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MULLARD - AUSTRALIA PTY. LTD.



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Our cover picture this month is reproduced from one of the Mullard Radiant Screen posters which may be seen on railway stations, public transport and road sites throughout the Commonwealth.

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## OUR COVER—FLUORESCENT FRIENDS

Picture tubes—key performers and the last link in the magic chain—what romance the potential set-owner must conjure around this fluorescent gem and the anticipation of enjoyment and entertainment to come.

Throughout the land with outdoor posters large and small, in the press, in trains, trams, buses, ferries, on show cards and price tags—the crisp confident theme of our cover will help you sell receivers equipped with Mullard Radiant Screen Long Life Picture Tubes.

It will help you sell TV receivers to the first wave of starters and moreso to the second and third wave followers—timid and groping for product confidence.

Retailer readers, we urge you to take up the thread, develop this theme and if you have not already received your store display pieces, contact the Mullard distributor in your state.

Good luck and all success to your TV merchandising.

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# VIEWPOINT WITH MULLARD

## I.R.E. RADIO ENGINEERING CONVENTION, MAY, 1959

An exhibition of electronic equipment was staged in Wilson Hall in conjunction with the recent Convention held at Melbourne University by the Institution of Radio Engineers Australia and Mullard is justly proud of its participation in what must be regarded as the finest display of its kind seen in this country. The Convention was officially opened by Sir George Paton, Vice-Chancellor of the University and his address proved to be most illuminating.

Considerable interest centred around the Mullard stand as the selection of working exhibits appealed to engineers in many branches of the industry, whilst demonstrations of the Mullard 5 Stereo 7 amplifier and the screen-

coupled to a television receiver displayed on an oscilloscope the video information contained in a single line of a television picture. The line displayed was indicated on the picture tube by a marker. The equipment enabled any line from an odd or even frame to be selected at will.

In the field of ultrasonics the well known Mullard 60W ultrasonic drill for machining tungsten carbide, ceramics, glass, etc., was in operation whilst the new 250W twin beaker ultrasonic cleaning unit, capable of removing particulate contamination down to one micron or less even from hidden interstices, created considerable interest in view of its many potential applications in industry.

## U.K. MULLARD EXECUTIVE VISIT TO AUSTRALIA



A recent visitor, Mr. K. O. Rees, Commercial Manager of Mullard Limited, London, returned to the United Kingdom via Bombay on 24th July. During his stay, Mr. Rees spent some time in Melbourne and Adelaide and acquainted himself generally with the local scene. Prior to his present appointment Mr. Rees was Valve Export Manager and in view of this international background some comments made before his departure are significant. He said the quality, standard, presentation and display of the Australian merchandise was equal to anything he had seen elsewhere and added that he was most impressed with the efficiency of the local factories he had inspected. Mr. Rees prophesied the widest acceptance of the new frame grid valves—particularly in television fringe areas and also the contribution these valves would make towards lower priced receivers.

Mr. Rees said that the recently completed semiconductor factory at Southampton was already being expanded and that semiconductor production by Mullard in the United Kingdom was increasing at an enormous rate. He went on to say that the electronic industry in Great Britain was running at a high level and that it was also particularly gratifying that Mullard valves were now widely used in the United States.

control alternating currents up to 3.5 amps and by the choice of suitable thyratrons this principle may be extended to the control of power at a much higher level. A tandem carbon potentiometer is used as the control element for the variable A.C. supply, thus rendering the unit suitable for remote operation by simply extending the potentiometer leads.



ing of technical films proved very popular with visitors. The display featured a selection of the more specialised types from the range of valves, electron tubes and semiconductors together with electronic equipment such as a transistor stabilised power supply unit, transistor tester, dual trace oscilloscope, television line selector, valve voltmeters, high and low pass audio filters, delay lines and magnetic matrix stacks for computers. Also on show were a number of recently developed ferrite components and microwave devices, some of which were laboratory samples not yet in production. A television line selector

A three decade counter chain demonstrated the circuit simplicity obtainable with the recently introduced cold cathode counter tube type Z302C. This tube permits the design of decade counters without interstage amplifiers since each tube generates an output pulse of sufficient amplitude to drive the next counter tube in the chain. Counting speeds up to 1000 pulses per second are readily attainable with the Z302C.

Two thyratrons XR1-1600 connected in inverse-parallel (see "Mullard Outlook" Vo. 2 No. 3 May-June 1959 page 33. Ed.) were used to

# SEVEN-WATT STEREOPHONIC AMPLIFIER

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.

This article gives details of an alternative balance control circuit, enabling the use of a single potentiometer instead of a ganged unit. The range of adjustment of 6db will be found adequate for normal applications. An additional leaflet featuring the Mullard "2-Stereo-2" Amplifier and speaker enclosures for stereophonic reproduction is available on request.

"Circuits for Audio Amplifiers" will shortly be available from Mullard-Australia Pty. Limited, Sydney and Melbourne.

The circuit diagram drawn in Fig. 1 is for a high-quality dual-channel amplifier designed principally for stereophonic reproduction but also providing facilities for monaural applications. Only one channel of the amplifier is drawn. The circuitry appearing between the dotted lines is for the left-hand channel: it should be duplicated for the right-hand channel. The circuitry drawn outside the dotted lines (the power supply, for example), is common to both channels.

The total complement of valves used in the amplifier consists of one double triode, type 12AX7/ECC83, four triode pentodes, type 6BM8/ECL82, and one full-wave rectifier, type 6CA4/EZ81. The double triode is shared between the two channels, one section of the valve being used in each channel for voltage amplification. Two of the 6BM8/ECL82s are used in each channel. The triode sections of these valves form a phase-splitting stage and the pentode sections are arranged as a push-pull output stage with distributed

loading. The 6CA4/EZ81 forms a conventional power supply with resistance-capacitance smoothing, providing the h.t. for both channels.

The rated output-power reserve of each channel is 7W, at which level the harmonic distortion is always better than 0.5%. The low level of distortion is achieved by using 21dB of negative feedback, the feedback voltage being taken from the secondary winding of the output transformer in each channel to the cathode circuit of the corresponding input stage. The sensitivity of the amplifier, even with this high value of feedback, is 100mV, for an output of 7W, which is ample for use with existing stereophonic crystal pick-up heads.

## CIRCUIT DESCRIPTION

Resistors and capacitors appearing in the left-hand channel of the amplifier are numbered 1, 2, 3, etc.; the corresponding components in the right-hand channel are numbered 101, 102, 103, etc.

