PW 'STOUR' TOP-BAND TRANSCEIVER

PART 1

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Now that 160m has been confirmed as an amateur band at the 1979 WARC there seems to be an upsurge in activity using this band. The author required an s.s.b. transceiver for 160m to use in a caravan when on holiday in Wales. The commercial transceiver, which had been used for this purpose until recently, had several shortcomings.

Firstly, when in a farmer's field with very little man-made noise and a large $\frac{1}{2}\lambda$ antenna, it did not cope with strong signals as well as one would have liked. Secondly, the current drain was alarming. Although there are now commercially available solid state units that cover 160m it was decided to "have a go" at building a rig which was more economical on current consumption during receive, and possessing a larger dynamic range with good signal handling capabilities.

It must be stated at the outset that the author is not professionally qualified and neither is he weighed down by superb test equipment. A g.d.o., d.c. meter and test oscillator (not a commercial signal generator) represented all that was available.

As several other people had shown more than a passing interest in the project it was decided that the various circuits should be as repeatable as possible.

To this end, and after many preliminary trials with various circuits, it became clear that one of the problems was the varying gains between different transistors of the same type number. A standard broad-band amplifier is used in many situations with a large amount of feedback, including an un-bypassed emitter resistor. This was used throughout the transceiver designs and the results after this method of approach was adopted proved extremely effective. The un-bypassed emitter resistor in each stage was found to be an easy method of setting the various gains in each stage and it is strongly advised that they are strictly adhered to.

Initial tests of the *PW* Stour prototype were carried out by using a Yaesu FT101B as the main piece of "test gear", but grateful thanks go to G4CEN who performed the rather more stringent tests and whose figures are quoted at the end of this article.

Because of the limited test equipment, modular construction was decided on. All sections were built and tested in such an order that simple functional tests could be performed without additional test gear.

The original front end of the receiver consisted of a 40673 r.f. amplifier feeding a diode mixer. After two months and about six printed circuit boards, this idea was given up. The cross-mod performance was, at its best, only as good as the commercial transceiver.

A design was then found using a pair of v.h.f. transistors in a broad-band push-pull circuit. This was quickly knocked up, and the results obtained were greatly improved. Similarly, the original p.a. used tuned circuits and worked quite well using a single 2N5591. However, being converted to broad-band techniques by the receiver front end success, a much more stable p.a. was evolved by adopting a similar approach.

Diode switching was used wherever possible to save the inevitable bulk of wiring associated with relay switching. *Pin* diodes were used for this purpose and although various articles have suggested the use of silicon switching diodes as a cheaper alternative, the author cannot comment on their effectiveness as they have not been tried.

CONSTRUCTION RATING Advanced

BUYING GUIDE

All components required for the construction of this project should be available from suppliers advertising in the magazine. Buying information will be provided in subsequent issues as appropriate.

