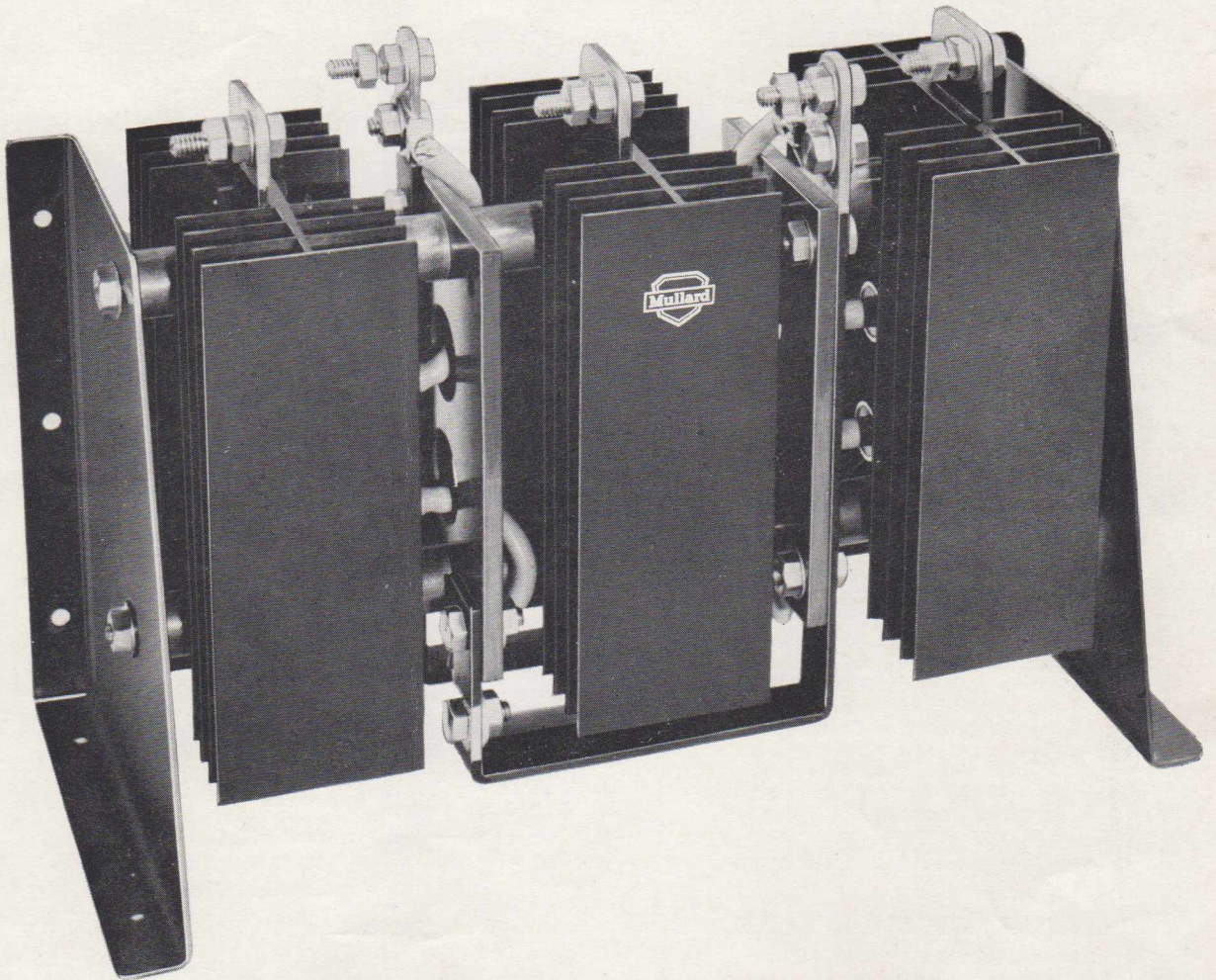


Mullard Outlook

AUSTRALIAN EDITION



VOL. 6, No. 6
NOVEMBER-DECEMBER, 1963



MULLARD-AUSTRALIA PTY. LTD.



VOL. 6 — No. 6 NOVEMBER-DECEMBER, 1963

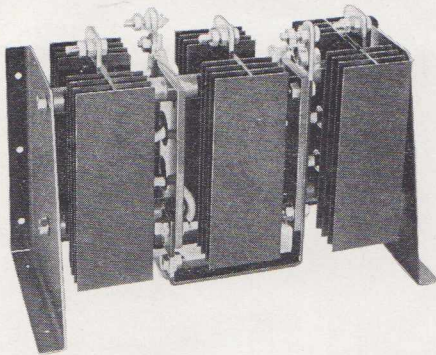
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Editor:
JOERN BORK

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A three-phase bridge connected Mullard silicon rectifier stack assembly, type OSK4500, consisting of six rectifiers, types BYY15 and BYY16, mounted on three heatsinks of the Mullard 40D extrusion*, which may be used at a supply of 280V r.m.s., 50 c/s. The maximum output average forward DC current into a resistive or inductive load is 75A ($T_{amb} < 35^{\circ} C.$).

*A detailed description may be found on pages 80 and 81.

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Associated with
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4 Score and 500 Million

The first, years—the second, valves; for Stanley Robert Mullard the Founder and still a Director of our parent Company, Mullard Limited, recently celebrated his eightieth birthday, which coincided with the 500,000,000th valve produced by the Company in England. To mark the occasion a golden replica of this historic valve was presented to Capt. Mullard who established the Company 43 years ago. Our Viewpoint with Mullard page in this issue is indeed such.

Any Colour

To emulate Henry Ford "any colour as long as it's black", but Mullard heatsinks not Model T automobiles. For the best thermal characteristics of the heatsinks require them to be black, we sink.

Greetings for 1964

May our readers have good health, good fortune and enjoy the fruits of their labour.

M.A.B.

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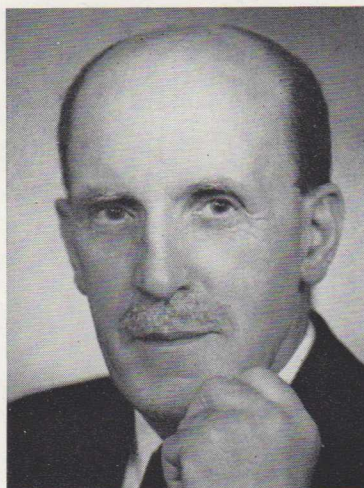
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VIEWPOINT WITH MULLARD

Our Founder, S. R. Mullard, M.B.E., Celebrates 80th Birthday

Although retired for some years Stanley Mullard has remained a Director of the Company. He was born in London on November 1st, 1883, the third of five children, the family being not well off. His father was works-manager of a small chemical manufacturing firm and his salary left little to pay for an elaborate education for the children. At 15, after only a basic schooling and a year at a polytechnic institute, the young Mullard was apprenticed to a firm of electrical engineers, his wage 10/- for a 56 hour week.



S. R. MULLARD, M.B.E.

During his five year apprenticeship he attended evening classes at the Royal Institution, the City & Guilds of London Institute, the Institution of Electrical Engineers and various technical colleges. This training and study would have led him to a career in electrical engineering, "But", he says, "when I learned that a qualified shift engineer at a power station earned 7½d an hour I began to have second thoughts".

Early Experience With Electrical Lamp Production

He asked for and was given a transfer to another branch of the firm concerned with the manufacture of electric lamps and X-ray tubes. He believes that it was this move that really led to the formation of the Mullard company, for it was from this early work on lamps and X-ray tubes that his interest in radio valves stemmed.

