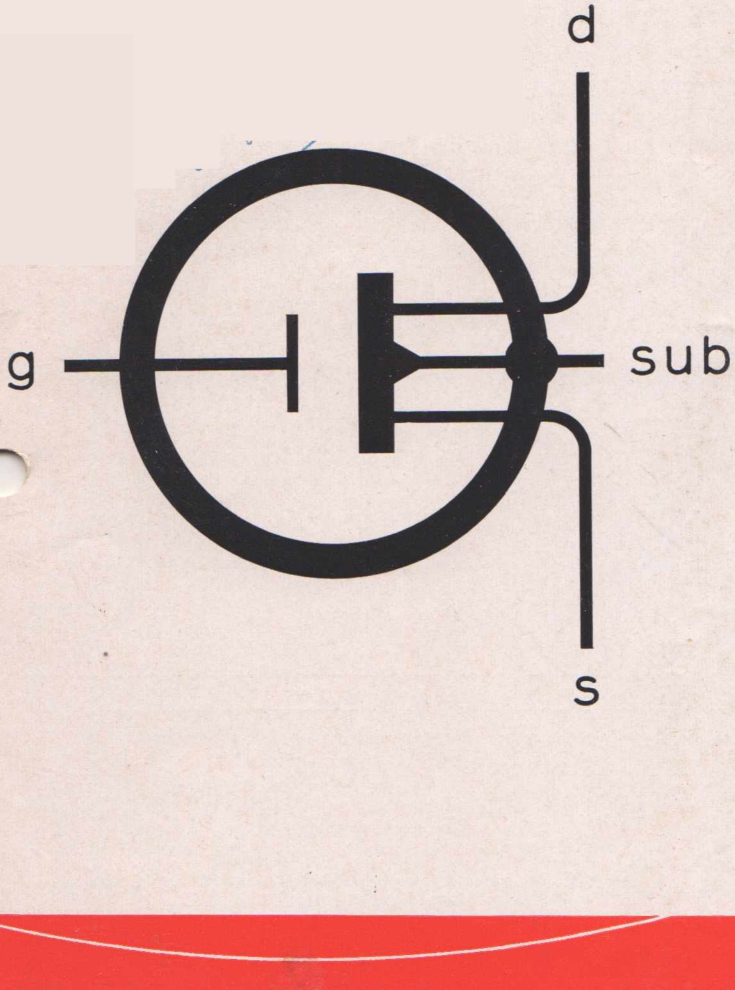
Mullard Outlook

AUSTRALIAN EDITION



THE MOST

JANUARY, FEBRUARY, 1965
VOL. 8, No. 1

MULLARD-AUSTRALIA PTY. LTD.

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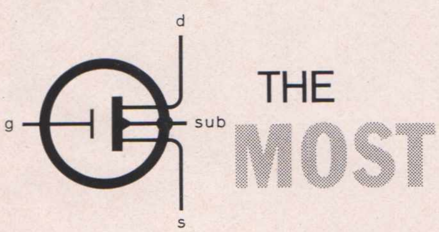

The M.O.S.T. (metal-oxide-silicon-transistor) has an input resistance of one million megohms (10^{12})*—far higher than that of conventional transistors or even of field effect transistors.*
A description and preliminary data may be found on page 9.

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THE DUNROSSIL MEMORIAL LECTURE

The Council of the Institution of Radio and Electronics Engineers Australia must be highly commended for their mature thought and inspiration in establishing a Memorial Lecture to honour a previous Patron and Governor-General of the Commonwealth of Australia, the late Viscount Dunrossil.

In addition, they must be commended for their decision to invite His Royal Highness the Duke of Edinburgh to deliver the inaugural Dunrossil Memorial Lecture.

By graciously accepting the invitation, His Royal Highness not only honours the late Viscount Dunrossil but also the Institution and, in fact, all learned institutions in Australia and assures the dignity, the success and the contribution that will be made through the years by future Dunrossil Memorial lecturers.

M.A.B.

VIEWPOINT WITH MULLARD

GENERAL MANAGER RETURNS FROM OVERSEAS

Mullard General Manager, Mr. M. A. Brown, has recently returned from a visit to the Far East, Europe, United States and Canada and we are pleased to present on this page a few impressions that may be of interest to Outlook readers.

Tribute to Retiring Managing Director

Whilst in London in November, Mr. Brown attended the unveiling of a portrait of retiring Mullard Limited Managing Director, S. S. Eriks, K.B.E., who so ably guided the development of the Company over the past 34 years (*see Outlook, Volume 4, Number 5, Ed.*). The ceremony took place in the Mullard Limited, Board Room at Mullard House and was performed by Captain Stanley R. Mullard, Chairman and founder of the Company. Mr. Eriks' successor as Managing Director is Dr. F. E. Jones.

New Developments

In the light of his recent visit and in dealing with new developments and trends, Mr. Brown feels that one must first look at countries, their economy, people and their skills and the degree of employment, for technological advancement suggests a pattern relative to a country's ability, its resources and, in some to a major degree, to the by-products of government expenditure, particularly by defence electronics development and research.

Influence of Labour Force

Mr. Brown goes on to comment that all over Europe there is an extreme shortage of skilled, semi-skilled and process labour which has created a climate for the ready acceptance of automation and its associated electronic control equipment and, whilst this situation exists in some measure in the United States, the emphasis there is towards lower cost of production in view of the higher labour rates compared to other countries. Somewhat different motives, but encouraging similar aids to manufacture.

Relative to Australia, Mr. Brown feels it is self-evident that we could benefit from these moves—and need to if we are truly mindful of the export markets where we could operate and if we are realistic about the level of tariff protection on the home market. Rising labour costs in Australia, the short working day and week, the clamour for more and more holidays, only emphasise the need for investment in labour saving production aids and the products being specially designed to take full advantage of low cost production methods.

Many Specialised Companies

He said "It was stimulating to see the enterprise or many small and key groups specialising in industrial control for a particular industry, even portions of a particular industry and their marrying together of many process control facilities with the fullest scope and ingenuity. More important, these companies are profitable and seem to remain that way provided the original proprietors remain actively in their businesses and it does not grow to be unwieldy."

A Piece of String

Mr. Brown stresses that one must come to grips with the basic necessities relative to costs and time and he had many cases illustrated to him where the over-enthusiastic electro-mechanical fellows spent many hours of effort and money in endeavouring to arrive at an electro-mechanical solution when the process could be faster, cheaper and more adequately handled by a jet of compressed air or by the inclusion of a rubber band or a piece of string!

New Fields

He points out that it is equally apparent that some of the "volume production" industries, such as the automobile industry, where the electronic engineers have developed first-rate electronics systems for auto-ignition and fuel atomisation—the former with semiconductors and the newer ferrites and the latter by ultrasonics—it has been shown that the existing methods are cheap, efficient and reliable. A philosophical view is being taken that it is perhaps a shame to spoil something already sound and proven! On the other hand, alternators in lieu of DC generators in automobiles show a major advantage and it is inevitable, he feels, that all automobiles will have AC systems in the immediate future.

Low Cost Fractional Horse Power Motors

It was interesting to see in the United States the extent to which the basic cost of an item is being analysed and the cost of copper and assembly time of wound fields is saved by applying semiconductors. For example, it was found in some cases to be cheaper to manufacture a small motor by using permanent magnet fields, having these die-cast into the housing and employing a silicon rectifier to provide the DC source from the mains. Here indeed they seem to be "splitting hairs" on basic costs but Mr. Brown feels it only illustrates the basic design of a product to reduce the assembly labour content. Analogous to this is the need for good physical and aesthetic design and the encouragement given to it on a national basis by the governments of most countries.

