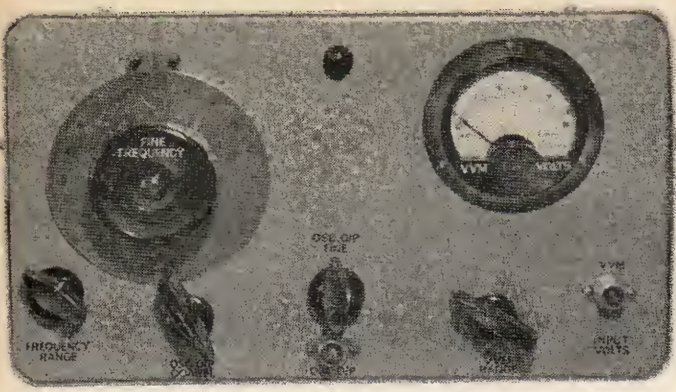


AUDIO OSCILLATOR & VALVE VOLTMETER

PART ONE

By H. T. KITCHEN

SPECIFICATION

Oscillator

Frequency Range	Output
1. 25c/s to 250c/s	1. 10 volts
2. 250c/s to 2,500c/s	2. 1 volt
3. 2,500c/s to 25kc/s	3. 100 mV
4. 25kc/s to 250kc/s	4. 10 mV

The range and output are continuously variable.

Distortion 0·2% 100c/s to 25kc/s;
0·5% 25c/s to 100kc/s
Frequency response ±1dB 25c/s to 50kc/s;
± 2dB 25kc/s to 150kc/s

Valve Voltmeter

Input Range
1. 500 volts
2. 50 volts
3. 5 volts
4. 0·5 volt
5. 0·05 volt

Frequency response on ranges 3, 4, and 5 only:
±1dB 25c/s to 50kc/s;
±2dB10c/s to 150kc/s

MANY AMATEURS who take audio seriously, progress to the stage where they want to carry out tests on equipment they already possess, or may be building to perform a particular task. In order to make these tests, suitable equipment is necessary and it is at this stage that the short-comings of the multi-range testmeter are often revealed owing to the shunting properties of the relatively low resistance meter coil. The acquisition of a valve voltmeter can prove to be an expensive proposition, unless one is able to build such an instrument himself.

This article sets out a suitable specification which combines an audio frequency oscillator with a valve voltmeter in one cabinet, without incurring excessive expense, while at the same time being reliable and reasonably simple to construct. Care had to be exercised to avoid instability in the h.t. line by using generous smoothing and decoupling arrangements to reduce this to an immeasurably low value. All the components are conservatively rated to provide long life, to minimise heat dissipation, and to obtain good frequency stability of the a.f. oscillator.

It is not intended to give point-to-point instructions, since it is felt that the complete unit will appeal more to the advanced constructor, who will not only be able to work from the information given, but will most probably modify it to suit his own requirements and whatever components he has to hand. The less experienced constructor however, should be able to build the unit provided he is capable of working from a circuit diagram used in conjunction with a wiring layout.

Standard, easily obtained components are used throughout with one exception—the thermistor. It is the author's experience that an order placed for the thermistor may take up to six weeks to materialise although some shops do stock them. With regard to the other components, buying new, or carefully and thoroughly tested old ones, is the best guarantee of success; too much otherwise excellent equipment may be rendered virtually useless because of salvaged and untested components being used.

CASCODE

Several commonly used circuits were considered and the reason why the present circuit was chosen may prove of interest. There are two basic forms of a.c. voltmeter using valves or transistors.

The first type the "rectifier/amplifier" is commonly used for r.f. measurements and usually consists of a diode rectifier followed by a high gain d.c. amplifier. The d.c. amplifier has to be carefully designed to guard against drift, and the rectifier requires several hundred millivolts across it to provide a reasonably linear scale, this precluding all very low voltage measurements. This type, therefore, is almost automatically excluded for most audio frequency work.

The second type is the "amplifier/rectifier" and is most suited for audio frequency measurements, for with careful design, a full scale deflection can be obtained for an input as low as 1mV. Some very expensive commercial instruments are even more sensitive but are seldom necessary to most amateurs.