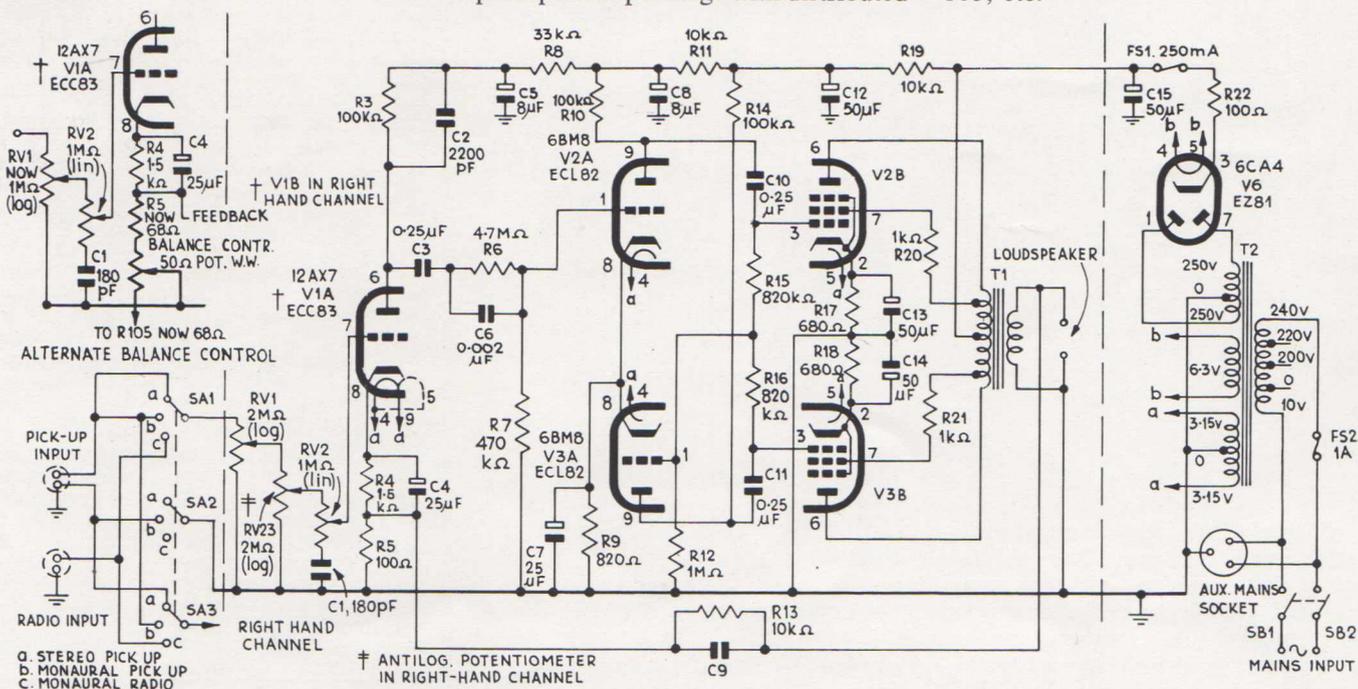


Fig. 1 — Circuit diagram of seven-watt stereophonic amplifier (left-hand channel only is shown: circuitry between vertical dotted lines should be repeated in right-hand channel)

### Input Selector Switch

The input stages of both channels are connected to the 3-way selector switch SA. The switch positions indicated in Fig. 1 provide the following facilities:

- Stereophonic reproduction from stereophonic crystal pick-up heads.
- Dual-channel monaural reproduction from a monaural pick-up head.
- Dual-channel monaural reproduction from an A.M. or F.M. tuner unit.

### Input Stage

The triode sections of the 12AX7/ECC83 are used for voltage amplification, one section being used in each channel.

## LIST OF COMPONENTS

Resistors and capacitors in the left-hand channel are numbered 1, 2, 3, etc.; corresponding components in the right-hand channel are numbered 101, 102, 103, etc.

### Resistors

Circuit ref.	Value	Tolerance (±%)	Rating (W)
RV1 and RV101	2 × 2 MΩ	log. pot.	
RV2 and RV102	2 × 1 MΩ	lin. pot.	
R3, R103	100 kΩ	10	½
R4, R104	1.5 kΩ	10	½
R5, R105	100 Ω	10	½
R6, R106	4.7 MΩ	10	½
R7, R107	470 kΩ	10	½
R8, R108	33 kΩ	10	½
R9, R109	820 Ω	10	½
R10, R110	100 kΩ	10	½
R11, R111	10 kΩ	10	½
R12, R112	1 MΩ	10	½
R13, R113	10 kΩ	10	½
R14, R114	100 kΩ	10	½
R15, R115	820 kΩ	5	½
R16, R116	820 kΩ	5	½
R17, R117	680 Ω	10	2
R18, R118	680 Ω	10	2
R19, R119	10 kΩ	10	½
R20, R120	1 kΩ	10	½
R21, R121	1 kΩ	10	½
R22	100 Ω	10	6
*RV23	2 MΩ	log. pot.	
*RV123	2 MΩ	antilog. pot.	

\*10% law

### Capacitors

Circuit ref.	Value	Description	Rating (V)
C1, C101	180 pF	silvered mica	
C2, C102	2200 pF	silvered mica	
C3, C103	0.25 μF	paper	275
C4, C104	25 μF	electrolytic	3
C5, C105	8 μF	electrolytic	300
C6, C106	0.002 μF	paper	275
C7, C107	25 μF	electrolytic	3
C8, C108	8 μF	electrolytic	300
C9, C109	Adjust to suit	output transformer	
C10, C110	0.25 μF	paper	275
C11, C111	0.25 μF	paper	275
C12, C112	50 μF	electrolytic	300
C13, C113	50 μF	electrolytic	30
C14, C114	50 μF	electrolytic	30
C15	50 μF	electrolytic	300

Tolerance of silvered mica capacitors is ±10%

### Output Transformer

Primary Impedance: 9kΩ

Secondary Impedance: as required

### Mains Transformer

Primary: 10-0-200-220-240V

Secondaries: H.T. 250-0-250V, 150mA

L.T. 3.15-0-3.15V, 4A (for 12AX7/ECC83 and 6BM8/ECL82s)  
0-6.3V, 1A (for 6CA4/EZ81)

### Valves

Mullard 12AX7/ECC83, 6BM8/ECL82 (four), 6CA4/EZ81

### Miscellaneous

- 1 Mains switch
- 1 H.T. supply plug (pre-amplifier)
- 2 Fuseholders
- 2 Fuses, 250mA and 1A
- 1 Lampholder
- 1 Pilot lamp, 6.3V, 0.15A
- 2 Input sockets
- 2 Output plugs

## Valveholders

1 B9A (noval) Nylon-loaded, ceramic or PTFE with screening skirt (for 12AX7/ECC83).

5 B9A (noval)

## Balance Control

To compensate for any differences in acoustical output resulting from unequal outputs from the stereophonic pick-up head or unequal sensitivities of the loudspeakers, a balance control consisting of RV23 and RV123 is included between the input and the grid of the first valve. This is made up of a logarithmic potentiometer connected in reverse in one

channel and an antilogarithmic potentiometer connected normally in the other.