Television

For black and white television, he believes this to have arrived at a level of compromise on picture size and cost, with valves still holding their own. In regard to picture tube size, 23″ seems to be the ultimate for the Number One receiver. In the United States, more than half the black and white receivers are 19″ and Mr. Brown suggests that cost and bulk would perhaps limit the acceptance of 25″ to higher priced receivers. In regard to techniques, the metal-rimmed "P" type tubes are rapidly being accepted on a world basis for all picture tube sizes. He feels that thin film techniques may encourage the use of modular construction and, inevitably, wider use of semiconductors, particularly in countries where high production volume exists. The reliability of components, including valves, on a cost basis, did not encourage semiconductors at

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Captain Stanley R. Mullard and Mr. M. A. Brown with the portrait of the retired Mullard Limited Managing Director, S. S. Eriks, K.B.E.

GENERAL MANAGER RETURNS FROM OVERSEAS

this time, except perhaps in small television receivers where heat is a problem. He feels, too, that we must be mindful in Australia, where we see semiconductors being employed in the front end of television receivers both in the U.K. and in Europe, that this is dictated to some degree by the favourable noise parameters of semiconductors at UHF. As we are only interested in VHF in Australia, it is sensible that valves be fully exploited rather than that we endeavour to employ semiconductors with all the attendant complications of cross-modulation, AGC and so on.

Colour Television

As many visitors to the United States and Europe have seen either the conventional NSTC colour programmes or colour under laboratory conditions, there is not much to be discussed except to emphasise that good colour reception and reproduction is outstanding, although one can accept poor black and white more comfortably than poor colour. Mr. Brown feels it is a pity there has been so much indecision regarding IEC colour standards and, whilst it is somewhat *sub-judice* at this time, he senses a feeling that a decision will be arrived at this year—even if it were "agreed to disagree" —and that colour will obtain a real boost from the European approach. He anticipates the enthusiasm of Australians to have what the other fellow has, could well result in the introduction of colour television to Australia in 1969, or maybe earlier.

Radio and Tape Recorders

He said that radio is enjoying a strong acceptance now that AM and FM sound broadcasters have settled down to living with television. The emphasis on daytime listening encouraging auto radio and portables and a continuing strong market for gramophone record reproduction; and that VHF, FM and stereo broadcasting for the music lover in the thickly populated areas is now strongly established, the receivers being produced at a relatively low cost. The strong penetration of domestic tape recorders in Europe relative to the United States was of interest—due perhaps to a different living approach?

In the British Crown Colony of Hong Kong, there is developing a strong entertainment electronics industry, competing most favourably with the adjacent production centres of Japan and Taiwan and Mr. Brown thinks it is inevitable that Hong Kong will extend its export market to Australia, where previously it has been limited almost solely to the United States and the United Kingdom. It is evident also in these areas that manufacturers are not particularly happy with their profit margin on the small, hand portable receivers and they look upon these more as a necessity, but are concentrating their efforts on the larger receivers with higher unit cost which will, in turn further challenge Australian manufacturers already affected by imports from Japan.

Mullard Applications Laboratories

Well-known for their applications engineering service, and no less here in Australia, Mr. Brown visited Mullard Applications Engineering Laboratories in the United Kingdom and the laboratories of associated companies in Canada and the United States. He emphasises that the interchange of information from each of the laboratories is of great benefit to the personnel concerned but more importantly, to our customers in many parts of the world.

"Looking to the future", Mr. Brown said, "Australian manufacturers will have a full colour TV engineering applications service on which to draw."

Servicing

The self-evident, the success of well-run facilities, also wholesalers and jobbers offering the widest range of components, were a highlight in the maintenance market, some wholesalers specialising solely in small shelf appliances—and with great success—and others, mindful of the industrial potential, by selling industrial valves, semiconductors and associated components.

Small Shelf Appliances

He observed that retailers everywhere are enjoying a steady turnover from small shelf appliances, in particular items such as shavers, hair dryers, power-driven meat carving knives, can openers, home intercommunication systems and so on, as well as irons, toasters, kettles, etc., with a strong replacement demand.

Youth Training

"The Mullard Company is making its contribution in many fields," he said, "not the least of these being technical education and November, 1964 was the 10th Anniversary of the Mullard Education Service, marked by an Exhibition at Mullard House, opened by Lord Bowden, Minister of State Department of Education and Science."*

Thin Film and Microminiaturisation Techniques

As a valve, electron tube and semiconductor principal, it is logical that Mullard is strongly engaged in the thin film and integrated circuit area and, whilst thin film circuits are offered now in Australia as well as the United Kingdom, the field for microminiature integrated circuits is somewhat limited in Australia. Elsewhere, these can be ancillary to other devices, such as computer memory storage packages for computer manufacturers—a field where Mullard, U.K. is most active. Nevertheless, the development continues apace and may ultimately change the existing concept of less sophisticated electronic units such as radio and television receivers, an exciting prospect for the future.

The Local Industry and the Market Place

"Many travellers returning from overseas proclaim the virtues of Australian industry and, whilst this harping becomes trying, I feel we can be justly proud of our particular industry as it is developing," Mr. Brown said. "We must hope that in the domestic field there will be more real selling rather than the employment of fine merchandise purely as a vehicle to loan money. Equally, we must go out into the market place to develop a sound export business."■

The Semiconductor Measurement and Applications Laboratory, Mullard Semiconductor Plant, Southampton, England.

* *More than 8000 teachers and lecturers in Britain and the Commonwealth now make use of the facilities of this service. Space does not allow a full report on this Exhibition; however, it will appear in the next issue of Outlook. A similar Educational Service is operated by Mullard-Australia.*

Editor.

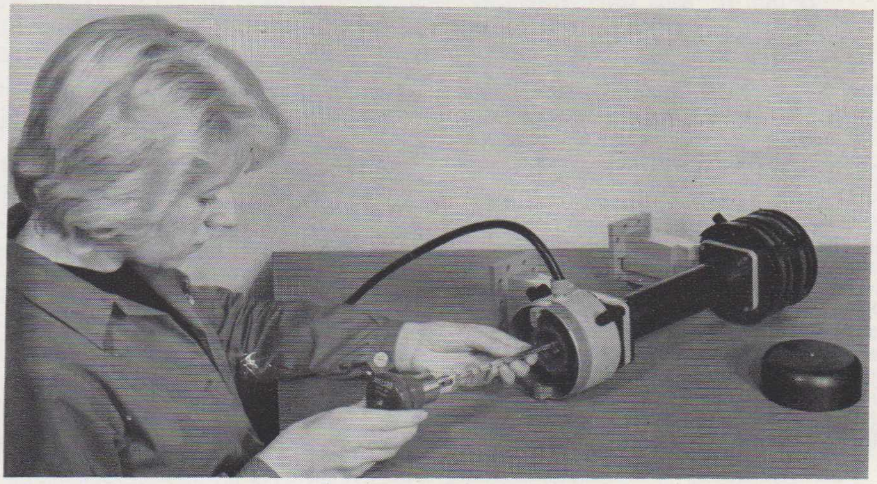
NEW HIGH POWER TRAVELLING WAVE TUBE

One of the most advanced travelling wave tubes yet offered to the field of microwave telecommunications is the new LB4-20. It will supply a saturated output power of 20W, which is an increase of 100% over previous types designed specifically for telecommunications.

With a gain of 40dB and a frequency range of 3·7 to 4·2Gc/s, either a wider spectrum providing for more channels, or an increased distance from link to link, is now possible with no increase in distortion.

The tube, which is contained in mount type P4L-5, is of unpackaged construction; this means that a replacement tube can be fitted, using the existing mount, with only simple realignment of the mount being necessary. The focusing controls have been brought out to the front end of the mount to facilitate alignment. Positive location of the tube is by a special valve base which eliminates the need for a bulky cable harness.

Travelling wave tube LB6-20 has been developed as a complement to the LB4-20 and also gives a saturated output power of 20W, but operates over the frequency range 5·9 to 6·5 Gc/s with a gain of 37dB. Despite this high power output, the noise level of the LB6-20 is extremely low.■



Operator mounting High Power Travelling Wave Tube type LB4-20 into mount type P4L-5.

