Mullard Outlook

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MULLARD - AUSTRALIA PTY. LTD.

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JOERN BORK

CONTENTS:

The Mullard 7W High Quality Stereophonic Amplifier was recently released in "Circuits for Audio Amplifiers" published by Mullard Limited in the United Kingdom. More detailed information on this amplifier and the full range of Mullard High Quality Amplifiers and Pre-amplifiers may be found in this publication, which will shortly be available from Mullard-Australia Pty. Limited, Sydney and Melbourne.

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"WINTER—THE SELLING SEASON"

The seasonal sales pattern of Winter—the peak selling period for entertainment electronic equipment—radio receivers, television receivers, tape recorders, and amplifiers, is again with us.

This Winter, the full force of a changed selling approach is paramount and it is our view that retailers, small and large, throughout the land, must adjust their outlook accordingly, to achieve and maintain their share of the market and further develop this great Industry.

Ask your wife, relatives or friends when the last person called at their homes suggesting they purchase a new radio set or a new television receiver, or for that matter an electrical appliance; even with the present rate of canvassing we feel you will be surprised at the answers you will get. In your district there is this potential on which to operate, whether your approach is a cross between Dale Carnegie and the Fuller Brush Man—or highlighted by the particular selling ability of your own sales folk.

VIEWPOINT WITH MULLARD

The fourteenth meeting in the "Viewpoint with Mullard" series was held at "Westella," Auburn, New South Wales, on May 6th. Retailers from Sydney's inner western suburbs were addressed by Messrs. M. A. Brown, General Manager; J. R. Goldthorp, Senior Applications Engineer; P. C. Bidencope, Maintenance Valve Sales, and B. P. A. Beresford, Technical Service Department.

Mr. Bidencope welcomed the guests and briefly outlined the new publicity campaign aimed to support manufacturers, service organisations and retailers that use Mullard valves and picture tubes, and also acquainted those present with some of the display service!

Later in the evening Mr. Beresford described the services provided by the Mullard Valve and Picture Tube Service Centres at Petersham in Sydney and in Melbourne and said that similar service centres would shortly be opened in the other capital cities. He went on to describe picture tube guarantee arrangements and stressed the importance to retailers of registering guarantee cards at the time of sale and so covering their customer and in turn themselves. Mr. Beresford urged salesmen and servicemen to assist their customers to fill in the cards and also informed those present that the new Mullard guarantee cards would be

Glimpses of Guests at Auburn

pieces and material available. Mr. Bidencope also referred to the Mullard films and film strips and how these are being applied by retailers in sales promotional activities at local schools, clubs and so on.

Mr. Brown emphasised the scope covered by Mullard electronic valves and picture tubes, semiconductors and industrial and scientific equipment. He discussed entertainment valves in particular and suggested to those present that as many television receivers are now, or would be shortly, out of Hire Purchase Agreements and as this would coincide with increased service insurance premiums, the scope for an efficient service organisation, big or small, was considerable. He said that he felt that the increased importance of service business and the growing opportunities for retailers to set up profitable service departments was not fully appreciated and had not been helped any by the earlier unsuccessful ventures of some retailers into T.V. service. He said, however, it was interesting to see in Sydney and the metropolitan areas some retailers disposing of their retail shops and concentrating on service and this he felt was a healthy sign—at least with regard to reply paid. He said the Mullard Valve and Picture Tube Service Centres were equipped for testing semiconductors and advised servicemen present that constructional details of a simple semiconductor testing device was available on request. [See "Mullard Outlook," Volume I, No. 4—Ed.]

The Mullard film, "Principles of the Transistor," was shown to an interested audience and Mr. Goldthorp then demonstrated and explained some of the range of Mullard valve and transistor amplifier circuits including the Mullard 2 Stereo 2 Amplifier. He referred to the great advantages to be obtained by the future use of silicon diodes in rectifier applications and forecast a change in cabinet design, chassis and circuit design due to semiconductors. Already an experimental fully transistorised television receiver had been produced in the Mullard Research Laboratories in the United Kingdom and ultimately techniques proven in this way would be adopted by set manufacturers.

Following the screening of "The Manufacture of Radio Valves" a buffet supper was served.

MULLARD FILM STRIP LIBRARY

The last issue of the "Mullard Outlook" gave details of 35 mm. film strips available from the Mullard Library. In order to more readily control this service it has been found necessary to group Strips in sets. In future film strips will be available in sets as shown below:—

ELECTRONIC VALVES AND TUBES

E1 An Introduction to Electronics.
E2 Electronic Devices I (Electronic Tubes).
E4A Basic Valve Circuits.
E4B Basic Valve Circuits.
E7 Valve Characteristics Valve Manufacture and History of Radio.
E13 History of Radio.
E15 The Manufacture of Thermionic Valves.
E28 The Thermionic Valve.
E50 The History of Radio.

SEMICONDUCTORS

E3 Electronic Devices II (Semiconductors).

CATHODE RAY TUBES

E6 Principles of the C.R.T.
E17 The Manufacture of C.R.T.'s.
E29 The Cathode Ray Oscilloscope.

MAGNETS AND MAGNETIC MATERIALS

E21 Magnets and Magnetic Materials.

SECONDARY CELLS AND D.C. MACHINES

E22 Secondary Cells.
E23 D.C. Machines.
E24 Armature Windings.
E25 Armature Reaction.
E26 Commutation.
E27 D.C. Motors.

ILLUMINATION

E30 Filament Lamps.
E31 Discharge Lamps.
E32 Photometry.
E33 Indicating Instruments.
E34 Energy Meters.

ALTERNATING CURRENT AND ALTERNATORS

E35 A.C. and the Alternator.
E36 Vectors.
E37 Transformers.
E38 Rectification.
E39 Power Distribution.
E40 Underground Power Cables.

TELEVISION

7 Television—Part 1.
8 Television—Part 2.
14 The Story of Television.

ELECTRONICS

U39 Electronics—The Radio Valve, Parts 1 and 2.
U40 Electronics—The Radio Valve, Part 3.
U41 Electronics—The Radio Valve, Part 4.
U42 Electronics—The Radio Valve, Part 5.
U43 Electronics—The Radio Valve, Part 6.

OSCILLOSCOPE FOR TELEVISION SERVICE

The oscilloscope circuit, Fig. 1, described in this article is designed to meet the need for an adequate but not over-elaborate instrument for television and audio servicing. It makes use of standard components which are likely to be available in the service department. The cost and size of the completed instrument have been kept down by the use of a low-voltage c.r.t., the Mullard DG7-32. This three-inch tube operates at a final anode voltage of only 400V, therefore quite a small and modest power unit is required.

