong marker points across the 14 mc band. It is important that the output from any calibrator be easily recognised among the signals present on the band, this being a failing with most 100 kc circuits when used above about 10 mc.

Two years ago the writer developed a circuit suitable for use with an HF bands communications receiver and was pleasantly surprised to find that useful markers could be obtained up to 150 mc, whilst on 14 mc they were S9.

V14 and V14A are two halves of a 12AU7 twin-triode, V14 operating as a Pierce oscillator at 100 kc, with its anode coupled through D4 and D5 to the grid of V14A, the harmonic amplifier. The two semi-conductor diodes D4 and D5 are the harmonic generators and are connected in opposition with a 47000-ohm resistor (R82) between D5 and V14A grid. In this way they behave as a non-linear resistor and generate strong harmonics from the 100 kc input; SW2 is a push-button switch in the HT line to the oscillator, and is mounted on the front panel of the transceiver.

With the crystal used (a gold-plated surplus-type vacuum mounted with octal base connections) a 5 $\mu\mu$F condenser (C86) was required to "pull" the frequency to 100 kc exactly. With different crystals this value may be substituted for some other figure to suit the particular crystal.

*(To be continued)*

REFERENCES

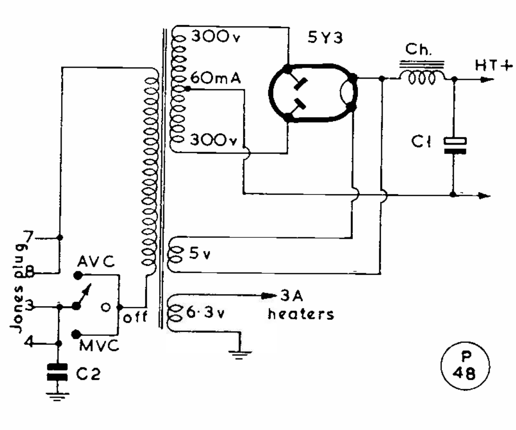
(1) "SSB Topics," *Short Wave Magazine*, December, 1957; February, 1958.
(2) Vester, "Mobile S.S.B. Transceiver," *QST*, June, 1959.
(3) "The Collins KWM-1 Transceiver," *QST*, April, 1958.
(4) Vester, "Surplus-Crystal High-Frequency Filters," *QST*, January, 1959.
(5) Newland, "A Safe Method for Etching Crystals," *QST*, January, 1958.

# Power Supply for the BC-348

## OPERATION FROM AC MAINS

FOR the reader who wishes to convert the originally 28-volt DC operated BC-348 to AC working a variety of modifications are possible. A source of high tension of between 230 and 250 volt DC capable of supplying some 65 mA, and a low tension supply of 6·3 volts AC at about 3·6 amps will get the receiver going with a minimum of effort—of course, after heater modification, as in the original they are wired in series-parallel for 24-28v. DC. In any case, the dynamotor must be removed and this constitutes the first step. The dynamotor and its associated filters should be stripped from the platform and the mounting dimples carefully flattened out. The five spade terminals which connect to the sub-base of the dynamotor platform should not be disarranged since they are the HT and LT feeder circuits, and if the power supply is built on the dynamotor platform they will provide a satisfactory method of power distribution.

A typical power supply suitable for erection on the dynamotor platform is shown in the diagram. The heater wiring will also have to be re-arranged, by paralleling and removal of the original ballast resistors on the heater circuit. Removal of the 28-volt DC circuit wiring from the Jones plug on the receiver rear apron can be most effectively carried out as follows: Cut the earth connection free from pin No. 7 on the plug and remove the dial light supply wire from terminal (1) on the front section of the AVC-MVC switch on the front panel (orange or yellow tracer in most receivers). Then the pins No. 7 and No. 3 may be used to feed AC into the receiver with a front panel-operated switch controlling the mains input, as shown in the diagram. It is recommended that the heater balancing resistance be removed from the circuit altogether or wired across, using the ends of the resistance as soldering points. In order to wire the heaters in parallel with a minimum of disturbance the circuit should be carefully traced before this part of the work is started. An important point to watch is that HT negative should be returned to the tag board on the dynamotor platform and *not* to earth, otherwise the biasing network will be shorted out. Pins 2 and 6 on the Jones plug at the rear control the screen supply voltage. A stand-by switch should be fitted on the front panel in place of one of the phone jacks and wired across these pins. Connection to the mains will now enable the receiver to be tested for satisfactory operation on AC mains. It should be mentioned that the dial light wire is reconnected to the AC filament supply on the ungrounded side and the lamps rewired in parallel with the other end, being grounded directly instead of through the balancing resistor and dimmer rheostat. These wiring details will be clear on examination of the receiver out of its cabinet.




