INEXPENSIVE OSCILLOSCOPE

By
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PART TWO

THE construction and layout of the oscilloscope is clearly shown in various detailed drawings and photographs included in this month's article.

As will be noted, tag boards and tag strips are used extensively throughout for the mounting of the smaller components, both above and below the chassis. The large block capacitors, mains transformer and smoothing choke are mounted on the top; also on the top are the tag boards associated with the e.h.t. supply, calibration unit and attenuator. The actual layout above and below the chassis can be seen from Figs. 5, 6 and 7.

METAL WORK

Both the chassis and the front panel are made from $\frac{1}{16}$in aluminium sheet. Drilling details for the front panel are given in Fig. 4, while the chassis dimensions and drilling details appear in Fig. 5. The various brackets and clamps for the tag boards, c.r.t. mounting, etc., are also made from the same material.

It is advisable to cut out all the larger holes in the chassis before bending, the smaller holes being marked off from the actual components and drilled to suit. Few dimensions other than for valveholder centres, transformer, choke, and c.r.t. are given as the actual size of tag boards and components used will vary somewhat between individual units. The position of all parts is obvious, however, from the drawings and sufficient space is available to compensate for any differences in dimension which may occur.

It will be noted from the drawings that the mains switch S1 is mounted at the rear of the chassis. This saves having to run two lengths of mains lead the full length of the chassis—as would have to be done if the switch were on the front panel—and so prevents the pick-up and screening problems which would ensue if such an operation were carried out.

SCREENED LEADS

It will also be noted that quite a number of screened leads are used throughout in the wiring. Here again this is to prevent stray pick-up and interaction between circuits. The use of screened leads also allows much more freedom in circuit layout. Generally speaking, the components associated with a particular stage are mounted on the tag board or strip next to that stage, the connecting leads to the valve pins being short and direct. Some of the components however, particularly bias and grid return resistors, can be wired directly between the valve pins and a suitable earth tag or tag strip. The positioning of the various earth tags is shown in the appropriate drawings.

It may be mentioned that the layout in general is by no means critical. Those parts of the circuit with which rather more care should be taken are the first section of the Y amplifier and synchronising sections. Here, the leads should be kept as short as possible and well away from heater wiring, etc.

The heater leads themselves should consist of tightly twisted twin wire and should be wired in first, being laid along the bottom of the chassis. The sequence of heater wiring should be transformer x-x to V2, V3, V6, V5, and V4, in that order. The heater centre tap and h.t. secondary centre tap should be earthed together with the incoming mains earth lead to the earth tag on the rear of the chassis under the fixing screw of T1 (see Fig. 6). The heater wiring should be kept as clear as possible from the various valve component tagboards and associated wiring.

The e.h.t. and calibration components should be wired up on their tag boards as shown in Fig. 9 and flying leads provided for the various input and output connections. The tag boards are then mounted vertically on their brackets to the chassis (see Fig. 5). The flying leads can be made off later to fit in with existing wiring runs. This procedure not only makes construction simpler but gives a much neater appearance when finished.

If K3/25 rectifiers are used in place of OA210s, they will be found to be too large to mount on the tag board; they can, however, be mounted vertically between tag strips on the back of the bracket which supports the base of the tube.

The Y attenuator resistors are also mounted on a tag board with short leads connected (see Fig. 9), the tag board is then mounted vertically as close as is practicable behind S3 (see Figs. 5 and 6), to which the leads are then connected, these being kept as short as possible. C11 is connected directly between the input coaxial and OZ sockets, and S3. The earth tag on the rear of the coaxial socket and the earth tag on the base of V2 should be connected together, all earth

