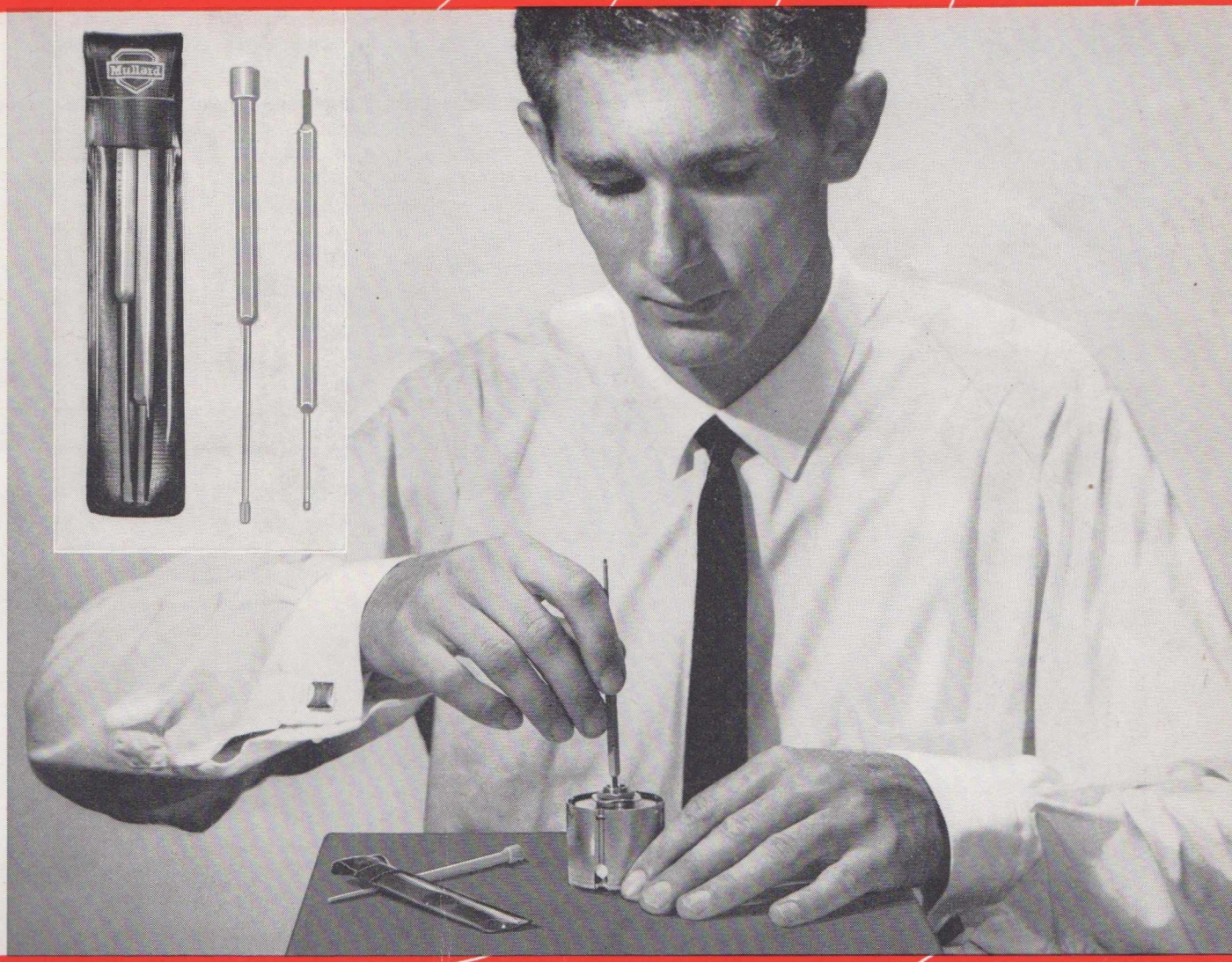
Mullard Outlook

AUSTRALIAN EDITION



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MULLARD-AUSTRALIA PTY. LTD.

VOL. 7 — No. 1 JANUARY-FEBRUARY, 1964

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The Debunkers and Other Stories

Most opinion claims the good salesman must sense when he is not welcome, or is about to overstay his welcome. A frank assessment for the uninhibited, for the odds are against faint hearts winning the day, but strong is the heart able to accept debunking and on it build a realistic sales approach.

To the young career sales executive and old campaigner alike, the wealth of instruction, training courses and general advice has been referred to in other issues of Outlook; but in this, we take the liberty of suggesting that in your home town newsagent's there are three paperbacks* for the total of 19/6d. that we feel could be classified almost as essential reading—"The Hidden Persuaders", "The Waste Makers", "The Status Seekers". For the thoughtful, these three for less than £1 cost, could, through the years, be worth thousands, certainly more so than "Bird Watching" or "Fanny Hill"!

Not that it is directly related to our industry or selling consumer products, but a year or two ago we were also impressed by another paperback*, "How I Turned 1,000 Dollars Into a Million in Real Estate in My Spare Time". One of the claims on the flyleaf of the book, encouraging and enthusiastic, stated—"you will find that the risks to you are tiny—and your chances for success are enormous."

Selective reading is exciting—and often disappointing when it is driven home that time is insufficient for us to read all that we would like. We hope that you are able to read and gain some benefit from Outlook. It is subscription time once more, to ensure your receiving future copies of Volume 7, your 12/- would be welcome.

** All paperback versions of highly successful clothbound books.*

Our Cover

Last year we found there was a dearth of suitable aligning tools and we subsequently developed the kit shown on our cover, which caters for 96% of the small tuned circuit alignment needs in Australian equipment and which, in future, will be available from our good friends Watkin-Wynne of 20 Falcon Street, Crows Nest, N.S.W.

The response to this effort has been overwhelming, in some cases touching, and we wish to thank all those for their courtesy in expressing their appreciation. Needless to say we suggest you specify Mullard when next ordering valves, semiconductors or picture tubes.

M.A.B.

VIEWPOINT WITH MULLARD

TRAVELLER RETURNS

Our Chief Engineer, Mr. Harry Watson, returned home in December after two months with our parent company Mullard Limited, London, a month in the United States and Canada, and a month on the Continent. Mr. Watson here expresses some of his views. Commencing at the Institute of Electrical and Electronic Engineers West Coast Convention at San Francisco (WESCON), he touches on some trends and developments which may be of interest to readers.

One can't help but be awe-inspired by the organising ability of the Americans. Some 35,000 people converged on San Francisco during the 24 hours preceding the opening of WESCON, all accommodation being pre-arranged by the WESCON Committee. Each hotel had an enquiry booth and free publications such as "Electronics News" were available on every floor of each hotel. Four bus routes were set up to carry visitors to and from the city and to the airport on a half-hourly schedule.

The exhibition was held at the Cow Palace, a meeting place for longhorns, but this week it was aerospace. The floor area covered by the exhibitors would be equal to the three main halls at the Sydney Show Ground and this area was occupied by some 350 exhibitors.

All exhibitors were somehow or other associated with the aerospace programme and as the theme of the convention was "Frontiers in Electronics" there were no exhibits at all related to the entertainment or industrial control industry. The emphasis was on research, and it is worth noting that some 23 companies displayed lasers while 33 were listed as displaying integrated circuit devices. The aerospace electronics industry is mainly located in Los Angeles and there does not seem to be any significant section of the electronics industry in San Francisco. In fact, one wonders why the WESCON is held in San Francisco at all, as the cost of transporting all these people and exhibits to San Francisco must be enormous.

The American Professional Electronics Industry

Traditionally the entertainment industry has supported or led the way to development of professional and industrial products, however in the United States these industrial product activities have been supported by defence and aerospace contracts. Unfortunately, commercial outlook has become one-eyed, with the result that relatively few electronic developments are undertaken with a view beyond the electronics industry.

It would seem that all the companies represented at WESCON were sub-contracting each other and all the goods produced by these exhibitors were bought and sold within the electronics industry, the final customer being the Government. I find it difficult to believe this is a healthy state of affairs and as one exhibitor put it, "the whole industry is inbred and making little attempt to produce goods for the outside world".

Mr. H. S. Watson on arrival.

