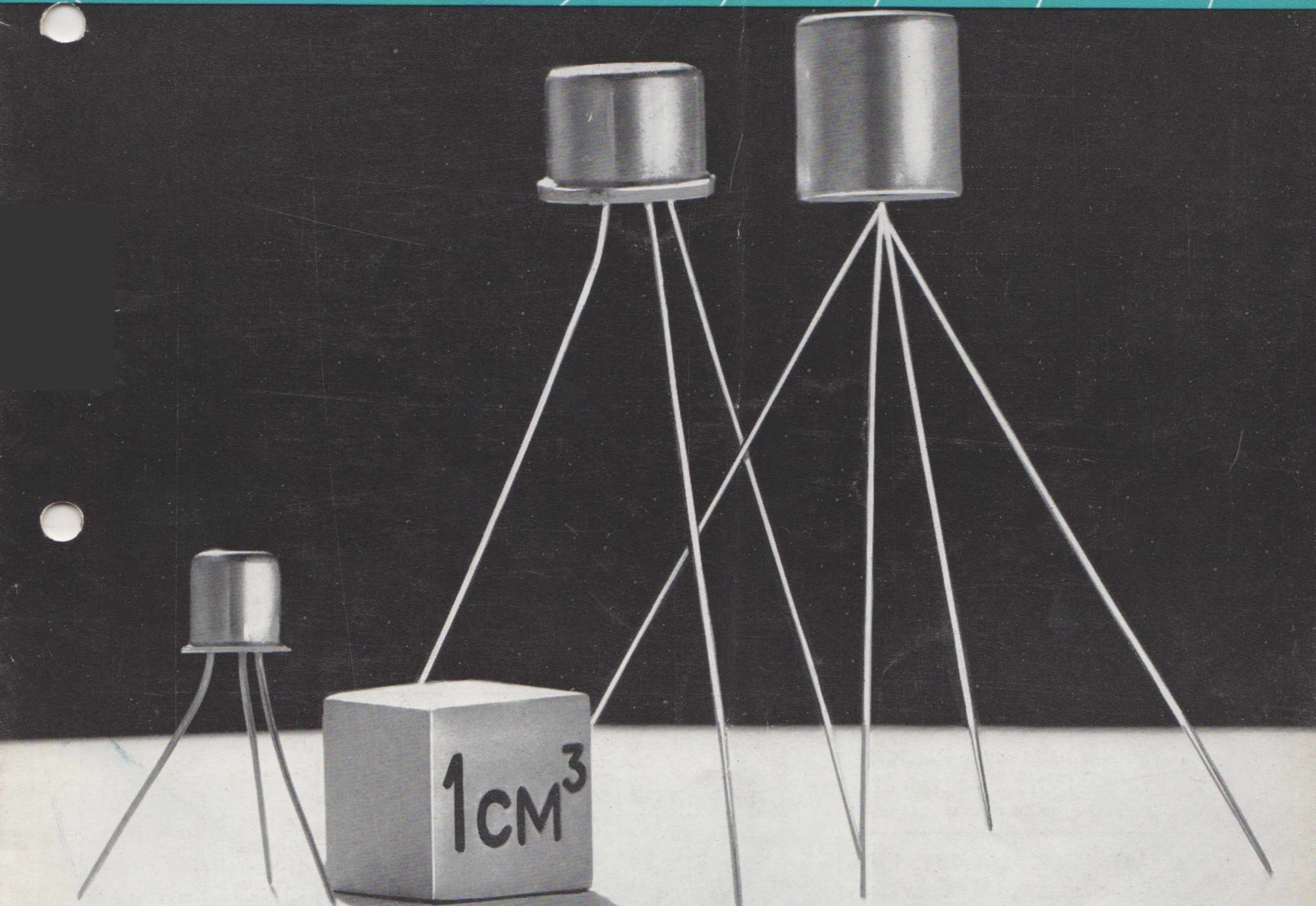
Mullard Outlook

AUSTRALIAN EDITION



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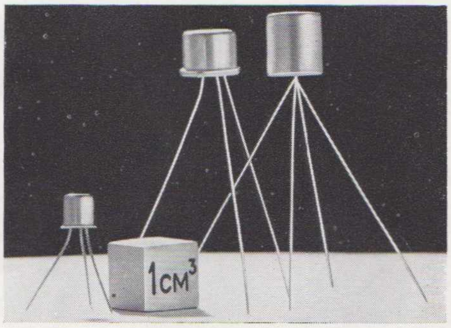

The compact TO-18 outline of a BC107 silicon planar transistor, on the left, with previously introduced transistors following TO-5 and TO-7 outlines respectively.

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Five Feet Long

Picture tube development has greatly influenced domestic television receiver design. Should research and tube gun technology have remained at the 1938 level, the 25″ picture tube of to-day would be over 5′ long! New phosphors for greater brilliance and larger tubes have destroyed some of the togetherness of huddling around a small tube for reasonable viewing comfort. Indeed for very small rooms it is felt some viewers may favour smaller sets with smaller screens as being optimum, in that the human eye can only define one minute of arc and to lose the line structure with a 25″ tube, in many small rooms one requires to back out the door or sit in the hall. A situation which would be considerably aggravated if the tube was 5′ long.

As most folk favour sitting in the living room rather than the hall and are content with a motor car that develops 60 horse power rather than 200 horse power, then maybe there is a grand future for a smaller picture tube screen. In any case for all sizes it is Mullard Long Life picture tubes for bright, clear, crisp, true-to-life performance.

A Collector's Piece

As this issue goes to press some readers may care to know that a brochure prepared to explain our end of the year rort held in the Lane Cove Town Hall on December 1st had only limited printing and with the many requests for copies from those unable to attend we have decided to reprint this in the next issue, Volume 9, No. 1.

It is our intention during 1966 to re-introduce our Viewpoint meetings in all States and in to-day's vernacular we might say, a semi-technical rort.

We extend our best wishes for all success and good health in 1966.

M.A.B.

VIEWPOINT WITH MULLARD

END OF THE YEAR RORT IN SYDNEY

Lane Cove Town Hall was the venue on December 1st for a convivial gathering of representatives of the electronics industry in New South Wales. Over 300 attended and the theme "An End of the Year Rort".

Early in the evening whilst welcoming the guests, our General Manager Mr. M. A. Brown said the reason for the invitation giving the location as the Lower Hall, yet the function was held in the Main Hall, was simply that "we found we had more friends than we thought we had". He went on to point out that "should there be someone next to you whom you do not know, then it is most probable that he is in some allied activity, perhaps the x-ray business, telecommunications, geophysical surveys, in fact many far removed from our better known field of semiconductors, radio and television receiving valves and picture tubes".

Each guest was presented with a brochure describing a rort and Mr. Brown referred to this in his welcoming address. As mentioned elsewhere, this has already become somewhat of a collector's piece and it will be reprinted in the January-February 1966 (Volume 9, No. 1) issue of Outlook.

A novel feature of the evening was a presentation to the guest with a lucky number and this, by coincidence, was won by Denis Woolgar of our N.S.W. distributors, Martin de Launay, the prize a small oil painting of a Snowy Mountain area by a well-known Australian landscape painter.

Mullard-Australia Sales Manager Laurie Wade acted as M.C. for the evening—an opportunity to express our appreciation of the help of our many supporters in the industry and moreso perhaps, as Mr. Brown expressed it, "the happy friendship and trusted liaison on which we have built our business and must in turn rely so much on each other." ■

AT THE RORT

(Above) Reg Boyle (PMG's Dept. and President I.R.E.E. Aust.), Maurie Brown (Mullard), John Fieguth (STC), Vern Kenna (ABC) and Carl Wilhelm (ABC).

(Left) Denis Woolgar, the lucky ticket prize winner being presented with a landscape painting by Mr. M. A. Brown, our General Manager.

(Below) Sonny Cohen (l) George Brown & Co., Canberra and Neville Piper (r) Martin de Launay, Sydney with Bob Denmeade of "the old firm".

SCIENCE ESSAY COMPETITION

The Mullard display at the "Science in the Development of Australia" exhibition at the R.A.S. Showground, Sydney featured an essay competition for secondary school students.

Entrants were invited to write an essay in two parts presenting their ideas of the method of operation of two electronic devices on display. Entries were judged on the students' knowledge of the basic principles of operation of the devices, presentation and neatness.

Prizes were awarded to:—

First Prize—Avo Multiminor Mk. 4

Graeme Douglas Tait, 17 Stanhope Road, Killara—Sydney Church of England Grammar School.

Second Prize—£5.5.0 Open Order

David W. E. Blatt, 44 Congham Road, West Pymble—Sydney Church of England Grammar School.

Third Prize—£2.2.0 Open Order

Gregory Alec Smith, 67 Crieff Street, Ashbury—Canterbury Boys' High School.

Quite a large number of entries were received and all entrants, in addition to the prize winners, were presented with a set of Mullard technical booklets.

FEASIBILITY OF A DOMESTIC UHF FM RECEIVER

On 16th November in Melbourne and 29th November in Sydney, Mr. Z. Uzdy, head of the Microwave Section of the Mullard Applications Laboratory read a paper before the Institution of Radio and Electronics Engineers Australia entitled "The Feasibility of a Domestic FM Receiver Operating in the 500Mc/s Region".

Mr. Uzdy's lecture was introduced by Mr. H. S. Watson, Mullard-Australia Chief Engineer, who outlined the scope of the present work and how this might be helpful in evaluating the feasibility and the possibility of UHF FM broadcasting. He went on to detail the development of VHF FM in the United States and Europe, with particular reference to stereo broadcasting. In discussing available channels, Mr. Watson suggested that one could readily examine the service areas by directly interpolating the service areas from the existing TV stations. He went on to say that perhaps it would be sensible to locate UHF broadcasting stations in the same areas, perhaps on the same towers.

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THE PICTURE IS BRIGHT ON TUBES

Had television research and gun technology remained at the 1938 level, the 25" picture tube of today would be over 5' long! Years of research resulting in improvements to picture tube components, from the highly-efficient cathode to the new large screen, have resulted in consistent high quality and long life of Mullard television picture tubes.