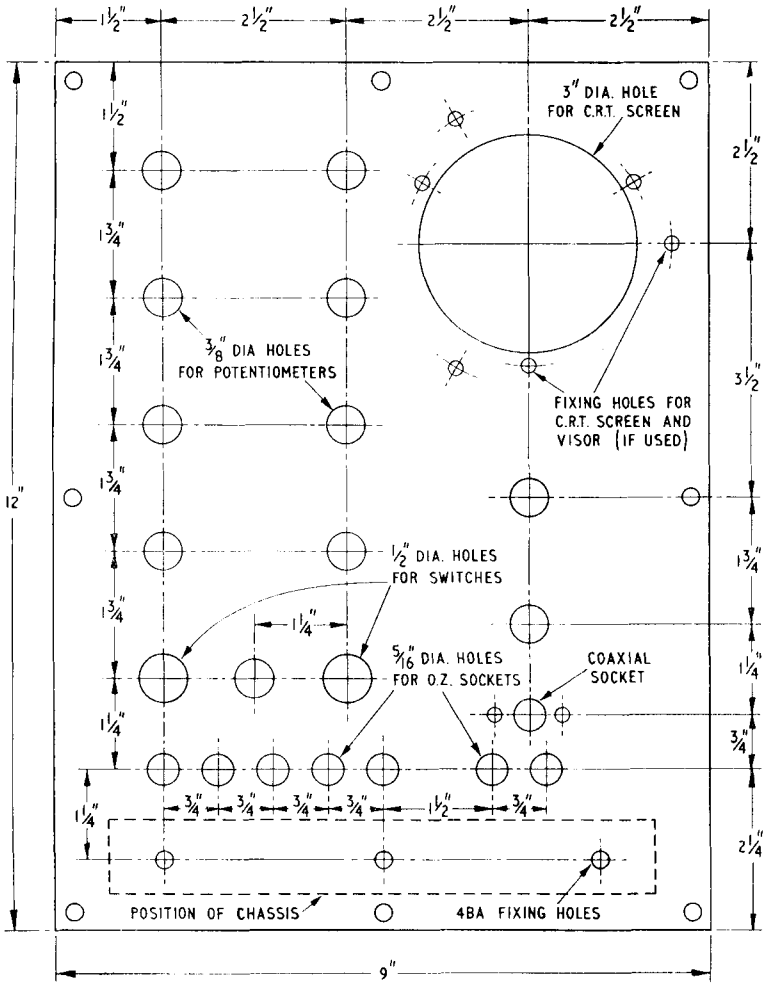


Fig. 4 (left). The front panel drilling details. This panel consists of a piece of aluminium sheet $\frac{1}{16}$in thick

Fig. 5 (facing page, top). Plan view of the top of the chassis. All essential dimensions for the construction of the chassis appear in this diagram or in Fig. 6 immediately below. Details of the visor are also included

Fig. 6 (facing page, bottom). Side view of the complete assembly. Here are included certain dimensions not shown in the plan view, Fig. 5. The location of all the major components is indicated, but the wiring is omitted

connections in the attenuator circuit and V2 circuit being taken to this common earth line. All other wiring should be kept well away from this part of the circuit.

WIRING UP THE CONTROLS

The various wires to the front panel controls are brought up from beneath the chassis through a number of grommets situated along the front of the chassis. Wiring from the c.r.t. base to the e.h.t. board is quite short as this board is mounted quite near the tube base. The e.h.t. leads to the focus and brilliance controls are rather long, but this does not matter as they are only carrying d.c. and are effectively decoupled.

The connections between the amplifier outputs and the tube deflection plates should be wired correctly, i.e. V3a anode must be connected to Y1 on the tube. This ensures that the convention of positive going signals giving an upwards deflection and the time base scan going from left to right is maintained.

If the 3BP1 tube is used, it should be mounted in the position shown in Fig. 11. Looking at the base end of the tube the spigot should be approximately 40 degrees anticlockwise from the lower vertical axis. This ensures that the time base line lies in the horizontal plane.

Types 3EP1 and 3GP1 should be mounted with their spigot at bottom centre. This is also shown in Fig. 11.

