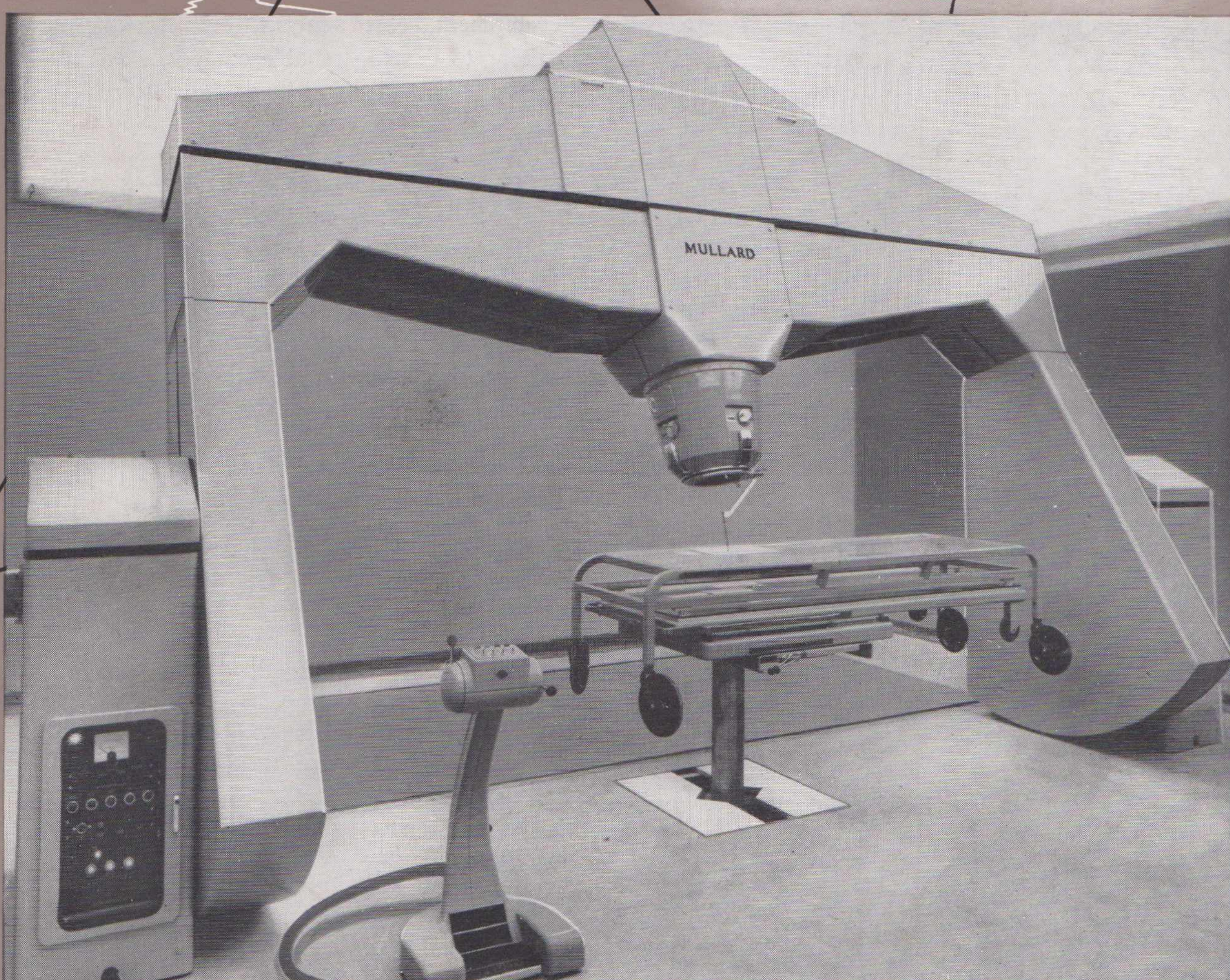
Mullard Outlook

Australian Edition



VOL. 4 No. 6 NOVEMBER-DECEMBER
1961

MULLARD - AUSTRALIA PTY. LTD.

VOL. 4—No. 6 NOV.-DEC., 1961

Editorial Office:
35-43 Clarence Street, Sydney.
Telephone—BX 2006.

Editor:

JOERN BORK

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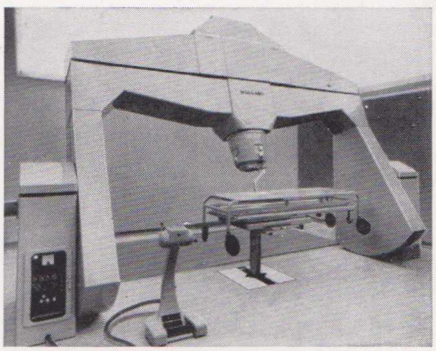

The Mullard linear accelerator, recently installed and commissioned at the Peter MacCallum Clinic in Melbourne. This shows the gantry which, with its 5½ tons of moving weight, may be rotated through an arc of 270°. (See page 64.—Ed.) Photographs on front cover and page 64 by courtesy of Peter MacCallum Clinic.

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APPLICATIONS ENGINEERING

Most devices are developed to fulfil a particular specification and end use—no less valves, electron tubes and semiconductors. Given these key items and other components, the apparatus development engineer is faced with the selection of the units best suited to his particular requirement—be it a broadcast or television receiver, a unit of telecommunications equipment, an industrial device or a scientific instrument.

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VIEWPOINT WITH MULLARD

THE REPLACEMENT TV RECEIVER MARKET

In a previous issue of Outlook, Vol. 4, No. 5, it was suggested that unless transmitting and receiving techniques changed somewhat or progressive and practical measures were taken to encourage the replacement of TV receivers, by 1970 new receiver sales in Australia would not exceed 350,000. This figure already allows for 200,000 receivers in the replacement market, 100,000 in new homes and the remaining 50,000 for second receivers, multiple dwellings and community installations, the quantities being based on natural growth, rate of new homes, the possible immigration rate and so on.

LONG LIFE RECEIVERS

Before considering the replacement market in detail or, for that matter, obsolescence, it is as well that we come to grips with what constitutes the useful life of today's TV receiver. With a few years' experience now tucked under its belt, the Industry is not only producing TV receivers far superior in performance and reliability, but engineering circuit design has shaken down to proven and accepted techniques providing extreme operating stability. Above all, manufacturers have available more reliable components, particularly capacitors and resistors with figures of stability and leakage undreamed of when TV first came to Australia. Much the same goes for the other components, for example, silicon rectifiers having replaced "old faithful" thermionic rectifiers the best of which were, to say the least, sometimes unfaithful apart from dissipating some 30 to 40 watts of heat within the cabinet to aggravate general deterioration, not only to the small electronic components but also cabinet veneers and finishes. Apart from polyester insulated capacitors, there are polyester resin finished cabinets, durable and permanent surface finishes which retain the original lustre without the attention of a fussy housewife. In short, today's TV receiver has perhaps a good, long and useful life of, say, 8 to 9 years at the least.

OBSOLESCENCE

This might be split into two main groups:

(a) "built-in" obsolescence, and
(b) "planned" obsolescence.

Built-in obsolescence in the sense of shorter useful life and planned obsolescence in presentation or some other feature that encourages the purchase of a new receiver. Not that the Australian manufacturers have ever, we believe, deliberately under-engineered components to give a product a shorter life, but in view of the great strides made in component development in the last few years, it can be claimed that although the manufacturers did not know it at the time, the early receivers had built-in obsolescence to some degree.

Given higher quality components and other factors more or less equal, by far the most important element of obsolescence is appearance or appeal and an outstanding example of planned obsolescence is womens' fashions, with the ultimate four new wardrobes a year, each year and every year, and the strong possibility that in some irrational period, maybe 10, 15, 20 or more years, fashion is back where it started, although in the meantime the manufacturers are thankful for their allies—the moths!

NEED FOR FRESH APPROACH

Using dress in a different sense, the automobile industry if they are on what appears to be a winner, add an embellishment or two and dress up the same body tools year after year, but conversely are likely to do the same thing if the sales of a particular model are slow and use it as a stop gap until a complete new model is released.

This, today, is apparent in the consumer products market generally and with special emphasis on TV, to an extent that continuance with the same trimmings, for example, escutcheon mask, knobs and so on, can have a diverse and odd effect on sales, not so much on the consumer but the salesman, where familiarity breeds contempt and there is greater interest for him in selling a newly introduced model with a freshness that has planned obsolescence, so catering for the salesman's enthusiasm as much as the potential owner.

An overseas journal recently pointed out that if the public is able to afford and happens to desire new things—and if manufacturers are willing and free to supply them—the result is a continuing flow of new products. Inevitably, existing products become obsolete in the process . . . the alternative of obsolescence is stagnation.