ENCAPSULATED MODULE FOR THYRISTOR CONTROL

The thyristor drive module MY5000 is designed to simplify the use of thyristors in a wide range of ordinary electrical applications. This is the first module of a range and will drive up to two 70A, high current thyristors at the same time; for example, as two legs of a single-phase bridge circuit.

The MY5000 compared to a rule with a scale of 1/16".

Although more complicated drive modules are necessary for sophisticated high accuracy motor speed control with complex feedback loops, this low cost module will provide a most satisfactory economic solution for most applications of motor speed control, furnace control, light dimming and also the control of AC power by a back-to-back thyristor arrangement.

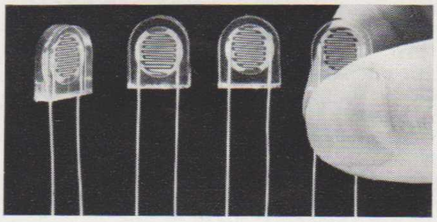
One of the problems in the application of the thyristor, is the provision of reliable drive pulses which will satisfactorily fire the thyristors and also control the position of the pulse by means of a control element or feedback loop. Each application naturally requires its own feedback loop arrangement.

The trigger module MY5000 is completely protected against environmental effects by plastic encapsulation, a feature which protects circuit components and interconnections from damage by mechanical vibration or shock.■

NEW MULLARD LIGHT-DEPENDENT RESISTOR

A new, inexpensive light-dependent resistor RPY30 has been added to the Mullard range of photoconductive devices. It will reduce the cost of card and paper-tape readers for computers, signalling systems, train indicator boards and other photoconductive applications where it is advantageous to use a light source to trigger an electric circuit. As the resistors have a relatively fast recovery rate, they can also be used in moving displays such as animated-strip, news and advertising signs, with moving punched paper-tape or film placed between the light source and the resistors.

In harbour signalling systems, for example, a number of light-dependent resistors would be connected so that they switch on the signal lamps whenever they are illuminated by light passing through holes punched in a card. The pattern of the holes corresponds to the configuration of lamps to be lit. By maintaining a stock of cards, each punched with a different configuration, a rapid change of signalling lamp codes may be effected.

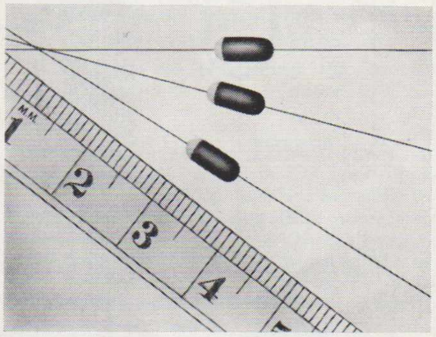


Light-dependent resistors, type RPY30.

RPY30 is, in effect, a small photoconductive cadmium sulphide cell housed in a robust clear-plastic encapsulation measuring 10·8mm x 12·2mm x 3·6mm. The dark resistance is 10MΩ and the light resistance at 1000 lux is between 75Ω minimum and 300Ω maximum. The maximum applied voltage is 150V and the continuous power dissipation 200mW. The RPY30 may be used at ambient temperatures ranging from −30°C to +60°C.■

NEW ENCAPSULATED GENERAL PURPOSE RECTIFIERS

Pursuing the trend towards inexpensive encapsulation for semiconductor devices, a plastic encapsulated silicon rectifier type BYX10 for general purpose use, is now included in the Mullard range. The hard plastic encapsulation is so successful that it readily fulfils the stringent requirements of the accelerated damp heat tests recommended by the I.E.C.



General purpose silicon rectifiers, type BYX10.

Designed to operate with an average forward operating current up to 200mA, the BYX10 will withstand a repetitive peak reverse voltage of up to 1·6kV and momentary "switching on" surge currents of up to 15A—both very important properties for an item which may be used in heavily inductive circuits.

Used in a single-phase half-wave circuit with resistive load, the rectifier can supply 200mA at 250V. These figures can be doubled to 400mA at 500V by using four rectifiers in a single-phase full-wave bridge circuit.

The wide range of possible applications include; power supplies for transistor and valve instrumentation, rectifiers for DC-DC low power converters, logic elements in electro-mechanical systems and blocking diodes in mains safety circuits.■

VARIABLE POWER SUPPLY FOR SERVICE

In Outlook, Volume 7, Number 2, page 19, a "Stabilised Transistor Power Supply Unit" was discussed. The unit featured a dual output for flexibility in the laboratory rather than for service. The unit discussed here is the second in a series to be published in Outlook and its most important feature is that it "fails safe" when short-circuited. This is achieved by absorbing in a resistor the excess short-circuit current. With a voltage rating of 0 to 15V and a current rating of 500mA, this supply will be usable with the majority of transistor equipment normally encountered by the serviceman.

The circuit shown in the diagram was developed to replace the dry batteries normally needed when a variety of transistor circuits requiring different voltages is handled in a workshop. The output of the supply is adjustable from 0 to 15V at 0·5A, thus covering the majority of transistor circuit requirements. With an output resistance of about 0·4Ω, this supply has an adequate performance for most applications; hence a current increase of 0·5A causes a voltage decrease of only 0·2V. The supply can be continuously adjusted to any voltage within its range and is not damaged by an accidental short-circuit provided that one of the approved transformers, shown below, is used.

Circuit Description

The voltage across the centre-tapped secondary winding of the transformer is rectified to give two supply lines. Full-wave rectification by D_1 and D_2 gives a high-current source that is positive in respect to the centre tapping and is used to supply the output current of the unit. Full-wave rectification by D_3 and D_4 gives a low-current source which is negative with respect to the centre-tapping; this is an auxiliary supply that feeds only the reference voltage circuit. The negative supply, smoothed by C_3, R_3 and C_4 provides a voltage which is stabilised by the zener diodes D_5 and D_6. The control potentiometer R_8 which provides a continuously variable voltage to the base of TR_2 is connected in parallel with zener diodes D_5 and D_6. Since the current requirement is less than 50mA, the OA91 diodes are suitable. The resistor R_2 is included to limit the peak current through D_3 and D_4, particularly during the switch-on period.

Protection

If the output terminals become short-circuited, transistor TR_1 bottoms; that is, the collector-to-emitter voltage becomes very small and the emitter current tends to become much larger than required for normal transistor action. The short-circuit current, however, is limited to a safe value, just over 2A, by resistor R_1 which, therefore,