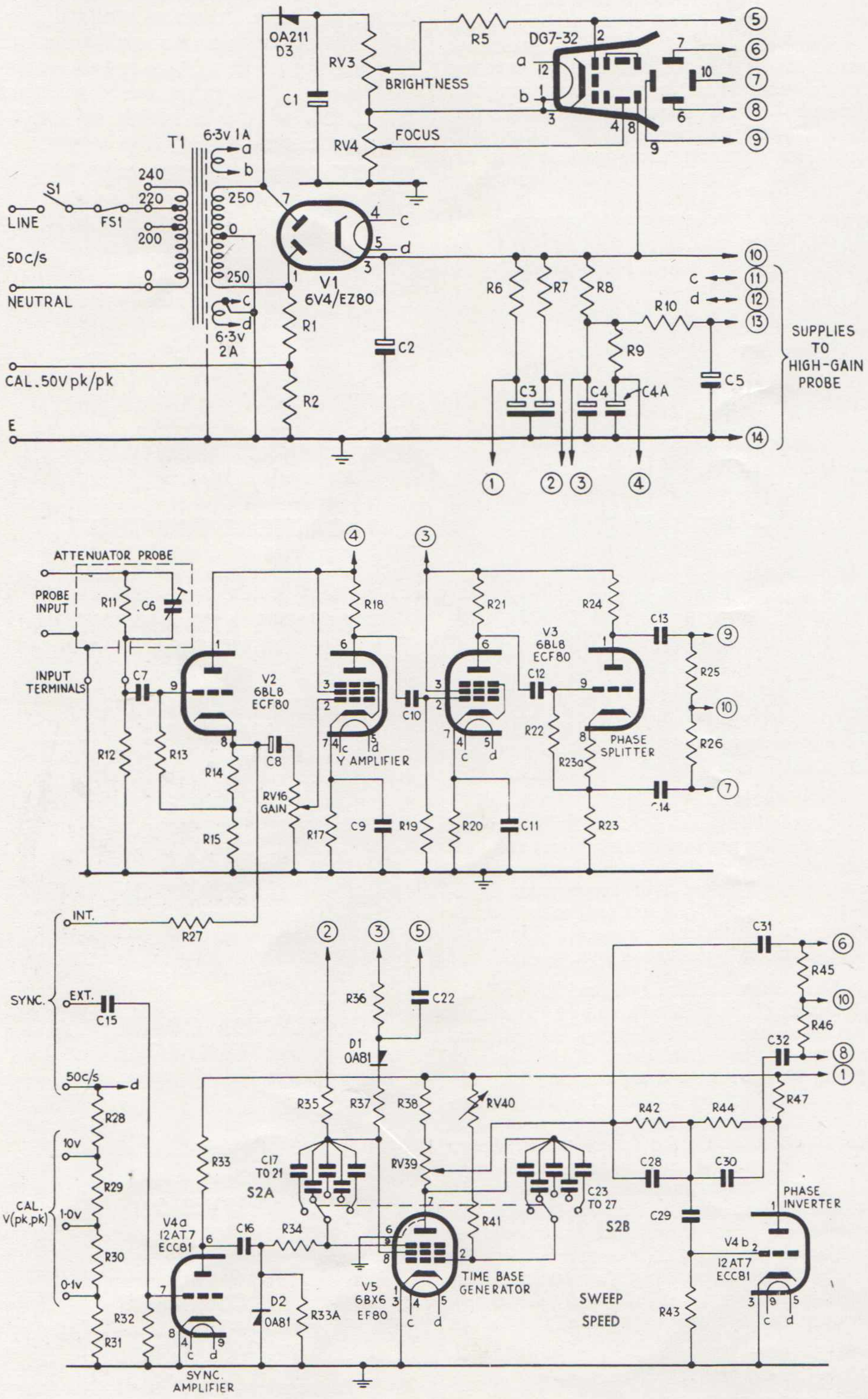


Fig. 1—Main Circuit

CIRCUIT DESCRIPTION

All supplies are obtained from one transformer. The rectifier V1 supplies 310V for the Y amplifier, the timebase, and the c.r.t., while D3 provides —300V for the c.r.t.

Y AMPLIFIER

The Y amplifier uses two triode-pentodes. The triode of V2 is a cathode follower, with its grid connected to the input socket. The output of the cathode follower is coupled via C8 to RV16, which gives continuously variable gain control. The slider of RV16 goes to V2 pentode grid, and the anode is coupled by C10 and R19 to the grid of the other pentode, V3. The two pentodes provide a gain of about 60. Some frequency compensation is obtained by means of C9 and C11, which are effective only at high frequencies.

The output from the V3 pentode is coupled by C12 to the triode, which acts as a 'concertina' phase splitter. Symmetrical paraphase outputs from anode and cathode are taken to the Y plates via C13 and C14, and the mid point of R25-R26 is connected to the c.r.t. final anode to prevent astigmatism.

TIMEBASE

The timebase generator uses the pentode V5 in a Miller-transitron circuit, while the double triode V4 acts as a sync amplifier and as a paraphase amplifier for the sawtooth sweep. Sweep speed depends on the time constant of RV40-R41 and a capacitor selected by S2b—the coarse frequency control. RV40 is the fine frequency control; it gives some overlap between the ranges selected by S2b. The frequency range is from 20c/s to 20kc/s.

For each range, the ganged switch S2a selects a g_2-g_3 coupling capacitor to give a 150V sawtooth at V5 anode. Sweep amplitude is adjusted by RV39, with the slider feeding one of the X plates via C31. The other X plate is fed via C32 from the anode of V4b, which is an a.c.-coupled seesaw phase inverter. The sweep width is 2cm to 8cm, continuously variable.

A negative pulse from g_2 of V5 is limited by D2. The flat-topped wave developed across R36 is then fed to the c.r.t. grid via C22 to suppress flyback.

SHIFT CONTROLS

X and Y shift controls are not included in the main circuit diagram. They can be added as shown in Fig. 2, with R25, R26, R45, and R46 all reduced in value and connected to the sliders of the controls. The mean deflector-plate potential is still maintained at final anode potential, since the final anode is now taken to the junction of R8 and R9.

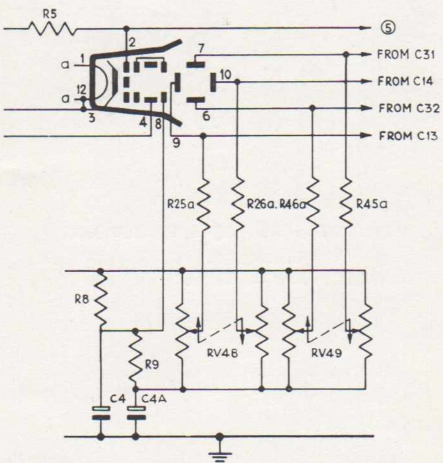


Fig. 2—Shift Controls (optional)

SYNC AMPLIFIER

Synchronising signals, obtained from the Y amplifier, or from the mains, or externally, are fed to the grid of the sync amplifier valve V4a. An amplified and limited version of the signal appears at the anode and is d.c. restored to earth by D2. It is then fed as a positive-going signal, in series with the g_2 resistor R34 of the time-base generator.

CALIBRATION

The gain of the Y amplifier can be checked by means of 50c/s voltages of 50V, 10V, 1V, and 0.1V peak-to-peak taken from the mains transformer.

INPUT

The high-impedance input attenuator consists of R11 and C6, in a screened box. It introduces an attenuation of 10 times, and gives an input resistance of 10MΩ. The alternative high-gain probe consists of an EF86 in a conventional circuit (Fig. 3). It gives a 100 times gain over a range from 5c/s to 20kc/s when connected by two feet of 75Ω television type screened coaxial cable. It incorporates a switched × 10 attenuator.