APPROXIMATE COST £185

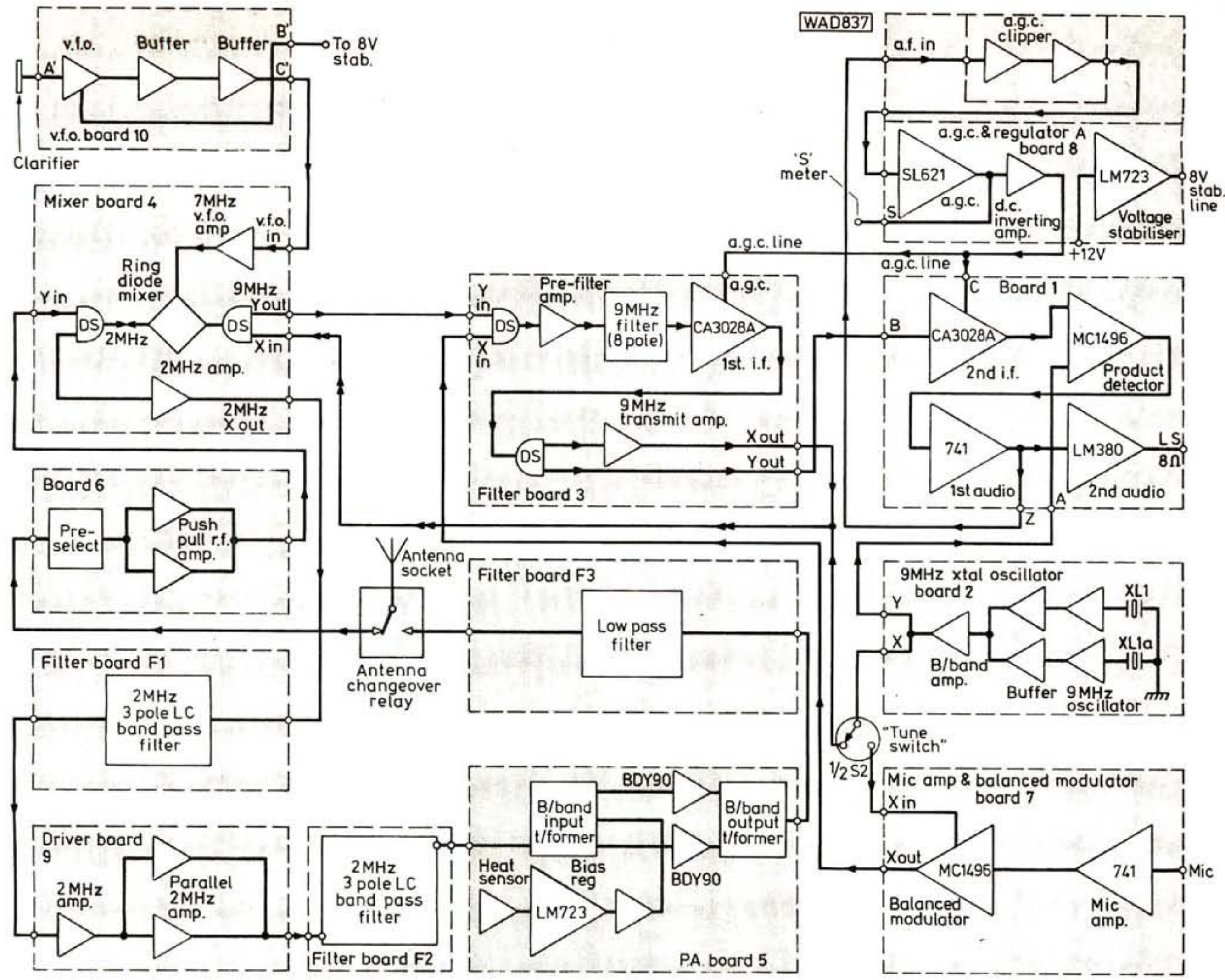


Fig. 1: The full block diagram of the *PW* Stour transceiver

Circuit Description—Receiver

(Refer to the functional block diagram of the transceiver shown in Fig. 1.)

The v.f.o. frequency is variable in the range 7–7·500MHz, with separate control of the receiver frequency available over a plus or minus range of 2–3kHz. The v.f.o. obtains its supply from an eight volt stabiliser.

Signals from the antenna are passed through a 2MHz filter and are then amplified by the push-pull front end before being fed to the mixer.

The v.f.o. output is fed to the mixer board where it is amplified by a broad-band amplifier before being fed to the doubly balanced diode mixer. This mixer uses HP2800 hot carrier diodes.

Mixed v.f.o. and amplified signals produce a 9MHz i.f. output from the mixer. The importance of terminating the mixer output correctly is paramount. The circuitry L5, C23 forms a parallel tuned circuit providing high impedance at the resonant frequency of 9MHz. At other frequencies a 50Ω terminating impedance is effected by means of the resistor R20. C24 and L6 are also series resonant at 9MHz. The mixer input and output are diode switched for transmit and receive functions.

The 9MHz i.f. signals are then passed to the filter board where a single stage of amplification is introduced before the filter. This amplifier is run at a fairly high current to minimise the effects of cross-modulation. Signals then pass through the 9MHz filter and on through a CA3028A 1st i.f. amplifier. Transmit and receive selection on this board is also accomplished by diode switching.

The 9MHz i.f. undergoes a second stage of amplification, again a CA3028A, located on board 1. From here, signals pass to the product detector which uses an MC1496. This receives its carrier insertion from the 9MHz oscillator board (board 2).

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.

The audio so produced is amplified by a 741 op. amp. and then by an LM380 to give adequate loudspeaker volume.