The "amplifier/rectifier" meter can again be divided into two basic types: cascade amplifiers and cascode amplifiers. A glance at the circuit diagram of a television turret tuner will show that the r.f. amplifier is almost always cascode connected, providing high gain and good bandwidth, this being the reason for the present choice of circuit shown in Fig. 1.

Cascade amplifiers are capable of providing very high gain, but due to "Miller" and other esoteric effects, the h.f. response is rather restricted and decreases further as more stages are added to try to increase the overall gain. Cascode amplifiers on the other hand have an enhanced h.f. performance for a given gain and with care can be made very stable.

METER CIRCUIT

Referring to Fig. 1., V1 is the cascode stage where V1a, which has R8 as its anode load, acts as the anode load of V1b. Resistors R1 to R5 form the input potential divider and should be of the best quality possible, for any change of resistance or noise generated here will affect the meter reading. C1 serves to block any d.c. voltage which might be present, such as the ripple voltage on an h.t. line which is being measured. R10 and R12 form the bias resistors for V1a and V1b, and also the potential divider for applying negative feedback. C3 is the normal cathode decoupling capacitor.

The signal from the anode of V1a is direct coupled to the grid of V2a, which functions as a cathode follower. Since its input impedance is high V1b is only lightly damped to prevent undue loss of h.f. performance. Lack of phase reversal in V2a means that negative feedback can be applied from the anode of the output stage (V2b) to the cathode of V1b.

The amplified output from the anode of V2b is applied via C7 to four GEX34 germanium rectifiers connected in bridge form to the meter. C8 is provided to damp the needle movement.

C6 is the cathode bias capacitor connected across R16 and has the low value of 1μF. At low frequencies C6 has very little effect on the gain of V2b, since its reactance is high in comparison with R16. As the frequency across C6 increases, its reactance decreases shunting R16 more and more, hence increasing the gain of V2b and compensating for voltage losses at high frequencies. The junction of D3 and D4 is returned to the junction of C3, R10, and R12, via R11.

During calibration R12 is adjusted so that the meter reading corresponds to a given input. In the prototype a value of 33 ohms was just right, but due to component tolerances it may require adjusting in subsequent models. It may be easier to substitute a wirewound potentiometer with a resistance of 50 or 100 ohms.

OSCILLATOR

Fig. 2 gives the circuit of the audio oscillator, which is based on a conventional Wein bridge with three EF80 valves, the first two forming the oscillator proper and the third being arranged as a cathode follower.