At the outbreak of World War I he was head of the Ediswan lamp laboratories and enlisted in the Engineers Battalion of the Royal Naval Division, by Admiralty instructions he remained at Ediswan to continue his technical work. His interest now extended to wireless valves, a field in which his knowledge of vacuum techniques gained in the lamp laboratories enabled him to make important contributions to the fast growing military use, as it was then known—wireless communication. He later saw

service in France and earned a Mention in Despatches and military M.B.E.

The Beginning

In 1920 the Admiralty asked him to manufacture valves and, lacking funds, he asked them for a contract to obtain financial backing and was given a firm order for 250 silica envelope transmitting valves at £66 each, the first Mullard order.

His backers were an odd assortment; two had connections with the radio industry, the others were respectively a bacon producer and a firm of East India merchants, and so in September 1920 was formed the first company to bear his name, The Mullard Wireless Valve Company.

Receiving Valves

With a growing interest in experimental broadcasting and the need for smaller valves he set about developing and manufacturing receiving valves, one type the ORA the initials signifying the three main functions: oscillate, rectify and amplify. These had a ready market, were superior to the imported valves at the time and in demonstrating that reliable valves could be made cheaply, he materially helped to lay the foundations of the British radio industry.

A temporary litigation setback occurred in 1922 when Marconi's Wireless Telegraph Co. Ltd. issued writs against The Mullard Wireless Valve Company alleging infringement of two of their patents, Mullard defence was that one of the patents could not be valid because the design of the valve was based on a principle published earlier in a German paper, the Marconi witness claiming that if the valve were constructed as shown in the paper it would never work. The Court adjourned for the day, Mullard rushed back to the works and made a few sample valves, in fact 20, lashed one into a receiver and took it to court next day and the Marconi witness had the disconcerting experience of listening to a broadcast from Paris through a valve he claimed would never work.

Foundation of Applications Engineering

In 1924, the demand for his valves was such that he was forced to give more attention to the commercial activities and formed a second company—The Mullard Wireless Service Company—to handle distribution and marketing. That his title contained the word "service" was no accident. Then, as now, service, whether to the set manufacturer, the dealer or the public, ranked high in the company's battle order. Then, as now, the salesmen were backed by an equally strong cadre of technical people who were interested not so much in selling a valve as in helping the buyer to get the best results from it.

Retirement

In 1929 he decided reluctantly to relinquish the leadership of the company, and was succeeded by Mr. S. S. Eriks, for his

MULLARD-AUSTRALIA PERSONALITIES



Mr. R. L. WEBB

Mr. Webb, our senior applications engineer, graduated B.A. (Hons.) University of Melbourne in 1950 and for some time was a teacher of English and French with the N.S.W. Department of Education. Subsequently, following up a boyhood interest in radio, he enrolled at the then N.S.W. University of Technology, qualifying in 1962 for B.Sc. (Tech.) in Electrical Engineering.

This unique combination and a Diploma of Education has reflected in the technical papers that he has presented, also his popularity as a lecturer illustrated recently in the highly successful servicemen's series on semiconductors.

A keen circuit analyst and observer of semiconductor behaviour, his engineering is directed to specific semiconductor applications with a particular regard to ratings and reliability.

health had been in question since 1926 when, after a serious breakdown, his doctors warned him to ease up. "They told me," he said recently, "that unless I did so I would be forced to give up all activity. But that was thirty-seven years ago and I hope that by now I have satisfied them of their error."

Now under the new leadership the company continued its growth, in 1938 established its main valve factory at Blackburn in Lancashire, this factory also producing the glass and fine wire used in valve manufacture: the labour demand relieving the unemployment caused by the decline in the cotton trade. Two years later the factory was making a considerable contribution to the war effort. In post-war years (World War II) the Mullard Research Laboratory was set up in Surrey, new valve and semiconductor factories and a new picture tube factory at Simonstone, Lancashire—the latter unique in the world in that it also produces its own glass.

Today our companies have 18 factories
(Continued on page 84)

MULLARD PREFERRED RANGE OF VALVES, TUBES AND SEMICONDUCTOR DIODES

For Television Receivers in Australia

Current television receiver design practice has been taken into account in the preparation of this list. The description of each type is only typical and for different applications of any particular type, the maximum ratings should be observed. For additional information please contact one of the Mullard Technical Service Departments.

VALVES

Description	
1S2	Half-wave EHT rectifier
6AL3	Booster Diode
6AL5	Double diode with separate cathodes
6AU6	RF pentode
6BL8	Triode pentode with separate cathodes
6BM8	Triode, power pentode with separate cathodes
6BX6	RF pentode
6BY7	Variable μ RF pentode
6CK6	Video output pentode
6CM5	Line output pentode
6CQ8	Medium μ triode, sharp cutoff tetrode
6CS6	Dual control heptode
6DT6	Dual control pentode
6DX8	Triode, power output pentode
6EH7	Variable μ RF pentode
6EJ7	RF pentode
6ES8	VHF double triode
6GV8	High μ triode, frame output pentode
6GW8	High μ triode, AF output pentode
6HG8	Triode pentode for tuner service
12AU7	Low μ double triode
DY86	
EY189	
EAA91/EB91	
EF94	
ECF80	
ECL82	
EF80	
EF85	
EL83	
EL36	
—	
EH90	
—	
ECL84	
EF183	
EF184	
ECC189	
ECL85	
ECL86	
ECF86	
ECC82	

GERMANIUM AND SILICON DIODES

Description	
AA119	Germanium point contact diode
2-AA119	Germanium diode matched pair for ratio detectors
OA90	Germanium junction diode for general purpose
OA91	Germanium junction diode for general purpose
OA95	Germanium junction diode for general purpose
OA210	Silicon power diode for voltage doubling applications
BY100	Silicon power diode for use as mains rectifier

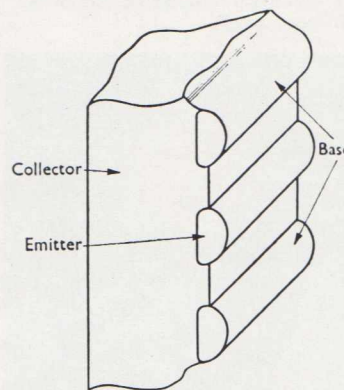
TELEVISION PICTURE TUBES

Description	
AW47-30	19" 114° single faceplate
19ASP4	19" 110° double faceplate
AW59-91	23" 110° single faceplate
23CRP4	23" 110° double faceplate

"STRIPE CONSTRUCTION" USED IN VHF TRANSISTOR

A germanium p-n-p transistor, the AFY19, has been recently introduced, utilising a new manufacturing technique referred to as "stripe construction". This form of manufacturing ensures narrow base width together with low collector capacitance thus enabling operation at very high frequencies. The AFY19 will dissipate a total power of 800mW at an ambient temperature of 25°C and has a typical f_t value of 350 Mc/s. The transistor is, therefore, ideal for operation as a power amplifier in VHF transmitters operating at frequencies up to 180 Mc/s.

The AFY19 transistor has a TO-5 encapsulation; maximum collector-to-base voltage ($-V_{CB}$) may be as high as 32V.



XENON THYRATRON TYPE XR1-12A

The addition of grid cooling fins and a new form of cathode construction have made possible an improvement in the performance of the thyatron type XR1-12. The new type, designated XR1-12A, is rated for an average cathode current of 12.5A (maximum averaging time 7 sec) and a peak cathode current of 160A. The peak anode voltage (forward and reverse) is 1.5kV and the forward voltage drop is 16V at a cathode current of 12.5A.

Typical applications include resistance welding and industrial power control.

Overall dimensions of the XR1-12A are 288mm length by 135mm diameter.



MULLARD HEATSINKS FOR RECTIFIERS, TRANSISTORS AND SCRS.

The user of semiconductor diodes and silicon controlled rectifiers, as well as transistors, requires not only the devices themselves, but also a full supporting programme of auxiliary components and technical information.

