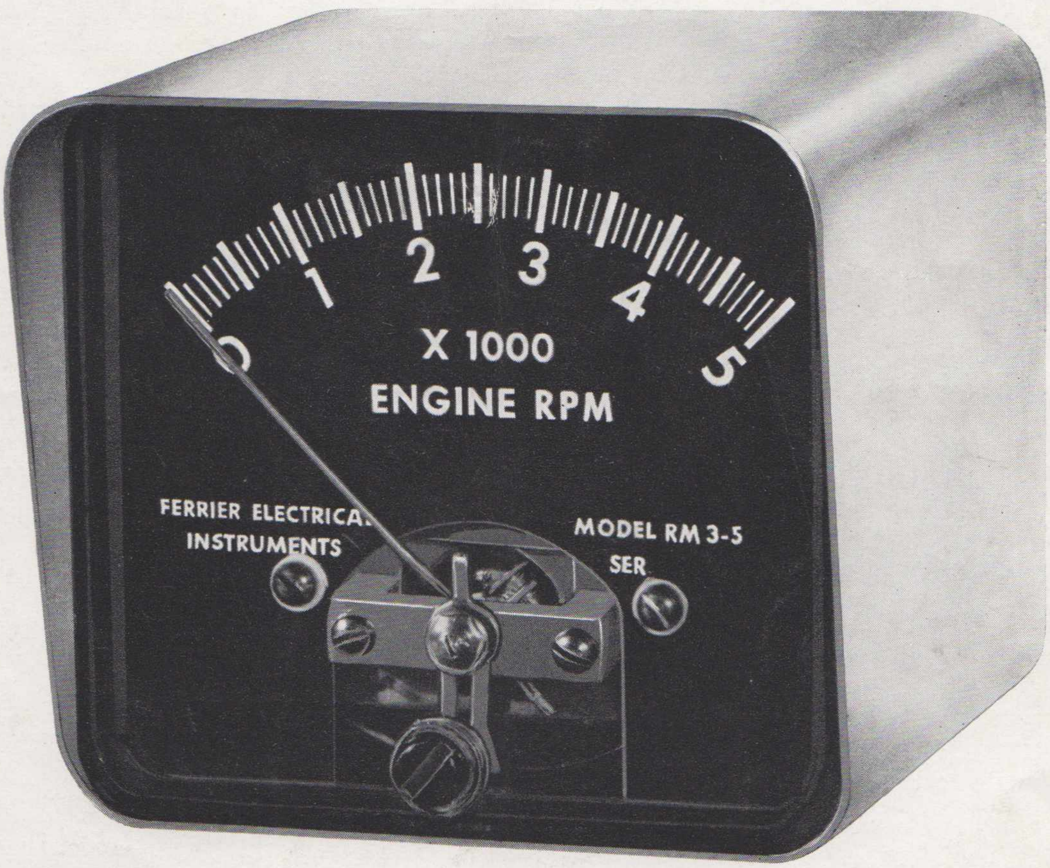
Mullard Outlook

AUSTRALIAN EDITION



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MULLARD-AUSTRALIA PTY. LTD.

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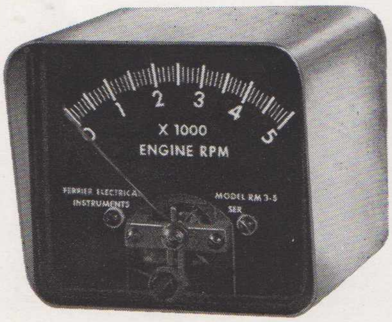
JOERN BORK

TABLE OF CONTENTS



This versatile electronic tachometer may be operated with internal combustion engines with 4, 6 or 8 cylinders and 6V or 12V, positive or negative earthed, electrical systems. Whilst this tachometer was primarily designed for use in motor vehicles, it may also be used with marine engines having battery ignition. For more detailed information see page 64.

MULLARD-AUSTRALIA PTY. LTD.

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VICTORIA
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Associated with
MULLARD LTD., LONDON

"Youth is a wonderful thing, what a crime to waste it on children."

— GEORGE BERNARD SHAW.

In matters technical, perhaps the dilemma of youth is deciding in which field of technology to concentrate and in turn with some detailed speciality be it trade or profession—or alternatively some job without training or future and the hopeful "get into advertising".

Lectures, training films, publications, this steady stream from the Mullard Educational Service has been directed to industry, technical training establishments, hobbyists and schools. More recently to the secondary school in view of the rapidly expanding Youth Radio Club Scheme.

It is our obligation to encourage young people to have healthy and absorbing pastimes with the possible groundwork for a future career. In this regard our full training facilities are available to the Youth Radio Club in your district; most secondary schools have either established clubs or are contemplating their establishment and we will be glad to add your school to our training scheme mailing list and send our special brochure.

M.A.B.

VIEWPOINT WITH MULLARD

MULLARD X-RAY DIVISION CHIEF IN AUSTRALIA

Many advanced contributions by Mullard to progress in X-Ray techniques were recently revealed during the Australian lecture tour of Mullard Limited, London, X-Ray Division Manager Mr. Andrew Beetlestone. An international figure in X-Ray tube development, he has recently been engaged in a series of lectures to radiologists and radiographers, commencing by presenting a paper "Some Contributions of Technology to X-Ray Diagnosis and the Reduction of Patient Dosage" to the Annual Meeting in Hobart of the College of Radiologists of Australia.

Mr. Beetlestone is a member of the Institution of Electrical Engineers; a Fellow of the Society of X-Ray Technology; Member of the College of Radiologists; and is a Council Member of the British Institute of Radiology. The Mullard X-Ray Division is situated at the Mitcham, Surrey factory where Mr. Beetlestone is also responsible for the design and production of Mullard Geiger-Müller counter tubes.

Watson Victor Ltd. — Local Distributor

In pursuing a policy of special distribution, Mullard X-Ray tubes are handled exclusively in Australia by Messrs. Watson Victor, the well-known medical and scientific equipment firm and should readers by good circumstances or otherwise have an X-Ray examination the odds are in favour of it being with a Mullard X-Ray tube!

Low Stray Radiation Tubes

Whilst in Australia, Mr. Beetlestone outlined the development of the new "Guardian" range of Mullard tubes designed for extremely low level of stray off-target radiation which substantially reduces the chances of excessive radiation to patients and radiographers, in fact the design of these tubes being so successful that the maximum stray leakage is 10 milliroentgens per hour, being only one-tenth of the official permissible level set by the International Commission on Radiation Protection.

MR. A. BEETLESTONE

Major Advances in Early Detection of Breast Cancer

Mr. Beetlestone had discussions with with radiologists relating to the recent advances in the early diagnosis of breast cancer and in particular regard to the special tubes that he had developed for this technique, allowing soft radiation at short exposure times and of extremely fine focus. It is envisaged that mass mammagraphic examinations of women in the future will be on a similar basis to mass chest X-Ray examinations, the particular technique passing the X-Ray through the breast tissue from directly above the breast with a negative beneath.

Advice to Radiographers

At his lectures Mr. Beetlestone presented a series of colour slides showing the damage to X-Ray tube target anodes resulting from mishandling and misadjustment of the equipment. A short film was also shown on the history of X-Rays, commencing from the early achievements of Professor Wilhelm Roentgen in 1895 in discovering the rays which emanated from the bombardment of a metallic plate by high velocity electrons in an evacuated tube.

A typical 150kV rotating anode X-Ray Tube in the "Guardian" range, featuring a leakage radiation only one-tenth of the permissible level set by the International Commission on Radiation Protection.