Those attending took the opportunity of holding meetings of the various associations attached to the electronics industry and I was invited to attend the Electronics Sales Managers Association meeting held for the purpose of discussing problems of United States export. As an outsider it was interesting to hear points of view put forward by some of the more notable American companies and to learn that they are conscious of the fact that they have a shortage of goods marketable in other parts of the world. They believe the European electronics industry will, in terms of gross turnover, reach 60% of the total United States industry and already the Europeans are actively engaged in exports to the United States.

The American Entertainment Electronics Industry

The general public do not seem to be taking much interest in colour television and the retailers I visited felt sales this year were well below expectation. The U.S. industry estimated a production figure of 700,000 units for 1963, which is only 12% of the monochrome sales but represents about 40% in money value. Colour receivers seem to range in price from $500 to $650, with one manufacturer at $450. The Japanese are offering a 14" colour receiver in the United States for $425, however the American public seem unwilling to accept colour at four times the price of monochrome. On the other hand, FM stereo appears to be rapidly increasing in popularity and serious music programmes are becoming very popular with the listening public. These programmes of operatic or symphonic works may be heard almost without interruption, advertising being brief and unobtrusive.

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MULLARD-AUSTRALIA PERSONALITIES

MR. ARTHUR F. FELTON

In our Melbourne sales office Mr. Felton is closely in touch with stock and stock control and is well known through his long and obliging association with telephone order, and calling customers.

A keen sportsman, it will be a surprise to many of his business friends to know that, along with less spectacular sports, Arthur had a remarkable record of being undefeated as a preliminary boxer at the Melbourne Festival Hall, however a recent leg injury has affected his boxing fitness and he has now curtailed his major sporting activity to 'A' Grade cricket and, of course, in Victoria, Australian Rules football. In his last bout as a professional boxer, he dealt with his opponent in 20 seconds from the first gong!

With another of our Melbourne office colleagues, John Battista, he takes an active interest in amateur theatrical work. His training is in business and sales management; his appointment and responsibility now including our sales to Melbourne metropolitan wholesalers.

Well able to take care of himself and no less in his conscientious endeavours for the company Mr. Felton is well respected by his colleagues and customers alike.

Continued from page 3

TRAVELLER RETURNS

The transistor radio market is almost completely in the hands of the Japanese. When in New York in September the ruling F.I.S. price for a 6-transistor radio was $4.50. When in New York again in December I found that the price was $4.30 and I understand the current price is $4.25.

The Americans do not enjoy tariff protection on transistor radios and in England, it is understood, all trade barriers will be removed by 1966. As the Japanese Government is agitating for improved balance of trade in all parts of the world, including Australia, and at a time when the TV market in Japan is approaching saturation, the Australian industry cannot afford to become dependent on tariff protection.

No Enthusiasm for Transistors in TV

My visit to Chicago, the traditional home of the TV manufacturer, was very interesting, if only to find a conservative attitude towards circuit and component design. Manufacturers do not seem to be impressed with transistorised TV and feel that for the present, economics dictate that they should stay with valves. Hybridisation, they claim, offers nothing to themselves or the purchaser. It is interesting to note, they have no plans to change from germanium to silicon planar transistors in their transistor equipped products and expressed a desire to stay with their traditional suppliers.

The trend is now away from 23″ and currently 40% of TV production is 19″ and smaller—some manufacturers, notably G.E. and Westinghouse, are having considerable success with 11″ receivers. TV is no longer a status symbol, but is now considered a household necessity, rather like the change from console to mantel radios in the 1940s; space is needed for Hi-Fi anyhow. We may not be ready for this situation in Australia for two reasons. Firstly, the same price differential between large and small receivers would be hard to realise while excise is applied to picture tubes and without reducing margins on small receivers as in America. Secondly, in terms of spending power, an 11″ receiver costs the American purchaser only £A25, the price of a mantel radio in Australia.

Tape Recorders

The use of tape recorders in the United States, I feel, requires special mention because the market is by no means as buoyant as in Europe and the situation as reported in Outlook, Volume 5 No. 2 page 15 still exists to-day except in utility applications, such as continuous tapes synchronised to cash registers, turnstiles, even toilet doors. So much tape recorded advice is given that one feels almost on Candid Camera!

I.F.A.C. Congress

The electronics industry in Europe is developing a most sophisticated range of goods for sale to the outside world, particularly in the field of control and instrumentation. This was highlighted at the exhibition held in Basle, Switzerland in association with the International Federation of Automatic Control Second World Congress. The displays at this exhibition were complex but extremely well prepared and reflected the high standard of workmanship currently available in this field. The U.K. and European electronics industry is very much alive to the possibilities of industrial electronics and, neglecting the influence of Government spending, anticipate the entertainment industry expanding by 100% in the next ten years but the professional electronics group expanding at twice this rate.

New Products

The electronic industry should be forever striving to find applications for its products in new fields. An excellent example of this is demonstrated by a range of suggested products utilizing the new Mullard 2kW and 5kW continuous-wave magnetrons. For example, I enjoyed a meal of ravioli prepared in a domestic size oven fitted with a 2kW magnetron, which raised the temperature of the meal from −15°C to 80°C in three minutes. On another occasion my meal was raised to eating temperature in a conveyor-type oven in less than one minute.

Thirty Second Frank

I do not foretell an overnight revolution in our eating habits but this type of cooking could, in time, have a far-reaching effect on our concept of food preparation, particularly for hotel and restaurant meals. A frankfurt snack at one airport restaurant was taken from the deep freeze and heated to eating temperature in 30 seconds!

3000°C Without Combustion Products

A most spectacular application for the continuous-wave magnetron is a plasma torch. The torch simply consists of a co-axial capacitor used as an ionisation chamber. When a gas is blown through the ionisation chamber it takes up an ionisation energy and emerges from the orifice in a highly ionised condition, the recombination outside the chamber being in the form of a flame which can provide a temperature of 3000°C. An important advantage of the plasma torch is that no chemical reaction takes place and it does not produce combustion products. Perhaps with this technique many new industrial and chemical processes may be found.

Ultra-fast Switching

In the device field the semiconductor still steals the limelight. Perhaps the most impressive development is the introduction of new semiconductor materials. For example, a gallium arsenide diode has recently been released by Mullard, London with a hole storage time so short it has not yet been satisfactorily measured and may be regarded as practically non-existent.

Diffusion of gallium arsenide has its problems, but thin-film diodes and transistors have been created from graded cadmium sulphide films. These films are produced by evaporating controlled amounts of zinc sulphide and cadmium sulphide from separate sources.

Field effect transistors have been developed from a metal-on-oxide silicon chip providing a gate input impedance of $10^{15}\Omega$ and 2 pF. They operate in an enhanced mode, that is, a gate field causes current to flow rather than constricting the channel as in conventional field effect devices.

In America and Europe and no less Mullard Limited, the development effort in silicon planar transistors is considerable and there is little doubt that silicon transistors will be extensively used in the future.

The Administrative Offices and Applications Laboratory, Semiconductor Plant, Southampton.

At this stage germanium is cheaper to produce and easier to control, if for no other reason than the lower number of process steps. However the silicon planar process, once mastered in mass production, should provide transistors of lower spread than germanium. Certain parameters are still difficult to control, perhaps the most important being the intrinsic base impedance which influences noise figure and cut-off frequency. When an improvement in this direction is made, the same improvement can be made to germanium transistors, consequently in terms of cut-off frequency and noise figure, germanium still remains one step ahead of silicon planar.

Reliability

A most impressive research programme currently undertaken at Mullard is in the field of reliability. This programme is not simply concerned with statistical life test and quality control but coupled to an exhaustive research study of failure mechanisms. Considerable progress has already been made in this programme which will be an invaluable contribution to the reliability and life expectancy of all transistors.

Continued on page 7

MULLARD THIN-FILM CIRCUITS FOR MICROMINIATURISATION

Microminiaturisation is a key to future circuit component design and will be the answer to many current equipment developmental problems, as it promises high reliability, reduction in size and eventual low cost. It is not aimed at size reduction for its own sake, but small size is inherent in all solid state techniques and these play a major part in microcircuit manufacture.

The impact of microelectronics on the electronics industry will be a profound and basic one. Its effect will not be limited to a small class of devices but eventually affect to some degree the manufacturing, fabrication and assembly processes of the entire industry.

Microcircuits may be manufactured by any of three basic processes.

