PW 'STOUR' TOP-BAND TRANSCEIVER

PART 2

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Following the outline description of the transceiver and details of Board 1, we continue this month with detailed descriptions and circuit diagrams of Boards 2, 3 and 4.

Board 2—9MHz Oscillator

The oscillator board contains the following circuitry:
1. Crystal oscillator 2Tr1.
2. Buffer amplifier 2Tr2.
3. Broad-band amplifier 2Tr3.

Circuit Description

The oscillator board uses five transistors in all, 2Tr1 and 2Tr2 are duplicated forming two separate oscillator and buffer amplifiers. The +12V to either of these oscillators is switched from the upper/lower switch located on the front panel to give upper or lower sideband. The outputs from both buffer amplifiers are connected via 2C10 to a common broad-band amplifier.

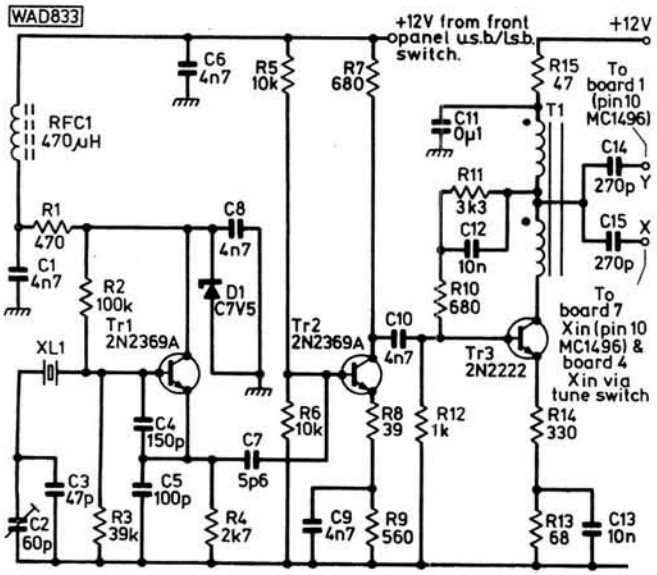


Fig. 6: Circuit diagram of Board 2

The original oscillator board consisted of 2Tr1 and 2Tr2 only, but the output seemed only just sufficient to drive the balanced modulator *or* the product detector. At some stage the author hopes to try a diode ring modulator

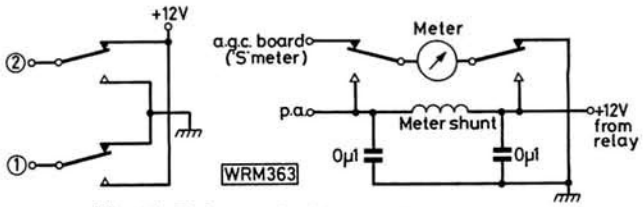


Fig. 7: Relay switching and p.a. supply

where considerably greater drive power will be required. With this in mind a further amplifier 2Tr3 was used in the final board, as shown, which is run at a very low level, with its gain being controlled by 2R14.

The level of injection used seemed at its optimum. A reasonable carrier balance is achieved at this level and there is adequate injection to the product detector. If less than 9MHz output is used then the mic. amp. has to be run at a much higher level, causing considerably more distortion.

Connections to Board 2

X connects to 1. Balanced modulator, Board 7 (X In); 2.Mixer, Board 4 (X In.). (Via front panel switch to give tune facility.)

Y connects to Board 1 product detector.
N.B. The 12V points associated with 2Tr1 and 2Tr2 are switched via a front panel switch to give upper or lower sideband as required. The +12V to 2Tr3 is on at all times.

Readers who intend to operate the Stour should be in possession of the appropriate licence issued by the Home Office to those who have passed the City and Guilds Radio Amateurs' Examination. Details may be obtained from: The Home Office, Radio Regulatory Department, Amateur Licensing Section, Waterloo Bridge House, Waterloo Road, London SE1 8UA.