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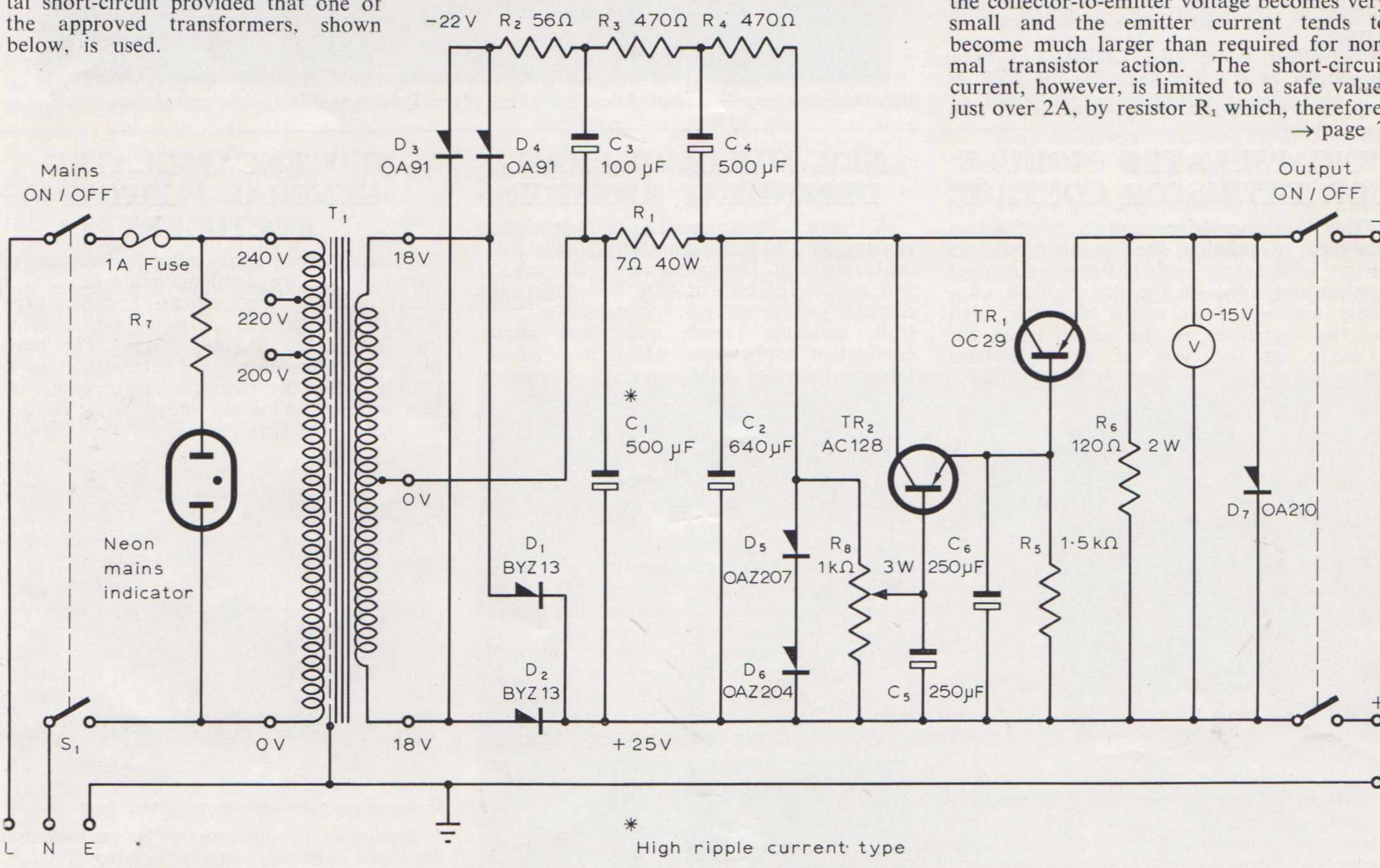


COMPONENTS PARTS LIST

Resistors

R_1 •	7 Ω	10%	40 W
R_2	56 Ω	10%	½ W
R_3	470 Ω	10%	2 W
R_4	470 Ω	10%	2 W
R_5	1·5 kΩ	10%	½ W
R_6	120 Ω	10%	2 W
R_7 ▲	270 kΩ	10%	¼ W
R_8 (pot.)	1 kΩ	10%	3 W

• *Standard Resistor Co., 296a Willoughby Road, Naremburn, N.S.W.*

▲ *This value will depend on the particular neon indicator used.*

Capacitors

C_1	1000 μF	Electrolytic	50 V
C_2	500 μF	Electrolytic	40 V
C_3	100 μF	Electrolytic	64 V
C_4	500 μF	Electrolytic	25 V
C_5	250 μF	Electrolytic	25 V
C_6	250 μF	Electrolytic	25 V

Transistors

TR_1	Mullard	AC125
TR_2	Mullard	OC29

Miscellaneous

Miniature Neon Indicator (see also R_7)

Voltmeter 0 to 15 V

Diodes

D_1	Mullard	BYZ13-OA31
D_2	Mullard	BYZ13-OA31
D_3	Mullard	OA91
D_4	Mullard	OA91
D_5	Mullard	OAZ207
D_6	Mullard	OAZ204
D_7	Mullard	OA210

Mains Transformer

Primary Winding	0, 200, 220, 240V
Secondary Winding	18-0-18V at 2·5A
Special Transformers	*Type ST2791*
Ferguson Transformers	*Type PF2344*
A & R Transformers	*Type PT5526*
Trimax Transformers	*Type TP5045*

NEW MULLARD FILMS

Two new 16mm films will shortly be available from the Mullard Film Library.

The first film, "Electromagnetic Waves", is in two parts—Part 1 deals with the discovery and generation of electromagnetic waves (running time 19 minutes) and Part 2 covers the properties and behaviour of electromagnetic waves (running time 21 minutes). The film was produced by Mullard in conjunction with the Educational Foundation for Visual Aids and Part 2 has won a bronze award at the IX Rassegna Internazionale del Film Scientifico—Didattico (9th International Exhibition of Scientific Teaching Films). This exhibition is one of the leading scientific film festivals and attracts entries from all over the world. It is organised by the University of Padua, Italy, in conjunction with the Venice Film Festival.

"Thin Film Microcircuits" is the title of the other new Mullard film which is in colour and has a running time of 15 minutes.

In the opening scenes of this film the launching of a satellite emphasises the need for small light-weight electronic components which must be of the utmost reliability. As an example, part of the telemetry equipment for use in the third stage of the ELDO rocket is then shown. Although no bigger than a cigar box it contains over 2000 resistors and capacitors, as well as 500 transistors and diodes.

The film then goes on to describe the manufacture of thin-film microcircuits from the design stage to the finished product. Final testing and evaluation are shown and further scenes illustrate the severe environmental tests which are performed, including vibration and humidity tests.

Finally, some other applications of thin-film microcircuits are shown including an IF amplifier, an attenuator, a flow meter and a miniature computer for rocket guidance systems.

"Thin Film Microcircuits" and "Electromagnetic Waves" will be available for loan on application to the Mullard Film Library after March, 1965.■

UHF QUICK HEATING DOUBLE TETRODE

The latest addition to the Mullard range of quick-heating valves is the YL1190 UHF double tetrode which heats from cold to give 70% output in less than 0·5 sec. with a 1·1V, 3·8A filament.

This type of valve is of considerable advantage in mobile applications where immediate operation after 'switch-on' is required and consumption must be kept to a minimum.

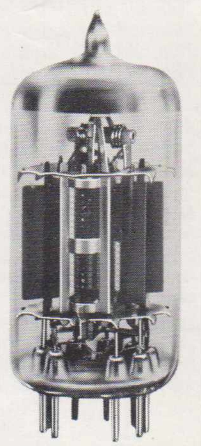
Designed for use in mobile transmitter output and frequency multiplier stages, the YL1190 is capable of operating efficiently up to a frequency of 500Mc/s. The output power is 33W at 200Mc/s and 20·5W at 500Mc/s.

This double tetrode is of single-ended construction, thus simplifying circuit design.

With the YL1190 available in development sample quantities, Mullard are now able to supply valves for all applications in VHF and UHF mobile transmitters.

These quick-heating valves virtually eliminate current consumption during standby periods. Other advantages include much greater valve life and large reductions in heat dissipation within the unit—the latter being of great importance when transistors are used elsewhere on the chassis.

Outlook Volume 6, Number 2, page 36, featured the range to which the YL1190 belongs.■



The Mullard UHF Quick Heating Double Tetrode YL1190.

120mA/V INDUSTRIAL TETRODE

A new industrial high slope tetrode, QV08-200, recently introduced to the Mullard range, has a mutual conductance of 120mA/V. This high value of Gm ensures that the valve will operate effectively at low drive powers. Applications of the QV08-200 include ultrasonics and audio service, shunt and series stabilisers and SSB transmitters.

The QV08-200 has been specially designed to produce the maximum possible power gain so that it may be driven, if required, by transistor circuits. The anode has been designed to withstand intermittent operation at a peak emitted power of 1370W and continuous operation at 400W. The valve produces this high output at a relatively low anode potential—600V instead of the more usual 2kV supply. The low anode voltage enables considerable reductions in cost to be made in the power supply unit since the ratings of components such as smoothing capacitors are lower.

Particular attention has been paid to the demands placed on this type of valve in service. The 'knee' of the Ia/Va curve, for example, is positioned carefully so that an anode current of 3A is obtained with an anode voltage of 90V. A high anode current is possible without making the control grid positive, a vital characteristic for series stabilisers and linear applications.■

MAILING LIST

If you change your location, don't forget to let us know in good time, otherwise your Outlook may reach you late or never. And please, when you change, quote both your old and your new address. We can then be sure of destroying the obsolete mailing plate.

