Mullard Outlook

AUSTRALIAN EDITION

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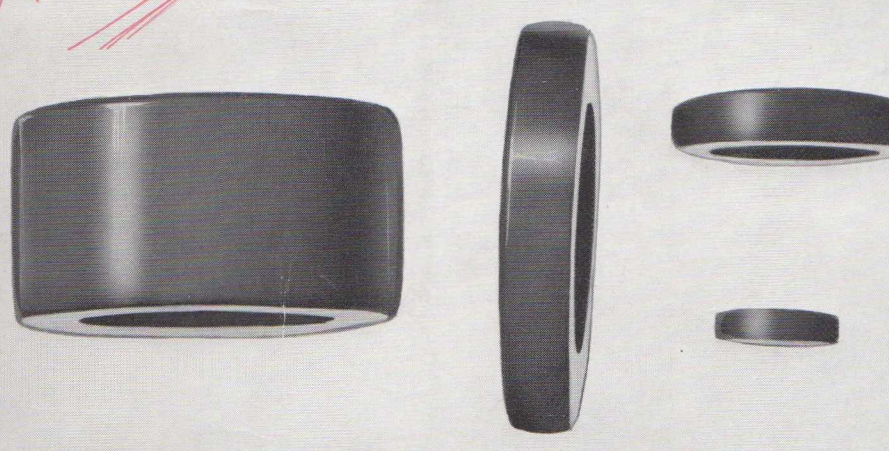

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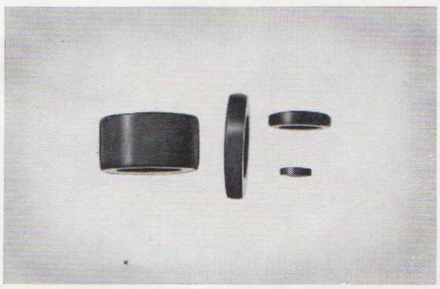

Several sizes of Mullard ferroxcube toroids are now available with nylon coating. Unlike other insulating materials employed to coat toroids, nylon will not chip, flake or crack. More comprehensive information may be found in this issue.

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FOOTPATHS AND NATURE STRIPS

In some States called nature strips and in others footpaths, but always that bare asphalt or concrete area or an undefinable ledge of eroding shale, a sandy ridge or a luxuriant growth of paspalum. Nevertheless that part in front of Emoh Ruo and the never ending rows of Emoh Ruos in our newly developed satellite suburbs.

Building statistics show that almost half of all new Australian dwellings are home units, efficient and sophisticated housing development in tune with the greater population density of today, something recognised long before in other places.

We must be mindful of the newer pattern in efficient house design, with individual home developers offering a variety of well designed and aesthetically pleasing homes with special efforts for split levels and just a little of Le Corbusier—that a house, to some degree, "is a machine for living in". Let us be mindful also of the abundance of furniture of good taste and simple design influenced by our Scandinavian friends, even though it might look and be called "oiled teak", but inside what appears to be a stable preparation of pine pieces and pulverised poultry pellets.

Our theme in this changing pattern is a new and sensible approach to "music" in the home—in particular for home units—that does not clutter up the restricted space with large boxes adorned with tizz and paraphernalia. We suggest that some of the palaver and mumbo-jumbo of Hi-Fi might be extracted and somewhere in between, there is offered for this new generation of discerning folk, a small and simple record player box containing a radio tuner and a solid state stereo amplifier to be neatly tucked away on top of a bookshelf or small table and, just as unobtrusively, two small high quality speaker boxes lost amongst Churchill's Memoirs, The Group and Lady Chatterley's Lover!

Semiconductors make this possible ensuring a neat, small, cool running device and we must emphasise "Mullard" semiconductors and circuit design.

M.A.B.

VIEWPOINT WITH MULLARD

SILVER MEDAL AWARD FOR MULLARD FILM

Mullard Educational films and filmstrips have long been recognised by science instructors and teaching organizations throughout the Commonwealth, as a valuable addition to their educational programme.

The Mullard colour film, "Thin-film Microcircuits", was awarded a silver medal (1st prize) in its category at the 10th International Festival of Scientific-Teaching Films, organised by the University of Padua, Italy in conjunction with the 1965 Venice Film Festival. Over 150 films from 18 countries were entered and of these 52 were selected for showing to the international jury.

One of the first Mullard films to receive an award at the International Festival of Scientific-Teaching Films, was the film "Mirror in the Sky" which won a first award in 1957. Two years later, the Mullard film "Conquest of the Atom" received the Gold Award for educational films in Rome.