The Mullard approach to the sale and application of semiconductors is to provide the user with as comprehensive a service as possible. In line with this policy, Mullard-Australia Pty. Ltd. are now augmenting their range of heatsinks and associated components.

Three types of heatsinks are available in the Mullard range with different thermal properties to meet a variety of requirements. These three extrusions, known as 30D, 40D and 50D, are supplied either in standard lengths or cut to the lengths in which they are used in Mullard silicon rectifier stack assemblies. The cut lengths can be supplied either plain or drilled to standard hole patterns.

Full mechanical details of the available extrusions are given, and for each extrusion thermal characteristics are provided in graphical form.

It can be deduced from the curves that, if heat is generated by a single rectifier, transistor or SCR mounted at some point on the heatsink, there is a maximum useful length for the heatsink.

For short lengths, an increase of length increases the thermal dissipation linearly. When, however, the maximum useful length is exceeded, and the configuration becomes long and narrow, each successive addition to the length becomes less and less effective as a radiator. For the 30D, 40D and 50D extrusions the maximum useful length is between nine inches and twelve inches. If a number of semiconductors are mounted at various positions along a heatsink, these length limits do not apply. The curves also show the effect of surface blackening.

All the curves relate to operation of the heatsinks with natural convection cooling. A low-velocity forced draught will give a marked improvement in performance. In general, however, there will be some loss of efficiency if these extrusions are used with high-velocity air cooling. Under these conditions, the outer fins and the tips of the inner fins will be cooled almost to the temperature of the incoming air, so that these parts of the heatsink will be relatively ineffective as dissipators. With high-velocity cooling it is generally preferable to use the heavier extrusions 60D or 110D.

Auxiliary Components

In addition to the heatsink extrusion, a rectifier stack requires busbar connections, mounting brackets, and various interconnecting pieces. In most applications, the heatsink must be insulated from its supports.

Standard Mullard stacks and bridges are built from the extrusions already described, with an appropriate number of insulators and other auxiliary items of hardware. These auxiliary components form a range of standardised items which may be made available on request.

High-Dissipation Heatsinks

Heatsinks larger than the 30D, 40D and 50D extrusions are required for 150A diodes, for very large SCRs, and even for

maximum current operation of 50A and 70A SCRs. Two new extrusions, the 60D and 110D are now under construction for these applications. The 60D extrusion is intended for convection cooling, and it has a thermal resistance of about 0.5°C/W per 8 in length. The 110D extrusion has much thicker fin roots. It is intended for forced air cooling and a thermal resistance of something like 0.15°C/W per 4 in length can be achieved.

These heavier extrusions are intended to accommodate either diodes with flat mounting bases (for example, the BYY93 to BYY96 series) or stud-mounting devices such as the BTY69 and BTY70. Both extrusions will be available in standard lengths. Since it is envisaged that the main use of these heavier extrusions will be in customers' special designs, rather than in standard assemblies, they will be supplied undrilled only.

More comprehensive details of the 60D and 110D extrusions will be published later.

PERFORMANCE AND OPERATION OF EXTRUDED HEATSINKS

The equipment designer must ensure that the temperature ratings of rectifiers, transistors or SCRs mounted on these heatsinks are not exceeded. In arriving at the actual operating conditions, variations in supply voltages, components tolerances, and ambient temperature must be taken into account, and allowance must be made for the accumulation of dust and for other causes of restricted ventilation.

Performance

The performance curves are for various lengths of blackened and unblackened sections. The curves of total input power are plotted against the rise above ambient temperature of a point on the cooling fin $\frac{1}{8}$ in away from a centrally mounted device, and can be used directly for a stud-mounted

device having a 12mm ($\frac{1}{2}$ in) or greater, stud diameter mounted with a minimum torque of 7lb/ft.

For devices having smaller studs, or which are not stud-mounted, the curves can be used only as a guide. The actual performance should be checked as in operating note 4.

To obtain correct results from the performance curves, the heatsink must be mounted vertically with an unrestricted air flow.

Operating Notes

1. In order to keep the junction temperature within the published ratings for the device, the length of extrusion required should be determined as follows:

From the published data obtain T_{case} , for the known P_{tot} .

The maximum permissible temperature can then be obtained from

$$T_{heatsink} = T_{case} - \theta_1 \cdot P_{tot}$$

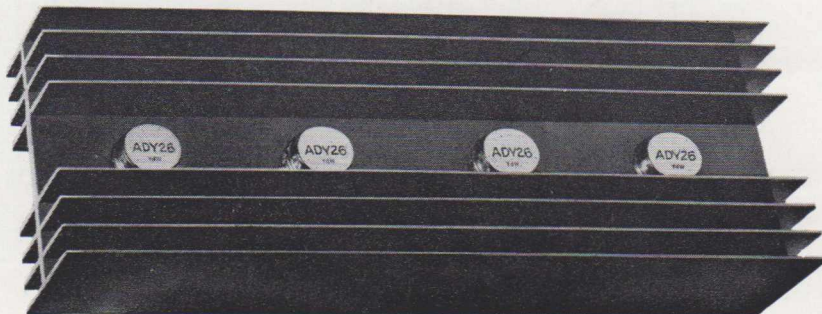
where θ_1 is the contact thermal resistance.

Determine the maximum expected value of ambient temperature, which must take into account the heating of the adjacent air by other components. The change in ambient temperature can then be found from

$$\Delta T = T_{heatsink} - t_{amb}$$

For this value ΔT , the required length of extrusion can be read off the performance curves. If the calculated length lies between two preferred lengths, the next largest should be used.

2. With a 12mm stud-mounted device mounted directly on the heatsink, a typical value for θ_1 is 0.15°C/W. If, however, a mica washer is required for electrical insulation, the data on the device must be consulted.



A push-pull parallel arrangement of four ADY26 transistors mounted onto a 40D heatsink extrusion.

3. It is permissible to mount two devices on one heatsink, and to use the same curves, provided that each device is mounted on its own half of the heatsink and that the dissipation is shared equally between them. The dissipation would then be the total of the two devices, and ΔT would be the rise above ambient temperature of the cooling fin adjacent to the mounting base of the upper device.
4. The suitability of any design can be checked by measuring, with a thermocouple, the case temperature of the device operating at the selected dissipation. The point defined by the rise in case temperature and the total dissipation must lie within the area of permissible operation as shown in the published data for the device. If the point lies outside this area, the design is inadmissible and the dissipation must be reduced or the heatsink size increased.
5. The use of silicone grease is recommended when attaching the device to the heatsink. For long-term connections a busbar jointing compound should be used to ensure good contact between the dissimilar metals of the heatsink and the device.
6. All burrs or thickening at the edges of holes drilled in the heatsink must be removed to ensure good thermal contact between the device and the heatsink.

Ambient Temperature Measurement

A high-conductivity copper washer is inserted between the device and the heatsink. The washer should be $\frac{1}{16}$ in thick, and of approximately the same plan as the device. It should have the same hole size(s) and disposition as the heatsink to which the device is attached. A thermocouple hole,

0.08in diameter, is drilled into the edge of this washer, to the centre of gravity or to within 0.02in of the central hole where present. The temperature is measured with a Chromel-Alumel thermocouple in conjunction with a valve voltmeter. The thermocouple must be at the end of the hole. Where an electrically insulating spacer is used, this should be placed between the washer and the heatsink.

Calculating Temperature Rise with Off-Centre Mounting

A rectifier will not necessarily be mounted centrally on the heatsink. In these circumstances the thermal resistance curves given in this article will not be directly applicable, and a simple calculation will be required.

In the extreme case, a rectifier, transistor or SCR is mounted at the end of the heatsink. Here the situation is approximately equal to that of a rectifier mounted centrally on a heatsink of twice the length, but with the performance divided by two.