← from page 6

protects TR_1. R_1, in conjunction with C_1, also provides a degree of smoothing of the high current supply. The ripple current through C_1 will be approximately 2A when a short-circuit occurs, therefore this electrolytic capacitor should be of the high-ripple type.

To obtain a low output impedance, the transistors TR_1 and TR_2 are connected in cascade as a compound emitter follower. Hence, the output voltage at the emitter of TR_1 closely follows that at the base of TR_1, which is obtained from the slider of the output voltage control potentiometer R_8. The voltage difference between the base of TR_2 and the emitter of TR_1 is the sum of the base-to-emitter voltages of the two transistors.

The capacitors C_5 and C_6 decouple the bases of TR_2 and TR_1 and reduce the ripple appearing at the output. With the values shown in the circuit, the output ripple voltage should be less than 1mV r.m.s. Resistor R_5 provides a path for the leakage current of TR_1 and resistor R_6 allows the output voltage to be reduced to zero. A diode D_7 is shown connected across the output to prevent damage which would be caused by connecting a reverse voltage to the output terminals. It may be omitted where this danger does not exist.

An output switch is included to permit the output voltage to be set up with the external circuit connected.

Heatsink Extrusions

At low output voltages the power dissipation of TR_1 approaches 10W; therefore, the transistor should be mounted on a substantial heatsink. In the prototype, a 6″ length of Mullard 35D heatsink extrusion (type 35D6CB) was used as a common heatsink for the two diodes as well as for the OC29 transistor. The heatsink is at a potential of +25V and was mounted insulated from the chassis. As the case of the OC29 is the collector connection, which is negative in respect to the heatsink, the transistor was mounted on the same heatsink by means of insulating bushes and a mica washer. When using a transistor with a mica washer, a smear of silicone grease should be used between the heatsink, the mica washer and the transistor, to ensure an adequate thermal bond.

If it is preferred, the diodes and the transistor may be mounted on separate extrusions with a 3″ length of Mullard heatsink (type 35D3CB) used for the diodes and a 4″ length of Mullard heatsink (type 35D4CB) for the transistor.

In the prototype, the heatsink dimensions were determined to allow for cool operation of the equipment and the heatsink was mounted in such a way that other heat-radiating components were physically as far away from the heatsink as possible. In layouts different from the prototype, other heatsink dimensions may be required and the reader is referred to the Mullard leaflet "Heatsinks for Transistors Diodes and Thyristors".*

Components

Resistor R_1 has a value of approximately 7Ω and dissipates nearly 40W when a short-circuit occurs. Such a resistor has been made available by the Standard Resistor Company (see Parts List). Other combinations of series and parallel resistance, giving the same total resistance and power dissipation may, of course, be used.

The circuit diagram shows a voltmeter connected across the output. For some service applications it may even be desirable to include a 0 to 500mA meter in series with the negative output of the regulated supply. These meters may be omitted and a multimeter could be used externally.■

* *This leaflet is obtainable from Mullard offices throughout the Commonwealth upon receipt of a stamped, self-addressed, foolscap envelope endorsed "Heatsinks".*

PHOTO-SENSITIVE RELAY
(with interlocking and reset facilities)

A light-sensitive relay in the form of an "Infra-Red Burglar Alarm" using the phototransistor OCP71, was featured in Outlook, Volume 5, Number 3, page 35. The unit described below may well serve for more sophisticated applications in industry. Whereas the peak spectral response of the OCP71 falls into the infra-red region (1·55μm), the maximum sensitivity of the ORP12 occurs at a wavelength of 0·67μm.

The circuit shown in the diagram is designed to operate relays when a beam of light is interrupted. The unit has many and varied uses; for example, if the light beam is interrupted by a machine tool operator, the relays can stop the machine and so prevent a possible accident; if the light beam is interrupted by a car, the relays can start the mechanism opening the garage doors. Other uses would include liquid level controls, edge-detection (in paper making, textiles and belting), burglar alarms and smoke detection.

Circuit Description

A beam of light is directed on to the Mullard photocell ORP12 so that it crosses the path of a possible intruder. When the beam of light is interrupted, the resistance of the photoconductive cell increases. Therefore, the base of TR_1, which is connected to the cell via D_1, becomes more negative. (The diode is included to prevent the base of TR_1 becoming more negative because of the current which would otherwise flow via R_7, R_8 and the photocell.)

Transistors TR_1 and TR_2 form a monostable stage which does not operate until the base of TR_1 attains a certain negative potential. When this happens, TR_1 conducts, relay RL_A operates and TR_2 is cut off by a signal fed via C_2. Relay RL_A remains energised with TR_1 conducting and TR_2 cut off until C_2 discharges and the potential at the base of TR_2 becomes sufficiently negative to allow TR_2 to conduct. A positive signal is then fed via R_7 to the base of TR_1. This transistor is thus cut off, and the circuit returns to its stable state.

By means of contacts on relay RL_A, an alarm may be given during the short period that TR_1 conducts. With the values shown in the circuit, this period will last only 2·5 seconds. The contacts on the relay could be used, of course, to energise another relay or circuit that could energise an alarm system and lock itself on. With the "Photo-Sensitive Relay", however, a continuous alarm is given by means of a relay in an Eccles-Jordan bistable circuit.

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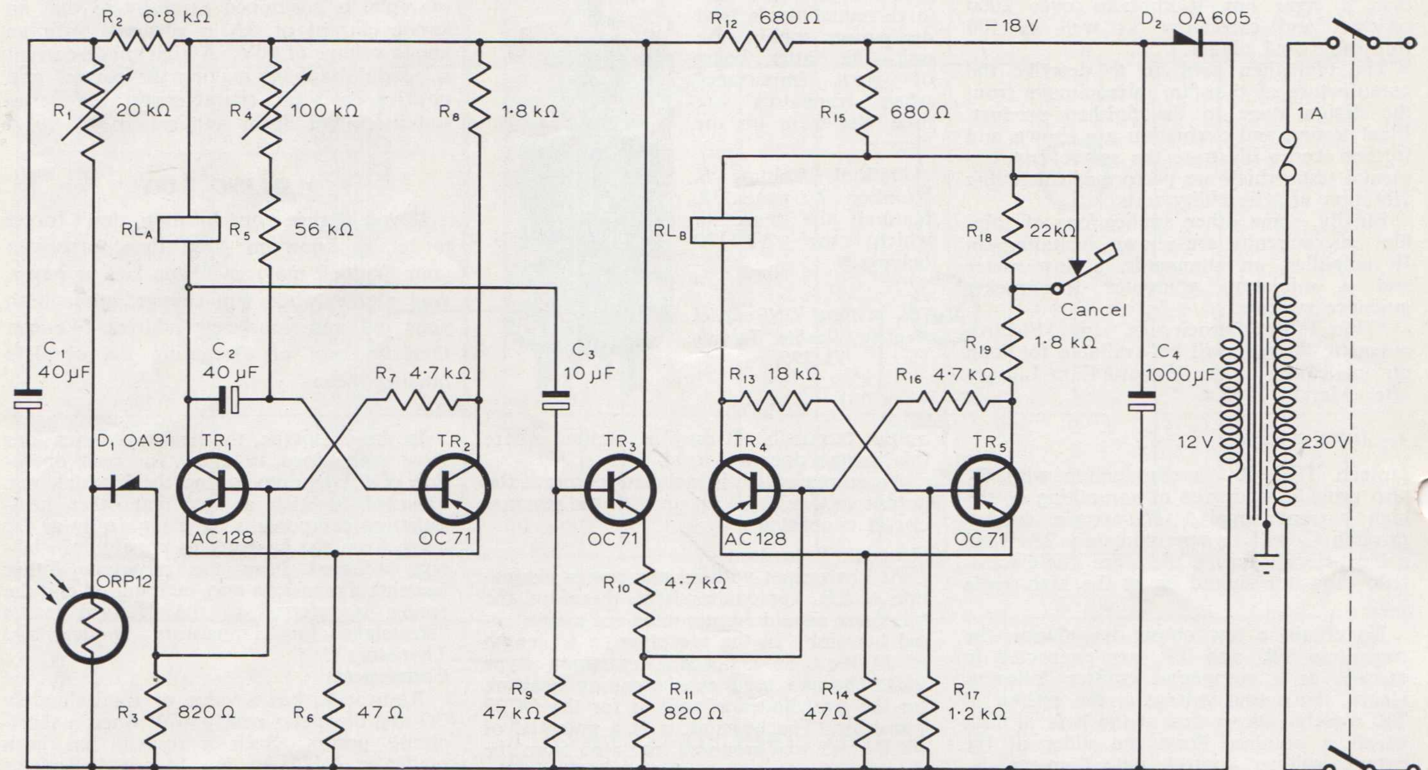