★ components

BOARD 2

Resistors

¼W 5% Carbon Film

39Ω	2	R8,8a
47Ω	1	R15
68Ω	1	R13
330Ω	1	R14
470Ω	2	R1,1a
560Ω	2	R9,9a
680Ω	3	R7,7a,R10
1kΩ	1	R12
2·7kΩ	2	R4,4a
3·3kΩ	1	R11
10kΩ	4	R5,5a,R6,6a
39kΩ	2	R3,3a
100kΩ	2	R2,2a

Semiconductors

2N2369A	4	Tr1,1a,Tr2,2a
2N2222	1	Tr3
BZX61C7V5	2	D1,1a

Capacitors

Silver Mica

150pF	2	C4,4a
100pF	2	C5,5a

Ceramic Disc

5·6pF	2	C7,7a
47pF	2	C3,3a
270pF	2	C14,15
4·7nF	10	C1,1a,C6,6a,C8,8a,C9,9a, C10,C10a
10nF	2	C12,13
0·1µF	1	C11

Miniature Trimmers

5-65pF	2	C2,2a

Inductors

470µH r.f. choke	2	RFC1,1a
7 turns bifilar wound 22 s.w.g. wire on a Neosid 28–002–27 toroid	1	T1

Miscellaneous

HC18-U plug-in crystals 9001·50kHz (1); 8998·50kHz (1); HC18-U p.c.b. sockets (2); printed circuit board.

Note: Component refs. in text are pre-fixed with the board ref. 2.

Constructional Details

The oscillator is built on double sided glass fibre p.c.b. 2Tr1 and 2Tr2 circuitry is duplicated to provide both upper and lower sideband. The filter is usually purchased complete with both crystals and so it was felt worthwhile to include both in the design. (Some u.s.b. fish phone can at times be quite entertaining and there is the added bonus of being able to check on the distortion products of other s.s.b. signals.)

Accordingly the components 2R1–2R9, 2C1–2C10, 2Tr1–2Tr2, 2D1, 2XL1, and 2RFC1 are duplicated.

If any differences in Xtal tolerance etc. show differing 9MHz output then 2R8 may be adjusted to ensure both upper and lower sideband circuits give approximately the same output.

2T1 is a standard broad-band transformer consisting of 7 turns bifilar wound on a Neosid 28–002–27 toroid.

The oscillator board should be mounted away from the balanced modulator as any stray pick up by this board will degrade the carrier suppression. (The prototype required a screen, as without thinking, these two boards were mounted adjacent to each other.)

Board 3—Filter Board

The filter board contains the following circuitry:

(1) Diode switch 3D1, 2, 3 and 4 switching the input to the pre-filter amplifier.
(2) 3Tr1, pre-filter amplifier.
(3) 9MHz 8 pole crystal filter.
(4) CA3028A 1st i.f. amplifier.
(5) Diode switch 3D7, 8, 9 and 10 switching the output of the CA3028A.
(6) 3Tr2, 9MHz transmit amplifier.

Circuit Description

The diode switch, consisting of 3D1, 2, 3 and 4 is used to switch the two inputs to the pre-filter amplifier, 3Tr1, a 2N2222A. Input X, the transmit line, receives low level double sideband, from the balanced modulator during transmit. During receive this path is blocked and Input Y is switched to 3Tr1 base. This input is from the mixer board and contains the 9MHz i.f. signal.

