MODIFYING THE GC1U RECEIVER. Part 1.

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This is the first of two articles describing modifications which have been successfully carried out on the Heathkit 'Mohican' Communications Receiver Model GC-1U. The concluding article will appear next month.

Editor's Note

The modifications described in this and next month's articles should be carried out only by the experienced constructor who fully understands the principles involved. We have been asked by Heath (Gloucester) Limited to point out that the GC-1U is no longer a current Heathkit model and is therefore no longer available, and that Heath cannot supply any of the parts needed for the modifications nor can they enter into any correspondence concerning them. Further, under their general terms Heath (Gloucester) Limited cannot accept equipment for service which has been modified in any way.

THIS TWO-PART SERIES DESCRIBES SOME MODIFICATIONS to the popular GC-1U communications receiver which should provide improved performance, stability and s.s.b. reception. The two principal points discussed are the inclusion of an internal regulated mains power unit to replace the existing UBE-1 eliminator unit normally used with this receiver and the addition of a simple internal product detector for improved s.s.b. reception. Whilst the circuits described relate principally to the GC-1U receiver, the product detector could be applied to many receivers which lack this facility. The power unit, with minor changes, could also be used to supply most transistor receivers from the domestic mains supply. The circuits therefore offer some scope to the practical experimenter as, with minor modifications, they could be applied to many receivers other than the type specifically mentioned here. These points will be discussed next month.

The GC-1U is essentially a good general purpose receiver, being found in a great many amateur and s.w.l. stations throughout the world. It is however a little 'dated', having been one of the first all-transistor communications receivers to appear on the amateur market. It was designed for battery operation with the choice of the UBE-1 eliminator as an optional extra for mains operation, this unit fitting into the receiver internal battery box. Compact size, good sensitivity and reasonable selectivity, together with wide frequency coverage and excellent bandspread features, are included among its better points. Its performance on s.s.b. is not particularly good, however, and both short term and long term frequency drift, particularly on the h.f. bands, is sometimes noticeable. This is particularly so when the dial light switch on the front panel is operated. This switch is provided in the interests of power economy when using batteries.

NEW POWER SUPPLY

The first necessity was considered to be a stable power supply. The load characteristic of the UBE-1 eliminator as checked by the author is shown in Fig. 1. As can be seen, taking the extremes of load variation with and without dial lights (indicated in the diagram as 'maximum load change'), the d.c. supply variation was 3.8 volts. The d.c. output was also directly proportional to changes in mains voltage. The output of the alternative power supply, which will next be described, is also shown in Fig. 1 for comparison.

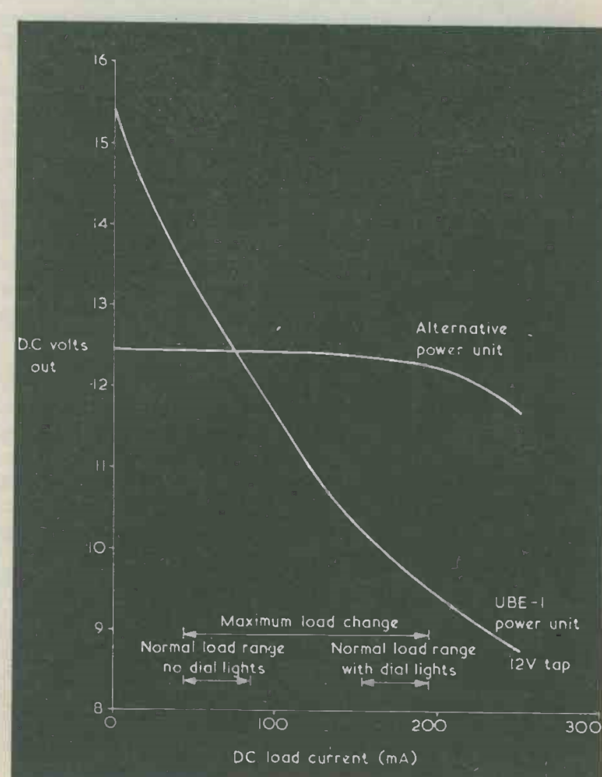
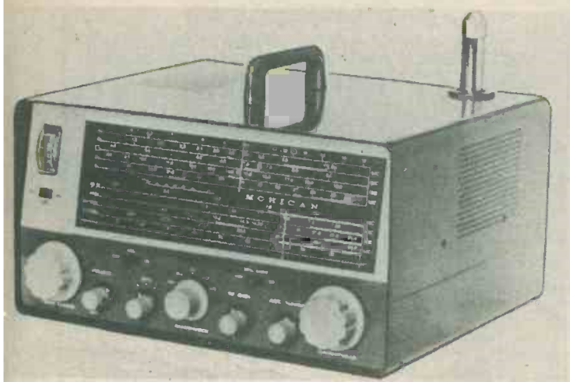