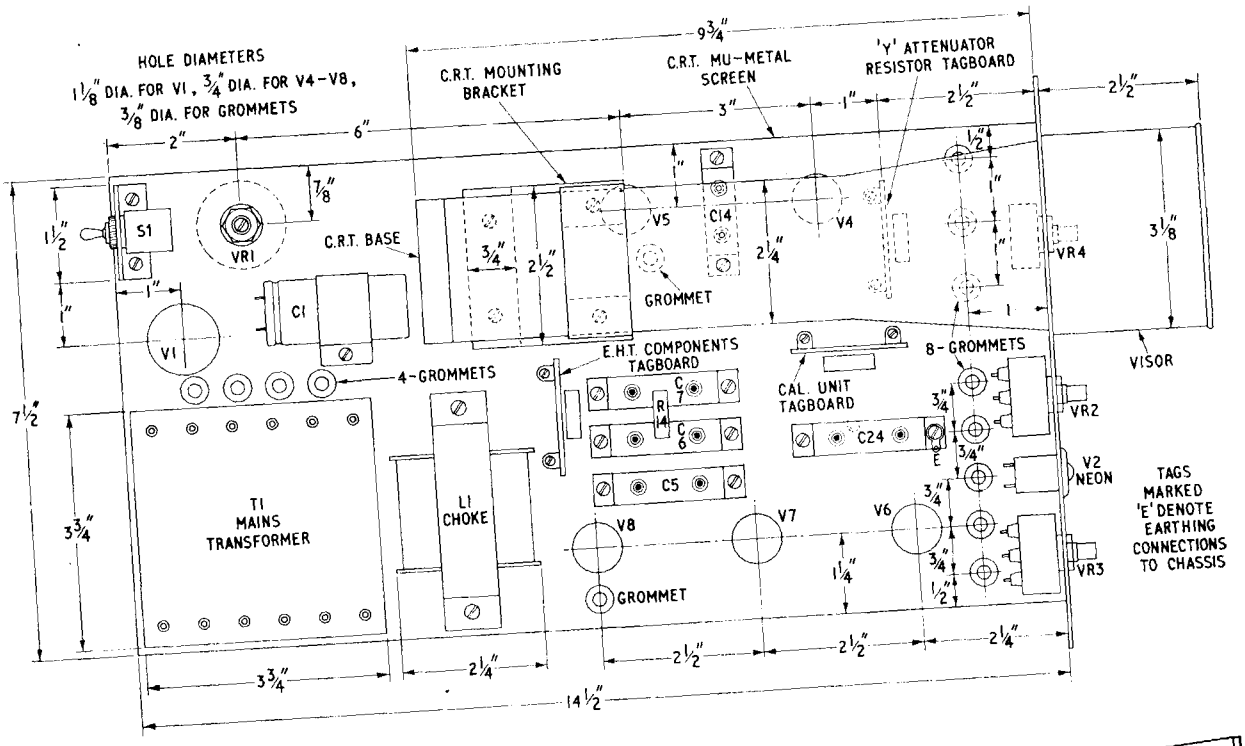
Any final adjustment to the c.r.t. orientation can be made later with the oscilloscope in operation, after which the base clamp is locked in position.