Continued on page 72.

MULLARD-AUSTRALIA PERSONALITIES

MR. H. S. WATSON

Mr. H. S. Watson heads our Applications Engineering team and is a member of the Management Executive of the Company.

Born in the Murrumbidgee area of N.S.W., he has travelled far and wide since that time. Following his discharge from the Navy, he has been actively engaged in TV design for some 13 years, firstly with the U.K. 405 line system and then with the C.C.I.R. system since its inception in 1950. This, coupled with further design experience in telemetering and defence communication equipment, provides a fund of sound experience in application engineering and techniques particularly suited to the Australian environment.

The Editorial in this issue deals in some measure with applications engineering. The key factor being not only acquainting manufacturers with the capabilities of our valves, semiconductors and other goods, but assisting them with their engineering problems. Based on the applications service existing over the past thirty years of our Parent Company, Mullard Limited, London, Mr. Watson's Department continues this tradition of a service that directly and indirectly benefits the end user, the retailer and the manufacturer.

4,000,000 ELECTRON VOLTS
FOR THERAPY AND MEDICAL RESEARCH

Recently installed at the Cancer Institute of the Peter MacCallum Clinic in Melbourne, a 4 MeV (million electron volt) linear accelerator, manufactured by Mullard Equipment Limited of England, will be used in medical research and deep-ray therapy.*

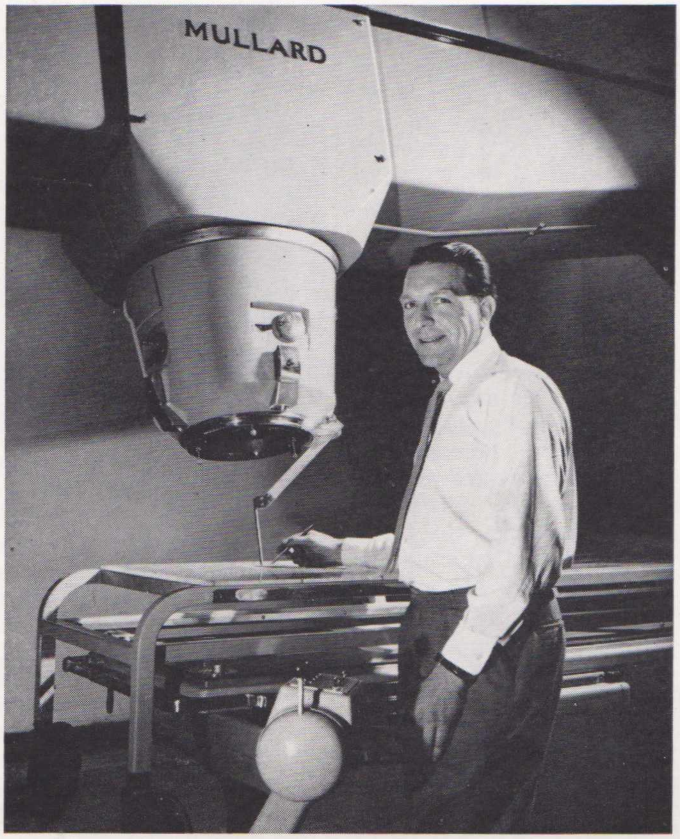
In these days of spectacular scientific advances, when rockets and satellites, radio telescopes and nuclear power stations make everyday news, the less publicised achievements of medical science tend, perhaps, to slip by unnoticed; yet these achievements are among the most outstanding events of the age. During the past few years they have made possible the suppression of such killing diseases as malaria and tuberculosis. Medical research scientists have discovered and developed new drugs to relieve pain and new treatment techniques that have materially increased the life-expectancy of man. Sometimes a new discovery, such as the Salk poliomyelitis vaccine, becomes a public talking-point. Usually, however, the struggle against disease goes along quietly, inch by inch, and the public rarely realises the significance of each small but vitally important step. Today, medical science has a powerful ally in electronics, whose own development has been equally remarkable in recent times. Electronics has already made possible some of the most advanced medical techniques and is an increasingly important factor in the progress of medicine.

**An electron volt is the energy gained by an electron when accelerated through a potential difference of one volt.*

The linear accelerator has a number of advantages in deep-ray therapy over cobalt 60. For instance, the high power available reduces the treatment time per dose, thus enabling the treatment of many more cases per day than available by previously established techniques. The high degree of accuracy available in controlling the dosage rates allows a maxmium of flexibility and, together with the fine adjustment possible, allows the X-ray beam to be directed on to the malignant tissue with a tolerance as low as 1 mm., resulting in a minimum of external skin damage.

PRINCIPLE OF OPERATION

The electrons are injected from an 'electron gun' into the first section of the accelerator in a series of 'bunches' at a velocity of about 0.4 times the speed of light. They are accelerated to a velocity approaching the speed of light in the main section of the accelerator which consists of a circular corrugated waveguide. They then receive a forward acceleration due to the influence of the axial component of the electric field of a radio-frequency wave, generated by a tunable magnetron developing a peak energy of 2 million watts in pulses of 2 microseconds' duration.



Mr. A. O'Connor indicates the X-ray head pointer which is used to ensure correct positioning of the beam.

ELECTRON VELOCITY

As the electrons pass through the central aperture of each corrugation they gain speed finally acquiring an energy equivalent to that obtained with a potential of 4.3 million volts. The axial path of the electrons is maintained by a magnetic field produced by a series of focussing coils mounted externally along the length of the waveguide. The corrugated waveguide has a length of only 1 metre, the whole of the accelerating process taking place over this distance. Thus, apart from a 50 kV injection potential applied to the electron gun (pulsed by the modulator which drives the magnetron), the electrons are accelerated without the use of high voltage.

MEDICAL APPLICATION

For medical purposes the accelerated electrons are caused to strike a heavy metal target producing extremely penetrating X-radiation under closely controlled conditions. Alternatively, by replacing the target with a thin metal "window" electrons may be extracted and used for deep ray therapy. The linear accelerator shown on the cover of this issue is supported by a gantry housed in a special building designed to give complete protection against stray radiation. The radiographer's control console has been specially designed for simplicity of operation and to differ as little as possible from the control desk of a more familiar therapy machine. The controls include dose rate meters, dose meters, dose setting controls and a timer, as well as those necessary to indicate and govern the movement of the couch and gantry during arc and rotation therapy treatments.

There is still much to be accomplished in the study and treatment of tumours in the human body. Indeed it is only in recent years that any positive progress has been made and today medical scientists are increasing their efforts still further in attempting to solve this problem. The linear accelerator provides medical scientists with greater opportunities for success in this field of research and may well lead to the eventual elimination of this most virulent threat to man's health and long life.

The Mullard linear accelerator at the Peter MacCallum Clinic was installed by Mr. A. O'Connor, a Mullard Equipment Limited project engineer visiting Australia for this express purpose. Mr. O'Connor has travelled widely on company business of this kind and, as he himself has said, is a scientist, an engineer, cost accountant, salesman and general handyman, all in one. He recently visited Japan arranging for the supply of a complex electronic unit and after leaving Australia will travel to Russia to install a linear accelerator in Leningrad.

The installation of a new Mullard linear accelerator makes the Peter MacCallum Clinic the first in the Southern Hemisphere to operate two units. The first machine was installed in 1956 and the addition of the Mullard unit results in this Centre being one of the best equipped in the world. This, in effect, will enable the Peter MacCallum Clinic to add even further distinction to its already worldwide fame.

CORDLESS TRANSISTOR RADIOGRAM

The unit described is designed to satisfy the requirements for a portable radio-gramophone receiver, having adequate RF sensitivity with a Ferroxcube aerial rod and, in the gramophone application, high gain and high input impedance.

The receiver is basically a modification of that described in the previously published article, "A Cordless Transistor Receiver" (Mullard Outlook, Vol. 4, No. 3, May-June, 1961).

In order that the audio stages of the receiver may be used as a gramophone amplifier for a crystal pick-up cartridge, a pre-amplifying stage is required ahead of the audio driver stage. As this pre-amplifying stage must also serve as a DC power-amplifier for AGC, in which application it is connected as an emitter-follower, it is convenient that it should operate as an emitter-follower in the audio application. Although there is then no voltage gain, a high input impedance and useful power gain are obtained. These are, of course, essential in the gramophone amplifier, and they can be exploited in the radio application to present a high impedance to the diode detector, with substantial equality between the DC load and the AC load. In this way the overall receiver sensitivity is improved and there is less detection distortion.