1. A lithographic pattern technique on a silicon substrate coupled with a metal-over-oxide technique to form passive circuit elements coupled to active semiconductor junctions diffused in the same substrate. This process is commonly known as the silicon planar integrated circuit.
2. Metallic film evaporated on an insulating substrate to which discrete active elements are added. This process is known as the thin-film technique.
3. Metallic film evaporated on an insulating substrate together with a deposition of thin-film active elements to form a thin-film integrated circuit.

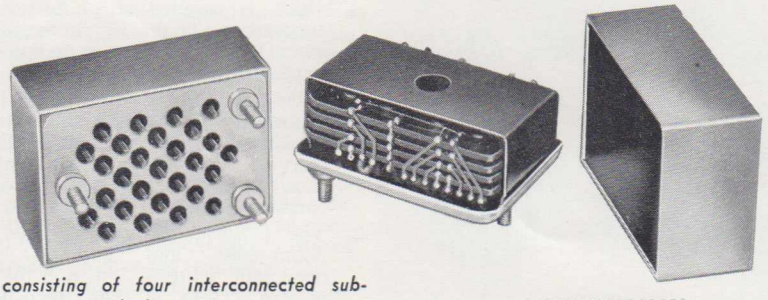
The first method is well developed but is limited at this stage to low power digital circuitry. It offers extreme miniaturisation but production yield is relatively poor which tends to keep the cost high.

The second method is more common in Europe and is the process chosen by Mullard, as it permits the use of a wide variety of semiconductors and, in addition, components which are not of minimal size may be added to the substrate. This will permit the eventual application of microcircuits to a wide variety of linear amplifier applications.

The third method may offer some of the advantages of both the silicon planar and thin-film circuits, however it is not yet beyond the developmental stage.

Advantages of Thin-Film Microcircuits:

The total number of joints in a microcircuit is considerably less than in the conventional miniature form, using printed wiring boards and subminiature components, remembering that in the conventional form, not only are there joints between lead-out wires and the rest of the circuit but there are also joints in the components themselves. It is this reduction in the number of joints, and the fact that the soldering is done with carefully prepared wire and films so that joints which are both electrically and mechanically sound are readily produced, that gives the microcircuit its inherent high reliability.



Module consisting of four interconnected substrates.

Tests to assess the reliability in statistical terms are still in progress and are divided into two main groups; one using large numbers of thin-film resistors and capacitors in different environments, and the other testing unencapsulated and encapsulated microcircuits at ambient temperature.

In the first group 10,000 thin-film resistors and 10,000 capacitors are on test under a variety of conditions. These include operation under conditions typical of digital logic circuitry, as well as accelerated life test. No failures have occurred, and the drift of any resistor is typically 0.2%.

It is difficult to produce a reliability figure in terms of failures per thousand hours, however it may be stated that to date the first group of tests represents 15,000,000 component test hours without failure.

In the second group of tests modules containing 15 to 20 microcircuit shift registers in the unencapsulated state have been operated for more than 15,000 hours without a failure. Further tests on more complex modules are being carried out to establish the reliability over working periods of 30,000 hours.

Completed modules have also been subjected to many hours of vibration testing at frequencies from 50 c/s to 2 kc/s and at accelerations of up to 30 g. Shock tests up to 300 g have also been carried out. The modules have withstood these tests without damage.

Microcircuits enable a reduction in equipment size of between 50 and 100 times compared with the conventional miniature form. This reduction in size not only has application in defence and aviation, where space and weight are always at a premium, but can offer advantages to the commercial user. Complex equipment can be built in a practical size using this technique, and with more conventional equipment, savings can be made in the cost of housing, ventilation and other ancillary services.

The cost of a microcircuit is comparable with that of the conventional miniature form and as the production of microcircuits increases, the cost will decrease. It has already been mentioned that savings can be made on housing and ancilliary services because of the reduced size of microcircuit equipment, and it is expected that within a few years, equipment made by the microcircuit technique will be very competitive with that made by any production method.

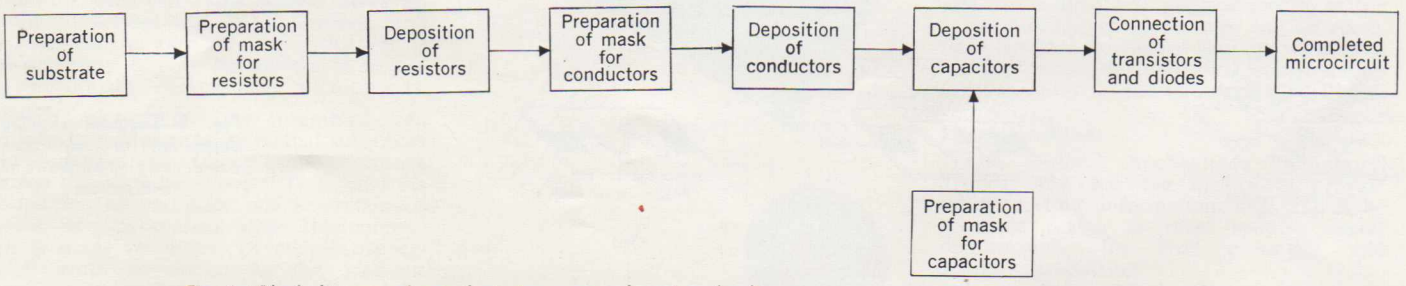


Fig. 1—Block diagram of manufacturing process for microcircuits.

Continued from page 5

A Manufacturing Process:

The manufacturing process of microcircuits is outlined in the block diagram of Fig. 1. It will be seen that the main stages are the preparation of the substrate, deposition of the resistors and conductors, deposition of the capacitors and connection of the transistors and diodes. The substrate used for Mullard microcircuits is borosilicate glass measuring 20 x 30 mm.

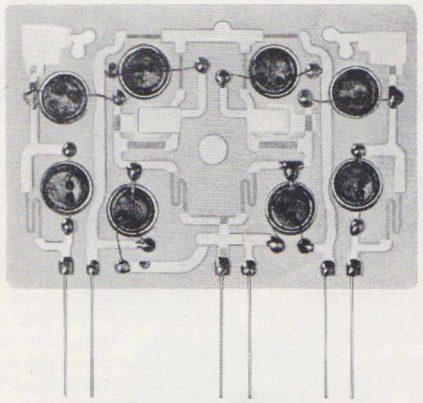


Fig. 4—Photograph of typical microcircuit.

This material has been selected because of its good electrical, chemical and mechanical properties. The glass is optically polished on the side on which the components are deposited and fine-ground on the reverse side.

The various process steps in the deposition of the resistors and conductors are illustrated diagrammatically in Fig. 2, and the capacitor deposition is illustrated in Fig. 3. After a thorough cleaning process the circuit is applied to the substrate in the following manner:—

1. The substrate is coated with copper to which is applied a photo-resist, then exposed through a photo-pattern in much the same manner as conventional printed circuitry.

   After etching a nichrome layer is deposited over the substrate. The remaining copper is then etched away carrying with it the excess nichrome, thus leaving a nichrome resistor and conductor pattern on the substrate.
2. The substrate is again coated with a photo-resist and exposed to the conductor pattern, but not the resistor pattern. Gold is then deposited over the surface, the excess being carried away by removal of the photo-resist, thus forming a gold conducting layer on top of the nichrome conductor pattern. The gold "shorts-out" the underlying nichrome film while those parts of the circuit forming the resistors are unaffected. By using a nichrome ground layer in this way, a sound bond is obtained between the gold and the glass.
3. Capacitors are formed from deposited aluminium electrodes with silicon monoxide as the dielectric. The value of the capacitor depends on the area of the electrodes and the thickness of the dielectric.

   Three vacuum depositions are used to form a capacitor. The first deposition produces the lower electrodes of the capacitors, connecting them into the resistor - conductor pattern already deposited. The second deposition produces the dielectric film, and the third produces the upper electrodes which are also connected into the existing resistor-conductor pattern.
4. The final stage in the manufacture of microcircuits is the fitting of the transistors and diodes, and soldering the lead-out wires into the circuit. The photograph of a typical microcircuit in Fig. 4 shows clearly how transistors and diodes are incorporated, and also shows the form of the other components.