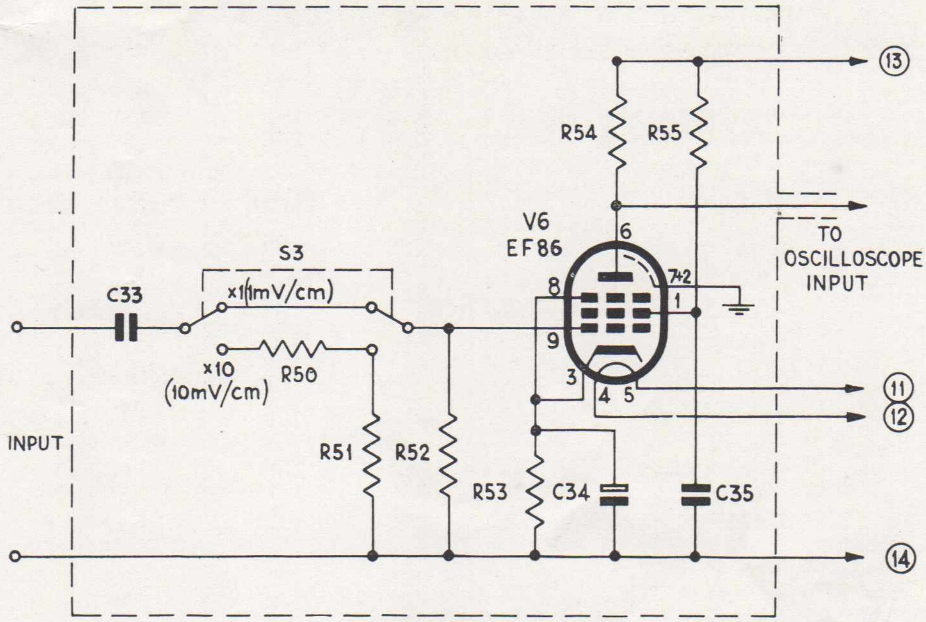


Fig. 3—High Gain Probe

OPERATION AND PERFORMANCE

CHOICE OF INPUT

For general purposes a direct input with an unscreened lead is satisfactory. When a screened lead is necessary to avoid pick-up (from, say, the line time-base of a receiver) there will be greater capacitive loading of the circuit which is being examined, but the sensitivity and signal-handling ability of the 'scope will not be affected.

When a higher input impedance or a greater maximum signal limit is required, the attenuator probe R11-C6 is used. This probe is essential when investigating circuits which include impedances higher than 100kΩ; and it is useful for TV servicing, where a sensitivity better than 1V/cm is rarely needed.

Alternatively, the high-gain probe may be plugged in instead of the attenuator probe R11-C6; it is designed for low-level audio frequency investigation, and its bandwidth is restricted.

The various input arrangements are compared in the table:

	Direct input	*High-impedance attenuator probe*	*High-gain probe* × 1	*High-gain probe* × 10
Input resistance	1.0	10	0.5	0.5 MΩ
Input capacitance	20	10	10	10 pF
Max. sensitivity	100	1000	1	10 mV/cm
Max. signal input	30	300	0.3	3V

SYNCHRONISATION

The trace usually needs to be synchronised to the Y amplifier, and the SYNC EXT and SYNC INT sockets are linked. For some purposes, notably the examination of video waveforms at frame frequency, SYNC EXT may be linked instead to the '50c/s' socket. Alternatively, a signal from a suitable point in the receiver may be fed directly to the SYNC EXT socket.

The impedance at SYNC EXT is about 1.0MΩ in parallel with 10pF. Adjustment of the Y gain control does not affect synchronisation.

CALIBRATION

The calibration voltages can be used to set the gain control to a known sensitivity, so that voltages can be measured from the trace. Thus, if the input terminal of the high-impedance probe is fed from the 50V peak-to-peak calibration socket, the trace height is, say, 1.5cm. If, without touching the gain control, the probe is now connected to the grid of a line output valve, and a trace of 4.2cm amplitude is seen, then the peak-to-peak grid voltage is $50 \times 4.2 \div 1.5 = 140$V. The oscilloscope thus provides observation of the shape and amplitude of a waveform. Both are important in servicing.

EARTHING

Since the instrument is designed primarily for TV servicing, its chassis cannot be tied to earth; hence either the earth lead on the probe, or a separate wire from the earth socket, must always be connected to the earth of the circuit which is being examined. The c.r.t. face can be touched without trace distortion.

VALVE COMPLEMENT

C.R.T.	DG7-32, with mumetal shield
V1	6V4/EZ80
V2, V3	2 x 6BL8/ECF80
V4	12AT7/ECC81
V5	6BX6/EF80
V6	EF86
D1, D2	2 x OA81
D3	OA211

PARTS LIST

T1	Primary: 240V, 220V, 200V Secondary: 250V-0-250V/40mA 6.3V 2A 6.3V 1A
FS1	1A Fuse
S1 Switch ..	250V/2A
S2a/b	2-pole 5-position Yaxley type switch
S3	Double-pole changeover switch
4 mm sockets (10 required).	Belling-Lee L1318
Plugs to fit	Belling-Lee L378/4

Mains selector panel if required

6 B9A ...... Valve Holders

1 Four-pin miniature plug and socket

13 Rubber Grommets

3 Tag Strips

RESISTORS

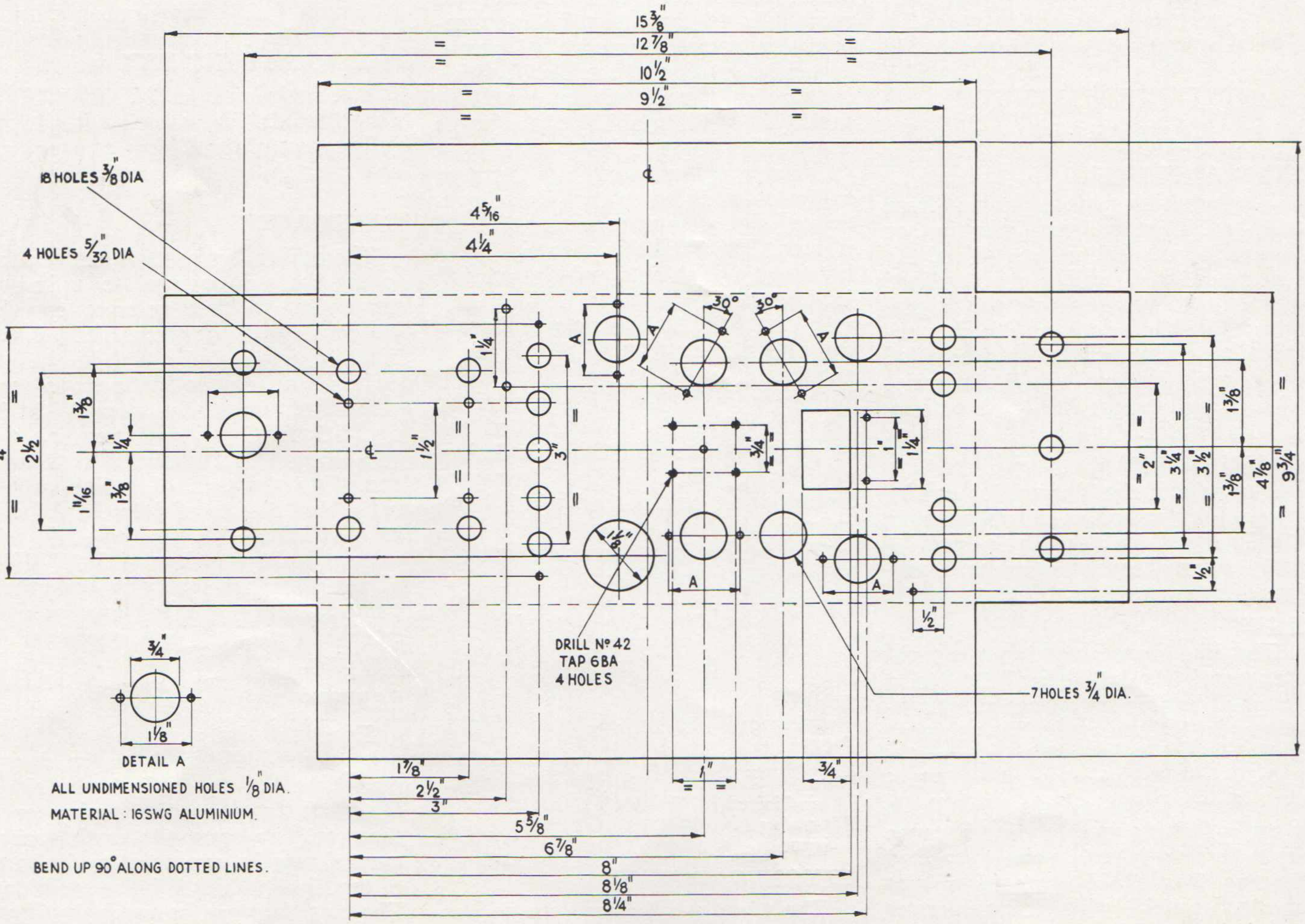
R1	150	kΩ	1W
R2	22	kΩ	¼W
RV3	50	kΩ	1W linear
RV4	100	kΩ	1W linear
R5	270	kΩ	¼W
R6	2.2	kΩ	¼W
R7	2.2	kΩ	¼W
R8	2 x 8.2	kΩ	2 x 2W in parallel
R9	8.2	kΩ	2W
R10	100	kΩ	½W
*R11	10	MΩ	¼W
R12	1.2	MΩ	¼W
R13	1.0	MΩ	¼W
R14	330	Ω	¼W
R15	10	kΩ	¼W
RV16	10	kΩ	1W linear
R17	220	Ω	¼W
R18	5.6	kΩ	½W
R19	1	MΩ	¼W
R20	270	Ω	¼W
R21	5.6	kΩ	½W
R22	1	MΩ	¼W
R23	10	kΩ	½W
R23a	820	Ω	¼W
R24	10	kΩ	½W
R25	4.7	MΩ	¼W
**R25a	3.9	MΩ	¼W
R26	4.7	MΩ	¼W
**R26a	3.9	MΩ	¼W
R27	10	kΩ	¼W
R28	390	Ω	¼W
R29	470	Ω	¼W
R30	47	Ω	¼W
R31	2 x 10	Ω	2 x ¼W in parallel
R32	1	MΩ	¼W
R33	82	kΩ	¼W
R33a	10	kΩ	¼W
R34	100	kΩ	¼W
R35	27	kΩ	½W
R36	10	kΩ	¼W
R37	10	kΩ	¼W
R38	4.7	kΩ	¼W
RV39	25	kΩ	1W linear
RV40	2	MΩ	1W linear
R41	390	kΩ	¼W
R42	1	MΩ	¼W
R43	10	MΩ	¼W
R44	1.2	MΩ	¼W
R45	4.7	MΩ	¼W
**R45a	3.9	MΩ	¼W
R46	4.7	MΩ	¼W
**R46a	3.9	MΩ	¼W
R47	100	kΩ	¼W
**RV48	2 x 2	MΩ	two-gang, linear
**RV49	2 x 2	MΩ	two-gang, linear
†R50	470	kΩ	¼W
†R51	47	kΩ	¼W
†R52	470	kΩ	¼W
†R53	1.5	kΩ	¼W
†R54	120	kΩ	¼W
†R55	470	kΩ	¼W