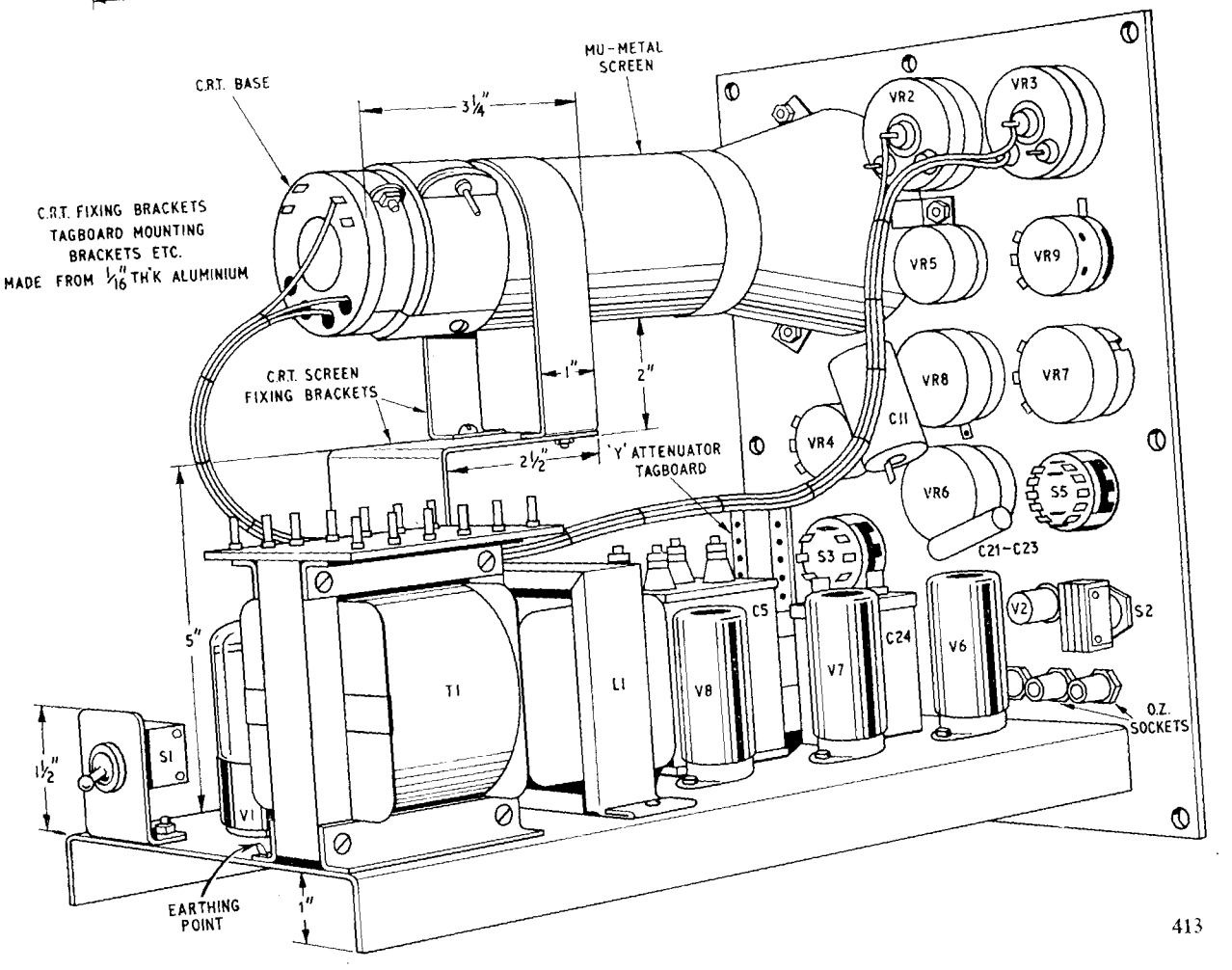
Base connections for the three types of tube previously mentioned (3BP1, 3EP1 and 3GP1) are given in Fig. 11.

Perhaps it should be repeated at this juncture that all the above mentioned tubes are American surplus types. Although type 3BP1 is used by the author, the other two alternatives are very similar and can be used with confidence. Any minor readjustments that may be necessary for the 3EP1 or 3GP1 tubes will be described in the final article in this series which will deal with testing and setting up the oscilloscope.

MU-METAL SCREEN

The mounting and fixing arrangements for the mu-metal screen can be seen in Figs. 5 and 6. This arrangement can be varied to suit individual requirements, as the clamping and fixing arrangements tend to vary slightly depending upon the type of screen obtained. There is ample space on the chassis to meet the various requirements and, as mentioned previously, the layout is not too critical so that the component layout on top of the chassis may be slightly rearranged if necessary.


HOLE DIAMETERS
1⅛" DIA. FOR V1, ¾" DIA. FOR V4-V8,
⅜" DIA. FOR GROMMETS
C.R.T. MOUNTING BRACKET
C.R.T. MU-METAL SCREEN
'Y' ATTENUATOR RESISTOR TAGBOARD
9¾"
3"
2"
6"
1"
2½"
1½"
7/8"
S1
V1
C.R.T. BASE
V5
C14
V4
VR4
3⅛"
GROMMET
C1
V1
4-GROMMETS
E.H.T. COMPONENTS TAGBOARD
8-GROMMETS
VISOR
CAL. UNIT TAGBOARD
C24
VR2
V2 NEON
TAGS MARKED 'E' DENOTE EARTHING CONNECTIONS TO CHASSIS
7½"
3¾"
T1 MAINS TRANSFORMER
L1 CHOKE
C5
V8
V7
V6
VR3
1¼"
GROMMET
3¾"
2¼"
14½"