Geiger Counter Tubes

Mr. Beetlestone stressed the particular techniques associated with X-Ray tube manufacture, hard pumping and extreme cleanliness with all components completely free from contamination. In referring to Geiger-Müller tubes, Mr. Beetlestone claimed that the need with this type of device was for uniformity of each unit one to another and the advantages to be gained by developing specific types of Geiger counter tubes for a particular end use and to integrate these in a range best suited for most phases of science and industry.

Commercial Considerations

As highly skilled in the commercial activity as in vacuum techniques, Mr. Beetlestone's twenty-five years with the Company have resulted in a customer relationship understanding and the sound merchandising approach that a successful business transaction must be satisfactory to both the buyer and the seller, something well worth pondering over.

MULLARD-AUSTRALIA PERSONALITIES

MR. J. T. LAKE

With this issue we have pleasure in introducing Mr. John Lake, a member of our Head Office Technical Service Department who, apart from answering technical enquiries from a host of random and ever-increasing regular confidantes, handles the distribution of specialised technical literature. Subscribers to the Mullard Technical Handbook Service will know of him as he operates this service exclusively.

Mr. Lake joined the Company several years ago, bringing with him a background of more than 20 years' association with Army Signals. He was commissioned in 1940 and served in the Middle East, South-West Pacific Area and with the Occupation Forces in Japan.

For recreation, Mr. Lake enjoys boating on the Georges River and also plays a little golf. He may be occasionally found on clear nights "star-gazing", using his 6" Newtonian telescope—the mirror he ground and polished as a layman project at the University of N.S.W.

DESIGN FOR AN ELECTRONIC TACHOMETER

Over recent months tests have been carried out at Mullard-Australia Pty. Ltd. with an electronic tachometer based on a design published in "Electronic Engineering" October 1959. The simplicity of the design, plus the claimed accuracy, was impressive and the performance of the unit constructed has been most satisfactory. The tachometer may be used with 6V or 12V battery ignition systems of either positive or negative earth and with engines of various cylinder complements. Parts required are few, consisting of the meter, one Zener diode, four germanium diodes, one capacitor, one variable calibrating resistor, one small choke coil and one fixed resistor. The fixed resistor is not required for 6V systems.*

The unit is connected directly across the ignition coil primary, polarity of course being observed. With positive-to-frame systems the positive input is connected to the "CB" coil terminal and the negative input to the "SW" terminal. The input is reversed in the case of negative-to-frame systems. The functions of the choke coil and Zener diode and their roles in producing symmetrical pulses to the metering section of the unit, are discussed in the original article. It is sufficient to say that the limiting action of the Zener diode in both its forward and reverse conducting modes, together with the complete isolation by the choke of all oscillatory currents which occur at the instant of contact breaker opening, produce clean metering pulses of uniform size.

Contact Bounce

In addition, the choke coil has two other important effects. It eliminates loading of the ignition system by the tachometer, and, due to its time constant, prevents the effects of possible contact bounce at high engine speeds from reaching the metering section of the instrument. The pulses developed are fed to the metering section of the tachometer which consists of a bridge meter rectifier in series with a capacitor. The rectified meter current is directly proportional to the size of the capacitor and the pulse frequency. Thus, by changing the capacitor, the tachometer may be used with engines of any number of cylinders and with meters of various maximum r.p.m. dial scales (see Table A).

TABLE A

r.p.m. Meter scale	*Cylinders*		
	4	*6*	*8*
0 – 5000	·68μF	·47μF	·33μF
0 – 7000	·47μF	·33μF	·22μF
0 – 9000	·33μF	·22μF	—

The values shown in the Table are for use with a moving coil meter of 100Ω internal resistance and 1mA F.S.D.

COMPONENTS

Choke Coil — This coil has an inductance of approximately 1 Henry and, in order to keep its size to a minimum, a Mullard transformer core consisting of two half cups, type FX2240, was used in the experimental model. The winding consists of 480 turns of 36 SWG enamelled copper wire wound on a 25 mm former type DT2179. The wound former is housed in the FX2240 core and the assembly completed by the use of a DT2228 mounting clip and DT2227 printed circuit mounting board. Due to circuit simplicity, printed wiring is considered to be unnecessary, however the clip and board make for cheap and easy assembly of the coil. The terminal pins on the printed circuit mounting board enable the winding wire to be brought out for termination, making heavy "lead out" wires unnecessary.

In order to accommodate the number of turns required, care must be taken to wind the coil as evenly as possible. To prevent distortion of the thin cheeks of the former it should be firmly supported during winding operations.

After the winding is completed, it should be secured with a number of turns of thread wound around the coil followed by a layer of good quality electrical tape. Because of the low voltages involved, impregnation of the coil is not considered to be necessary.

Assembly of Choke

The leads of the coil should be carefully scraped clean of enamel to within about ¼" of the former. After enclosing the coil in the two Ferroxcube half cups, it should be placed onto the DT2227 board, locating the leads adjacent to the terminal pins. The pot core should be seated on the terminal board, the two raised portions of the board being located in the appropriate slots in the Ferroxcube cup. The DT2228 clip is then placed over the pot core and, whilst applying pressure against the spring tension of the clip, the four tips of the clip are turned over the underside of the mounting board and the ends hooked over into the oval holes by using a pair of long nosed pliers. The "lead out" wires should then be soldered to convenient pins completing the assembly of the choke.

Zener Diodes — The recommended types to be used are as follows:—

12V Systems — OAZ224
6V Systems — OAZ222

The rated dissipation of these diodes allows for their use without heat sinks, and, whilst a lower rating diode such as the OAZ204 could be used with 12V ignition systems, its maximum dissipation rating may be approached when used in conjunction with a battery at maximum voltage under charge. The higher rating diode (OAZ222) should always be used with 6V systems.

Meter Rectifier — Four germanium diodes, type OA91, are used in a bridge configuration as the meter rectifier.

The remaining components used are as follows:—

Calibrating Resistor — 1kΩ carbon trimming potentiometer.

The 1kΩ calibrating potentiometer will enable the meter reading to be adjusted correctly when the standard capacitances as indicated are used.

Fixed Capacitor — Polyester 125 VW. Capacitance in accordance with the requirements shown in Table A.

Resistor R1 — This resistor, used only with 12V systems, should be 120Ω, 1W. For 6V systems the resistance of the choke (approximately 14Ω) is sufficient to limit the Zener current.

Meter — The meter and case used in the experimental model was supplied by Messrs. Ferrier Electrical Instruments, 45 Albany Street, Crows Nest, N.S.W., and is available with a choice of 0–5000, 0–7000, or 0–9000 r.p.m. scales. The overall size of the meter assembled in the case is 2 3/16" x 2½" x 3".

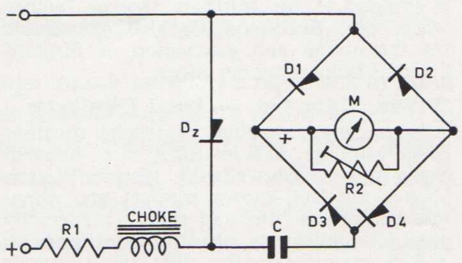


Fig. 1—Circuit diagram of Tachometer

A piece of 1/16" bakelite, cut to the size and drilled in accordance with the template (Fig. 2), will mount upon the terminals of the meter, the whole assembly being easily contained in the meter case supplied. Two leads from the tachometer are connected across the ignition coil, as previously indicated.