The electron gun is now smaller, more accurate and robust than it has ever been, indeed a television tube could very well be categorised as a Special Quality Long-Life Tube. Thorough investigation of phosphors used in the activated luminescent layer has resulted in a bright, clear, crisp, true-to-life performance.

The six salient features of long picture tube life are:—

1. Hard vacuum
2. Good inter-electrode insulation
3. Consistent cathode emission
4. Protected high-voltage performance
5. Controlled aluminium thickness
6. High-efficiency screen phosphors.

Ideally, the only particles required in the cathode-ray tube are the electrons emitted from the cathode surface. Any residue of air and of gases released by materials in the tube is only a nuisance; therefore in picture tube manufacture as few gas molecules as practicable are left.

During manufacturing operations the gas pressure is reduced to a minimum by continuous oil diffusion pumping. During pumping the glass bulb is heated to a high temperature to drive off as much occluded gas as possible.

Final operation in the production of a hard vacuum is the firing of the getter. An external coil produces a field that induces energy in a minute piece of metal, causing it to vaporize. Result is the deposition of a thin layer of metal (usually barium), over most of the interior surface of the bulb. This layer (not to be confused with the aluminium layer) cannot be seen except for a small area in the neck above the top collar of the gun.

The getter has the quality of absorbing gas molecules left by the final pumping and processing operations. It also absorbs the gas molecules, which inevitably still come out during the life of the tube, from the glass envelope, the metal and other components of the gun. The getter thus acts, in effect, as a "continuous pump" during the life of the tube. The material quality, and control of deposition of the getter are thus very important in maintaining high vacuum over a long time.

Ionization

Why is a high vacuum necessary and what effect does it have on life? Gas molecules in an electrical field, and particularly in a stream of electrons, become ionized (i.e. they become individually charged either negatively or positively). Positive ions are produced in the region of the electron gun on the cathode side of the final anode (which is at EHT). Repulsed by the positive EHT they are accelerated towards the cathode, hitting it at high speed and burying themselves in the cathode surface. They chemically "poison" the cathode, i.e. they upset the physical chemical equilibrium by which sufficient thermionic electrons are produced. Thus fewer and fewer electrons are emitted. The "softer" the vacuum during life the faster this emission "failure" occurs.

Regarding the second item in the above list, good inter-electrode insulation, in the absence of this, several categories of fault can arise.

Direct electrical breakdown through the insulation now rarely happens in hard vacuum; progress here has followed improvement in the purity of materials. But repeated thermal expansion and contraction of cathode and heater, caused when the set is switched on and off, can cause physical break-up, either permanent or intermittent. Careful control of the composition of the heater/cathode insulating materials is needed to prevent this. Switching surges can also cause movement of the cathode itself if not firmly held.

Leakage Paths

When a metal such as a nickel cathode is heated to a high temperature in a vacuum, it begins to form a vapour, just as in air a heated liquid forms a vapour above its surface. The metal vapour condenses on cooler areas, including the insulation between the electrode assemblies and the inside of the glass neck. Such a film can be a low-resistance "path" between any two electrodes (electrode, in this sense, includes mounting rods and connectors through the base).

This particular problem is approached in a number of ways. First, the cathode nickel temperature is controlled to be as low as possible, consistent with good life and quick warm-up time. The lower the cathode temperature the less "vapour" is produced. Secondly, where possible, the surface of the insulator is made rough to increase the effective surface path. Further, the geometry of the insulator can be designed so that vital electrodes touch the insulator only in areas where least deposition of metal occurs. The composition of the cathode barrel metal must also be controlled to have a metal which gives least deposit.

Another hazard is the possibility of a loose particle lodging in the narrow gap between two electrodes, e.g. cathode and grid. The only remedy is to keep the tube as free as possible from loose particles during manufacture.

Some of these faults give a direct "short" which renders the tube completely inoperative, while some give low-resistance paths between electrodes. The latter can result in degradation of brightness, contrast and electrostatic focus.

The third feature in the list is consistent cathode emission. When the cathode is manufactured, a paste of mixed barium and strontium carbonates is spread on the emitting area. During pumping the cathode is heated, driving off carbon dioxide and leaving a coating of mixed barium and strontium oxides. At this stage the cathode emission is very low indeed. If used in a set, it would be weeks before the emission rose enough to give a satisfactory picture.

Before the tube can be considered operational it must, therefore, be "aged". This entails running the cathode at rather higher than normal temperatures with a continuously controlled cathode current. In this way a few weeks are condensed into a few hours and the chemical equilibrium necessary to provide the consistent cathode emission is established. It is the "ageing" schedule which determines the stability of the cathode emission during the first few hours and weeks of life. Unstable cathode emission will give a picture which varies in brightness, and possibly focus, during a normal viewing period.

Protected high voltage performance was awarded fourth place in the list. In all high-voltage devices there occurs a phenomenon about the cause of which there are many theories. This phenomenon is known, in television tube circles at least, as "flashover". It consists of a momentary short circuit between a surface at very high (EHT) potential and a surface at low (earthy) potential. It is accompanied by a streak of light (similar to a lightning flash) between the two points. Flashover occurs at a much lower level of EHT than would be expected from field emission theory alone. Physically the light flash can be produced only by a column of an ionized gas. The mystery is, whence comes the ionized gas-column—in a vacuum?

My favourite hypothesis is that there must exist a tiny pointed fragment on the low-potential surface (see the diagram). The proximity of the high-potential surface produces a strong electrostatic field around the pointed fragment, one strong enough to tear the fragment from the low-potential surface and project it at high velocity towards the high-potential surface. On impact the particle vaporizes.

This article was written by J. N. Brakspear, B.Sc., Head of the Quality Laboratory (TV tubes) of Mullard Limited, England

Since there are always a few gas molecules in the space between the two electrodes, the path of the particle will ionize them, leaving a lower resistance path or "electrostatic tunnel" into which the newly produced, highly localised gas ions will pour. This column of ions produces a negligible resistance path into which the high-potential surface then rapidly discharges its electrons. Its potential falls until ionization can no longer be sustained. "Flashover" ceases, the gas column rapidly discharges into the surrounding vacuum and

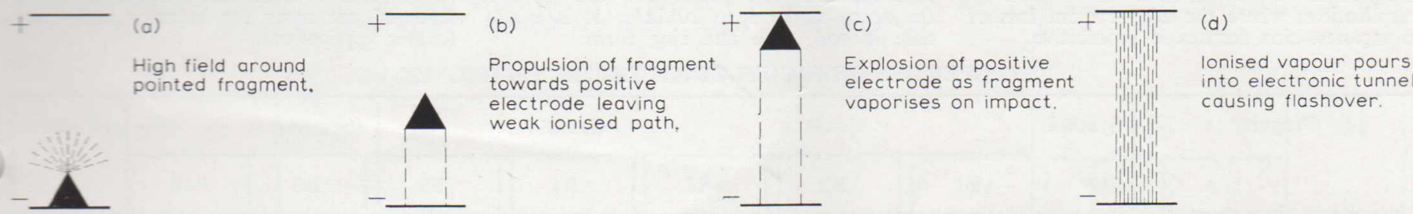
The vacuum and the gun and its protection were given priority in the list because a controlled electron beam is really the "source" of the picture. The phosphor screen is the canvas and frame upon which the picture is painted. So we now come naturally to the protection of the phosphor during its life.

Behind the phosphor screen we have a thin aluminium layer which acts as a mirror to the light emitted from the phosphor and so enhances brightness as viewed from the front. This aluminium layer must be thin

Growth of a small dark patch of approximately one square centimetre area in the centre of the screen denotes negative ion burn. To avoid this, and have a bright picture, we must have a controlled aluminium thickness (point five).

In the early days of television picture tubes, ion burn pattern on the screen was an "inevitable" sign of wear-and-tear during life. Now it has been completely eliminated by the aluminising process.

And so to the final feature in the list, high efficiency screen phosphor. In itself, the



the high-potential surface is restored to its original voltage.

It follows that "protected high voltage performance" demands that all surfaces be clean and smooth and the tube as free as possible from minute particles.

Intermittent flashover of this kind has never been known to harm a tube. However, in bad cases of repeated flashover, damage can occur, presumably due to localised heat and electrostatic force. Ceramic insulating rods can become cracked and cathode surfaces be damaged; in some cases, the gas pressure in the tube rises.

enough to allow the electrons to penetrate to the screen. It cannot be too thin, however, otherwise much larger negative ions (emitted through the gun at high velocity) will also penetrate.

If the ions reach the screen, they "poison" the phosphor. That is, by chemical action they reduce the illuminating power of the area of phosphor on which they land. Being much heavier than electrons, the negative ions are deflected only slightly and therefore mostly bombard a small area in the centre of the screen.

efficiency does not promote long life. All phosphors depend for their efficiency on maintenance of pure chemical composition. High efficiency results from keeping the phosphor scrupulously free from contamination during manufacture and during the processing in the tube.

Throughout its life, efficiency depends on protection from contamination by ionic bombardment. A hard vacuum and a controlled aluminium thickness together ensure that the intrinsic brightness of the screen remains at a high level. ■

GREAT CIRCLE MAP OF THE WORLD

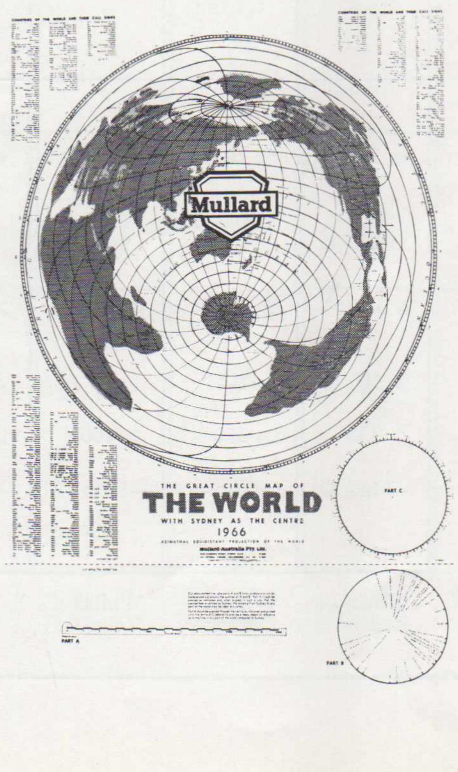
This Great Circle Map of the World, with Sydney as the centre, is an original four-colour print, measuring 2′ x 3′ prepared by Mullard-Australia Pty. Ltd. Since it is an Azimuthal Equidistant Projection of the World, it is possible to determine the Great Circle bearing, as well as the distance in miles of any point on earth from Sydney.