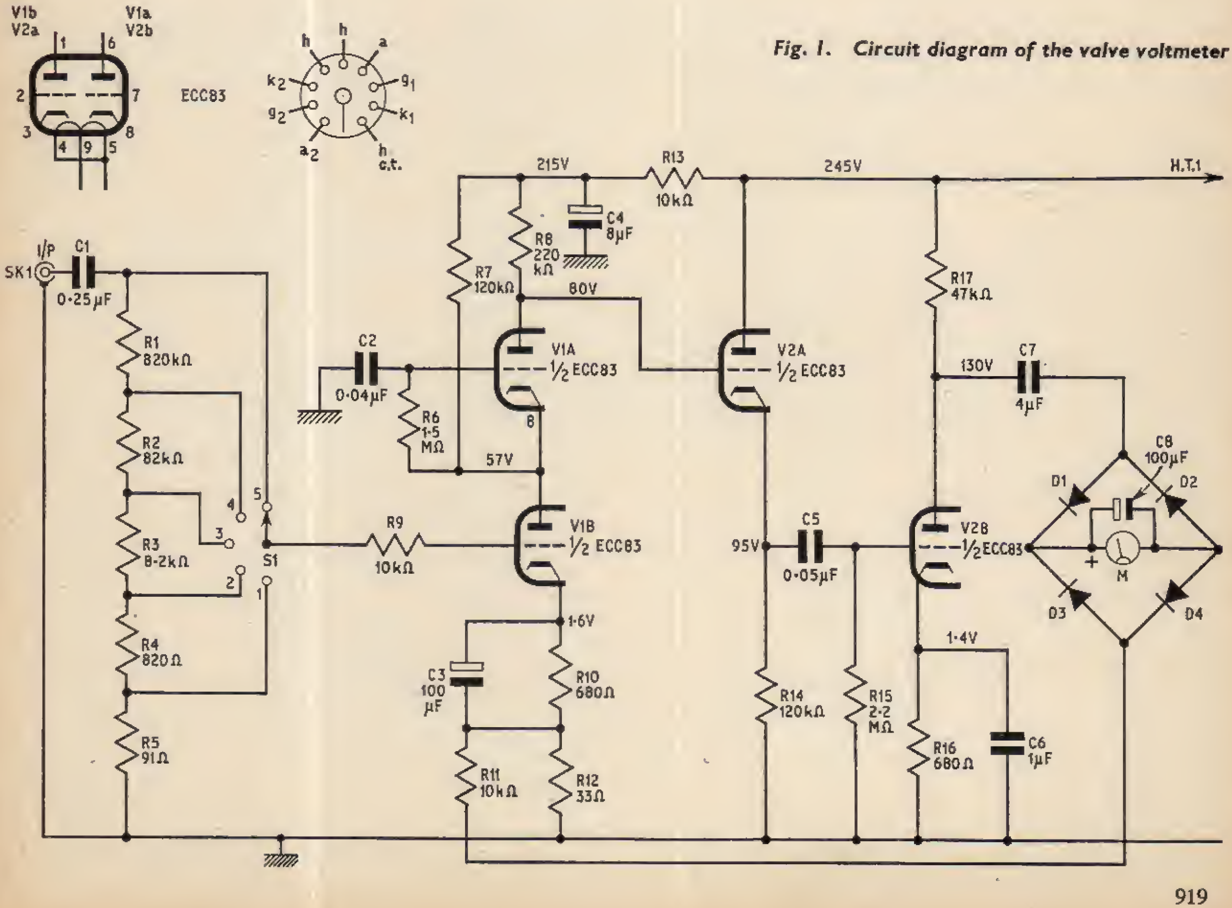
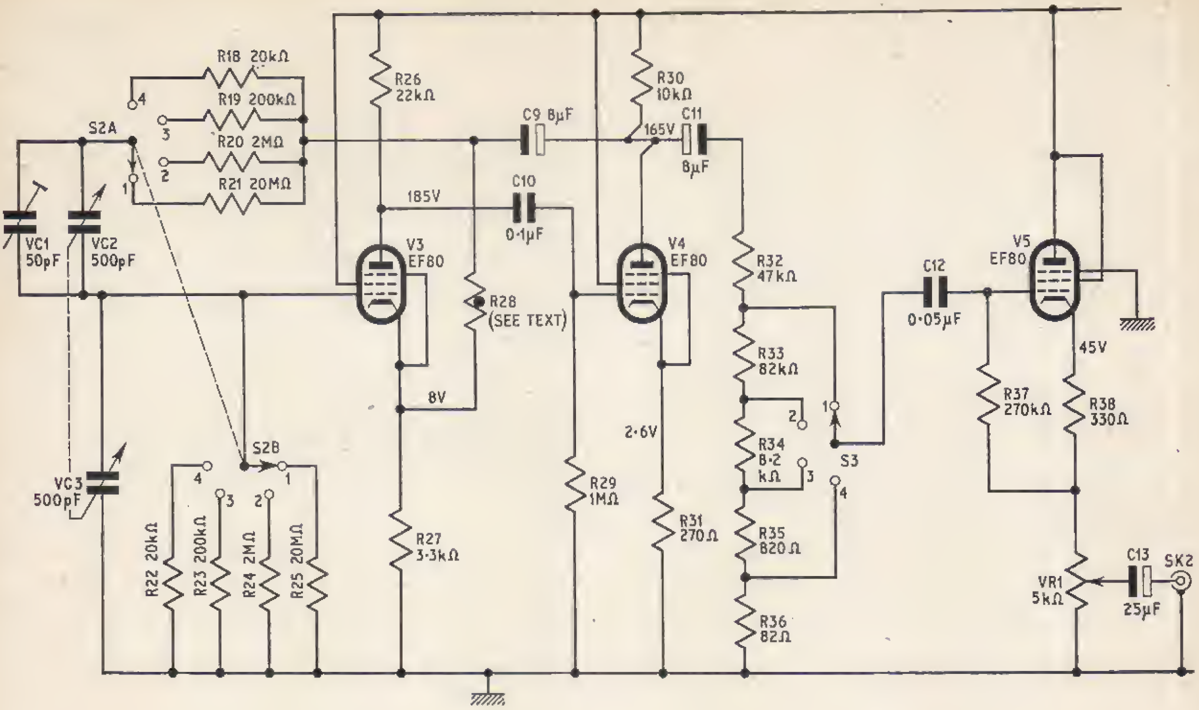