CONSTRUCTION

Referring to Fig. 3, insert a tagged eyelet in each of the three holes, to be used for mounting the diodes and one end of the capacitor, the eyelet for the capacitor should be mounted with its tag on the upper surface; those for the diodes should have their tags on the underside. The holes in which the eyelets are fixed are marked 'F' in Fig. 2. The lower diode eyelet and the capacitor eyelet adjacent to it should be connected together. Mount the choke assembly as indicated in Fig. 3 and fasten it by means of two, ¼" x 6 BA screws and nuts; the four 3/16" holes in the panel accommodate the mounting clip ends, allowing the choke assembly to mount flush with the surface of the panel. Push the tags of the calibrating potentiometer through the slotted holes and bend the ends of the tags out to hold the potentiometer firmly to the panel. A lead from the slider tag is brought up through the ⅛" hole adjacent to the left-hand meter assembly hole and a wire from the tag in the bottom slotted hole through the ⅛" hole adjacent to the right-hand meter

* "An Electronic Tachometer for Automobiles" by M. J. Wright, B.Sc., of Joseph Lucas (Electrical) Ltd.

assembly hole. The negative terminal is to the right of the calibrating potentiometer and has solder lugs below and above the panel. The positive terminal is located on the centre left-hand edge of the panel, requiring only a solder lug above the panel. These are fastened with ¼" x 6 BA screws and nuts. A lead from the negative terminal is connected to the tag of the diode eyelet closest to the choke coil, continued on and brought up through the ⅛" hole immediately to the right of the choke. The Zener diode is mounted through the hole in the top right-hand corner of the panel, a large solder tag being mounted under the diode body on top of the panel. The washer supplied is placed under the panel and the nut screwed up to hold the diode securely. The lead previously brought up in the hole to the right of the choke is soldered to the top terminal of the Zener diode.

Assembly

The panel should now be mounted on the meter terminals and two solder lugs clamped under the mounting nuts as indicated in Fig. 3. The remainder of the wiring is carried out above the panel in accordance with the circuit diagram. When wiring the tachometer for a 12V ignition system, a 120Ω, 1W resistor is connected between the positive input terminal and one side of the choke coil. For 6V ignition systems, the resistor is not required and the terminal is connected directly to the choke coil. The other side of the choke coil is connected to the large tag mounted under the Zener diode body and from this point the appropriate capacitor is connected to the eyelet with its tag above the panel, as previously mentioned. This completes the wiring of the unit.

CALIBRATION

For 12V ignition systems, quite accurate calibration may be obtained by using 6·3V AC from the heater winding of a power transformer, which, if connected to 50 c/s mains, should enable the meter pointer to be adjusted by means of the calibrating potentiometer to 1,500 r.p.m. for a four-cylinder engine, 1,000 r.p.m. for a six-cylinder engine and 750 r.p.m. for an eight-cylinder engine. It was found in the experimental model that this method of calibration gave almost identical results to adjustments by stroboscopic methods. In the case of the 6V systems, where the OAZ222 Zener diode was used, this method was not quite as successful, due to the knee characteristic of the lower voltage Zener diode. It does, however, give a fair approximation, but the meter should be finally brought to the correct point by calibrating against the known revolutions of the car engine.

Precise Calibration

A suggested method for precise calibration requires the use of a neon pilot light connected to the 50 c/s mains. By placing two chalk marks 180° apart on the outer edge of the fan-belt pulley attached to the crank shaft of the engine, a stationary pattern will be observed at 3,000 r.p.m., when the pulley is illuminated by the neon light held a few inches away in darkness or in conditions of low ambient light. This procedure calls for the assistance of another person and can usually be achieved by the observer operating under the front of the vehicle. The second person notes the meter reading as he gradually increases the engine speed until the pattern on the pulley appears stationary. By means of the calibrating potentiometer, the dial reading is adjusted to indicate 3,000 r.p.m. Several checks should be made to ensure that the calibration is correct. At this point, two additional chalk marks may be drawn on the pulley exactly between the marks originally made, making four chalk marks 90° apart. A stationary pattern should now be observed at 1,500 r.p.m.

—J. T. LAKE.

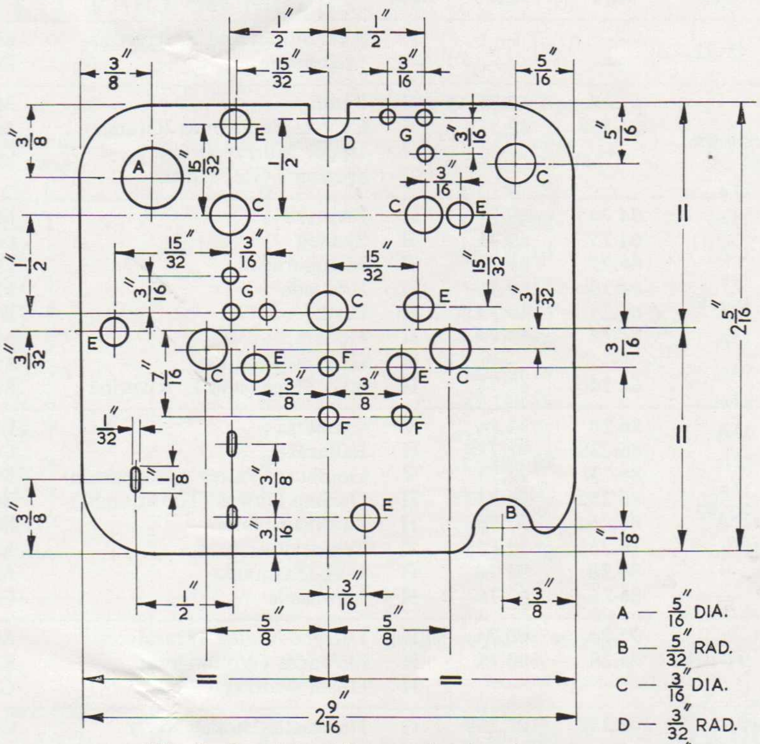


Fig. 2—Template of the mounting board

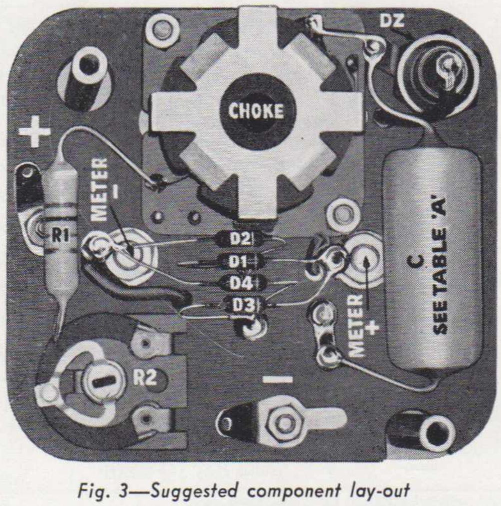


Fig. 3—Suggested component lay-out

COMPONENT PARTS LIST

D1/D4	OA91 Germanium Diodes	Hardware	4 6 BA x ¼" brass screws and nuts
D_Z	OAZ222 — for 6V systems OAZ224 — for 12V systems		
C	125 VW 10% (see Table A)		3 small solder lugs
R1	120Ω 1W 10% — 12V systems only		3 large solder lugs
R2	1kΩ 1W carbon trimming potentiometer		3 Matrix board tagged eyelets
Panel	1/16" bakelite (see template Fig. 2)	Meter and Case	0 – 1mA 100Ω Ferrier type B.T.
Choke	See text		

*To assist the home constructor, copies of the actual size template of the mounting board have been printed and are available from the Editor on receipt of a stamped, addressed envelope (marked "Template").

