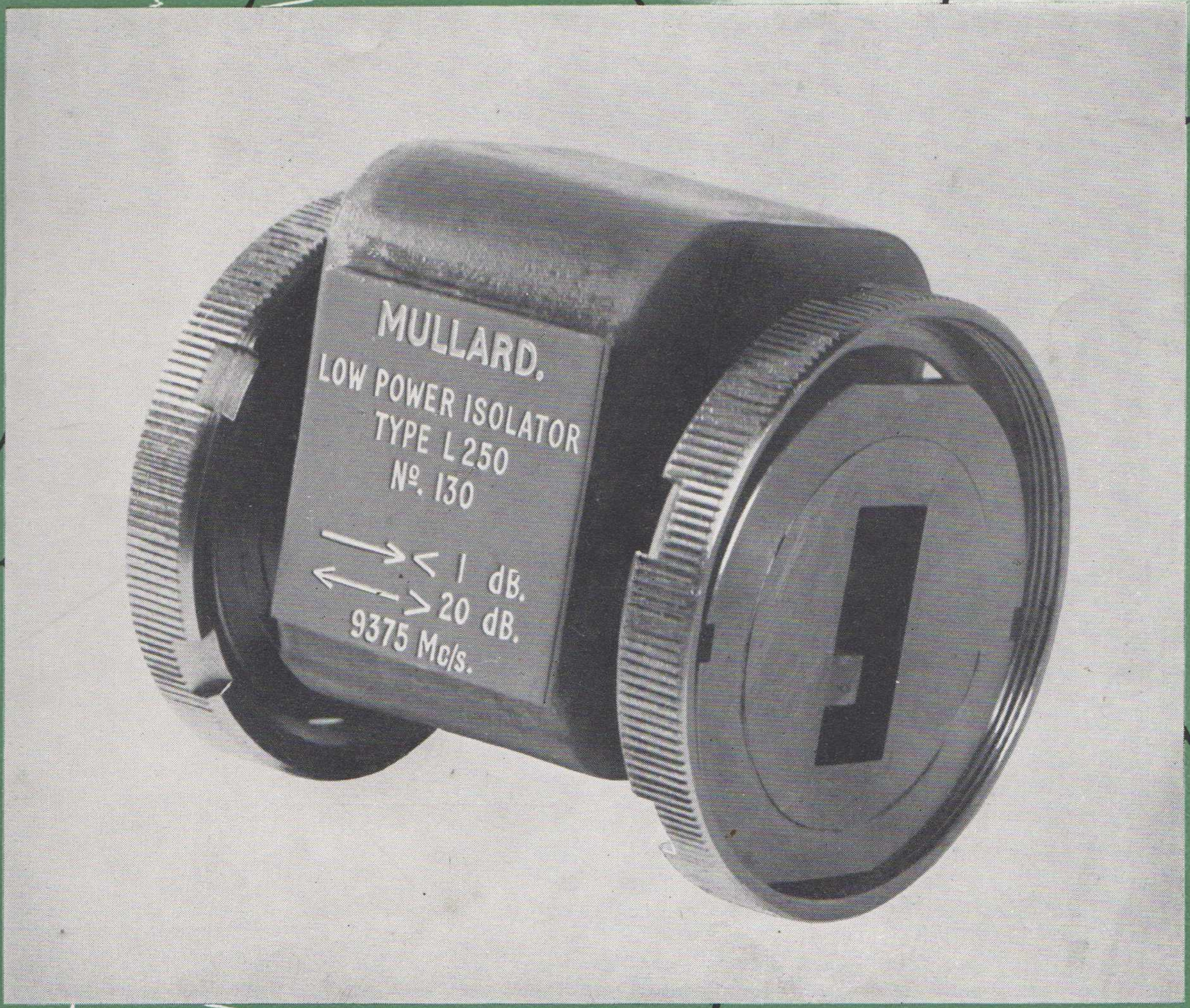
Mullard Outlook

Australian Edition



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MULLARD-AUSTRALIA PTY LTD.

VOL. I—No. 4 JULY-AUGUST, 1958

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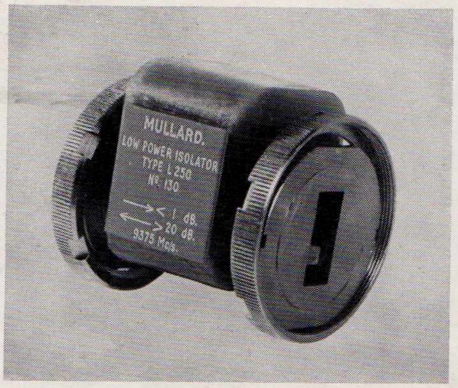

Our front cover shows the Mullard X-band low power isolator type L.250. A detailed description is given on page 32.

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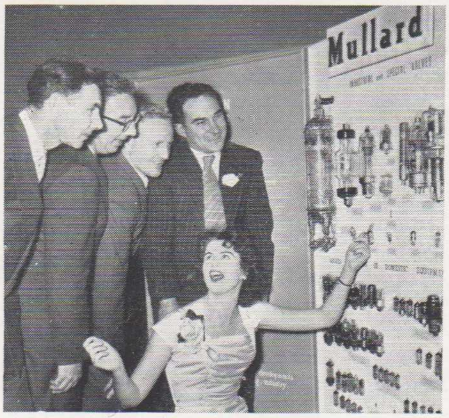
We offer no excuse for devoting almost a complete issue of the Mullard Outlook to the application of semi-conductors.

Recent improvements in manufacturing techniques have made available to the circuit design engineer many new types and forms of transistors and as a consequence the field of application is continually being broadened. The remarkable contributions made recently by those employed in this field illustrate the way in which these devices engender enthusiasm in all who use them. We are thus assured that the progress already made will continue and, indeed, be accelerated as more and more development engineers apply their thoughts to semi-conductor circuit design.

This augurs well for the future as one could foresee completion of the circle from galena and catswhisker through the electronic valve to the whole gamut of crystal lattice semi-conductor devices.

VIEWPOINT WITH MULLARD

The recent Melbourne Viewpoint with Mullard featured transistors and their applications. A completely transistorised 10W audio amplifier constructed in a small cabinet the size of a normal audio pre-amplifier and complete with dry battery, together with the showing of a film entitled "The Principles of Transistors", placed the emphasis on these interesting components.



An interested group at the Melbourne Viewpoint.

The guests were welcomed by Mullard Victorian Manager, Mr. Joffre Smiley, who pointed out that Mullard's Viewpoints had been most successful and over 1000 retailers had attended the series since its inception. Mullard General Manager, Mr. M. A. Brown, was present and took the opportunity of addressing the guests.

Messrs. Goldthorp and Tollow of Mullard Head Office testing the popular Mullard range of audio amplifiers. In the foreground, the 10W and 40W transistors amplifier may be seen. These units will be described in later issues of the "Outlook".

After outlining Mullard activities Mr. Brown introduced Mr. J. R. Goldthorp, who explained the difference between thermionic valves and semiconductors and demonstrated two transistorised amplifiers. These comprised 250mW and 10W units complete with their own dry battery power supplies. Mr. B. P. A. Beresford dealt with the replacement of valves and television picture tubes under guarantee. After outlining the method that should be adopted by retailers when claiming for replacements he stressed that all Mullard picture tubes replaced under guarantee also carried a further six months guarantee.