Automatic gain control is accomplished by the use of an SL621 a.g.c. system preceded by a clipper.

A relay is at present used to switch the antenna, the 12V/0V supplies required for the diode switching and the d.c. switching. Transistor switches could be used for the latter, but it was felt that as a relay was required for the antenna the spare contacts might as well be used to switch the necessary d.c.

Although not yet tried the only requirement on receive to produce a receiver on any amateur band between 160m and 10m is a change in v.f.o. frequency and one filter, with possibly more r.f. amplification on the high frequencies.

★ specifications

GENERAL

Single conversion with 9MHz i.f.

Frequency Range: Transmit 1·8–2·00MHz.
Receive 1·5–2·00MHz.

Modulation: A3J, upper and lower sideband (selectable). CW facility available.

Supply Voltage: 11·5–14V, 13·8V nominal.

Current Consumption: 500mA receive, 6A nominal peak transmit.

Frequency Stability: Less than 100Hz drift in any 30 minute period. (After initial warm up period at normal room temperature.)

Size: Case measurements 240mm deep × 190mm wide × 140mm high.

TRANSMITTER

Input Power:	45–55 watts } 12–13·5V
Output Power:	20–25 watts } 12–13·5V
Output Impedance:	50Ω
Microphone:	High impedance, dynamic type
Out of Band Spurious Radiation:	50dB down, on wanted signal at rated output. (80m output 50dB down, all other spurii >60dB down.)
Carrier Suppression:	45dB down relative to wanted signal.
In Band Ripple:	1·80–2·00MHz ±0·66dB.

RECEIVER

Input Impedance:	50Ω
RIT:	±2·5kHz
Preselector Range:	1·50–2·00MHz
Filter:	Centre frequency 9MHz.
Specifications:	8 Pole. Passband: 2·4kHz @ −6dB. 4·3kHz @ −60dB.
Audio Output:	1·5–2·00W (dependent upon supply voltage.)
Sensitivity:	0·3μV for 10dB S + N/N.
3rd Order Intercept:	−14dBm.
Loudspeaker Impedance:	8Ω

Circuit Description—Transmitter

Audio signals from the microphone are amplified by a 741 operational amplifier which feeds into the MC1496 balanced modulator. The microphone gain is controlled by means of a potentiometer located on the printed circuit board. Carrier injection, at 9MHz, is obtained from the carrier oscillator board and the output from the MC1496 modulator (double sideband suppressed carrier) is passed to the filter board.

The filter board acts in the same manner on transmit as it does on receive, with one exception. After the output from the CA3028A, and via the diode switch, the 9MHz single sideband undergoes a further stage of amplification through the broadband amplifier 3T2. The resultant signal is then fed to the mixer board.

9MHz s.s.b. signals are mixed and converted to 2MHz by means of the doubly balanced mixer. Switching required during transmit and receive is again accomplished by the use of a pin diode switch. The mixer board also contains one stage of 2MHz amplification via 4T2, a standard broad-band amplifier. This amplifier is the first in the 2MHz amplifier chain and the gain of the whole chain may be adjusted by altering the value of the un-bypassed emitter resistor. At the level at which it has been set however, no instability has been encountered and it is recommended that this resistor remains unaltered unless full output cannot be obtained. The low level s.s.b. at the output of 4T2 is then passed to the drive board via a band-pass filter F1.

The driver board uses three stages: first stage being in Class A and the other two being in parallel, operating in Class A. The output from this board is at approximately 1 watt, which is then transferred to a second band-pass filter F2 and finally to the p.a.

The p.a. consists of a pair of BDY90 switching transistors which operate satisfactorily at 2MHz. (They should, in fact, be OK to above 9MHz as they have an Ft of about 90MHz.)

These transistors are operated in class B at an input of approximately 50 watts. The broad-band transformers were wound using partly trial and error techniques to obtain the turns ratios eventually used. The BDY90s seemed fairly rugged devices and have sustained both short and open circuit loads under full output on more than one occasion without coming to grief. However, it is not recommended that this procedure is adopted too often! The output from the p.a. is fed through a low-pass filter and then to the antenna changeover relay.