**Circuit of a suitable AC power supply unit for the BC-348; it can be fitted on the dynamotor mounting, after removal of the machine. Values are: C1, 16 $\mu$F, 350v. working; C2, .01 $\mu$F; Ch. 12-Hy, 100 mA; and T a 300v. transformer with suitable LT windings.**

# An SSB Transceiver for Twenty

## CONSTRUCTION — WIRING — SETTING UP AND TESTING — POWER SUPPLY UNIT — RESULTS

**J. D. HEYS (G3BDQ)**

*The first part of this interesting and informative article appeared in the February issue of* SHORT WAVE MAGAZINE. *Here, our contributor deals with the final constructional points and the test and setting-up procedure for the Transceiver, with which he is getting very good results on the air.—Editor.*

THE first part of this article, in the February issue, dealt with the circuit details of the Transceiver and also gave detailed descriptions of the VFO and crystal filter. Those thinking of embarking upon the construction of a similar transceiver need not be deterred, for the whole project as described here and in February, including power pack and time spent overcoming teething troubles, took only about three months to complete, working at week-ends and occasional periods on work-a-day evenings. The writer's " workshop facilities " are meagre (as any visitor would realise) and all the work entailed is within the scope of the average amateur using ordinary hand tools.

It is suggested that the VFO, filter, and calibrator be first built and tested. They will always be useful as separate units if any change of plans takes place at a later date. The VFO should be adjusted to cover from 5595 to 5955 kc, and given long " soak " runs to age the components and its valve.

The chassis is a standard 13½ ins. × 9 ins. aluminium type, 2¼ ins. deep. No base plate is used. The cabinet is a contemporary style wrap-round design similar to that used for Collins equipment and was made to order by E. J. Philpotts Metalworks Ltd., of Loughborough. It measures 15 ins. × 7 ins. × 10 ins. deep and is of steel in grey-hammer finish. The panel is of ⅛ in. aluminium and was also supplied by Philpotts. When ordering a similar cabinet specify that no bottom flange is required. This point was overlooked—an unpleasant hour had to be spent with a broken hack-saw blade removing this stubborn strip of metal. (Should this flange be there the chassis will not slide into the cabinet, if the writer's method of construction is followed.)

Front panel layout must be considered both from the point of view of easy handling and from its æsthetic appearance. So many amateur equipments present crowded, unbalanced panel layouts which could have been avoided with a little thought and planning.

An Eddystone dial (Type No. 898) was used, but as only one amateur band was going to be tuned all but the lower section was disregarded and hidden. An 8 in. by 1 in. slot cut in the front panel was sufficient for dial viewing, and as a result the metal escutcheon supplied with the dial was discarded and a new one fabricated (from a Woolworth's black plastic door plate, the window being cut from green plastic supplied as a motorist's sun visor by the same emporium). Small Eddystone knobs are used for the panel controls, with the exception of the tuning dial, which was furnished with a 1½ in. fluted knob with skirt. Greater visibility of the dial face is given by a pair of micro-bulbs (12 volt, Radiospares Ltd.)

Examination of the illustrations—here and in the February issue—and of Fig. 7 should give a good idea of the general layout of the main components and sub-units. The PA compartment measures 7 ins. × 3¼ ins. × 4 ins. high and a piece of expanded aluminium makes a suitably ventilated cover. This cover is held in place by small self-tapping screws at 1½ in. intervals. Behind the PA box the aerial relay is mounted on a vertical strip of thick aluminium.