† High-gain probe.

* High impedance input attenuator.

** Shift control circuit.

Resistors are ± 10%.

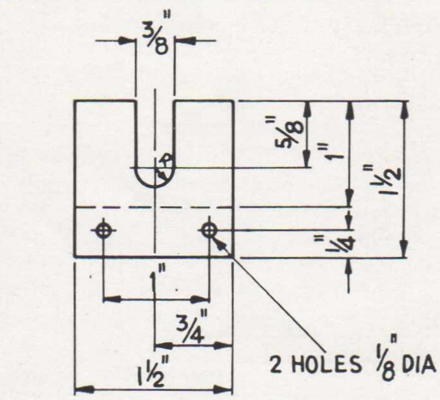


CAPACITORS

C1	Electrolytic	32	μF	350V
C2	Electrolytic	16	μF	350V
C3	Dual Electro	50 + 50	μF	300V
C4	Electrolytic	100	μF	300V
C4a	Electrolytic	100	μF	300V
C5	Electrolytic	16	μF	350V
*C6	Trimmer	0.3 to 3	pF	500V
C7	Paper	0.1	μF	500V
C8	Electrolytic	25	μF	50V
C9	Ceramic	220	pF	350V
C10	Paper	0.1	μF	350V
C11	Ceramic	220	pF	350V
C12	Paper	0.05	μF	350V
C13	Paper	0.25	μF	350V
C14	Paper	0.25	μF	350V
C15	Silver-Mica	1800	pF	350V
C16	Paper	0.01	μF	350V
C17	Paper	0.05	μF	350V
C18	Paper	0.01	μF	350V
C19	Silver-Mica	2200	pF	350V
C20	Silver-Mica	560	pF	350V
C21	Silver-Mica	150	pF	350V
C22	Paper	0.1	μF	350V
C23	Paper	0.1	μF	350V
C24	Paper	0.02	μF	350V
C25	Paper	0.005	μF	350V
C26	Silver-Mica	1200	pF	350V
C27	Silver-Mica	300	pF	350V
C28	Ceramic	33	pF	350V
C29	Paper	0.05	μF	350V
C30	Ceramic	33	pF	350V
C31	Paper	0.25	μF	350V
C32	Paper	0.25	μF	350V
**C33	Paper	0.1	μF	350V
**C34	Electrolytic	100	μF	6V
**C35	Paper	0.1	μF	350V

* High impedance input attenuator.
** High-gain probe.

BEND UP AT 90° ALONG DOTTED LINE



MATERIAL: 16SWG ALUMINIUM
BRACKET 1OFF

CONSTRUCTION AND LAYOUT

The prototype shown has been made up with conventional chassis and wiring methods to demonstrate how compact the finished instrument can be.

While the circuit is not particularly critical, care should be exercised in the layout and wiring. The timebase and Y amplifier should be reasonably well spaced.

In the prototype instrument a chassis 11″ × 5″ × 2″ is used, with the mains transformer mounted at the back of the chassis. The Y amplifier is arranged to the right of the tube, and the timebase to its left.