Fig. 1. Circuit diagram of the valve voltmeter



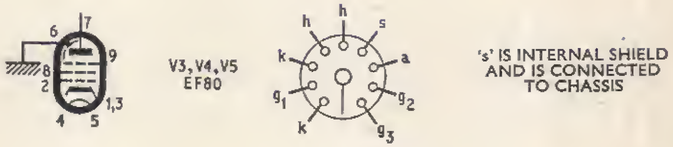


Fig. 2. Circuit diagram of the audio oscillator

Although the ouput could be taken from the anode of V4 the small extra expense of a cathode follower is well worth while, since it completely isolates the oscillator section from the effect of varying loads, so preventing unwanted deviations in frequency.

The cathode follower loads, from infinity (open circuit) to zero (short circuit), have no noticeable effect on the frequency and in fact the output can be connected directly to a loudspeaker under test, although the applied voltage will be very low.

V3 and V4 are used to form the oscillator, of which the frequency determining components are VC2, VC3 and R18 to R25, the resistors being selected by S2a and S2b. The lowest frequencies are obtained with the highest value resistors (range 1) and with VC2 and VC3 at maximum capacitance. The frequency of oscillation is given by

$$f_0 = \frac{1}{2\pi\sqrt{(R_1R_2C_1C_2)}}$$

where R_1 includes the valve and load resistances in parallel. The required voltage gain is

$$N = 1 + \frac{R_1}{R_2} + \frac{C_2}{C_1}$$

Since $R_1 = R_2$ and $C_1 = C_2$, f_0 is inversely proportional to R and C and the output voltage is a third of the input, or 9·5dB. If the gain of the oscillator valves, and their phase shift, can be kept at 9·5dB and zero degrees respectively, the valves will oscillate at a frequency equal to f_0. From the anode of V3 the signal is passed to the grid of V4, which brings about the phase reversal necessary for oscillation, and returns the signal to V3 via C9 and the frequency determining components.

To minimise unwanted phase shift in the oscillator valves, which could upset the oscillator frequency, negative feedback is introduced into the cathode of V3 by means of thermistor R28. This also stabilises the oscillator output keeping the amplitude constant within 2dB over the entire range and within 1dB up to 50kc/s.

From the anode of V4 the signal is fed via C11 to a coarse attenuator which introduces 60dB attenuation in three 20dB steps, providing outputs of 10V, 1V, 100mV and 10mV, which can be further attenuated by VR1 acting as a fine output control.

POWER SUPPLY UNIT

Fig. 3 shows the power supply circuit which is quite simple and calls for no special comment. C16, and C17 in conjunction with the l.f. choke form the main smoothing components, while R38, C14, R39 and C15 provide further smoothing and assist in decoupling the two h.t. supplies which are considerably ripple free. Cross-modulation between the oscillator and meter circuit via the h.t. has not been detected.