Fig. 1. Regulation curves obtained by the author with the original mains unit and the alternative unit



The circuit diagram of the alternative power unit is given in Fig. 2(b) with the original circuit, for comparison, in Fig. 2 (a). As can be seen from the curve in Fig. 1, the maximum voltage change with the new supply unit is only 0.2 volt, a regulation improvement of almost 20 times. The ripple factor is similarly improved, being 0.1% as against 0.35% at 100mA. The receiver power circuits are also simplified, as can be seen in the 'before and after' circuit diagrams of Figs. 2 (a) and (b). All components designated in the receiver circuits relate to those in the published circuit diagram and receiver handbook.

The alternative power unit is quite conventional and uses standard components. It is designed to fit into the receiver internal battery box. The secondary output from a small mains transformer, T1, is fed into an encapsulated diode bridge, this providing full-wave rectification. T1 is an R.S. Components 'filament transformer' offering 16.3 volts at 0.3 amp centre-tapped (Home Radio Cat. No.TH5A) whilst the diode bridge is a Mullard BY164 (available in the Home Radio semiconductor list under the same number). Smoothing is provided by the filter circuit consisting of C1, R1 and C2, R1 also providing current limiting for the zener diode D5, which stabilizes the 12 volt d.c. output. This diode is of the stud-mounting variety and is mounted on a 1¼ in. square aluminium plate which acts as a small heat sink. The output is fed via the Internal-External switch to the receiver circuits. The muting link is left in the positive line, whilst C22 is retained to decouple the supply line at radio frequencies. An additional smoothing capacitor, C3, is added in the receiver to further reduce ripple and ensure negligible