BRISBANE

On June 26th the first Brisbane "Viewpoint with Mullard" was held at Lennon's Hotel. It was conducted in conjunction with Mullard's Queensland distributors, B. Martin Pty. Limited whose Chairman, Mr. B. Martin, and Manager, Mr. R. N. Humphrys, introduced the Mullard team. Mr. M. A. Brown in addressing the gathering said that his company was preparing for television in Queensland and in

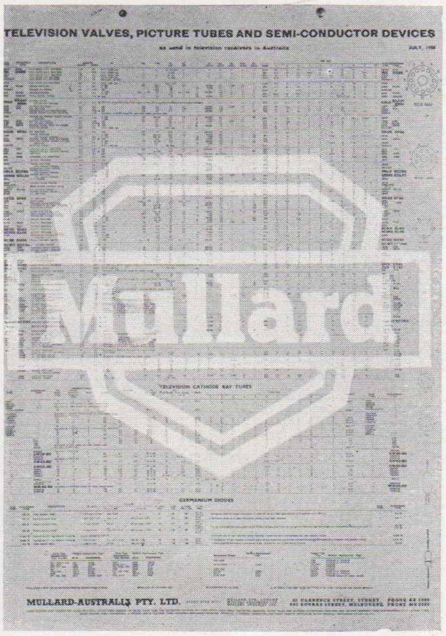
Mr. D. Irvine chats with Mr. Noel Humphrys, Manager of B. Martin Pty. Limited, Brisbane.

conjunction with B. Martin Pty Ltd. a valve and picture tube service depot would be set up in Brisbane. It would contain a full complement of the latest test equipment and a Mullard technical representative would be on hand at all times. Illustrating the diversity of his company's activities Mr. Brown referred to some of the remarkable heat sensitive cells on display. At the other end of the scale he showed a Mullard Ferroxcube Matrix Plane capable of storing 1024 "bits" of information. The 10W transistorised audio amplifier was shown in Brisbane together with a new 40W version which was being displayed for the first time. Demonstrations of the Mullard range of High Quality Amplifiers together with a film screening brought the evening to a conclusion.

FUTURE MEETINGS

Orange: Hotel Canobolas, Tuesday, 28th October, 1958, at 8 p.m.

TELEVISION VALVES, PICTURE TUBES AND SEMI-CONDUCTOR DEVICES



This data sheet has been compiled to assist the Television Service Engineer. The wide variety of valve and tube types found in television receivers in Australia is largely due to circuits developed overseas; thus it has been necessary for the T.V. Service Technician to have ready access to abridged data for a multiplicity of valve and tube types. This new Mullard wall chart aims to assist T.V. repairmen by providing a speedy reference.

Copies are available from Mullard offices and Mullard distributors throughout Australia.

X-BAND LOW POWER ISOLATOR

A number of microwave applications require that some form of isolation be provided between the circuit elements of a system. This becomes necessary in order to reduce or eliminate the effects of reflections due to unavoidable mismatch. The Mullard X-band low power isolator, which is shown on the front cover of this month's issue, provides the element required to achieve such isolation. The device will find application in the fields of radar, communications, and microwave investigation in the laboratory.

The X-band low power isolator type L.250 is a non-reciprocal waveguide component having an insertion loss in the direction of propagation of less than 1 dB and a reverse loss of greater than 20 dB. The device depends for its action on the non-reciprocity exhibited by ferrite materials at microwave frequencies. This property is due to the effect of gyromagnetic resonance.

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

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

The low power isolator is suitable for use in standard X-band circuits and special waveguide bends, and mechanical fixing arrangements may be made available to specification.

PHOTOCONDUCTIVE CELL ORP 90

Low-R photoconductive cell of the cadmium sulphide type just introduced by Mullard will give sufficient current to operate a relay directly with only a low applied voltage. The low resistance is achieved by an interdigital pattern of copper strips on the cadmium sulphide element. Cadmium sulphide cells have only recently become available in commercial form and are notable for their high sensitivity compared with photo-emissive cells and other photoconductive types. They are slower in response than photo-emissive devices, but this particular cell will perform switching operations at speeds up to about 50 per second. With illumination of 5 foot-lamberts, at a colour temperature of 1500°K (reddish yellow light), the cell will give about 20mA for an applied voltage of 10V. From the same illumination but at a colour temperature of 2700°K (yellowish white) the current is approximately 6mA. Doubling the applied voltage gives a four-fold increase of current within the permissible power dissipation which is 1 watt at 25°C or 200mW at 75°C. The dark current is only 2.5μA (at 25°C) with 300V applied to the cell. Spectral response covers the entire visible spectrum and extends nearly into the infra-red region.

CHARACTERISTICS (measured at 25°C)

Cell current at 10V d.c., 4.5 lm/ft^2 (foot candles) and lamp colour temperature = 1500°K

Minimum	6.0	mA
Average	20	mA
Maximum	31	mA
*Ultimate dark current at 300V d.c.	2.5	μA

COLD CATHODE COUNTING AND SELECTOR TUBES

Mullard has pleasure in announcing the introduction of two decimal stepping tubes—the Z303C counter and the Z502S selector.

The Z303C, which is equivalent to the British Services' type CV2271, is a tube with cathodes 1 to 9 brought out together and cathode 0 taken to a separate pin on the international octal base. The glow discharge is stepped round the tube by applying sequential negative pulses to the two sets of auxiliary or guide electrodes. The tube can count in a clockwise or counter-clockwise direction at a maximum speed in the region of 4 Kc/s. Applications include nucleonic scalers, industrial counting, frequency division, timers, etc.

The Z502S, which is equivalent to the CV2325, operates in a similar manner to the Z303C, but has all ten main cathodes brought out to the B12E special 12-pin base. It is suitable for industrial batching, welding control, electronic tachometry, telemetry, computing, etc.

In both types the glow is clearly visible through the dome of the bulb, and its position may be identified by means of an additional numbered escutcheon.

Brief data on these tubes is given below. Both these types are available in sample quantities.

ADVANCE DATA FOR BOTH TYPES

Characteristics:

Max. counting rate (sine or pulse drive)	4.0 Kc/s
Min. time difference between two successive input signals	250 μS
Maintaining voltage at I_k = 300 μA	186 to 196 V

Recommended Operating Conditions:

Double pulse drive circuit

Supply Voltage	475 V
Bias voltage on k_o	—12 V
Guide bias	+40 V
Pulse amplitude	100 V
Pulse width	75 μS
Anode load	820 KΩ
Output cathode load	120 KΩ
Anode current	340 μA
Resultant output pulse	35 V

Sine wave drive

Guide bias	+10 V
Sine wave drive voltage (r.m.s.)	40 to 70 V

(otherwise as for pulse drive)

TECHNICAL SUMMARY

ELECTRICAL

Forward loss	Less than 1 dB over the band 8925-9825 Mc/s.
Reverse loss	Greater than 20 dB at centre frequency of 9375 Mc/s.
Bandwidth	The bandwidth is such that over the range 8925 - 9825 Mc/s the reverse loss is greater than 15 dB while the forward loss remains less than 1.0 dB.
Input VSWR.	Better than 0.85.