## Phase-splitting Stage

The output from the anode of V2A is taken to the grid of V3A by way of the resistors R15 and R12 (R115 and R112). These components also form the grid-leak resistance for the pentode section V2B, and R16 and R12 (R116 and R112) comprise the grid-leak resistance for V3B. Balance between the output voltages from the triodes of the phase-splitter is governed by the values of these three resistors.

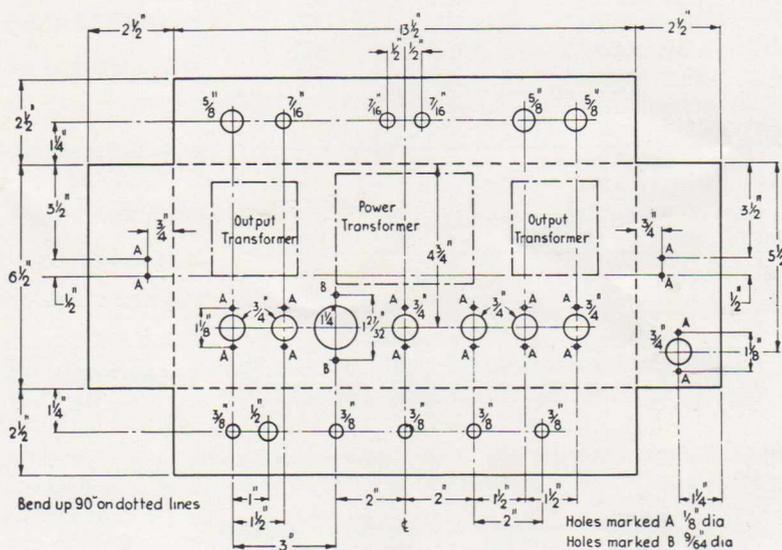
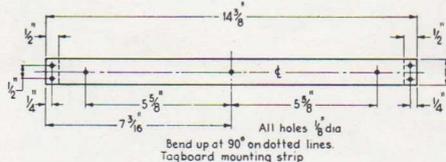


Fig. 2 — Chassis details (the pieces should be bent up at 90° at all dotted lines)

(a) (above) Main chassis

(b) (below) Tagboard mounting strip



## Output Stage

The pentode sections of the 6BM8/ECL82s are used in a push-pull output stage. Distributed loading is used, and the primary winding of the output transformer is tapped so that 20% of the winding in each anode circuit also appears in the corresponding screen-grid circuit.

## Negative Feedback

21 dB of negative feedback is used in each channel. Under these conditions the output resistance in each channel is 0.54 ohms measured at the 15 ohm output terminal.

## Power Supply

The conventional power supply using the Mullard full-wave rectifier type 6CA4/EZ81, with resistance-capacitance smoothing, provides the high tension for both channels. The total high tension current drawn by the amplifier is 150mA at 260V.

## CONSTRUCTION

The chassis for the 5-Stereo-7 amplifier was made from two separate pieces of 16 s.w.g. metal sheet. Each piece should be marked as shown in the drawings of Fig. 2, and holes should be cut as indicated.

Most of the smaller components are grouped on tagboards, the wiring of which is shown in Fig. 3.

Point of Measurement		Voltage (V)	Range of D.C. Avometer* (V)
C15 Common to both channels		260	1000
	C12	230	1000
	C8	210	1000
	C5	190	1000
V2, V3 6BM8/ ECL82	Pentode anodes	256	1000
	Pentode screen grids	255	1000
	Pentode cathodes	21	100
	Triode anode V3	130	1000
	Triode anode V2	110	1000
	Triode cathodes	2.0	25
V1 12AX7/ ECC83	Anode	90	100
	Cathode	1.5	25

\*Resistance of Avometer:

1000V-range, resistance = 20MΩ

100V-range, resistance = 2MΩ

25V-range, resistance = 500kΩ

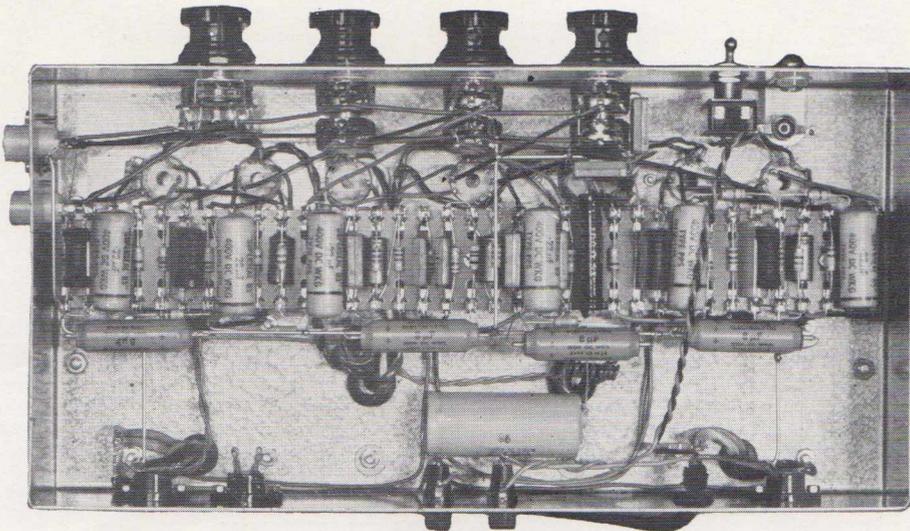
## PERFORMANCE

### Distortion

The total harmonic distortion was measured in the prototype amplifier with a continuous sine wave input signal at 400c/s. With 21dB of negative feedback the distortion for the rated output of 7W per channel is lower than 0.5%.

### Sensitivity

With the full amount of negative feedback applied to the amplifier the input sensitivity is 100mV for the rated output of 7W (for each channel).