The output impedance of an emitter-follower amplifier is relatively low, being roughly equal to $\frac{1}{\beta}$ times the source impedance. It is desirable, however, that the driver transistor should be driven from a reasonably high source impedance, of the order of, say, 5 kΩ. This may be satisfied on gramophone operation provided that the source impedance to Tr3 (the pre-amplifying transistor) is sufficiently high. For this reason the feedback capacitor from the emitter-follower output (C16) is connected to the DC biasing potential divider network R13, R14, R15, so as to increase the apparent impedance of R13 and avoid any shunting effects by this network. By the same means the input impedance at the base of Tr3 is raised, increasing the power gain of the pre-amplifying stage by comparison with what would be achieved with a simple DC biasing network.

Negative current feedback, proportional to the output voltage, is used over the driver and output stages. Some 6dB of negative feedback is applied in gramophone operation, but on radio, with the volume control fully advanced, only about 3dB of negative feedback is applied, because of the much lower output impedance at the emitter of Tr3 under this condition. Reducing the volume-control setting increases the negative feedback to approximately the same figure as on gramophone operation.

It will be noted that on gramophone operation the mean current of Tr3 is much less than on radio operation and the AGC circuit is disconnected. On the other hand, the DC biasing network R13, R14, R15 has negligible effect on radio operation.

Components

The new specifications for the demodulator transformer, are as follows:—

Demodulator Transformer T4

Scramble-wound on Ducon miniature pot-core assembly.

Wire: 0.0032″ en. cu. single rayon covered.

Primary (wound first): 45 turns
Secondary : 90 turns

All other wound components are identical to those used in the Cordless Transistor Receiver. Values of the additional resistors and capacitors are included in the circuit diagram.

Summary of Performance

1. Radio Operation:

Sensitivity (50 mW output):

600 kc/s:	80 μV/m
1000 kc/s:	75 μV/m
1400 kc/s:	70 μV/m

RF bandpass characteristics at 1 Mc/s:

+20 kc/s	=	—53.0 dB
+10 kc/s	=	—31.0 dB
+3 kc/s	=	—5.3 dB
0 kc/s	=	0 dB
—3 kc/s	=	—6.9 dB
—10 kc/s	=	—31.5 dB
—20 kc/s	=	—48.5 dB

AGC characteristic at 1000 kc/s:

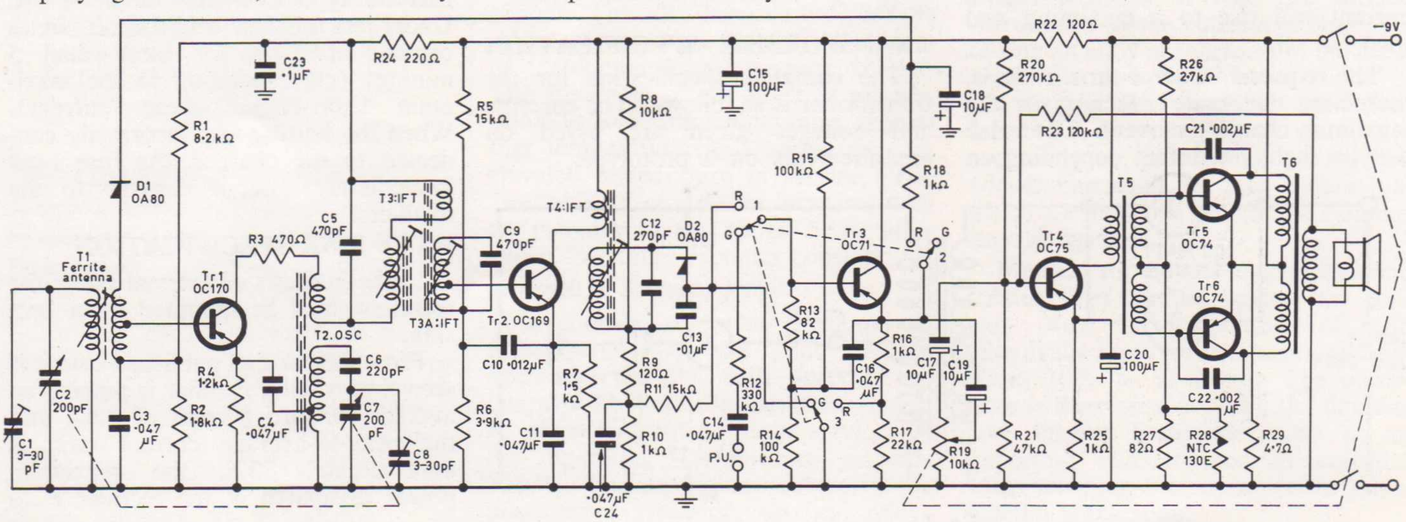
Field Strength (mV/m)	Level (dB)
1000	0
10	— 7
1.0	— 14
0.1	— 37

Noise performance:

S/N ratio at 100 μV/m: 18.5 dB
1.0 mV/m: 40 dB

2. Gramophone operation:

Input impedance : 380 kΩ
Sensitivity (200 mW): 102 mV
Frequency response:
(—3 dB points relative to 200 mW at 1000 c/s): 120 c/s to 7800 c/s.



PROTECTED BATTERY CHARGER

This article describes a practical battery charger, suitable for use by car owners or in small garages. Either 6V or 12V batteries may be charged directly from the output terminals without switching. Accidental short-circuiting of the output is taken into account. The rectifiers used are two Mullard BYZ13 silicon junction diodes. On a practical heat sink 3A per rectifier can be readily obtained. With two rectifiers connected in a full-wave circuit the total charging current can then be up to 6A.

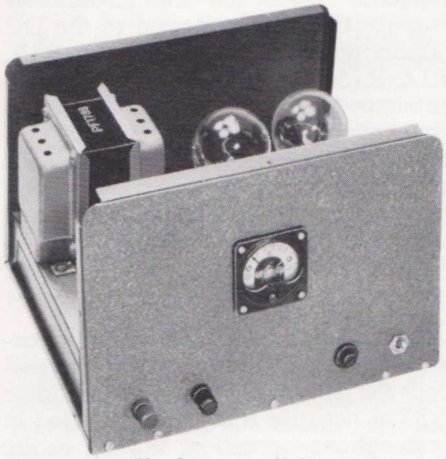
The circuit used for the battery charger is shown in Fig. 1. Full-wave rectification is produced by means of a transformer with a centre-tapped secondary winding supplying two BYZ13 rectifiers. Protection of the rectifiers under short-circuit conditions is obtained by including a high resistance in series with the primary of the transformer. Thus, if the output is accidentally short-circuited, most of the supply voltage will be dropped across the resistance, and the output current will be limited to a safe value for the rectifiers in the secondary circuit.

To reduce cost, lamps rated at the normal mains voltage are used as the resistance in preference to an expensive high-wattage resistor. An additional advantage of the lamps is that as the primary current increases, their resistance increases (Fig. 2) thus decreasing the voltage drop across the primary and limiting the secondary current still further.

CIRCUIT DESIGN

When a circuit of this type is used, the transformer primary current is virtually constant because of the limiting effect of the lamp resistance. Thus, for an increase of secondary current, the value of n (that is, the ratio of secondary turns to primary turns) must be decreased. If n is made too low, however, the voltage available at the secondary can become less than the voltage of the battery, thus giving no charging current. Therefore, as the turns ratio is decreased, the charging current will rise to a maximum and then fall off.

The required value of turns ratio is, therefore, the value which gives the maximum charging current. The value will be slightly different depending on



The Prototype Unit

whether a 12V or 6V battery is being charged. Since 12V batteries are now predominantly used in motor cars, the required value of turns ratio has been considered as that needed for a 12V battery; but there is only a small difference in the charging rate when the charger is used with 6V batteries.

CHARACTERISTICS OF LAMPS IN PRIMARY CIRCUIT

The charge usually required for a 12V battery is between 3 and 4A. A preliminary calculation shows that two 100W lamps connected in parallel and placed in series with the transformer primary winding should be suitable for this output current.

The resistance of two 250V 100W lamps taken at random and connected in parallel, is shown in the graph of voltage and resistance against current in Fig. 2.

TRANSFORMER SPECIFICATION

The complete specification for the transformer is as follows. The currents and voltages given are based on measurements on a prototype.

Input voltage	150	V
Off-load primary saturation current (with 220Ω lamp resistance in series with primary)	0.6	A
Turns ratio (primary to each half of secondary)	0.094	
Primary current	0.75	A r.m.s.
Secondary current (to allow for increased current when charging a a 6V battery)	4.5	A r.m.s.

In order to obtain satisfactory performance it is essential to conform to the above specifications.

Major Australian transformer manufacturers have produced transformers which have been approved by the Mullard Applications Laboratory.

CHECK ON RECTIFIER PERFORMANCE

With a 250V supply and a 12V battery, $I_{pk} = 7.97A$.

The peak current under short-circuited output conditions was 11.18A with 250V input. The corresponding value of the mean current under similar conditions was 7.54A.