MECHANICAL

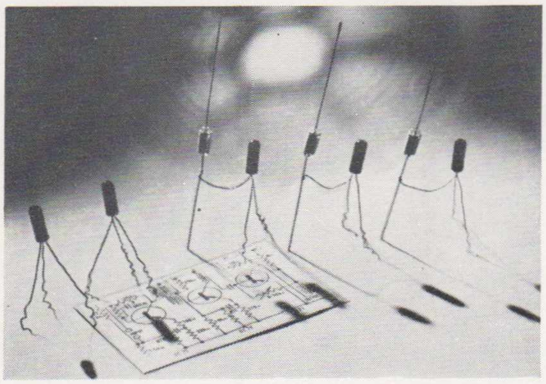
Waveguide	W.G. 16 with the internal dimensions 0.9 in. by 0.4 in.
Overall dimensions	3 in. long by 2½ in. by 2 in.
Flanges	Normally fitted with screw type plain flange at output port (R.C.S.C. Cat. No. Z830004) and screw type choke flange at input port (Z830-003), but alternative types can be fitted to order.

Mullard

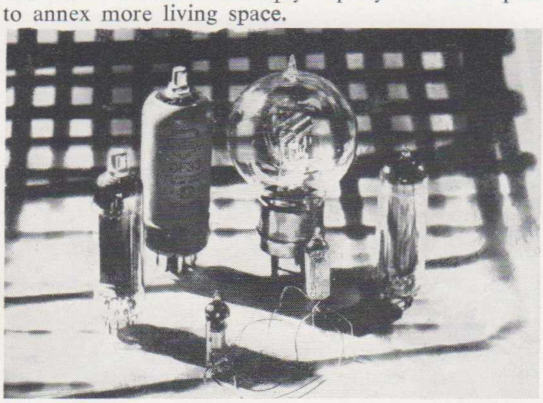
THE WAR OF THE TRONS AND THE SEMICONS

The Story

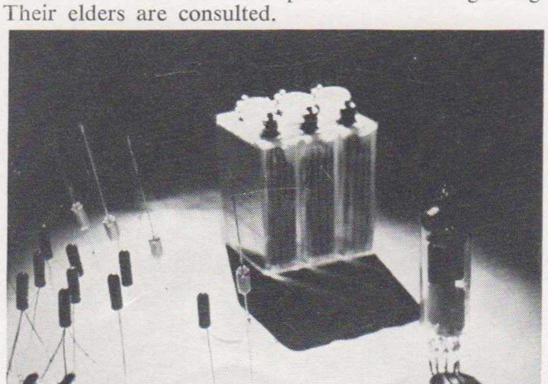
So Far...



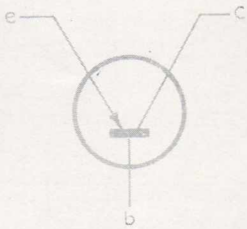
1. Latest products of evolution in Free Space, the diminutive Semicons multiply rapidly and soon plan to annex more living space.

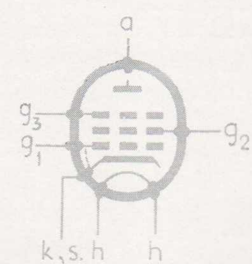


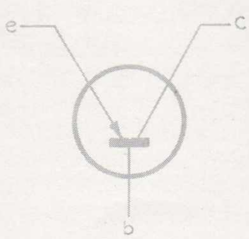
2. Semicon moves spell trouble for the Trons who have been Lords of Free Space from the beginning. Their elders are consulted.

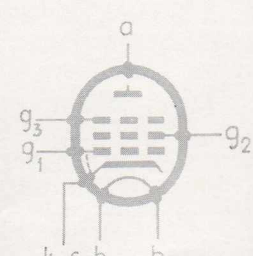


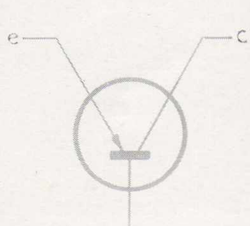
3. Semicons are small and active: more than 100 of them can thrive on the supplies needed for only one Tron.

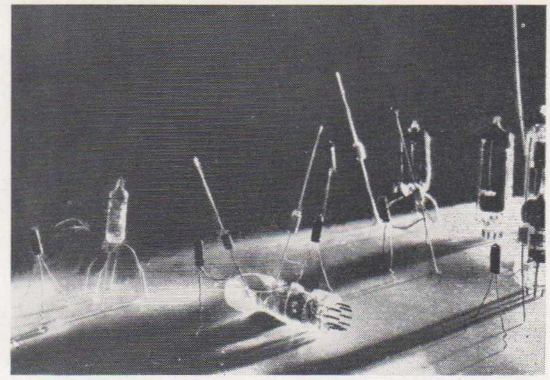




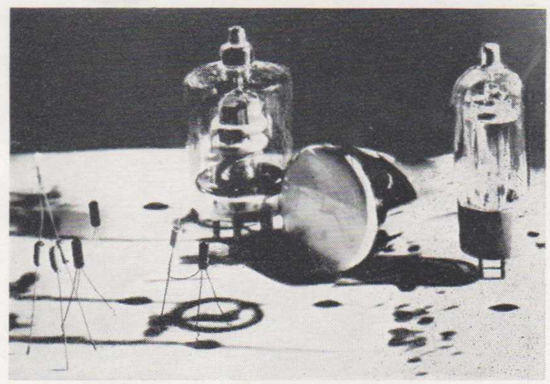




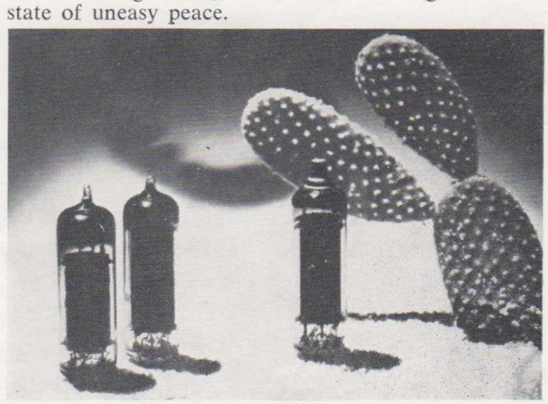




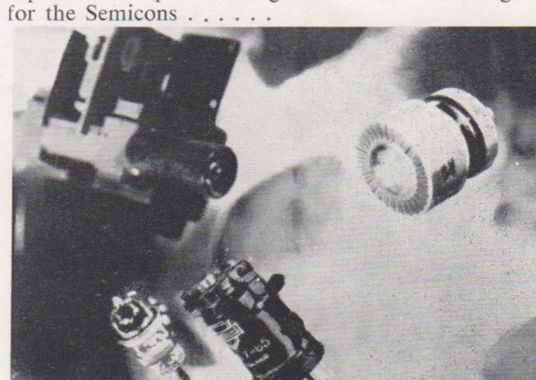
4. The Semicons join battle. At once their task forces overwhelm the advance defences of the Trons.



5. But the main Trons army is too strong for them. Truce is negotiated. Both sides live together in a state of uneasy peace.



6. In some spheres, however, Trons still reign supreme: in equatorial regions the heat is too great for the Semicons . . . . . .



7. . . . . . . and in higher space regions. Semicons are no match for the specialised types of Tron that have evolved there.