General Constructional Notes

Due to the component density required for this project, the p.c.b. layouts must be rigidly followed. Most boards employ ground plane, double-sided techniques. Ensure adequate clearance for component leads as they pass through the copper ground plane layer. Countersinking of the holes is recommended, but do not countersink holes that are earth connections.

Components

Before purchasing the required components the lead-out spacings should be checked. The values of components should be exactly as shown: avoid using inferior quality types. The size of the 0·1μF capacitors must be reasonably small and the author had difficulty in obtaining the same size on a second purchase of both these and the silver mica capacitors.

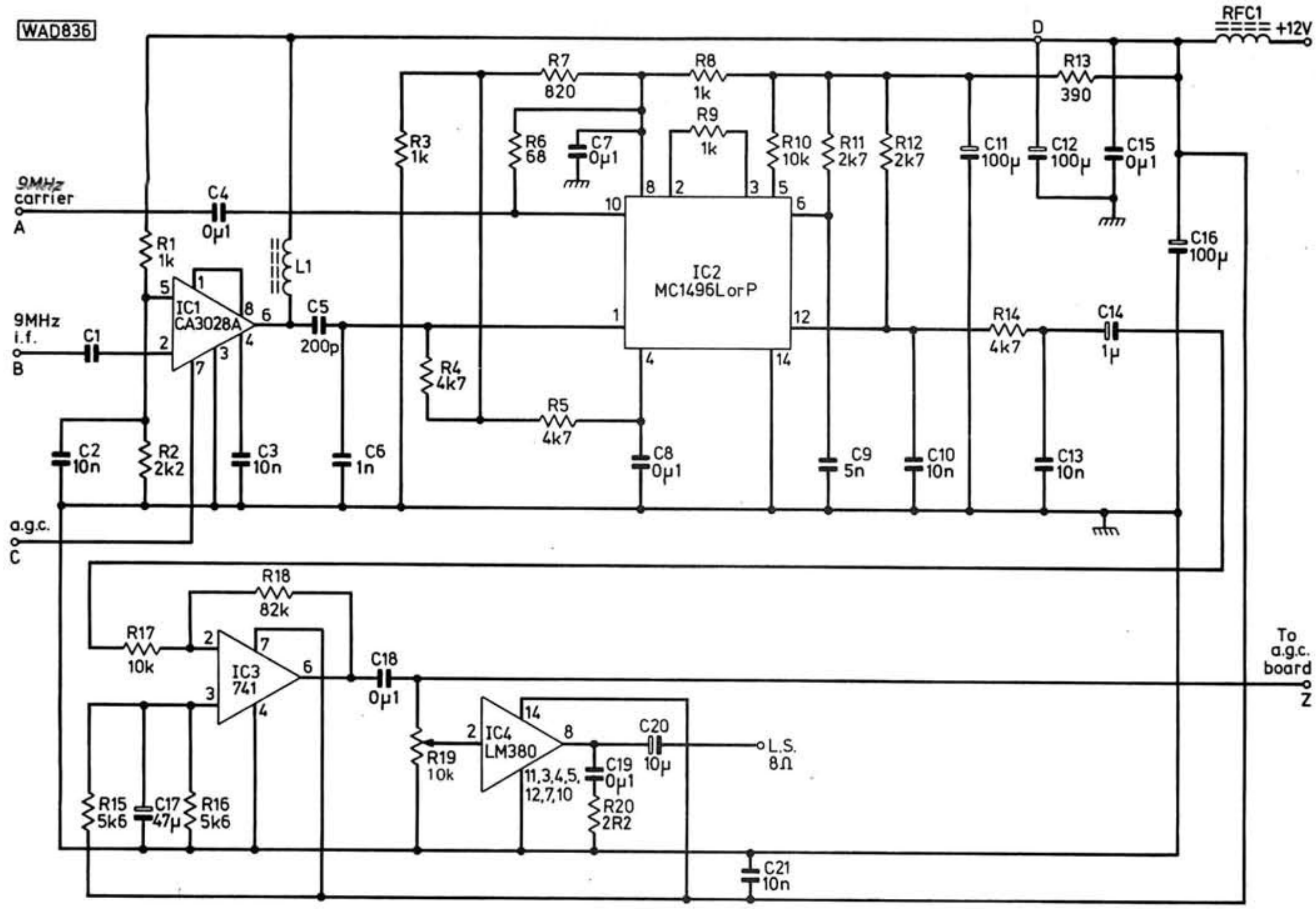
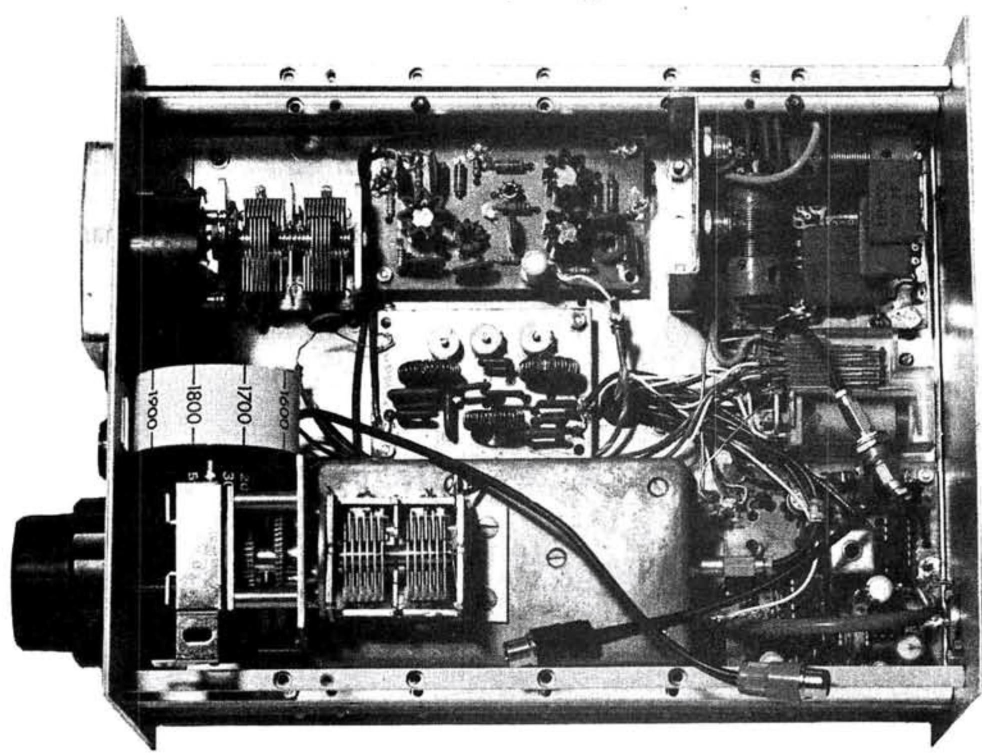