Underside view of prototype amplifier

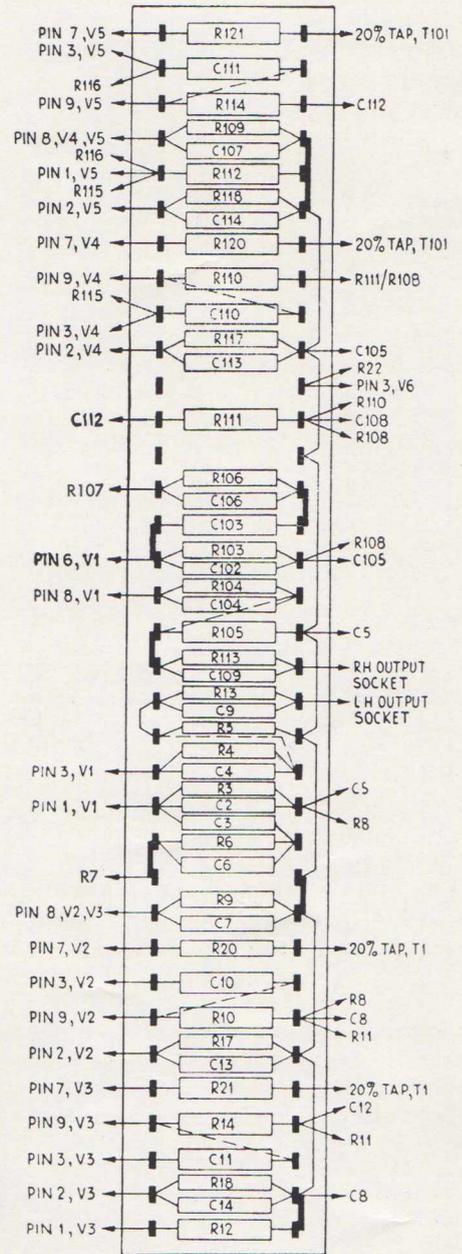
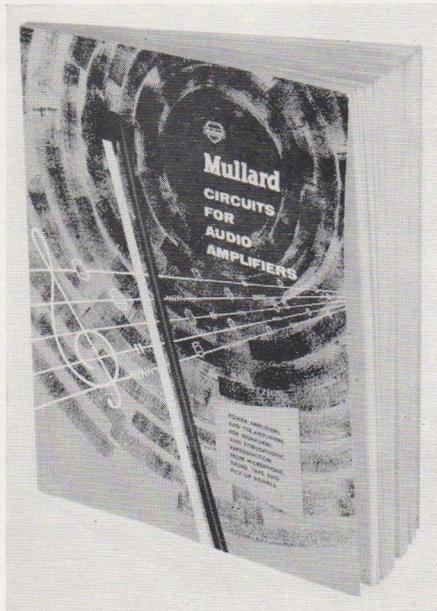


Fig. 3—Tagboard

For more detailed information please refer to the Mullard publication "CIRCUITS FOR AUDIO AMPLIFIERS".

# CIRCUITS FOR AUDIO AMPLIFIERS



Circuits for Audio Amplifiers is a new Mullard Publication in which the wide range of Mullard high-quality audio circuits is presented conveniently in one book. Four introductory chapters are devoted to theoretical and practical considerations of high-quality sound reproduction either with monaural equipment or with stereophonic systems. The rest of the book comprises circuit descriptions, constructional details and performance figures of twelve Mullard circuits. These circuits include well-known Mullard designs, some modifications and improvements to these designs and a number of completely new designs.

“Circuits for Audio Amplifiers” will shortly be available from Mullard-Australia Pty. Limited, Sydney and Melbourne.

- Chapter 1—Amplifying Systems.
- Chapter 2—Sources of Distortion in Recorded Sound.
- Chapter 3—High-Quality Amplification.
- Chapter 4—General Notes on Construction and Assembly.
- Chapter 5—Twenty-watt Amplifier.
- Chapter 6—Ten-watt Amplifier.
- Chapter 7—Three-watt Amplifier.
- Chapter 8—Seven-watt D.C./A.C. Amplifier.
- Chapter 9—Two- and Three-valve Pre-amplifiers.
- Chapter 10—Input-mixing Pre-amplifier.
- Chapter 11—Three-watt Tape Amplifier.
- Chapter 12—Tape Pre-amplifier.
- Chapter 13—Seven-watt Stereophonic Amplifier.
- Chapter 14—Three-valve Stereo-phonetic Amplifier.
- Chapter 15—Stereophonic Pre-amplifier.

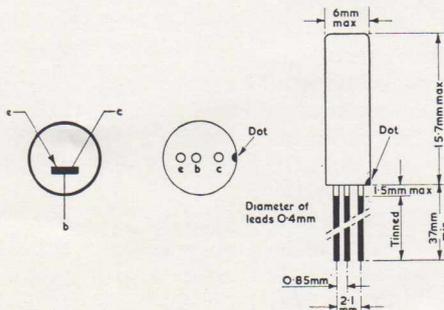
# SILICON ALLOY TRANSISTORS

The new Mullard silicon alloy transistor type OC201 is similar to the recently introduced OC200, however the average current gain has been increased from 20 to 30 and the minimum  $f_a$  increased from 0.5 to 2 Mc/s. Like other transistors in the Mullard silicon alloy range, the OC201 has a low bottoming voltage together with all the advantages of the well known OC71 germanium series. In addition these silicon transistors feature a low collector leakage, reduced noise figure and high permissible operating temperature. The maximum collector voltage is 25V for the OC201, but its low bottoming voltage allows it to be operated from supplies as low as 1.2V. The linearity of current gain vs. collector current is maintained up to 50mA. The 2 Mc/s cut-off frequency and high permissible junction temperature rating of 150°C enable this transistor to be operated at relatively high frequencies with a power dissipation of 100mW at 100°C. The table provides a ready comparison between the silicon transistors type OC200 and OC201 and their germanium counterparts the OC70 and OC71.

## ABRIDGED ADVANCE DATA FOR OC200 AND OC201 WITH GERMANIUM COUNTERPARTS FOR COMPARISON

	Silicon types		Germanium types		
	OC200	OC201	OC70	OC71	
<b>Limiting Values</b> (absolute ratings)					
Collector voltage (grounded base or grounded emitter)					
$V_{c(pk)}$ max	-25	-25	-30	-30	V
$V_e$ max (av or d.c.)	-25	-25	-20	-20	V
Collector current					
$i_{c(pk)}$ max	50	50	50	50	mA
$I_c$ max (averaged over any 20ms)	15	15	10	10	mA
<b>Temperature Ratings</b>					
Max $T_{junction}$ , continuous operation	150	150	75	75	°C
$T_{junction}$ rise above ambient	0.5	0.5	0.4	0.4	°C/mW
<b>Characteristics at <math>T_{junction}=25^\circ\text{C}</math></b>					
<b>Grounded base</b>					
$I_{c(o)}$ at $I_e = 0$ av	0.01	0.01	5.0	4.5	$\mu\text{A}$
max	0.3	0.3	13	13	$\mu\text{A}$
$I_{e(o)}$ at $I_c = 0$ av	0.01	0.01	3.0	3.5	$\mu\text{A}$
max	0.3	0.3	13	13	$\mu\text{A}$
<b>Grounded emitter</b>					
$I'_{e(o)}$ at $I_b = 0$ av	0.02	0.02	110	150	$\mu\text{A}$
max	1.0	1.0	225	325	$\mu\text{A}$
$V_{ce}$ (bottoming) av	-130	-100	-100	-80	mV
max	-320	-320	-330	-210	mV
Noise figure av	8.0	6.0	10	10	dB
max	—	—	16	16	dB
<b>Typical grounded base cut-off frequency</b>					
$f_a$ min	0.3	2.0	0.2	0.3	Mc/s
av	1.0	4.0	0.5	0.6	Mc/s
max	3.5	—	1.0	1.0	Mc/s

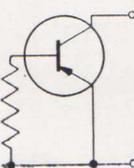
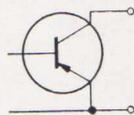
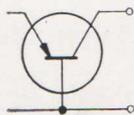
OC200  
OC201



# POWER TRANSISTOR APPLICATION LIMITS

Normally, in published data, transistors have their maximum usable collector voltages specified under three sets of conditions:

- A: The collector breakdown in grounded base with open circuit emitter;
- B: The collector breakdown in grounded emitter with open circuit base;
- C: A more realistic specification—grounded emitter with base connected to ground with a resistance or impedance of less than some given value.