COMPONENTS PARTS LIST

Resistors

R_1	20	kΩ	lin. pot.
R_2	6·8	kΩ	
R_3	820	Ω	
R_4	100	kΩ	lin. pot.
R_5	56	kΩ	
R_6	47	Ω	
R_7	4·7	kΩ	
R_8	1·8	kΩ	
R_9	47	kΩ	
R_{10}	4·7	kΩ	
R_{11}	820	Ω	
R_{12}	680	Ω	
R_{13}	18	kΩ	
R_{14}	47	Ω	
R_{15}	680	Ω	
R_{16}	4·7	kΩ	
R_{17}	1·2	kΩ	
R_{18}	22	kΩ	
R_{19}	1·8	kΩ	

Capacitors

C_1	40	μF	16 V
C_2	40	μF	16 V
C_3	10	μF	16 V
C_4	1000	μF	25 V

Transistors

TR_1	Mullard AC128
TR_2	Mullard OC71
TR_3	Mullard OC71
TR_4	Mullard AC128
TR_5	Mullard OC71

Diodes

D_1	Mullard OA91
D_2	Mullard OA605

Photocell

Mullard ORP12

Relays (see text)

M.O.S.T.

(Metal-Oxide-Silicon-Transistor)

This article is an introduction to the M.O.S.T. type 95BFY—the latest device in the series of Mullard field-effect transistors. As the development of this new transistor is not complete, all its potentialities are not yet known and therefore the information in this article is intended only as a guide to the many applications of the 95BFY.

The 95BFY is an insulated-gate field-effect transistor, the insulation being achieved by means of a silicon dioxide dielectric. This new transistor is a majority carrier device and is well suited for use in amplifiers and impedance converters requiring a high input impedance. It has negligible transit time effects, unlike the more conventional transistors—hence its high-frequency performance is limited only by stray capacitances. The 95BFY has a fourth electrode and, because of this, it may be used as an oscillator-mixer, a variable gain amplifier and in other similar applications.

It is a unique four-terminal device with an input capacitance of 4pF, an input resistance approximately $10^{12}\Omega$ and a mutual conductance exceeding 1mA/V. Under certain operating conditions, it has voltage-current-characteristics that have a square law relationship. Therefore, the 95BFY can be used to construct RMS voltmeters and other devices requiring square law characteristics. It can also be used in modulation and detection circuits which are analogous to anode modulation and anode bend detection circuits.

The 95BFY is particularly suitable for use in chopper circuits because it has no "offset" voltage and negligible offset current. Early samples have been used quite successfully in switching circuits. Their characteristics are such that the switches are "on" when the controlling voltage is zero. In some applications, however, it is desirable that the switches should be "off" when the controlling voltage is zero; devices with the appropriate characteristics for these applications have been developed.

Operation

The 95BFY consists of two diffused super-rich n-regions (or n+ regions) on a p-type silicon substrate. The proposed symbols for the transistor and its electrodes are shown below. The n+ regions, which are known as the "source" and the "drain" are close together; on the substrate between them, a thin layer of silicon dioxide acts as a dielectric between the substrate and an aluminium electrode called the "gate".

When the gate is made positive with respect to the source, holes will be repelled from and electrons attracted to the surface of the substrate. Consequently, an n-type layer is formed in the substrate near the oxide dielectric; the greater the applied potential the thicker will be this inversion layer. The inversion layer forms a conducting path; therefore current will flow between the n+ regions if a potential is applied between the drain and the source. As it controls the thickness of the inversion layer, the gate voltage also controls the magnitude of the current.

With the substrate suitably doped, a transistor can be developed so that an inversion layer exists when the gate potential is zero. With this transistor, it is necessary to apply a negative voltage to the gate in order to remove the inversion layer and cut off the current. This voltage is known as the "pinch-off" voltage. It can be positive, negative or zero, depending on how the substrate is doped.

The source and drain form p-n junctions with the substrate, one of which must be reverse biased and, hence, the source-to-drain cut-off current is of the same order as the collector-to-base leakage current in a conventional silicon planar transistor. The gate is well insulated from the substrate by the oxide layer and therefore leakage between the gate and the other electrodes occurs mainly along the surface of the encapsulation. Consequently, the gate current is extremely small and the gate input resistance is of the order of $10^{12}\Omega$.

The breakdown voltage of the oxide dielectric cannot be measured without permanently damaging the transistor. If the oxide layer is punctured it will not reform; a conducting path will be formed between the gate and the inversion layer, thus greatly reducing the input resistance. For this reason the published voltage ratings should not be exceeded—even by transients.

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ABRIDGED PRELIMINARY DATA

Electrical

Maximum gate-to-all-other electrodes voltage,	$V_{G\text{-}all}$	±35	V
Maximum drain-to-source voltage,	V_{DS}	±35	V
Maximum drain-to-substrate voltage,	$V_{D\text{-}sub}$	−35	V
Maximum source-to-substrate voltage,	$V_{S\text{-}sub}$	−35	V
Maximum drain-to-source current,	I_{DS}	100	mA

Thermal

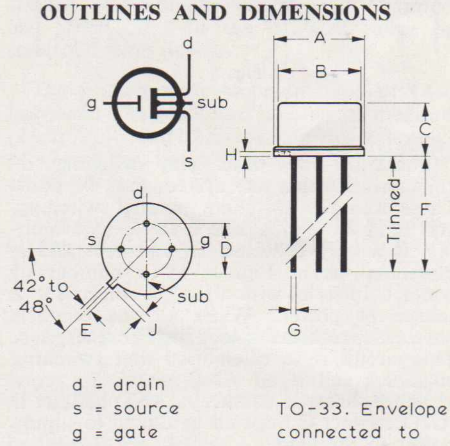
T_{stg}(min)	−65	°C
T_{stg}(max)	150	°C
T_{amb}(min)	−65	°C
T_{amb}(max)	150	°C
P_{tot}(max) (T_{amb} = 25°C)	300	mW

CHARACTERISTICS

(T_{amb} = 25°C; V_{DS} = +20V; substrate connected to source)

	A	B	C	
Pinch-off voltage, $V_{GS(P)}$	−1 to −5	−4 to −8	+1 to +4	V
Drain current, I_{DSS} (V_{GS} = 0)	1·0	4·0	—	mA
Drain cut-off current, I_{DSX} (V_{GS} = −15V; T_{amb} = 50°C)	500	500	500	nA

OUTLINES AND DIMENSIONS



d = drain
s = source
g = gate
sub = substrate

TO-33. Envelope connected to substrate.

DIMENSIONS (mm)

A	8·9 $^{+0·5}_{-0·26}$	F	38 min.
B	8·15 $^{+0·35}_{-0·4}$	G	0·45 nom.
C	5·23 max.	*H	0·4 nom.
D	5·08 nom.	J	0·85 $^{+0·16}_{-0·11}$
E	0·79 $^{+0·07}_{-0·08}$		

* Thickness of locating tab.