MAINS — OPERATED D.C. STABILI

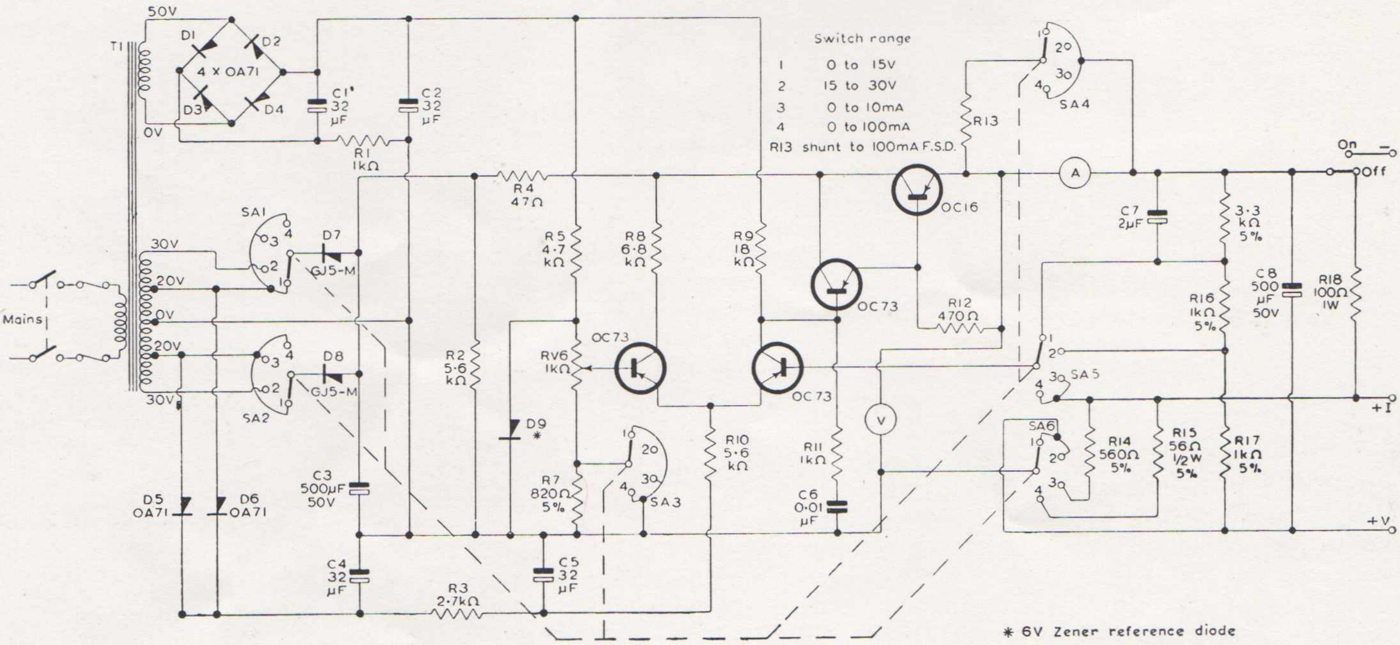


Fig. 1—The complete circuit.

This article describes a design for a stabilised power supply, which fully demonstrates the use of transistors in this type of circuit. Stabilisation is achieved by the use of d.c. feedback and the incorporation of a silicon zener diode as reference. The design was developed from one giving much higher current output. [T. H. Brown and W. L. Stephenson: 'A Stabilised D.C. Power Supply Using Transistors', *Electronic Engineering*, Vol. 29, No. 355, Sept. 1957, pp. 425 to 428.] This previous design was complicated by the need to protect the series stabilising transistor from excess dissipation. This consideration applies equally to the present design, but, by limiting the maximum output current to 100mA, the maximum dissipation cannot exceed 3.2W if the maximum voltage is less than 32V. This limitation removes the problem for all practical purposes.

The design described here possesses facilities for constant voltage and constant current outputs, the ranges being 0 to 30V and 0 to 100mA. These ranges are split into smaller ranges, respectively 0 to 15V and 15 to 30V, and 0 to 10mA and 0 to 100mA.

The treatment which follows shows the theoretical considerations governing the design of individual stages, and indicates how these requirements have been fulfilled in the final design.

CIRCUIT

The complete design is shown in Fig. 1.

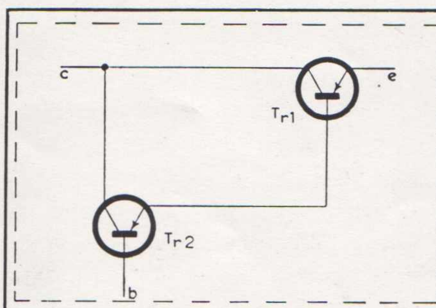


Fig. 2—Two-transistor emitter follower

Constant Voltage Output

The simplest form of voltage stabiliser using transistors is the emitter follower with the base connected to a reference battery. The emitter follower may be a single transistor or of a compound type with two or more transistors in cascade as shown in Fig. 2.

The d.c. output voltage, in the general case, $V_o = V_r - V_{be}$, where V_r is the constant voltage across the internal resistance of the reference and V_{be} is the base-emitter voltage.

The value of V_{be} is very much less than 0.5V. Due to the high collector resistance the variation of V_{be} with collector voltage is negligible. V_{be} varies with current but, at a fixed current, it can still vary with temperature (variation about 2.5mV/°C). Hence even with constant load current the output voltage can vary with transistor working temperature.

For a compound emitter follower circuit, this temperature effect increases

SED TRANSISTOR POWER SUPPLY

proportionately with the number of transistors used.

The relatively high output resistance of the emitter follower circuits leads to a consideration of d.c. feedback, to effect some reduction.

D.C. Feedback

The block diagram of Fig. 3 consists of an emitter follower with the addition of d.c. feedback applied through a phase-reversing amplifier.

The presence of the feedback loop reduces the d.c. output resistance of the compound emitter follower by a factor of (1 + A) where A is the gain of the feedback amplifier. The effect on the output of variation in the unstabilised supply, can be eliminated almost completely by suppling the feedback amplifier from a separate stabilised line.

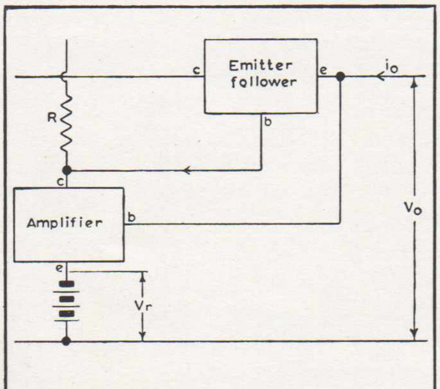


Fig. 3—Use of d.c. feedback

It can be shown that the effect of applying feedback to a single transistor amplifier and a compound emitter follower of two transistors, is to reduce the output resistance by a factor of several hundred. The output voltage is dependent on V_{be2} where this voltage applies to Tr2 in Fig. 2. V_{be2} is in turn dependent on variations with temperature of V_{be1}. Because of feedback this variation of V_{be2} is negligible compared with its own variation with temperature 2.5mV/°C.

The variation of output voltage can be minimised by using a long-tailed pair as the amplifier shown in Fig. 4.

Since the temperature variations of V_{be3} and V_{be4} (related to Tr3, Tr4 respectively) are equal, they will balance out. The output voltage then varies only with V_{be2} which, as has already been seen, varies only slightly.

The d.c. feedback as described considerably reduces the d.c. output resistance. The long-tailed pair does not itself greatly reduce the output resistance, but does make it less dependent on the internal resistance of the reference source. The output voltage is made less dependent on temperature provided that the internal resistance of the reference source is low.