The BYZ13 rectifiers are thus working within their limits under the worst possible conditions which may occur.

FUSE SPECIFICATION

Tests were carried out and a suitable fuse was found to be the English Electric type Z509112 rated at 5A. Under test this fuse held a short-circuit current of 7.1A for more than 5 minutes (corresponding to the maximum short-circuit mean current). When the battery was incorrectly connected to the charger, the fuse blew immediately without damage to the rectifiers.

HEAT SINK SPECIFICATION

In the interests of thermal safety the rectifiers must be mounted on a heat sink.

From the BYZ13 published data it is seen that when a rectifier is passing an average forward current of 2.8A and the peak-to-average current ratio is approximately 3.6, the maximum power dissipated in the rectifier P_{total}

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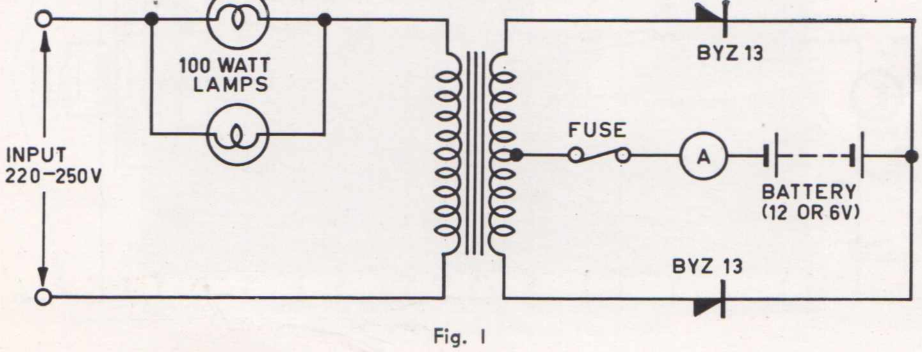

Fig. 1

"BACK TO TAWS"

This article was prompted by the sight of an elderly craftsman sitting on the side of the road wiping a lead sheath. He had nothing to aid him but a small metal tube, a stick of solder and a lighted candle. By blowing through the tube into the candle flame, the solder was melted; and using the molten wax as a flux, the job was quick and the finish perfect.

SOLDER

It is not often we have the opportunity in this machine-age of watching a craftsman from the old school at work and it prompted us to dust down our school books for a refresher course on the subject of solder.

Soldering, one of the oldest methods of joining, is an exacting and often time consuming operation. Like a boy scout and his knife, the technician and his iron seem to belong together, yet we rarely give the subject much thought.

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is 8.9W. With this maximum power dissipation the BYZ13 data sheet also states that the mounting base temperature (T_{amb}) must not exceed 97°C.

Tests have shown that a blackened vertical aluminium heat sink, measuring 6in x 6in and made from 16 s.w.g. sheet, with both rectifiers mounted on the centre line and 3in apart, is quite satisfactory.

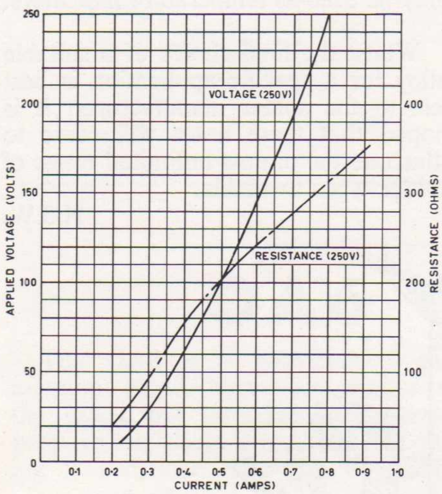


Fig. 2

COMPONENT PARTS LIST

Semiconductors:	Two Mullard BYZ13's
Incandescent lamps:	Two 250V 100W
Transformers:	Ferguson PF1788 National D8395 A & R PT2215 (or equivalent types)
Fuse:	English Electric Type Z590112 rated at 5A (or equivalent type)
Meter:	Paton Type RN216 (or equivalent type)
Heat Sink:	As described

Chassis, hardware, etc., as required.

Figure 4 illustrates the range of soldering alloys available today in order of temperature with the temperature of the base metals also given to show the marked change in melting point after alloying. The range is by no means complete as each solder manufacturer can offer a wide range of alloys for special applications. The alloys illustrated in Figure 4 are the better known types which may be used for electrical purposes and solder readily with non-active fluxes. For example, high temperature silver solder has not been included as the soldering technique is different and the melting point of 650°C makes electrical jointing difficult.

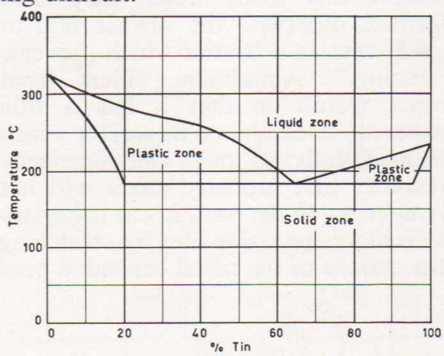


Fig. 1

TIN/LEAD ALLOYS

Alloying or "wetting" of the joint.

The most common type of solder used in electrical equipment is tin/lead alloy. Tin "wets" copper very well because of their mutual solubility thus forming an alloy layer with the copper. The alloy layer varies from the solder composition through all phases of tin/copper alloys to pure copper. The thickness of the layer is proportional to soldering temperature, time at that temperature, and ageing time at elevated temperature in service. The "wettability" of a solder increases with an increase in tin up to 50% after which "wetting" becomes constant.

Strength of soldered joints.

In choosing a solder it should be remembered that the joint strength decreases rapidly with increase of temperature and consideration should be given to joint stress in service. If the operating temperature exceeds 120°C in assemblies subjected to pressure or vibration, tin/lead alloys

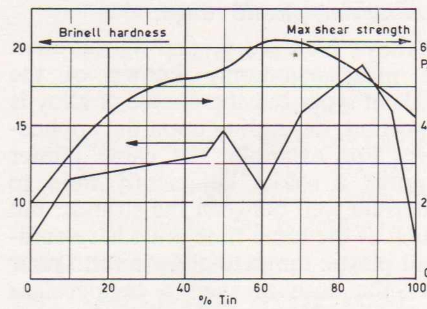


Fig. 2

are likely to be unreliable and a special high temperature alloy such as No. 3 should be used. Figure 3 illustrates the decrease in strength at high temperatures. The shear strength figures are obtained from rapid tests at .060"/min. but over long periods soldered joints will creep and as a general rule the maximum load applied should not exceed 5% of the shear strength.

Eutectic point.

The eutectic state is the point of alloying at which the mixture becomes completely homogeneous. The melting point is below that of each of the constituents and is well defined. Below this temperature it is solid; above it, the alloy is molten, with a complete absence of a plastic state.

In the case of tin/lead alloys the eutectic state occurs with a 63/37 alloy but if the lead content is increased excess particles of lead are formed surrounded by the eutectic mixture. On raising an alloy of this form to the melt-point the eutectic mixture melts at 185°C; the lead particles then float forming a pasty or plastic state until eventually a temperature is reached (depending upon the lead content) at which the lead melts and the liquidus state is reached.

Figure 1 shows both the liquidus and solidus lines plotted against tin content. Note the temperature of solid alloy is the same for compositions from about 20% to 97% tin. The plastic state is the region between the liquidus and solidus boundaries and is an important characteristic to consider when selecting a composition to suit a specific application.

Figure 2 shows the effect of tin content on the Brinell hardness and shear strength. The maximum shear strength occurs at the eutectic point, but the maximum hardness occurs at 83% tin. Note the sharp difference in hardness between 50% tin and 60% tin compositions.

Fluidity and plastic range.

Alloys Nos. 4, 6, and 7 represent the most commonly known of the tin/lead types but the choice of alloy is important, depending upon the application. For example, the cable jointer requires a solder sufficiently fluid to penetrate well between the strands, but which at the same time must have sufficient plastic range to allow him to pour over the core at such a temperature that it will start to set between the cable and the ferrule before running out. For this purpose the jointer would probably choose an alloy between 50/50 and 40/60.

Solders for wiping need to have a very long plastic range in order that the jointer has sufficient time to complete the wipe, but at the same time the molten solder must adhere well to the sheath. The jointer would probably choose an alloy between 40/60 and 30/70 for this work.