A complete up-to-date listing is also provided tabulating approximately 400 countries of the World together with their prefixes.

It is suggested that the Great Circle Map is mounted on to strawboard approximately 1/16″ thick. With certain types of strawboard, particularly the lighter variety, there is a tendency to warp and in order to counteract this, it is suggested that a sheet of neutral paper is applied to the other side.

The Map, at 10/- ($1.00) each, plus 1/1 ($0.11) for packing in a cardboard mailing tube to avoid damage and 11d. ($0.09) postage, may be obtained by filling in the enclosed order form and forward it, together with your remittance to:—

Mullard-Australia Pty. Ltd.,
35-43 Clarence Street,
SYDNEY. N.S.W. ■



OUTLOOK BINDERS

Outlook Binders are available from the Mullard-Australia Pty. Ltd. Sydney Office priced at £1/5/- or $2.50 plus postage (parcel postage rates as shown below).

POSTAL RATES

	per binder	
N.S.W. (Metropolitan area)	2/-	$0.20
N.S.W. (Country area)	2/6	$0.25
Q'land, Victoria, Tasmania	3/-	$0.30
W.A., S.A., N.T., T.P.N.G.	4/-	$0.40

The method of securing copies of Outlook into the binder is new to Australia and individual copies may be removed and re-inserted with ease. A self-adhesive, inter-changeable strip from which appropriate portions may be detached for titling purposes will be supplied with each order, thus making the binder suitable for past and future issues.

When ordering by mail, please print your name and address and the number of binders you require, clearly and in block letters, in order to avoid misdirection in the mail. ■

Mullard

F E R R O X C U B E   S E

There are two types of ferrite material that are in general use for inductive components. These are the manganese-zinc ferrites and the nickel-zinc ferrites. Both these materials are available in various grades for particular applications. In order to assist you in the selection of the best grades of material, brief details of the two types of material are given together with typical applications.

NICKEL-ZINC FERRITES

This ferrite material is currently available in seven grades, each grade being applicable to a particular frequency range. In general, nickel-zinc ferrites are used for the higher-frequency applications.

Grade B1. A relatively high permeability material with a high resistivity, for use at frequencies up to 1Mc/s. It is used in applications where the eddy-current loss of manganese-zinc ferrites is prohibitive.

Grade B2. This grade is widely used for applications in the frequency range 500kc/s to 2Mc/s. It is used particularly for rod aerials, but is also available in a wide variety of rods, tubes and toroids.

Grade B3. Developed for use in the frequency range 1 to 5Mc/s, this grade is available in rod, tube and ring form.

Grade B4. The grade for use in the frequency range 5 to 20Mc/s. It is available in rod, tube and ring form.

Grade B5. This grade is for use in the frequency range 20 to 50Mc/s, and is available in small rod, tube, and ring form.

Grade B6. This grade is for use in the frequency range 50 to 100Mc/s, and is available in small rod and tube form only.

Grade B10. A low-loss, high-stability material for use in the frequency range 1 to 15Mc/s. It is normally available in the form of pot cores for inductor and transformer applications.

PROPERTIES OF NICKEL-ZINC FERRITE MATERIALS

Property	Symbol	Grade B1	Grade B2	Grade B3	Grade B4	Grade B5	Grade B6	Grade B10	Units
Initial permeability	μ_i	⩾ 500	200 to 400	100 to 200	40 to 80	10 to 25	6 to 10	⩾ 100	
Loss factor at frequency (Mc/s) 0·06	$\frac{\tan\delta}{\mu_i}$	⩽ 30							$\times 10^{-6}$
0·10		⩽ 35							
0·25		⩽ 55							
0·50		⩽ 80	⩽ 75						
1·0			⩽ 90	⩽ 85					
2·0			⩽ 140	⩽ 100					
5·0				⩽ 200	⩽ 210			⩽ 85	
8·0					⩽ 250				
10					⩽ 300			⩽ 130	
30						⩽ 800			
40						⩽ 1200			
50						⩽ 2000			
100							⩽ 6000		
Temperature factor of μ_i between 20 and 50°C	$\frac{1}{\mu_i^2} \cdot \frac{d\mu_i}{dT}$	⩽ 10	⩽ 15	⩽ 20	⩽ 30	⩽ 40	⩽ 50	⩽6·0	$\times 10^{-6}$ per °C
Magnetising force	H	10	10	30	50	80	200	30	Oe
Magnetic flux density at 25°C	B_{sat}	⩾ 2200	⩾ 3200*	⩾ 2500	⩾ 2000	⩾ 1500	⩾ 1200	⩾ 3300	Gs
Resistivity	ρ	⩾ 10^5	⩾ 10^5	⩾ 10^5	⩾ 10^5	⩾ 10^5	⩾ 10^5	⩾ 10^5	Ωcm
Curie temperature		⩾ 125	⩾ 250	⩾ 350	⩾ 400	⩾ 500	⩾ 500	⩾ 300	°C
Magnetostriction	ψ_{sat}	–4 to –6	–7 to –12	–13 to –18	–18 to –27	–22 to –32			$\times 10^{-6}$
Colour code		White/ Brown	White/ Red	White/ Orange	White/ Yellow	White/ Green	White/ Blue	White/ Brown/ Black	

*2200Gs at 100°C

LECTION CHART

MANGANESE-ZINC FERRITES

Seven grades of manganese-zinc ferrite are currently available. Five of these grades are intended mainly for use in industrial or professional wound components, while the other two are for use in entertainment applications.

Grade A1. This is the original high-permeability low-loss material. It is still widely used in the form of rods and tubes for simple transformers, and in the older styles of pot cores.

Grade A2. This grade is used for applications involving high flux densities but where the core loss and disaccommodation are of minor importance. Although it has been generally superseded by later materials, it is still available in U-core form.

Grade A4. A high-permeability material with reasonably low losses, normally used for communication transformers. It is available in the form of E, I, and U cores, and as rods and toroids.

Grade A5. A widely used, low-loss high-stability material for use at frequencies up to 200kc/s. It is available as pot cores and toroids.

Grade A9. This is now the standard material for applications where high flux densities and high voltages are encountered, for example, in television line output transformers. It can be used at frequencies up to 100kc/s, and is normally available in U-core form.

Grade A10. Complementary to Grade A5, this is a low-loss high-stability material for use at frequencies between 200kc/s and 2Mc/s. It is normally available as pot cores and rods.

Grade A13. A very-low-loss, high-permeability high-stability material. It is used in the form of pot cores for frequencies up to 300kc/s, or in toroidal form for pulse and wideband transformers operating up to 100Mc/s.

PROPERTIES OF MANGANESE-ZINC FERRITE MATERIALS

Property	Symbol	Grade							Units
		A1	A2	A4	A5	A9	A10	A13	
Initial permeability at $B_{max} < 0{\cdot}5$Gs	μ_i	⩾ 500	⩾ 1000	⩾ 1200	⩾ 1150		⩾ 600	⩾ 1840	
Cyclic permeability	μ	⩾ 900 at 2000Gs ⩾ 600 at 3000Gs	⩾ 1000 at 2500Gs	⩾ 2200 at 2000Gs ⩾ 1000 at 3000Gs	⩾ 1200 at 2000Gs ⩾ 600 at 3000Gs	⩾ 1000 at 3200Gs ⩾ 1000 at 4000Gs			
Loss factor at $B_{max} \leqslant 0{\cdot}5$Gs and frequency (kc/s)	$\frac{\tan\delta}{\mu_i}$								$\times 10^{-6}$
4					⩽ 2·5			⩽1·2	
30					⩽ 5·0				
60		⩽ 16		⩽ 35					
100					⩽ 12		⩽ 10	⩽ 5·0	
250		⩽ 27		⩽ 80					
450		⩽ 50		⩽ 120			⩽ 14		
500							⩽ 32		
Temperature factor of μ_i between 20 and 50°C at $B_{max} \leqslant 0{\cdot}5$Gs	$\frac{1}{\mu_i^2} \cdot \frac{d\mu_i}{dT}$	0 to 3·0		0 to 4·5	0 to 2·0		0 to 2·5	0·5 to 1·5	$\times 10^{-6}$ per °C
Hysteresis factor	C_h	⩽ 5·8		⩽ 9·2	⩽ 0.97		⩽ 1·16	⩽ 0·695	$\times 10^{-6}$
Magnetic flux density at H = 10 Oe, and temperature (°C) 15 to 30	B_{sat}	⩾ 3200	⩾ 3200	⩾ 3600	⩾ 3200	⩾ 4500	⩾ 3500	⩾ 3400	Gs
100		⩾ 2100	⩾ 2200		⩾ 2200	⩾ 3700*			
Coercive force (average value)	H_c	0·4	0.4	0·3					Oe
Resistivity	ρ	⩾ 20	⩾ 20		⩾ 20		⩾ 150	⩾ 100	Ωcm
Curie temperature (°C)		⩾ 130	⩾ 150	⩾ 140	⩾ 150	⩾ 210	⩾ 150	⩾ 170	°C
Disaccommodation 1min to 24h	DA	⩾ 3·0			⩽ 2·5		⩽ 2·5	⩽ 2·5	%
Total losses (15 to 30°C)			200			120			mW/cm³
Colour code		Red/ Brown	Red/ Red	Red/ Yellow	Red/ Green	Red/ White	Red/ Brown/ Black	Red/ Brown/ Orange	

*at 85°C

THERMISTOR THERMOMETER

A battery operated bridge thermometer for measuring surface temperatures in the range of 20°C to 90°C comprising a miniature bead thermistor, a small battery, a variable resistor and a 1mA meter. Calibration is linear and the overall accuracy is ±2°C.