C.R.T. FIXING BRACKETS
TAGBOARD MOUNTING
BRACKETS ETC.
MADE FROM 1/16" THK ALUMINIUM
C.R.T. BASE
MU-METAL SCREEN
3¼"
C.R.T. SCREEN FIXING BRACKETS
1"
2"
2½"
'Y' ATTENUATOR TAGBOARD
VR2
VR3
VR5
VR9
VR8
VR7
C11
VR4
VR6
S5
C21-C23
S3
C5
C24
V6
V2
S2
O.Z. SOCKETS
5"
T1
L1
V8
V7
S1
1½"
V1
EARTHING POINT
1"

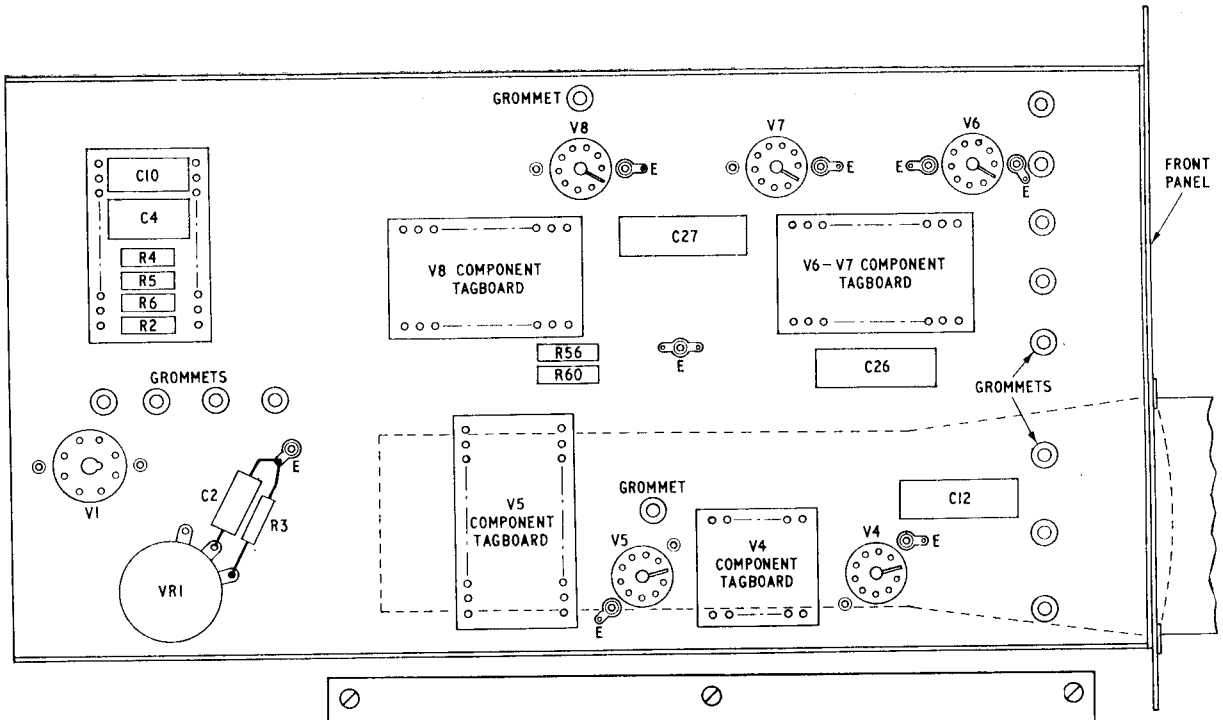


Fig. 7 (above). Layout of tag boards and other major items underneath the chassis. Details of the component tag boards are given in Fig. 9