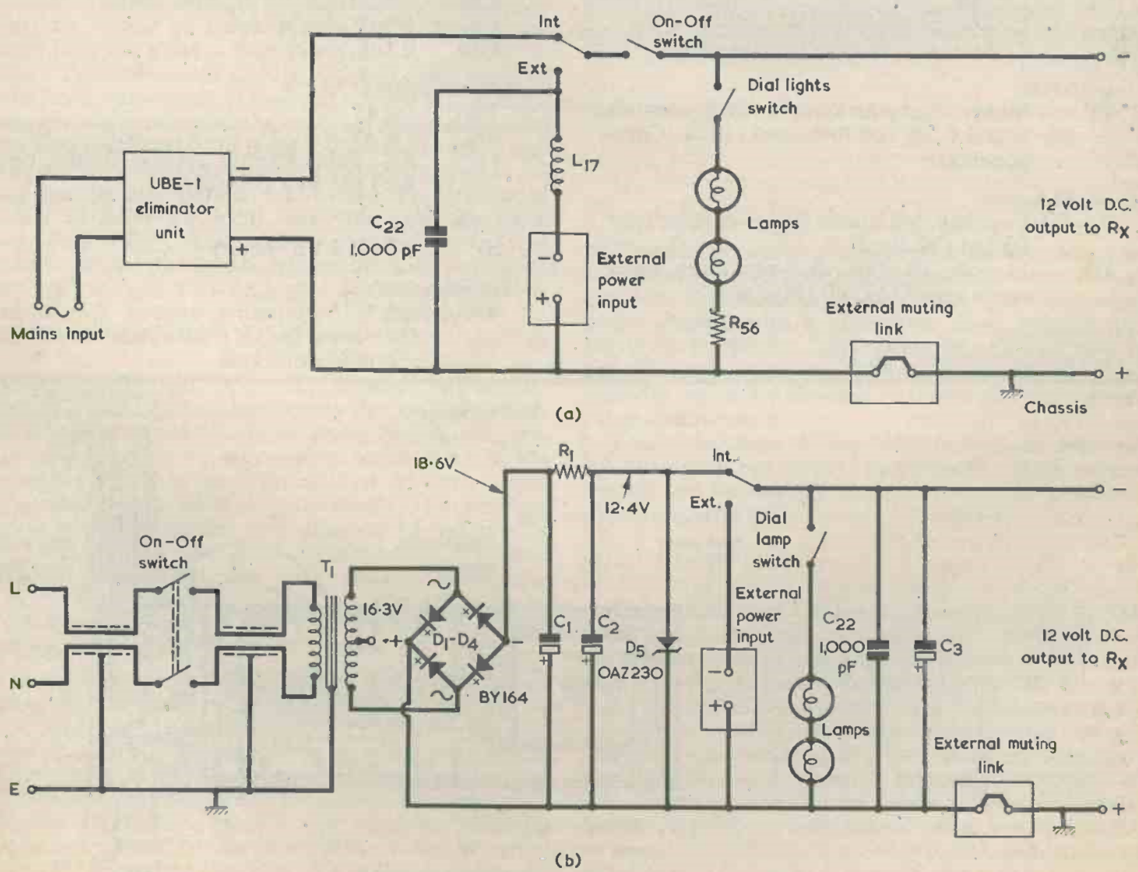


Fig. 2 (a). The original mains power circuit
(b). Modified circuit incorporating the alternative power supply

hum even at maximum volume. The dial lights and light switch are connected directly across the 12 volt receiver supply. Economy resistor R56 and r.f. choke L17 can be omitted.

One further disadvantage with the original circuit was that no mains switch was incorporated in the UBE-1 eliminator, the on–off receiver switch on the a.f. volume control being in the 12 volt d.c. line. This meant that the mains transformer primary was permanently energised, even with the receiver switched off. In the alternative circuit the switch is taken out of the d.c. line and put into the mains supply to T1 primary. The double-pole switch required is already on the rear of the a.f. volume control and can be safely used for this purpose, being rated at 250 volts 1 amp a.c. Insulated twin screened cable is used to take the mains supply both to and from this switch, and this prevents hum pick-up in the adjacent circuits on the receiver printed board. The mains wiring is terminated at a 6-way tagstrip fixed to the side of the battery box, as shown in Fig 3.

COMPONENTS

Power Supply

Resistor

R1 25Ω 5 watts wire-wound

Capacitors

C1 1,000μF electrolytic, 25 V.Wkg
C2 1,000μF electrolytic, 15 V.Wkg
C3 2,500μF electrolytic, 15 V.Wkg

Transformer

T1 Mains 'filament transformer', secondary 16.3V 0.3A centre-tapped. (R.S. Components)

Semiconductors

D1–D4 Encapsulated silicon bridge rectifier type BY164 (Mullard)
D5 12 volt, 10 watt, stud-mounting zener diode type OAZ230 (Mullard)

Miscellaneous

6-way tagstrip (see Fig. 3)

COMPONENTS

Product Detector

Resistors

(All fixed values ¼ watt 10%. R47 and R54 are new values for existing resistors.)

R1 100kΩ
R2 5.6kΩ
R3 220Ω
R4 3.3kΩ
R5 6.8kΩ
R6 330kΩ
R7 3.3kΩ
R8 2.2kΩ
R9 220Ω
R10 470Ω
R11 470Ω
R12 750Ω
R47 1kΩ potentiometer, linear wire-wound
R54 2.2kΩ

Capacitors

C1 100pF silvered mica
C2 100pF silvered mica
C3 0.1μF plastic foil
C4 680pF silvered mica
C5 0.0068μF plastic foil
C6 0.1μF plastic foil
C7 1μF plastic foil
C8 0.47μF plastic foil (see text)
C9 0.1μF plastic foil
C10 0.1μF plastic foil

Semiconductors

TR1 OC45
TR2 OC45
D1 6.8 volt 400mW zener diode type BZY88C6V8 (Mullard)