The colour film "Electromagnetic Waves —Part II" produced by Mullard in conjunction with the Educational Foundation of Visual Aids, has won a bronze award at the IX Rassegna Internazionale del Film Scientif—Didattico (9th International Exhibition of Scientific-Teaching Films).

"Thin-film Microcircuits"

This 16mm Kodachrome colour film, with a running time of 15 minutes, is now available from the Mullard Film Library.

In the opening scenes of this new Mullard film the launching of a satellite serves to emphasise the need for small light-weight electronic components which must be of the utmost reliability. As an example, part of the telemetry equipment for use in the third stage of the ELDO rocket is shown. Although no bigger than a cigar box it contains over 2,000 resistors and capacitors as well as 500 transistors and diodes.

Because of their greatly reduced size and weight, low cost and extremely high reliability, thin-film microcircuits are becoming more widely used in many types of electronic equipment.

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

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

The film will be of interest to electronic engineers and others wishing to familiarise themselves with the manufacturing techniques of thin-film microcircuits and to those with a general interest in recent developments in electronics.

A comprehensive catalogue listing Mullard films and film strips is entitled "Mullard Film & Film Strip Library" and may be obtained on application to the Film Library at either the Melbourne or Sydney Offices.

Conditions of Loan

The 16mm sound films are available for hire at 50c (5/-) per film and this charge is payable on confirmation of the booking. To avoid disappointment, application should be made at least 21 days prior to the intended screening dates and before returning, borrowers are requested to rewind the films on their original spools and to detail any damage encountered.

Films will be airfreighted to their destinations free of charge and where air service is not available the fastest means of transportation will be used. The films should be returned by the same means of transport at the borrower's own expense and, to ensure smooth running of the hiring system, it is requested that despatch arrangements be made to allow the films to arrive at their office of issue on their due dates. 35mm filmstrips and lecture notes are available free of charge with the same conditions of loan as outlined above. ■

THERE IS MORE TO SERVICE THAN REPAIRING A SET

This is the title of a humorous poster in full colour, 19" x 29" mounted on hardboard to hang in a prominent spot, as a constant reminder of the need for good and complete service with all the facets of dress, approach and bedside manner.

Customer Confidence

A poster also directed to your customers so they know you consider these factors seriously and do something about it. To assist build good customer relations and the impression that dealing with you is a transaction with a determined desire to please with a relationship of trust and confidence.

Distribution

The posters are at present available from our Distributors in each state and if you have not received yours then perhaps you are not in contact with them or giving your customers the benefit of Mullard Quality and Service.

Contact the Mullard Distributor in your State who will be pleased to send along a poster, if you have a large workshop and are anxious to show the message to your customers as well, ask for two and as a peace offering put Mullard valves in your service kits.

Brickbat or Bouquet

One reader said that apart from displaying a poster in the workshop he had hung one on the back of the toilet door and even our most sensitive souls took this as a compliment, for practical innovation and originality are the stuff to engender that extra that makes for success.

The Service Engineer— Ambassador-Extraordinary

Readers will recognise from the poster the illustrations from the article on pages 68 and 69 of Outlook, Vol. 8 No. 5. Your chaps may be encouraged to read this again and incidentally it has made such impact that we have had many requests for reprints which are available in any quantity on request, one service organisation requested 750 and we gladly responded, for this information is for our customers and potential customers and our contribution to better standards and recognition of that front line in the home ambassador—the Service Engineer.

The poster measures 19" x 29", is printed in full colour and mounted on a stiff cardboard backing.

One enthusiast told us he had read the article six times and each time with fresh interest and firm resolve to persevere with the suggestions and thoughts presented. He told us his team was infected with the spirit and as a by-product had resulted in a happier workshop and better team effort. No wonder we are enthusiastic too! ■

M.A.B.

LOW COST HIGH-QUALITY SOLID STATE AUDIO FREQUENCY AMPLIFIERS

This short review is an introduction to a series of solid state amplifiers to be described in future issues of Outlook. The circuit techniques may be interpreted for use in commercially produced record reproduction equipment of various grades but equally for the home constructor. The theme is high-quality at low cost and an appraisal relative to the particular end user, be it in the home for run of the mill record reproduction or to the dedicated audiophile.

Influence of Industrial Usage of Semiconductors

The ever widening use and application of semiconductors in industrial and professional equipment continues unabated in that design engineers before deciding on the use of a hard or gas filled thermionic electron tube will first examine all of the available semiconductor devices. This philosophy stems directly from the inherent advantages of solid state devices, factors of reliability, temperature rise and so on and can be directly applied in certain consumer products, for example washing machine controllers and for this particular theme radiograms and players, with due regard to certain cost factors; however, the trend is developing both here in Australia and other places. Most audio frequency amplifiers are now solid state with loudspeaker manufacturers offering a wider choice of standard voice coil impedances.