CHASSIS

The chassis should be constructed from a sheet of 18 s.w.g. aluminium 16¼in × 11¼in drilled and bent in accordance with Fig. 4. The valve holder and

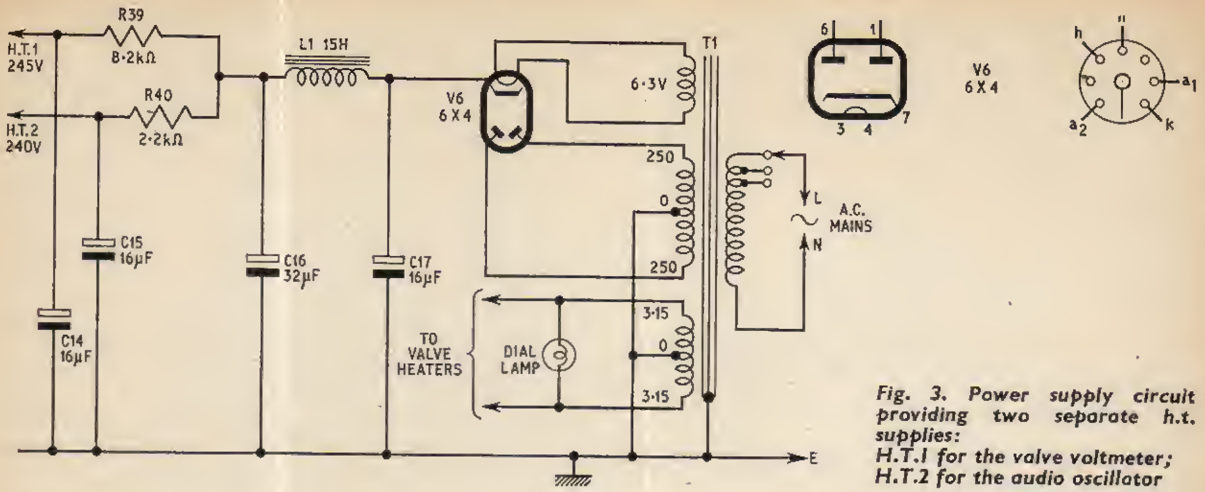


Fig. 3. Power supply circuit providing two separate h.t. supplies: H.T.1 for the valve voltmeter; H.T.2 for the audio oscillator

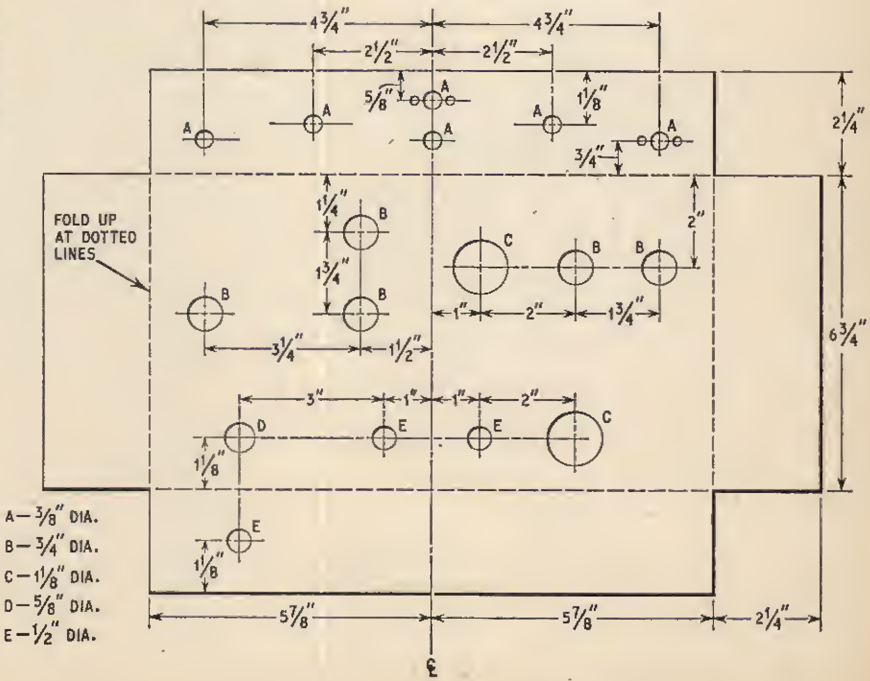
smoothing capacitor holes should be positioned as shown. The remaining components should then be placed in position and the positions of the fixing holes marked and drilled or filed out. Although the controls along the front of the chassis are shown staggered, they can if so desired be placed in a straight line, the size of the components actually used being taken into consideration.