All these conditions are protected by quality control tests in the transistor factory, ensuring that every transistor meets the specifications.

When transistors are used with resistive loads in their collector, these cut-off conditions normally represent the position of greatest voltage stress on the device. In such a resistive load circuit — as the current increases, the voltage across the transistor falls, and it is possible to draw all normal load lines and still remain within the published data requirements, whether stated or implied. If, however, an inductive load is used with the transistor in grounded emitter, and the transistor (having been fully driven on its base to, say, 2 amps collector current) is suddenly cut off, then current continues to flow in the collector. The voltage across the inductance rises in the right direction to maintain this current, thus the transistor is instantaneously subjected to a condition of high voltage and high current which is never met with in ordinary resistive or theoretical transformer applications.

The graph shows three curves of collector voltage plotted against collector current.

In curve "A," represented by condition "A" above, a normal diode breakdown occurs and the transistor softens at, for example, 90V.

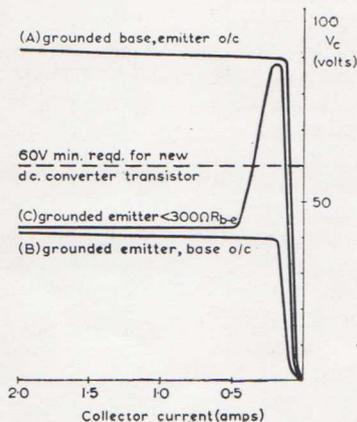
In curve "B" — transistor in grounded emitter with open circuit

base—normal avalanche breakdown causes the device to soften at 40V. Again, this is a normal breakdown effect, and the curve is a straightforward one.

In curve "C," however, the breakdown voltage at low currents remains nearly that of the collector by itself, as in curve "A"; but as soon as additional drive current is applied to the transistor to give higher collector currents, the breakdown voltage rapidly falls, and at 0.5 amp it is only a little greater than in curve "B."

**TO OBTAIN GOOD LIFE THE TRANSISTOR MUST NOT BE OPERATED EVEN UNDER TRANSIENT CONDITIONS ABOVE THIS REGION OF HIGH CURRENT AND VOLTAGE BREAKDOWN.**

For example, if the transistor is passing 2A into an inductive load connected to a 24V accumulator, and is suddenly cut off so that the voltage across the transistor rises above its breakdown value of 40V, then the internal dissipation will be 80W. Such a peak dissipation is quite destructive. At 6A (and it is normally a peak current such as this which occurs immediately before switch-off) the dissipation is 240W.



Future Mullard data will specify the maximum voltage that can be applied under these conditions to existing types. New transistor types will, as far as is possible, be designed to accept the highest possible stresses under these conditions without breaking down. To obtain good life, however, whatever the published breakdown of the transistor used, this

published maximum voltage should never be exceeded at all.

An article entitled "An Introduction to the Use of Transistors in Inductive Circuits: Delayed Switch-off Effects" has been published in Mullard Technical Communications (Vol. 4, No. 35, Nov., 1958, pages 157 to 160). It gives full information on the physics behind this phenomenon.

So far as is known, limit figures for this breakdown phenomenon have very rarely, if ever, been published before. Some considerable amount of application work in the Mullard laboratories will be necessary before we can be quite certain that we have covered every eventuality; but this preliminary announcement should draw full attention to the importance of the phenomenon and the steps which we are taking to overcome its implications.

## MULLARD SEMICONDUCTORS FOR INDUSTRY

### Transistors

OC22	} high frequency power applications	
OC23		
OC24		
OC70	Low $\alpha'$	} General purpose low level audio amplifiers
OC71	Medium $\alpha'$	
OC75	High $\alpha'$	
OC72	200mW	} Push-pull audio output
OC30	2W	
OC16	10W	
OC41	} r.f. computing	
OC42		
OC44	15Mc/s average $f\alpha$ cut off	
OC45	6Mc/s average $f\alpha$ cut off	
OC76	General purpose	} Switching and industrial
OC77	High voltage	
OC200	Silicon version of OC70	
OC201	Silicon version of OC71	
OCP71	Germanium phototransistor	

### Diodes

OA81	} General purpose point-contact
OA85	
OA91	Subminiature version of OA81
OA95	Subminiature version of OA85
OA86	High-voltage computing, point-contact
OA5	High-voltage, gold-bonded
OA7	} Low-voltage, high-frequency computing, gold-bonded
OA47	
OA10	Low-voltage, high-current, computing
OA31	Power rectifier for transistor supplies
OA210	} Silicon high-voltage power rectifiers
OA211	
OA214	
OA202	Silicon rectifier 150 P.I.V.
OAZ200 to	} Zener diodes, 4V to 9V
OAZ207	
OAZ208 to	} Zener diodes, 4V to 12V
OAZ213	

# BIAS FOR A SPEECH RECORDER

The present article shows the introduction of the transistor into yet another branch of magnetic recording—that of the dictation machine.

## QUALITY STANDARDS

Most magnetic recorders require a built-in oscillator to generate a bias supply. Its purpose is to ensure that recording takes place only on the linear parts of the magnetisation characteristic of the tape or wire. Briefly, as the magnetising force is increased from zero the resulting magnetisation does not increase linearly until a certain level has been reached. Use of this early part of the characteristic would produce distortion, therefore a high-frequency bias oscillation is used to blank out this part of the characteristic. A fuller discussion of the process will be found in the Mullard booklet, "Circuits for Tape Recorders" (now out of print), or in the new Mullard handbook, "Circuits for Audio Amplifiers" (available shortly).

## BIAS REQUIREMENTS

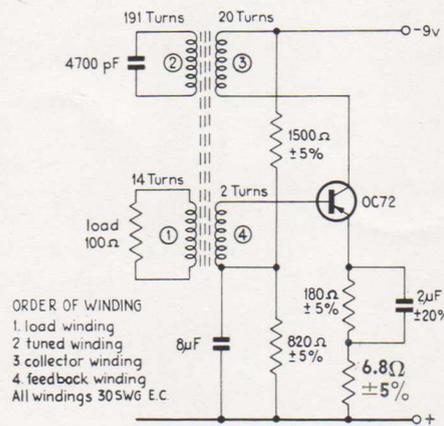
The required bias signal is a symmetrical sine wave with very little harmonic distortion. Anything else will produce noise and will waste magnetising energy. The frequency of the signal must obviously be outside the audio range. It must also be high enough to avoid any beat effects, but not so high that it will tend to demagnetise the tape. A common rule (which is based on what is found to work, rather than on complicated and uncertain theory) is to use a bias frequency nearly five times the highest frequency which is to be recorded. In a dictation machine a suitable bias frequency is therefore about 20kc/s. The required power is about 50mW, and the harmonic distortion should be less than 5%.