A simple and inexpensive thermometer for the measurement of the surface temperature of heatsinks and other devices is described. The temperature range to be covered is from 20°C to 90°C, and the required accuracy is ±2°C throughout this range.

The design of the thermometer has been achieved by using a very simple circuit which results in a linear calibration curve which can be easily obtained by determination of two or more fixed points (20°C, 90°C).

The factors governing the design, the details of the method of calibration, the errors, and the use of the thermometer, are described in the following sections.

FACTORS GOVERNING DESIGN

The circuit had to be as simple and as cheap as possible. This requirement suggested a series circuit consisting of a milliammeter, a battery, a thermistor, a variable resistor, and a 'push to operate' switch. The variable resistor is for calibration purposes. The switch is included to conserve the battery power by preventing the circuit from being inadvertently left on. The circuit is shown in Fig. 1.

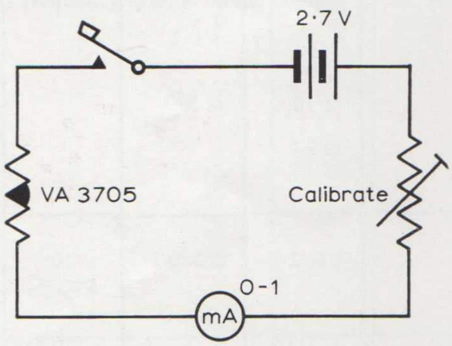


Fig. 1—Circuit of thermistor thermometer

Choice of Operating Current

As meters with a full-scale deflection of 1mA are reasonably cheap, the maximum current passed through the circuit was set to be 1mA, this current being passed when the thermistor temperature is 90°C. With a maximum current of 1mA flowing through the thermistor, the self-heating effect is small and, because of the method of calibration, of little importance.

Choice of Battery and Battery Voltage

The choice of battery is important, as the calibration of the circuit is very dependent on the battery voltage. Normal dry cells are ruled out, as they show a marked fall of voltage throughout discharge. On consideration, mercury cells seem to be an ideal alternative, as they provide a substantially constant voltage over most of their life. This choice limits the range of battery voltages to multiples of 1·35V. It was found that two mercury cells connected in series to give an e.m.f. of 2·7V resulted in the most linear calibration curve.

Choice of Thermistor

The choice of thermistor is determined by the following conditions:

1. It should have a small thermal mass, so as not to affect appreciably the temperature of the surface to be measured.
2. It should have a quick response to external temperatures. This necessitates the mounting of the thermistor element in a good conductor of heat, which should preferably be an electrical insulator. Glass is a suitable material as it also provides mechanical protection for the thermistor element.
3. It should have a high temperature coefficient of resistance ('B' factor). This enables the change of resistance for a given change of temperature to be as high as possible, so that the change of current is as great as possible.
4. The resistance of the thermistor at 90°C must not exceed 2·7kΩ, otherwise full-scale deflection current of 1mA will not be attained.

A Mullard Varite thermistor type VA3705 was selected, as its resistance is 6·8kΩ ±20% at 25°C, and about 700Ω at 90°C. Its 'B' factor is the highest in the range of thermistors with suitable resistance values. The thermistor is in miniature glass bead construction and is designed for rapid response to temperature changes.

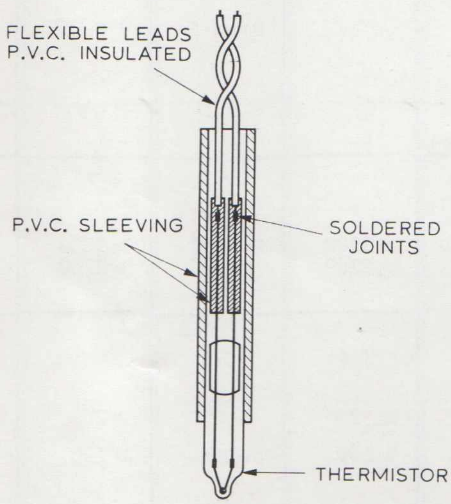


Fig. 2—Thermistor mounting

Fig. 2 shows a simple way of mounting the thermistor and insulating its leads. This latter point is important, as shorting the thermistor leads together would overload the meter.

CALIBRATION

The variable resistor was set at its maximum value, and the thermistor was fully immersed in an oil bath which was at a temperature of 90°C. The variable resistor was adjusted until the meter indicated full scale deflection. Meter readings were then taken with the oil temperature reduced by steps of 5°C down to 20°C, the setting of the variable resistor being left unchanged. The calibration curve obtained is shown in Fig. 3.

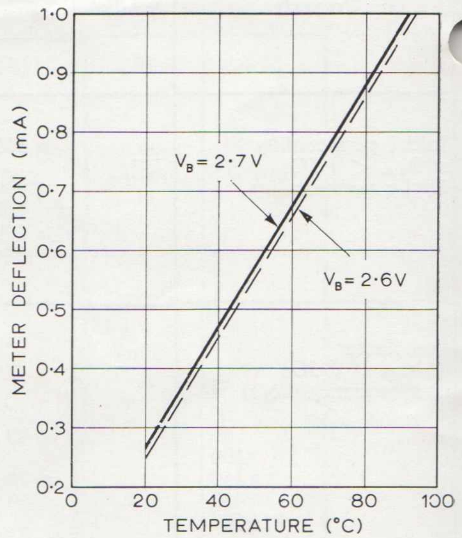


Fig. 3—Calibration curves obtained with one sample of VA3705 thermistor
—— with battery voltage of 2·7V
- - - with battery voltage of 2·6V

Both leads from the thermistor are soldered to flexible insulated wires, then the two bare leads and joints are insulated from each other by sheathing each wire in p.v.c. sleeving. The whole assembly is then pushed into a length of larger diameter p.v.c. sleeving, so that the tip of the thermistor protrudes by about 0.5 inches from one end of the sleeving, the other end of which extends well past the joints between the leads and the flexible conductor. The diameter of the outside sleeving is chosen so that it closely fits the glass encapsulation of the thermistor.

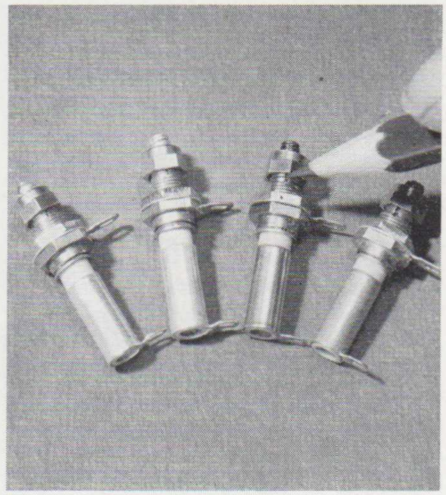
Under the conditions for which the thermometer was designed a second calibration was performed with the tip of the thermistor in contact with a heated surface. The tip of the thermistor was placed in a small dimple drilled in an iron block, and good thermal contact was ensured by the use of silicone grease. The block was immersed in a heated oil bath with the upper surface of the block about ⅛ inch above the oil surface. The bulb of a mercury-in-glass thermometer was placed in a hole drilled in the block, and this hole was nearly filled with oil. The arrangement is shown in Fig. 4.

New High-Quality Ceramic Trimmers with Locking Facility

Two new high-quality, inexpensive trimmers have recently been added to the established COO4EA range. The trimmers, types COO4EB/6E (6pF) and COO4EB/12E (12pF) have good stability, high accuracy of adjustment and incorporate locking facilities. Especially useful in civil and military communications equipment, they consist of an internally ground ceramic tube, with an Invar rotor guided by a threaded cap. The rotor, after adjustment, can be locked in position.

Abridged Data

	COO4EB/6E	COO4EB/12E	
Variation of capacitance	⩾6	⩾12	pF
Zero capacitance	⩽0·7	⩽1·0	pF
Temperature coefficient	−10 ±60	−200 ±150	pF/°C × 10^{-6}
Angle of rotation	11 × 360	11 × 360	°
Permissible working voltage	800	800	V DC
Test voltage	1600	1600	V DC
Permissible temperature range	−50 to +100	−50 to +100	°C
Contact resistance (between tag and rotor)	⩽0·003	⩽0·003	Ω
Parallel damping (at 1·5Mc/s and C_{max})	⩾20	⩾20	MΩ



With the earlier resistor setting unchanged, meter readings were taken at 5°C intervals from 90°C down to 20°C, as indicated by the mercury-in-glass thermometer. The resulting calibration curve showed negligible deviation from the curve shown in Fig. 3.

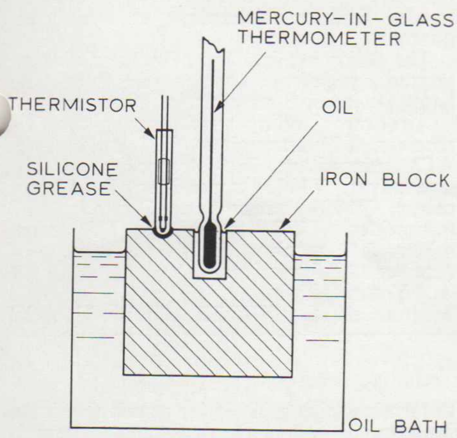


Fig. 4—Calibration method for surface temperature measurement

ERRORS

Errors may be introduced by calibration discrepancies, variation of characteristics between one thermistor and another, battery voltage changes, and dissipation in the thermistor.

Calibration Method

If the circuit is calibrated with the thermistor fully immersed in oil, and is then used for surface temperature measurement with only the tip of the thermistor in contact with the surface, there may be some discrepancy between the true temperature of the surface and the temperature read off the calibration curve.