AUSTRALIAN TELEVISION CHANNELS – 1963

Channel Number	Band Mc/s	Vision Mc/s	Sound Mc/s	Aerial Polari-sation	Transmitting Area	Transmitting Site	National Stations	Commercial Stations	
0	45-52	—	—	H	S.W. Slopes and E. Riverina	Mt. Ulandra	—	—	φ
		—	—	—	Melbourne	Dandenong		ATVO	φ
1	56-63	57.25	62.75	V	Bendigo	Mt. Alexander	ABEV1		
		57.258	62.758	V	Central Tablelands (Orange)	Mt. Canobolas	ABCN1		*
		—	—	H	Upper Murray (Vic.)	Goschen	—		φ
		—	—	—	Spencer's Gulf North	—	—		φ
2	63-70	64.24	69.74	H	Brisbane	Mt. Coot-tha	ABQ2		
		64.25	69.75	H	Sydney	Gore Hill	ABN2		
		64.25	69.75	H	Melbourne	Dandenong	ABV2		
		64.26	69.76	H	Adelaide	Mt. Lofty	ABS2		
		64.25	69.75	H	Perth	Bickley	ABW2		
		64.24	69.74	H	Hobart	Mt. Wellington	ABT2		
		—	—	H	Grafton-Kempsey	Mt. Moombil	—		φ
		64.24	69.74	H	S.W. Slopes and E. Riverina	Mt. Ulandra		RVN2	*
3	85-92	86.24	91.74	V	Canberra	Black Mountain	ABC3		
		86.238	91.738	H	Ballarat	Lookout Hill	ABRV3		
		86.23	91.73	V	Goulburn Valley (Shepparton)	Mt. Major	ABGV3		*
		86.252	91.752	H	Darling Downs (Toowoomba)	Mt. Mowbullan	ABDQ3		*
		86.26	91.76	H	Rockhampton	Mt. Hopeful	ABRQ3		*
		86.268	91.768	H	Townsville	Mt. Stuart	ABTQ3		*
		86.20	91.70	H	N.E. Tasmania	Mt. Barrow	ABNT3		
		86.25	91.75	H	Newcastle	Great Sugarloaf		NBN3	
4	94-101	95.24	100.74	H	Latrobe Valley (Traralgon)	Mt. Tassie	ABLV4		
		95.28	100.75	H	Illawarra (Wollongong)	Knight's Hill		WIN4	
		—	—	H	Upper Murray (Vic.)	Goschen		AMV4	*
5	101-108	102.258	107.758	H	Newcastle-Hunter River	Great Sugarloaf	ABHN5		
5A	137-144	138.25	143.75	H	Illawarra (Wollongong)	Knight's Hill	ABWN5A		
6	174-181	175.26	180.76	H	Richmond-Tweed (Lismore)	Mt. Nardi	ABRN6		*
		175.25	180.75	H	Hobart	Mt. Wellington		TVT6	
		175.248	180.748	H	Ballarat	Lookout Hill		BTV6	
		175.256	180.756	V	Goulburn Valley (Shepparton)	Mt. Major		GMV6	
		—	—	V	Wide Bay (Q'land)	Maryborough	—		φ
7	181-188	185.25	187.75	H	Brisbane	Mt. Coot-tha		BTQ7	
		182.25	187.75	H	Sydney	Gore Hill		ATN7	
		182.25	187.75	H	Melbourne	Dandenong		HSV7	
		182.26	187.76	H	Adelaide	Mt. Lofty		ADS7	
		182.25	187.75	H	Perth	Bickley		TVW7	
		182.258	187.758	V	Canberra	Black Mountain		CTC7	
		182.26	187.76	H	Rockhampton	Mt. Hopeful		RTQ7	
		182.25	187.75	H	Townsville	Mt. Stuart		TNQ7	
		—	—	H	Upper Namoi, N.S.W. (Tamworth)	Mt. Dowe nr. Mt. Kaputar	—		φ
8	188-195	189.258	194.758	V	Central Tablelands (Orange)	Mt. Canobolas		CBN8	
		189.25	194.75	H	Richmond-Tweed (Lismore)	Mt. Nardi		RTN8	
		189.25	194.75	V	Bendigo	Mt. Alexander		BCV8	
		—	—	V	Wide Bay (Q'land)	Maryborough		—	φ
9	195-202	196.25	201.75	H	Brisbane	Mt. Coot-tha		QTQ9	
		196.25	201.75	H	Sydney	Willoughby		TCN9	
		196.248	201.748	H	Melbourne	Dandenong		GTV9	
		196.26	201.76	H	Adelaide	Mt. Lofty		NWS9	
		196.238	201.738	H	N.E. Tasmania	Mt. Barrow		TNT9	
		—	—	H	Upper Namoi, N.S.W. (Tamworth)	Mt. Dowe nr. Mt. Kaputar		NEN9	*
10	208-215	209.246	214.746	H	Latrobe Valley (Traralgon)	Mt. Tassie		GLV10	
		209.26	214.76	H	Darling Downs (Toowoomba)	Mt. Mowbullan		DDQ10	
		209.24	214.74	H	Grafton-Kempsey	Mt. Moombil		NRN10	*
		—	—	H	Sydney	—		TEN10	*
11	215-222	—	—	—	—	—		—	φ

* Due to commence shortly.
φ Call signs not yet allocated.

TELEVISION TURRET TUNERS

BISCUIT PART NUMBERS

Model NT3011 Biscuits

Channel	*Type Number (Printed Circuit)*	*Identification On Strip*
0	CZ.320.160	CZ 0
1	CZ.320.161	CZ 1
2	CZ.320.162	CZ 2
3	CZ.320.163	CZ 3
4	CZ.320.164	CZ 4
5	CZ.320.165	CZ 5
5A	CZ.320.166	CZ 5A
6	CZ.320.167	CZ 6
7	CZ.320.168	CZ 7
8	CZ.320.169	CZ 8
9	CZ.320.170	CZ 9
10	CZ.320.171	CZ10
11	CZ.320.172	CZ11

Model NT3009 Biscuits

Channel	*Type Number (Printed Circuit)*	*Identification On Strip*
0	A3.178.70	AU 0
1	A3.156.82	AU 1
2	A3.156.83	AU 2
3	A3.156.84	AU 3
4	A3.156.85	AU 4
5	A3.156.86	AU 5
5A	A3.178.71	AU 5A
6	A3.156.87	AU 6
7	A3.156.88	AU 7
8	A3.156.89	AU 8
9	A3.156.90	AU 9
10	A3.156.91	AU10
11	A3.178.72	AU11

Model NT3006 Biscuits

Channel	*Type Number*	
	Aerial	*RF and Osc.*
0	CZ.320.084	CZ.321.057
1	CZ.320.085	CZ.321.058
2	CZ.320.086	CZ.321.059
3	CZ.320.087	CZ.321.060
4	CZ.320.088	CZ.321.061
5	CZ.320.089	CZ.321.062
5A	CZ.320.090	CZ.321.063
6	CZ.320.091	CZ.321.064
7	CZ.320.092	CZ.321.065
8	CZ.320.093	CZ.321.066
9	CZ.320.094	CZ.321.067
10	CZ.320.095	CZ.321.068
11	CZ.320.096	CZ.321.069

Model NT3001 Biscuits

Channel	*Type Number*	
	Aerial	*RF and Osc.*
0	**CZ.320.097**	**CZ.321.070**
1	**CZ.320.098**	**CZ.321.071**
2	CZ.320.058	CZ.321.038
3	CZ.320.059	CZ.321.039
4	**CZ.320.100**	**CZ.321.073**
5	**CZ.320.101**	**CZ.321.074**
5A	**CZ.320.102**	**CZ.321.075**
6	CZ.320.062	CZ.321.042
7	CZ.320.063	CZ.321.043
8	CZ.320.064	CZ.321.044
9	CZ.320.065	CZ.321.045
10	CZ.320.066	CZ.321.046
11	**CZ.320.103**	**CZ.321.076**