## PRACTICAL OSCILLATOR

These requirements can be met by some attractively simple transistor oscillators. Unfortunately, they don't start reliably, or they work with one transistor but not with another of the same type, or they go adrift on VERY hot afternoons.

A slightly more complex but practical circuit, built around the Mullard OC72 transistor, is shown in the diagram. It meets all the requirements.

A prototype circuit built in the laboratory was tried with a number of transistors, ranging from the highest published value of current gain to the lowest. The voltage at the collector stayed within  $\pm 7.5\%$  of the design value, which means that the power outputs obtained with various transistors ranged from 45mW to 59mW. The frequency of operation was 19.25kc/s. The battery voltage (nominally 9V) could be taken down to 3V or up to 14.5V without the oscillator stopping. There is, however, a limitation here: the battery voltage must not be greater than 9V when the ambient temperature exceeds 55°C.



## CIRCUIT DESCRIPTION

The circuit works in a similar way to a valve oscillator. The emitter is analogous to the cathode, the base to the grid, and the collector to the anode. Energy from the collector circuit is fed back, through the transformer, to the base in such a way as to keep oscillation going. With the component values shown, the circuit is self-starting with any OC72. The transistor is used in grounded emitter, which ensures minimum drive for the required output.

## TRANSISTOR WORKING POINT

Automatic bias is applied by using a suitable capacitor across the emitter resistor. With the 2 $\mu$ F capacitor shown, an average OC72 will work in Class B; a high gain OC72 will tend towards Class C, and a low gain OC72 towards Class A. This means that power output is kept reasonably close to 50mW. Also, high gain OC72s are prevented from bottoming, and the sine wave output is not clipped. A larger value

of capacitor could cause squegging; a smaller value would not maintain oscillation.

The alternating energy which is fed back to the base is rectified at the base-emitter diode, producing d.c. which charges up the 2 $\mu$ F capacitor so that the mean base-emitter potential tends towards zero. Only negative pulses at the base cause a flow of current at the collector.

No appreciable a.c. potential is developed across the 8 $\mu$ F capacitor in the base circuit. It would be possible to use a 3V battery tap in place of this capacitor and the potential divider.

## LOAD

For the component values shown, the optimum load is 200 $\Omega$ . An actual load of some other value (say 100 $\Omega$ , as shown) is accommodated by a suitable turns ratio for the load winding, given by

$$\frac{\text{No. of secondary turns}}{\text{No. of primary turns}} = \sqrt{\frac{\text{Load}}{200\Omega}}$$

## TUNING

With a Mullard pot core type LA1 for the transformer, the collector winding must have 20 turns to give the correct inductance. To tune this a capacitor of 0.44 $\mu$ F would be necessary. Since this is a large and awkward value the 191-turn tuned winding is used with a more convenient capacitor of 0.0047 $\mu$ F.

## FEEDBACK

Calculation gives 1.6 turns for the feed-back winding. The use of a practical 2-turn winding provides a margin for loss of drive voltage in the emitter circuit. The amplitude of the oscillation is determined by the small unbypassed section of the emitter resistor, whose value of 6.8 $\Omega$  is chosen with transistor spreads in view.

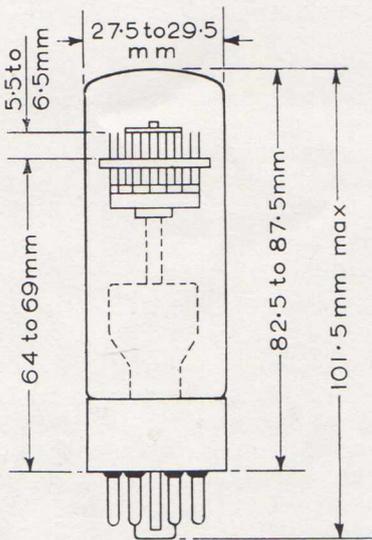
The design of the circuit was based on the required limitation of harmonic distortion to less than 5%. This figure is achieved in practice.

The transistor operates with an average collector-to-emitter voltage of 6.0V; a collector current of 50mA peak, 15.9mA mean; and a collector dissipation of 39.25mW. These conditions, and the operating frequency of about 20kc/s, are safely within the published OC72 ratings.



# COLD-CATHODE DECADE COUNTER Z302C

The increasing use of cold-cathode decade stepping tubes for computing, industrial control, counting, and similar applications, has led to a demand for tubes which offer extreme circuit simplicity. Such tubes would allow low equipment cost without any sacrifice of reliability. This demand is met by the newly introduced Mullard Z302C. With this tube, complete counter chains can be built without interstage coupling amplifiers. A con-



siderable simplification of the circuit is thus achieved.

## STRUCTURE

The Z302C consists of a circular anode surrounded by thirty cathodes which are connected to form ten repeated groups of three electrodes. In each group (going clockwise) is a guide cathode (GD), an extinguish cathode (E), and a main cathode (k). All the guide cathodes are connected together and brought out to a single base pin. All the main cathodes are similarly brought out. The extinguish cathodes, however, are connected in three separate groups:  $E_{\text{odd}}$  ( $E_1, E_3, E_5, E_7, E_9$ ),  $E_{\text{even}}$  ( $E_2, E_4, E_6, E_8$ ), and  $E_0$  (which is slightly displaced from the ring of cathodes, and has a higher breakdown voltage) on its own. Thus there are six external connections to the tube:

GD, k,  $E_{\text{odd}}$ ,  $E_{\text{even}}$ ,  $E_0$ , anode.

The last four stages of the tube,  $k_4$ ,

to  $k_0$ , are shown in the diagram with the basic circuit arrangements.

With suitable circuit conditions, a discharge is formed between the anode and one of the main cathodes. Its position is shown by a visible glow on the tip of the cathode, which remains in position until the discharge is moved to the next main cathode by a suitable input signal.