Switch

S1 2-pole 3-way rotary

Miscellaneous

Veroboard, 0.15 in. matrix, approx. 2 by 2⅛ in. (12 strips by 13 holes) Aluminium for mounting brackets

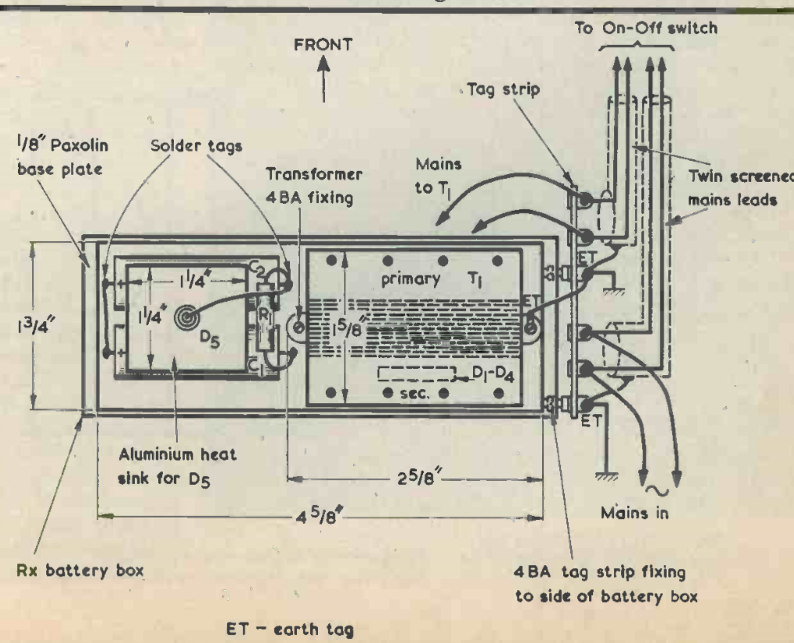


Fig. 3. Layout of the components in the new mains supply unit

POWER UNIT CONSTRUCTION

The construction of the power unit should offer no problems. The components are mounted on an ⅛ in. Paxolin board resting on the bottom of the battery box, the capacitors and resistor being mounted between solder or turret tags mounted in the board. Add an insulating strip of Paxolin to ensure that the bottoms of these tags do not short-circuit against the metal base of the battery box. The zener diode, D5, is mounted, as already mentioned, on a 1¼ in. square heat sink, and it is soldered between the appropriate tags by means of 18 s.w.g. wire so that it becomes self-supporting. The encapsulated diode bridge is beneath T1 top plate, being wired directly to the appropriate secondary tags.

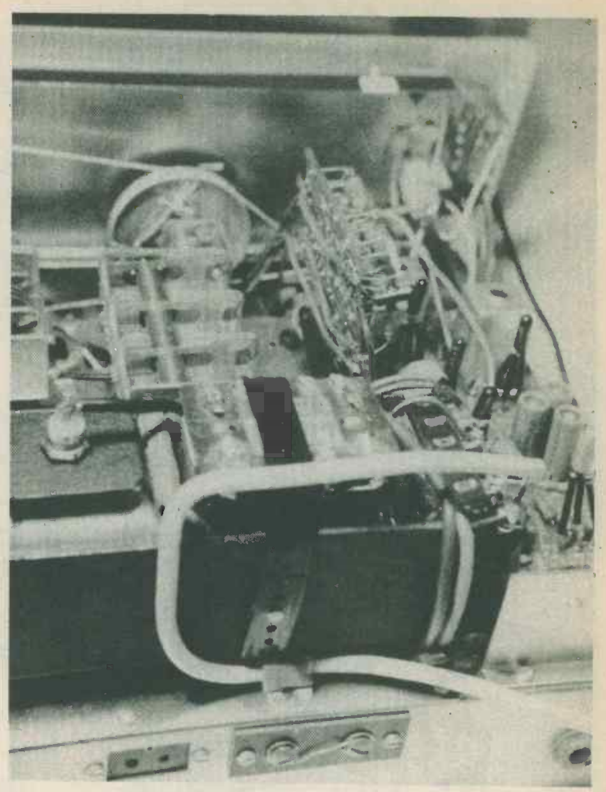
A general view of the power unit, together with relevant dimensions, is given in Fig. 3 and a list of the additional parts required appears in the accompanying Components List. A small grommet can be let into the back of the receiver cabinet to allow for the outgoing mains lead. The extra smoothing capacitor, C3, is positioned under the i.f.-a.f. printed board, being fastened to the underside plate of the chassis by means of an insulated spring clip secured by a 6BA countersunk screw. As the can will normally be common to the negative lead of the capacitor it must be insulated from the chassis which is, of course, positive. Hence the use of an insulated clip. The mains cables going to and from the power switch are held in place along the top edge of the printed board by small clips, these being fixed to the chassis by means of the existing 6BA screws which already hold the printed board in place.