However, the check calibration that has been described (Fig. 4) has shown that such errors will be negligibly small. In practice, therefore, the circuit can be calibrated in one way (the simple immersion method), and used in another (the measurement of surface temperature), without this difference in conditions causing significant error.

Thermistor Spreads

Individual thermistors will not have precisely identical characteristics, therefore every circuit that is built must be separately calibrated. It is not acceptable to calibrate one circuit and then to use the same value of series resistance, and the same calibration curve, for all other circuits.

Battery Voltage

As this simple circuit is very dependent on the battery voltage, measurements have been made to determine the error incurred if the circuit is calibrated at 2·7V and is then used at a lower voltage without recalibration.

The broken line in Fig. 3 is the calibration curve obtained with a battery voltage of 2·6V. It shows that, if the battery voltage falls from 2·7V to 2·6V, and the 2·7V calibration curve is used, the temperatures read off will be from 1°C to 1.5°C below the true temperature.

Thermistor Dissipation

Current flows through the thermistor during operation, therefore the temperature of the thermistor is raised and its resistance will change. This is of no consequence if the device is at the same temperature as its surroundings during calibration and measurement. It is therefore essential that the tip of the thermistor should be in good thermal contact with the surface whose temperature is being measured. This can be achieved by the use of silicone grease.

To minimise this self-heating effect, the dissipation in the thermistor has been kept low; at any temperature in the measuring range it is less than 1·5mW. The dissipation constant of the VA3705 is about 1mW/°C, therefore the error caused by imperfect thermal contact will not exceed 2°C.

Overall Accuracy.

If the circuit is calibrated with reasonable care, the battery voltage is correct, and good thermal contact is ensured during temperature measurement, an overall accuracy of better than ±2°C can be achieved.

Occasional recalibration is advisable, even if only as a reassurance. The drifts in the thermistor characteristic, in the resistor value, and in the accuracy of the milliammeter, will not be great. The most likely source of error is an unnoticed fall in battery voltage. ■

J. H. MOORE

Mullard Central Applications Laboratory.

NOTE: Since the accuracy of this circuit is very dependent on battery voltage, it is suggested that two Mercury Batteries Type ZM1 be used in series with the circuit. These batteries are obtainable from:

Mallory Batteries (A/Asia) Pty. Ltd.
504 Pacific Highway,
ST. LEONARDS. N.S.W.

or their interstate branches. ED.

Page 83 ←

He said that should anyone have any doubt about what might be classified a country area he would nominate a near Sydney metropolitan town such as Camden, as being inadequately served by AM, at least from the Sydney commercial stations.

In regard to the work on the solid state stable oscillators, Mr. Watson said that the study was to look at the feasibility of a domestic FM receiver operating in the 500Mc/s band and whilst Mr. Uzdy's work had been on cavity oscillators this was only to prove that it could be done at this frequency, there were many other methods with other types of tuner oscillators that would be equally acceptable.

The paper covers oscillator stability, noise performance, cross modulation, intermodulation and spurious responses, oscillator pulling and the technical factors to provide adequate receiver performance at realistic noise figures. At signal frequency the noise calculations have been made with the Mullard AF186 transistor.

Mr. Uzdy concluded his paper by stating that a 500Mc/s domestic receiver was indeed feasible and at a cost little different to its VHF counterpart.

The discussion that followed the paper covered an extremely wide field, from propagation conditions, effect of rain squalls, whether the emphasis might be on monophonic or stereophonic reception or both, the advantages for country listening as distinct from city listening, the possible market, in all the lively and practical discussion would indicate there is an extremely healthy interest in UHF FM broadcasting in the 500Mc/s region.

During the discussion and question time a number of the audience suggested that if Australia might be examining UHF FM that it might consider other standards of transmission than the American F.C.C. Pilot Tone System and for that matter also the standard IF of 10.7Mc/s. To this Messrs. Uzdy and Watson pointed out that to achieve the performance as set out by the F.C.C. Pilot Tone System they were setting a more difficult task than by other means and they suggested with the experimental licences recently granted it would be sensible to carry out field strength measurements and cover the other relevant parameters with a known system, in that some direct evaluation and comparisons could be made and should this be more difficult or impractical for other factors. it would be time then to consider alternative systems. ■

SIGNALS EQUIPMENT — R.A.A.F. MUSEUM

Group Captain A. G. Pither, C.B.E. has made an appeal on behalf of the Royal Australian Air Force for assistance in establishing a Radio Section within the R.A.A.F. Museum at Point Cook. It is with much pleasure and we are not too proud to say with much sentiment, that we reproduce the Group Captain's request, as throughout our organisation we have a strong and enthusiastic team of ex-R.A.A.F. types.

We have sent "the weather" on the old long wave T28 and used it on the Adcock D/F watch, we have passed traffic on a T22 in a Wapiti and a wooden Seagull and diligently turned off the filaments before landing to save them from disintegrating; we have frozen on the met flights and have copied the friendly chaw chitty chaw, chitty chaw chaw chaw etc. etc. of the T1087, we have dabbed our wet finger on the O.T.P.* of the R1082, we have remembered the tuning drill of the T1083, and we must all have used the coil boxes for "the big spit" and sheepishly smuggled them out of the aircraft!

We have looked in awe at the final tank coil of the T28 that required a barn to house it and the ATI a wall to hold it together—for nostalgia is something that we can all engage in—for a while.

It could be that you have some gear around or some photograph or two, or that reminiscence about how we sent "best bent wire/G", in fact most of us could send it on the leg of a chair.

So, chaps, let's follow the Duke of Edinburgh's version of "Dieu et Mon Doigt" and not P/O Prune's.

Perhaps there is a score to be evened, for George Pither was the best man at the writer's wedding in wartime London.

Maurice A. Brown.

* Oscillator test point!

Dear Sir,

The R.A.A.F. intends to establish a radio section within the R.A.A.F. Museum at Point Cook, Victoria, to this end, efforts are being made to obtain suitable papers, photographs, documents or equivalent from ex-members of the Service.

The attached letter has been sent to those ex-members whose present whereabouts are known; but there are many others who might well be able to contribute and whom we might possibly reach through the good graces of your publication.

I would be grateful, therefore, if you could arrange for a suitable paragraph to be published in your journal, appealing to anyone who may have suitable material or documentation to contact me at Headquarters Support Command, R.A.A.F., Victoria Barracks, St. Kilda Road, Melbourne.

The other day I set about preparing a lecture on communications in the R.A.A.F. from the beginning; "From Smoke Signals to Satellites" I called it. When I set out to collect a set of records and slides I found to my horror that the R.A.A.F. has no records whatever of our prewar radio organisation.

There are beautiful albums in the R.A.A.F. Museum at Point Cook showing operations in Mesopotamia, early Point Cook and Laverton, workshops, aero engines, armament and instruments, but no radio. There is one piece of radio equipment and that is German, and the Radio School has none. The only saving grace is that Wing Commander Hall is preparing a history, and you can guess what a task faces him.

Our access to this sort of information is disappearing rapidly. Harry Hannan promised me a history of the Darwin radar but he died the next week. Any of us could follow his lead any time so it becomes us to contribute while there is time.

The museum at Point Cook is a fine start and it has a grand collection of relics. We must make it complete with suitable radio relics and history and I am writing to ask that you take a look around. Please look for photos, papers, and old manuals in old boxes and trunks, and for prewar, or any radio equipment.

When you find it, please attach a tag to it saying what it is and outlining its history, and add "Presented by ....," then send it, or preferably, take it to Point Cook. A call to the Base Administrative Officer will ensure you a welcome. Alternatively, get in touch with Squadron-Leader Charles Richardson at this headquarters.

The following is a list of prewar air and ground equipment. Our museum would be happy to receive any part of these sets.

Airborne: Sterling spark transmitter, TF receiver, T21 transmitter, T22 transmitter, AT2 transmitter, TR9 transceiver, TR11 transceiver, T1073 transmitter, R1082 receiver, T1083 transmitter. Ground: AT1 transmitter, T19B transmitter, T28 transmitter, R49 receiver, R1084 receiver, AR4 receiver, AR5 receiver. ■

Yours faithfully,

A. G. PITHER (Group Captain)

LUXISTOR ORP39

Cadmium sulphide photoresistor and filament lamp in an opaque epoxy resin encapsulation, with terminal pins suitable for standard printed circuit mounting. Applications include use as a remotely controlled variable resistor in television camera and audio equipment. There is complete electrical isolation between input and output circuits and the adjustment of resistance is noise free.

ABRIDGED ADVANCED DATA

Maximum input (lamp) voltage	12	V
Nominal input current ($V_{in} = 12V$)	65	mA
Maximum photoresistor dissipation ($T_{amb} = 25°C$)	15	mW
Nominal output resistance ($V_{in} = 4.5V$)	220	Ω

Characteristics (measured under DC conditions, at start of life, with $T_{amb} = 25°C$)

Typical input current range ($V_{in} = 12V$)	60 to 70	mA
Input voltage for output resistance of 100Ω	4.0 to 7.5	V

NOTE: A description of the Luxistor may be found on Page 92 and complete information may be obtained through the Mullard Technical Handbook Service.

NORBIT TIMER YL6015

One of the more recent sub-assemblies to be added to the range of Mullard Norbits is the improved timer YL6015. This timer is based on a completely new circuit which has made it possible to considerably reduce the physical size of the unit, and is equivalent to six basic Norbits. The single-screw method of mounting makes it suitable for use with the standard mounting chassis or any other convenient form.