As the cabinet is 1 in. deeper than the chassis, extension spindles are needed on the rear controls and the two power plugs are mounted on small pillars along the back of the chassis. Suitable holes to accommodate these items must be cut in the rear of the cabinet, circular screw punches being useful for this purpose. Several Int. Octal sized holes are also cut out beneath the cabinet to give ventilation.

### Wiring

Because of the rather involved circuit switching in the Transceiver some form of colour coded wiring can prove useful, both during construction and at a later date should a fault develop. After the principal components, valve bases and sub-units are assembled it is best to run in the heater wiring; blue plastic covered wire was used for this. Then tag strips were located at strategic points near each valve base and the HT and relay wiring was run in. Black was used for the 12-volt relay supply and in the case of the HT wires three colours were used: Red for points marked " D " in Fig. 2

(*see* Part 1, p.629, February); green for points marked "A," and yellow for points marked "B." This pattern of coding was extended throughout the construction so far as possible, *e.g.* all the wiring connected with V11 and V11A was coded red, whereas all the wires in the carrier oscillator circuit (V10) were yellow. Some lacing of wire groups can be done at an early stage, to get them tidily out of the way.

From the circuit diagram (Fig. 2, p.629) it will be noticed that several wires are shown as being screened. Thin coax can be used in some cases where it will fit in conveniently. The output lead from the VFO to V6 was made of coax cable. Where a number of sharp bends are necessary it is best to use ordinary flexible screened wire. It is particularly important that the screened leads from the IF relay to V8A and V11A be of equal length and capacity, otherwise the second IF amplifier will be de-tuned in either the "transmit" or "receive" position.

## Constructional Details

A grid-dip meter is essential when making the coils and it saves hours of frustrating "cut and try." In the case of L6 and L8, these coils must tune to the required frequency with just the valve and stray capacities across them. Here, a reference to a valve manual is helpful, and the coils can be grid-dipped in position with the associated valves in their sockets but not connected to any power supply.

All the screens across valve bases are shown in Fig. 7. V13 is arranged so that its input circuit cannot "see" V12 grid circuit. This is made easier by mounting RFC8 in a screening can above the chassis. Valve bases are orientated so as to reduce lead length, especially all leads to grids and anodes.

If good carrier suppression is to be achieved, V10 and its circuitry must be shielded from the balanced modulator and IF stages: V10's location on the chassis, the position of the VFO box, and putting the balanced modulator sub-unit above the chassis all contribute towards this shielding. The oscillator crystal is tucked away amongst a number of earthed metal components, and a special shield for it is not required.

The balanced modulator is built in a rectangular aluminium box measuring $3\frac{1}{2}$ ins. × 2 ins. × $1\frac{1}{4}$ ins. As it is a balanced bridge circuit at RF potential, a symmetrical layout of parts and wiring must be the aim. It should not be necessary to remind the reader to use heat sinks when soldering the diodes into position. This applies, of course, to all the semi-