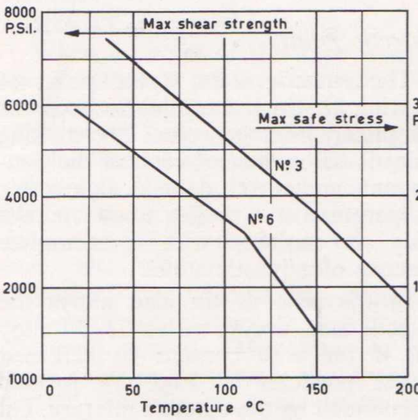


Fig. 3

For hand soldering of electronic equipment a lower melting point together with good fluidity is desirable in order that the solder will penetrate the joint in the shortest possible time and for this reason a 60/40 alloy is usually chosen. On the other hand, a solder with a larger plastic range is desirable for printed circuit boards due to the nature of the joint and to allow time to shake off the excess, and so an alloy between 60/40 and 50/50 would be chosen.

SOFT SOLDERS FOR ELEVATED TEMPERATURES

Alloys Nos. 1, 2 and 3 are representative of the high temperature soft solders suitable for electrical equipment operating at temperatures of 120°C to 150°C. No. 1 is simply the lead/silver eutectic state (304°C) and consequently has no plastic range. This is a rather difficult solder to use and is usually restricted to the hot dipping process. Alloy No. 2 contains 5% tin and "tins" more readily than No. 1. It can be used with a non-corrosive flux and finds use in hot dipping of commutators and other electrical equipment. Perhaps the most interesting of the high temperature solders is the tin/antimony alloy (No. 3), which can be used in place of tin/lead solder and is easily applied with a conventional hand iron. This type of solder is useful for all electrical equipment designed for 120°C operation.

SOLDERS FOR ALUMINIUM

When metals such as copper or brass are soldered, a flux is used to provide protection against oxidation and to remove any oxide which may have formed, otherwise the surface film of oxide acts as a barrier which prevents "tinning." Aluminium differs from other metals in that it has a thin coherent oxide film on its surface which forms rapidly; so tough and chemically resistant that ordinary fluxes will not remove it. In the past, it was necessary to remove the oxide film by scratching the surface of the metal beneath a pool of solder in order that the surface would tin before reoxidation could take place, however, fluxes and solders are now available which make aluminium soldering almost as easy as tin/lead soldering of copper. Solder suitable for aluminium is usually a tin/lead/zinc alloy represented by No. 5. The alloy indicated in the diagram has a high liquidus temperature but would have good capillary flow characteristics due to the large plastic range and would be an excellent choice for aluminium cable jointing. Alloys are available with a shorter plastic range (170°C-176°C) with which hand iron soldering is possible.

LOW TEMPERATURE AND FUSIBLE ALLOYS

The fusible alloys shown in Figure 4 (Nos. 8, 9, 10 and 11) make excellent soft solders and can be applied in the same way as tin/lead alloys. Low temperature alloys are often required where materials such as plastics, fabrics, lacquer or glass are easily damaged by heat. They are often used for glass to metal seals and are also used extensively for casting and pattern making. Eutectic alloys in this range exhibit a sharply defined melting point and for this reason are often used as safety plugs or fuses and also may be used as temperature indicators.

Whilst the final choice of a suitable alloy for a specific application is best left to the solder manufacturer, it is hoped that these notes will serve to illustrate the almost unlimited range of solder types available.

H.S.W.

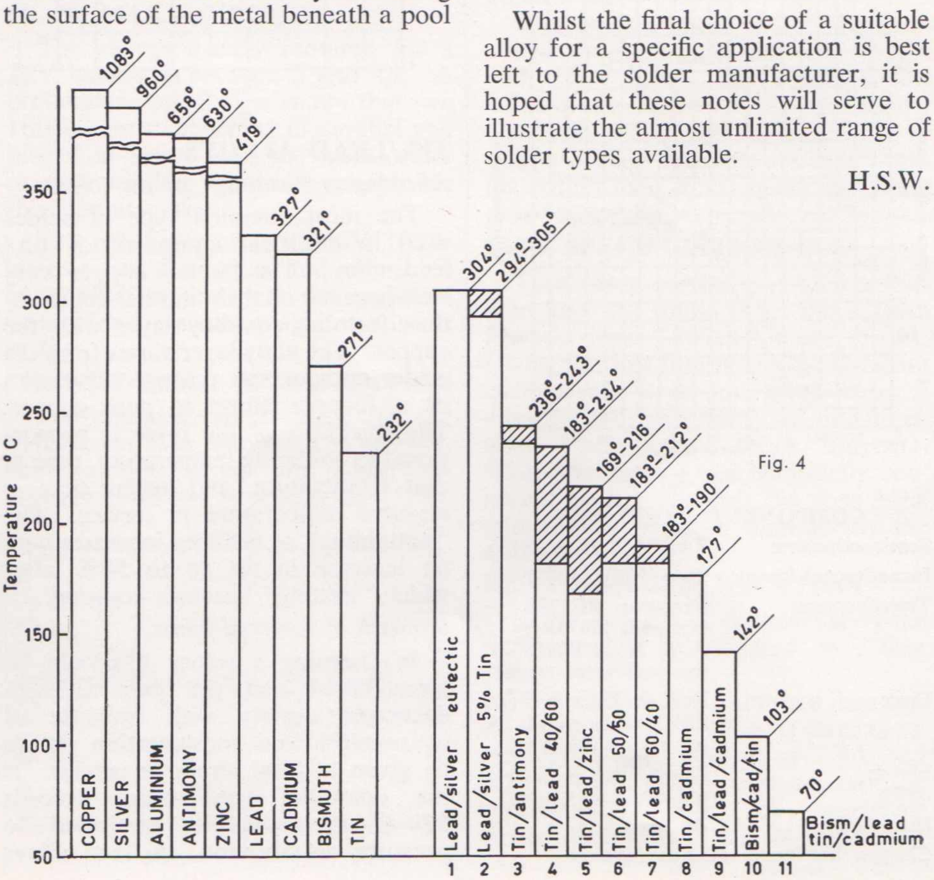


Fig. 4

PRE-AMPLIFIERS USING THE AC107 LOW NOISE TRANSISTOR

The Mullard AC107 is a low noise, high cut-off frequency transistor specially suited for use in input stages of sensitive audio equipment. Such pre-amplifiers can be designed to work from magnetic microphones, magnetic pickups, crystal pickups and similar devices, and to feed into transistor stages or valve amplifiers.

Completely versatile pre-amplifiers, similar to valve pre-amplifiers, can be designed using the AC107. But, in common with all pre-amplifiers and particularly those using transistors, improved overall sensitivity and signal/noise ratio can be achieved if they are designed to meet specific requirements.

Two pre-amplifiers are described as typical examples of various considerations affecting circuit design.

PRE-AMPLIFIER FOR A MAGNETIC PICKUP (Fig. 1)

This pre-amplifier is designed to feed into a valve amplifier. The circuit is therefore selected to give maximum voltage output. The loading on the pickup is chosen (by suitable operating conditions and series input resistor) to give a high effective output; that is, one not requiring much further equalisation later in the amplifier.

Collector current: 600μA

Max. ambient temp. for satisfactory operation: 45°C

Supply voltage: + 50V ± 10V

Pickup characteristics:

L = 500mH

R = 800Ω

Output voltage (o/c) 8mV at 4 cm/sec

Pre-amplifier output:

Output level at 4 cm/sec = 550mV

Equalisation (to RIAA characteristic) within 2.5dB of lkc/s level from 40c/s to 12kc/s

Harmonic Distortion:

< 0.1% at 0.5V output

< 0.3% at 3.0V output

Signal/noise ratio with reference to 1kc/s output of 500mV is better than 66dB (with filter simulating ear response)

TWO TRANSISTOR PRE-AMPLIFIER WITH TONE CONTROLS FOR CRYSTAL PICKUPS (Fig. 2)

This pre-amplifier is designed to feed into a transistor amplifier. The two transistors are direct coupled, and overall DC feedback stabilises the operating currents of the transistors. Tone control circuits in the AC feedback path provide bass boost and top cut.