## CIRCUIT

The input or count signals are applied via R1 to the guide cathodes (which are also connected to earth via



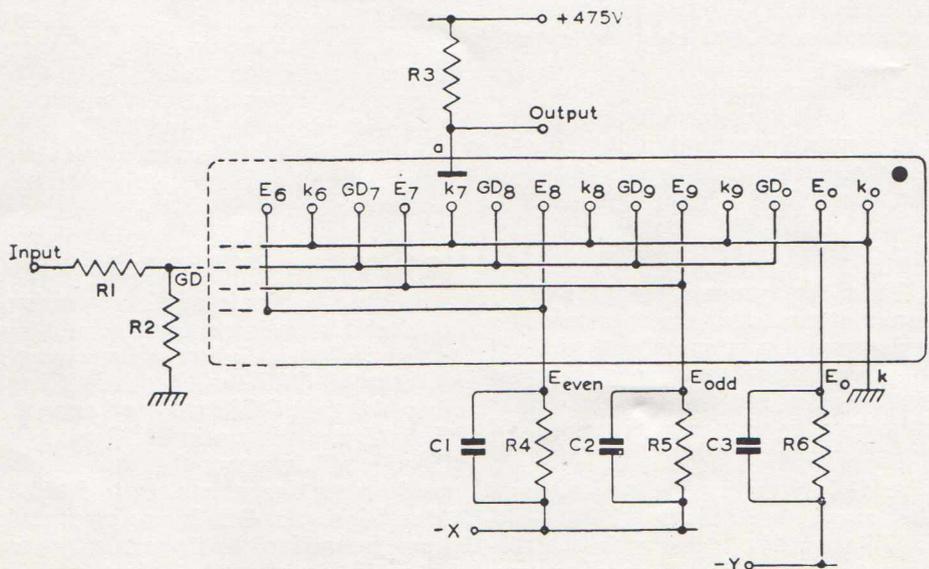
the high resistance R2). The two groups of extinguish cathodes,  $E_{\text{odd}}$  and  $E_{\text{even}}$ , are taken via RC networks

to a negative supply  $-X$  (about  $-30V$ ); while the remaining extinguish cathode,  $E_0$ , is taken via an RC network to a more negative supply  $-Y$  (about  $-120V$ ). The main cathodes are earthed. The anode (from which the output signal is taken) is connected through a limiting resistor R3 to a 475V supply. The output is normally coupled to the input of the next counting tube.

If the discharge is resting in, say, the seventh position, there will be a discharge to  $E_7$  and  $k_7$ , and the potentials of these two electrodes will be approximately the same. The current division between  $E_7$  and  $k_7$  is determined mainly by R5, which is chosen so that the current to  $k_7$  is about ten times greater than to  $E_7$ , and the main glow is therefore on  $k_7$ . The ionisation in the region between  $k_7$  and  $GD_8$  will therefore be much greater than that between  $GD_7$  and  $E_7$ .

## TRANSFER

If a negative input pulse is now applied to the guide cathodes, the discharge will transfer to  $GD_8$  rather than to  $GD_7$ , since  $GD_8$  is better primed than  $GD_7$ . It will then transfer to the negative cathode  $E_8$ , and C1 will act initially as a short circuit which clamps  $E_8$  to the  $-X$  line. Since the maintaining voltage of the tube is constant (about 190V), the potential at the anode will fall by about  $X$  volts and



# M8196, SPECIAL QUALITY 6AS6

will then return linearly to its original value. Similarly, C2 will momentarily hold  $E_7$  at earth potential. These effects ensure that the discharge to  $E_7$  and  $k_7$  is extinguished and that the  $E_7-k_7$  region is deionised.

As C1 charges, the potential of  $E_8$  will rise towards 200V. When  $E_8$  is sufficiently positive with respect to  $k_8$ , the main discharge will transfer from  $E_8$  to  $k_8$ , and the current distribution will adjust itself so that the current to  $k_8$  is about ten times that to  $E_8$ . The transfer of the glow indication from main cathode to main cathode ( $k_7$  to  $k_8$ ) is now complete. During the transfer, C2 starts to discharge exponentially with a time-constant  $R5C2$  towards  $-X$  volts as soon as the discharge has moved to  $GD_8$ . When C2 has discharged to  $-X$  volts, the circuit is back to its original state, and is ready for a further input pulse which moves the discharge in a similar manner from  $k_8$  to  $k_9$ .

## OUTPUT

The tenth input pulse must initiate two simultaneous effects:

- (i) transfer from  $k_9$  to  $k_0$
- (ii) generation of an output or "carry" pulse to drive the next counter tube.

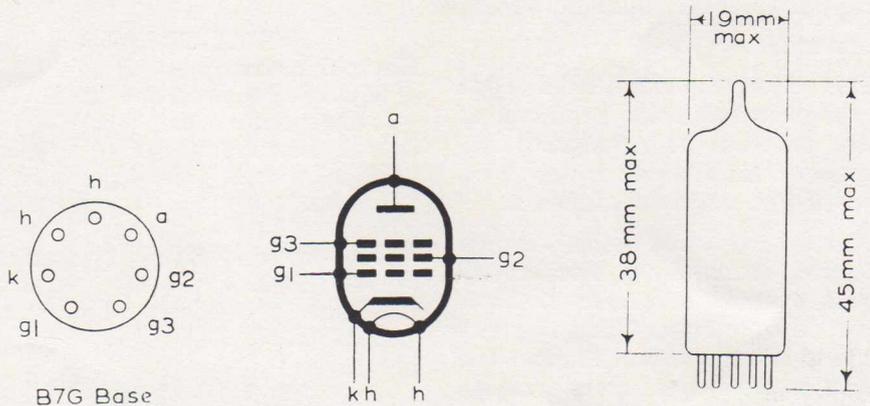
The process is at first similar to that already described; but when the discharge moves to  $E_0$  the anode potential will fall by about  $Y$  volts, which is four times the normal fall of  $X$  volts. Thus at the anode, and therefore at the output point, each complete revolution of the discharge will produce nine small pulses (as the discharge moves successively to  $k_1, k_2, k_3 \dots k_9$ ) followed by one large  $k_0$  pulse.

All the output pulses are fed to the guide cathode connection of the next counting tube; but the positive bias on the guide cathodes ensures that only the large tenth pulse will step the glow discharge. This positive guide bias is obtained by the high value resistor between the guides and earth, and by the fact that the guides act as probes in the main cathode discharge.

The maximum speed at which the Z302C will count reliably depends on tube and circuit parameters which are still under investigation. In a practical circuit it is expected that counting speeds up to about 1000 pulses per second will be attainable.

A ruggedised version of the 6AS6, which has a short suppressor base is now available under the type number M8196. This valve is a dual control pentode for switching or gating, and it may also be used as a frequency changer. It is equivalent to the Services'

type CV4011 and the American 5725/6AS6W. It is for use in equipment where mechanical vibration and shocks are unavoidable, and where statistically controlled major electrical characteristics are required. Full data sheets are in course of preparation.