In the practical design dealt with in this article, the requirement of a maximum voltage of 30V makes two voltage ranges essential. This is necessary to avoid exceeding the maximum voltage rating of the series transistor, which is 32V. These ranges were chosen to be 0 to 15V and 15 to 30V nominally, with a minimum overlap of 1V. The a.c. inputs for these ranges are 20 and 30V r.m.s. respectively.

Voltage control is obtained by variation of the reference voltage in order to maintain control throughout the whole range down to zero output. Supplies to the amplifier are —50V from a separate transformer winding and +16V from the 20V tap on the main winding.

Constant Current Output

By the simple method of adding fixed resistors in series with the output, to provide feedback, the voltage range control may be used. The output resistance is the value of the feedback resistor multiplied by the gain of the feedback amplifier. Thus the output resistance is inversely proportional to the maximum current of the range.

The most common requirement is a low current at as high a resistance as possible. The low range, 0 to 10mA, was chosen with this in mind, the high range, 0 to 100mA, was added with no additional complication so that the full current potentialities of the unit were utilised.

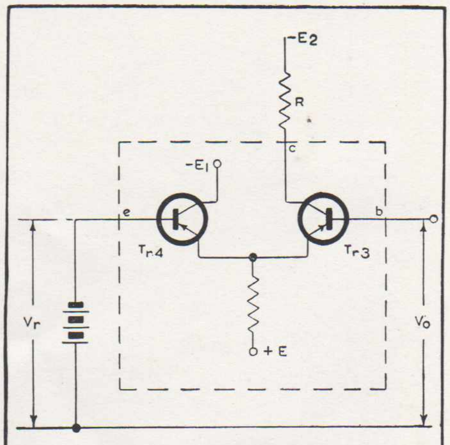


Fig. 4—Long-tailed pair.

OPERATION

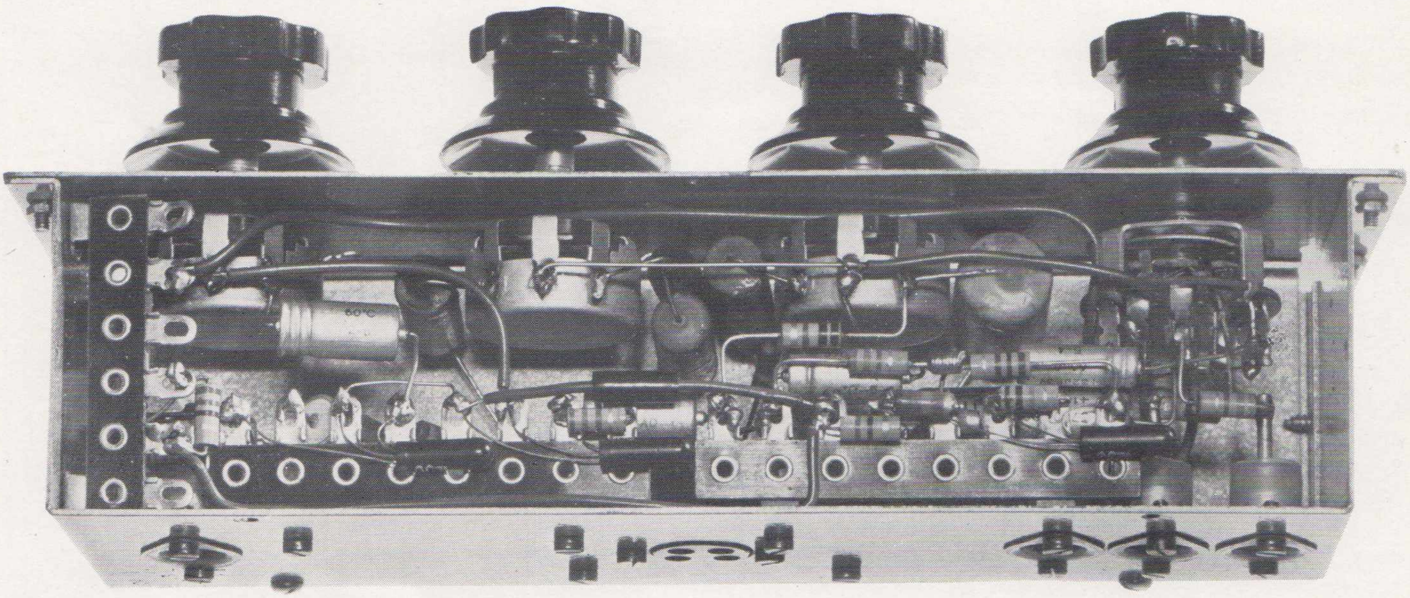
Separate terminals are provided for current and voltage outputs. This is to avoid the possibility of error in use. To facilitate the setting up of the current, the d.c. output switch, when in the 'Off' position, connects a load of 100 Ω across the current output terminals. The required current is then set up on the meter before being switched into the external load in the 'On' position. The 10mA meter is normally shunted to read 100mA full scale deflection, but on the 10mA current range the shunt is switched out.

PERFORMANCE

The variation in output for a 10% change in mains input is less than 1%. Output ripple is less than 1mV r.m.s. which is negligible compared with most output voltages which may be required. The table below shows the output resistance characteristics on all ranges for d.c. conditions and at 100kc/s.

Range	R_{out} d.c.	R_{out} 100kc/s
0 to 15V	0.12 Ω	0.18 Ω
15 to 30V	0.2 Ω	0.2 Ω
0 to 10mA	150 kΩ	5 kΩ
0 to 100mA	15 kΩ	0.8 kΩ

TRANSISTOR PRE-AMPLIFIER AND TONE CONTROL UNIT



THE PROTOTYPE CONTROL UNIT

This pre-amplifier unit provides for microphone and gramophone input positions. It includes pickup compensation for the Goldring type 500 pickup and gain and tone controls. However, there is more than adequate gain for all types of magnetic pickups found on the market. A typical output under average conditions with an LP record is 270mV. This output is more than sufficient to drive valve amplifiers such as the Mullard 5-10, 5-20 and 3-3 amplifier.

On the prototype model shown in the illustration, the total harmonic distortion was less than 0.3%. The frequency response was substantially flat to within about ± 1dB from 40 c/s to 12kc/s. *With this type of pre-amplifier there is no possibility of introducing hum or microphony.*

The noise level is comparable to that of a valve circuit. This is achieved by choosing suitably low operating currents and placing part of the pickup compensation at the output of the pre-amplifier. The supply voltage is not critical and can vary within 12 to 14V.

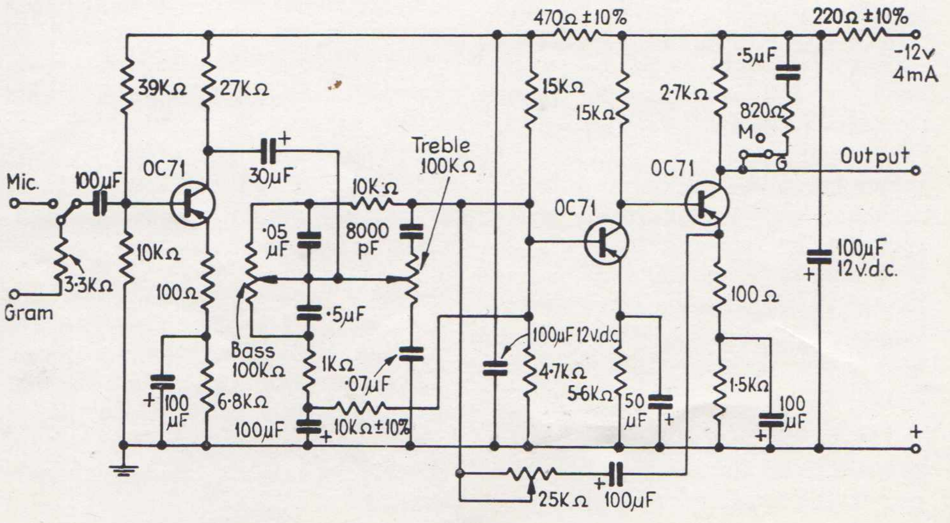
An RC filter network is recommended should the pre-amplifier and main amplifier be fed from a common supply.