The YL6015 comprises an RC delay circuit coupled to a Schmitt Trigger and it is so designed that the timing range of from 0·02 to 60 seconds is covered in only three stages, compared to the earlier timer which requires twelve stages. The real advantage of the YL6015 stems largely from the fact that the three capacitors which are necessary to achieve the complete timing range, are built into the standard module and can be selected simply by connecting the appropriate input leads.* Fine adjustment is then made by means of a readily accessible potentiometer. The maximum delay of 60 seconds can be extended by adding an external capacitor.*

Extended Temperature Range

The introduction of silicon transistors and low value/high stability capacitors in the YL6015 has made it possible to extend the temperature range of the units and has given the new timer a much higher degree of stability. The temperature range of −10°C to +50°C which now applies to the YL6015 is the same as for all other units in the Norbit range. This, together with a stability factor of better than 5% over the whole temperature scale, will serve to make the new unit an integral part of the Norbit range.

Drive Requirements

With the exception of the emitter follower YL6001, the YL6015 can now be driven by any other Norbit unit and this, coupled with the fact that it is now less critical with regard to form and width of the input pulse, will extend its use for general applications beyond the Norbit range. ■

* See Mullard publication "Norbit Sub-Assemblies YL6000 Series" available free of charge on application to Mullard Offices.

Abridged Specification of the Timer Unit YL6015

Dimensions

2·5 × 1·6 × 3 inches. When mounted on Chassis YL6007 the unit occupies the space equivalent to six Norbits.

Supply

−24V	DC	±5%	8mA
+24V	DC	±5%	8mA

Timing Ranges

The period of delay time is dependent upon the connection of capacitors C_1, C_2, C_3* and the adjustment of a potentiometer. Three ranges of delay times are available.

Range 1	0·02	to	0·4	seconds
Range 2	0·3	to	6·0	seconds
Range 3	5·0	to	60	seconds

Temperature Range

−10°C to + 50°C

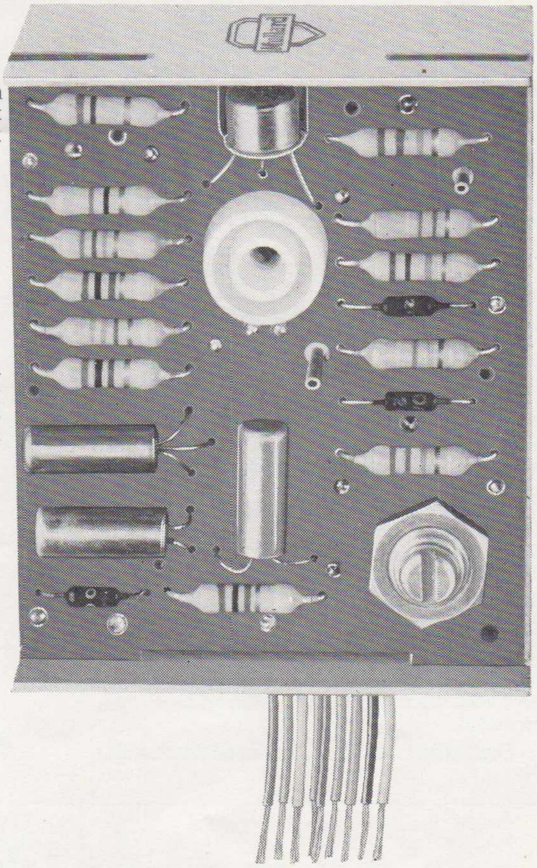
Input and Output Requirements

6 Drive Units

Minimum input −18V DC

Mounting

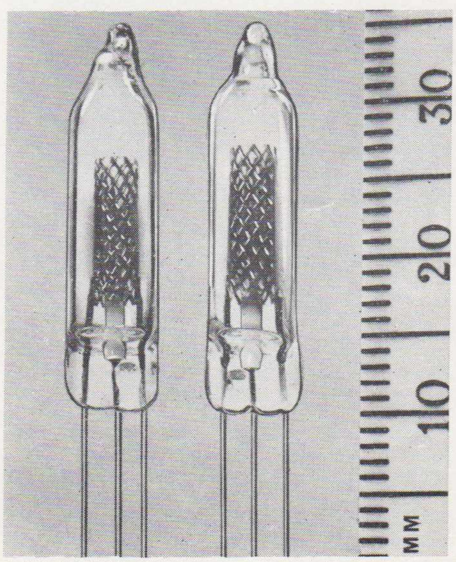
Mounting is by a single screw which is supplied with the unit.



NEON LOGIC INDICATOR ZA1004

Manufacturing costs of high quality neon logic display panels can be lowered as a result of yet another addition to the Mullard range of gasfilled cold cathode tubes.

The ZA1004 indicator diode, an inexpensive, shock and vibration resistant subminiature flying-lead neon indicator tube, is intended as a display device for medium-voltage transistor circuits, particularly in regard to the indication of the position of two-state circuits. It therefore has wide application in the manufacture of display panels for digital computers, analogue-to-digital converters, digital voltmeters and most instrumentation and control equipment. In these fields it is extremely useful as a general purpose low-cost indicator: for example, as a warning indicator of overload conditions.



ZA1004 Indicator for neon logic display panels.

Low Cost Reliability

The ZA1004 not only has extremely reliable electrical characteristics, at a cost not in excess of the cost of many less reliable devices but, in addition, has a life expectancy of 20,000 hours; furthermore, only a minimum amount of associated circuit design is required.

The tube has a maximum breakdown voltage of 93·5V, a minimum extinction voltage of 83·5V with a preferred cathode current (DC or rectified AC) of 1·0mA; a control voltage of less than 6V may be used in certain circuits. Illumination at a distance of 2mm from the bulb surface opposite the anode cylinder is 45 lux when the cathode current is 1mA. ■

DC INVERTER - 240V - 15W - 50c/s

This article describes a DC inverter for use with 12V supplies, particularly with car batteries. The inverter operates at 50c/s and has an output voltage equivalent to the 240V AC mains. The inverter is therefore very suitable for use with mains-voltage electric shavers, and other mains-operated equipment requiring an input power of about 15W.

Any electronic system for converting DC power from one voltage to another must first 'switch' the DC input voltage to convert it into a periodically varying waveform. This waveform can then be fed to a transformer to produce a periodic output waveform at the required voltage. The output waveform can be used to drive AC equipment, or rectified (as in the DC converter) to give a DC output voltage. The switching of the DC input voltage can be performed by electro-mechanical means, as in the vibrator used for valve car radios, or by transistors.

The circuit of an experimental DC inverter is shown in Fig. 1. The two transistors are connected in push-pull so that one is conducting while the other is cut off. If TR_2 is conducting while TR_1 is cut off, the AC component of collector current of TR_2 is flowing through C_1 and the two half-primary windings N_{p1} and N_{p2} in series, will increase towards its maximum value. The transformer windings are designed so that as I_{C2} reaches its maximum value, the base potential of TR_1, induced in winding N_{f1} becomes negative. TR_1 therefore conducts and the collector current, I_{C1}, starts to increase. This causes the base potential of TR_2 to become positive and I_{C2} to fall (by transformer action). TR_2 is now cut-off and TR_1 fully conducting. When I_{C1} reaches its maximum value, the base potential of TR_2 induced in winding N_{f2} becomes negative and TR_2 starts to conduct. The cycle is then repeated.

The output voltage is induced in winding N_s.

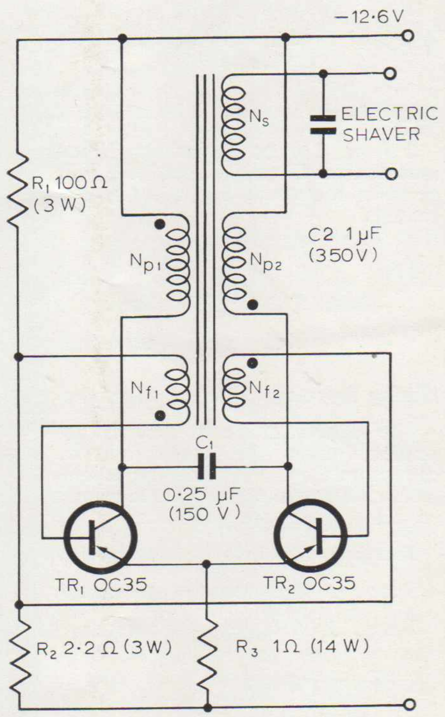


Fig. 1—Circuit diagram of inverter.

Transformer Winding Details

Core: ¾ in stack, 2¼ x 1⅞ in lamination.

Primary Windings (N_{p1} and N_{p2}): each 116 turns, 22 s.w.g.

Feedback Windings (N_{f1} and N_{f2}): each 41 turns, 34 s.w.g.

Secondary Windings (N_s): 2,960 turns, 36 s.w.g.

Circuit Description

The frequency of operation of the inverter is determined by the inductance values of the two half-primary windings, N_{p1} and N_{p2}, and the value of C_1. Capacitor C_1 also prevents spurious oscillation caused by the leakag[e] inductance of the transformer windings.

The transformer is designed so that with no load, the core saturates at about one third of the maximum design value of the collector current. On full load, which in the case of an electric shaver is mostly an inductive load, the collector current is allowed to reach the maximum design value just before the core saturates. Details of the transformer are given in the table. Capacitor C_2 is connected across the secondary winding of the transformer to limit the transistor peak collector voltage to a safe value.

The common emitter resistor R_3 and the resistance of the half-primary winding of the transformer, limit the maximum transistor current. Resistors R_1 and R_2 ensure reliable starting of the inverter even with a low battery voltage. Care should be taken to connect the inverter to the car battery correctly, as in many cars the negative pole of the battery is earthed. ■

LUXISTOR ORP39

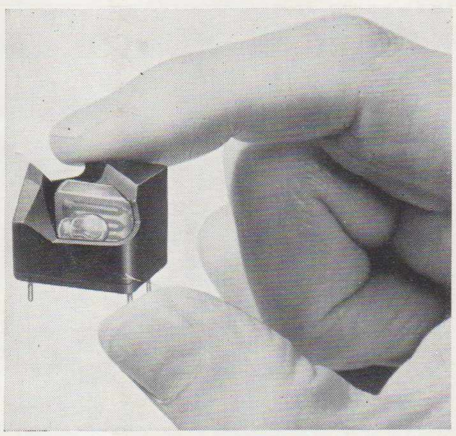
An inexpensive variable resistor which features a completely noise-free control.