Semiconductors and Record Playing Equipment

Outlook, Vol. 4 No. 3, May-June 1961 showed in some detail a solid state cordless AM broadcast receiver, Vol. 4 No. 6, November-December 1961 a cordless radiogram and in the intervening time complementary symmetry and other semiconductor type grouping has provided a complete new look, in that for an additional semiconductor or two and the deletion of all transformers, not only allows considerable improvement in performance but a receiver of this type can be produced at lower cost, indeed most of the portables and mantel receivers manufactured in Australia today are of this technique.

High-Quality at Low Cost—The Old Mullard 5-10 Valve Amplifier

It will be recalled that the 5-10 was introduced 12 years ago and stressed high-quality at low cost. It set the pattern for subsequent valve amplifiers with appropriate loudspeakers and enclosure technique.

To translate this amplifier to semiconductor thinking, and with particular emphasis on low cost, the amplifiers to be described in future issues are all equipped with low cost entertainment equipment transistors even in the output stages and it is self-evident that the removal of the driver and output transformers, the use of a much smaller power transformer not only offers considerable cost advantages but more important much lower heat dissipation, smaller physical size, lower power consumption and the complete unit considerably reduced in weight.

The Mullard Applications Laboratory circuit technique information covers solid state audio frequency amplifier systems from 1W to 10W and higher if needed. As mentioned earlier it has been orientated in the broad sense to assist both the receiver manufacturer and the enthusiast and therefore in regard to performance and cost it is anticipated each will interpret his own approach to a particular end product. It must also be emphasised this development has been related to preferred semiconductor types and in particular the types recently introduced and with a view to the incorporation of additional types from time to time.

Amplifiers for Small Record Players

For both battery operated and mains operated players there are certain economies, for example where a 9V rail is applied, a particular amplifier, perhaps on a printed board, can be operated both from a 9V dry battery or from a nominal 9V supply from an over-winding on the player motor field. Where the emphasis may be on purely mains operated players and the technique has been to use higher rail voltages, this has been highly successful although with certain limitations from the 5 or 6 Volt Amps permissable as the additional load on the motor field; however, in choosing Mullard complementary symmetry semiconductors these will provide two clean 2W channels from a 17V rail and considered quite adequate for this type of device.

Small Radiograms

To apply this technique to a low cost stereo radiogram be it portable, transportable, in full console configuration or a small player with separate speakers for bookshelf mounting, when listening to the radio the motor would be spinning and it is suggested that in all but a purely portable device that the inclusion of a small power transformer is desirable and that the cost relative to the higher costs of cabinet, carton and so on is acceptable.

Higher Powered Domestic Equipment

In this regard the reader's attention is drawn to the editorial in this Outlook, in that with due respect to the dedicated audiophile with his high standards and his powers of debate has prompted a higher and higher standard of components be it in pick-ups, loudspeakers, amplifiers and recordings. It is believed there is now a very significant force in a new generation of ordinary listeners who can be encouraged to demand higher quality not knowing that it would cost them little more. if that last ounce of finesse was to be withdrawn and perhaps reserved for the dyed in the wool enthusiast.

With available solid state devices and the present stage of the art and cost a consideration—there is a gap between 3W and 10W where to offer clean power over 3W it is almost as economical to provide 10 and the low cost high-quality Mullard stereo amplifier to be described in future issues has a basic specification of a full r.m.s. power of 10W per channel at 0.5% total distortion and within $\pm$1dB from 5c/s to 40kc/s and $-$3dB at 60kc/s. It might be pointed out here that the extension to 60kc/s was a pre-requisite in the development specification to cater for certain industrial applications, but nevertheless significant and somewhat academic to the audio enthusiast.

It is not intended in this issue to detail audio frequency power and its interpretation of r.m.s., "music power" or the exaggerated claims in other places where the total "music power" in both channels is quoted as 50 or 100W, nor where there is an excessive power to overcome the high power loss in low cost loud speaker systems.

In short—the application of solid state techniques provide a tremendous flexibility on which to base engineering for more acceptable record reproduction equipment in the home.

Loudspeakers

It has been said by cynics outside the orbit of Hi-Fi enthusiasm that given the ultimate in ick-ups, amplifiers, loudspeakers and loudspeaker enclosures and recordings, anyone could finish up with the ultimate in record reproduction and therefore it offers little interest and this comment could well spark off a train of vigorous debate; however, to offer adequate reproduction versus cost, one must have a suitable pick-up, amplifier and loudspeaker system and on this score perhaps with a new phase of **Hi-Fi** for **the people** one should start from the end rather than the beginning and decide on what form the device might take, and in particular the loudspeaker and loudspeaker housings, for example the trend towards small sealed boxes for bookshelf mounting and loudspeakers with low resonance, high mass and high compliance are well established but cannot be bracketed at the present time as low cost; however, some compromise is necessary to offer a small player unit and radio tuner with speaker housings that **do fit** into bookshelves and just as important unobtrusively, for the pick-ups, motors and amplifiers are no problem.