B7G Base

## Advance Data for M8196

### Limiting Values (absolute ratings)

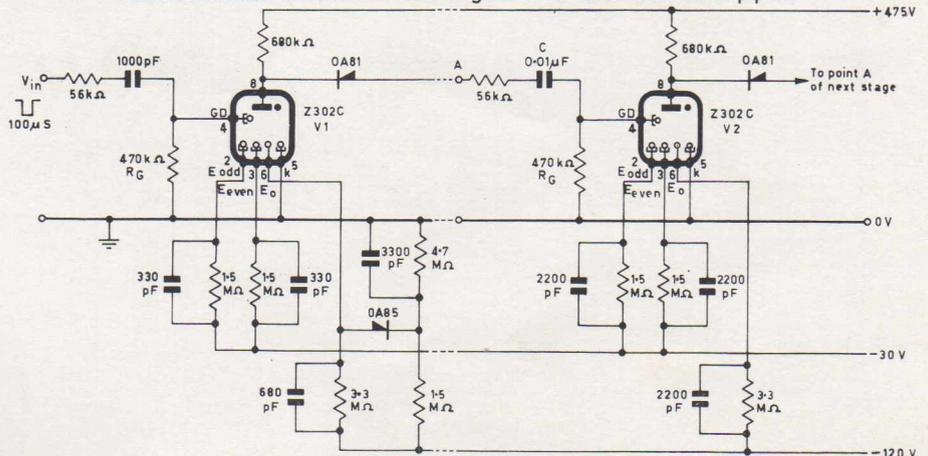
$V_{a(b)}$ max	400	V
$V_a$ max	200	V
$V_{g3}$ max	30	V
$V_{g2(b)}$ max	310	V
$V_{g2}$ max	155	V
$p_a$ max	1.65	W
$p_{g2}$ max	550	mW
$I_k$ max	20	mA
$V_{h-k}$ max	100	V
$T_{bulb}$ max	140	°C
Max overall length	45	mm
Max seated height	38	mm
Max diameter	19	mm

$V_h$	6.3	V
$I_h$	175	mA
Base	B7G	

### Characteristics

$V_a$	120	120	V
$V_{g2}$	120	120	V
$V_{g3}$	-3.0	0	V
$V_{g1}$	-2.0	-2.0	V
$I_a$	3.6	5.2	mA
$I_{g2}$	4.8	3.5	mA
$g_m (g_1, a)$	1.85	3.2	mA/V
$g_m (g_3, a)$	810	470	$\mu$ A/V
$r_a$	—	150	k $\Omega$
$V_{g1} (I_a = 100\mu A)$	—	< -7.5	V
$V_{g3} (I_a = 20\mu A)$	-10	< -15	V
$R_k$	0	0	$\Omega$

## RECOMMENDED CIRCUIT for counting rates of less than 1000 p.p.s.





# VARIABLE X-BAND ISOLATOR

In addition to the high and low power Isolators—types L 251 and L 250, Mullard has added yet another type which covers a range of 2,000 Mc/s. within the X-Band.

This Isolator, L 324 will find application in the fields of radar, communications, and because of its flexibility, for micro-wave investigations in the laboratory.

This device depends for its action on the non-reciprocity exhibited by ferrite materials at micro-wave frequencies. This property is due to the effect of gyro-magnetic resonance.

A small trapezium shaped laminar of ferrite, backed by a block of dielectric material of similar shape is placed in a section of waveguide surrounding this magnetic assembly. The magnet serves to produce a magnetic field in the laminar of ferrite.

The device is capable of absorbing one watt of power without loss of performance, and since power will mainly be absorbed by the procreation of signals in the reverse direction, this represents a relatively high power handling capacity in the forward direction.

The Variable Isolator is suitable for use in standard X-Band circuits and special waveguide bands, and mechanical fixing arrangements may be made available to specifications.

## TECHNICAL SUMMARY ELECTRICAL

Frequency range:  
8,000 - 10,000 Mc/s.

Insertion loss:  
Less than 1 dB.

Isolation:  
18-22 dB over band.

Power absorption capacity:  
1 watt.

## MECHANICAL

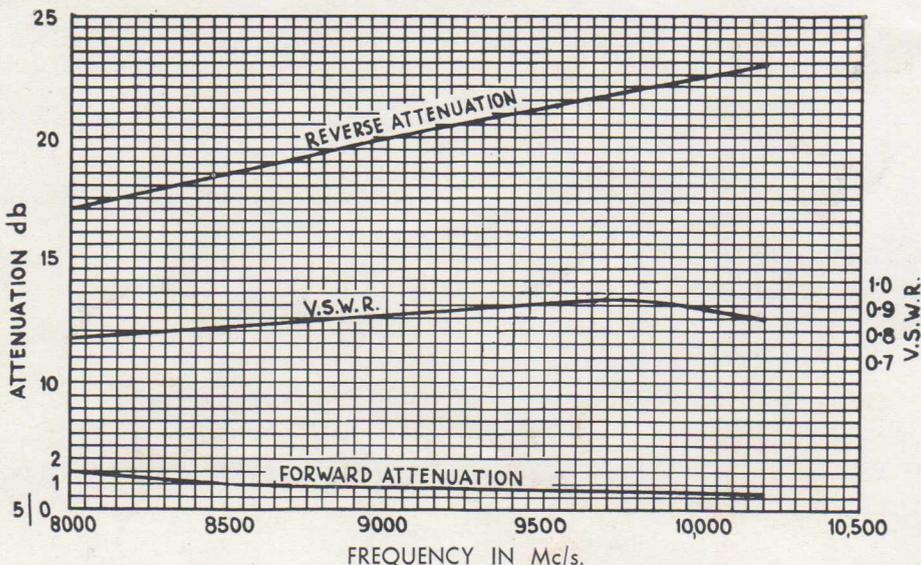
Waveguide size:  
W.G.16. 0.9 in. x 0.4 in. internal dimension.

Overall dimension:  
3¼ in. wide x 4 in. high x 1½ in. deep.

Flanges:  
Input port — Screw type choke Z830003.  
Output port — Screw type plain Z830004.



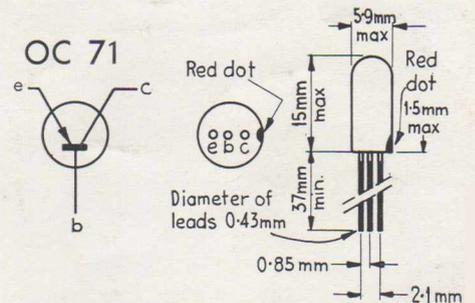
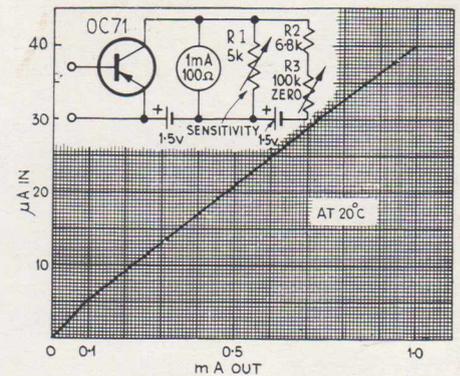
L324 TYPICAL PERFORMANCE CHARACTERISTICS



# AMATEUR EXPERIMENTERS COLUMN

## TRANSISTOR DC AMPLIFIER

A transistor OC71 is used to raise the sensitivity of a moving-coil DC mA meter 25 times. Thus, with an input of 40µA, a meter deflection of 1 mA may be obtained. The input resistance of the transistor DC amplifier is approximately 10kΩ. The function of µA<sub>in</sub> vs. mA<sub>out</sub> is not entirely linear, and the graph shows the deviation to be in the vicinity of 20%.



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