The ORP39 is particularly suitable to control low level video and audio signals. The device, type number ORP39, comprises a cadmium sulphide cell and a 12V 65mA filament lamp encapsulated in a plastic block measuring 17 x 17·5 x 22 mm. The block has four lead-out pins and is suitable for standard printed circuit mounting.

The ORP39 has been specifically designed for use as a remotely controlled variable resistor in television cameras to control brightness (beam current) and black-level clamping. It can also be used as a feedback element in audio circuits, for overall gain control, as a remotely controlled brightness/contrast control for television receivers and for remote control in video tape-recorders, video signal repeater stations and television translator equipment.

By varying the brightness of the lamp the resistance of the cell can be controlled over at least three decades (say from 100 to 10,000Ω).

The adjustment of the resistance is completely free of noise and there is no electrical connection between the control and the output. This results in good electrical insulation and isolation and also permits long leads to be used from the remote controlling point to the equipment with no interference to the controlled circuit.



A cut-away section of the ORP39 shows the 12V lamp with the cadmium sulphide cell.

The capacitance between the controlling and controlled circuits is of the order of 2pF. The device is resistive and does not become reactive over the video signal range. It has a fast response time—far faster than the operation time of a manual control and is inexpensive when compared with any other similar high-quality device capable of remote control. The ORP39 is particularly suitable for use in circuits where any interaction between control and controlled circuit is undesirable, as a rheostat with no contact noise or, in general, as a transducer, converting a voltage input to a resistance output with complete electrical isolation between input and output.

As the impedance and phase angle of the cell vary with its resistance and the frequency applied to it, the useful upper frequency limit of the output resistor depends on the tolerance of the application to the changes and is probably a few megacycles. ■

NOTE: Abridged advanced data of the ORP39 is tabulated on Page 90.

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SPECIAL QUALITY VALVES AND EQUIVALENTS

Mullard

A QUICK REFERENCE CHART

SPECIAL QUALITY VALVES

This chart enables you to identify at a glance the Mullard Special Quality Valve Equivalents of C.V. Services Types, American Types and Mullard Standard Types.

In addition, abridged data is provided to assist in the selection of the Special Quality Valve most suited to your specific circuit requirements.

Full data and operating characteristics on each of the valves listed are available on request, and for certain valves further operational information is available. Mullard Special Quality Valves owe their type numbers to their development from two principal sources: (a) valves designed specifically for industrial applications (b) valves developed primarily for military use.

AN EXPLANATION OF MULLARD SPECIAL QUALITY VALVE TYPE NUMBERS

Valves developed specifically for industrial applications have type numbers composed of the normal letters and figures associated with Mullard receiving valves, but the figures follow the first letter and precede the second and subsequent letters. This facilitates recognition of SPECIAL QUALITY types e.g. E80F. It should be noted that, in general, there is no valve performance relationship between a SPECIAL QUALITY valve and a normal receiving valve whose type number contains the same letters and figures e.g. E80F is not a SPECIAL QUALITY version of EF80.

Valves developed primarily for military use have a special numbering system which involves the use of the letter M as a prefix. It should be noted that the actual number of each type does not indicate in any way the prototype from which it was derived but is taken directly from the experimental number of the special quality development.

Some recent additions to the range in each category have the same characteristics and specifications as certain American types. In these cases the actual American type number has been adopted by Mullard in order to indicate more clearly the identity of characteristics.

British Services, American and Mullard Equivalents

Mullard Standard Types to Special Quality Types

STANDARD PRODUCTION		SPECIAL QUALITY PRODUCTION	
Mullard Type Number	Services Type Number	Commercial Type Number	Services Type Number
EAC91	CV137	M8097	CV4059
EB91	CV140	M8079	CV4025
EC71	—	5718	CV3930
EC86	—	E86C	—
EC88	—	E88C	—
EC90	CV133	M8080	CV4058
EC91	CV417	M8099	CV4070
EC98	—	M8248	CV5311
ECC70	—	6021	CV3986
ECC81	CV455	M8162	CV4024
ECC82	CV491	M8136	CV4003
ECC83	CV492	M8137	CV4004
ECC88	CV5358	E88CC	CV2492
ECC91	CV858	M8081	CV4031
ECF80	CV5215	E80CF	—
EF86	CV2901	M8195	CV4085
EF91	CV138	M8083	CV4014
EF92	CV131	M8161	CV4015
EF95	CV850	M8100	CV4010
EF730	—	5636	CV3928
EF731	—	5899	CV477
EF732	—	5840	CV3929
EF734	—	6205	CV2432
EL71	—	5902	CV4029
EL91	CV136	M8082	CV4063
EY84	CV2235	M8091	CV4044
QVO3–12	CV2129	M8096	CV4039
6AL5	CV283	M8212	CV4007
6AS6	CV2522	M8196	CV4011

CV Type Nos. to Mullard and American Type Nos.

SPECIAL QUALITY PRODUCTION		
Services Number	Mullard Type Number	American Type Number
CV477	5899	5899
CV2432	6205	6205
CV2492	E88CC	6922
CV2493	E88CC/01	—
CV2729	E80F	6084
CV3928	5636	5636
CV3929	5840	5840
CV3930	5718	5718
CV3986	6021	6021
CV3998	E180F	6688
CV4003	M8136	‡6189/12AU7WA
CV4004	M8137	‡6057
CV4007	M8212	‡5726/6AL5W/6097
CV4010	M8100	5654/6AK5W/6096
CV4011	M8196	‡5725/6AS6W
CV4014	M8083	‡6064
CV4015	M8161	‡6065
CV4024	M8162	‡12AT7WA
CV4025	M8079	‡6058
CV4029	5902	5902
CV4031	M8081	‡6101/6J6WA
CV4039	M8096	‡6062
CV4044	M8091	‡6443
CV4058	M8080	‡6100/6C4WA
CV4059	M8097	—
CV4063	M8082	‡6516
CV4066	M8190	‡5783WA
CV4070	M8099	—
CV4085	M8195	—
CV5214	E90CC	5920
CV5304	6463	6463
CV5311	M8248	‡6J4WA
CV5354	E188C	7308
CV5808	E55L	8233
CV5809	E810F	7788
CV5989	E80CC	6085
CV8431	E180CC	7062

American Type Nos. to Mullard and CV Type Nos.

SPECIAL QUALITY PRODUCTION		
American Type Number	Mullard Type Number	Services Type Number
‡6J4WA	M8248	CV5311
‡12AT7WA	M8162	CV4024
5636	5636	CV3928
‡5654/6AK5W/6096	M8100	CV4010
5718	5718	CV3930
‡5725/6AS6W	M8196	CV4011
‡5726/6AL5W/6097	M8212	CV4007
5840	5840	CV3929
5899	5899	CV477
5902	5902	CV4029
5920	E90CC	CV5214
6021	6021	CV3986
‡6057	M8137	CV4004
‡6058	M8079	CV4025
‡6062	M8096	CV4039
‡6064	M8083	CV4014
‡6065	M8161	CV4015
6084	E80F	CV2729
6085	E80CC	CV5989
‡6100/6C4WA	M8080	CV4058
‡6101/6J6WA	M8081	CV4031
‡6189/12AU7WA	M8136	CV4003
6205	6205	CV2432
6211	6211	—
6227	E80L	—
‡6443	M8091	CV4044
6463	6463	CV5304
‡6516	M8082	CV4063
6686	E81L	—
6687	E91H	—
6688	E180F	CV3998
6689	E83F	—
6922	E88CC	CV2492
7062	E180CC	CV8431
7119	E182CC	CV5766
7308	E188CC	CV5354
7643	E80CF	—
7722	E280F	—
7737	E186F	—
7788	E810F	CV5809
8233	E55L	CV5808
8254	EC1000	—

Mullard Special Quality Valve Type Numbers and British Services, American and Mullard Standard Equivalents