In this the "Hi-Fi" connoisseur can be of considerable assistance where cost is a factor and already the ultimate is well catered for, but more important is the measure of de-grading that is acceptable and where the broader thinking professional enthusiast is able to arrive at a reasonable compromise that would in the first instance not damn "Hi-Fi for the people" for all time.

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Transient Performance of Heatsinks for Power Devices

The thermal performance of heatsinks during temporary current overloads can be calculated simply from the thermal capacity of the heatsink, or more accurately from the thermal capacity and the thermal time-constant. This simple calculation gives pessimistic results, and heatsinks designed to allow for the thermal effects calculated in this way would have a substantial margin of safety. The expressions given can be used to calculate the maximum tolerable duration of an overload, or the maximum allowable initial current where an overload of known amplitude and duration will be superimposed, or the maximum tolerable overload that may be superimposed on a given initial current for a given time. One or other of these conditions frequently has to be solved when thyristors or other power devices are used with loads such as motors, which draw variable currents.

The purpose of a heatsink is normally regarded as the provision of a suitable 'thermal resistance', which allows a power device to be run continuously at a given dissipation without a specified value of mounting base temperature being exceeded. A heatsink also provides a useful 'thermal capacity' which allows appreciable overload currents to be carried for periods of up to a few minutes.

To obtain a given thermal resistance with the minimum quantity of heatsink material requires a design with relatively thin fins. On the other hand, to obtain a large thermal capacity for a given thermal resistance requires the part of the heatsink on which the device is mounted to be relatively thick.

A compromise has to be achieved between these two requirements, and this is often linked with mechanical considerations. In the case of the 30D, 40D, and 50D extrusions (Fig. 1), the centre part of the extrusion was limited in thickness by the requirement to fix studded devices (for example, the BYZ14) through the centre part with a nut on the other side. This type of design resulted in thermal time-constants, for natural convection, of about 5 minutes for the rise in heatsink temperature.

For the 60D extrusion (Fig. 1), designed primarily for the flat-based BYX14 device, the centre part is considerably thicker. This means that when a studded device is used, the hole for mounting has to be specially drilled and tapped. However, the thermal time-constant for the 60D extrusion is about twice that of other extrusions, resulting in an improved transient performance.

In some installations forced-air cooling can be used with advantage to reduce the thermal resistance of a given heatsink. An unfortunate side-effect is that the thermal time-constant is also reduced. In consequence, special care must be taken when considering overload currents with forced-air cooling.

THEORETICAL CONSIDERATIONS

Two approaches may be used when considering the transient performance of 30D, 40D, 50D, and 60D heatsinks. One is a simple method, which uses only the thermal capacity of these extrusions, and another which uses the thermal time-constant.

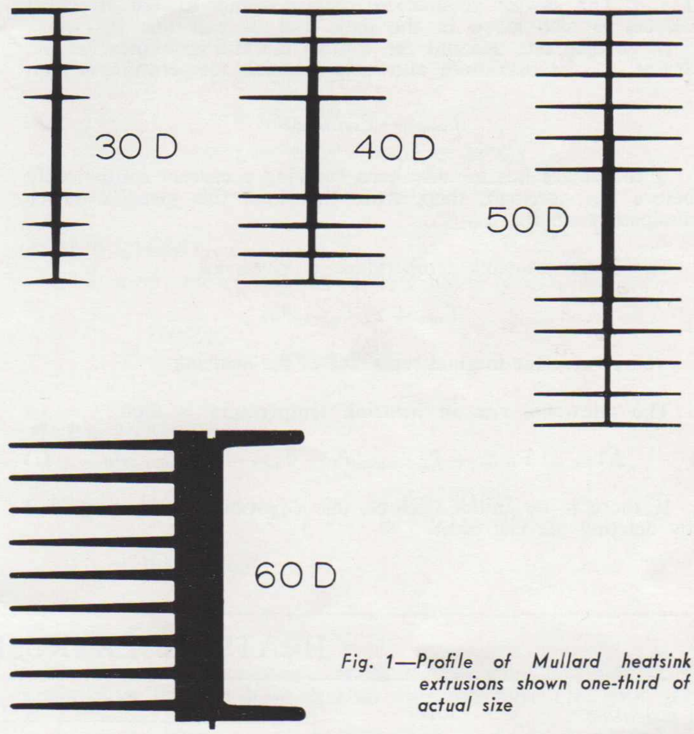

Fig. 1—Profile of Mullard heatsink extrusions shown one-third of actual size

Although either of these methods can be used for these types of extrusion, based on the same properties of the material, they cannot always be applied to other types of heatsink, for example thin plates.