Supply voltage: —7V

Collector currents:

1st transistor: 250μA

2nd transistor: 850μA

Overall current gain: 100 at 1kc/s

Harmonic distortion at 100μA output < 0.3%

Tone Control Characteristics:

Max. bass boost 15dB at 50c/s

Max. top cut 13dB at 15kc/s

Fig. I

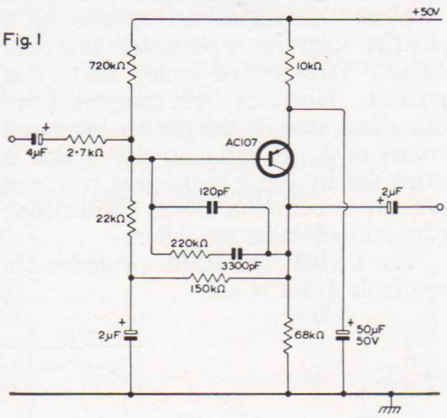
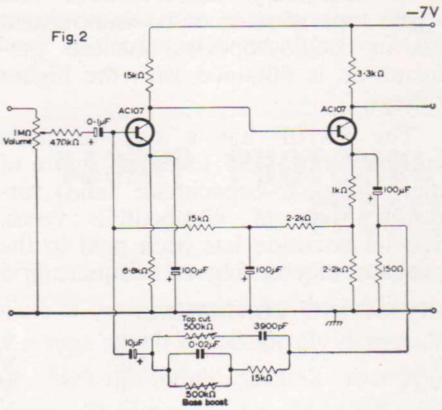


Fig. 2



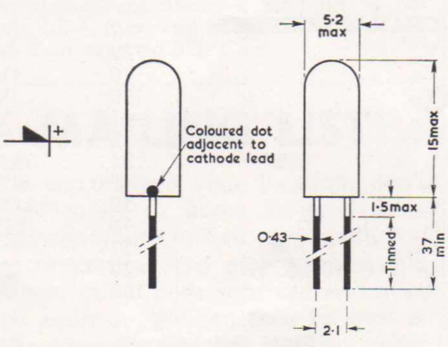
OA6 GOLD-BONDED DIODE

The OA6 is a gold-bonded germanium diode, somewhat similar to the OA5, but intended for general-purpose use where a medium PIV rating is sufficient. For the OA6, the maximum PIV is 60V at an ambient temperature of 25°C, as compared with 100V for the OA5.

The typical reverse current at max PIV is only 3 μA at 25°C.

The OA6 represents an economical solution where the full PIV rating of the OA5 is not required.

The OA6 is available from stock.



ABRIDGED PRELIMINARY DATA FOR OA6

Ambient Temp. = 25°C

Max reverse voltage (pk or DC)	60	V
Max forward current		
Peak (at max PIV)	350	mA
Average (over any 50ms period, or DC)	115	mA
Storage temperature limits	−55 to + 90	°C
Max forward voltage		
At forward current of 10mA	550	mV
At forward current of 200mA	1·0	V
At forward current of 300mA	1·25	V
Max reverse current		
At reverse voltage of 10V	6·0	μA
At reverse voltage of 50V	9·0	μA

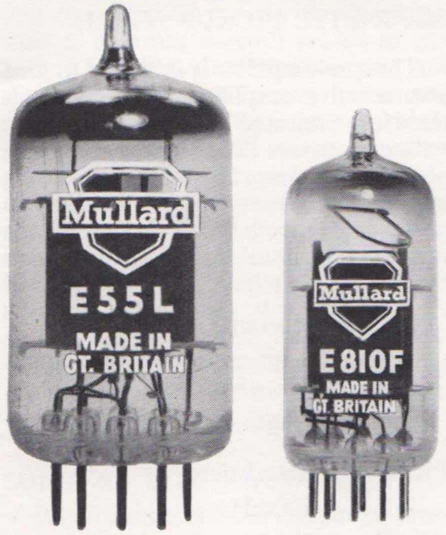
SPECIAL QUALITY WIDEBAND OUTPUT PENTODES

E55L and E810F

The E810F and E55L are special quality high-slope RF pentodes which are intended for general industrial use. They are of particular interest to designers of wideband amplifiers for use in oscilloscopes or other applications.

In oscilloscope amplifiers, if it is necessary to achieve a wide bandwidth, a large swing in anode current must be allowed for. For a high anode current, a fairly large cathode surface is required. Since the internal capacitances of the valve are then relatively great, the slope of the valve must be as high as possible to obtain the most favourable slope-to-capacitance ratio. In the E810F and E55L this is achieved by means of a frame grid structure for the control grid. In addition, a favourable I_a/I_{g2} ratio is achieved by the use of a frame grid structure for the screen grid, the ratio being considerably better than that of conventional pentodes having the same order of c_{a-g1}.

Both types have been developed with long-life requirements in mind. In this connection, alternative maximum cathode current ratings are included in the data. Where very long life is a primary consideration (for example, in telephone repeaters) the lower cathode current ratings should be observed.



But for applications in which long life is a secondary consideration, and where operation may be intermittent (as in oscilloscopes), enhanced performance is obtained with the higher ratings.

The E810F has a slope-to-anode current ratio of 1·5:1, and its figure of merit (slope-to-capacitance ratio) surpasses that of competitive types. Special attention has been paid to the problem of ensuring an adequate grid base which will enable the valve to handle relatively large signal voltages without running into grid current. Thus a limitation which is met in some conventional pentodes has been overcome in the E810F.

While the figure of merit of the E55L is lower than that of the E810F, it still exceeds that of any other available pentode capable of operating at a maximum anode dissipation level of 10W. Both types show a restricted spread in characteristics, a favourable microphony level, and stability of characteristics when switching from low to high anode current.

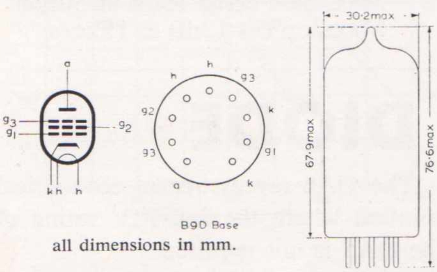
When the E55L and E810F are used in cascaded amplifier stages, it is possible to construct amplifiers with bandwidths and pulse response rise times comparable with those which were previously only realisable by the use of distributed amplifier techniques.

When the valves are driven by a positive step function some low frequency variation of anode current is present. However, the magnitude of this effect, despite the greatly increased values of g_m, is less than that which is exhibited by other multi-grid valves at present in common use in oscilloscope vertical deflection amplifiers.

The E810F and E55L pentodes are available from stock.

E55L

ABRIDGED PRELIMINARY DATA



all dimensions in mm.

HEATER

V_h	6.3	V
I_h	600	mA

CAPACITANCES

	Unshielded	Shielded	
c_{a-g1}	110	80	mpF
c_{in}	18	18	pF
c_{in} (I_k = 55.5mA)	28	28	pF
c_{out}	4	6	pF

CHARACTERISTICS

V_a	125	V
V_{g2}	125	V
V_{g3}	0	V
V_{g1}	—3.0	V
R_k	0	Ω
I_a	50	mA
I_{g2}	5.5	mA
g_m	45	mA/V
r_a	20	kΩ
μ_{g1-g2}	30	
r_{g1} (f = 50Mc/s)	1.0	kΩ

OPERATING CONDITIONS

V_{a-e}	140	V
V_{g2-e}	140	V
V_{g3-k}	0	V
V_{g1-e}	+12	V
R_k	270	Ω
I_a	50	mA
I_{g2}	5.5	mA
g_m	45	mA/V

LIMITING VALUES (absolute ratings)

$V_{a(b)}$ max.	400	V
V_a max.	200	V
p_a max.	10	W
$V_{g2(b)}$ max.	350	V
V_{g2} max.	175	V
p_{g2} max.	1.5	W
—V_{g1} max.	55	V
+V_{g1} max.	0	V
*I_k max.	75	mA
R_{g1} max.	125	kΩ
V_{h-k} max.	200	V
*T_{bulb} max.	180	°C

*In applications where a long life is not required, I_k max. can be increased to 100mA and T_{bulb} max. to 220°C.

E810F

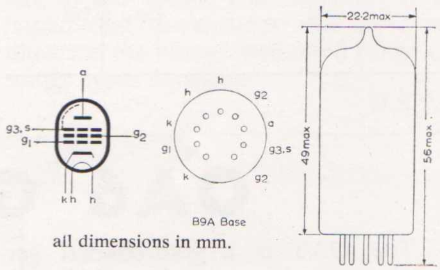
ABRIDGED PRELIMINARY DATA

HEATER

Suitable for parallel operation only, AC or DC

V_h	6.3	V
I_h	340	mA

The maximum variation of heater current at 6.3V is ±17mA.



all dimensions in mm.

CAPACITANCES

	Unshielded	Shielded	
c_{a-g1}	32	28.5	mpF
c_{in}	14.5	14.5	pF
c_{in} (I_k = 40mA)	23	23	pF
c_{out}	3.5	4.1	pF

CHARACTERISTICS

V_a	120	V
V_{g3}	0	V
V_{g2}	150	V
V_{g1}	—1.9	V
R_k	0	Ω
I_a	35	mA
I_{g2}	5.0	mA
g_m	50	mA/V
r_a	70	kΩ
μ_{g1-g2}	57	
r_{g1} (f = 100Mc/s)	420	Ω
R_{eq}	100	Ω

E810F Data continued on Page 71.