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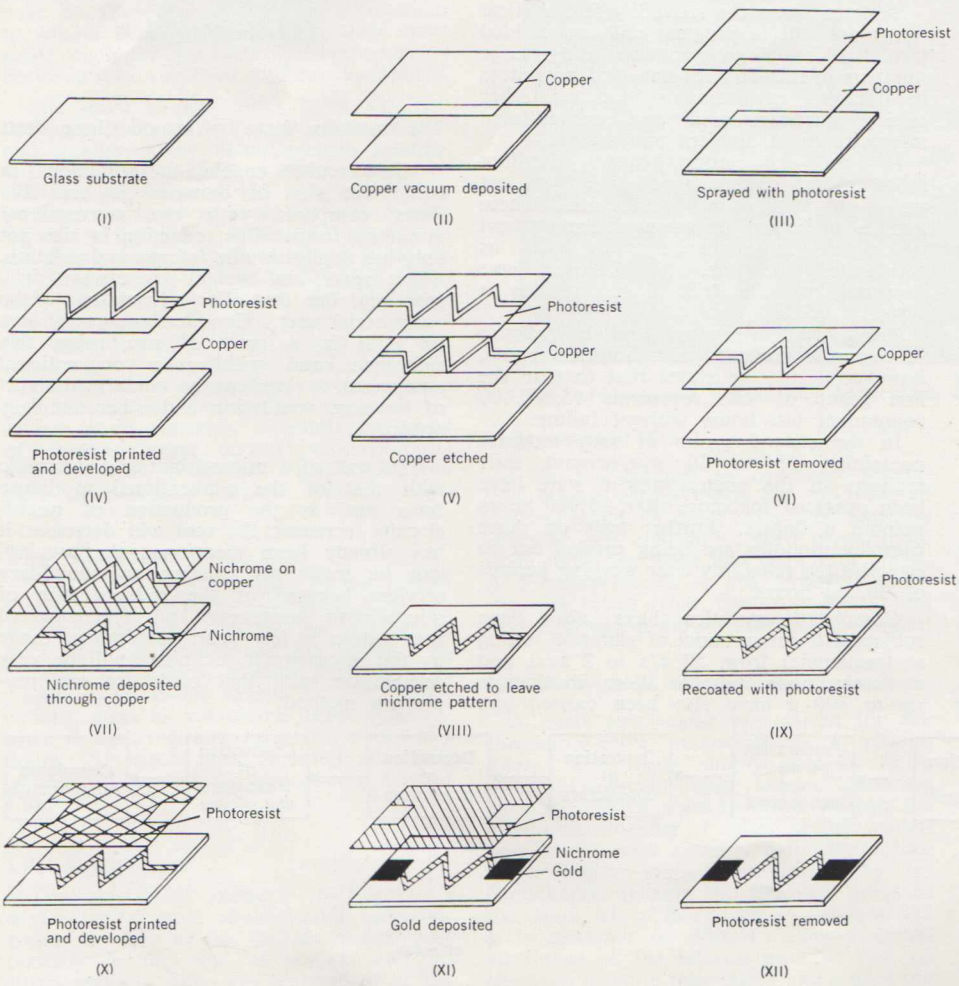


Fig. 2—Diagram showing deposition of resistors and conductors.

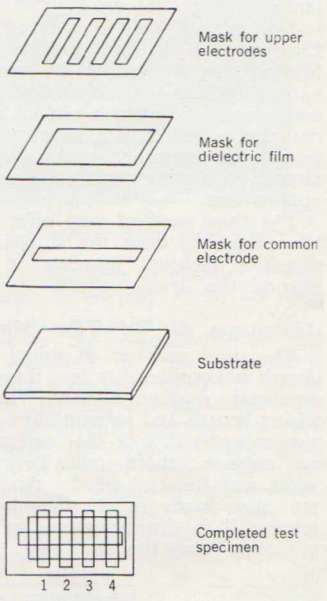


Fig. 3—Diagram showing deposition of capacitors used for component evaluation.

Continued from page 4

Microcircuits

As mentioned earlier, some 33 companies demonstrated integrated circuits at the WESCON convention. These microminiature circuit elements are created by the application of a combination of lithographic, metal deposition and junction diffusion processes to a single silicon slice, thus achieving a network of passive elements integral with the active elements.

An alternative process is the thin-film technique which is the deposition of metals on an insulating substrate to which discrete active elements are added. This process is favoured in Europe and is the choice of Mullard Limited, as it permits the use of a wide range of semiconductors and in addition, components which are not of minimal size may be added to the substrate. This will permit the eventual application of microcircuits to a wide variety of linear amplifier applications.

With increased production rate microcircuits will eventually be cheaper than present methods because they lend themselves so well to automation and standardized fabrication techniques.

Applications Engineering

After four months outside Australia with one's efforts concentrated on the electronic industry, it will be appreciated that these notes touch only on a few points, and naturally, where prudence dictates or for commercial reasons, are limited to some degree.

An overseas visit of this type makes one realize just how vast, diverse and sophisticated the electronic industry has become. It is some time since I last visited England and Europe and my concept of applications engineering had been restricted somewhat to the Australian scene, however throughout the many research, development and applications laboratories of Mullard Limited, it was my privilege to visit, I found one common theme in which we all share. We believe our first duty is to create components which fulfil the requirements in all conceivable conditions. As we see it then, our responsibility lies in the systematic development and application of components, to match the evolution of equipment design, with progressive and predictable performance. This is our task and our common bond.

H. S. Watson.

A FOUR ELEMENT PHOTOCONDUCTIVE RELAY RPY13

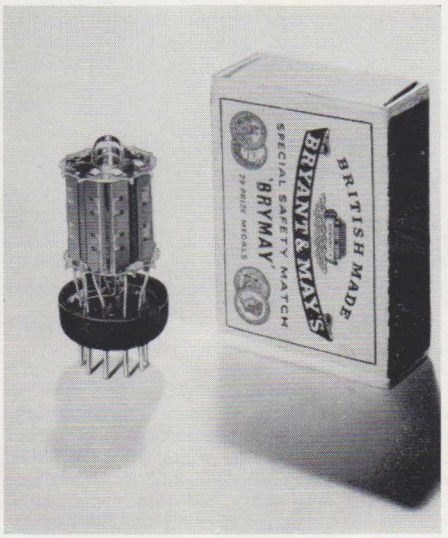
This device is the equivalent of an electro-mechanical relay with four "make" contacts. It has no moving parts and can operate unimpaired in dusty or corrosive atmospheres.

It consists of a filament lamp surrounded by four pieces of photoconductive cadmium sulphide, sealed in a glass envelope. When the lamp is energised, the resistance of each cadmium sulphide cell falls from many megohms to a few ohms, producing a condition analogous to the closing of a relay contact.

Contact "bounce" experienced with conventional relays is eliminated and the response time (several msec) of the cadmium sulphide prevents the transient spikes caused by fast acting mechanical contacts.

Since one cell may be connected to control up to four others, it can replace conventional relays in logic circuits.

Using this principle (i.e. one cell energising another) it seems possible to develop a control system for a passenger/goods lift, incorporating AND gates, OR gates, bistable circuits, phase reversal networks and floor indicators.



ABRIDGED PRELIMINARY DATA

(T_{amb} = 25°C)

Lamp filament	current	60	mA
	voltage	24	V
Max power dissipation (each cell)		150	mW
Absolute max cell voltage	AC (r.m.s.)	140	V
	DC	200	V
Resistance of each cell at V_f =	24V	15	Ω
Resistance of each cell at V_f =	0V	$>10^7$	Ω
Max overall dimensions (excluding pins)	height	49·2	mm
	diameter	22·2	mm
Base		B9A	

Continued from page 6

Interconnections and Assembly:

The greatest reduction in equipment size is provided by the interconnection of a multiplicity of substrate circuits all sealed within the same can. This method, however, is not convenient for all applications, and in cases where extreme size reduction is not necessary it may be preferable to use the individually encapsulated microcircuits.

When microcircuits are assembled into multi-layer modules the individual substrates are supported by silicon rubber combs bonded to a metal hoop. This hoop is welded to the end-plate which contains a number of glass-to-metal seals. Interconnection is made by means of etched copper-nickel wires connected to the lead-out points of the substrate. A small module, illustrating this method of assembly, is shown on page 5.