For example, it can be seen from the thermal resistance curve for the blackened 50D extrusion that, with an input power of 60W to a semiconductor mounted centrally on a 4in length, the rise in temperature above ambient at the mounting point is (from the '2in' curve) about 78°C.

If, under the same conditions, the semiconductor is mounted at the end of the heatsink, the rise in temperature would be twice the rise indicated by the '4in' curve; namely, $2 \times 48 = 96^\circ\text{C}$.

For any mounting point between the centre and the end of the heatsink, the rise in temperature varies in an approximately linear manner between the values for central and end mounting.

A semiconductor is not mounted at a 'point', and it cannot therefore be mounted

at the precise end of a heatsink, since the device necessarily occupies a finite area. For these reasons, there are errors in the above calculation which are small enough to be ignored in practice.

Similarly, the thermal resistance of a heatsink depends to some extent on its rise in temperature above ambient but, except in the case of a very large heatsink with very low dissipation, the above calculation is still substantially true.

Effect of Mounting Position

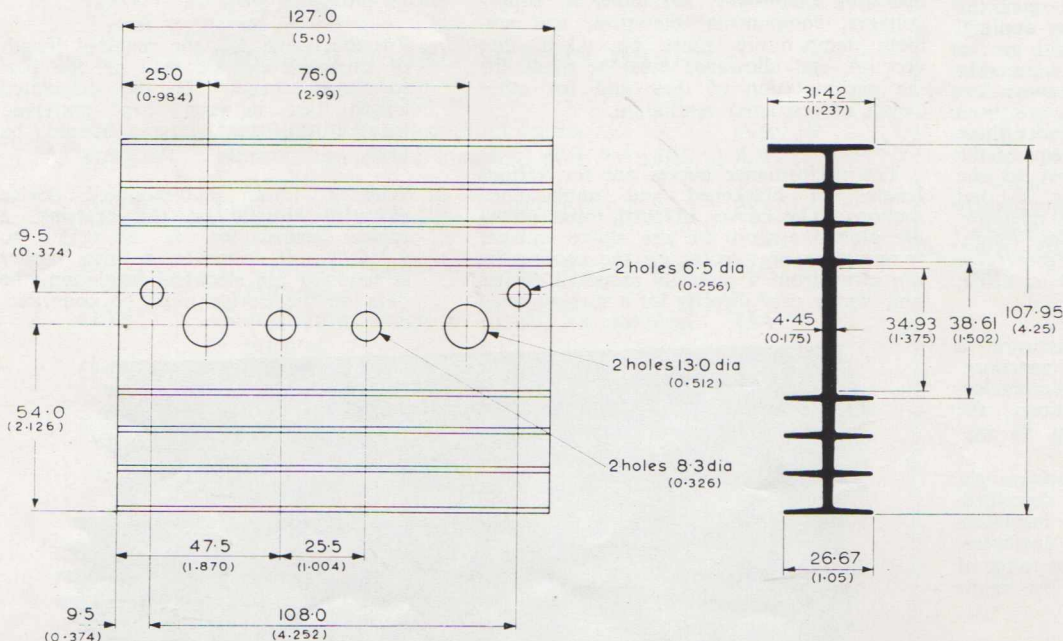
There will be no change in the performance of two or more heatsinks, mounted in proximity to one another, provided that:

- (a) When mounted side by side, with fins vertical, there is at least a 2in space between adjacent heatsinks.
- (b) When mounted one above another, with fins vertical, there is at least a 3in space between adjacent heatsinks.
- (c) When mounted in a cabinet, there is at least a 2in space between any heatsink and the wall of the cabinet.

The expression "with fins vertical" means with the major axis of the fins vertical, which arrangement allows maximum cooling by natural convection. Any other arrangement will degrade the performance of the heatsink.

The minimum spacings which have been quoted may be decreased. It should be noted, however, that although the performance will fall off only marginally for small decreases in the spacing, any substantial reduction will have a more serious effect. Certainly, for spacings only half of those quoted, the performance of the completed assembly should be checked under actual operating conditions, to ensure that the maximum permissible temperature of the semiconductors is not exceeded.

30D HEATSINK EXTRUSION



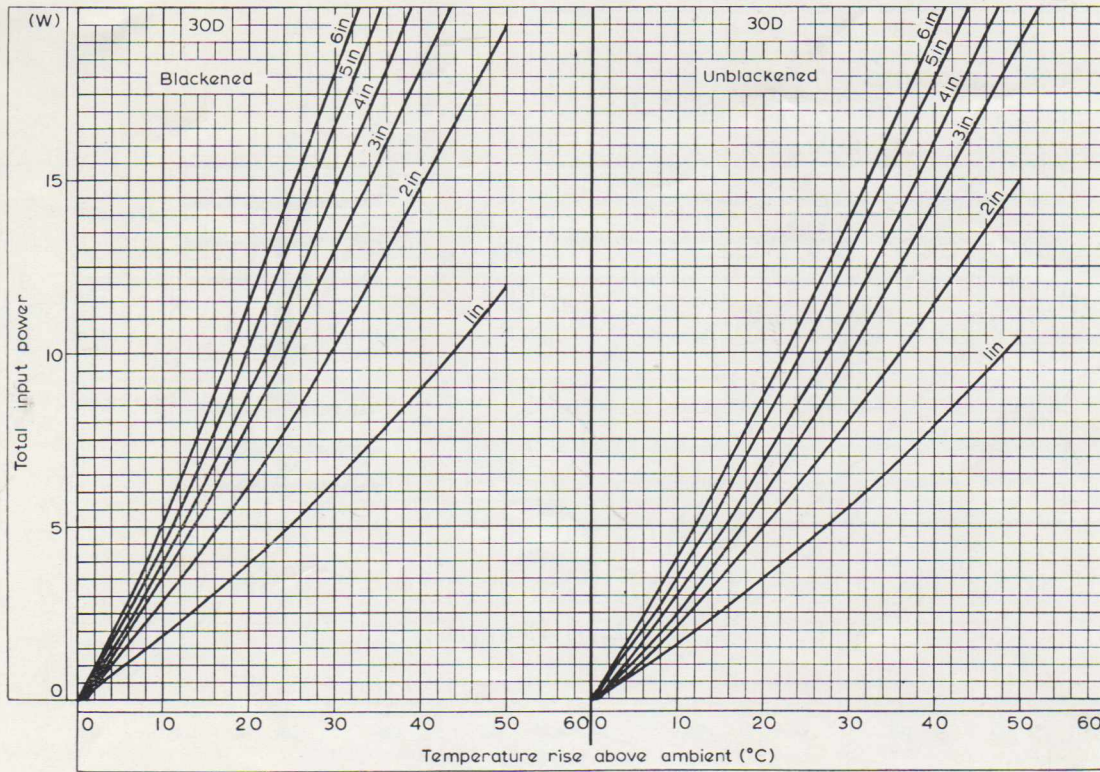
Notes:

1. This outline drawing represents the extrusion rather less than half actual size. Dimensions in mm; inch conversions in brackets.
2. The holes shown in the outline drawing are typical for a stack assembly. This extrusion may be obtained with or without the holes and cut to standard lengths.
3. Designers please note the 40D extrusion is the locally produced and preferred type in Australia. Assemblies should be designed around this extrusion wherever possible.