Model AT7580 Biscuits

Channel	*Type Number*	
	Aerial	*RF and Osc.*
0	**CZ.320.104**	**CZ.321.078**
1	**CZ.320.105**	**CZ.321.079**
2	A3.747.08	A3.747.03
3	A3.747.09	A3.747.04
4	**CZ.320.106**	**CZ.321.080**
5	**CZ.320.107**	**CZ.321.081**
5A	**CZ.320.108**	**CZ.321.082**
6	A3.746.75	A3.746.70
7	A3.746.76	A3.746.71
8	A3.746.77	A3.746.72
9	A3.746.78	A3.746.73
10	A3.746.79	A3.746.74
11	**CZ.320.109**	**CZ.321.083**

ADDITIONAL NOTES

1. Type numbers in **bold** are the necessary biscuits to convert superseded turret tuners to the new frequency allocations.
2. Modified biscuits for Tuner AT7580 and NT3001 carry the suffix "M". The addition of a red paint marking on the end of the coil former identifies the biscuit for Tuner AT7580.
3. Modified biscuits are readily available and, when ordering biscuit assemblies, servicemen and retailers should take care to quote the correct part numbers.
4. Turret Tuner type NT3003 is designed to permit electrical remote fine tuning of the oscillator frequency and, apart from an additional terminal and modified fine tuning control shaft, it is identical to the NT3006 which uses mechanical fine tuning.

Read-out and On-Off Circuits using a BPY10 Silicon Photovoltaic Cell

Operation of the Mullard BPY10 silicon photovoltaic cell in series and parallel configurations is examined, with particular reference to tape and card reading, edge detection, and other on-off applications. The preferable parallel configuration is analysed, and design and setting-up procedures are given, with recommendations concerning amplifier circuits to follow the detector stage.

Introduction

The Mullard BPY10 photovoltaic cell is a silicon p-n junction, moulded in resin for chemical protection and physical strength, with an accurately masked window that allows access to light over a defined area 1·68 × 1·68mm (0·066 × 0·066in). The rectangular shape, with lead-outs at one end (as shown in the photograph), is designed to facilitate stacking for in-line read-out. The dimensions, 0·086 × 0·088 × 0·25in, allow a row of six devices to be arranged under standard 11/16in tape with five digit holes and a location hole. The width of the cell is controlled within ±0·001in.

The device is intended for on-off light-detection applications, such as tape and card reading and edge detection, where detection of light over a small area is required. It may also be used for revolution counting, modulated light beam detection, and optical sound-track pickup. The spectral response peaks at 0·8µm, so that the device is sensitive to a tungsten lamp.

Characteristics

Under dark conditions the p-n junction acts as a normal silicon diode junction with high ohmic leakage when a voltage is applied to it (Fig. 1). When energy quanta

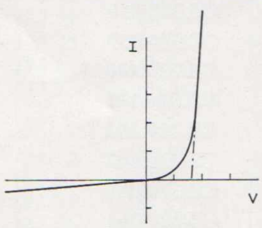
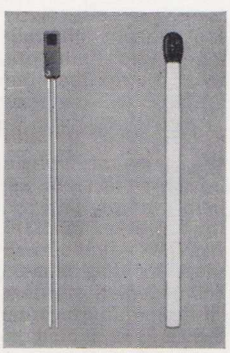


Fig. 1—Dark characteristic of diode

in the spectral response band impinge on it, hole-electron pairs are created, and those carriers of the appropriate polarity in the depletion layer are swept over the junction potential barrier as free carriers.



Actual size of Silicon Photovoltaic Cell BPY10

Reprinted from Mullard Technical Communications, Vol. 7, No. 61, November 1962, by J. F. Miles, Mullard Semiconductor Measurement and Application Laboratory.

If a low-resistance circuit is connected to the device, these carriers appear as a current in the external circuit, in the reverse direction of the diode. If a high-resistance circuit is connected to the device, the excess free carriers lower the internal barrier field at the junction, causing a potential at the terminals in the forward direction of the diode. If the circuit has a resistance intermediate between these limiting cases, the device acts as a variable generator with non-linear resistance, giving a combination of forward voltage and reverse current as shown in Fig. 2. This

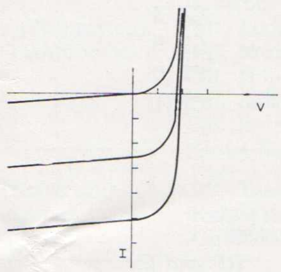


Fig. 2—Effect of incident light

characteristic may be considered as consisting of the diode characteristic of Fig. 1 together with a current, proportional to the incident energy, added in the reverse direction. Reversal of the sign of the current axis gives the more usual presentation of these curves, as shown in Fig. 3.

As with all semiconductor diodes, the characteristic is temperature-dependent. The theoretical diode characteristic is given by

$$I = I_{SAT}(\exp(qV/KT)-1)$$

where I_{SAT} is the saturation reverse current and is exponential with temperature. A leakage current, which is approximately ohmic, occurs across the junction, and this also varies exponentially with temperature. Adding the light current $-c\Phi$ (where Φ is the illumination and c the sensitivity) shifts the curve negatively, giving the curves of Fig. 3, where

$$I = I_{SAT}[\exp(qV/KT)-1]+V/f(T)-c\Phi$$

Measurements on the device show that the reverse leakage current measured at −1V bias and dark conditions increases with temperature to 70µA at 100°C, the published maximum rated temperature. The short-circuit sensitivity, when the leakage current may be ignored, is also subject to a small variation with temperature of the order of 0·2% per degC.

Circuit Considerations

The BPY10, being photovoltaic, requires no bias for normal operation, and as the leakage is small the cell may be used with direct coupling into an amplifier. It is, however, desirable to use silicon transistors in the amplifier, so that the transistor leakage current shall not detract from the sensitivity of the cell. In this case, it is necessary to add a bias to the voltage generated by the cell, the total voltage being sufficient to overcome the high base-emitter voltage of the transistor. There are two ways of providing this voltage bias.

The curves of Fig. 3 show that if the diode is back biased, the characteristics tend towards a constant current state, and the voltage across the device may be increased beyond the V_{be} of the transistor (0·4 to 0·7V) without appreciably affecting the current. If the cell is connected in the

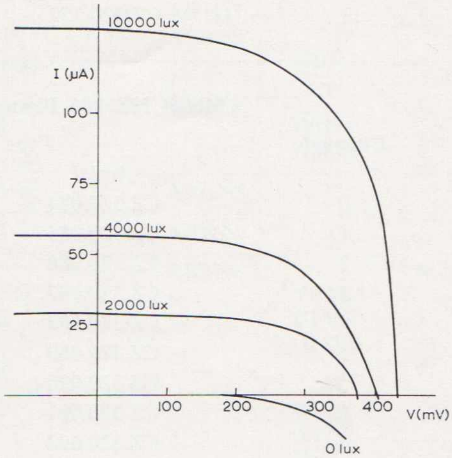


Fig. 3—Typical voltage/current characteristic of BPY10 at T_{amb} = 20°C, using a lamp of colour temperature 2700°K

reverse direction across the base-emitter diode of the transistor, and the two are fed from a constant current source (Fig. 4) then the transistor will receive a current I_b which is the difference between the

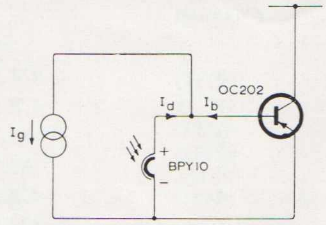


Fig. 4—Parallel configuration

current source I_g and the cell current I_d which is proportional to the incident light. The diode voltage will adjust itself to the base-emitter voltage without affecting the diode current. The transistor will also protect the cell, as the current source may be chosen so that when all the current feeds into the transistor, the voltage generated does not exceed the maximum diode reverse voltage.