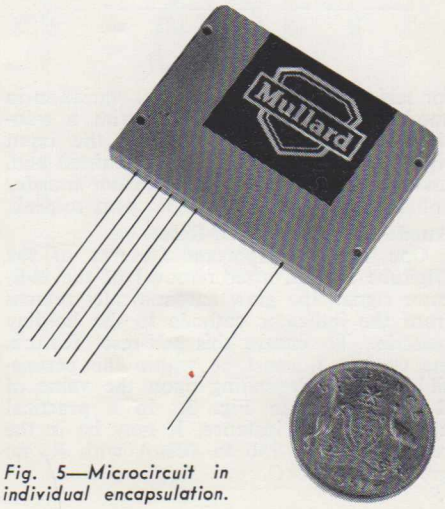


Fig. 5—Microcircuit in individual encapsulation.

In the individual encapsulation method the connecting wires are passed through a glass preform and the microcircuit is placed in a deep drawn aluminium can. The can is filled with polyurethane to within a few millimetres of the top, and an epoxy resin is added to seal the lead-out wires. The microcircuit in the individual encapsulation form is shown in the photograph of Fig. 5.

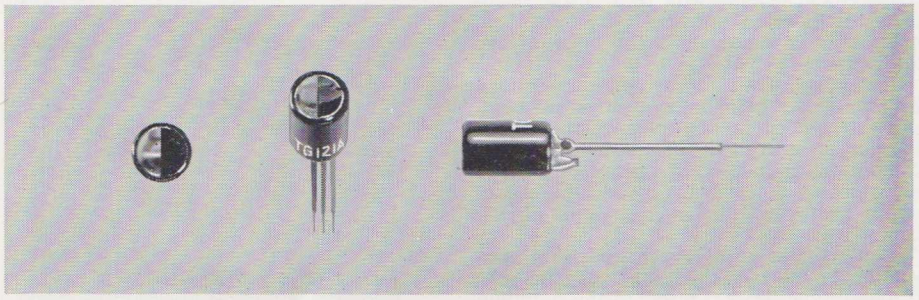
Local Facilities:

The Mullard Applications Laboratory, Sydney, now has the facility to provide initial costing information and undertake substrate design to meet specific circuit requirements, for both prototype and quantity production.

H. S. Watson.

DIGITUBE TG 121 A

Small Size – Clear Visual Indication – Instant Operation
Self-Reset of Display



Cold Cathode Indicator Tubes are readily accepted as efficient devices for obtaining clear visual read-out and have the same long-life advantages as other cold cathode devices. The Digitube TG 121 A, the latest addition to this range, combines adequate visibility and small size with the additional advantages of low cost and almost negligible heat dissipation.

The TG 121 A may be driven by a low voltage transistor in contrast to the conventional neon lamp which requires voltage amplification when used for display purposes in transistorised equipment. Approximately 200V at 300μA (60mW) is required at the holding cathode in the 'ready' condition and in order to transfer is applied to the indicator cathode. Upon removal of the indicating signal the Digitube resets itself to the 'ready' condition.

The TG 121 A has very stable characteristics and life tests indicate that, after 20,000 hours, no appreciable change is observed in light output or electrical characteristics. The high input impedance characteristic of the indicator cathode adds insignificant loading to existing circuits and it may, therefore, be used in high speed logic applications up to 5 Mc/s.

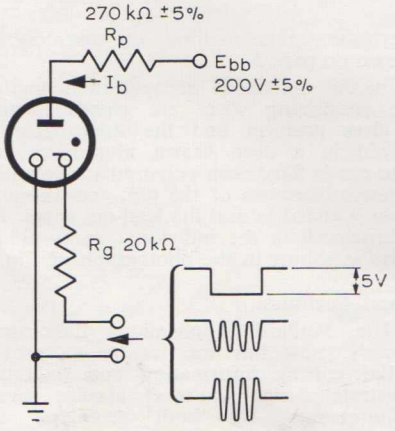


Fig. 1—Standard Circuit.

Input Signal Requirements

Under normal conditions, —5V DC are required to transfer the glow from the holding cathode and, although the wave shape and frequency of the transfer signal are relatively unimportant, a voltage of about 5V peak-to-peak should be maintained (see Fig. 1). If, however, the frequency of the transfer signal appreciably increases above 2000 or 3000 c/s, a larger input voltage will be necessary to facilitate the transfer.

The input voltage E_t varies with different values of I_b and R_g as shown in Fig. 2. As may be seen from this family of curves, the TG 121 A may be operated by a fairly low voltage with a low value of R_g or, conversely, the use of a bias voltage to the indicator cathode would increase the sensitivity, under a given set of conditions. Fig. 3 shows the permissible region of operation

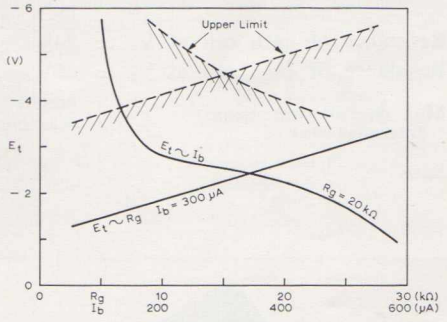


Fig. 2—E_t —R_g, I_b

for self-reset and the effect of a variation in anode supply voltage (E_{bb}). With a transistor flip-flop circuit supplying the input signal, the resistor R_g may be omitted and, under these conditions, the indicator transfer voltage may be as low as 3V peak-to-peak.

Anode Current and Self-Reset

One of the important features of the Digitube is that, after removal of the indicator signal, the glow automatically returns from the indicator cathode to the holding cathode. To ensure this self-reset feature, the current I_b must be within the permissible region (depending upon the value of R_g) as shown in Fig. 3. In a practical application, for instance, I_b may be in the region of from 250 to 400μA with R_g no greater than 20kΩ.

Anode Supply Voltage

The anode supply voltage E_{bb} and the anode resistance R_p may be determined by the following equations:

$$R_{p\ min.} = \frac{E_{bb\ max.} - E_{b\ min.}}{I_{b\ max.}}$$

$$R_{p\ max.} = \frac{E_{bb\ min.} - E_{b\ max.}}{I_{b\ min.}}$$

In standard circuits (and providing $R_g = 20k\Omega$)

$$R_{p\ min.} = \frac{(E_{bb\ max.} - 109)}{4 \times 10^{-4}\Omega}$$

$$R_{p\ max.} = \frac{(E_{bb\ min.} - 115)}{2.5 \times 10^{-4}\Omega}$$

For practical applications, values for E_{bb} and R_p are 200V and 270kΩ ± 5%, respectively.

Limiting Resistance R_g

The value of R_g represents all DC resistances including the input circuit resistance between the indicator cathode and (common) ground. The total recommended value of 20kΩ for R_g is necessary to ensure self-reset and also to maintain I_b within permissible limits. From Fig. 2 it may be seen that a low value of R_g coincides with the low value of E_t.

Mounting Position

Whilst the TG 121 A may be mounted in any position, under normal conditions the axis of the tube should be in line with the observer and the window cut-out should be in the uppermost position, otherwise the glow around the holding cathode in the 'off' position may be mistaken for the visual 'on' indication. As with other optical read-out devices, a hood may be used to minimise the effects of ambient light and to improve the clarity of the display.

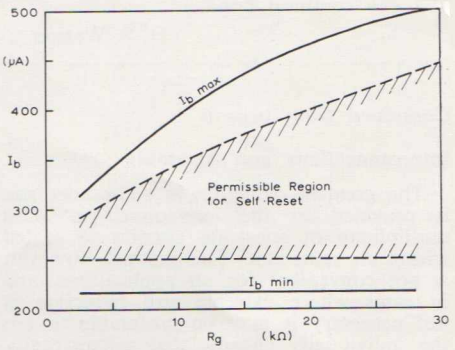


Fig. 3—R_g —I_b max., I_b min.

Other Applications

When the TG 121 A is used in other applications, the maximum ratings should be observed. Since E_t, I_b and R_g are interdependent, the family of curves in Figs. 2 and 3 should be consulted for any new design.

Continued on page 9

FILM NEWS

16mm SOUND FILMS

The latest addition to the Mullard Film Library is the 16mm colour film entitled "The Electroneers". It was selected by the British Industrial Film Association as one of fifteen representing the U.K. in the Fourth International Film Festival in Madrid during October last year.

The main theme traces the development of a travelling wave tube from the first conception through to final production and the film ends with some interesting applications of travelling wave tubes.

This sound film, which has a running time of 25 minutes, is intended primarily for schools, training establishments and specialist audiences, rather than for general viewing.