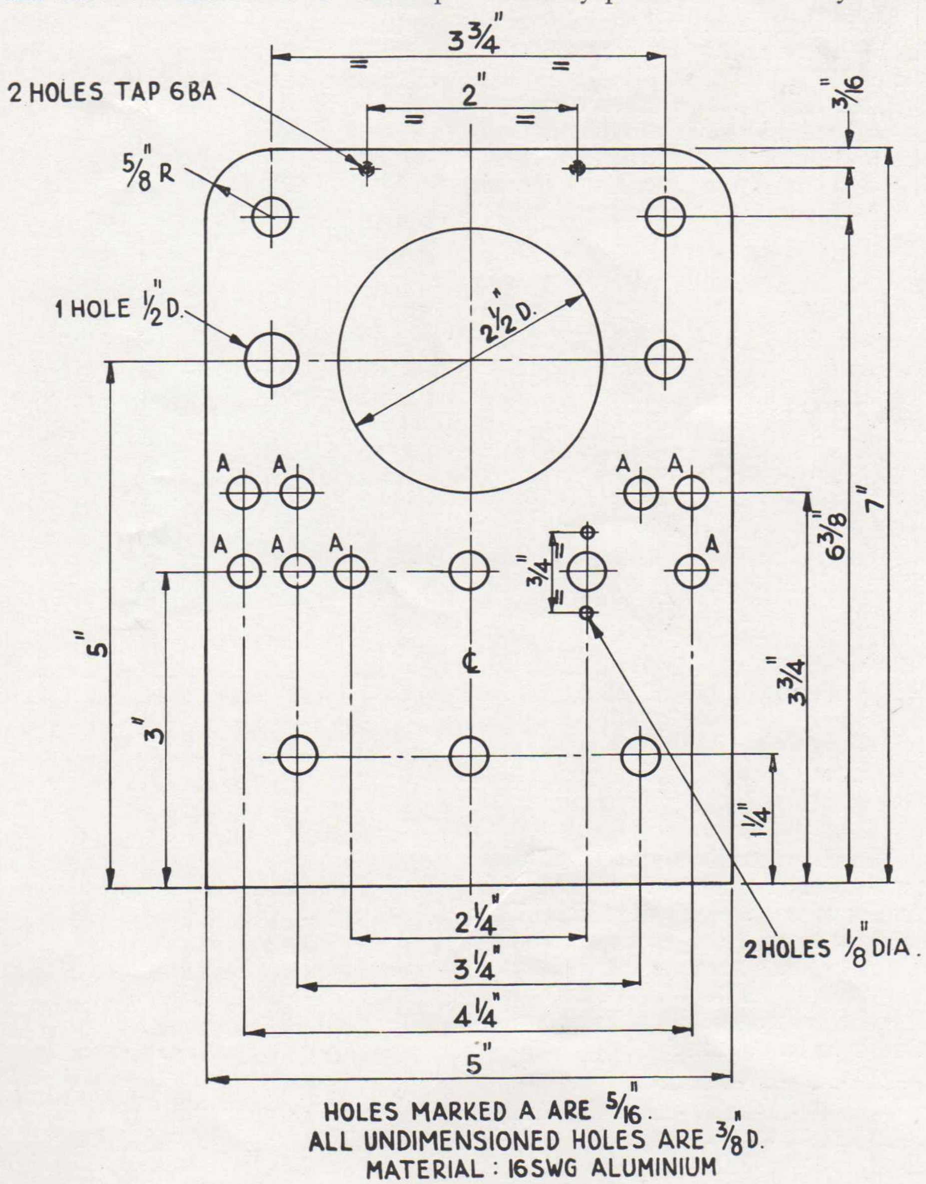
The switch S2 is mounted on the vertical centre line below the chassis, and RV40 above it. RV39 is to the left of S2, and RV16 to the right. The input sockets are mounted on the panel above the chassis.

No internal screens are used, but the wire from the anode of V5 to RV39 is screened. Throughout the instrument, leads should be kept as short as possible, particularly in the Y amplifier. Excessive stray capacitance to earth should be avoided if the full bandwidth is to be maintained.

CHECKING THE INSTRUMENT

Before switching on, turn the brightness control right down. Switch on, and allow the instrument to warm up for a minute or so. Turn the brightness control slowly until a line appears on the screen. Turning the focus control should enable this line to be focused, while adjustment of the width control will vary its length, clockwise movement increasing the length.

Next, turn the fine and coarse frequency controls fully clockwise, and connect a wire between the input socket and the calibrator 1.0V socket. Several cycles of a 50c/s sine wave should be seen on the screen. The amplitude of these can be varied by the Y gain control, and with this fully clockwise the trace should nearly fill the tube face. The trace will probably appear to run across the screen. By connecting a wire between SYNC IN and SYNC OUT, and slightly adjusting the fine frequency control, a stationary pattern of several cycles of



HOLES MARKED A ARE 5/16".
ALL UNDIMENSIONED HOLES ARE ⅜" D.
MATERIAL: 16SWG ALUMINIUM
PANEL 1OFF

a 50c/s sine wave should be obtainable. As the fine frequency control is rotated anti-clockwise, several stationary patterns will appear, and somewhere near the full anti-clockwise position of the control a stationary pattern of a single cycle of a sine wave will be seen. These settings of the fine and coarse frequency controls are those which will generally be used when examining the frame timebase and associated circuits in a television receiver. Turning the coarse frequency control anti-clockwise increases the timebase frequency, and with this control fully anti-clockwise and the fine frequency control clockwise, the frequency should be about 10kc/s, so that, if the input socket is connected to a point in the line timebase of a receiver, a stationary pattern should again be obtained.

If the instrument passes these tests, its performance may be deemed satisfactory; but to assist in diagnosing possible faults, the voltages measured at various points in the circuit are listed below. These voltages were measured with an Avometer model 8 (resistance 20,000 ohms per volt).

Point	*Meter Reading (volts)*	*Meter Range (volts)*
V1 cathode	310	1000
Junction R6-C3	300	1000
Junction R7-C3	300	1000
Junction R8-C4	200	250
Junction R9-C4	105	250
CRT a_1, a_3 (pin 8)	+310	1000
CRT a_2 (pin 4)	—100	250
CRT g (pin 2)	—240	250
CRT k (pin 3)	—200	250
V2 k_t (pin 8)	41	100
V2 a_p (pin 6)	81	100
V2 k_p (pin 7)	1.5	10
V3 a_p (pin 6)	166	250
V3 k_p (pin 7)	3.1	10
V3 a_t (pin 1)	125	250
V3 k_t (pin 8)	75	100
V4 a′ (pin 6)	120	250
V4 a″ (pin 1)	115	250
V5 a (pin 7)	150	250
V5 g_2 (pin 8)	215	250

The above readings were taken with the timebase running at 50c/s and with no input to the Y amplifier. The brightness and focus controls were adjusted to give a normally focused trace. They are typical of the values which may be encountered; but some variation is to be expected.

Checking the Probes

The high input impedance probe consists of a 10MΩ resistor in parallel with a 2pF trimmer capacitor, and it is necessary to adjust this to make the whole circuit (including the stray capacitance from the input socket to ground) aperiodic. This may be done by connecting the input of the high impedance probe (plugged into the 'scope) to the cathode of the picture tube of a television set. With the timebase adjusted to line frequency, the positive-going line sync pulse should be examined and the trimmer adjusted until it appears as a rectangular pulse with no overshoot.

The high-gain preamp is best checked by connecting its input to the output of an a.f. oscillator. With an input of 1mV a trace of 1cm amplitude should be obtained at maximum gain. The response should be flat within 3dB to about 20kc/s, assuming that the length of cable between probe and oscilloscope is two feet.

PLEASE NOTE: This instrument cannot be supplied by Mullard. The model shown is only one of the possible realisations of the circuit.