SPECIAL QUALITY PRODUCTION			DESCRIPTION	STANDARD PRODUCTION		
Mullard Type Number	Services Type Number	American Type Number		Mullard Type Number	Services Type Number	American Type Number
E55L	CV5808	8233	High slope wideband output pentode	—	—	—
E80CC	CV5989	6085	Double triode for industrial use	—	—	—
E80CF	—	7643	Triode pentode with separate cathodes	ECF80	CV5215	6BL8
E80F	CV2729	6084	Voltage amplifying pentode	—	—	—
E80L	—	6227	Output pentode	—	—	—
E81L	—	6686	Output pentode	—	—	—
E83F	—	6689	Voltage amplifying pentode	—	—	—
E86C	—	—	U.H.F. triode	EC86	—	6CM4
E88C	—	—	U.H.F. grounded grid triode	EC88	—	6DL4
E88CC	CV2492	6922	Double triode for use in computers and cascode circuits	ECC88	CV5358	6DJ8
E88CC/01	CV2493	—	Double triode for use in computers and cascode circuits	—	—	—
E90CC	CV5214	5920	Double triode for use in computers	—	—	—
E91H	—	6687	Dual control heptode for use as a gating valve	—	—	—
E92CC	—	—	Double triode for use in computers	—	—	—
E180CC	CV8431	7062	Double triode for use in computers	—	—	—
E180F	CV3998	6688	High slope wideband amplifying R.F. pentode	—	—	—
E182CC	CV5766	7119	Double triode for use in computers	—	—	—
E186F	—	7737	High slope wideband amplifying R.F. pentode	—	—	—
E188CC	CV5354	7308	Double triode for use as cascode amplifier	—	—	—
E280F	—	7722	High slope wideband amplifying R.F. pentode	—	—	—
E288CC	—	—	Double triode	—	—	—
E810F	CV5809	7788	High slope wideband amplifying pentode	—	—	—
EC1000	—	8254	Subminiature triode for use in measurement probes	—	—	—
ECC2000	—	—	Double triode for use as V.H.F. cascode amplifier	—	—	—
M8079	CV4025	‡6058	Double diode with separate cathodes	EB91	CV140	—
M8080	CV4058	‡6100/6C4WA	R.F. power triode	EC90	CV133	6C4
M8081	CV4031	‡6101/6J6WA	V.H.F. double triode with common cathode	ECC91	CV858	6J6
M8082	CV4063	‡6516	Output pentode	EL91	CV136	—
M8083	CV4014	‡6064	R.F. pentode with separate g3	EF91	CV138	—
M8091	CV4044	‡6443	Half-wave rectifier designed for operation at high altitudes	EY84	CV2235	—
M8096	CV4039	‡6062	V.H.F. power tetrode	QV03–12	CV2129	5763
M8097	CV4059	—	Low impedance diode with medium μ triode	EAC91	CV137	—
M8099	CV4070	—	Triode for use as grounded grid amplifier	EC91	CV417	—
M8100	CV4010	‡5654/6AK5W/6096	Low noise, R.F. pentode	EF95	CV850	6AK5
M8136	CV4003	‡6189/12AU7WA	Low μ double triode	ECC82	CV491	12AU7
M8137	CV4004	‡6057	High μ double triode	ECC83	CV492	12AX7
M8161	CV4015	‡6065	Variable μ R.F. pentode	EF92	CV131	—
M8162	CV4024	‡12AT7WA	Medium μ double triode	ECC81	CV455	12AT7
M8195	CV4085	—	Low microphony, low hum A.F. voltage amplifying pentode	EF86	CV2901	—
M8196	CV4011	‡5725/6AS6W	Dual control pentode	6AS6	CV2522	6AS6
M8212	CV4007	‡5726/6AL5W/6097	Double diode with separate cathodes	6AL5	CV283	6AL5
M8248	CV5311	‡6J4WA	U.H.F. grounded grid triode	EC98	—	‡6J4
5636	CV3928	5636	Subminiature high slope R.F. pentode	EF730	—	—
5718	CV3930	5718	Subminiature U.H.F. triode	EC71	—	—
5840	CV3929	5840	Subminiature high slope R.F. pentode	EF732	—	—
5899	CV477	5899	Subminiature variable μ R.F. pentode	EF731	—	—
5902	CV4029	5902	Subminiature output pentode	EL71	—	—
6021	CV3986	6021	Subminiature U.H.F. double triode	ECC70	—	—
6205	CV2432	6205	Subminiature high slope R.F. pentode with separate g3	EF734	—	—
6211	—	6211	Double triode for use in computers	—	—	—
6463	CV5304	6463	Double triode for use in computers	—	—	—

‡ **The American types shown in this leaflet have the same electrical characteristics as the appropriate Mullard Special Quality type and they may, in general, be regarded as interchangeable. In the case of those types marked ‡ there are, however, certain differences in the test specifications.**

Abridged Data on Mullard Special Quality Valves

Full data on individual types is available on request.

FREQUENCY CHANGERS AND MIXERS

Type	Base	V_h (V)	I_h (mA)	V_a (V)	V_{g2} (V)	$-V_{g1}$ (V)	I_a (mA)	I_{g2} (mA)	g_c (µA/V)	r_a (kΩ)
E80CF	B9A	6·3	330	170[b] 100[c]	170 —	3·5 1·7	8·0 14	2·5 —	2,400 5,000 (g_m)	500 3·6
E91H[a]	B7G	6·3	270	150 150	75 75	0 10	5 to 6·5 <0·2	— —	— —	— —

[a] The voltages given for this valve are supply voltages and are applied to the valve via the following resistors: $R_a = 20k\Omega$, $R_{g2+g4} = 470k\Omega$, $R_{g1} = 47k\Omega$. $R_{g3} = 47k\Omega$ with $V_{g3} = 0V$. When $V_{g3} = -10V$ and $V_{g1} = 0V$, $I_a < 0{\cdot}2mA$.
[b] Mixer Section [c] Triode Section

DOUBLE DIODES

Type	Base	V_h (V)	I_h (mA)	P.I.V. max (V)	I_a max. (mA)	$i_{a(pk)}$ max. (mA)
				(Design centre ratings)		
M8079	B7G	6·3	300	420	9·0	54
M8212	B7G	6·3	300	330	9·0	54

OUTPUT PENTODES AND TETRODES

Type	Base	V_h (V)	I_h (A)	$V_a = V_{g2}$ (V)	$-V_{g1}$ (V)	I_a (mA)	I_{g2} (mA)	g_m (mA/V)	P_{out} (W)	r_a (kΩ)
E55L	B9D	6·3	0·6	125	3·0	50	5·5	45	—	—
E80L	B9A	6·3	0·75	200	4·4	30	4·1	9·0	2·7	7·0
E81L	B9A	6·3	0·375	210	3·0	20	5·3	11	1·0	15
E810F	B9A	6·3	0·34	V_a = 120 V_{g2} = 150	1·9	35	5·0	50	—	—
M8082	B7G	6·3	0·2	250	13·8	16	2·4	2·6	1·4	16
M8096	B9A	6·0	0·75	250	7·5	45	4·5	7·0	—	—
5902	B8D/F	6·3	0·45	100	8·3	30	1·2	4·2	1·0	3·0

SMALL RECTIFIER

Type	Base	V_h (V)	I_h (A)	V_a max. (V r.m.s.)	I_{out} max. (mA)	$V_{h-k(pk)}$ max. (V)
				(Design centre ratings)		
M8091	B9A	6·3	1·0	Capacitor Input 625 500 Choke Input 700	 125 150 150	650

VOLTAGE AMPLIFYING PENTODES

Type	Base	V_h (V)	I_h (mA)	V_a (V)	V_{g2} (V)	$-V_{g1}$ (V)	I_a (mA)	I_{g2} (mA)	g_m (mA/V)	r_a (MΩ)
E80F	B9A	6·3	300	250	100	2·0	3·0	0·65	1·85	1·5
E83F	B9A	6·3	300	210	120	2·0	10	2·1	9·0	0·5
E180F	B9A	6·3	300	190	160	1·3	13	3·3	16·5	0·09
E186F	B9A	6·3	320	180	150	1·25	13	3·3	16·5	0·1
E280F	B9A	6·3	315	180	150	1·6	20	6·0	26	0·1
E810F	B9A	6·3	340	120	150	1·9	35	5·0	50	0·07
M8083	B7G	6·3	300	250	250	2·0	10	2·6	7·6	0·5
M8100	B7G	6·3	175	180	120	2·0	7·7	2·4	5·1	0·40
M8161	B7G	6·3	200	200	200	2·5 27	8·25 —	2·1 —	2·45 0·025	0·9 —
M8195	B9A	6·3	200	250	140	2·0	3·0	0·6	2·0	2·5
M8196	B7G	6·3	175	120 120	120 120	2·0 2·0[d]	5·1 3·5	3·5 4·8	3·2 2·0	0·15 —
5636	B8D/F	6·3	150	100	100	1·4	5·3	4·1	3·2	0·11
5840	B8D/F	6·3	150	100	100	1·5	7·5	2·4	5·0	0·26
5899	B8D/F	6·3	150	100	100	1·1 15·5	7·2 —	2·0 —	4·5 0·025	0·26 —
6205[e]	B8D/F	6·3	150	100	100	1·5	7·5	2·4	5·0	0·26

[d] $V_{g3} = -3{\cdot}0V$ [e] Identical to 5840 but with separate g_3 connection

TRIODES AND DOUBLE TRIODES

Type	Base	V_h (V)	I_h (mA)	V_a (V)	$-V_g$ (V)	I_a (mA)	µ	g_m (mA/V)	r_a (kΩ)
E80CC	B9A	6·3 12·6	600 300	250	5·5	6·0	27	2·7	10
E86C	B9A	6·3	165	175	1·5	12	68	14	4·9
E88C	B9A	6·3	155	160	1·25	12·5	70	13·5	5·2
E88CC E88CC/01	B9A	6·3	300	90	1·2	15	33	12·5	2·65
E90CC	B7G	6·3	400	100	2·1	8·5	27	6·0	4·5
E92CC	B7G	6·3	400	150	1·7	8·5	45	6·0	7·5
E180CC	B9A	6·3 12·6	400 200	150	1·85	8·5	46	6·4	7·2
E182CC	B9A	6·3 12·6	640 320	120	2·0	36	24	15	1·6
E188CC	B9A	6·3	335	90	1·2	15	33	12·5	2·6
E288CC	B9A	6·3	475	90	1·5	30	25	18	1·4
EC1000	B8D/F	6·3	185	80	2·0	14	27·5	14·5	1·9
ECC2000	B10B	6·3	335	90[f] 90[g]	2·1 2·0	15 15	27 28	13 17	2·1 1·65
M8080	B7G	6·3	150	250	8·5	10·5	17	2·2	7·7
M8081	B7G	6·3	450	100	0·85	9·0	38	5·6	6·8
M8099	B7G	6·3	300	250	1·5	10	90	8·5	10·5
M8136	B9A	6·3 12·6	300 150	250	8·5	10·5	17	2·2	7·7
M8137	B9A	6·3 12·6	300 150	250	2·0	1·2	100	1·6	62·5
M8162	B9A	6·3 12·6	300 150	250	2·0	10	60	5·5	11
M8248	B7G	6·3	400	150	1·35	13·5	50	13·5	3·7
5718	B8D/F	6·3	150	100	1·3	8·5	27	5·8	4·7
6021	B8D/F	6·3	300	100	1·0	6·5	35	5·4	6·5
6211	B9A	6·3 12·6	300 150	100	2·2	4·6	28	3·6	7·8
6463	B9A	6·3 12·6	600 300	240	9·0	14·5	20	15·2	3·85

[f] Input Triode [g] Output Triode

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MULLARD OUTLOOK

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MULLARD PRODUCT TYPE NUMBER INDEX

The tabulation below is compiled of Mullard product type numbers, in alphabetical and numerical order, which are frequently referred to and which have appeared in Outlook, Volume 8.

MULLARD DISTRIBUTORS

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