Fig. 2: Circuit diagram of board 1; i.f., product detector and audio stages. Below: Board 1 is located in the bottom right-hand corner of the prototype



The toroids in the broad-band circuits did not seem at all critical and other types would obviously work quite well. A high μ is however essential. The toroids associated with the filters however should not be substituted unless the filter is to be re-designed. The individual component lists will specify the correct grades, etc.

Wiring

It is essential that 50Ω screened cable is used where shown between boards. The miniature p.t.f.e. type of coax is ideal, but any cable with the correct impedance will suffice. The filters in particular will not be terminated correctly if other impedances are encountered.

Board 1—IF Product Detector and Audio Stages

Board 1 contains the following circuitry:

1. IC1, a CA3028A, 2nd i.f. amplifier.
2. IC2, an MC1496, product detector.
3. IC3, a 741, 1st audio amplifier.
4. IC4, an LM380, audio amplifier to provide loudspeaker drive level.

Circuit Description

A full circuit diagram of board 1 is shown in Fig. 2. Point B receives the 9MHz i.f. from the filter board (board 3). It is routed to pin 2 of IC1 via C1. This stage is operated in its cascode mode and has a typical power gain of 39dB at 10·7MHz. In conjunction with the preceding i.f. amplifier this would give a post filter gain of approximately 80dB. The output load to the CA3028 consists of the tuned circuit L1, C5 resonant at 9MHz, this inductor being slug tuned. The output is capacitively tapped into pin 1 of IC2 via C5 and C6.