The second method of biasing is to connect the device in series with the transistor base, and to add a bias (Fig. 5) so that the bias provides the base-emitter voltage,

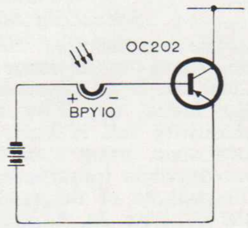


Fig. 5—Series configuration

and the diode current can force the transistor into conduction. By making the source resistance of the bias supply low, and adjusting the bias level, it is possible to keep the diode voltage small, which keeps the temperature-dependent components of the current small.

Parallel Configuration

A circuit employing the device in the parallel configuration is shown in Fig. 6.

As already mentioned, this configuration has the advantage that the cell resistance is high and the cell can be used as a current

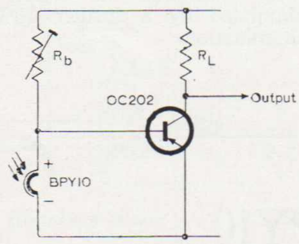


Fig. 6—Practical parallel circuit

switch. It has the disadvantage of working at the base-emitter voltage, which may be as much as 0·7V reverse bias with attendant high leakage currents. A sample calculation is shown on the opposite page.

To ensure that the circuit is stable the circuit must allow for the following variations:

1. Drift of V_{cc} power supply; for example, 12V±6%.
2. Variation of leakage current up to 30μA at 1V bias and 75°C, which is equivalent to 20μA at 700mV bias, the approximate working point.
3. Variation of transistor characteristics. Thus, the current amplification factor h_{FE} may be between 25 and 85 when an OC202 transistor is used.
4. Variation in the relative amounts of light falling on the cell in the ON and OFF conditions.
5. Variation of the short-circuit sensitivity of the device—approximately ±10%.

The light falling on the cell in the OFF condition is determined by the light transmission of the tape or card that is being read (paper tape may transmit as much as 50% of the light falling on it; card transmits between 5% and 20%) and also by the intensity of the light source. As the light output of a lamp varies approximately cubically with applied voltage, it is advisable to power the lamp from a stabilised supply. A typical variation of ±1% in the supply will then give ±3% variation in the light intensity.

Calculation

If I_s is the leakage current of the cell, I_l the light current in the OFF state when the cell is illuminated, and I_b the base current, then

$$I_b = \frac{V_{cc}-V_{be}}{R_b} - I_l - I_s + I_{CBO} \quad \ldots (1)$$

The collector leakage current I_{CBO} of the OC202 is small (1μA max) compared with I_s (20μA at 75°C) and may be ignored. Variation in V_{be} is small compared with V_{cc} and may also be ignored.

In the OFF state we may set R_b just to cut off the first transistor of the amplifier at the most adverse limits of the parameters. Then V_{cc} becomes V_{cc}+6%, R_b becomes R_b−1%, and from I_l must be subtracted the variation in illumination and variation of sensitivity. Thus

$$\left(\frac{V_{cc}-V_{be}}{R_b}+7\%\right) - 0 - (I_l - 3\% - 10\%) = 0$$

and

$$\frac{V_{cc}-V_{be}}{R_b} = \frac{I_l}{1\cdot 23}. \quad \ldots (2)$$

In the ON state we wish to bottom the transistor, which requires a base current of $(V_{cc}/R_L)(1/h_{FE})$. Again substituting into Eq(1), using the most adverse tolerance limits, and defining k as the ratio of the illumination in the ON and OFF states, we obtain

$$\frac{V_{cc}}{R_L}\frac{1}{h_{FE}} = \left(\frac{V_{cc}-V_{be}}{R_b} - 7\%\right)$$

$$-(kI_l + 3\% + 10\%) - 20\mu A \text{ (at } 75°C) \quad \ldots (3)$$

From Eqs(2) and (3), taking V_{cc} as −12V, and h_{FE} as 25, we obtain

$$I_l > \frac{20+(0\cdot 48 R_L)}{0\cdot 76 - 1\cdot 13k} \mu A \quad \ldots (4)$$

where R_L is in MΩ and I_l in μA.

If R_L is at least 470kΩ, the fraction $0\cdot 48/R_L$ may be ignored.

Examples

1. For card reading, where k is approximately 0·15,

   $$I_l = 36\mu A.$$

   As the minimum sensitivity is 15μA at an illumination of 2000 lux, the minimum light intensity would in this case be 36/15×2000 = 4800 lux, which is easily attainable.

2. For tape reading, using paper tape, k may be as high as 0·5. Then from Eq(4)

   $$I_l > \frac{20}{0\cdot 2} = 100\mu A \text{ at } 75°C$$

   The minimum illumination is 100/15 ×2000 = 13 400 lux.

More Critical Applications

If it is desired to work at higher temperatures and lower illumination levels than those analysed above, the leakage current will necessitate individual setting up of circuits. This may be avoided by a modification to the circuit.

The leakage current $I_{SAT}[\exp(qV/KT) - 1] + V/f(T)$ is voltage-dependent. Therefore if a bias is added to the device to overcome the transistor base-emitter voltage,

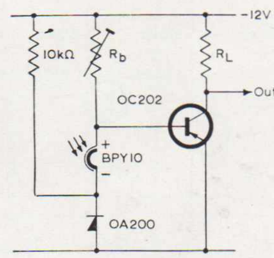


Fig. 7—Parallel circuit with bias

the device works at low voltage and the leakage current is considerably reduced. Fig. 7 shows the application of a bias voltage, stabilised by a silicon diode, in series with the cell. The cell is now loaded by the base-emitter diode of the transistor, in series with the external diode, which together present a load of the order of 200Ω. With a maximum signal current of 200μA, only 40mV is developed across the cell, together with any difference between the forward voltages of the diode and the transistor base-emitter diode. The total does not exceed 200mV, which limits the leakage current to approximately one-fifth of its value at 1V (that is, 14μA at 100°C).

As the diode characteristic and the transistor input characteristic vary with temperature in the same way, the diode will also provide temperature stabilisation of the working point.

Series Configuration

Under *Circuit Considerations* a series configuration is suggested, in which the diode current is used directly to switch on the transistor, the base-emitter voltage being overcome by a series bias (Fig. 5). As there is no parallel path in this configuration, the leakage current flows into the transistor, and it is no longer possible to use the cut-off state to indicate the OFF condition. The circuit may be adjusted so that the transistor just bottoms in the ON condition by adjustment of the collector load. This, however, makes the operation of the circuit dependent on h_{FE}, which is temperature-dependent, and on the input resistance of the following amplifier, which may also vary. The series configuration is therefore inferior to the parallel configuration, and a detailed analysis will not be given.

Following Circuits

The waveform from either of the above circuits is a function of the variation of the illumination falling on the cell. If, for example, the illumination is governed by a rectangular card hole passing over the square window of the device, the waveform will consist of a nearly linear rise and fall, bridged by a constant voltage. If, however, it is governed by a series of round holes in paper tape passing over a round masking hole, the waveform will be as in Fig. 8, possibly clipped if a high-sensitivity diode or low-transparency tape is used.

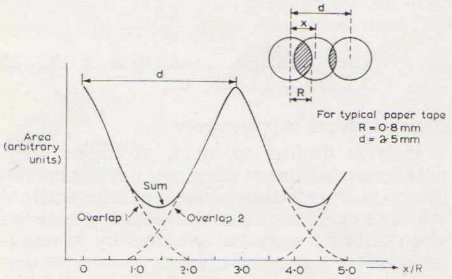


Fig. 8—Area of overlap of a round hole passing over a row of similar holes

If square pulses are required, a switching circuit must be used after the first transistor to define the ON and OFF states. The most suitable circuit for this purpose is a Schmitt trigger circuit (Ref. 1), an example of which is given in Fig. 9. As the circuit is drawn, it gives positive pulses. The circuit is capable of reading pulses from a paper tape with k = 0·3 and an illumination of 5000 lux with any cell, provided that the ambient temperature does not exceed 75°C.