Negative feedback is supplied to the input transistor by an unbypassed emitter resistor. As the second and third transistor stages are directly coupled, a variable overall amount of feedback is provided by virtue of the gain control. Even when this gain control is set at maximum position the amount of feedback is still 20dB.

TABLE OF PERFORMANCE

Maximum input	30mV
Input impedance	5kΩ
Current gain	400
Voltage gain	220

The 0.5μF and 0.05μF capacitors are paper with a tolerance of ± 10%. The 0.07μF capacitor is not standard but can be made up of 0.05 and 0.02μF capacitors in parallel. The 8000pF capacitor is silver mica and should also be ± 10%. For all electrolytic capacitors used in this circuit 6V d.c. wkg. is sufficient unless otherwise marked. The 100μF capacitors which are connected across the supply voltage should be rated at 12V d.c. wkg. All resistors used should be within ± 5% unless otherwise indicated.



HIGH GAIN LOW NOISE TRANSISTOR PRE-AMPLIFIER

This transistor preamplifier uses a single OC70 and is primarily intended for mounting in the pickup of a record reproducer. It can also be used with low impedance microphones and tape heads, provided it is mounted close to them. Because of the need for a highly compact unit, pickup compensation and tone controls are not included.

The output impedance is high, and maximum gain and the most favourable signal to noise ratio are obtained when the transistor preamplifier feeds into the high input impedance of a thermionic valve amplifier. The main commercial application of this circuit will therefore be in record reproducers primarily equipped with valves, which require a high gain low noise preamplifier stage in a compact assembly suitable for mounting in the pickup arm or head.

The high gain transistor preamplifier uses a single OC70 in common emitter connection and operates from a 250V line with a voltage gain of 330. The basic circuit arrangement for the preamplifier is shown in Fig. 1. For convenience it will be referred to as "A". The preamplifier can be fed from the supply of a valve amplifier by using the slightly modified form of the circuit shown at "B" (Fig. 2).

This preamplifier has distinct advantages over a unit using thermionic valves. *First, two valves would be required to get comparable gain. Second, the transistor preamplifier is completely free from hum and microphony,* provided that hum pick-up on the input leads (which are floating), is avoided by keeping them fairly short. Although thermal noise is not quite as low as in a valve circuit it is low enough to make the preamplifier acceptable for most applications. Pickup compensation and tone controls are not included in the circuit.

PERFORMANCE

For a nominal circuit, with an input voltage of 5.5mV and a voltage gain of about 330, the output voltage is about 1.8V.

The input impedance at X-X is 200Ω and the output impedance at Y-Y is of the order of 5kΩ.

The frequency response depends to a certain extent on the source impedance. With a 50Ω source a 3dB reduction in gain is reached at 15 c/s and 12 kc/s.

The harmonic distortion (mainly 2nd) is 0.4% for 0.5V output, rising to 2% for 1.8V output.

The current drain is low, about 0.7mA from the 250V supply.

CIRCUIT DESCRIPTION

In both "A" and "B" (Figs. 1 and 2) sufficient d.c. stabilisation is provided by the potential divider R2-R3 and emitter resistor R5 to ensure satisfactory operation up to an ambient temperature of 45°C (110°F).

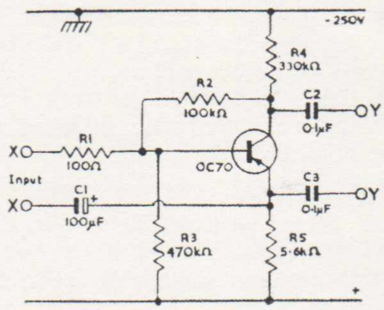


FIG. 1

Besides the d.c. feedback provided by R2 and R5, there is an a.c. feedback path formed by R2. Part of the a.c. voltage developed across the potential divider, made up of R2 and R1 in series with the source impedance, is tapped off and fed back into the base. By including a 100Ω resistor R1 in the a.c. feedback circuit, effective feedback is ensured even when the source impedance is very small. Apart from improving the frequency response and reducing distortion, the a.c. negative feedback decreases the input and output impedances. If thought desirable a.c. feedback can be prevented by making R2 up of two nearly equal resistances and bypassing the common point to ground by a suitable capacitance, of the order of 0.5µF.

Even with a supply voltage as high as 250V the circuit is so designed that the collector to emitter voltage never exceeds the d.c. voltage rating of $V_c$max = —5V for the OC70 under the worst possible combination of conditions. The effect of resistance tolerances (± 5%), supply tolerances, change of ambient temperature, and spread in transistor characteristics have all been considered in the design. For a nominal circuit the collector current is 0.7mA and the collector to emitter voltage approximately 4V. An OC70 with a low current amplification factor α′ and low leakage current I′c(o) in common emitter causes the highset collector to emitter voltage of 5V. A transistor at the other extreme gives a collector to emitter voltage of about 0.8V at the maximum ambient temperature of 45°C, and allows an output of about 400mV r.m.s. under these conditions.

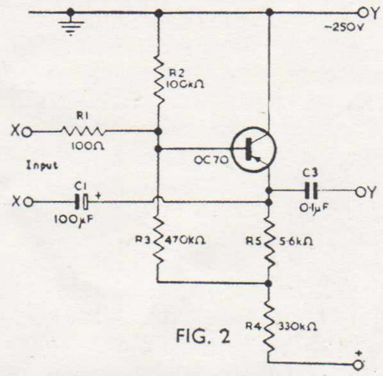


FIG. 2

RESISTOR TOLERANCES

In order to keep available the maximum voltage across the transistor, while allowing a tolerance of ± 10% on the supply voltage, the resistance tolerances should be within ± 5% to prevent the 5V rating from being exceeded. High stability resistors should be used.

INPUT AND OUTPUT CONNECTIONS

In the set up shown at "B" in (Fig. 2) one side of the output is earthed, whereas in "A" (Fig. 1) the input and output are "floating" at some voltage above the chassis.

The input is fed between base and emitter through R1 and C1 so that R5 does not contribute a.c. negative feedback but forms part of the load.

The output in "A" can be taken from between C2 and chassis if desired, but it then becomes slightly smaller than when taken from C2-C3, because R5 no longer forms part of the load.

Although the input terminals in both "A" and "B" are "floating", there should be no risk of hum being introduced provided the preamplifier is mounted reasonably close to the microphone or pickup.

If the circuit is used in the form shown at "A" care must be taken not to short the input terminals to earth. In the arrangement shown at "B" the current through the pickup or microphone will not be excessive if the input is accidentally shorted to earth.

This circuit is similar to that described by J. J. Davidson, in an article entitled "High Gain Transistor Amplifier". ("Audio", October, 1955).