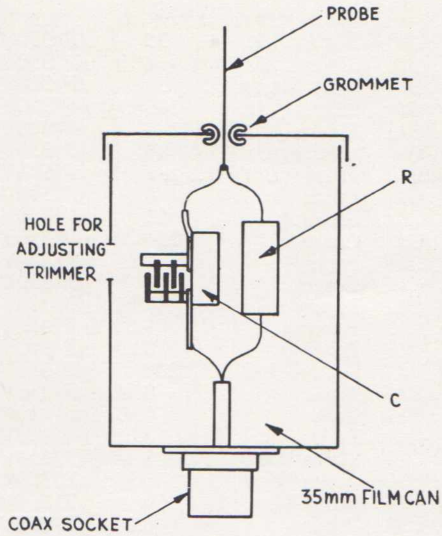
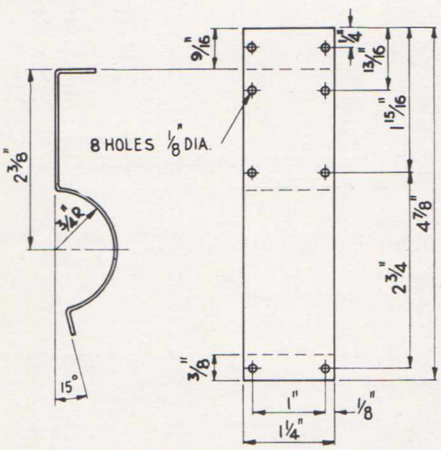
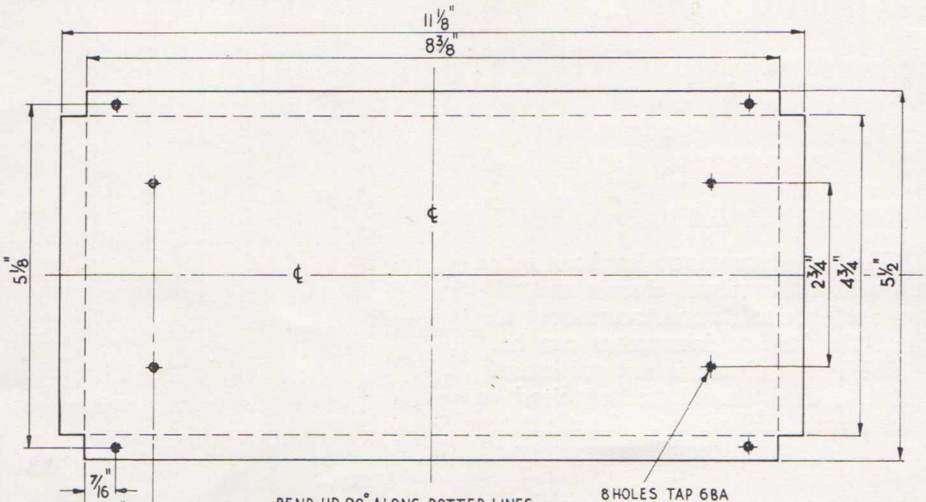


DIAGRAM OF ATTENUATOR PROBE



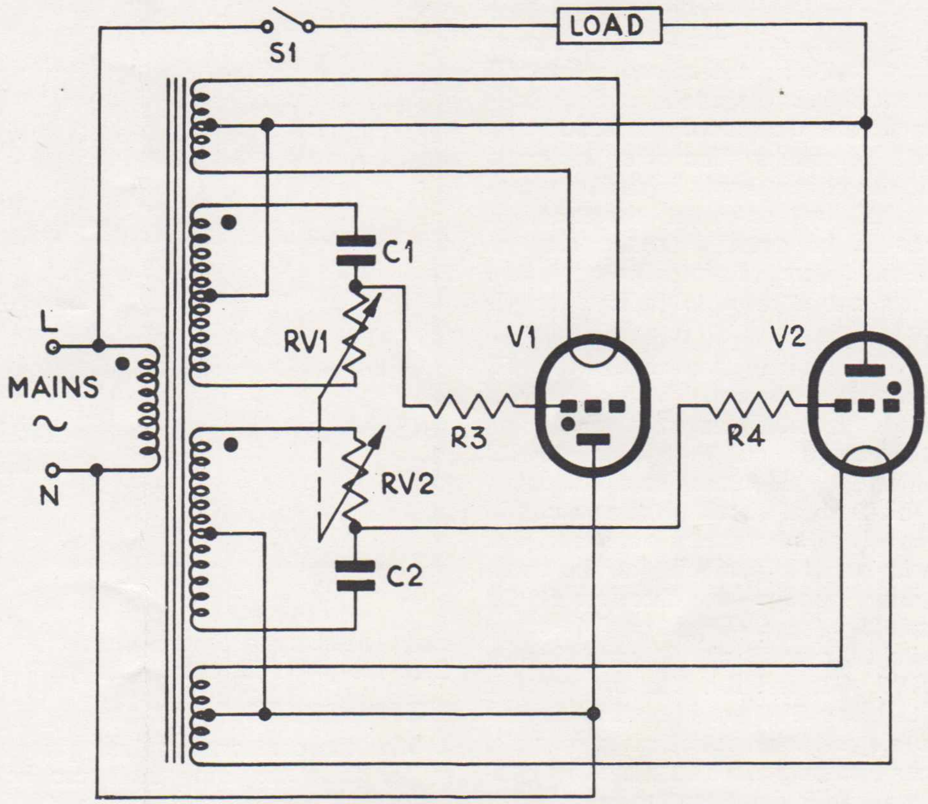
BEND AS SHOWN AT DOTTED LINES
MATERIAL: 16 SWG ALUMINIUM
TUBE SUPPORT 2 OFF



BEND UP 90° ALONG DOTTED LINES
MATERIAL: 16SWG ALUMINIUM
BASEPLATE 1 OFF

VARIABLE A.C. SUPPLY UNIT

It is often useful, and even necessary, to have a source of a.c. power which can be varied from a low value to maximum. One way of getting this is to use a transformer with a tapped secondary and a multi-stud switch; but this gives a stepped output and a limited number of voltages (a limitation which can be alleviated by the use of a sliding resistor for fine control). A more popular arrangement, which can be regarded as an infinitely-tapped transformer and, at the same time, a sliding resistance, is the familiar variable auto-transformer. This device is efficient, and it gives continuously variable control. But it is not absolutely immune from contact troubles (since the a.c. power flows through the moving contact); and, if remote control is required, it is necessary to use a motor drive or some other mechanical device.



● Indicates polarities of mains and phase shift winding

ELECTRONIC METHOD

A simple alternative form of a.c. controller, using electronic methods, is described in this article. The only sliding contacts are not in the power circuit but in low-current control circuits. Remote operation is achieved simply by extending the leads to these potentiometers. Thus, the control panel can be mounted in the most convenient location, irrespective of where the power circuit may be, and it will not carry any large currents. If there are quite a number of power circuits, as in stage-lighting installation, the controls for all of them can still be mounted on a small panel in any situation which is desired.

THYRATRONS AS POWER CONTROLLERS

When two thyratrons are connected in inverse-parallel ('back-to-back') as in the circuit diagram, and are in series with an a.c. supply and a load, the current which flows through the load can be adjusted by changing the firing angle of the thyratrons.

A thyratron will conduct when the anode is sufficiently positive with respect to the cathode, if there is no hold-off voltage on the grid. When the supply is a.c., as in the present circuit, the anode voltage rises above the cathode voltage on the positive half-cycle. If the grid is at zero volts, conduction from cathode to anode starts as soon as the anode voltage reaches a certain breakdown value, and it continues until the positive cycle is almost down to zero again. The two thyratrons in the present circuit are connected in opposite directions, so that for one of them the half-cycle **above** the zero line is positive, while for the 'upside-down' thyratron the half-cycle **below** the zero line is positive. Both half-cycles of the supply therefore produce conduction.

If a sufficiently large negative voltage is applied to a thyratron grid, conduction will be prevented altogether in the next positive half-cycle (and of course in succeeding ones). This hold-off voltage will have a certain critical minimum value for the anode voltage at the peak of the half-cycle. If a smaller negative grid voltage is applied, conduction will start at some earlier point on the rising anode voltage waveform. If the grid voltage is adjustable, the point at which conduction starts in the rise of a particular half-cycle (and in succeeding ones) can be chosen at will.

Now, if a standing hold-off voltage is applied, an **a.c.** grid voltage (90° out of phase with the anode voltage) can be connected in series with it. This sine wave can be moved up or down by adjustment of the d.c. voltage. It is then possible to provide the appropriate grid voltage for conduction at **any** point in the positive anode half-cycle, both on the rise and the fall of the anode voltage. Thus the conduction period can be any required proportion of the half-cycle (except that there is a minimum anode voltage below which the anode will not normally start to conduct anyway; and there is another low anode voltage at which conduction will cease near the end of each half-cycle). Alternatively, the a.c. grid waveform can be moved horizontally by a simple phase-shift circuit.