When the new power unit is completed the receiver can be tried out with it. If desired, voltage and current checks may be made, and the readings obtained should be approximately equal to those indicated in Figs. 1 and 2 (b). An improvement in overall stability should be noted, particularly on the h.f. bands. The frequency stability of both the local oscillator and the b.f.o. should be virtually unaffected by the operation of the dial light switch, by normal changes in mains voltage or by changes in the r.f. and a.f. gain control settings.

RESISTOR SUBSTITUTION

Before dealing with the product detector, two further points of a more general nature may first be mentioned. After completing and testing the power unit, a complete check and if necessary, a complete realignment of the receiver, is worth-while. This assumes, of course, that the necessary signal generator is available. The complete alignment procedure for both i.f. and r.f. sections is fully described in the receiver handbook. Whilst a complete realignment can take several hours, the writer found it well worth-while in terms of increased sensitivity and selectivity and accurate local oscillator tracking.

The second point refers to the replacing of all existing carbon resistors by high stability metal oxide types. This gives a much improved performance with regard to noise. The older type of standard carbon resistor tends to be rather noisy, whilst the new 5% metal oxide resistor has a much superior noise and long-term stability factor. The r.f. and frequency changer circuits are particularly sensitive to this form of noise. Besides reducing the noise level by a noticeable amount, the long-term stability of the overall circuits is much improved by changing to this type of resistor. While again this task is rather time-consuming, and metal oxide resistors are more expensive than carbon types, the writer considers the results worth the extra time and expense. This modification can be recommended for any older receiver with a high noise level, whether it be valve or transistor. The writer has carried out this modification on several older receivers and has always found it extremely effective in improving the signal-to-noise performance.



A view of the new power supply unit fitted in the battery box

The replacement of the older type paper capacitors by new polyester types, particularly in r.f. and i.f. bypass and decoupling circuits, also helps to improve overall receiver performance and stability.

S.S.B RECEPTION

The inclusion of a product detector for s.s.b. reception was considered necessary for improved s.s.b. performance. With the original circuit s.s.b. reception was achieved by the earlier method of switching on the b.f.o., tuning in the required s.s.b. signal, reducing the r.f. gain as much as possible and readjusting the b.f.o. control for final tuning, the a.m. detector being left to resolve the signal. Such a method has several disadvantages. Any drift in the local oscillator frequency or b.f.o. frequency is sufficient to cause severe distortion or even a completely unreadable signal. Sudden changes in r.f. signal strength or changes in r.f. gain setting can produce a similar effect. To a certain extent, all these problems can be overcome by the inclusion of a well stabilized supply and a simple product detector.

The existing third i.f. stage and b.f.o. stage are shown in Figs. 4 (a) and (b) respectively. Fig. 5 shows the added product detector circuitry and its interconnection into the two stages illustrated in Figs. 4 (a) and (b). Also shown is the added function switch S1 (a) (b). The circuit is designed so as to keep the number of modifications to the receiver to a minimum.