SIMPLIFIED APPROACH TO TRANSISTOR TESTING

With the application of semi-conductor devices to domestic portable radio receivers, hearing aids and the like, the need exists for a simple instrument to enable rapid evaluation of a transistor. Two transistor testers are described in this article, one for testing transistors with dissipations of the 25mW order and one which would enable accurate evaluation of the larger power transistors such as those employed in the output stage of Hybrid auto receivers and other high power amplifiers.

A germanium junction transistor is basically two diodes connected back to back with of course common coupling through the base, and is connected into the circuit in such a manner that the emitter-base diode is biased in the forward direction and the collector-base junction in the reverse direction. Variation of current in the base-emitter circuit produces corresponding variations in the collector-base current, the ratio of these changes being the current amplification factor α in common base configuration. It should be noted that it is the base input current which controls the collector current compared with an electronic valve where the control grid voltage controls the anode current. A transistor may therefore be thought of as analogous to an electronic valve, the emitter corresponding to the cathode, the base to the control grid and the collector to the anode, but with the provision that base input current is the controlling factor and the transistor is a low impedance circuit element.

As we normally employ valves in common cathode connection it is not surprising that we commonly employ transistors in common emitter configuration or that we should test them in this type of circuit. To indicate that this method of connection has been employed the various symbols are affixed with a prime and so α' is the current amplification factor in common emitter configuration and Ico′ the collector leakage current with the base open circuit in common emitter configuration. The current amplification factor α' is somewhat analogous to the mutual conductance (gm) of an electronic valve but there is no analogous measurement for I′c(o). The collector leakage current, however, indicates the useful lower limit of collector current swing as it is the collector current flowing with no base input current. An increase in base input current produces a larger increase in collector current — although strictly the current amplification factor α' is the ratio of these current variations for very small signal excursions—since the transfer characteristic of a transistor is reasonably linear, a close approximation to α' is possible by noting the increase in collector current for a given base input current.

As the collector base junction is a diode biased in the reverse direction it is important that the zener potential of this junction should never be exceeded as otherwise the transistor will be destroyed. The mechanism by which this potential commonly referred to as the turnover voltage V_T may be determined is indicated in figure 1 where a suitable load line intersects the collector characteristic for zero base current.

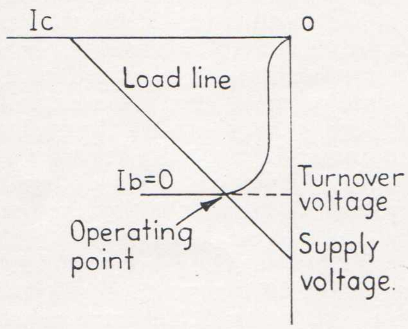


Fig 1.

We thus have three basic measurement circuits which are shown in figure 2.

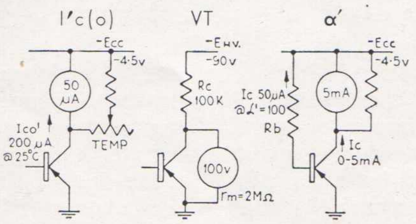


Fig 2

Reference to the characteristics of a wide range of pnp junction transistors shows that a collector supply voltage of 4.5V and a maximum collector current of 5mA is safe for all but the most sensitive VHF types and so the circuit values of the completed instrument have been determined on this basis. In addition some of the switching problems have been eased by placing the 90V battery for the V_T measurement in the emitter rather than the collector circuit whilst a variable shunt for the meter movement when evaluating I′c(o) enables compensation to be achieved for the variation of this parameter with temperature. This variation is such that I′c(o) doubles itself for every 8°C rise in junction temperature and so the measured figure will be dependent upon ambient temperature or alternatively if this variable shunt is adjusted for the ambient temperature the meter will indicate I′c(o) referred to the standard temperature of 25°C. The fundamental range of I′c(o) indication is 200μA at 25°C; two ranges of α' are provided, 0 to 100 and 0 to 200, the latter range to accommodate the higher gain RF types, whilst the turnover voltage indication is direct reading 0 to 100V. Provision is also made for monitoring the condition of the batteries—in the case of the 4½V battery by means of the bat-

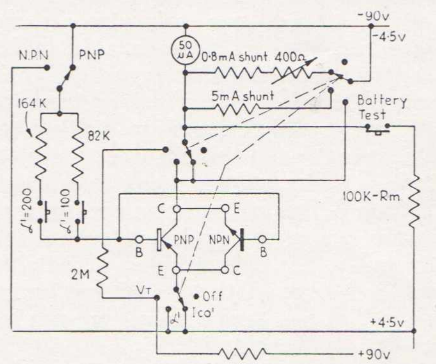


Fig 3.

tery check push button and for the 90V battery by switching to the V_T position with the transistor disconnected. The circuit of the complete instrument is shown in figure 3.

TESTING POWER TRANSISTORS

The testing of power transistors requires a different approach to that for evaluating the smaller amplifying types with collector dissipations of the 25mW order. This is because the drive power requirements of transistors in the 4W and greater collector dissipation class may seriously tax the capabilities of the driver stage whether this be another transistor or a special driver valve such as those developed for Hybrid auto receivers. Not only must the drive power be known but an indication of the mean input impedance is necessary to enable the designer to arrange suitable interstage matching. This is additional to the basic static measurements necessary to evaluate a semi-conductor device, see above, and the methods adopted must take into account the compression in current amplification factor which occurs in power transistors with increasing collector current.

One factor which should always be kept in mind is the current lack of standardisation amongst manufacturers in presenting semi-conductor data and with power transistors in particular the variations in the manner in which data is tabulated are numerous indeed. It is often found, for example, that the collector leakage current is specified either for common base or common emitter operation—but only occasionally for both—and as the current amplification factor at these low levels of collector current is seldom specified it becomes necessary to measure both Ic(o) and I′c(o).

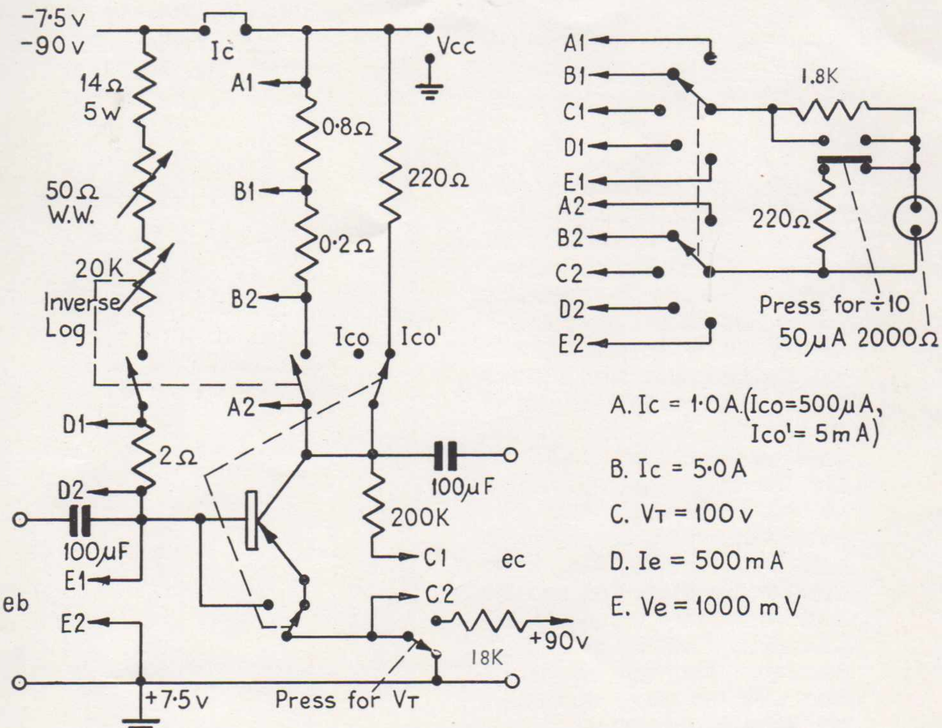


Fig. 4. Circuit diagram of a Power Transistor tester.