Properties of Heatsink Materials

The thermal capacities of the various metals normally used for heatsinks are given in Table 1.

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TABLE 1
Thermal Capacities of Heatsink Materials

Metal	Thermal Capacity (watt. sec/lb/°C)
Aluminium	407
Copper	175
Steel	204

TABLE 2
Effective Thermal Capacities of Aluminium Extrusions

Extrusion	Weight (lb/ft)	Effective Thermal Capacity/inch (watt. sec/°C)	Max length (inch)
30D	1·1	34	5
40D	1·8	55	6
50D	2·7	83	6
60D	7·1*	215	8

**for calculation of thermal capacity; the actual weight may be higher because of a recent change of profile.*

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For a heatsink, it has been shown that all the metal is not at a uniform temperature, but is hotter at the centre than at the tips of the fins (see, for example, Ref. 1). Thus, when considering the thermal capacity of a heatsink, we must modify the value given in Table 1 to take into account the fact that the temperature being considered is that adjacent to the device, not the average temperature. Since this calculation is approximate, it is usually satisfactory to take a factor of 0·9 to allow for this, resulting in the effective values given in Table 2 for the four Mullard extrusions. The maximum lengths for which this factor is approximately true are also given. For greater lengths than these, the heatsink must be regarded as having distributed thermal resistance and capacity.

Equations for Operating Temperatures

At the conclusion of the overload period, the published limit for mounting base temperature corresponding to the current during the overload period must not be exceeded. Suppose this is $T_{mb(o)}$. The device dissipation corresponding to the overload current is also given in the data. Let us call this $P_{tot.max(o)}$.

If we take into account the contact thermal resistance for the device, θ_i, the maximum allowable heatsink temperature is then

$$T_{mb(o)} - P_{tot.max(o)}\theta_i.$$

If the device has initially been carrying a current continuously before the overload, then, from the data, this gives a device dissipation of $P_{tot.max(i)}$.

The initial heatsink temperature is given by

$$T_{amb} + P_{tot.max(i)}\theta_{HS}$$

where θ_{HS} is the thermal resistance of the heatsink.

The allowable rise in heatsink temperature is then

$$\Delta T_{HS} = T_{mb(o)} - P_{tot.max(o)}\theta_i - T_{amb} - P_{tot.max(i)}\theta_{HS} \quad \ldots (1)$$

If there is no initial current, this equation can be simplified by deleting the last term.

If this expression gives a negative value of ΔT_{HS}, then the overload with which it is proposed to load the device is too great. Either the overload requirement must be reduced, or a larger heatsink used, or a higher current rated device used.

Simple Calculation of Transient Performance

The simple method used in determining the transient performance is to consider only the thermal capacity of the heatsink. The time for which the overload current can be carried is then given by

$$t \simeq \frac{C_{HS} \times \Delta T_{HS}}{P_{tot.max(o)}} \text{ seconds} \quad \ldots (2)$$

where C_{HS} = thermal capacity of heatsink

= (effective thermal capacity/inch) × (length in inches)

Transient Performance using Thermal Time-constant

The thermal resistance of the heatsink, together with the thermal capacity, gives a thermal time-constant for the rise in heatsink temperature. Thus

$$\text{Thermal time-constant} = \theta_{HS}.C_{HS} \quad \ldots (3)$$

The heatsink temperature is aiming for a temperature given by

$$T_{amb} + P_{tot.max(o)}\theta_{HS}.$$

That is, the ultimate rise, as a result of the overload, would be

$$(P_{tot.max(o)} - P_{tot.max(i)})\theta_{HS}.$$

Thus, after time t (in seconds) the rise is

$$(P_{tot.max(o)} - P_{tot.max(i)})\theta_{HS}\left[1 - \exp\left(\frac{-t}{\theta_{HS}.C_{HS}}\right)\right].$$