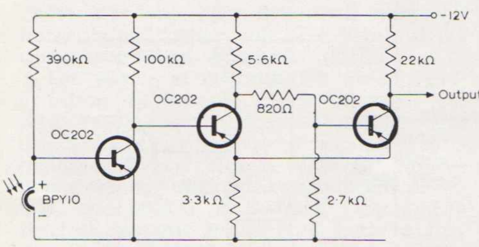


Fig. 9—Schmitt trigger circuit

Conclusions

The BPY10 cell is suitable for tape and card reading and similar on-off light detection applications, in an ambient temperature of up to 75°C, with illumination levels in the ON state in the range 2000 to 10 000 lux, provided that the illumination in the OFF state does not exceed 30% of that in the ON state. The majority of tape and card readers should fall well into this group.

If it is desired to work at temperatures above 75°C, with an illumination less than 10 000 lux, it may be necessary to use low-transparency tape, or to adjust each circuit individually.

REFERENCES

1. NEWELL, A. F. and TOURTEL, P. A. 'Transistor Backlash Circuits'. **Mullard Technical Communications,** Vol. 6, No. 51, Sept. 1961, pp. 22 to 29.

APPENDIX

Setting Up the Circuit

The sensitivity of the device may have any value in the range 15µA to 50µA at 2000 lux. If the circuit is designed to accept the lowest sensitivity cells, and a high-sensitivity cell is used, the output in the OFF state, using a card or tape with an ON/OFF light transmission ratio of less than 10, will be of the same order as that in the ON state. In the majority of cases it is therefore necessary to match the circuit to each individual cell by means of a set-in-test or variable resistor.

The parallel circuit may be set up by adjustment of R_b (Fig. 6). The required value may be calculated from Eq(2):

$$R_b = \frac{1 \cdot 25\ (V_{cc} - V_{be})}{c\Phi},$$

or by practical adjustment of the resistor.

When setting up the circuit by practical adjustment, the resistor is set at the point where the transistor just cuts off under full illumination. Device and circuit must be under the conditions already stipulated under *Calculation*; namely, maximum V_{cc}, minimum illumination, and low temperature. Variation in sensitivity may be simulated by a further 10% decrease in illumination.

Silicon Photovoltaic Cell BPY10

Abridged Preliminary Data

Silicon photovoltaic cell suitable for use in tape and card readers.

Sensitive area	43·5 × 10^{-4}	in^2
Sensitivity	32µA at 2000	lux
Maximum ambient temperature	100	°C
Peak spectral response	0·8	µm

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no cell exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must also be taken into account.

Reverse voltage V_R	1·0	V
Forward current I_F	10	mA
Storage temperature		
Maximum	100	°C
Minimum	−20	°C
Maximum ambient temperature	100	°C

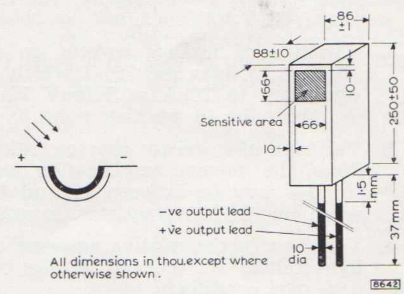
CHARACTERISTICS (measured at T_{amb} = 25°C and using a lamp of colour temperature 2700°K)

	Min.	*Typ.*	*Max.*	
Short-circuit current at 2000 lux	15	32	50	µA
Dark reverse current I_R (V_R = 1V)	—	0·35	10	µA

INFORMATION FOR CIRCUIT DESIGN

Sensitive area		
1·68 × 1·68mm	43·5 × 10^{-4}	in^2
Peak spectral response	0·8	µm
Short-circuit current at 10,000 lux	160	µA
Dark reverse current I_R (V_R = 1·0V, T_{amb} = 75°C)	<30	µA
Capacitance (V_R = 0)	<1000	pF

OUTLINES AND DIMENSIONS



OPERATING NOTES

1. The cell may be soldered directly into a circuit but heat conducted to the junction should be kept to a minimum by use of a thermal shunt.
2. Care should be taken not to bend the leads nearer than 1·5mm to the seal.

MULLARD SILICON RECTIFIER DIODES

(Maximum Ratings)

The two new silicon rectifier diodes OA605 and OA610, recently announced in Outlook Vol. 6 No. 4 complete the range of Mullard low current, medium power silicon rectifiers. This range of diodes was previously supplied with a mounting stud following the SO-17 outlines but is now supplied with flying lead terminations only, as shown in Fig. 1.

The preferred types for entertainment applications are the OA210 in voltage doubler service and the BY100 for conventional full-wave circuits and input voltages up to 250V r.m.s.

Type Number	*Peak Inverse Voltage* (V)	*Peak Forward Current* φ (A)	*Forward Current* * (A)	*Ambient Temperature* (°C)	*Storage Temperature* (°C)	*Filter Input Capacitor* (μF)	*Minimum Surge Limiting Resistance*** (Ω)
OA605	50	5	0.5	70	150	200	4
OA610	100	5	0.5	70	150	200	4
OA620	200	5	0.5	70	150	200	4
OA630	300	5	0.5	70	150	200	4
OA210	400	5	0.5	70	150	200	4
OA650	500	5	0.5	70	150	200	5
OA660	600	5	0.5	70	150	200	5
OA670	700	5	0.5	70	150	200	5
BY100	800	5	0.45	70	150	200	6

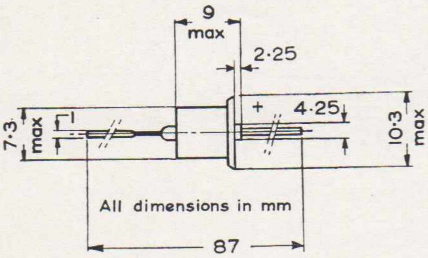


Fig. 1.

φ Capacitive and/or inductive load.

* DC component or 50 msec average.

** When minimum value of surge limiting resistance is used, the appropriate data sheets (Mullard Technical Handbook, Vol. 4) should be consulted to ensure operation within ratings.

Minimum Surge Limiting Resistance $= R_{SEC} + n^2R_{PRI} + R_{ADD}$.

where R_{SEC} = transformer secondary winding resistance.

R_{PRI} = transformer primary winding resistance.

n = transformer turns ratio.

R_{ADD} = additional resistance in circuit (if any).

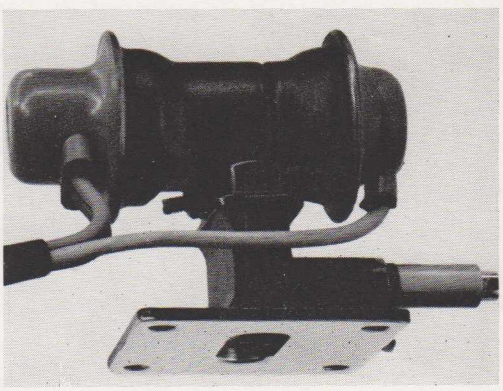
LIGHTWEIGHT X-BAND KLYSTRON TYPE YK1040

Rugged construction and a weight of only four ounces (113g) make this new X-band klystron particularly suitable for use in airborne equipments operating at frequencies between 9·0 and 9·6 Gc/s. Coupled cavity tuning is incorporated.

Under typical operating conditions with a resonator voltage of 300V, the minimum output power is 35mW, whilst at the minimum resonator voltage of 275V, power output is 25mW. Temperature coefficient is —100kc/s per °C.