THE A, B, C OF STATIC SWITCHING

In all fields the tempo of modern production has called for the replacement of devices with moving parts by equivalent units with at least the same performance, but which contain an absolute minimum of mechanical parts.

In accordance with this trend, Mullard have developed the series of basic electronic circuit elements known as Norbits. These elements have been produced as a result of many years' development and research into the requirements of industry.

They are particularly suited to doing the jobs which have in the past been performed by relays. In practice it has been found that the field of application of Norbits is rather wider than that of relays, due to their fundamental reliability and the fact that their speed of operation is considerably higher, up to 1,000 operations per second.

Norbits use no moving parts whatsoever, simply transistors and other circuit components, hence they are called 'static switches'. It is this feature of no moving parts which gives the Norbits their high reliability and complete freedom from maintenance.

The relay is proved to be eminently suitable for all purposes by the functions it provides; we shall see how the Norbit can function just as usefully and in many instances, more efficiently.

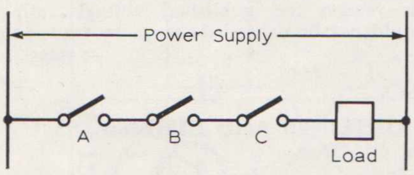


Fig. 1

There are three basic relay switching circuits, from which any system may be built. These are series switching, parallel switching, and hold switching. The first, series switching, is a very common arrangement and is illustrated as in Fig. 1, by a number of contacts in series with a load, connected to a source of power. When all the contacts have been closed the load will be energised. This circuit is so often used that switching engineers call it an AND circuit for convenience, because contact A AND contact B AND contact C must all be closed to supply power to the load.

The second basic operation is parallel switching. This too is very commonly found and is illustrated in Fig. 2. In this case the load is energised by closing any of the contacts. Switching engineers call this an OR circuit, because closure of contact D OR contact E OR contact F will cause the load to be energised.

The third fundamental switching circuit is known as the hold circuit, and is illustrated in Fig. 3. Here the load is energised by momentarily closing contact G. If the load is a relay with an auxiliary contact H, then when the relay is energised, contact H closes and the relay remains energised until the normally closed contact J is opened. This circuit is also known as a memory circuit, while the contact J is sometimes called the reset contact.

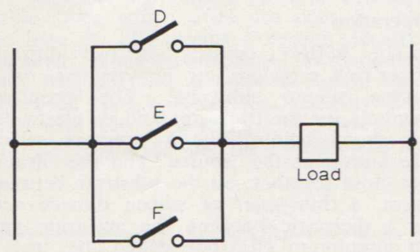
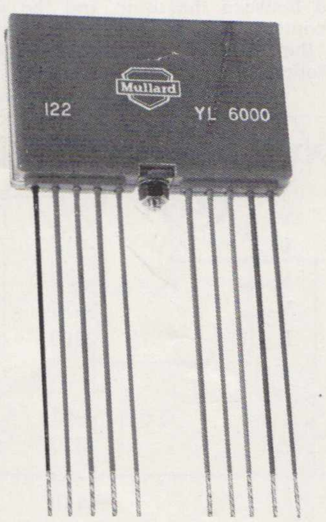


Fig. 2

Any system, no matter how complex, consists only of combinations of these three basic circuits, and as we shall see, it is just as easy to obtain these functions by using static switching. Let us, then, examine the characteristics of the Norbit system by



Basic Switching Norbit Type YL6000 which may be used as an 'AND' or as an 'OR' unit.

Physical dimensions of the YL6000 are 64 x 42 x 12 mm.

reference once again to relays, whose contacts can have two states, open or closed. In static switching, we also have two states, which are now represented by voltage levels.

Earth (zero volts) is called 'nought (0)' and the supply line (−24V) is called 'one (1)'. This terminology is used to describe the state existing at any point in the circuit, and could also be used in a circuit using relays. In Fig. 2, if the right hand supply rail is earthed, then when any of the contacts D, E or F is closed, the level of the left hand side of the relay coil changes from 0 to 1.

This brings us to the fundamental difference between relay and static switching. With the former, all combinations and functions required are obtained from the contacts, which are the device output. With a Norbit, all functions are performed on the input of the device by providing six separate inputs, only one output being provided. Thus a Norbit corresponds to a relay with six contacts, the relay having one (1) input and six separate outputs.

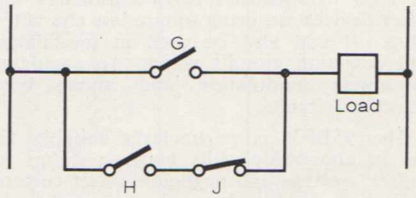


Fig. 3

Now the operation of the relay can be defined by two rules:

0 on input (that is, coil not energised), operates no outputs.

1 on input (that is, coil energised), operates all outputs.

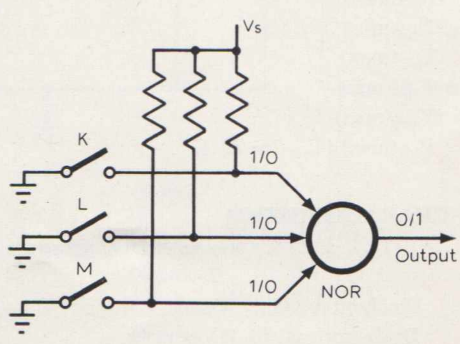


Fig. 4

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In the same way we can define the operation of the Norbit by two rules:

0 on all inputs gives 1 output.

1 on any input gives 0 output.

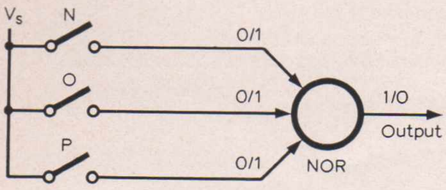

Fig. 5

The fact that the Norbit is concerned with one output and a number of inputs in fact makes the unit easier to apply than relays in most cases because it is just such a combination of facts which occurs in practice. A relay on the other hand has one input (the coil) and many outputs (the contacts).

Now refer to Fig. 5, in which switch contacts are used to provide the inputs to a Norbit. When all the switches are open, all inputs to the Norbit are 0, which results in a 1 output. If one of the switches is closed, the corresponding input becomes 1, which changes the output to 0. This circuit is an OR circuit because operation of any of the switches will cause the Norbit to change state. Thus it corresponds exactly to the circuit of Fig. 2, the parallel switching arrangement.

In Fig. 4, all the inputs to the Norbit are normally 1 (giving a 0 output), as the input terminals are connected to the negative supply via resistors. In our rules we noted that 0 on all inputs gives 1 output. So that all inputs must be changed to 0 by closing all the switches to make the Norbit produce a 1 output. Here we have achieved an AND circuit, which corresponds to Fig. 1, the series switching circuit.

Let us now examine the hold circuit when it is made with Norbits, as in Fig. 6. If both switches Q and T are open, the left hand Norbit (No. 1) will produce a 1 output, which causes the right hand Norbit (No. 2) to produce a 0 output. When switch Q is closed, Norbit No. 1 has a 1 input and therefore a 0 output, which being connected to an input of No. 2 causes it to produce a 1 output. This output is connected back to a second input of No. 1 Norbit, which thus has a 1 input even if switch Q is now opened. Thus both Norbits have changed state, and remain in the changed state even though the input signal has been removed.

If switch T is now operated, an input of No. 2 Norbit will be 1, so this Norbit will produce a 0 output, and No. 1 Norbit has 0 on both inputs, so its output will be 1. Thus both Norbits have changed state back to their original condition, although switch T has been opened again. The two Norbits will remain in this condition until switch Q is operated again.

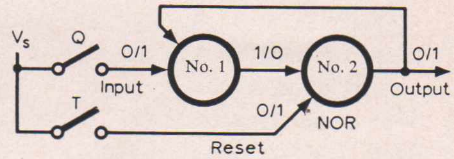

Fig. 6

From this discussion we can now see that the operation of the Norbit is very simple to understand and apply. All that needs to be remembered is the existence of the two states 0 and 1, corresponding to 0V and —24V, and the two rules:

0 on all inputs gives 1 output.