AFZ12 VHF TRANSISTOR

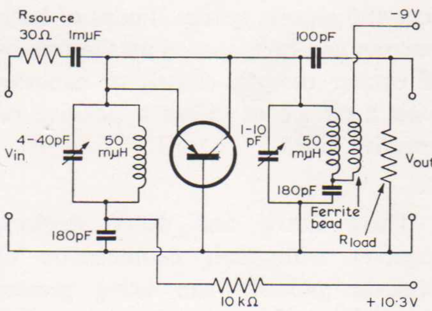
Since introducing the "alloy diffusion" method of transistor manufacture Mullard production techniques have been perfected and this has resulted in another important new germanium junction VHF transistor—the AFZ12.

The noise level at 200Mc/s is low and the AFZ12 may be safely recommended for "front end" service in VHF communications equipment. At 200Mc/s the noise figure in the power-gain-matched condition is typically 6dB — whilst the power gain in common emitter configuration at this frequency is greater than 10dB.

The AFZ12 is mainly intended for narrow band application at 200Mc/s but the stability of its "frequency-conscious" characteristics enables it to be used in a wide variety of video and other broad-band high-frequency applications such as telecommunications, relay repeaters and radar intermediate frequency amplifiers.

As such, the AFZ12 is of prime importance to all manufacturers of VHF communications equipment; for here is a thoroughly practical and efficient transistor suitable for amplifier application up to 200Mc/s. The AFZ12 is available from stock.

Power gain at f = 200 Mc/s
Typical power gain measured in circuit shown below = 13dB.



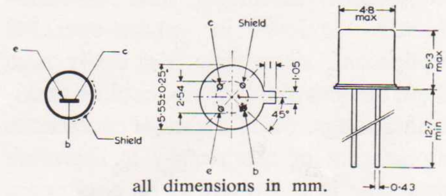
R_{load} is chosen such that the total impedance of the output tuned circuit is 2kΩ.

ABSOLUTE MAXIMUM RATINGS—

Collector voltage		
V_{cb} max. (I_e = 0mA)	—20	V
V_{ce} max. (+V_{be} >500mV)	—20	V
V_{ce} max. (I_c = 10mA)	—10	V
Collector current		
$i_{c(pk)}$ max.	10	mA
*I_c max.	10	mA
Emitter current		
$i_{e(pk)}$ max.	10	mA
*I_e max.	10	mA
Base current		
$i_{b(pk)}$ max.	1.0	mA
*I_b max.	1.0	mA
Reverse emitter base voltage		
V_{eb} max.	—500	mV
Reverse emitter current		
I_e max.	1.0	mA

*averaged over any 50ms period.

Current stocks of AFZ12 employ a case similar to the OC170 transistor series but in the near future a changeover to the TO-18 four-lead-case (shown below) is intended.



all dimensions in mm.

E810F Data continued from Page 70

OPERATING CONDITIONS

V_{a-e}	135	V
V_{g3-e}	0	V
V_{g2-e}	165	V
V_{g1-e}	+12.5	V
R_k	360	Ω
I_a	35	mA
I_{g2}	5.0	mA
g_m	50	mA/V

LIMITING VALUES (absolute ratings)

$V_{a(b)}$ max.	400	V
V_a max.	250	V
p_a max.	5.0	W
$V_{g2(b)}$ max.	400	V
V_{g2} max.	200	V
p_{g2} max.	1.0	W
—$V_{g1(pk)}$ max.	50	V
—V_{g1} max.	25	V
+V_{g1} max.	0	V
*I_k max.	50	mA
R_{g1-k} max.	200	kΩ
V_{h-k} max.	100	V
*T_{bulb} max.	200	°C

*In applications where a long life is not required, I_k max. can be increased to 65mA and T_{bulb} max. to 220°C.

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153AVP PHOTOMULTIPLIER FOR GAMMA SPECTROSCOPY

The Mullard range of photomultipliers is now extended by the addition of a type which is specifically designed for high-resolution gamma spectroscopy. This type, the 153AVP, is capable of giving a resolution of better than 9.5% for Cs^{137} gamma radiation at 0.662MeV.

Abridged Advance Data for 153AVP
Photocathode

Surface	caesium-antimony	
Peak spectral response	4,200±300	Å
Projected cathode area	15.2	cm^2
Min useful diameter	44	mm
Sensitivity*	50	μA/lm

*Measured with a lamp of colour temperature 2870°K

Characteristics (at $V_{a-k1(b)}$ = 1.8kV)

Min anode sensitivity	60	A/lm
Average anode sensitivity	500	A/lm
Current amplification	10^7	
I_{dark} max at min anode sensitivity	5×10^{-8}A	

Limiting Values (absolute ratings)

$V_{a(b)}$ max	1.8	kV
I_a max	1.0	mA
p_a max	500	mW

Mechanical

Number of stages	11	
Max diameter	57	mm
Max overall length	153	mm
Max seated height	134	mm
Base	B14A	

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Readers desirous of receiving Outlook for 1962 are reminded of the need to complete and return, without delay, the Renewal Card (illustrated above) contained in the last issue of Outlook (Volume 4, Number 5).

DETECTION OF MAINS-SUPPLY OVERVOLTAGES

It is well known that AC mains supplies are not free from overvoltages of various kinds, such as increases in the AC voltage, DC voltages imposed on the mains, and spikes or pulses on the peaks of the mains waveform. Any of these may be of short duration (perhaps a few microseconds) and of very irregular occurrence. It is therefore difficult to detect them with an oscilloscope, and attempts to do so can be time-consuming, expensive, and unrewarding.

Surges, however, can be harmful to thyratrons, rectifiers, and semiconductor devices in mains-operated equipment, since they can easily take these devices above their absolute maximum ratings. Some means of continuous monitoring of the supply is therefore desirable in the interests of equipment reliability and valve and semiconductor life.

A monitoring circuit is described in the March 1961 issue of *Mullard Technical Communications*. If the voltage across (say) a pair of thyratrons is to be monitored, the voltage is applied to an attenuator from which the trigger voltage of a cold cathode tube is derived. If a surge occurs, then the critical trigger voltage of the tube is exceeded, the anode circuit conducts, and a relay provides whatever protective action is required in the particular application. The attenuator can be connected to the trigger circuit in two different ways—to provide monitoring of either positive or negative surges. A rather more elaborate circuit is sensitive to both polarities.

The monitor is battery operated, so that it can be floated at any voltage level. It is also, for the same reason, independent of mains surges or mains interruption.

Units built in the laboratory have an accuracy of better than 1% for short-duration surges. There is some deterioration of accuracy with longer pulses.

REVERSED POLARITY HIGH POWER SILICON RECTIFIERS

The high safety factor 20A silicon rectifiers recently introduced by Mullard have now been made available in reversed polarity versions. Type-numbered BYY16 and BYZ15 these reversed polarity rectifiers make it possible to construct bridge rectifiers with only two heat sinks thus saving cost and chassis space. Diodes of both polarity can be mounted on the frames of exciter motors, chassis or cabinets with a choice of either a positive or negative earth.

These 200V and 400V devices, together with their counterparts of opposite polarity can bring greater simplicity and economy to a number of "heavy" electrical circuits. Because of their exceptionally high safety factors they reduce the need for elaborate protective fusing, surge limiting and load sharing when used in parallel operation. Although rated for a maximum forward current of 20A, all four types will withstand a forward current of 600A for 10 msec.

Brief electrical details are as follows:—

BYZ15 (Reversed polarity version of BYZ14)

This rectifier is rated for a maximum forward current of 20A and a maximum repetitive peak current of 100A. The maximum repetitive peak inverse voltage is 200V and the maximum allowable surge voltage 400V. A breakdown voltage in excess of 800V is guaranteed. Four of these rectifiers, when connected in a single phase bridge configuration, give a maximum forward current of 40A at 250V DC.

BYY16 (Reversed polarity version of BYY15)

This is similar to the BYZ15 except that the maximum repetitive peak inverse voltage is 400V and the maximum allowable surge voltage 800V.

LONG-LIFE NUMERICAL INDICATOR Z520M

The Z520M is a cold-cathode neon indicator tube which displays the numerals 0 to 9 in characters ⅝ inch (15.5mm) high. The structure of the tube, and its electrical characteristics, are similar to those of the earlier type, the Z510M; but a life of at least 5,000 hours can be expected with continuous display of any one numeral. If the display is changed from one numeral to another at least once in every 100 hours, as in the majority of applications, then the life expectancy should be 30,000 hours.

An additional feature of the tube is a built-in optical filter which ensures maximum readability of the display under all conditions likely to be encountered in practice.

A minimum supply voltage of 170V is necessary to ensure operation. A cathode current of 2.0mA is recommended.

The tube may be operated by mechanical switching, by the application of appropriate DC voltages to the cathodes, or by pulse operation.