With two thyratrons back-to-back, controlled in tandem in this way, we can construct a practical controller of a.c. power.

PRACTICAL CIRCUIT

For a relatively simple and non-critical application, such as this, the phase-shift ('horizontal') form of grid control is used, and the action is as shown in the waveform diagram. The curve marked **critical grid voltage** represents the grid voltage at which conduction will start when the anode is at the corresponding positive anode voltage. Conduction starts as soon as the dashed a.c. waveform carries the grid above this critical voltage line. If the a.c. grid waveform is moved (say) to the right, then conduction will start later in the anode positive half-cycle, and the shaded conduction area will be smaller. The other half-cycle of the power supply is similarly controlled by the other thyratron. It should be noted that the diagram shows phase relationships only, and does not attempt to indicate amplitudes.

The required phase-shift of the grid voltage of thyratron V1 is provided by RV1 and C1 across a winding on the transformer. A grid resistor R3 limits the grid current to a safe value. This form of circuit gives an a.c. grid waveform of constant amplitude, but with variable phase lag on the transformer voltage—and therefore on the anode voltage. Thyratron V2 has a similar control circuit consisting of RV2, C2, and R4. The two controls RV1 and RV2 are in tandem, so that a single-knob control gives identical conduction periods in the two thyratrons. It is important to ensure that the transformer windings are arranged so that the three points marked with a black spot are all positive-going at the same instant.

A switch S1 is included in the main power path, since the thyratrons must be given time to warm up before conduction is allowed. The incorporation of a delay switch in this position will ensure safety of the thyratrons.

Instead of the directly connected load, a transformer could be used to provide a stepped-up output voltage.

DESIGN DATA

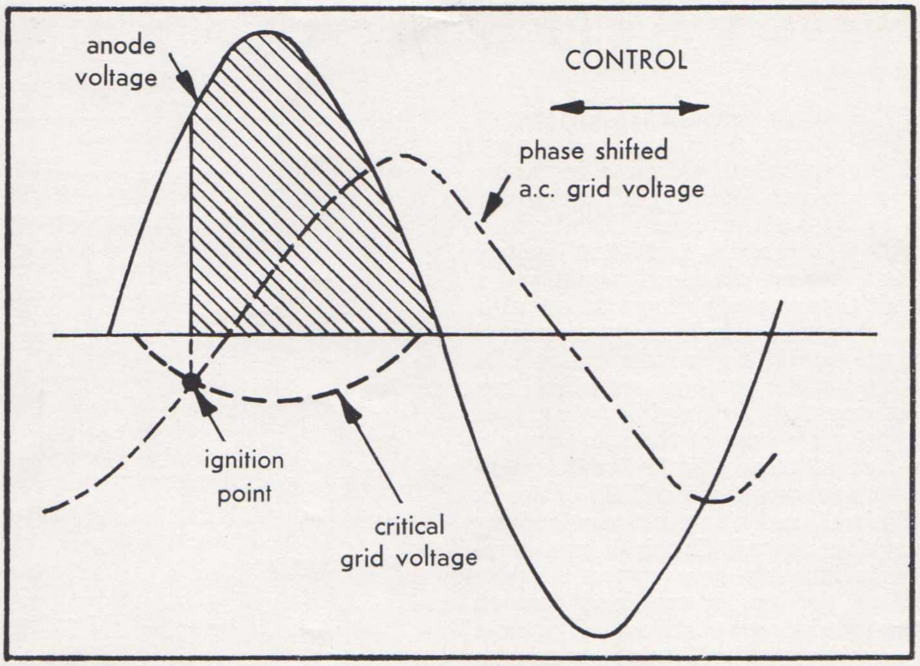
Any type of thyratron with a negative firing characteristic can be used, provided that allowance is made for the appropriate heater or filament voltage, grid current rating, and warm-up time. The cathode return connection must be made in accordance with the instruction given in the relevant thyratron data sheet.

A wide choice of suitable Mullard thyratrons is shown in the table. It will be seen that units may be designed for a variety of maximum loadings, ranging from 22mA to 27 amperes r.m.s. Mercury and rare-gas alternatives are given for some ratings.

PERFORMANCE

With the component values quoted in the table the firing angle can be controlled over the range 18° to 160°, which corresponds to a control from 95% to 8% of the normal maximum current (that is, the load current which would flow if the thyratrons were shorted out). The peak voltage of the output is the line voltage less the thyratron arc voltage drop of 10 volts or so.

The unit is free from the contact troubles which may develop in other forms of control. If it operates for a long time at one setting, there is no point of contact to overheat; and if the setting has to be frequently changed under high-current conditions, there is no sputtering and no wear of brushes.



Thyratron type	Max r.m.s. current * (A)	RV1 and RV2 § (kΩ)	R3 and R4 § (kΩ)	C1 and C2 § (μF)	V_g r.m.s. † (V)	V_h † (V)	I_h † (A)	Min warm up time (secs)
EN91	0.22	50	1800	0.25	25	6.3	0.6	10
EN32	0.66	50	200	0.25	50	6.3	0.95	15
XR1-1600	3.5	50	47	0.25	100	2.5	8.5	10
XG1-2500	5.5	50	22	0.25	100	5.0	4.5	**
XR1-3200	7.0	50	22	0.25	100	2.5	12	60
XR1-6400A	14	50	22	0.25	100	2.5	21	60
XG2-6400	14	50	22	0.25	200	5.0	10	**
XG2-12	27	10	10	1.0	100	5.0	14	**
XR1-12	27	10	10	1.0	100	2.5	34	60

* for a pair of thyratrons † per thyratron § each

** see heating and cooling curves in published data

MULLARD INDUSTRIAL VALVES FOR R.F. HEATING

APPLICATION	MAXIMUM LOAD POWER (continuous)	R.F. VALVE
Microwave therapy	100W 200W	JP2-0.1 12cm magnetron JP2-0.2 12cm magnetron
Electromedical diathermy	260W 630W 300W 790W	TY2-125 triode TY3-250 triode QY3-125 tetrode QY4-250 tetrode
U.H.F. therapy, 300Mc/s (experimental)	112W 230W	QV1-150A tetrode TD2-300A disc-seal triode
Industrial microwave heating Food processing and cooking	2.5kW c.w.	JP2-2 12cm magnetron
Dielectric welding and preheating, and induction heating (300W to 80kW)	630W 1.0kW 1.25kW 1.4kW 2.3kW 5.0kW 6.0kW 11kW 30kW 37kW 80kW	TY3-250 triode TY4-350 triode* TY4-500 triode TY5-500 triode TY6-800 triode TY6-5000A or TY6-5000W triode† TY7-6000A or TY7-6000W triode† TY8-15A or TY8-15W triode† TY12-20A or TY12-20W triode† TY12-25A or TY12-25W triode† TY12-50A or TY12-50W triode†

Many of these valves have higher power ratings for intermittent operation. Details are available on request.

*replacement type only.
†forced-air and watercooled types respectively.

The demand for oscillator valves for use as r.f. generators in industrial heating and electromedical diathermy, is increasing rapidly. Transmitting valves have been widely used for this purpose for some years. More recently, several new valves have been developed specifically for industrial service rather than for normal transmitting and communications requirements. This new conception of design permits a much increased degree of overload to be sustained in certain directions; and it allows the valve characteristics to be so arranged that the r.f. output maintains a more constant level with changes of load impedance. Reliability and long life under rigorous industrial conditions have been regarded as major design considerations in these new valves.