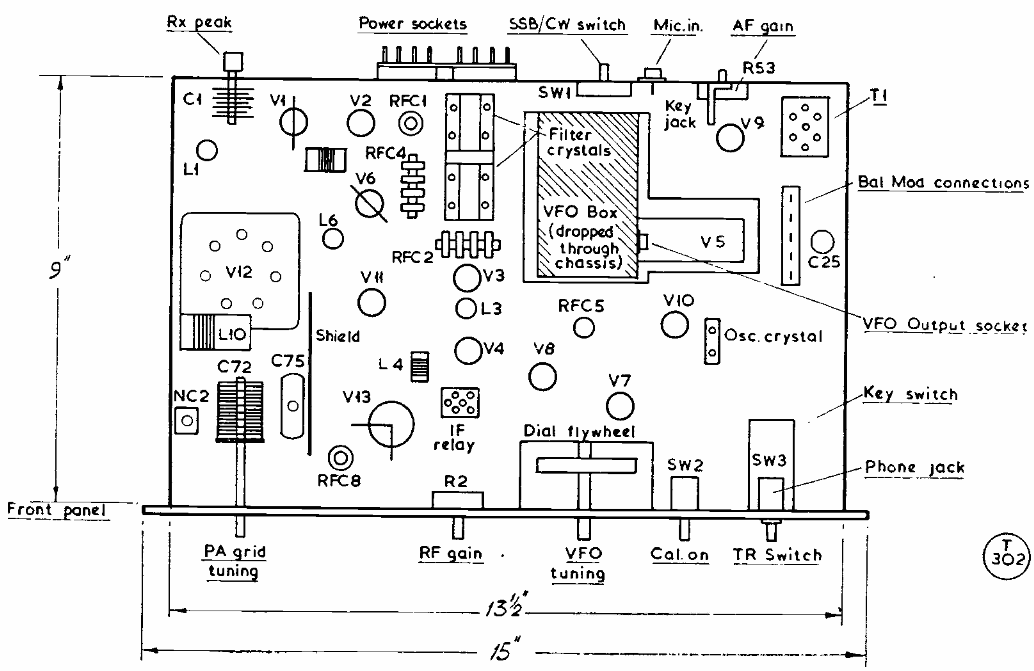



**Fig. 7. Sketch showing general chassis layout of the Transceiver — compare with the photograph p.627, February. The transformer T1, the two relays, the balanced modulator and filter unit, with the choke Ch.1, are mounted above the chassis. The VFO box is held rigidly half-way through so that its upper side is below panel level; the filter crystals are in holders mounted upside down against the under-face of the chassis.**

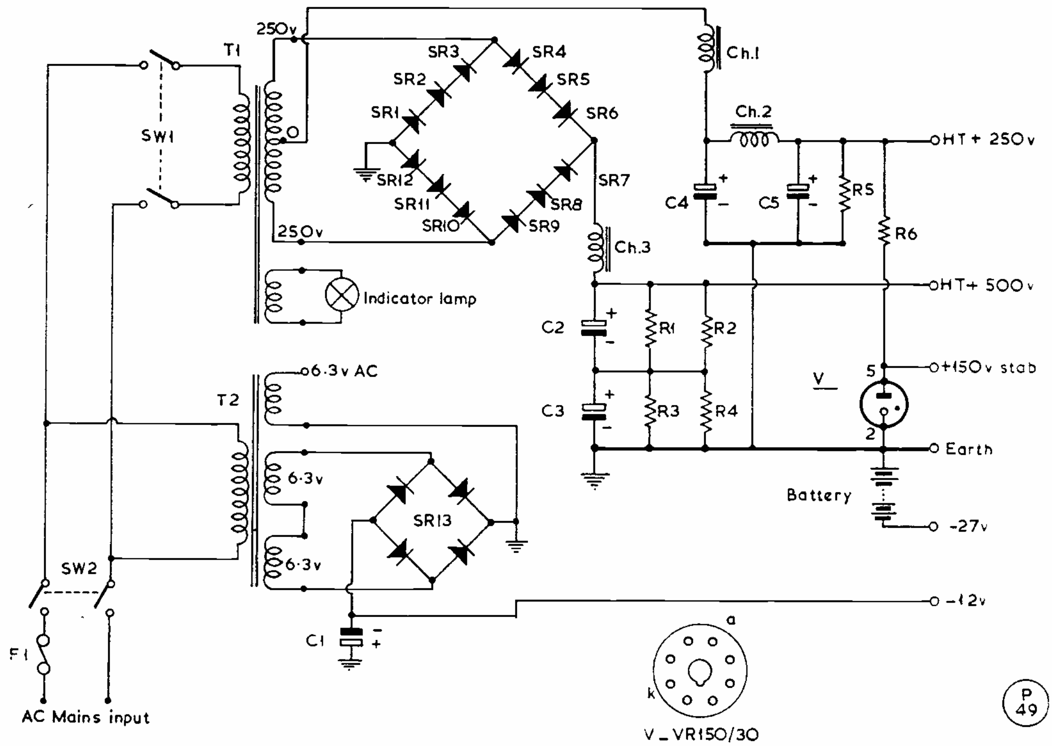



**Fig. 8. Circuit of the Transceiver power pack, an external item. The only heat generated comes from the bleeder resistors. The 12v. supply for the relays (and dial lamps) is obtained by rectifying the output from two 6.3v. heater windings connected in series. The tapped bleeder network across the 500v. HT line also ensures proper voltage distribution across the smoothing condensers C2, C3.**