"Girdle Round the Earth" is another Mullard sound film in the History of Modern Science Series, which is shortly to be included in the Mullard Film Library. Dealing with the history of telecommunications, it shows how the high-speed communications taken for granted today, were derived from simple basic principles discovered less than 150 years ago. The film opens with Oersted's discovery of the electromagnet in 1820. It covers the development of the first practical electric telegraph, the work of Samuel Morse, the laying of the first transatlantic cable, Marconi's first historic radio signal from Cornwall to Newfoundland and the great new vistas opened up by Fleming's invention of the radio valve. The closing sequences give some idea of what is at present being achieved in overcoming problems and making fresh advances in the telecommunications field.

In black and white, this film has a running time of 20 minutes.

35mm FILMSTRIPS

The 35mm filmstrips are a popular feature of the Mullard Film Library and the following are recent additions to the already extensive range:—

Electrical Meters and Measurements (E14). The first part of this filmstrip deals with the principles of various types of meter movement, damping and construction, whilst the second part attempts to show by analogy and numerical example that there is a certain philosophy attached to the correct usage of electrical meters. The internal resistance of meters, interaction with circuit parameters, shunts and multipliers, multimeters, bridge circuits, measurement of resistance and impedance bridges are described in detail and some attention is also paid to the electrostatic voltmeter.

Power Supplies for Communications (E70). This filmstrip is intended for use by students in technical colleges, industry and the Services. Aspects included are single-phase, bi-phase and polyphase rectification, smoothing, filters, regulation, bleeder resistors and voltage stabilisers. It concludes with sections concerning series regulators (valve and semiconductor), voltage multipliers, DC converters and EHT units.

Principles of Electrostatics (E113). This filmstrip attempts a visual approach to the subject of electrostatics and includes electrification, structure of the atom, electrostatic induction, charge density, lines of force, potential and capacitance. The subject concludes with descriptions of various electrostatic machines and measuring devices.

Film catalogues showing conditions of loan are available on request from Educational Service, Mullard-Australia Pty. Ltd., 35-43 Clarence Street, Sydney.

LECTURES ON TRANSISTOR RADIO SERVICING

The popularity of Mr. R. L. Webb's transistor lectures for servicemen continues unabated with another series scheduled for Brisbane and Adelaide. The lectures have been re-written and complete sets of roneod foolscap notes are now available for country readers at 10/- post paid. It has been suggested that Mr. Webb record on tape his explanatory notes and that the tapes be made available on loan to groups of servicemen unable to attend the lectures. We consider this is a sound suggestion and will advise readers through these columns when the tapes are available.

We wish to point out that we are pleased to provide lecturers for subjects relating to the application of valves, semiconductors and special electron tubes, these augment our Educational Service which includes 16mm training films, filmstrips, educational booklets and our recently introduced service to Secondary Schools.

In all, an educational service embracing the professional, amateur, home constructor and student spheres. Your enquiries please to Educational Service, Head Office, Mullard-Australia Pty. Ltd., G.P.O. Box 2118, Sydney.

GALLIUM ARSENIDE DIODE

Now included in the Mullard range is a new gallium arsenide diode, type M54CAY, believed to be the world's fastest. Under typical operating conditions in a VASCA* test circuit, the diode showed a reverse recovery time of between 0.25 and 0.5 nanoseconds. Special test equipment is under construction in order to make a more accurate assessment of recovery time.

The M54CAY will have extensive applications in high-speed logic switching circuits in computers and in microwave and UHF communications equipment.

** Valve and Semiconductor Association.*

Continued from page 8

RATINGS TG 121 A

Anode firing voltage:
E_z (Indoor natural light)
150V DC max.

Anode sustaining voltage:
E_b (I_b = 250 — 400μA DC)
112 ± 3V DC

Indicator cathode transfer voltage:

E_{t1} (R_g = 20kΩ I_b = 250μA DC)
— 5V DC max.

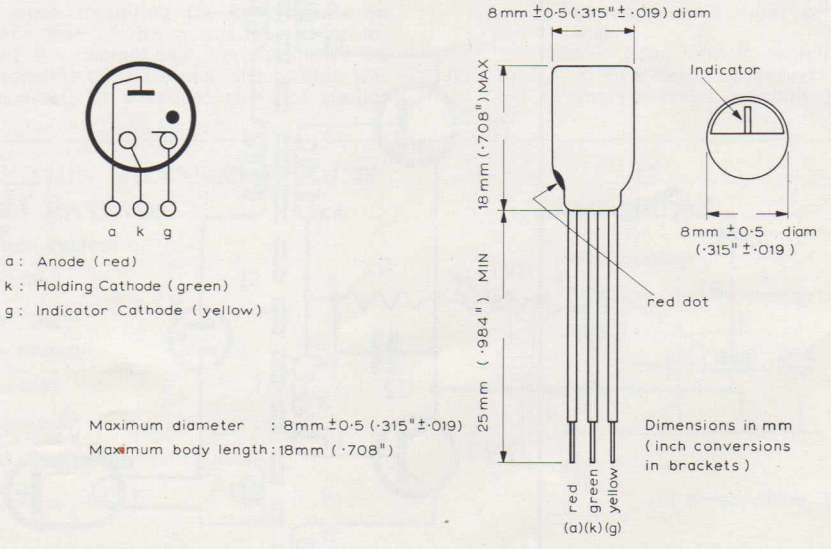
E_{t2} (R_g = 20kΩ I_b = 400μA DC)
— 4V DC max.

E_t' (flip-flop type input R_g = O)
± 3V DC max.

(I_b = 250 — 400μA DC)

Permissible range of anode current for reset (R_g = 20kΩ) 250 — 400μA DC

OUTLINES AND DIMENSIONS TG 121 A



VARIABLE EHT SUPPLY

The initial circulation of this article has resulted in a large number of enquiries for a variable EHT supply unit and it was felt that the following information would be of interest. This article describes a variable EHT supply unit which is uncomplicated, reliable and comparatively safe to use.

When designing the unit it was decided that it should provide an output which could easily be varied from zero to about 5kV with a maximum short circuit current of less than 2mA. It was also decided that for safety reasons the unit should contain a minimum of capacitance so that it would not store high voltages after it had been switched off. At the same time the design had to be such that the output should be virtually free from ripple.

In the first prototype, which operated from the 50c/s mains, it was found impossible to obtain good smoothing without using large value capacitors and a high value of series resistance. Thus the time constant of the circuit was such that the unit took some time to lose its voltage after being switched off.

A second factor which discouraged the use of mains supply was the variation in terminal voltage. In most parts of this Country variations of ±10% are fairly common and in some districts transient increases of 100% have been reported. Such increases in final output voltages from the EHT unit could well damage connected apparatus. It was for these and other reasons that the EHT unit described was designed around a transistorised DC push-pull converter circuit operating from dry batteries.

The Circuit

Fig. 1 shows the circuit of the final prototype. Two power transistors TR1 and TR2 are connected in a push-pull converter arrangement operating from a 12V battery at an average current of 500mA. The base resistor RV1 is variable and allows the base current of the transistors to be adjusted, thus providing a means of varying the EHT output. Using the transistors and transformers recommended, the converter oscillates at a frequency of about 2kc/s.

The EHT side of the transformer consists of two sets of windings connected in series. The alternating voltage produced in these windings is half wave rectified by the valve V1, the heater current of which is obtained from a few turns of wire wound on the transformer limb.

The DC output is smoothed by a conventional resistance/capacitance filter network C3, R3, C4. The capacitors are of low value since at a frequency of 2kc/s only a very small time constant is required to give good smoothing.

Across the output terminals of the unit a bleeder resistance chain, represented by R4 and R5 in the diagram, is connected. This bleeder helps to improve the regulation of the unit and also provides an ideal means of monitoring the output voltage, since a 100μA meter placed in series with the bleeder chain can be calibrated in kilovolts.

One of the disadvantages of transistor DC converters has been the difficulty of getting such circuits to start oscillating. In the circuit described here, however, the transistors commence oscillation even when the output terminals are short circuited. The neon bulb V2, placed in series with the secondary of the transformer, fires as soon as the transistors commence to oscillate and therefore serves as a warning that EHT is present.