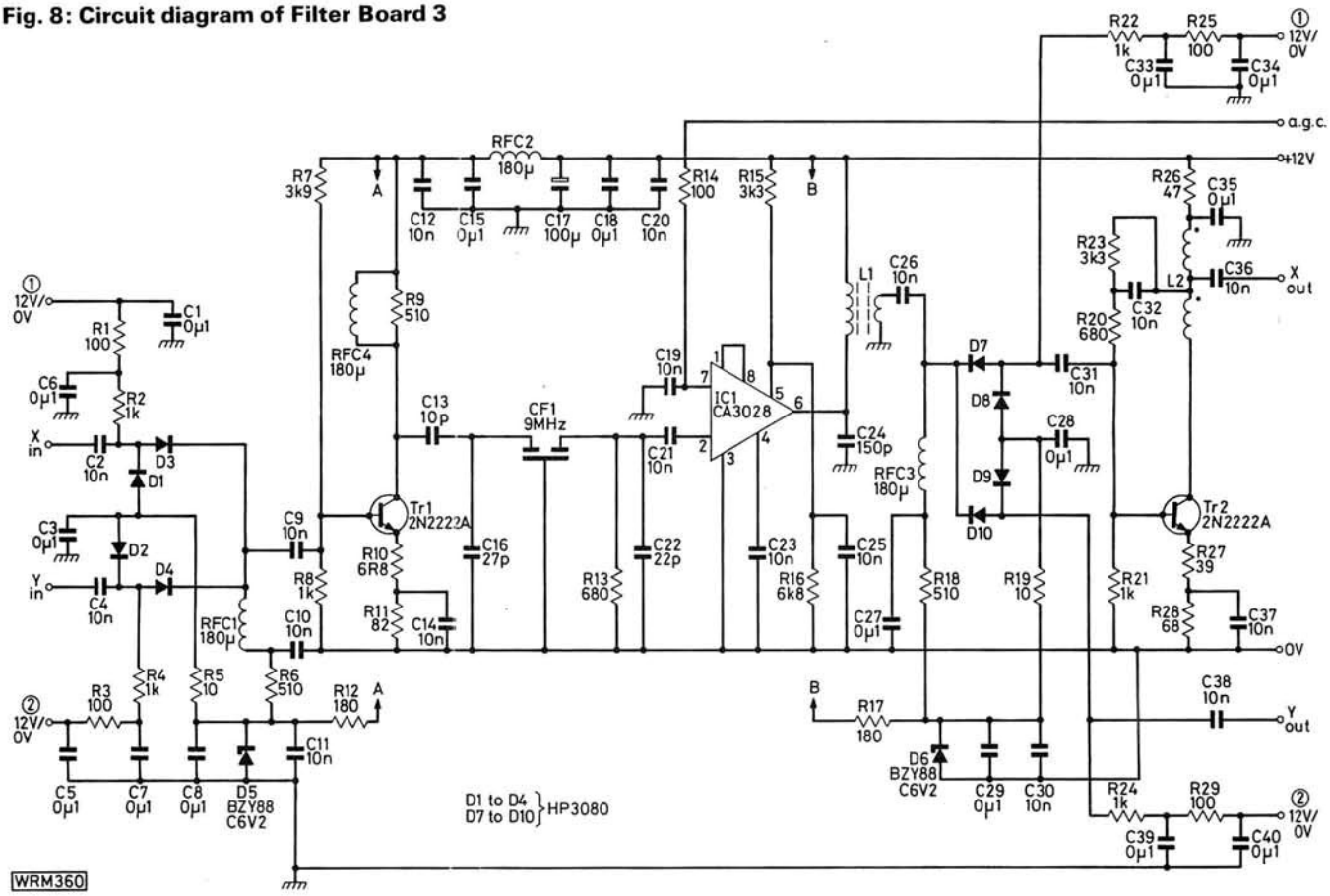
Transistor 3Tr1 consists of a common emitter class A amplifier run at a relatively high standing current, typically 25mA. The original circuitry was much more economical on current consumption but proved the weak point in the receiver chain. When large signals were present this stage seemed to be the one responsible for all the spurious responses encountered. The simple remedy of running 3Tr1 at a much higher standing current, and thus greatly improving its signal handling performance, was the final touch that seemed to transform the receiver. A dual gate f.e.t. was also tried in this stage and, although better than the original bipolar design, was not as good as the final circuitry.

After signals have passed through the filter, during both transmit and receive, a CA3028A is used as the first i.f. amplifier. Most of the receiver gain is required after the filter and a further CA3028A is used during receive.

Automatic gain control is applied to the CA3028 i.c.s via pin 7. The a.g.c. voltage is at its minimum during maximum signal levels. This minimum is in the order of +2V rising to a maximum of +9V during no or low signal conditions. During transmit this line is set at 8·5V via relay connections to the stabilised line.

Inductor 3L1 is resonant at 9MHz, with its resonating capacitor 3C24. This coil was wound on a miniature Neosid HA2 inductance assembly, the same type being