conductor diodes in the transceiver. Standard sized RF chokes would not go into the small modulator unit, so instead little single *pi*-chokes from an old R.1355 IF strip were used. These chokes can be obtained as surplus and have an inductance of about 100 $\mu$H. Alternatively the midget ferrite cored RF chokes for transistor circuits could be used.

The holder for the PA valve (V12) is mounted about $\frac{5}{8}$-in. below a $2\frac{1}{4}$ in. hole in the chassis. In this way the horizontal screening disc within the valve is brought level with the chassis and the overall screening between input and output circuits is enhanced. A Y-shaped piece of thin brass or copper sheet is used to connect heater and cathode pins together across the base, and an extension of this strip is secured to the chassis for earthing.

The manufacturers of the QQVO6-40 stress that suitable heat dissipating anode connectors be used. Two heavy brass segments from a large terminal block provided ready made connectors, each fitted with screws at either end. Flexible copper braid salvaged from old coaxial cable was connected between the parasitic stoppers (PC1 and PC2) which join directly to the anode connectors, and the junction of C74, C78 and RFC7. Rigid conductors should not be used, for there is then a risk of envelope fracture when thermal movements take place during operation.

The heater wiring of the transceiver is not shown in Fig. 2—p.629, February—but normal practice should be followed. One leg of the 6·3 volt heater supply is earthed and the "live" line is by-passed to earth with ·001 $\mu$F disc ceramics at *each* valve holder.

## Power Pack Design

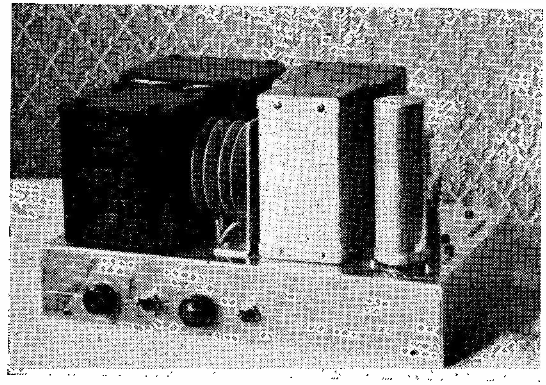
From the power pack circuit (Fig. 8) it will be seen that a single transformer T1 is used to obtain both the 250 volt and 500 volt HT supplies. This has been done by using a full-wave bridge circuit, the lower voltage being obtained from the centre tap on the secondary of the transformer. Silicon power rectifiers (SR1 to SR12) represent a considerable saving in power from the transformer as no heater current is required. They are far more efficient than conventional valve rectifiers, and can be tucked away in a very small space below the chassis. The rectifier diodes are Bradley type

DD.006, having a p.i.v. rating of 400 volts each, and when arranged in the full wave bridge circuit can be loaded up to 500 mA—they are only 7s. 10d. each and can be obtained as noted on p.236 of the July 1960 issue of the *Magazine*. Three diodes are used in each arm of the bridge, although for output voltages of 500 volts two in each arm would be sufficient. Using three increases the safety factor greatly, and output voltages up to 750 can be realised if needed.

The short duty-cycle of SSB amplifiers on telephony permits the use of smaller HT transformers than would be necessary for an AM or CW transmitter. T1 is a surplus C-core potted transformer rated at 250 volts, 300 mA, and it runs ice-cold despite the 100 mA or more drain at 250 volts, and voice peaks of 150 mA at 500 volts when transmitting. In amateur transmitting service the total transmitting time is much smaller than that spent receiving and the transformer runs well within its limits.