HEATSINK EXTRUSION TYPE NUMBERS

Extrusion Length (inches)	*30D*		*Preferred Types*				*50D*		*60D*	
			35D		*40D*					
	Plain	*Black*	*Plain*	*Black*	*Plain*	*Black*	*Plain*	*Black*	*Plain*	*Black*
2	—	—	35D2C	35D2CB	40D2C	40D2CB	—	—	—	—
3	—	—	35D3C	35D3CB	40D3C	40D3CB	—	—	—	—
4	—	—	35D4C	35D4CB	40D4C	40D4CB	—	—	60D4C	60D4CB
5	30D5C	30D5CB	—	—	—	—	—	—	—	—
6	—	—	35D6C	35D6CB	40D6C	40D6CB	50D6C	50D6CB	—	—
8	—	—	35D8C	35D8CB	40D8C	40D8CB	—	—	60D8C	60D8CB
9	—	—	—	—	—	—	50D9C	50D9CB	—	—
12	—	—	35D12C	35D12CB	40D12C	40D12CB	50D12C	50D12CB	—	—
24	—	—	35D24C	—	40D24C	—	50D24C	—	—	—
36			35D36C	—	40D36C	—	50D36C	—	—	—
60	30D60C	—	—	—	—	—	50D60C	—	60D60C	—
72	—	—	35D72C	—	40D72C	—	—	—	—	—

Mounting Brackets (pair) Type No. MB1

Note: The 35D heatsink extrusion has been introduced to accommodate semiconductors which follow the TO-3 outline or its equivalent.

Equating this to the allowable rise ΔT_{HS} gives

$$\Delta T_{HS} = (P_{tot.max(o)} - P_{tot.max(i)})\theta_{HS}\left[1 - \exp\left(\frac{-t}{\theta_{HS}.C_{HS}}\right)\right]. \qquad \ldots (4)$$

This can be manipulated to give

$$t = \theta_{HS}C_{HS}.\log_e\left[\frac{(P_{tot.max(o)}) - P_{tot.max(i)})\theta_{HS}}{P_{tot.max(o)}(\theta_{HS}+\theta_i)+T_{amb}-T_{mb(o)}}\right]. \qquad \ldots (5)$$

This is the maximum allowable time for which the overload can be carried.

By suitable rearrangement, the solutions to the following problems can also be obtained.

(a) If a power device and heatsink are required to carry a specified overload current for a specified time, what is the maximum allowable initial current before the overload?

(b) What overload can be carried for a specified time following a specified initial current? In this case, both $P_{tot.max(o)}$ and $T_{mb(o)}$ are unknown, therefore successive approximations will be required.

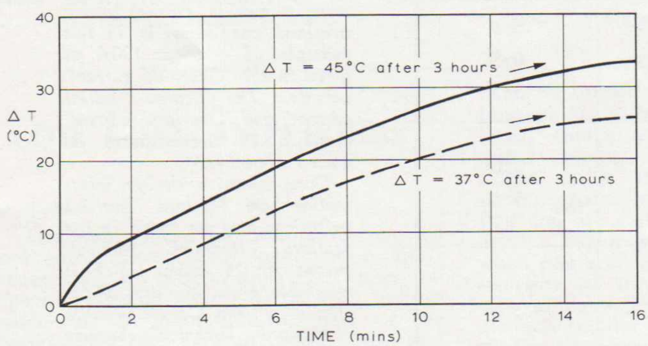

Fig. 2—Temperature gradient of 4 in length of 60D unblackened extrusion

Power into centrally-mounted studded device = 48W
T_{amb} = 23°C

——— thermocouple in heatsink at base of device

------ thermocouple at tip of outside fin

Repeated and Two-stage Overloads

The time-constant for cooling the heatsink after an overload is the same as that for heating, and it can be used in the calculations for repetitive overloads. If the interval between overloads is at least three times the thermal time-constant, then the heatsink can be assumed to have returned to its starting temperature before the occurrence of the next overload.

With two-stage overloads (that is, where one overload period is immediately followed by a second overload period at a different current level, with no intervening period of cooling), a calculation employing the super-position principle can be used.

EXAMPLES

Two examples are calculated, each by the simple method (Eq.2) and the more accurate method (Eq.5).

Example 1

A BTY99 thyristor is mounted on a 4 in length of 60D extrusion, carrying a steady initial current of 25A, 180° conduction, with $T_{amb} = 35°C$ and with natural convection cooling. For how long can an overload current of 50A be carried?

From the data

$P_{tot.max(i)} = 30W$

$P_{tot.max(o)} = 74W$

$T_{mb(o)} = 95°C$

$\theta_i = 0{\cdot}15°C/W$

$\theta_{HS} = 1{\cdot}08°C/W$ (for $\Delta T = 30°C$)

$C_{HS} = 215 \times 4 = 860$watt.sec/°C.

Method 1 (*Eq.*2)

$$\Delta T_{HS} = 95-(74\times 0{\cdot}15)-35-(30\times 1{\cdot}08) = 16°C$$

$$t = \frac{860\times 16}{74} = 186 \text{ seconds.}$$

Method 2 (*Eq.*5)

$$t = 1{\cdot}08\times 860 \log_e\left[\frac{(74-30)1{\cdot}08}{74(1{\cdot}08+0{\cdot}15)+35-95}\right]$$

$$= 395 \text{ seconds.}$$

Example 2

For the same conditions as in the previous example it is required to find for how long an overload current of 60A can be carried.