Fig. 8: Circuit diagram of Filter Board 3



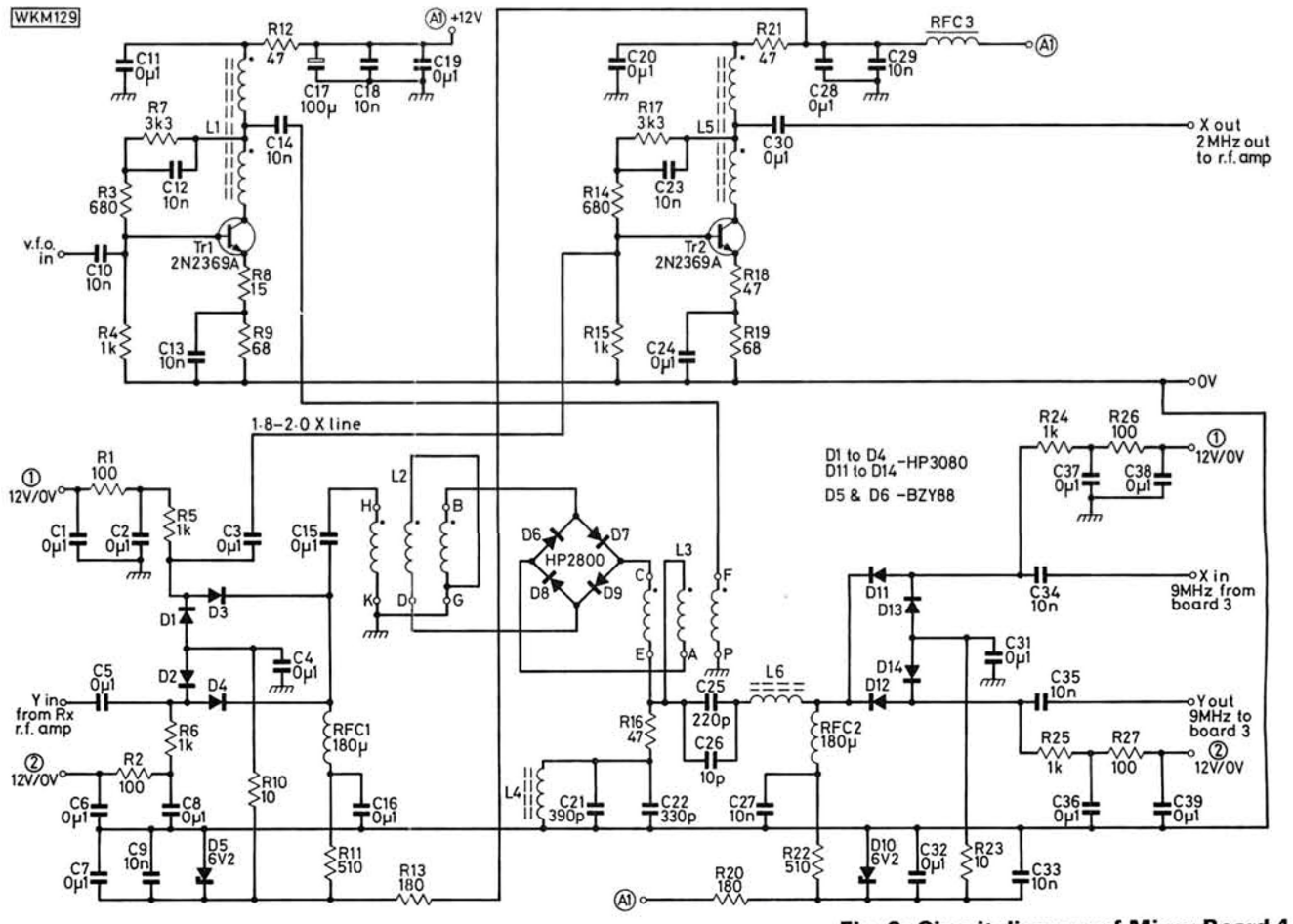


Fig. 9: Circuit diagram of Mixer Board 4

used in the r.f. board for the 2MHz filter and again on the mixer board. A toroidal coil and variable capacitor were also tried but the eventual method used saved valuable space.

The 9MHz signal is transferred to the diode switch 3D7, 8, 9 and 10 via a link coupling of 2 turns on 3L1 and also via 3C26. During receive this switch transfers the 9MHz i.f. to Board 1, whilst during transmit it routes the 9MHz s.s.b. to 3Tr2.

Operation of Diode Switch

A smaller circuit to that used in the filter and mixer boards is shown in Fig. 10. Capacitors C2 and C4 are the input capacitors whilst Ra and Rb represent 3R1 and 3R2 and 3R4 and 3R3 respectively. The capacitors not shown are for r.f. decoupling only and so do not affect the action of the switch in any way.

Assuming Input X to be in operation then, via relay connections, +6V appears at Point 1 and −6V appears at point 2. It may now be seen that D3 is connected between +6V and 0V through resistors Ra and 3R6. This diode is therefore forward biased and thus signals will pass through C2, D3 and C9. Diode D4, however, is reverse biased and so cannot conduct via Rb. The circuit through Rb, D2 and R5 ensures D1 is reverse biased.

The reverse procedure occurs when −6V appears at Point 1 and +6V appears at Point 2. Diodes D2 and D3 are then reverse biased and signals pass through the switch from Y via C4, D4 and C9.