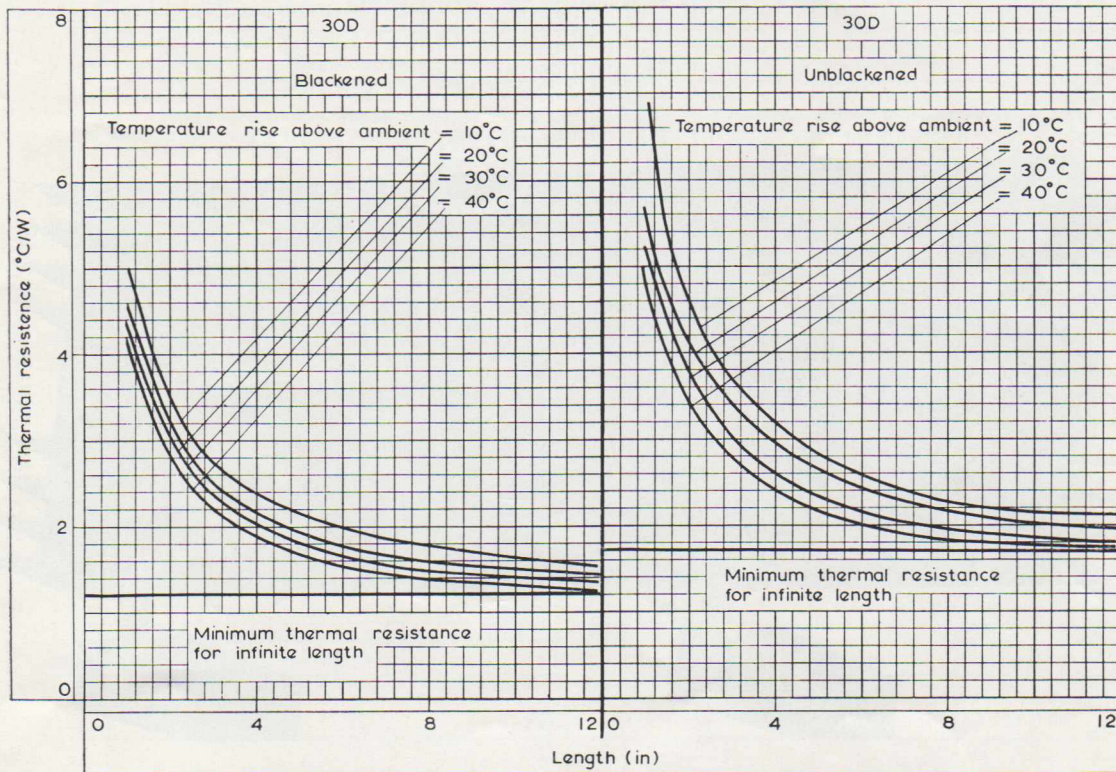
Type RS HS 30D 5 HP10.

The information contained herein does not imply any authority or licence for the utilisation of any patented feature.

30D HEATSINK EXTRUSION



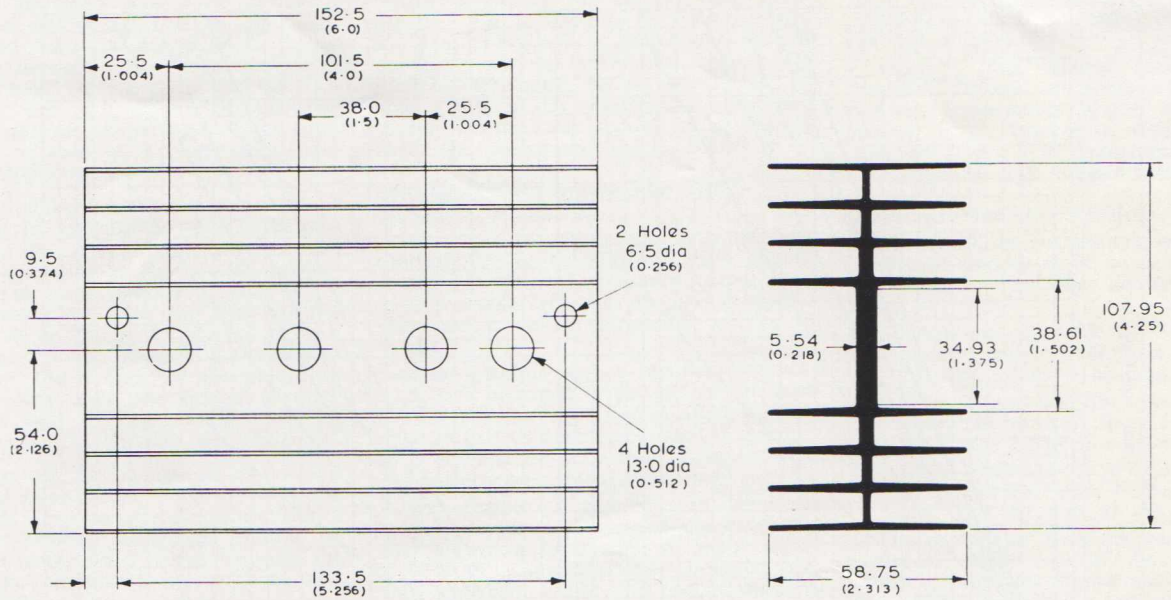
Total input power versus rise above ambient temperature for various lengths of extrusion, with natural convection cooling.



Thermal resistance versus extrusion length, for various rises above ambient temperature, and with natural convection cooling.



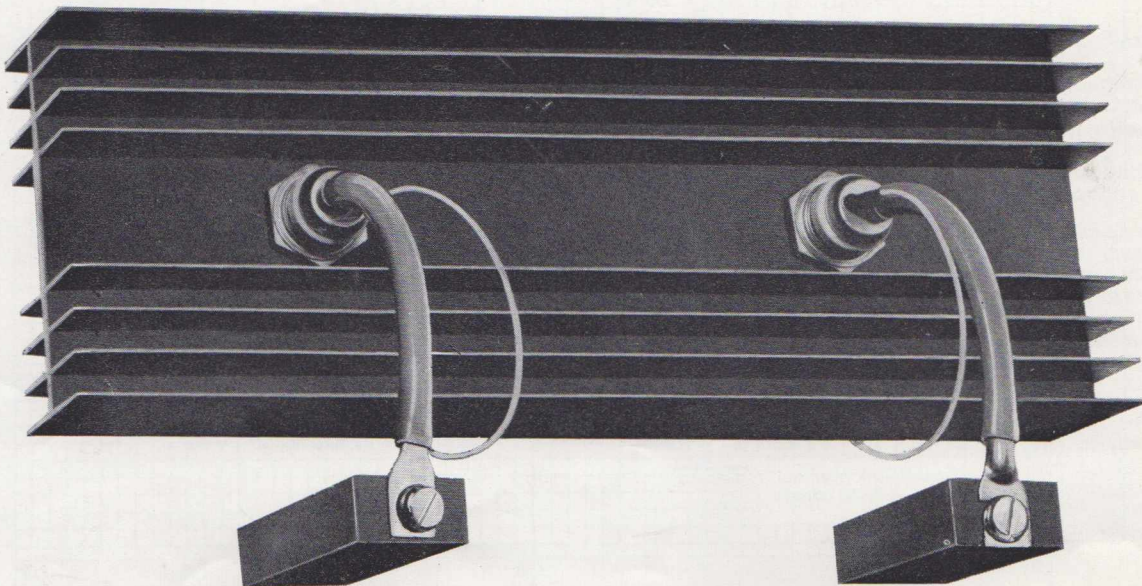
40D HEATSINK EXTRUSION



Type RS HS 40D 6 HP10.