From the data

$P_{tot.max(i)} = 30W$

$P_{tot.max(o)} = 96W$

$T_{mb(o)} = 86°C$

$\theta_i = 0{\cdot}15°C/W$

$\theta_{HS} = 1{\cdot}08°C/W$ (for $\Delta T = 30°C$)

$C_{HS} = 215 \times 4 = 860$watt.sec/°C.

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NOTE

When ordering heatsinks, it should be remembered that most types may be obtained in natural or in blackened finish, cut to standard lengths. Particulars of non-standard lengths may be obtained from Mullard Offices throughout the Commonwealth.

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Method 1 (*Eq.*2)

$$\Delta T_{HS} = 86-(96\times0\cdot15)-35-(30\times1\cdot08) = 4\cdot2°C$$

$$t = \frac{860\times4\cdot2}{96} = 38 \text{ seconds.}$$

Method 2 (*Eq.*5)

$$t = 1\cdot08\times860 \log_e \left[\frac{(96-30)1\cdot08}{96(1\cdot08+0\cdot15)+35-86}\right]$$

$$= 58 \text{ seconds.}$$

Comparison

From these calculations it can be seen that, for times comparable with the thermal time-constant of the heatsink, the second method gives a much longer time than the first method. The values calculated are closer to each other for shorter times.

The value of θ_{HS} changes with ΔT. The higher value corresponding to the lowest ΔT during the overload period has been used in these examples.

PRACTICAL MEASUREMENTS

Measurements have been made with a BYZ14 device on a 4 inch length of 60D extrusion, with an input power of 48W.

Curves showing the temperature rise against time for the heatsink adjacent to the device and also the fin tip are given in Fig. 2. These show reasonable agreement with the method using thermal time-constants.

Final thermal resistance = 1·0°C/W, giving final rise of 48°C.

Then thermal time-constant = 860 × 1·0 = 860 seconds.

After this time, the rise should be

$$0\cdot632\times48 = 30°C \text{ (measured } 32°C).$$

Alternatively, for an average ΔT of 25°C approx., θ_{HS} = 1·1°C/W, which would give a final rise of 53°C.

Then, thermal time-constant = 950 seconds.

After this time, the rise should be 0·632 × 53 = 33·5°C, which is closer to the measured value of 34°C.

It will be noticed that there is a more rapid rise in heatsink temperature adjacent to the device than would be expected from thermal time-constant considerations, during the first minute. This is because the heatsink has distributed thermal resistance and capacity, which have been lumped together to simplify the calculation. It is advisable to allow a fairly generous 'safety factor' when calculating overload conditions for times of one minute or less.

TABLE 3

Computed Transient Performance of Thyristor Stacks

Stack type	Rated continuous current	Overload Conditions		
		Initial current	Overload current	Overload time (mins)
OTH17-608	17A	0A	24A	5·0
		10A	24A	1·4
OTH23-608	23A	0A	32A	6·5
		15A	30A	0·5
		20A	25A	3·5
OTH36-608	36A	0A	50A	8·0
		20A	50A	1·5
OTH68-608	68A	0A	80A	13·5
		40A	80A	4·5
OTH110-608	110A	0A	140A	8·25
		70A	140A	0·5
		65A	130A	5·5

All currents are for 180° conduction and T_{amb} = 35°C

The overload currents tabulated in the table are total allowable currents. Thus, in the final example, an initial current of 65A is allowed to have a current of 65A superimposed on it for a maximum time of 5·5 minutes. The maximum allowable current under overload conditions, is, in this example, 65 + 65 = 130A, as given in the 'Overload current' column. The quoted 'Initial current' and 'Overload current' must in no circumstances be added together.

Comprehensive design information on Mullard heatsink extrusions may be found in the Mullard Heatsink Manual, priced at 25 cents, which is available from Mullard offices throughout the Commonwealth.

Mullard Technical Service Departments will assist you with specific heatsink design requirements.

STACK OVERLOADS

There is an infinite number of overload conditions that could be considered. Table 3 gives typical computed maximum overloads for some stacks in the Mullard range of single-phase bridge thyristor stacks. ■

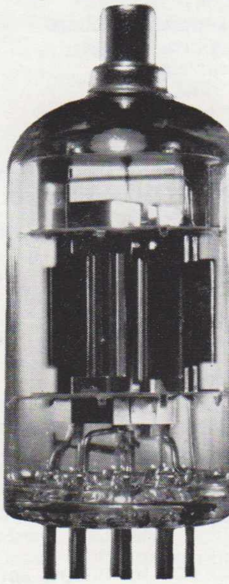
J. H. Tuley,
Mullard Semiconductor Electrical Development Laboratory.