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continued from Page 63

If this is the essence of progress that having developed say, a low cost refrigerator, let us make it and give the consumer the benefit of it now, but keep on developing and developing better refrigerators and sell these as well. However, with the present stage of the C.C.I.R. standard black-and-white TV technique, it is not expected that there will be any major engineering changes within the next few years, at least that could influence the sale of new sets, except perhaps in hammering reliability. Much of the appeal must therefore be on presentation and ancillary aids, some bordering on the gimmick.

PLAGUE OF USED TV RECEIVERS

Finally, what happens to the trade-in TV receivers that one time had all the gleam, sparkle and freshness of a new article in its "factory packed" carton? It is inevitable that the more the Industry sells obsolescence the more it must prepare itself for a glut of used TV receivers and their influence on the future potential replacement market.

Continued next issue of Outlook.

Printed in Australia
H. C. DURANT PTY. LTD. PRINTERS - SYDNEY

MULLARD TELEVISION TUBE INTERCHANGEABILITY LIST

Mullard Replacement	Type Number	Screen Size	Deflection Angle	Method of Focus	Heater Volts	Heater Amps	Ion Trap (Gauss)	Faceplate Type	Max. Overall Length
AW36-80	14RP4A	14"	90°	ES	6.3	0.6	>35	Single	13½"
	14WP4	14"	90°	ES	6.3	0.6	No	Single	13⅝"
	AW36-80	14"	90°	ES	6.3	0.3	59-67	Single	14½"
	CME1402*	14"	90°	ES	12.6	0.3	Yes	Single	$14\frac{9}{16}$"
MW43-69	17BP4A†	17"	70°	M	6.3	0.6	40 approx.	Single	19⅝"
	17BP4B/300†	17"	70°	M	6.3	0.3	40 approx.	Single	19⅝"
	172K	17"	70°	M	6.3	0.3	Yes	Single	19"
	173K	17"	70°	M	6.3	0.3	Yes	Single	19"
	A43-64A†	17"	70°	M	6.3	0.3	50 approx.	Single	19½"
	CRM171*	17"	70°	M	12.6	0.3	Yes	Single	19¾"
	CRM172*†	17"	70°	M	12.6	0.3	Yes	Single	19¾"
	MW43-64	17"	70°	M	6.3	0.3	49-67	Single	19½"
	MW43-69	17"	70°	M	6.3	0.3	49-67	Single	19½"
AW43-80	17AVP4A	17"	90°	ES	6.3	0.6	35 approx.	Single	16"
	17BJP4	17"	90°	ES	6.3	0.6	No	Single	15"
	AW43-80	17"	90°	ES	6.3	0.3	63-78	Single	16"
	CME1702*	17"	90°	ES	12.6	0.3	No	Single	15⅛"
AW43-88	17BZP4	17"	110°	ES	6.3	0.6	No	Single	12⅞"
	17BZP4/300	17"	110°	ES	6.3	0.3	No	Single	12⅞"
	17CKP4	17"	110°	ES	6.3	0.6	No	Single	12⅞"
	AW43-88	17"	110°	ES	6.3	0.3	No	Single	12⅞"
	CME1703*	17"	110°	ES	12.6	0.3	No	Single	12⅝"
	CME1704	17"	110°	ES	6.3	0.6	No	Single	12⅝"
AW47-30	19AKP4	19"	114°	ES	6.3	0.6	No	Single	12⅝"
	19XP4	19"	114°	ES	6.3	0.6	No	Single	11⅝"
	AME1951B	19"	114°	ES	6.3	0.6	No	Single	—
	AW47-30	19"	114°	ES	6.3	0.3	No	Single	$12\frac{15}{16}$"
MW53-20	21WP4A	21"	70°	M	6.3	0.6	35 approx.	Single	$22\frac{7}{16}$"
	21ZP4B	21"	70°	M	6.3	0.6	40 approx.	Single	23½"
	21ZP4B/300	21"	70°	M	6.3	0.3	40 approx.	Single	23½"
	CRM211*	21"	70°	M	12.6	0.3	Yes	Single	23½"
	MW53-20	21"	70°	M	6.3	0.3	63-78	Single	23¼"

Mullard Replace-ment	Type Number	Screen Size	Deflection Angle	Method of Focus	Heater Volts	Heater Amps	Ion Trap (Gauss)	Faceplate Type	Max. Overall Length
AW53-80	21ALP4A/B	21″	90°	ES	6.3	0.6	45 approx.	Single	$20\frac{3}{8}$″
	21ATP4	21″	90°	ES	6.3	0.6	>35	Single	$20\frac{3}{8}$″
	21ATP4A	21″	90°	ES	6.3	0.6	>35	Single	$20\frac{3}{8}$″
	21CBP4‡	21″	90°	ES	6.3	0.6	No	Single	$18\frac{3}{8}$″
	21CBP4A‡	21″	90°	ES	6.3	0.6	No	Single	$18\frac{3}{8}$″
	AW53-80	21″	90°	ES	6.3	0.3	63-78	Single	$19\frac{3}{8}$″
	CRM212●*	21″	90°	M	12.6	0.3	Yes	Single	$20\frac{1}{2}$″
AW53-83	AW53-83	21″	110°	ES	6.3	0.3	No	Single 33″ rad.	$14\frac{3}{4}$″
	21CEP4	21″	110°	ES	6.3	0.6	No	Single 33″ rad.	$14\frac{3}{4}$″
	21CEP4A	21″	110°	ES	6.3	0.6	No	Single 33″ rad.	—
	CME2102/H	21″	110°	ES	6.3	0.6	No	Single 33″ rad.	$14\frac{7}{8}$″
AW53-88	21DAP4	21″	110°	ES	6.3	0.6	No	Single	15″
	21DEP4	21″	110°	ES	6.3	0.6	No	Single	15″
	AW53-88	21″	110°	ES	6.3	0.3	No	Single	15″
	CME2101*	21″	110°	ES	12.6	0.3	No	Single	$14\frac{1}{2}$″
	CME2102	21″	110°	ES	6.3	0.6	No	Single	$14\frac{1}{2}$″
AW59-30	23MP4	23″	114°	ES	6.3	0.6	No	Single	$14\frac{5}{8}$″
	23WP4	23″	114°	ES	6.3	0.6	No	Single	$14\frac{15}{16}$″
	AME2351B	23″	114°	ES	6.3	0.6	No	Single	$14\frac{15}{16}$″
AW59-90	AME2354B	23″	110°	ES	6.3	0.6	No	Single	
	AW59-30	23″	114°	ES	6.3	0.3	No	Single	$14\frac{5}{8}$″
	AW59-90	23″	110°	ES	6.3	0.3	No	Single	$15\frac{1}{4}$″
23CRP4	23AVP4★	23″	110°	ES	6.3	0.6	No	Double	—
	23CP4	23″	110°	ES	6.3	0.6	No	Double	$15\frac{7}{8}$″
	23CRP4	23″	110°	ES	6.3	0.3	No	Double	—
	23HP4	23″	110°	ES	6.3	0.6	No	Double	$15\frac{9}{16}$″
	AME2350PB	23″	110°	ES	6.3	0.6	No	Double	—
	AME2352PB	23″	110°	ES	6.3	0.6	No	Double	—
	CME2302	23″	110°	ES	6.3	0.6	No	Double	
	ADDITIONAL TYPES								
14ASP4	14ASP4	14″	110°	ES	6.3	0.6	No	Single	$11\frac{5}{8}$″
17CGP4B	5/3T*	17″	70°	ES	8.0	0.3	No	Single	—
	AW43-20	17″	70°	ES	6.3	0.3	50	Single	—
	17CGP4B	17″	70°	ES	6.3	0.6	No	Single	$17\frac{5}{8}$″
	17HP4B	17″	70°	ES	6.3	0.6	35	Single	$19\frac{5}{8}$″
19AFP4	19AFP4	19″	114°	ES	6.3	0.6	No	Double	$11\frac{15}{16}$″
	19ARP4	19″	114°	ES	6.3	0.6	No	Double	$12\frac{15}{16}$″
24AEP4	24AEP4	24″	90°	ES	6.3	0.6	No	Single	$19\frac{1}{2}$″
	24DP4A	24″	90°	ES	6.3	0.6	40 approx.	Single	$21\frac{1}{2}$″
—	24AHP4	24″	110°	ES	6.3	0.6	No	Single	$15\frac{13}{16}$″
	27SP4	27″	90°	ES	6.3	0.6	40 approx.	Single	$23\frac{7}{16}$″
—	27VP4	27″	90°	ES	6.3	0.6	No	Single	$21\frac{7}{16}$″

* Except for heater ratings.
† Connect pin 7 to pin 10 or pin 11 for correct focus.
‡ Check cabinet clearance.
§ Check chassis clearance.
● Remove focus magnets from deflection yoke and apply focusing voltage to pin 6.
★ Anti-glare treatment.

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MVL 1261

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LANGLEA PRINT 24960