The test equipment should also enable the measurement of the current amplification factor at any value of collector current within the ratings of the power transistor, not only because of the variation in operating point from type to type, but to enable the matching of transistors at various points on the transfer characteristic. For this reason the base input current I_B has to be made variable and if this is measured together with the base to emitter voltage V_{BE} the base input resistance of the transistor at a specific operating point may be calculated, as can base input power. It is true that these are steady state constants but if these measurements are taken for the extremes of collector current swing an average value of input resistance and input power may be estimated.

As a power transistor test fixture of this type enables the transistor under test to be set at a pre-determined operating point it is a simple matter to arrange input and output couplings so that alternating signal voltages may be applied and either the hybrid parameters evaluated or dynamic power characteristics measured.

The tests are not complete unless the zener voltage of the base-collector junction V_T is measured as this determines the maximum collector voltage which may be safely applied to the transistor.

The instrument has been designed to accommodate transistors having collector current ratings up to 5 amps, turnover voltage up to 80V, base input current up to 500mA and base to emitter voltage up to 1000mV. At the same time collector leakage current in common emitter configuration up to 5mA is indicated whilst in common base configuration leakage current up to 500µA may be measured. To extend the usefulness of the instrument at lower power levels a press button is provided which divides all meter ranges by a factor of 10. To provide meter protection in the event of a transistor being connected which has a base collector junction breakdown it is suggested that the function switch be left in the V_T position and should an abnormally low reading be recorded the transistor be discarded. It should also be noted that in this position the condition of the internal batteries may be monitored as with no transistor connected the meter will indicate the collector supply voltage, and with the V_T button depressed the potential of the 90V battery.

DEFINITION OF PARAMETERS

Considering the transistor as a four terminal network where e_i and e_o are the input and output potentials and i_i and i_o are the input and output currents, the various parameters may be defined as follows:

The input impedance (with output short circuited to AC)

$$h_{ie} = h_{11}' = \frac{e_i}{i_i}$$

The current amplification (with output short circuited to AC)

$$h_{fe} = h_{21}' = \frac{i_o}{i_i} = \left[\frac{\partial I_c}{\partial I_b}\right] \quad I_b \to o$$

compared with the current amplification factor determined by the DC shift method

$$h_{FE} = \frac{\partial I_c}{\partial I_b}$$

However if ∂I_b is kept reasonably small then,

$$h_{FE} = h_{21}' = h_{fe} = \beta = \alpha'.$$

The voltage feedback ratio (with input open circuited to AC)

$$h_{re} = h_{12}' = \frac{e_i}{e_o}.$$

The output admittance (with input open circuited to AC)

$$h_{oe} = h_{22}' = \frac{i_o}{e_o}.$$

J. R. GOLDTHORP

This article is based on a paper presented before the 1957 IRE Convention in Sydney.

NOTES ON ADJUSTMENT OF ION TRAP MAGNET

An arrow is marked on the magnet assembly so that, when looking along the arrow, the north pole is on the right-hand side. An electron beam travelling between the pole pieces, in the direction of the arrow, will be deflected away from the actual magnet, which is located on the same side of the assembly as the arrow. Conversely, when the beam travels through the pole pieces in the direction opposite to that of the arrow, it will be attracted towards the magnet. Hence there are two possible ways of using an ion trap magnet to make the beam negotiate the bend in the gun; with the arrow pointing towards the screen or towards the base. The following procedure, which has been found to give the better spot size, should be adopted for adjusting the position of the magnet.

(1) (a) With the voltage supplies to the tube switched off and the base socket removed, slip the magnet assembly over the tube base with the arrow pointing *away* from the screen and diametrically *opposite* the position reserved for Pin No. 3 on the base. Adjust the assembly so that it is slightly in advance of the tube base.

(b) Fit the socket to the tube. Switch on the voltage supplies and adjust the brightness control. If necessary, adjust the position of the ion trap magnet until a raster is obtained. Ensure that the picture centering controls are set at zero shift.

(c) Move the magnet assembly along the neck of the tube towards the screen until the raster brightness begins to decrease. Then move the magnet back towards the base until the brightness once more begins to decrease. Return the magnet to the position of maximum brightness lying between these two extremes. The magnet should now be rotated slightly to find the mid-point of the range of rotation which gives maximum brightness.

(d) Lock the magnet in position, taking care not to alter its position.

(2) With the procedure given above more accurate centering of the beam in the final aperture can be produced if the beam diameter is increased by under-focusing.

Where there is penetration of the field of the focus unit into the ion trap region, an adjustment of the focus control will move the electron beam in the final aperture. This movement may be sufficiently large to "black out" the picture. Accurate centering with an under-focused beam reduces this possibility.

(3) The movement produced by the focusing field, and hence "blacking out," may also be reduced by the following additional procedure:—

Note the angle between the centre line of the ion trap assembly set by the procedure in (1), and the plane which passes through the bend in the gun of the cathode ray tube. If this angle is more than ±10°, rotate the magnet in a direction to reduce the angle and compensate any reduction in brightness by adjusting the angle between the focus unit and the tube neck. By successive adjustments, it will be possible to place the ion trap magnet in line with the plane containing the bend of the gun.

SUBMINIATURE TRANSISTORS OC65 and OC66

The OC65 and OC66 have been specially developed for use where small size is a particularly important consideration—for example, in hearing aids. Their length (excluding leads) is 7mm max., and their cross-section is 3.15×3.95mm max. The comparable dimensions for the OC70 and OC71 are: length 15mm max., diameter 5.9mm max.

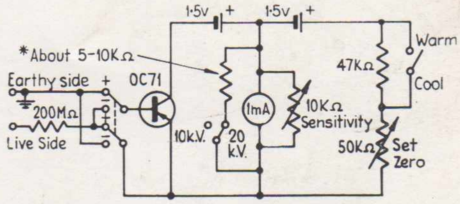
The electrical characteristics of the OC65 and OC66 subminiature types are similar to those of the OC70 and OC71 respectively. Full characteristics of both types are available on application.

AMATEUR EXPERIMENTERS COLUMN

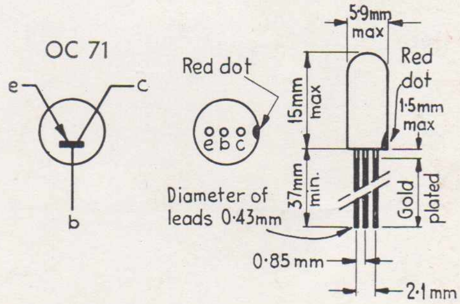
E. H. T. VOLTMETER

Basically the same circuit as that of the transistor voltmeter in the last issue. The circuit is a new approach to the problem of measuring E.H.T. in television receivers. Care should be taken in the construction of the probe containing the 200 MΩ resistor.

A resistor such as the IRC high voltage resistor type MVM 6/200. MΩ ± 2% will suit this circuit.



* 5-10KΩ depends on transistor.



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