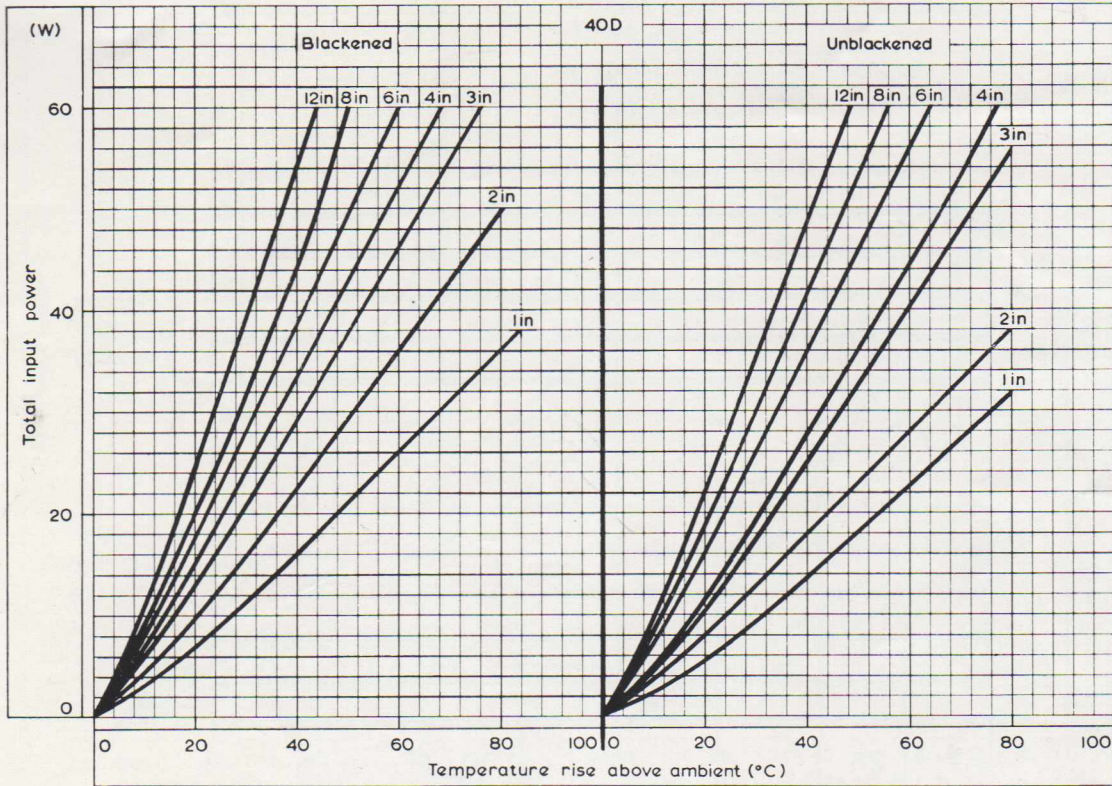
NOTES:

1. This outline drawing represents the extrusion rather less than half actual size. Dimensions in mm; inch conversions in brackets.
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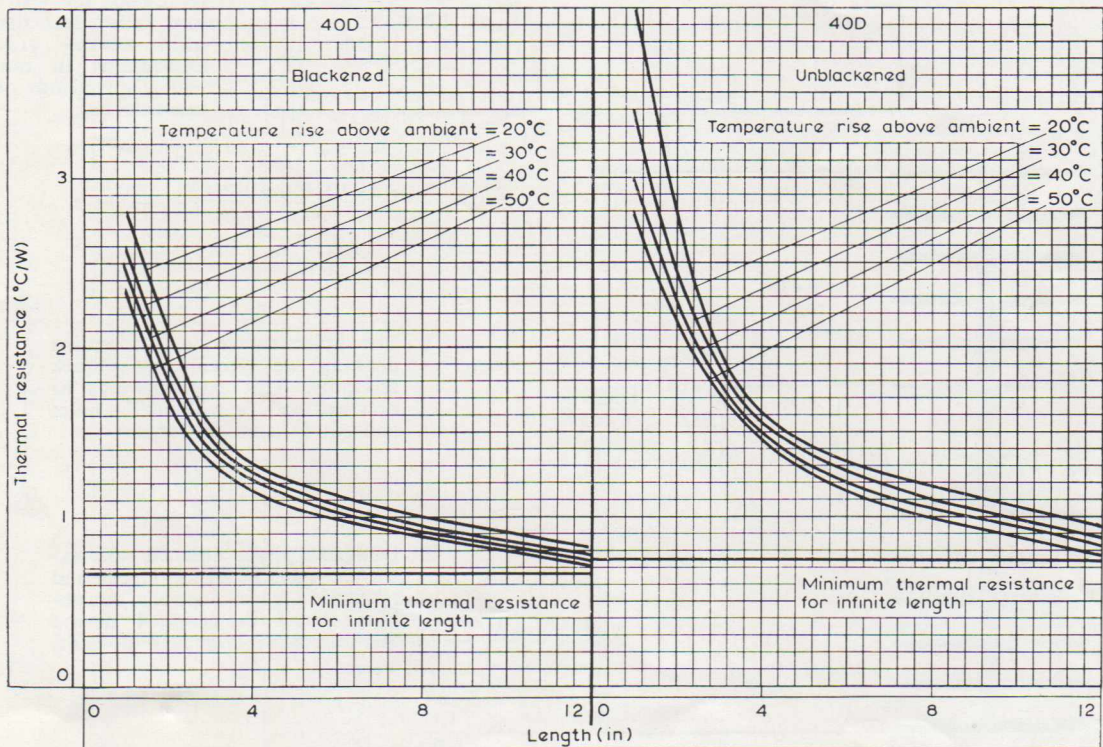


Two Mullard SCRs, type BTY70, which may be used at a maximum average forward current of 70A each, are shown mounted onto a 12 inch length of the 40D heatsink extrusion.