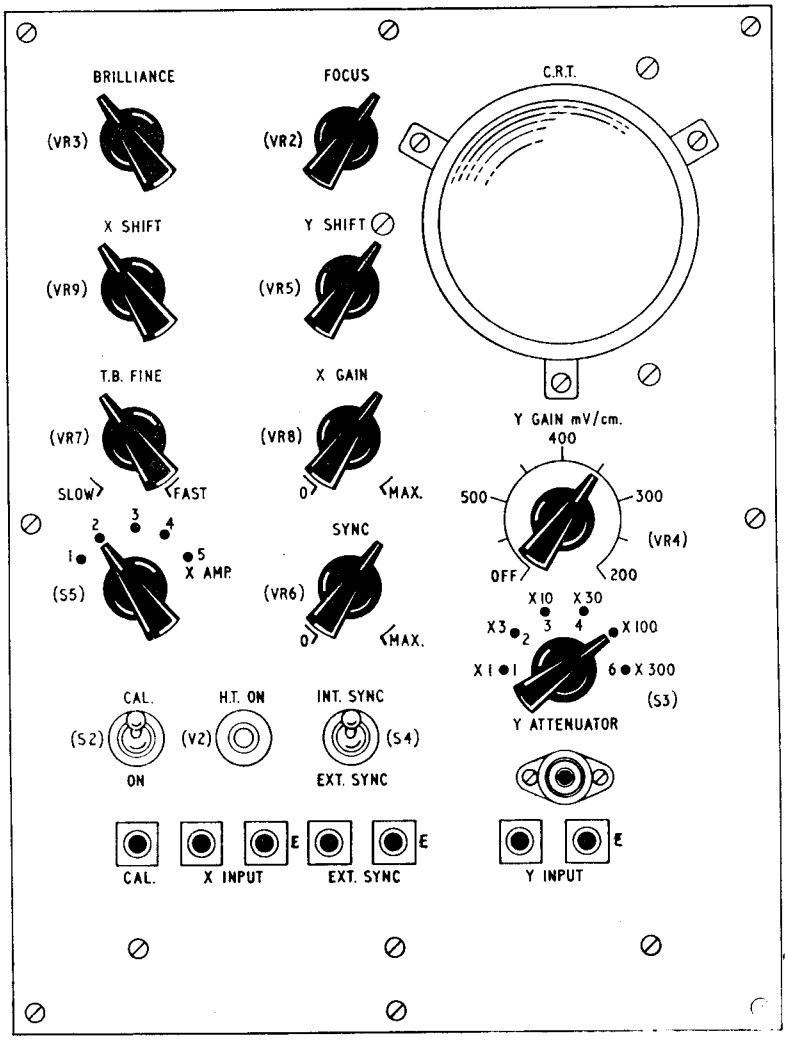


Fig. 8 (right). The completed front panel with all controls and sockets clearly labelled. Letter transfers are recommended for a neat and "professional" appearance