The circuit in Fig. 5 shows a simple product detector TR1, the circuit functioning on a non-linear characteristic. The b.f.o. output is fed via C2 into TR1 base, this signal being mixed with the i.f. output taken from transistor X6 emitter via C1. (The previous b.f.o. coupling capacitor, C60, is now removed.) The resultant product of these two signals is developed in amplified

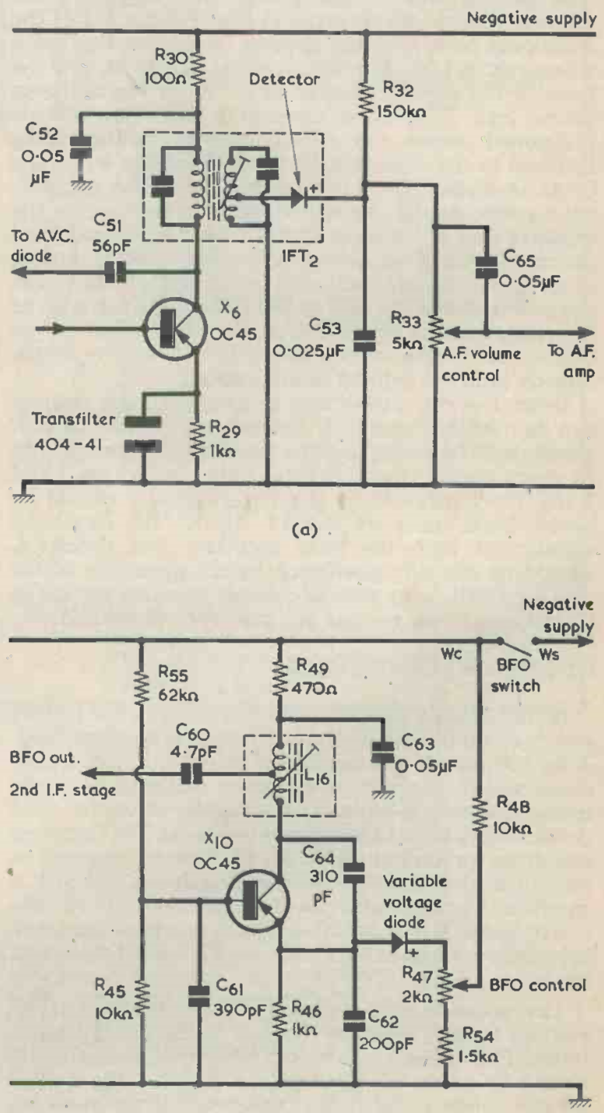


Fig. 4 (a). The third i.f. stage of the receiver in unmodified form
(b). The unmodified b.f.o. stage.