Choke input is used in both the HT smoothing circuits. This reduces the surges through the rectifiers and provides better voltage regulation. Ch.1 and Ch.2 in the 250-volt line are the two halves of a double-wound choke. Being a believer in long, trouble-free operation, the writer provides generously-rated filter condensers—in the case of C2 and C3 the bleeder chain formed by R1, R2, R3 and R4 ensures correct voltage distribution between the two condensers.

The stabilised 150-volt HT supply for the VFO is obtained from a VR150/30 (VR) neon stabiliser in a conventional circuit.



**The power pack for the Transceiver; the chokes and transformers are all of the potted type, and the tubular condenser C5 is octal-based plug-in. Note the mounting of the 12 volt selenium rectifier and the ventilating holes in the chassis above the resistors.**

T2 is also a surplus item and, besides supplying about 6 amps for all the valve heaters, has two other 6·3 volt windings which are series-connected to provide 12 volts for the relays and dial lamps. (If connected out of phase the output will be zero !)

The input switching is arranged so that T1 cannot be energised before the relay and heater supplies are switched on. Grid bias for V12 comes from three 9-volt batteries in series.

## Table of Values

**Fig. 8. Circuit of the Transceiver Power Pack**

| | |
|---|---|
| C1 | 25 $\mu$F elec., 50v. wkg. |
| C2, C3 | 64 $\mu$F elec., 450v. wkg. |
| C4 | 8 $\mu$F elec., 450v. wkg. |
| C5 | 60 $\mu$F elec., 450v. wkg. |
| R1, R2, R3, R4, R5 | 15,000 ohm 12 watt w/wound |
| R6 | 5,000 ohms 12 watt w/wound |
| SW1, SW2 | Double pole toggle switches |
| SR1, SR2, SR3, SR4, SR5, SR6, SR7, SR8, SR9, SR10, SR11, SR12 | Silicon rectifiers, Type DD.006 (G. & E. Bradley Ltd.) |
| SR13 | Selenium rectifier 12v. 2 amp. bridge |
| T1 | C-core surplus transformer ; 250-0-250 volts 300 mA. with 6v. winding for ind. lamp |
| T2 | C-core surplus heater transformer ; 6.3 volts at 6 amps., 6.3 volts at 4 amps., 6.3 volts at 1 amp. |
| Ch.1, Ch.2 | Dual wound smoothingchoke, 5 Hy. *plus* 5 Hy. at 150 mA. |
| Ch.3 | 10 Hy. at 250 mA. smoothing choke |
| VR | VR150/30 neon stabilising tube |
| Battery | Three 9 volt " clip-together " batteries |
| F1 | 2 amp. tubular fuse |

### Power Pack Construction

Before making or buying a chassis for the power pack it is best to arrange the chokes and transformers into a suitable layout on the bench. It is surprising how much space can be saved by a little " juggling." The actual chassis size will depend upon the dimensions of the components to hand. The use of potted chokes and transformers keeps all the wiring beneath the chassis and makes for a tidier piece of equipment.

The twelve silicon rectifiers are mounted in line along a paxolin tag strip, and the usual precautions employed when soldering them into position. C2 and C3 were only available as two 32 + 32 $\mu$F units in metal cans, which meant that the casing of C2 had to be suitably insulated from the chassis.

The only heat developed in the power pack comes from the resistors. These are arranged to lie close to the chassis sides, and ventilation holes are drilled through the chassis above them. They should also be kept away from the silicon rectifiers.