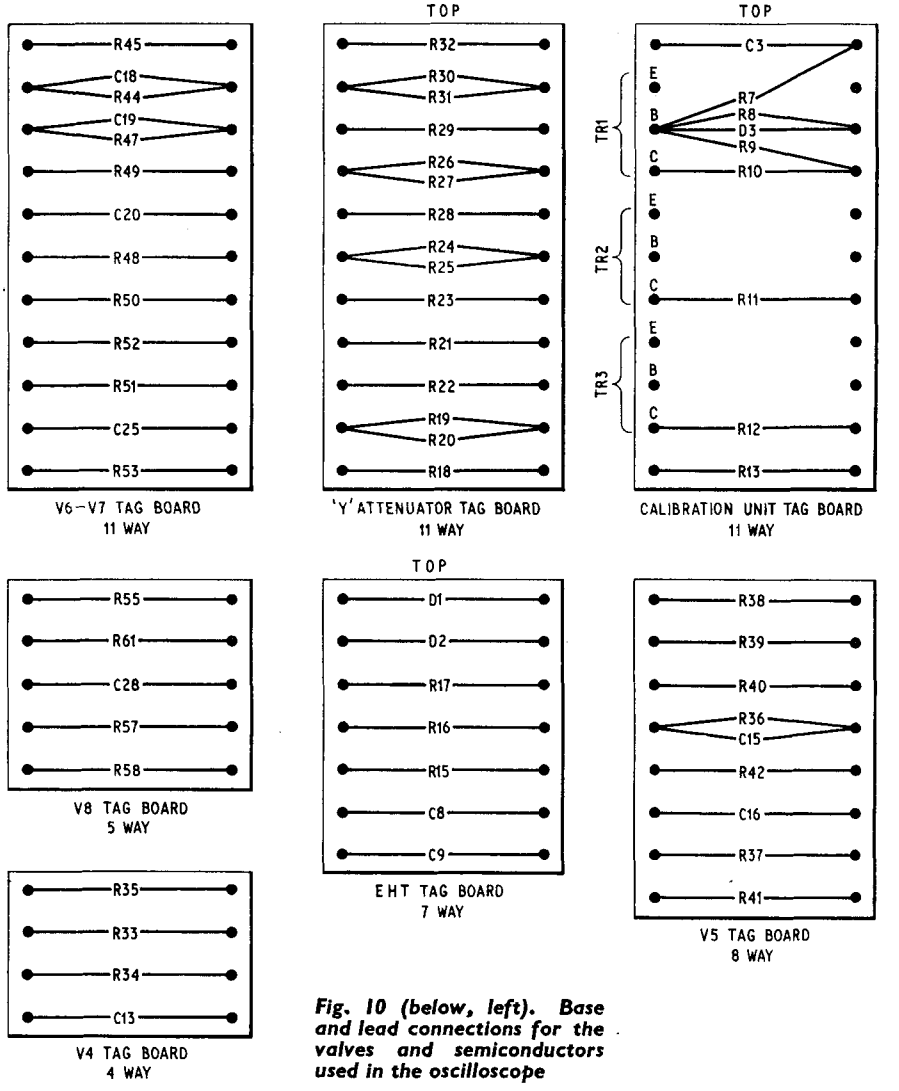


Fig. 9. Suggested arrangement of components on the various tag boards. Components should be assembled and wired up on these boards prior to the latter being fitted in position on the chassis

Fig. 10 (below, left). Base and lead connections for the valves and semiconductors used in the oscilloscope

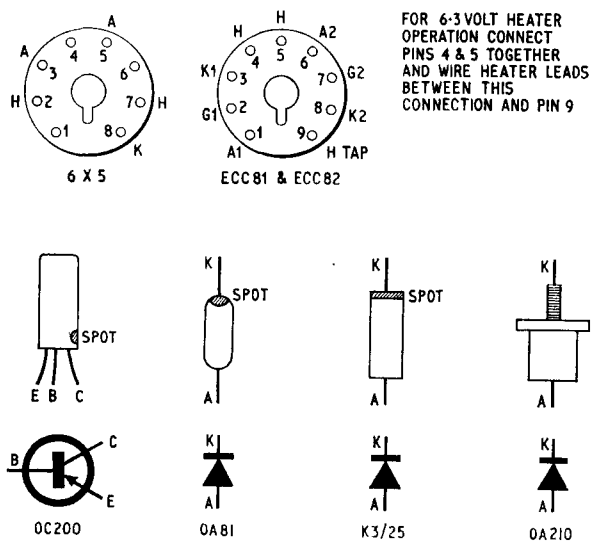
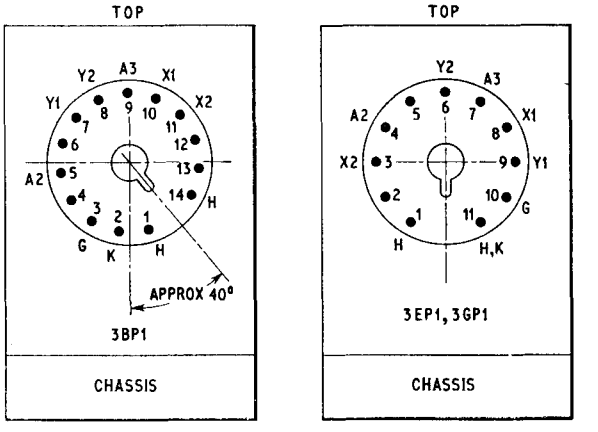


Fig. 11 (below). Base connections for the three types of cathode ray tube. Note the position of the spigot in each case; this determines the correct alignment of the trace with respect to the chassis of the instrument



Some components not shown in the drawings are the time base capacitors C21–C24. The large capacitor C24 is mounted as in Fig. 5, the remainder (C21–C23) are connected directly between the common point on this capacitor and the tags on S5. This keeps the lead length between the time base capacitors and S5 to a minimum.