Safety Precautions

There are very obvious and real dangers with any unit supplying outputs of the order of 5kV and every precaution must always be taken when experimenting with EHT. Every effort has been made with this design to provide as much built-in safety as possible. The short circuit current is less than 2mA; the off-load voltage is held down to 5kV by the bleeder resistance chain; either the positive or the negative output terminals can be earthed; the control shaft of RV1 is at low potential, since RV1 is in the base circuit of the converter. If the output meter is placed at the mid point of the bleeder chain, the potential difference between any parts of the meter—which is on the front panel and therefore accessible—and earth cannot exceed 2·5kV no matter which of the output terminals is at earth potential.

Regulation and Ripple Voltage

Fig. 2 illustrates the regulation characteristic of the prototype unit. The maximum

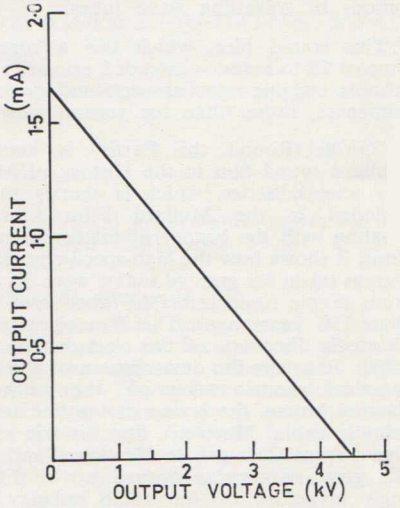


Fig. 2

output is just under 5kV and the maximum short circuit current is 1·6mA. As will be appreciated, the regulation curve is linear and indicates an output impedance of only 3MΩ.

The ripple voltage under normal operating conditions has been found to be better than 0·75%.

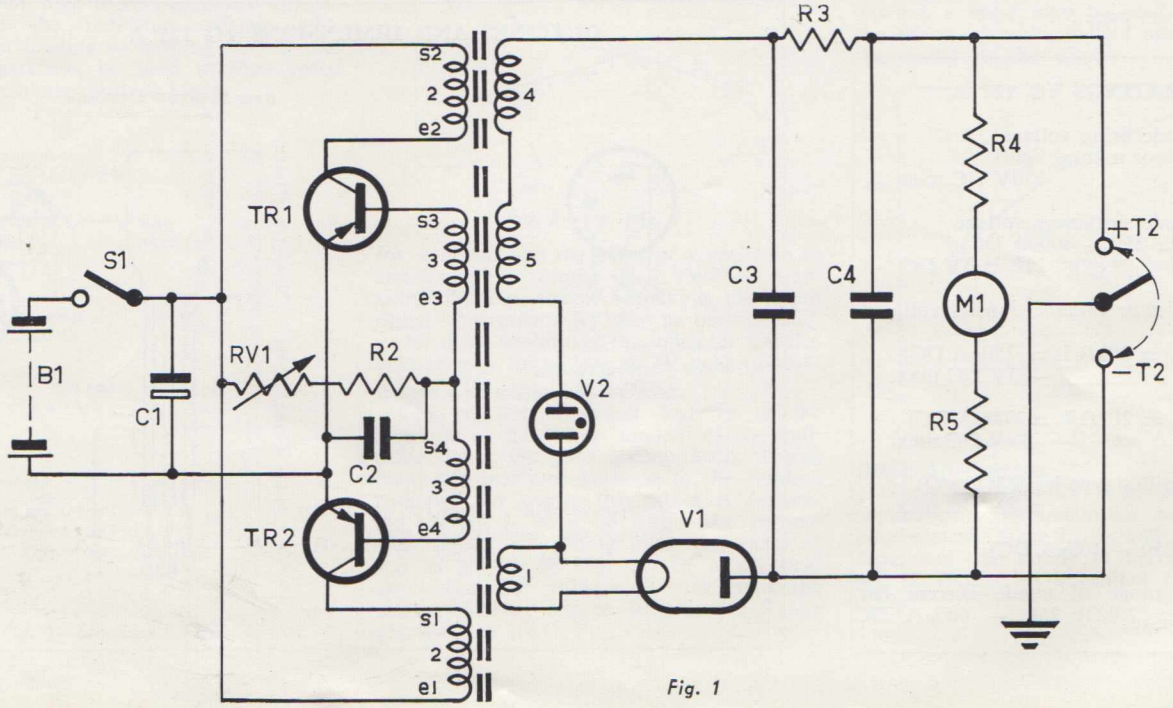


Fig. 1

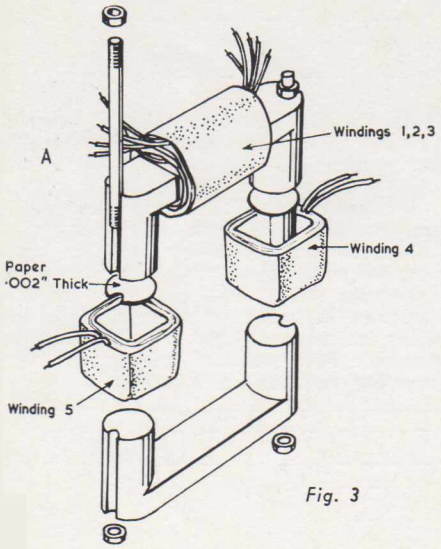
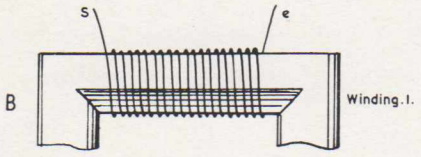
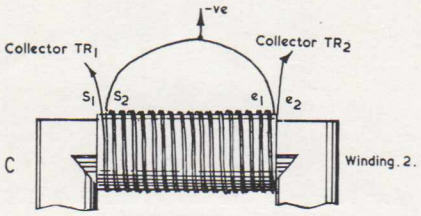
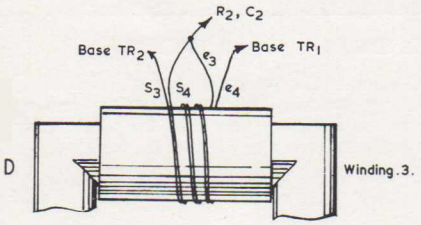


Fig. 3







The Transformer

The most important and critical component of the EHT unit is the transformer and every care should be taken when constructing this item.

Fig. 3A is a schematic diagram of the transformer showing all the windings. Details of the separate windings are shown and are in the order in which they should be placed on the core.

The core is made up from two Ferroxcube U cores — Mullard type FX2380 — which, after winding, are clamped together so as to form a square shaped core with a gap of 0·002 inches between the two pairs of faces. (The thickness of a single sheet of good quality writing paper is about 0·002 inches.)

When making up the transformer it is important that the windings are placed on the core in the correct order to obtain proper coupling. It is also important that all the coils are wound in the same sense (i.e. clockwise or anti-clockwise).

1. **V1 Heater Winding** (see Fig. 3B).
   20 turns of 22 s.w.g. p.v.c. covered single conductor copper wire wound in single layer over two layers of good quality p.v.c. tape. Finally, cover the winding with three layers of the same tape.
2. **Collector Windings** (see Fig. 3C).
   2 x 18 turns *bifilar* wound in single layer, 26 s.w.g. enamelled copper wire. Finally, cover with two layers of p.v.c. tape.
3. **Base Windings** (see Fig. 3D).
   2 x 3 turns *bifilar* wound in single layer, 26 s.w.g. enamelled copper wire. Finally, cover with two layers of p.v.c. tape.

   All the above windings are placed on the same limb of the transformer.

4 & 5. **Secondary Windings.**
   3,300 turns 40 s.w.g. enamelled copper wire, paper interleaved between layers and finally wax dipped. Both windings are placed over a single layer of polythene sheeting wrapped around the transformer limb.

It is of interest to know that a coil similar to 4 or 5 forms the primary winding of a standard output transformer with a 9/16 in. square core. Such transformers are easily obtained and can be pulled apart to provide the necessary windings. The prototype EHT unit in fact uses two coils taken from such a pair of output transformers.

Assembly

When assembling this unit, because of insulation problems, special care should be taken when mounting the components on the EHT side of the circuit. In the prototype all the components were mounted on the underside of a formica sheet. This was then covered by a second sheet of similar material to cover up the heads of the bolts. Certain components such as the on/off switch, meter, neon indicator, output control and the terminals are allowed to project through both layers of formica.

The transistors were mounted on heat sinks of dimensions 10 x 7cm and fashioned from 14 s.w.g. aluminium. These heat sinks are, of course, essential in this circuit.

A brass arm was placed centrally between the output terminals and grooved so that it could be put in contact with either terminal. This arm is connected to earth and thus provides a simple method of switching either the positive or the negative output terminals to earth potential.