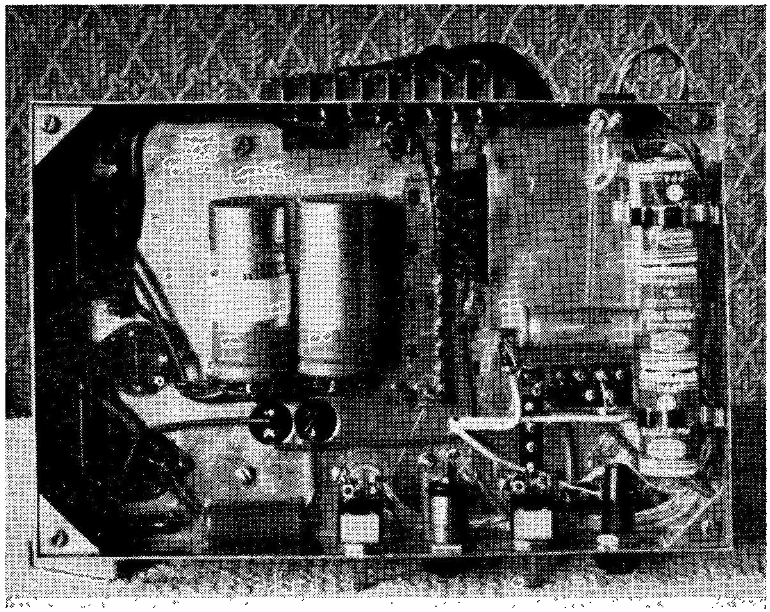
SR13, the 12-volt selenium bridge rectifier, is fixed to a metal bracket above the chassis so that its cooling fins lie in the vertical plane.

The three bias batteries clip together into one 27-volt unit and a pair of small Terry tool clips hold them against the chassis wall.

**Initial Testing**

The receiver section of the transceiver is lined up and tested first, and this also takes care of the common IF strip and the oscillators.

By listening on another receiver first, make sure that the VFO and carrier oscillator* are working. At this stage do not worry about the exact frequency setting of the latter, as this is done with the transmitter section operating.



**Under-chassis view of the power pack for the SSB Transmitter; the twelve silicon power rectifiers are mounted off the tag strip across the centre of the chassis; five of them can be picked out to the right of the two tubular condensers, these being C2, C3 (in the power pack diagram). The resistors are grouped on the left, close to the sides of the chassis; the bias batteries are on the opposite chassis wall.**

All the valves connected to the HT supply point " D " and the PA valve should be removed, the phones plugged in and the power pack switched on. Remember that 500 volts is now on the input socket, so take great care when making adjustments beneath the chassis. The AF amplifiers V7 and V7A can be quickly checked by touching their grid pins. A grid-dip meter tuned to 8400 kc can be used as a signal generator for peaking up the IF stages. If the filter is working correctly, there will be a sharp signal cut-off as the GDO tunes out of the 2 kc pass-band. This should take place on both sides of the pass-band. Should any IF instability appear (noticeable by self oscillation, or a high noise-level) V4 can be neutralised in the way described earlier in this article. The GDO can next be put on 14 mc and the RF amplifier (V1) coils set to this frequency. If all is well signals should be heard when the aerial is connected. Final adjustments can be made by peaking on a weak signal, and the calibrator should give healthy markers at 100 kc intervals, the odd harmonics from the calibrator being noticeably stronger than the even ones.

Before the transmitting section is energised the PA must first be neutralised. Again the indispensable grid-dipper can be used, this time in conjunction with a sensitive field-strength indicator. The latter device is used continuously by the writer to monitor carrier level and peak output from the Transceiver. It consists of a tuned circuit with a germanium diode rectifier connected to a 100 $\mu$A meter and makes an extremely sensitive "RF sniffer." The GDO is coupled to L9 and the FS meter to L10. Correct neutralisation is indicated when the FS reading falls to a very low level, not forgetting to tune L9 and L10 to resonance whilst adjusting the neutralising condensers. It is best to use an 80-ohm composition resistor as an output " load " at point X whilst performing this operation. Do *not* attempt to run the PA before neutralisation has been achieved as damage to the valve may result.

Assuming that all is now ready for final testing plug in all the valves, connect the aerial, put the key-switch (SW3) to " transmit " and put on the HT. The standing anode current of the QQVO6-40 with the supply voltages suggested and $-27$ volts bias should be about 40 mA. Tuning the grid or anode circuits should have *no* effect upon the anode current when the valve is *undriven.* If this is not so it means that the neutralisation is incomplete.