In the finished design +6V is used as the switch reference voltage, 0V being used in the above explanation. This allows +12V and 0V to appear as ±6V with respect to the +6V reference voltage.

Connections to Filter Board

(1) +12V at 3R26 is joined with wire to +12V entry point adjacent to 3L1. This is then routed to the +12V rail.
(2) "X In" connects to the balanced modulator-board 7 (X Out)—(9MHz d.s.b.).
(3) "Y In" connects to the mixer, Board 4 (Y Out)—(receive 9MHz in).
(4) "X Out" connects to the mixer, Board 4 (X In)—(9MHz s.s.b. transmit).
(5) "Y Out" connects to i.f.—audio board 1 (B)—(9MHz s.s.b. receive).
(6) Switching points 1 are joined together with wire and then taken to relay connections (see Fig. 7).
(7) Switching points 2 are similarly treated.
(8) Automatic gain control a.g.c. to Board 8 a.g.c.

Points A and B are connected together (A to A, B to B) via tracking on the board itself.

Relay Switching

The d.c. switching is shown in Fig. 7 and the same relay connections are used to switch Board 4 (mixer board).

Constructional Notes

Double-sided glass fibre p.c.b. is used with Veropins for all external connections. Radio frequency choke, 3RFC4, is located on the track side of the board and is soldered across 3R9 connections. Care must be taken when mounting the diodes as these are easily fractured. Correct sensing of 3L2 (collector load for 3Tr2) must be observed. Resistors 3R12 and 3R17 must be ½W rating. Inductor 3L2 consists of 7 turns, bifilar wound on a Neosid 28-002-27 toroid.

★ components

BOARD 3

Resistors

½W 5% Carbon Film

6·8Ω	1	R10
10Ω	2	R5,19
39Ω	1	R27
47Ω	1	R26
68Ω	1	R28
82Ω	1	R11
100Ω	5	R1,3,14,25,29
510Ω	3	R6,9,18
680Ω	2	R13,20
1kΩ	6	R2,4,8,21,22,24
3·3kΩ	2	R15,23
3·9kΩ	1	R7
6·8kΩ	1	R16

½W 5% Carbon Film

180Ω	2	R12,17

Capacitors

Disc Ceramic

10nF	19	C2,4,9,10,11,12,14,19,20, 21,23,25,26,30,31,32,36, 37,38
0·1µF	16	C1,3,5,6,7,8,15,18,27,28, 29,33,34,35,39,40

Sub-min. Ceramic

10pF	1	C13
22pF	1	C22
27pF	1	C16
150pF	1	C24

Tantalum Electrolytic 16V

100µF	1	C17

Semiconductors

Integrated Circuits

CA3028A	1	IC1

Transistors

2N2222A	2	Tr1,2

Diodes

HP3080	8	D1–4,7–10
BZY88C6V2	2	D5,6

Miscellaneous

180µH min. choke (4); 9MHz crystal filter; YF90H 2·4kHz 8-pole (Interface Quartz Devices); Neosid 28-002-27 toroid; p.c.b.

Note: Component refs. in the text are prefixed with the board ref. 3.

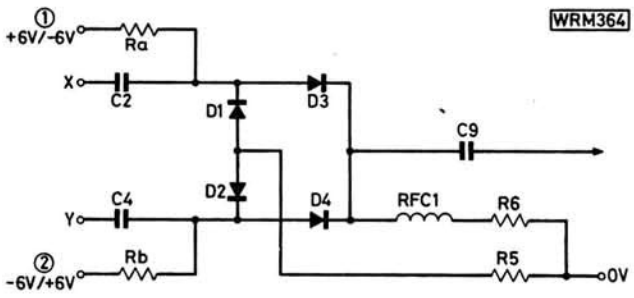


Fig. 10: Explanatory diode switching operation circuit

★ components

BOARD 4

Resistors

¼W 5% Carbon Film

10Ω	2	R10,23
15Ω	1	R8
47Ω	4	R12,16,18,21
68Ω	2	R9,19
100Ω	4	R1,2,26,27
180Ω	2	R13,20
510Ω	2	R11,22
680Ω	2	R3,14
1kΩ	6	R4,5,6,15,24,25
3·3kΩ	2	R7,17

Capacitors

Disc Ceramic

10nF	12	C9,10,12,13,14,18,23,27,29,33, 34,35
0·1µF	22	C1–8,11,15,16,19,20,24,28,30, 31,32,36,37,38,39