Another point which should be mentioned is the positioning of the mains transformer and smoothing choke. These two components should be aligned in the position where the magnetic field has least effect on the c.r.t. and the connections to it, i.e. the field should run parallel with the c.r.t. and not at right angles to it. This is to prevent magnetic pick-up effects which can give a distorted trace—and is, of course, one of the reasons why the mu-metal shield for the c.r.t. is of such importance.

The base and pin connections for the various valves, transistors and diodes are shown in Fig. 10.

Details of the lettering and layout of the controls, switches, sockets, etc., are shown in Fig. 8. The various titles and scales can be put on the front panel in a number of different ways. For those with a steady neat hand they can be marked with draftsman's ink. Another method is to use letter transfers of which a wide selection of types are available. Otherwise the various titles can be simply typed out and transferred by means of double backed adhesive paper to the front panel. Finally, a coating of clear quick drying lacquer (clear nail varnish is ideal) over the labels will keep them clean and legible.

VISOR AND GRATICULE

Two "extras" which may be simply constructed and add to the usefulness and appearance of the instrument are a visor and graticule.

The dimensions of a suitable visor are shown in Fig. 5. This item can be made from $\frac{1}{32}$in sheet brass bent around a former of suitable diameter, the joint being soldered. Alternatively, a tin of the right diameter can be cut to the appropriate length. The visor can be fixed to the front panel by means of three small right angle lugs, soldered to the visor and screwed into the front panel.

The inside of the visor should be painted matt black to prevent reflection and a piece of split heavy wire insulation (a piece of coaxial cable with the centre core and screen removed is ideal) gummed around the outer edge to prevent any cuts occurring. The visor will allow waveforms to be viewed under conditions of high ambient light and also help to prevent accidental damage to the c.r.t. face.

A graticule can be easily made from a piece of $\frac{1}{16}$in perspex or other transparent material. The engraving can be performed with a sharp cutting tool with a fine edge, care being taken not to let the tool slip when carrying out this operation. First the two axes, horizontal and vertical, are marked exactly at right angles to one another so that they intersect exactly in the centre of the circle of material. A series of fine lines exactly one centimetre apart are then marked from each of these centre lines so that the final result is a circle of material divided into one centimetre squares which just fits inside the visor and can be pressed flat against the face of the tube. The finely etched lines can be filled with black crayon so as to be easily seen against the tube face.

The advantage of a graticule is that it allows quick and reasonably accurate calibration checks to be made and allows signal levels to be read direct, the Y amplifier being calibrated in volts per centimetre. When making such measurements care must be taken to view the screen *directly* and not at an angle as this leads to parallax errors and consequent inaccuracy in the measurements.

Another point which may be mentioned is that while the calibration unit is an obvious asset to the oscilloscope, it is by no means essential to its function and can be omitted if required. For this reason the calibration circuit in Fig. 1 is shown inside a broken line and can always be added at a later date if necessary.

HOUSING THE INSTRUMENT

Finally, the outer case can be constructed from $\frac{1}{4}$in or $\frac{3}{8}$in plywood or, if adequate workshop facilities are available, from $\frac{1}{16}$in aluminium with metal bracing at the edges and corners. A number of ventilation holes should be drilled around the top and bottom edges of the sides, and a hole must be cut in the back plate in the appropriate position to allow access to the mains switch. A three or four inch handle on top of the case helps towards making the instrument relatively portable.

ERRATA

The following amendments to Part 1 of this article (last month) should be noted.

Specification (page 328): Time base range No. 3 should be 1ms/cm to 100μs/cm.

Components list (page 331): R45 is rated at 1W; *add* C28 0·1μF paper 150V.

Fig. 3. Time base generator and X amplifier circuit (page 335): Capacitors C21 to C24 inclusive have been inadvertently reversed in this diagram. These capacitors should be connected to the time base switch S5 as follows: switch position (1) C24; (2) C23; (3) C22; (4) C21.

Next month: Testing and setting up the oscilloscope