IC2, an MC1496, makes an excellent s.s.b. product detector. According to the application notes on this device it has a sensitivity of 3μV and a dynamic range of 90dB when operating at an i.f. of 9MHz. The resistor between pins 2 and 3 controls circuit gain, sensitivity and dynamic range. Extra decoupling was found to be necessary which consisted of C11, R13. This cured any tendency towards audio instability and did not seem to reduce the overall gain of the device. The circuitry around IC2 is similar to that of the balanced modulator but has no facility for carrier null, this not being necessary on receive. The audio output appears at pin 12 and is routed to pin 2 of IC3 via R14, C14 and R17.

IC3, a 741 operational amplifier, is used here as the first audio amplifier with its gain set by the ratio of R18 to R17. Increasing R18 will increase the available gain. The audio output at pin 6 is fed via C18 and R19 to pin 2 of IC4. R19 is the volume control and is located on the front panel.

IC4, an LM380, is used as the audio power amplifier. This amplifier was chosen as it needed a minimum of components around it, is short circuit proof (essential at the author's QTH) and has internal thermal limiting. The voltage gain of this device is fixed internally at 50. The output power of 2 watts, appearing at pin 8, is fed to the 8Ω loudspeaker via C20. R19 used in the prototype was a 100k log potentiometer, but a value of 10kΩ was found to be a better proposition as IC4 had a tendency to latch on switch on. C19 and R20 were included to prevent any instability in the LM380.

Fig. 3 (above): Full size track pattern of the underside of board 1

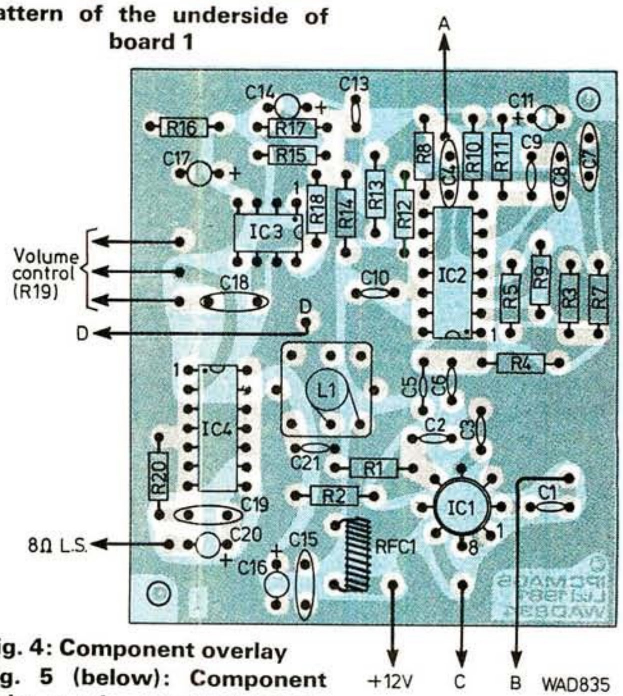
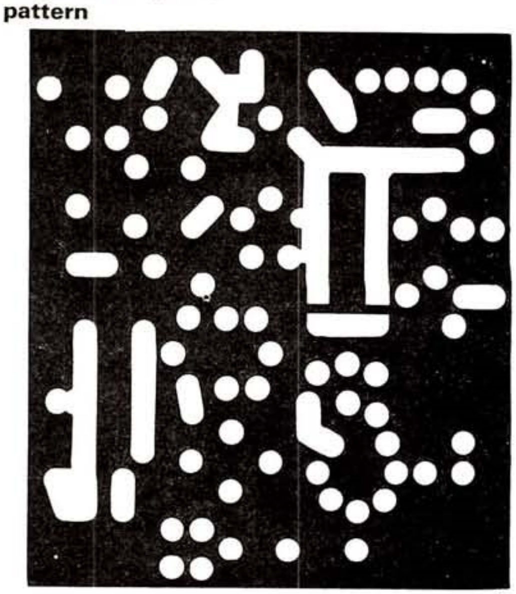


Fig. 4: Component overlay

Fig. 5 (below): Component side p.c.b. ground plane pattern



★ components

BOARD 1

Resistors
$\frac{1}{4}$W 5% Carbon Film

2·2Ω	1	R20
68Ω	1	R6
390Ω	1	R13
820Ω	1	R7
1kΩ	4	R1,3,8,9
2·2kΩ	1	R2
2·7kΩ	2	R11,12
4·7kΩ	3	R4,5,14
5·6kΩ	2	R15,16
10kΩ	2	R10,17
82kΩ	1	R18