1 on any input gives 0 output.

With this information at the fingertips, any system may be designed using these static switches.■

J. G. ALEXANDER.

M.O.S.T.

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Pinch-off Voltage

Making the gate more positive in the 95BFY, an n-type inversion layer device increases the drain current. If the gate voltage change is reversed, the drain current will decrease. The pinch-off voltage is the potential difference across the dielectric that will reduce the drain current to practically zero. Because of the difficulties of determining when the drain current is exactly zero, the pinch-off voltage is usually measured when the drain current is 20μA.

There are three types of 95BFY; they have pinch-off voltages of between —8 and —4V, —5 and —1V and +1 and +4V.

Current Ratings

For the Mullard 95BFY, the maximum drain-to-source current I_{DS}(max) is 100mA.

The drain current at zero gate-to-source voltage, I_{DSS}, depends on the pinch-off voltage, the drain-to-source voltage and the gain of the transistor.

The drain cut-off current, I_{DSX}, is the current when the gate voltage is more negative than the pinch-off voltage. For the 95BFY, the drain cut-off current for a drain-to-source voltage of +20V and gate-to-source voltage of 15V is 500nA at 50°C.

Large-scale production of the 95BFY is planned and meanwhile the transistor can be supplied in sample quantities. When produced in quantity the M.O.S.T. will be many times cheaper than any device of similar performance at present available.■

PHOTO-SENSITIVE RELAY

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Eccles-Jordan Circuit

The collector of TR_1 is connected by means of C_3 to the base of TR_3, which is normally cut off. When TR_1 is cut off, a negative pulse is fed to the base of TR_3, causing it to conduct. The Eccles-Jordan circuit formed by TR_4 and TR_5 is arranged so that TR_4 is usually cut off. If TR_4 is not cut off, it can be made so by means of the push-button switch. When this is operated, R_{18} is brought into the circuit; the base of TR_4 becomes more positive and TR_4 is cut off.

The base of TR_4 is directly connected to the junction of R_{11} and R_{16}. Therefore, when TR_3 conducts, the base of TR_4 becomes negative and TR_4 conducts. Relay RL_B operates and remains energised until the switch operates and TR_4 is again cut off.

Transformer and Relays

Any standard filament mains transformer with a secondary rating of 12V and at least 500mA, may be used in this circuit.

Whilst the relays used in the circuit may be of the 300 or 3000 type, the choice of their electrical properties is comparatively uncritical since the collector current of the AC128 transistor, when protected by a suitable heatsink, may be as high as 1A.■

NEW SILICON PLANAR TRANSISTOR BFY44 1.2W at 180Mc/s

A new n-p-n silicon planar epitaxial transistor for use in lightweight airborne communications equipment and other applications where high reliability is required has been added to the Mullard range of semiconductor devices.

The transistor, development type BFY44, has been designed for use as a medium power VHF amplifier and can, for example, provide a maximum power output of 1·2W at 180Mc/s.

The collector is connected to the envelope of the TO-5 encapsulation.■

Abridged Technical Data

V_{CB} (max)	=	90V ($I_E = 0$)
I_E (max)	=	1·2A
P_{out} (max)	=	2·1W ($V_{CB} = +40$V, f = 180Mc/s)
h_{FE} (min)	=	15 ($V_{CB} = +10$V, $I_E = 500$mA)
f_T (typ)	=	250Mc/s

SIMPLE TRANSISTOR MEASUREMENTS

This article is the third in a series being published in Outlook, containing suggestions and instructions on a number of experiments in which the properties and behaviour of alloy junction transistors are examined. They are intended to give the student a better understanding of the basic operation of the transistor and to illustrate its practical application.

Comparison of Common Base, Emitter and Collector Circuits

Common Base	*Common Emitter*	*Common Collector*
Current gain (α) less than unity	Large current gain (α')	Large current gain (α')
Low input impedance	Medium input impedance	Input impedance = α' x load impedance
High output impedance	Medium output impedance	Output impedance = $\frac{\text{input impedance}}{\alpha'}$
Small collector leakage current	Collector leakage current is increased by a factor α'	Collector leakage current is increased by a factor α'

LEAKAGE CURRENT

The leakage current in the transistor results from charge carriers (holes and electrons) released by thermal ionisation. Leakage current therefore increases with temperature. In a typical germanium transistor, leakage current increases by a factor of seven for a rise in temperature from 25°C to 45°C.

The current gain of a transistor is also temperature dependent and increases at the rate of 0·75% per °C.

MEASUREMENT OF COMMON BASE CHARACTERISTICS

When connecting circuits for the following experiments, reference should be made to the notes on equipment contained in "Practical Notes".

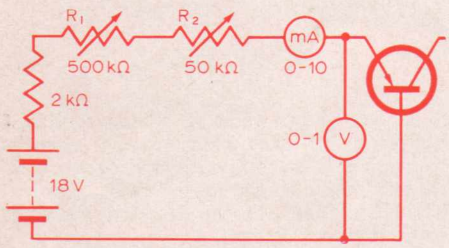


Fig. 9

Forward Emitter-Diode Characteristic

(a) Set up the circuit shown in Fig. 9 noting that the collector is left open-circuited. The emitter-base junction now acts as a simple diode but its characteristic will be affected by the base material between the base lead and the emitter junction proper. This material presents a comparatively high resistance which affects the characteristic when the diode is fully conducting.

(b) Increase the emitter current in steps up to a maximum of 10mA and record the simultaneous voltage readings for each value.

(c) Plot these readings to obtain a typical current-voltage relationship.

(d) Compare the small voltage drop required to pass 5mA of forward current with the voltage drop across a point contact diode, type OA90, for example.

(e) Calculate the base resistance of the germanium by measuring the slope of the curve.

PRACTICAL NOTES

Voltage Measurements

Normally a 1000Ω/V voltmeter draws sufficiently small current to exercise a negligible effect on circuit measurements. In transistor circuits, however, where currents may be well below a value of 1mA and may even be only a few μA, the standard voltmeter is no longer suitable for accurate measurements.

It is therefore advisable to use a high resistance meter, such as a valve voltmeter, for these measurements. However, transistors themselves can be used in high impedance measuring circuits and details of such a device were given in Outlook, Volume 1, page 28.

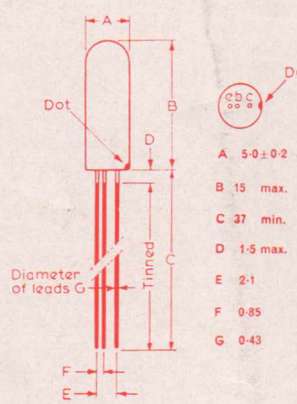
Equipment

It will be realised that, apart from the voltmeters referred to above, all the ancillary equipment mentioned should be available in the normal laboratory. When demonstrating these experiments, however it is not always convenient to have a bench littered with variable resistors, transistors and meters. Details of a unit containing all the required components, except batteries and meters may be found in Outlook, Volume 2, page 36.

Transistors

After carrying out the experiments described in this series of articles, it may be desired to investigate the application of transistors more deeply. Other circuits may be constructed, of course, providing care is taken not to overload the transistor.■

(To be continued)



Junction Transistor Type OC71
Limiting Values:

Max. Collector Voltage (V_c)	—20V
Max. Collector Current (I_c)	10mA
Max. Emitter Current (I_e)	12mA
Max. Base Current (I_b)	2mA
Max. Base/Emitter Voltage (V_{be})	10V

OUTLOOK BINDERS

In the last edition of Outlook we announced the preparation of plastic binders designed to contain up to three volumes of Outlook.

These binders are now in production and will be ready for despatch during March. Those readers who have expressed interest in these binders have already been contacted and additional binders may be obtained from the Sydney Office priced at £1/5/- plus postage (postal rates are shown below).

The method of securing copies of Outlook into the binder is unique to Australia and individual copies may be removed and re-inserted with ease. A self-adhesive, interchangeable 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.

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