Sub-miniature Ceramic

10pF	1	C26
220pF	1	C25
330pF	1	C22
390pF	1	C21

Tantalum Electrolytic

100µF	1	C17

Semiconductors

Transistors

2N2369A	2	Tr1,2

Diodes

HP2800	4	D6–9
HP3080	8	D1–4, 11–14
BZY88C6V2	2	D5,10

Inductors

180µH min. chokes	2	RFC1,2

Miscellaneous

32 s.w.g. enamelled copper wire; p.c.b. (1); Neosid 28-002-27 toroids (3); Neosid HA2 inductance assemblies (2).

Note: Component refs. in the text are prefixed with the board reference 4.

Board 4—Mixer Board

The mixer board contains within it the following circuitry.

(1) 7MHz broad-band amplifier for v.f.o. amplification (4Tr1).
(2) 2MHz broad-band amplifier for 1st transmit amplifier (4Tr2).
(3) Doubly balanced diode ring mixer using hot carrier diodes.
(4) Diode switch into mixer.
(5) Diode switch out of mixer.

Circuit Description

The v.f.o. signal amplified by 4Tr1 is fed to the diode mixer, during both transmit and receive, via 4C14 and 4L3.

The signals from the receiver r.f. amplifier pass through the diode switch consisting of 4D1, 2, 3 and 4 and then via 4C15 and 4L2 are fed to the mixer. During transmit this switch blocks the receive path and transfers the 2MHz r.f. to 4Tr2.

The amplifier 4Tr2 is a broad-band device and provides the first stage of amplification at 2MHz during transmit. The gain of this stage is set by 4R18 (47Ω).

The diode switch 4D11, 12, 13 and 14 switches the 9MHz s.s.b. into or out of the mixer.

During receive the circuitry 4R16, 4L4, 4C21 and 4C22 is designed to terminate correctly, at 50Ω, any unwanted products produced by the mixer; the required 9MHz signals passing through 4L6, 4C25 and 4C26. Both these circuits should resonate at 9MHz. During transmit the above circuitry acts as a 9MHz filter. The tuning of 4L6 is fairly flat whilst that of 4L4 should peak with a definite response.

Whilst a more simple diode switch could have been used the final circuits ensure that strong signal levels do not produce any spurious mixing effects when passing through the diodes.

The 6V Zener diodes are present to allow a ±6 volt operating point to be used in the above diode switching.

Connections to Mixer Board

(1) Switching points (1) are joined together with wire and then routed to the relay connections as shown in Fig. 7. Switching points (2) are also joined and similarly connected to the relay.
(2) "VFO" is connected to the v.f.o. output.
(3) "X In" connects to "X Out" from the filter, Board 3 (9MHz in).
(4) "Y In" connects to the r.f. amplifier, Board 6 (2MHz receive signals).
(5) A1 and A2 are joined with wire and are then routed to +12V. (They must be connected during both receive and transmit.)
(6) "X Out" connects to band-pass filter FL1. (Low level 2MHz s.s.b.)
(7) "Y Out" connects to the filter, Board 3 (Y In)—(9MHz i.f. signals).

Constructional Details

Double sided glass fibre p.c.b. is used with Veropins for all external connections.

Care must be taken when mounting the diodes as the glass casing will easily fracture if put under stress.

Great care must be taken to ensure the toroidal inductors 4L1, 2, 3 and 5 are correctly connected. The sensing shown on the diagram must be observed. Inductors 4L2 and 4L3 consist of 7 turns of 32 s.w.g. wire bifilar wound on a 28-002-27 toroid. Inductors 4L1 and 4L5 are of the same construction but only 6 turns of wire are required.

The inductors 4L4 and 4L6 are constructed on Neosid miniature HA2 inductance assemblies. In the prototype the number of turns necessary was calculated approximately and then adjusted together with their resonating capacitors. These inductor assemblies are provided with metallic screening cans to avoid any unwanted i.f. breakthrough during receive. Inductors 4L4 and 4L6, together with their resonating capacitors, should be resonant at 9MHz. Points A, B, C and D correspond with those shown on component layout to facilitate diode and transformer connections. Similarly, points 1, 2 and 3 show connections for 4L1 and 4L5. Radio frequency choke, 4RFC3, consists of 20 turns of 32 s.w.g. wire wound on a 28-002-27 toroid.

To be continued