When the last hole has been cut out the chassis should be cleaned and painted; hammer-finish paint is quite attractive but is by no means essential.

Dimensions for the front panel are not given since they depend on the meter actually used and upon the height of the tuning capacitor spindle from the chassis. Jackson Brothers supply a small template with the dial so no difficulty should arise on this score. The holes for the controls and coaxial sockets are accurately marked out by aligning the finished chassis with the front panel and scribing through. The greatest care should be exercised when working on the front panel and cabinet, for nothing looks worse than scratches and gouge marks where the file or drill slipped.

Two small screens should be made from aluminium to enclose the two range switches S1 and S2, these being shaped and dimensioned as required. The screen round S2 could perhaps be dispensed with without any ill effects but the screen round S1 is essential, because any hum picked up by the range resistors will show up as

Fig. 4. Drilling details of the whole chassis giving the positions of the main components to be mounted. Small holes for nuts and bolts are not detailed since they can be marked from the components used



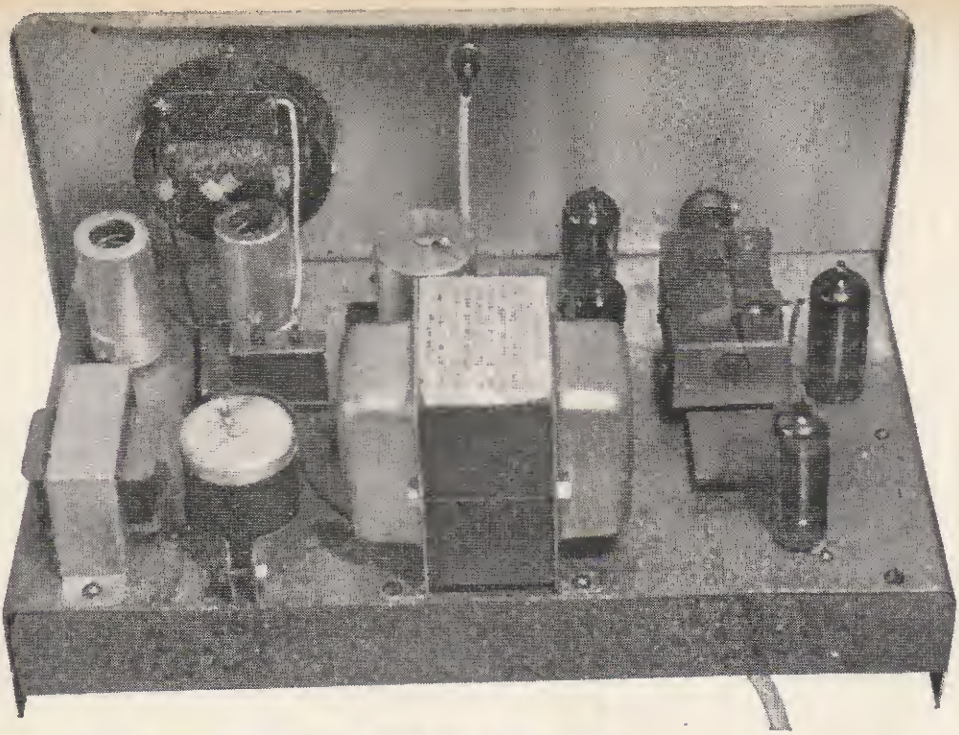
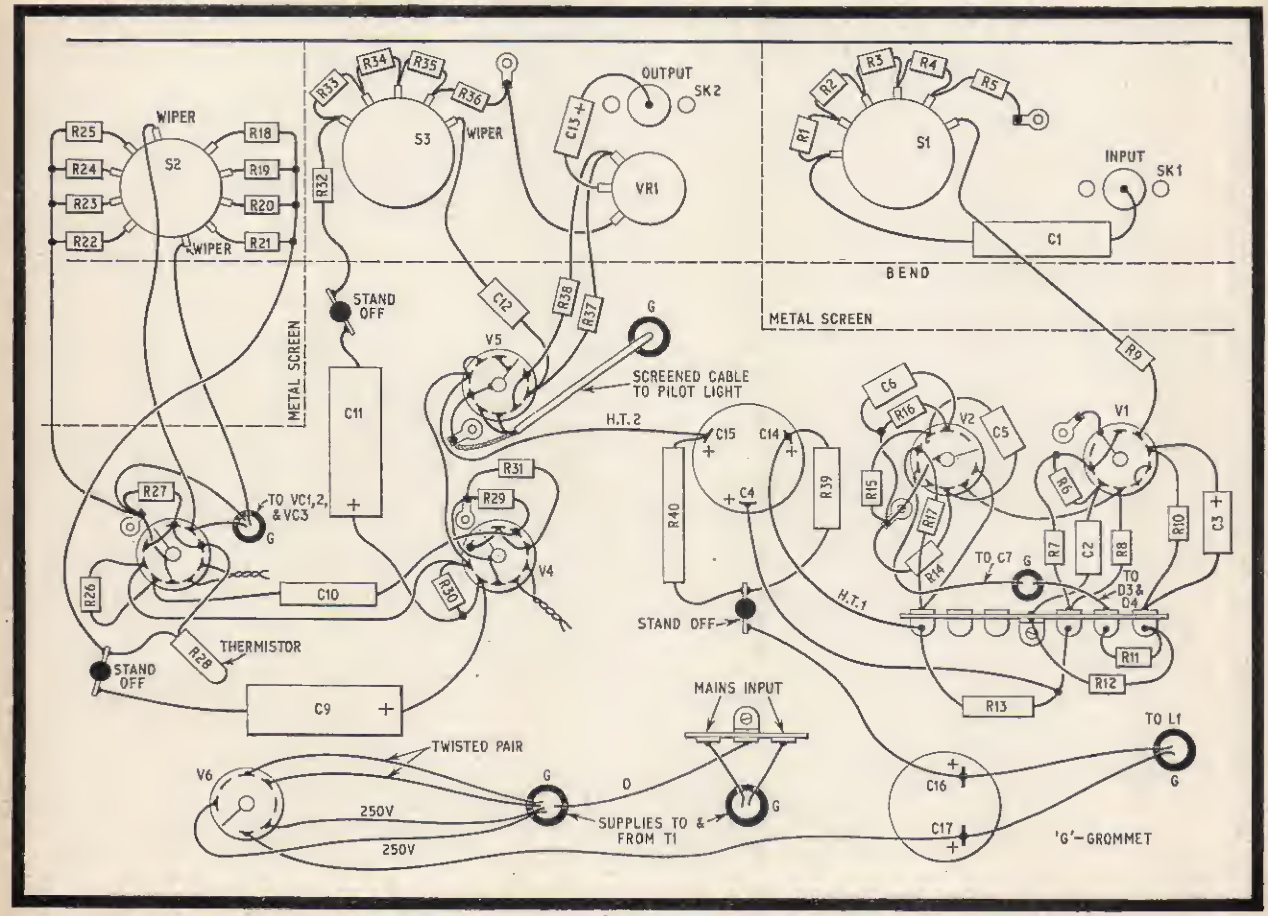


Fig. 5 (below). Layout of components on the underside of the chassis



COMPONENTS . . .

Resistors

R1 820kΩ
R2 82kΩ
R3 8·2kΩ
R4 820Ω
R5 91Ω
} 1% high stab. ½ watt

R6 1·5MΩ
R7 120kΩ
R8 220kΩ
R9 10kΩ
R10 680Ω
R11 10kΩ
} 5% ½ watt.

R12 33Ω (see text)
R13 10kΩ 10% 1 watt

R14 120kΩ
R15 2·2MΩ
R16 680Ω
R17 47kΩ
} 5% ½ watt

R18 20kΩ
R19 200kΩ
R20 2MΩ
R21 20MΩ
R22 20kΩ
R23 200kΩ
R24 2MΩ
R25 20MΩ
} 1% high stab. ½ watt

R26 22kΩ 5% ½ watt
R27 3·3kΩ 5% ½ watt
R28 200kΩ Thermistor type A5513/100 (S.T.C.)