The heater is rated at 6·3V, 0·6A; warm-up time is 30 sec.

Features of the YK1040 are its very small frequency drift during initial warm-up (3 Mc/s after five minutes operation) and a negligible variation in frequency of only 1 Mc/s with changing atmospheric pressures equivalent to altitudes ranging from 0 to 30,000 ft.



Klystron Type YK1040

Overall dimensions are 1·64 in x 2·6 in x 1·26 in. Connections are via 6″ flying leads.

INFRA-RED PHOTOCELL TYPE RPY24

This uncooled lead sulphide photoconductive cell is primarily intended for use in combustion safeguard equipment for gas-fired boilers. This cell is sensitive over a range extending from the visible to 2·7μm, peak spectral response occurring at 2·3μm.

ABRIDGED PRELIMINARY DATA

Resistance range	60 to 260	kΩ
*Signal-to-noise	>20 : 1	
*Signal	40	μV
Operating temperature	—20 to +50	°C
Overall dimension (excluding pins)		
height	10	mm
diameter	11	mm
Base	2-pin plug in	

* Referred to black body radiation at 200°C with 4·9μW of radiation falling on the cell.

MULLARD TV TUBE INTERCHANGEABILITY LIST

A new and revised edition of the Mullard Television Tube Interchangeability List, containing the latest released types, is now available. To obtain your copy, please send a stamped, self-addressed, foolscap envelope endorsed "TV TUBES".

MULLARD RELEASE NEW AUDIO POWER TRANSISTOR – AD140

The latest addition to the Mullard preferred range of transistors is the AD140. This audio power transistor is of the germanium junction p-n-p alloy type and is intended for use in the output stages of receivers and amplifiers operating from either battery or AC mains.

The AD140 power transistor supersedes the OC26 and should be considered for new equipment design. It is mounted in a TO-3 metal envelope identical to the OC26. Matched pairs (2-AD140) are available for Class 'B' push-pull output stages.

The data tabulated below is abridged, preliminary data only and more detailed information may be obtained from the Mullard Technical Handbook, Volume 4.

QUICK REFERENCE DATA

Germanium junction, power transistor of the p-n-p alloy type. Intended for use as an amplifier in the output stages of receivers and amplifiers operating from either battery or AC mains.

V_{CB} max. ($I_E = 0$mA)	–55	V
V_{CE} max. ($I_E = 0.5$A)	–55	V
V_{CE} max. ($I_E = 3.0$A)	–40	V
h_{FEL} ($I_C = 1.0$A)	30–100	

ABSOLUTE MAXIMUM RATINGS

The equipment designer must ensure that no transistor exceeds these ratings. In arriving at the actual operating conditions, variations in supply voltages, component tolerances and ambient temperature must be taken into account.

Collector voltage		
V_{CB} max. ($I_E = 0$)	–55	V
V_{CE} max. ($I_C = 0.5$A, $+V_{BE} = 2$V)	–55	V
V_{CE} max. ($I_C = 3.0$A, $+V_{BE} = 2$V)	–40	V
Collector current		
I_{CM} max.	3.0	A
*$I_{C(AV)}$ max.	3.0	A
Emitter current		
I_{EM} max.	3.5	A
*$I_{E(AV)}$ max.	3.5	A
Reverse emitter-base voltage		
V_{EBM} max.	–10	V
*$V_{EB(AV)}$ max.	–10	V
Base current		
I_{BM} max.	500	mA
*$I_{B(AV)}$ max.	500	mA

*Averaged over any 20ms period.

Total dissipation		
At $T_{case} \leqslant 37.5$°C	35	W
At $T_{case} \geqslant 37.5$°C		

$$\left(P_{tot} \text{ max.} = \frac{T_j \text{ max.} - T_{case}}{\theta_{j\text{-}case}} \right)$$

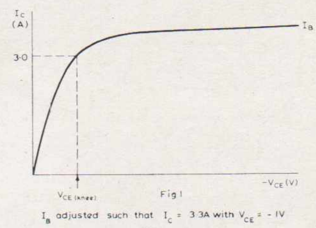
Temperature ratings		
T_{stg} max.	+75	°C
T_{stg} min.	–55	°C
T_j max. (continuous operation)	90	°C
†T_j max. (intermittent operation total duration 200 hours)	100	°C
$\theta_{j\text{-}case}$	< 1.5	°C/W

Likelihood of full performance of a circuit at this temperature is also dependent on the type of application.

CHARACTERISTICS at $T_{case} = 25$°C

Typical production spread

	Min.	Typ.	Max.	
Common base				
Collector leakage current I_{CBO}				
($V_{CB} = -500$mV, $I_E = 0$mA)	—	—	100	µA
($V_{CB} = -14$V, $I_E = 0$mA, $T_j = 100$°C)	—	—	10	mA
Common emitter				
Base input voltage V_{BE}				
($V_{CE} = -14$V, $I_C = 30$mA)	–100	—	—	mV
($V_{CB} = 0$V, $I_C = 1$A)	—	—	–750	mV
($V_{CB} = 0$V, $I_C = 3$A)	—	—	–1.2	V
Collector knee voltage V_{CE}(knee) (See Fig. 1)	—	–400	–800	mV



LARGE SIGNAL CHARACTERISTICS

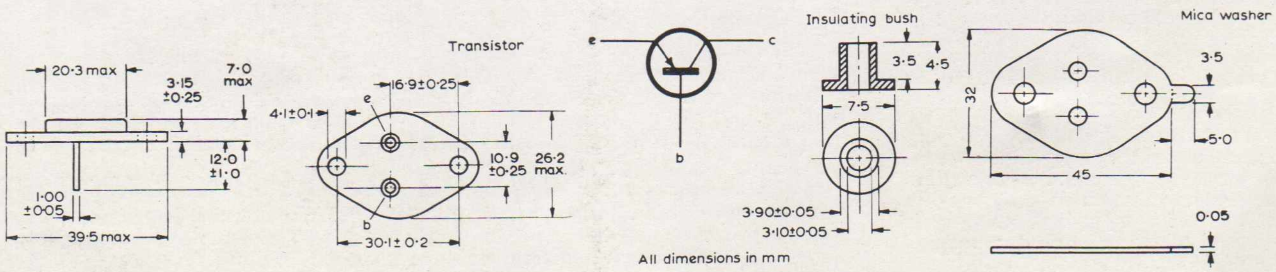
	Min.	Typ.	Max.	
Current amplification factor $h_{FEL} = \dfrac{I_C - I_{CBO}}{I_B + I_{CBO}}$				
($V_{CE} = -1$V, $I_C = 1$A)	30	—	100	
$\dfrac{h_{FE} \text{ at } I_C = 1.0\text{A}, V_{CB} = 0\text{V}}{h_{FE} \text{ at } I_C = 100\text{mA}, V_{CB} = -14\text{V}}$	0.5	—	—	
f_{hfe}	3.0	4.5	—	kc/s

CHARACTERISTICS OF MATCHED PAIR

(measured at $T_{case} = 25$°C)

Ratio of the current amplification factor of 2-AD140 at $I_C = 3$A — 1.25:1

OUTLINES AND DIMENSIONS



DESIGN FOR AN ELECTRONIC TACHOMETER

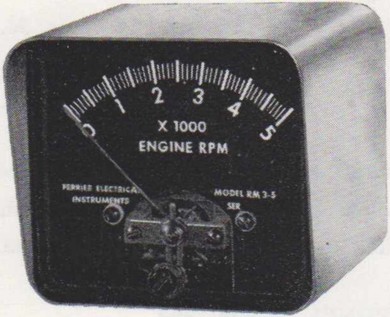


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TABLE OF CONTENTS — VOL. 6, 1963