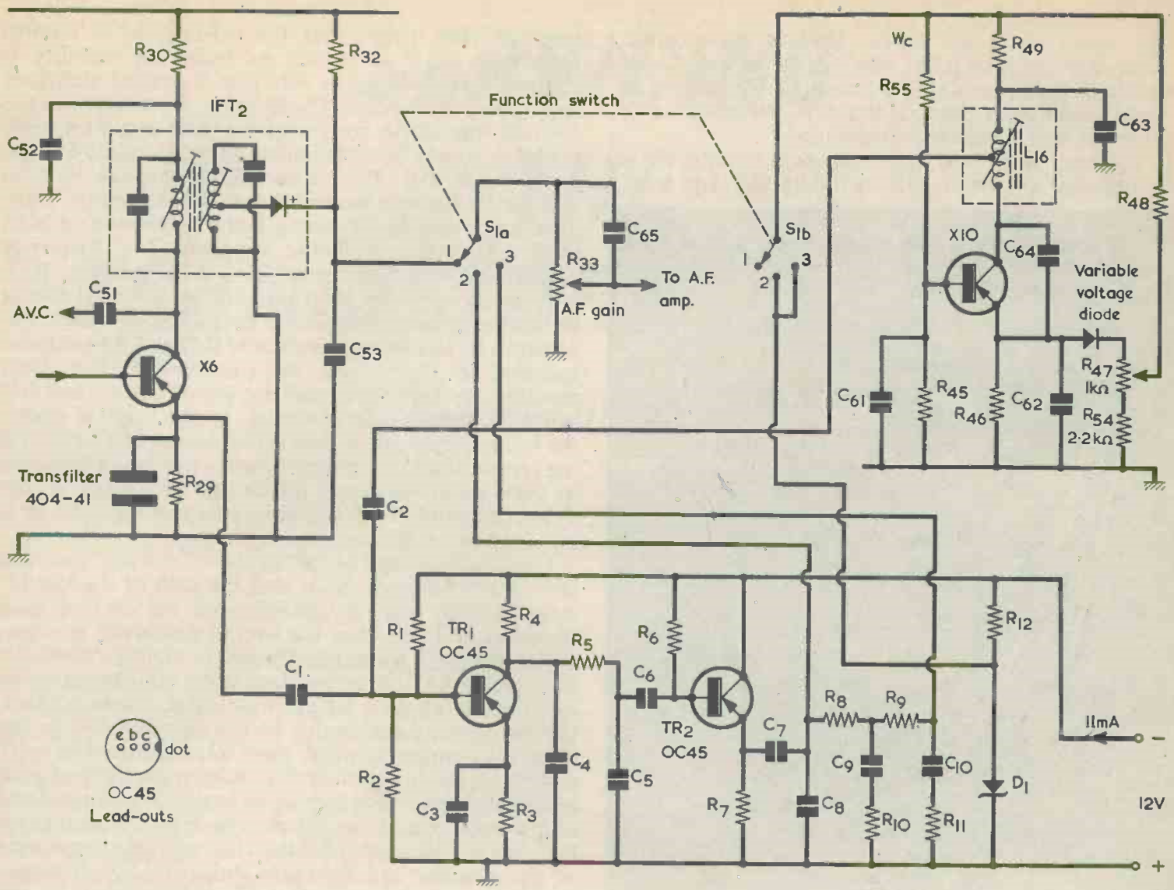


Fig. 5. The added product detector circuit, including the interconnections to the third i.f. and b.f.o. stages

form across load resistor R4 and fed into the filter circuit C4, R5, C5. The characteristics of this filter help give the resultant output the correct shape and frequency bandpass, the insertion loss involved being catered for by the signal gain achieved in TR1.

The filter output is fed via coupling capacitor C6 to the emitter follower TR2, the final output signal being developed across emitter load resistor R7. The purpose of TR2 is to give isolation between detector TR1 and the audio output circuits and also to provide a low impedance output for easy matching into the audio input circuit. The final output is taken via blocking capacitor C7, through the function switch S1, to the receiver first audio stage.

An optional extra audio filter circuit is also connected, via isolating resistor R8, to the output. This filter is formed by R9, R10, R11, C9 and C10 and it is a simple low-pass circuit which can be switched in by the function switch to give a narrow audio acceptance band. Such a facility can prove useful in both s.s.b. and c.w. modes. It would normally only be used under crowded band conditions and in effect it helps to improve selectivity. The filter can, however, be omitted if required. C8 forms a capacitor divider in conjunction with C7 and provides simple top cut. It clips overall upper bandwidth limits to an acceptable level, though it does tend to reduce sensitivity slightly. Its value can be altered to suit individual receivers.

Function switch S1 (a) (b) allows selection of a.m., s.s.b./c.w., and narrow band s.s.b./c.w. on positions 1, 2 and 3 respectively, and section (a) is inserted between the last i.f. stage and the a.f. input. In position 1 the output from the a.m. detector is taken directly, via S1 (a) to the a.f. input. In positions 2 and 3 the outputs from the product detector are taken to the a.f. input while the a.m. detector is left out of circuit. At the same time the supply to the b.f.o. is switched in by S1 (b). It will be noticed that the i.f. output is taken from the emitter of X6. This was done to avoid having to break into the I.F.T.2 circuit, with the resultant damping which would result due to the loading effect of the product detector. The point selected has a much lower impedance and is much less prone to the effects of external loading. In practice the a.m. performance of the receiver was completely unchanged.