The present Mullard range of triodes, tetrodes, and magnetrons for the various types of r.f. heating are given in the table—which includes the new types TY8-15A and TY8-15W.

Full data sheets for all types, and for the Mullard thyratrons and mercury or xenon rectifiers which are required in the associated power supplies, may be had on application.

Technical advice on valves for r.f. heating circuits at all power levels is freely available from the Communications and Industrial Valve Department.

Valves for Power Supply

Mercury Rectifiers

RG1-240A	RG3-1250
RG3-250	RG4-1250
RG3-250A	RG4-3000

Xenon Rectifiers

RR3-250	RR3-1250A
RR3-1250	RR3-1250B

Thyratrons

(for operation as	XG15-10
grid-controlled	XG15-12
rectifiers)	

NEW COMPUTER DOUBLE TRIODES

Two new indirectly-heated double triodes with separate cathode connections are being added to the Mullard range of computer valves: the 6463 and the 6211. They are plug-in replacements for the American valves with the same type numbers, and will be available in sample quantities very shortly. As in other Mullard computer types, their cathodes have been designed to give satisfactory operation where long periods under cut-off conditions may be required.

Abridged Advance Data for 6463 and 6211

Mechanical	6463	6211	
Base	noval	noval	
Overall length	67	56	mm
Max. diameter	22.2	22.2	mm

Limiting Values

	6463*	6211*	
V_a max	330	200	V
$V_{a(b)}$ max.	660	600	V
I_k max	31	14	mA
p_a max	4.4	1.0	W
p_a max	7.7§	—	W

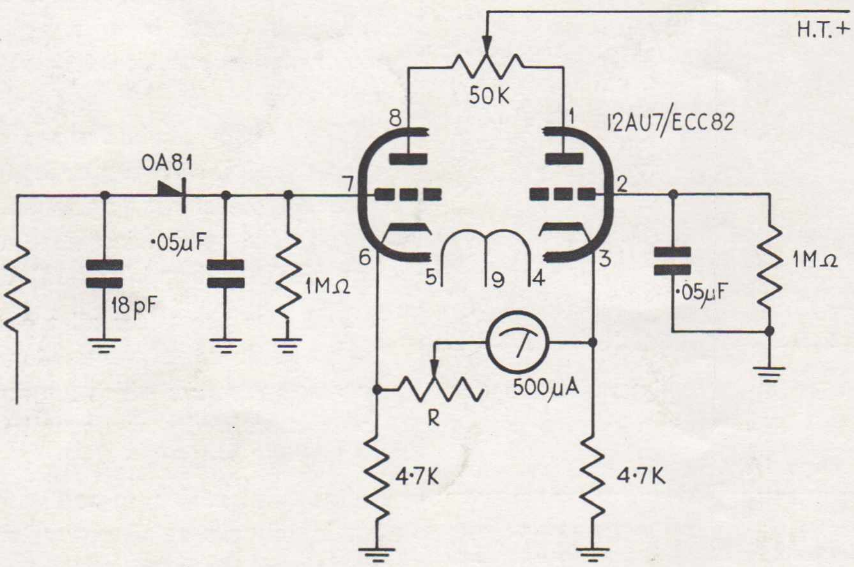
Characteristics

V_h	6.3(12.6)	6.3(12.6)	V
I_h	600(300)	300(150)	mA
g_m	5.2†	3.6**	mA/V
μ	20†	27**	
r_a	3.8†	7.5**	kΩ

*each triode §total for both triodes
†at V_a = 250V, R_k = 620Ω, I_a = 14.5mA approx.
**at V_a = 100V, R_k = 500Ω, I_a = 4.4mA approx.

TAPE RECORDER CIRCUITS

Following numerous requests from home constructors desirous of replacing the EM81 level indicator in Mullard tape recorder circuits with an indicating meter, it has been found necessary to develop and publish the circuit below. All components to the left of pin 7 of the 12AU7/ECC82 (which replaces the EM81) are already contained in the basic circuit and the values of the additional components are included in the circuit. It is therefore necessary to re-wire the socket to accommodate the 12AU7/ECC82, at the same time adding the additional components. The circuit is similar to that used in many valve voltmeters and has the indicator connected between the two cathodes. The grid of the second triode section is tied to earth and the 50kΩ potentiometer acts as a balance control. Rectification of signal voltage by the OA81 develops a potential at the grid of the first triode section resulting in a change of potential across the 4.7kΩ cathode resistor. The potential between the two cathodes is no longer balanced and hence an indication is received on the 500μA meter. Such indication is proportional to signal level and R may be adjusted to provide the desired sensitivity. The value of R will be to a large extent dependent on the characteristics of the indicating meter and, for convenience, it is suggested that a 10kΩ potentiometer be used with a fixed series resistor.



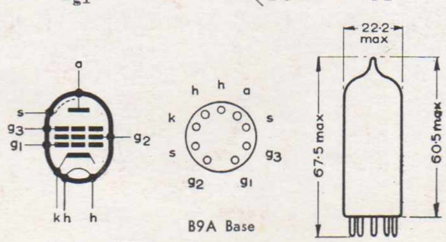
E80F USED AS AN ELECTROMETER

This special quality AF Amplifying Pentode is also suitable for use as an Electrometer.

Under favourable conditions a grid current of less than 10^{-10} amperes may be achieved.

Typical operating conditions as specified in the data sheet are:—

V_h	4.5	V
V_a	40	V
V_{g3}	0	V
V_{g2}	40	V
V_{g1}	−2.15	V
I_a	40	μA
I_{g2}	9.0	μA
I_{g1}	$<10^{-10}$	A

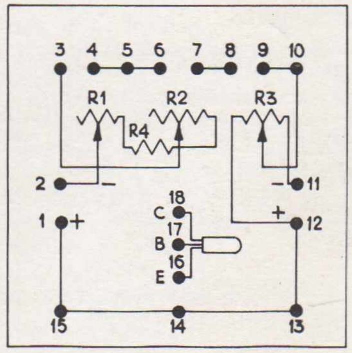


B9A Base
All dimensions in mm

AMATEUR EXPERIMENTERS COLUMN

TRANSISTOR DEMONSTRATION BOARD

The simple circuit given below will enable the young experimenter to obtain some first-hand experience with transistors and in addition may be used for demonstrating the properties of transistors or measuring their static characteristics. For convenience the components may be mounted on a 6″ square of ⅛″ perspex sheet.



R1 500 kilo-ohms pot. R3 500 ohms pot.
R2 20 kilo-ohms pot. R4 2 kilo-ohms

Fig. 1

The circuit is given in Figure 1 whilst Fig. 2 shows the layout and connections necessary for the measurement of characteristics of a transistor in common emitter connection. The external connections are shown in heavy line.

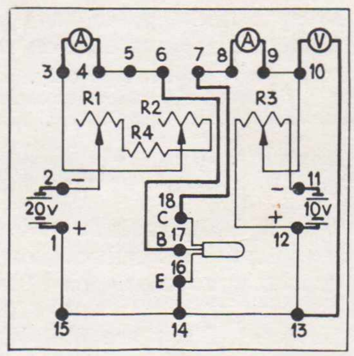


Fig. 2

APPLICATION. The provision of two or more sockets in parallel at certain points, as, for example, sockets 4, 5 and 6, in the input circuit, or sockets 1, 12, 13, 14 and 15 in the common 'ground' line, renders the unit adaptable for a wide variety of circuit arrangements. The sockets used for the external connections are of the familiar open type, Nos. 16, 17 and 18 being mounted upside down. The lock nuts may now be used for retaining the leads thus allowing transistors to be readily interchanged.

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