R29 1MΩ
R30 10kΩ
R31 270Ω
} 5% ½ watt

R32 47kΩ (see *Calibration* in part 2)

R33 82kΩ
R34 8·2kΩ
R35 820Ω
R36 82Ω
} 1% high stab. ½ watt

R37 270kΩ 5% ½ watt
R38 330Ω 5% ½ watt
R39 8·2kΩ 10% 2 watt
R40 2·2kΩ 10% 2 watt

Potentiometer

VR1 5kΩ linear carbon miniature

Capacitors

C1 0·25μF paper 500V
C2 0·04μF paper 500V
C3 100μF elect. 25V
C4 8μF elect. 350V (in same can as C14 and C15)
C5 0·05μF paper 250V
C6 1μF paper 150V
C7 4μF paper 250V
C8 100μF elect. 25V
C9 8μF elect. 450V
C10 0·1μF paper 350V
C11 8μF elect. 450V
C12 0·05μF paper 250V
C13 25μF elect. 25V
C14 16μF elect. 350V
C15 16μF elect. 350V
} (in same can as C4)
C16 32μF elect. 350V
C17 16μF elect. 350V
VC1 50pF trimmer
VC2 500pF
VC3 500pF
} twin ganged miniature

Valves

V1a and V1b ECC83
V2a and V2b ECC83
V3, V4, V5 EF80 (3 off)
V6 6X4

Diodes

D1–4 GEX34 or OA79 (4 off)

Switches

S1 Single-pole, 5-way rotary
S2 Two pole, 4-way rotary
S3 Single pole, 4-way rotary

Transformer

T1 Mains transformer. Secondary windings: 250–0–250V 60mA; 3·15–0–3·15V 2A; 6·3V 2A (Ellison type MT161)

Inductor

L1 15H 50mA l.f. choke

Miscellaneous

M1 1mA f.s.d. 100Ω moving coil meter LP1 6-volt miniature indicator lamp (Bulgin)
Five B9A valveholders with screens, two of which should have p.t.f.e. bases for V1 and V2
Chassis and metal case 12in × 7in × 7in (H. L. Smith & Co. type Y)
Dial type 4489 (Jackson Bros.). Two clips for mounting large capacitors (see photograph)
Coaxial input and output sockets (with plugs) 7-way and 3-way tag strips
Rubber grommets; knobs; 4B.A. and 6B.A. nuts, bolts, and solderings tags.

a deflection on the meter. A small hole should be drilled in the screen of S1 directly in line with the wiper tag of S1 and the "grid" tag of V1a. R9 should be passed through it, and wired as near to the grid as possible.

Two small pieces of s.r.b.p. or perspex sheet are required to carry the tuning capacitor and the four germanium diodes on the meter (Fig. 6). The frame of the tuning capacitor is connected to the grid of V3. It must be insulated from the chassis by being bolted to the s.r.b.p. or perspex which is in turn bolted to the chassis. The size used in the original was 4in × 1in, this was bolted to the chassis by means of a 4 B.A. screw at each end, the front screw serving to hold the screen round S2 under the chassis. An *insulated* coupler is essential between the tuning capacitor spindle and the dial which is earthed.

The piece of perspex or s.r.b.p. used for the meter diodes is 2in × 1½in, four holes being drilled in it, two 6 B.A. clearance and two 2 B.A. clearance. A 6 B.A. earth tag is screwed to each of the two smaller holes; the s.r.b.p. is attached directly to the meter terminals by means of the two larger holes, a 2 B.A. tag being placed on each terminal before the fixing nuts are tightened. The diodes are then soldered directly to these tags using heat shunts and leaving the leads as long as possible. Note the polarity of the diodes.

If the diodes are made to stand away from the panel room will be found for C7, which is soldered across the two 2 B.A. tags, again observing polarity. With the GEX34 the red end corresponds to the cathode of a thermionic diode and should therefore go to the positive terminal of the meter, as should the positive end of C7.

Next month: Calibration