In common with most simple product detectors it is still necessary to carry out final tuning with the b.f.o. control. This meant that the existing b.f.o. control required a little attention. As frequency stability is extremely critical it was felt that a special stabilized supply was warranted. The existing zener diode in the receiver was left to cope with the local oscillator only, the b.f.o. supply being taken via S1 (b) from the 6.8 volt zener diode D1. This is connected through limiting resistor R12 across the stabilized 12 volt supply. Thus, in effect, a double stabilizing factor is present on both local and b.f.o. oscillator supplies. The frequency variation covered by the existing b.f.o. control, R47, was found to be too great, making incremental tuning somewhat difficult. A smaller frequency coverage was obtained by changing the values of R47 and R54 to those specified in Fig. 5 and the Components List. This modification kept the overall d.c. conditions correct and provided greater ease of tuning. In the original circuit the b.f.o. supply was turned on by means of a switch on the rear of the b.f.o. potentiometer, this being operated by pulling out the centre spindle. As the supply is now switched on by S1 (a) (b), this control is replaced by a standard potentiometer.

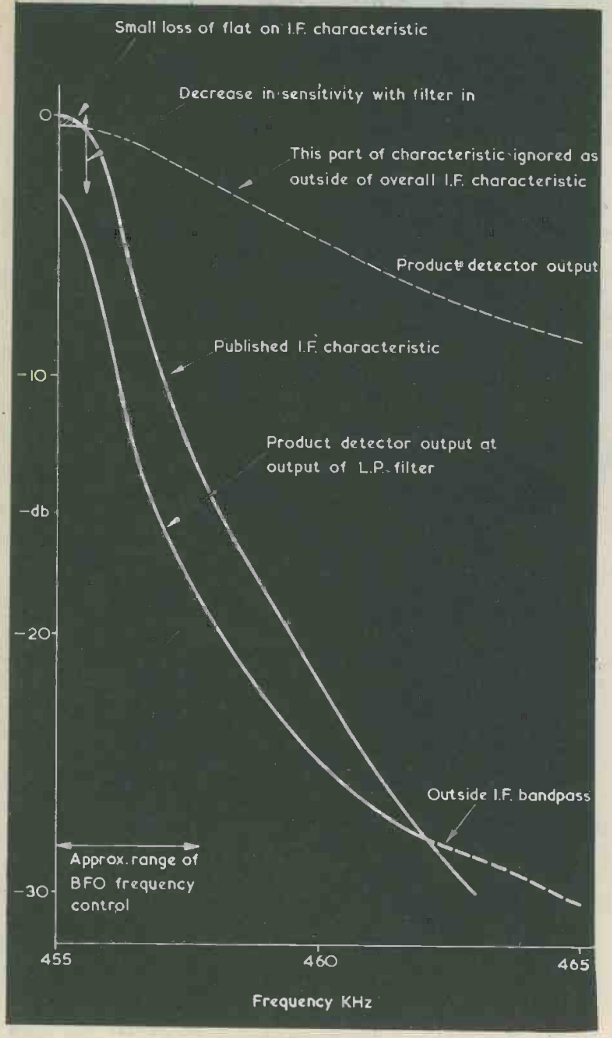


Fig. 6. The relative differences in sensitivity between the product detector output and published i.f. output. The measured characteristics are static only

One disadvantage of taking the i.f. output from the emitter of transistor X6 is that the gain of the last i.f. stage is lost. This is compensated for by the gain obtained in TR1. Thus the overall sensitivity is maintained although the selectivity suffers slightly. When the low pass audio filter is switched in (S1 (a) (b) in position 3) an apparent drop in sensitivity is of course noticed, this being unavoidable due to the insertion loss in the filter. As, under crowded band conditions, sensitivity is often of less importance than selectivity, this loss is of negligible importance in most instances. When measured under static signal conditions, the apparent sensitivity loss was in the order of 3db. The static characteristics of the detector and filter are shown in Fig. 6 superimposed over the published i.f. characteristic of the receiver. It can be seen that negligible flat loss occurs with the product detector in circuit. The choice of germanium OC45 transistors was simply in order to keep the modifications in line with the existing receiver circuit, this type already being used both for the i.f. stages and the b.f.o. The additional circuits will be virtually unaffected by normal temperature changes met with in practice.

Constructional details for adding the product detector circuit will be given next month. More precise details of the Veroboard and the brackets required for its mounting, as included in the Components List, will also be provided next month. The relatively large value capacitors specified for C7 and C8 are available from several suppliers, including Marco Trading, The Maltings Station Road, Wem, Salop. As will be explained in the next article, C8 may required adjustment in value.

(To be concluded)