40D HEATSINK EXTRUSION

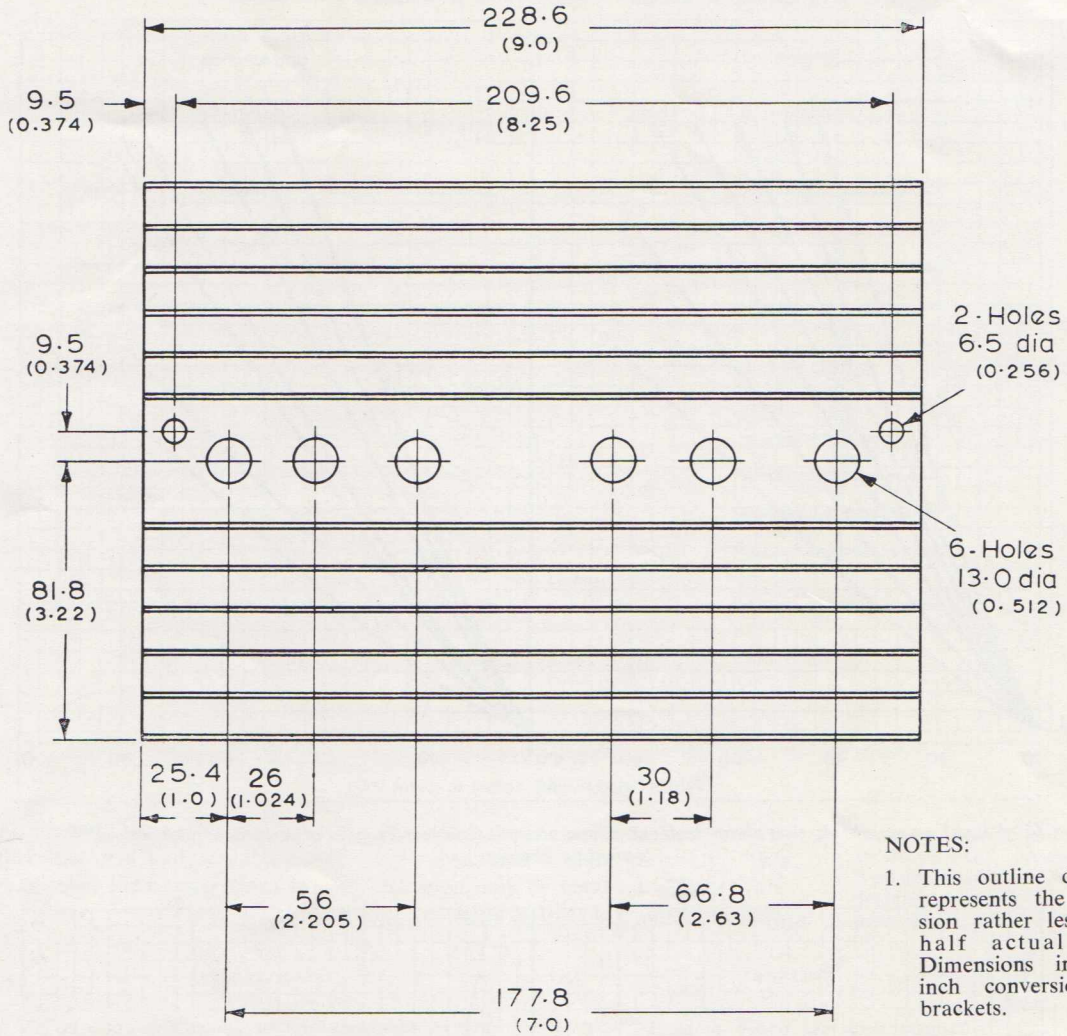


Total input power versus rise above ambient temperature for various lengths of extrusion, with natural convection cooling.



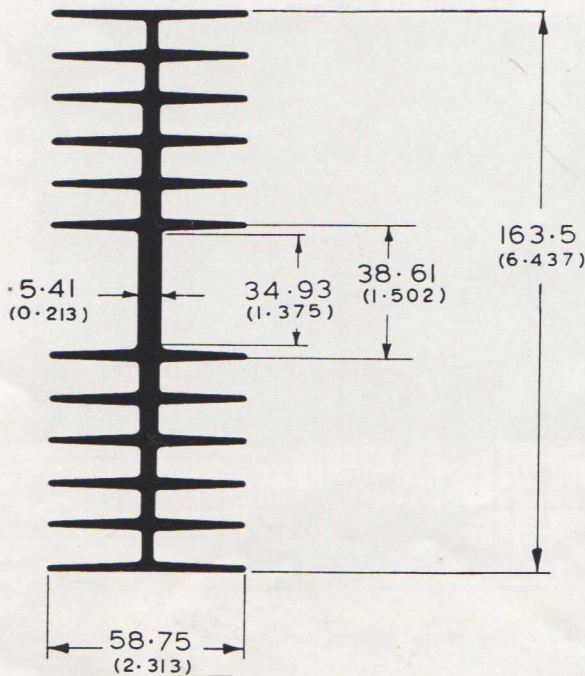
Thermal resistance versus extrusion length, for various rises above ambient temperature, and with natural convection cooling.

50D HEATSINK EXTRUSION



NOTES:
 1. This outline drawing represents the extrusion rather less than half actual size. Dimensions in mm; inch conversions in brackets.

Type RS HS 50D 9 HP11.

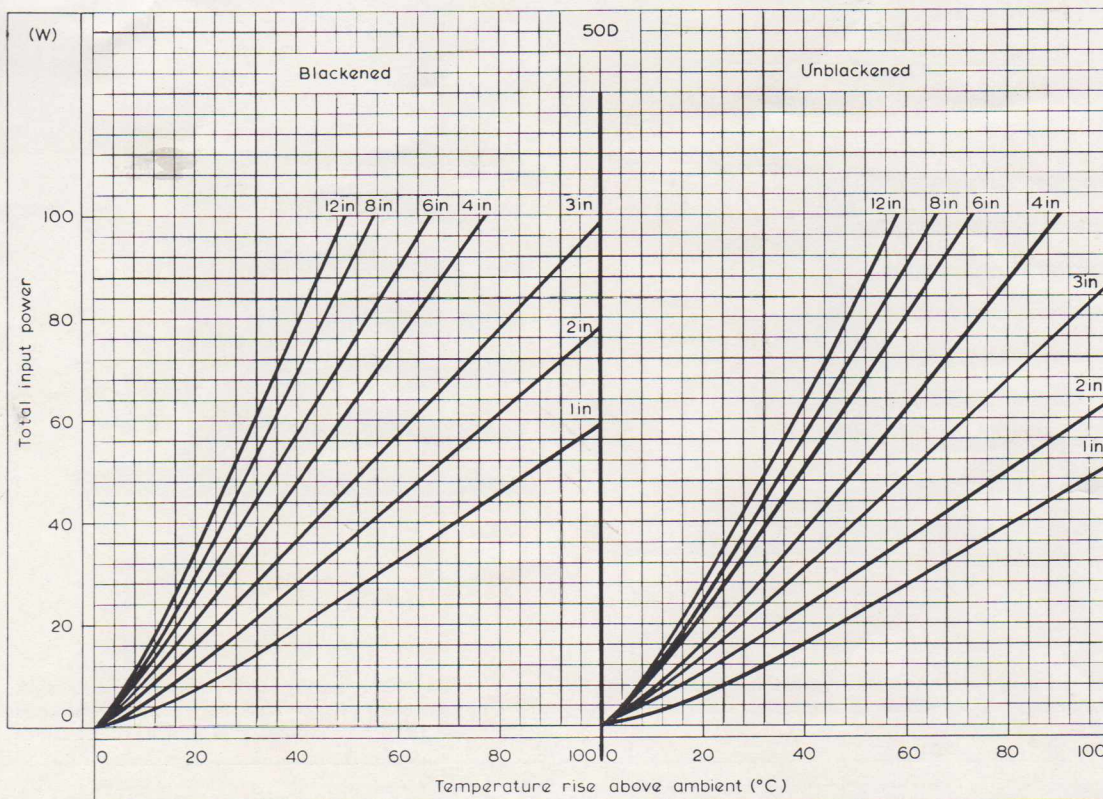


2. The holes shown in the outline drawing are typical for a stack assembly. This extrusion may be obtained with or without the holes and cut to standard lengths.

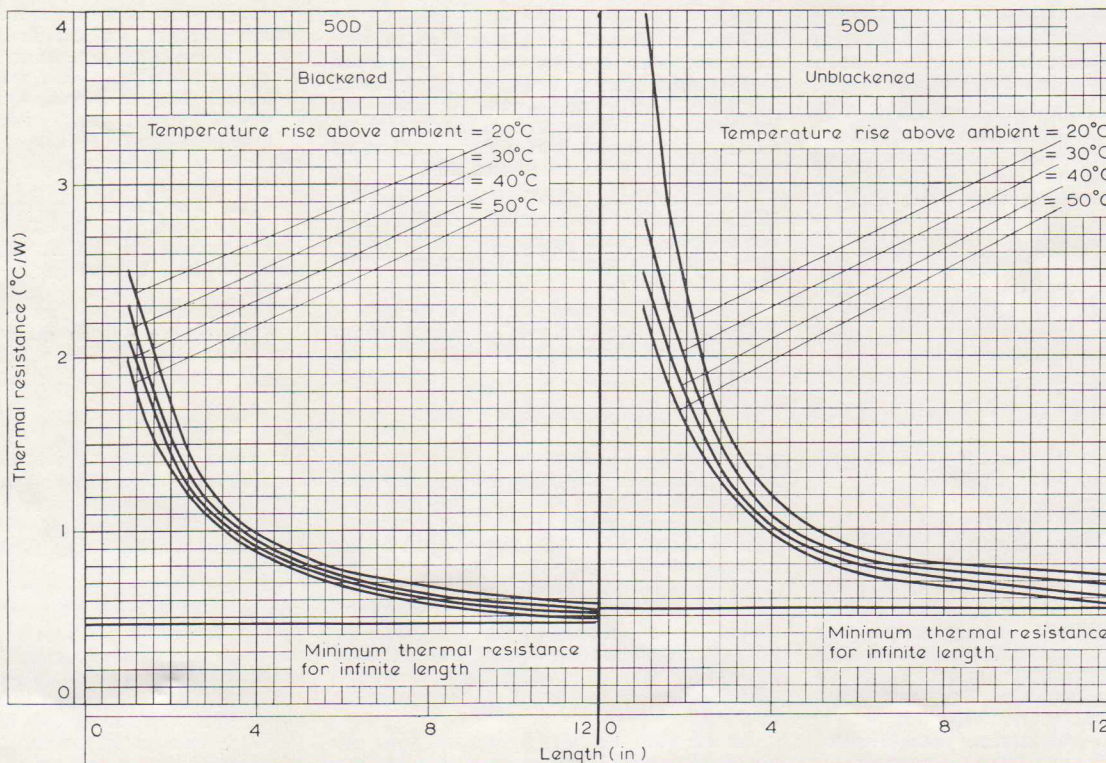
3. Designers please note the 40D extrusion is the locally produced and preferred type in Australia. Assemblies should be designed around this extrusion wherever possible.