In the prototype, the double sheet of formica formed the lid of a metal box measuring 9 x 9 x 3in.

Applications

This unit was developed primarily for educational experiments such as the operation of standard discharge tubes and other electrostatic experiments.

There are numerous other applications for this unit in the field of electronics and chemistry and it could also be applied in industry for purposes of insulation and breakdown tests.

COMPONENTS LIST

Resistors

RV1	50 kΩ wire wound linear potentiometer
R2	330Ω ½W carbon resistor
*R3	1 MΩ 1W carbon resistor
*R4	5 × 10 MΩ ¼W (in series)
*R5	5 × 10 MΩ ¼W (in series)

* High Stability

Capacitors

C1	1000 µF electrolytic, 15 VW
C2	1 µF tubular, 250 VW
C3	1000 pF 10 kVW
C4	1000 pF 10 kVW

Transistors

TR1	Mullard OC28
TR2	Mullard OC28

Valves

V1	Mullard 6X2/EY51 EHT rectifier
V2	110V neon, small bayonet cap fitting

Miscellaneous

M1	100 µA moving coil instrument. Preferably calibrated 0–10
T1, T2	Standard screw-down insulated terminals with 4mm central socket
S1	Single pole, on/off switch
B1	3 x EverReady 126 bell batteries in series (or equivalent)

JUNCTION TRANSISTOR OC28

ABSOLUTE MAXIMUM RATINGS

Collector voltage

V_{CB} max. ($I_E = 0A$)	−80	V
V_{CE} max. ($I_E = 0{\cdot}5A$)	−60	V
V_{CE} max. ($I_E = 6{\cdot}0A$)	−60	V

Collector current

I_{CM} max.	10	A
†$I_{C(AV)}$ max.	8·0	A

†Averaged over any 20 msec period.

Emitter current

I_{EM} max.	12	A
†$I_{E(AV)}$ max.	9·0	A

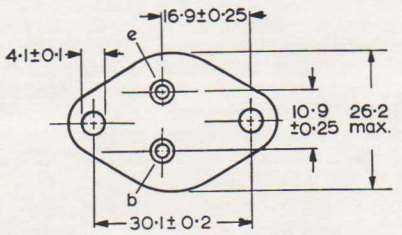
Base current

I_{BM} max.	2·0	A
†$I_{B(AV)}$ max.	1·0	A

Total Dissipation

at $T_{case} \leqslant 45°C$	30	W

DIMENSIONS



All dimensions in mm.

DOUBLE-TRIODE FOR TV DISTRIBUTION SYSTEMS

A new double-triode valve (ECC2000) for television VHF distribution systems and aerial amplifiers has been added to the Mullard range of Special Quality Valves. In addition to being suitable for the single-channel, broadband and distributed amplifiers, commonly used in such systems, the valve can also be used in the Y amplifiers of broadband oscilloscopes.

A neutrode screen in the input section reduces anode-to-grid capacitance (and thus feedback) and enables the valves to be used in many circuits without neutralisation. Mutual conductance of the input section is 13mA/V at an anode current of 15mA and 17.5mA/V at 27mA. The ECC2000 has a 10-pin base (B10B) which enables the neutrode screen to be earthed separately or used in a neutralising circuit.

The output section of the valve is intended for grounded-grid operation and is of conventional form giving a mutual conductance of 17mA/V at an anode current of 15mA and 22mA/V at 27mA. The valve can be operated in a low current condition when used as a small-signal amplifier or in a high current condition when used as a higher-gain voltage amplifier or power output stage.

A single stage, single channel aerial amplifier, using the two halves of the ECC2000, together with a two-stage broadband RF amplifier with a bandwidth of 64Mc/s at a centre frequency of 200Mc/s, will appear in the next issue of Outlook.

MAGNETRON FOR CIVIL RADAR BAND

This magnetron, the YJ1020, is the first available in Australia to meet the international frequency requirements of the recently allocated 33 Gc/s civil marine radar band. It is an air-cooled packaged magnetron based on the already established JP35-30*.

The operating frequency of the YJ1020 is fixed within the band from 31.8 to 33.4 Gc/s. Under typical operating conditions with an anode pulse current of 12.5 A, the peak pulse output power is 40 kW for a pulse duration of 0.1 μsec and a duty cycle of 0.0002. The weight is 1.0 kg (4lb 3oz) and cooling is by low-velocity air flow.

Other additions to the Mullard range of microwave valves for radar applications are the YJ1090 and YJ1091, two light-weight X-band magnetrons of rugged construction for airborne radar. Typical applications would also include transponders and guided missiles control apparatus. Both valves are mechanically tunable, weigh only 200 g (7oz) and give a pulse output power of 50W with an input pulse of 1.18 kV at 0.9 A. Under these conditions the pulse length is 1μsec and the duty cycle is 0.002. A common feature of these valves is excellent frequency stability; the frequency/temperature coefficient is guaranteed to be less than 100 kc/s per °C and frequency modulation with external vibration and an acceleration of 12 g at frequencies of 50 to 2000 c/s, is only of the order of 1 Mc/s.

The YJ1091 is tunable over the range of 8.5 to 9.0 Gc/s and the YJ1090 over the range 9.0 to 9.5 Gc/s.

** See Mullard Technical Handbook, Volume 3.*

NEW POT-CORE MATERIAL EXTENDS FREQUENCY RANGE UP TO 15 Mc/s

A new Ferroxcube material has been introduced which will enable Vinkor pot-core assemblies to be used at frequencies up to 15 Mc/s, the previous frequency limit being 2 Mc/s. The new material will be of particular interest to designers of HF communications equipment, enabling them to incorporate the benefits of Vinkors into their equipment.

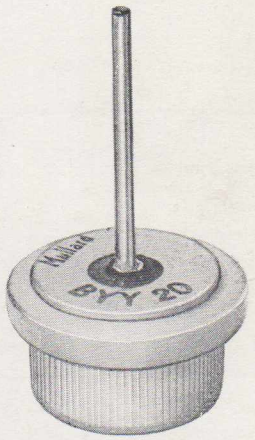
Pot-cores using the new material, which has the designation B10, are available in the 10, 12, 14, 16 and 18 mm sizes and all the accessories for these sizes of Vinkor can be used with the new material. By careful winding of the coils, Q-factors of 300 to 400 can be obtained.

The new range of Vinkors is colour-coded blue and joins the three existing ranges—red, yellow and violet—to provide a complete range of adjustable inductors covering frequencies from 400 c/s to 15 Mc/s. Inductors incorporating these Vinkors are highly stable and high Q-factors can be obtained. Both standard housings and clip-mounting versions are available.

LOW VOLTAGE SILICON POWER RECTIFIER

A recently introduced silicon power rectifier for use at low voltages represents a significant step in the development of silicon devices. Previously, high-voltage silicon power rectifiers have been uneconomic for low-voltage applications when compared with selenium devices. Since the new rectifier is specifically designed for low-voltage applications and is not derived from a high-voltage type, it has the very low forward voltage drop and low hole storage so desirable for its special applications. Together with the low forward voltage drop and fast response, the rectifier also has the high maximum stud temperature of 125°C for the full rated current of 18 A.

A bridge circuit of four BYY20s will deliver 36 A at 50 V and diodes can be connected in parallel for higher currents. For industrial applications such as power supplies and battery chargers, the BYY20/21 provides an economic solution to the problem of providing voltages up to 50V at high currents with exceptionally good regulation. For additional information see Outlook Volume 6, Number 2, page 26.



Low Voltage Silicon Power Rectifier BYY20 (twice actual size)

BYY20 **PRELIMINARY DATA** **BYY21**

Silicon diffused junction diode(s) having a recurrent peak voltage of 75V. They are specially intended for use in AC generating systems of motor vehicles having battery voltages up to 24V. The diode(s) may be press-mounted in the end-casing of the alternator. The BYY21 is a reverse polarity version of the BYY20.

Reverse current at reverse voltage of 75V (Tj = 140°C)	<4.0	mA
Forward voltage at Tj = 25°C and forward current of 12A	<1.15	V
*40A	<1.25	V
Maximum average forward current	18	A
Maximum peak forward current	40	A

** Measured under pulse conditions to prevent excessive dissipation. For more detailed information, see Mullard Technical Handbook, Volume 4.*

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