Potentiometer
Panel Mounting

10kΩ log.	1	R19

Semiconductors
Integrated Circuits

CA3028A	1	IC1
MC1496 LP	1	IC2
741	1	IC3
LM380	1	IC4

Capacitors
Resin Dipped Ceramic

1nF	2	C1,6
5nF	1	C9
10nF	5	C2, 3, 10, 13, 21

Sub-min Ceramic

200pF	1	C5

Disc Ceramic

0·1μF	6	C4,7,8,15,18,19

Tantalum Electrolytic

1μF	1	C14
10μF	1	C20
47μF	1	C17
100μF	3	C11,12,16

Miscellaneous
RFC1 20 to 30 turns of 32 to 38 s.w.g. wire on 28-002-27 toroid; L1 15 turns of 38 s.w.g. wire on Neosid inductance assembly type A6; printed circuit board.

The radio frequency choke and C15 provide r.f. decoupling to the board. This was found to be necessary when hooking the various boards together on the bench during preliminary tests on the receiver section.

The 9MHz carrier insertion enters at point A and, via C4, is routed to pin 10 of the MC1496. The a.g.c. voltage is applied to pin 7 of the CA3028 at point C. Point B is the 9MHz i.f. input to pin 2 of IC1.

To prevent any r.f. breakthrough during transmit the 12V supply is connected to this board during receive only via relay connections.

Constructional Details

The board is constructed on a double sided glass fibre p.c.b. and Vero pins are used for all external connections. It is important that the d.i.l. package is obtained for IC2 (this is also available in other forms). Similarly, the TO5 style package for IC1 and 14 pin d.i.l. package for IC4 are used.

R6, a 68Ω resistor, is connected between pins 10 and 8 of IC2 on the underside of the board.

A 100μF decoupling capacitor, C12, is included to ensure adequate audio decoupling. This capacitor is joined between point D (see component layout) and the earth plane on the top of the board.

Two holes between C13 and R8 are not used. A resistor was originally used between the input (point B) and earth, consequently there are two spare holes at this point also.

Connections to Board 1

Point A connects to the 9MHz oscillator on board 2, point Y. Point B connects to filter board 3, Y out. Point C connects to a.g.c. voltage, board 8 a.g.c. 0/9V. The +12V line connects to the +12V rail via relay contacts, during receive only. Point Z, the top of R19, volume control, connects to the a.g.c. board 8.

NEXT MONTH

The second part of this article will cover the construction of the 9MHz oscillators, filter and mixer boards.

BI-PHASE COMPARATOR

▶▶▶ *continued from page 21*

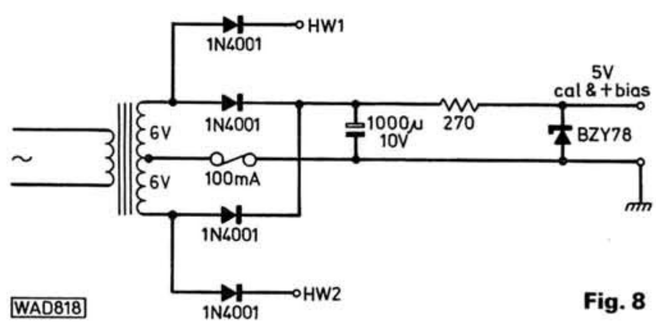


Fig. 8

For convenience, the bias controls are calibrated during construction using a multimeter temporarily wired for reference. Volts for valves, microamperes for transistors.

Practical Circuits

The valve versions of the bi-phase power supply and comparator are shown in Figs. 5 and 7 and that for transistors in Fig. 6. The valve power supply, Fig. 7, has provision for 6·3 volt heaters, negative bias and a stabilised voltage of 105 volts for the screen grids and calibration source. The transistor power supply in Fig. 8 has a 5·2 volt stabilised voltage for calibration and current bias source.

The two additional diodes in Fig. 6 are needed in the transistor comparator so that current in R1 or R2 is not diverted through the non-conducting transistor. ●