Dimensions in mm
 Inch conversions in brackets

50D HEATSINK EXTRUSION

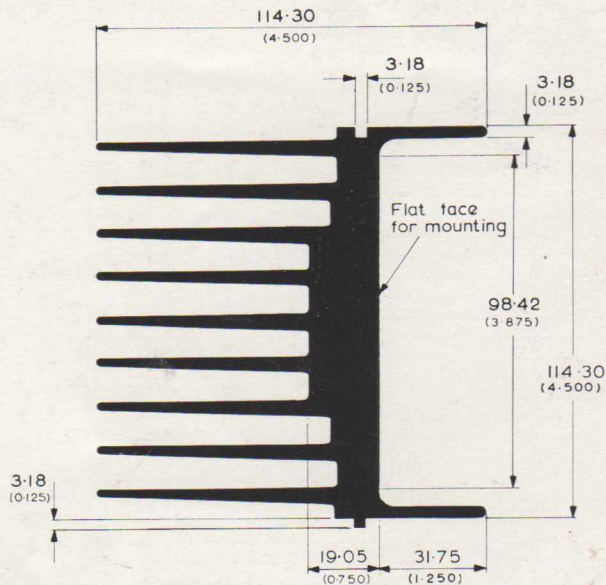


Total input power versus rise above ambient temperature for various lengths of extrusion, with natural convection cooling.



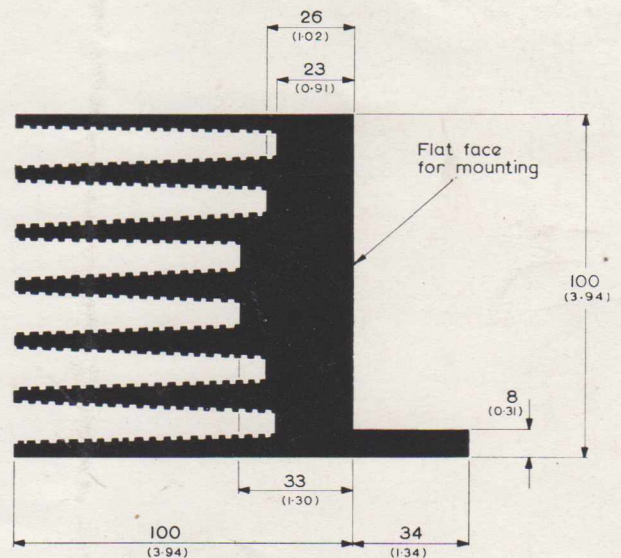
Thermal resistance versus extrusion length, for various rises above ambient temperature, and with natural convection cooling.

60D HEATSINK EXTRUSION



Type RS HS 60D 8 HPO.

110D HEATSINK EXTRUSION



Type RS HS 110D 60 HPO

1. These outline drawings represent the extrusions rather less than half actual size. Dimensions in mm; inch conversions in brackets.

2. Designers please note the 40D extrusion is the locally produced and preferred type in Australia. Assemblies should be designed around this extrusion wherever possible.

NEW HEATER RATINGS FOR 6AN7 AND 6BH5

The frequency changer 6AN7/ECH80 and the 6BH5/EF81 variable μ RF pentode were previously manufactured with a heater current of 225mA and 200mA respectively.

They are now being manufactured with a new heater rating of 6.3V at 300mA, included in the Mullard Preferred Range and, to indicate this change, their type numbers will now be known as 6AN7A and 6BH5A.

In most applications the respective increase in heater ratings may be ignored so far as the mains transformer is concerned. Where the 6AN7A or 6BH5A are used in a series heater string arrangement, shunt resistors may be dispensed with.

14kW PULSED MAGNETRON FOR USE AT HIGH ALTITUDES

This new packaged magnetron, type YJ1040, is intended for use in high altitude airborne radar equipments operating over a frequency range 9.345 to 9.405Gc/s (X-band). The flying, connecting leads are insulated with silicon rubber and the waveguide output is sealed to allow operation at high altitudes without pressurising.

Under typical operating conditions the YJ1040 requires an input of 6.7kV, 5.25A for a pulse output power of 14kW. Maximum pulse duration is 2.5 μ sec at a duty cycle of 0.0015.

The heater is rated for 6.3V, 0.55A. Overall dimensions are 115mm x 80mm x 140mm and the weight is 1.5kg (3.25 lb).

MINIATURE 160W MAGNETRON TYPE YJ1030

The YJ1030 is a miniature tunable magnetron intended for use in airborne transponder equipments operating at a frequency of approximately 5.65Gc/s (C-band).

Special features include low weight (only 7 ounces), rugged construction and, due to this magnetron's very low temperature coefficient of 50kc/s per $^{\circ}$ C, adequate frequency stability is obtained.

With the maximum pulse input of 1.18kV, 0.8A, the YJ1030 gives a pulse power output of 160W. Maximum pulse duration is 3.0 μ sec at a duty cycle of 0.002.

The heater is rated for 5.0V, 0.5A. Approximate overall dimensions, excluding leads, are 4 inches x 1.35 inches.

VIEWPOINT WITH MULLARD (Continued from page 75)

in England and employ nearly 20,000: 40% of the production being exported.

Blackburn Birthday Function

The "Lancashire Evening Telegraph", Tuesday, November 19th, 1963, records the function to mark his 80th birthday "PIONEER AT THE EXCITING BIRTH OF AN INDUSTRY. Many people who said 'We never knew there was a Mr. Mullard' had the surprising and happy experience of meeting him today—an erect, still-sturdy figure, rather bald but with a neatly-trimmed moustache, horn-rimmed glasses and a rather debonair manner. At one stage of the proceedings he apologised for being 'a little forgetful' but most people

present during the five-hour celebrations had nothing but admiration for the way in which he carried himself alertly, answered the speeches made in his honour and humbly gave credit to those who have helped in the industry he pioneered.

"A little of Mr. Mullard's exciting story was told to the large gathering of civic and industrial representatives in the Windsor Hall, where a champagne toast was proposed to him by Mr. S. S. Eriks, who succeeded Mr. Mullard as leader of the organisation in 1929."

As his 80th birthday coincided with the 500th million Mullard Valve, a golden replica of this historic valve was presented to him. A feature of the gathering was an

enormous birthday cake with 80 valves as candles and Mr. Mullard asked that the Mayor of Blackburn accept the very substantial first layer of the cake for distribution amongst deserving Blackburn townspeople.

Stanley Mullard has survived to see the company he formed 43 years ago, grow to occupy a leading position in the electronics industry. His retirement has been far from inactive, he has continued to participate in company affairs, albeit infrequently and since 1945 has interested himself in new developments in horticulture, a subject in which he is now a recognised authority. He has a son and three daughters and lives near Egham, Surrey.