There will be enough carrier leakage to be detected if the FS meter is coupled to the ATU, and adjustment of R24, the balance potentiometer, together with trimmers C25 and C28, will bring this down to some low figure. Switching SW1 to the CW position will allow drive to the PA, and the gain control R53 can be used to control the level. (It will be necessary to remove the FS meter from close proximity to the ATU when this is done or the meter may burn out !) Tuning up the transmitter is more easily done when operating in the CW mode. L8 can be set for maximum output and also L6 in the grounded grid stage. The ATU and its link coil are also best set-up at this stage.

Plugging in the microphone and switching SW1 to the SSB position allows SSB transmission. A monitor receiver in the muted condition may be used to listen to the signal. The gain control R53 is set to the correct level and C62 in the carrier oscillator circuit tuned for the most natural speech output from the Transceiver. This will be when the carrier oscillator frequency is between 20 and 25 dB down the LF slope of the crystal filter. The tuning slug in L7 may also be adjusted for correct carrier output to the balanced modulator. After these operations it may be necessary to re-set the balance control R24.

On speech peaks, when the PA is properly loaded to an aerial, the anode current should kick up to between 120 mA and 150 mA. Too much gain in the microphone amplifier can result in splatter or distortion and should be avoided. Any lengthy periods of tuning up should be carried out on a dummy aerial load otherwise your callsign will not be very popular amongst the SSB fraternity !

**Results**

Many DX contacts have been made with the Transceiver as described and illustrated here and the reports have been excellent. Tests carried out with other stations indicate that the carrier and unwanted sideband suppression are better than average, and speech quality entirely adequate for amateur communication. The receiver section performs as well as many commercial types in the upper price bracket despite its simplicity, and the slow tuning rate enables SSB stations to be brought " on the nose " as comfortably as AM phone signals on a conventional receiver.

**Conclusion**

There is no reason why the basic circuit should not be adapted for operation on other amateur bands. Different VFO frequencies or different carrier and filter frequencies can be used to do this. Switched carrier crystals may be used to give sideband switching, and there is no reason why a more complex multi-band version of the circuitry should not be attempted.

The complete Transceiver, excluding power pack, weighs 22 lbs. and it could easily be incorporated into a mobile installation, as in the case of the Collins KWM-2. Loudspeaker operation would be possible by adding a suitable AF output stage and, of course, VOX circuits can be provided.

No TVI on Channel 4 or Channels 10 and 11 has been experienced and the harmonic output is very low. However, in some cases it may be necessary to fit a high-pass filter in the TV receiver aerial lead to prevent direct break-through producing swamping effects on speech peaks.

It is to be hoped that this article will help to encourage more amateurs to sample the delights of DX SSB working and to discard those " wasteful, howling carriers."

* In the circuit on p.629, February, R64 should be connected to the screen of V10, the carrier oscillator, and not as shown.

*(Concluded)*

**INDEX TO VOL. XVIII**

Every copy of this issue has, as a free Loose Supplement, the Index to the last volume, which closed with the February issue. The contents of this Index show the wide range of amateur interest and activity covered in the last twelve issues of SHORT WAVE MAGAZINE. It also shows that the work of more than 50 outside contributors was used during the year—and we can say that between them they were paid upwards of £700. At the moment of writing, some back-number copies of all issues March 1960 to February 1961 are available, at 2s. 9d., post free. If on looking through the Index you find anything you particularly want, get the copy right away. And if the Index itself somehow missed this copy of the *Magazine*, you can get yours on application with a large stamped, addressed envelope.

**AMATEUR LICENCE FIGURES**

We are informed by the G.P.O. that as at the end of December, 1960, there were 8,999 amateur transmitting licences in issue in the U.K. Of these, 929 had the extra endorsement for mobile operation, and 78 were for amateur television transmission.

**WEATHER SHIP RADIO INSTALLATION**

The new ocean weather ship *Weather Adviser* (a conversion of the former R.N. frigate H.M.S. *Amberley Castle)* is fitted with Marconi NT-201 1 kW independent sideband transmitters, each complete with a remote-controlled aerial matching unit for the type of long whip aerial now becoming standard in modern ship installations; the frequency range covered is 1·8-23 mc, in five bands. A second frigate, H.M.S. *Pevensey Castle*, is also being converted for weather-ship duty.