REFERENCE

1. Tuley, J. H. 'Design of Cooling Fins for Silicon Power Rectifiers'. **Mullard Technical Communications,** Vol. 5, No. 44, June 1960, pp. 118 to 130.

45mA/V WIDEBAND OUTPUT PENTODE EL5070

Based on the well-established E55L but offering 25% reduction in output capacitance and an improved gain-bandwidth performance is a new special-quality wideband amplifier pentode, type EL5070.



This valve is designed to be used in microwave links coaxial repeaters, radar systems, television transmission equipment and measuring instruments. Data sheets and design curves will be isued shortly to subscribers of the Mullard Technical Handbook, Vol. 1.

The reduced output capacitance of only 2.9pF has been achieved by re-designing the internal structure and using a top-cap anode connection instead of a base pin. The top-cap anode also gives an improvement in the performance of oscilloscope deflection amplifiers, since the lead between the anode and cathode ray tube deflection plates may be kept short.

The EL5070 has a mutual conductance of 45mA/V at an anode current of 50mA. This high slope is obtained by using a frame-grid technique for both the control-grid and the screen-grid.

The improved gain-bandwidth performance of the valve makes it suitable for use as a video or pulse amplifier or as a cathode follower. It will therefore find application in microwave links, coaxial repeaters, radar systems, television transmission equipment and measuring instruments. ■

Abridged Advanced Data:

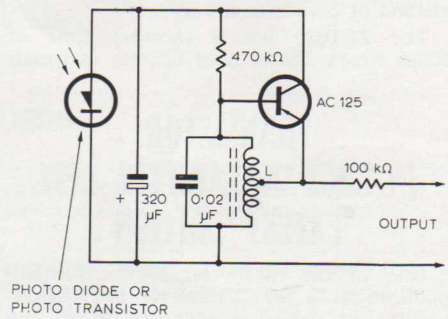
Average output capacitance (Pentode connected unshielded)	2·9	pF
p_a max.	10	W
p_{g2} max.	1·5	W
g_m	45	mA/V
I_a	50	mA
Heater voltage	6·3	V

LIGHT-OPERATED OSCILLATOR

The circuit diagram of this interesting device is shown below. It comprises a photovoltaic diode and a simple transistor oscillator. Moderate light intensities falling on the diode cause sufficient voltage to be generated to operate the oscillator. Both the magnitude and, to a lesser extent, the frequency of the oscillator vary with different light intensities.

When illuminated by a 0.5W pilot lamp placed 3cm away, the photodiode produces an 'on load' output of 100mV and the oscillator provides sufficient output at about 1kc/s to operate a high impedance crystal earpiece or a sensitive audio amplifier.

Most phototransistors and photodiodes exhibit the photovoltaic effect and this circuit operates successfully from the OCP71 phototransistor or the Mullard OAP12 photodiode.



Circuit of the light-operated oscillator.

The inductor used in the circuit consists of 300 + 300 turns of 39 s.w.g. enamelled wire wound on a coil former Type DT2178. Two half-cup cores Type FX2238 complete the inductor assembly. The inductance thus obtained, together with the 0.02µF capacitor, will tune the oscillator to approximately 1kc/s.

Applications of this circuit could include an example of direct energy conversion or some form of warning or monitoring device. ■

LOW COST AMPLIFIERS

← page 4

The Applications Laboratory has carried out some considerable investigation along these lines, working to an overall minimum speaker housing cubic specification and to cater for the dimensions of 90% of the bookshelves both built-in or otherwise and currently being offered by manufacturers of this type of furniture.

The development specification also laid down that the loudspeaker enclosure must give adequate performance with only one loudspeaker unit, be capable of housing two if necessary, a tweeter for example, and that the loudspeaker units themselves must be standard, low cost, locally produced speakers as currently offered to the industry. In all it has been necessary to keep an open mind and with one's feet firmly on the ground, in particular with regard to costs.

Cabinets and Packing

Should this task be always finished but never complete, the cost considerations for a manufacturer can well apply to the low cost of the two small speaker housings and equally small player and amplifier cabinet —considerably less than a large console cabinet be it containing the two stereo channels or perhaps with a separate cabinet housing the other channel. This conventional configuration is expensive both in initial cabinet costs and transportation carton costs, requires additional factory stowage space, time consuming cabinet fitting and are rather bulky and awkward to handle. All of these factors are well catered when one contemplates the small unit construction of the bookshelf theme and in view of there being less volume and weight a much smaller and lower cost corrugated cardboard carton. ■

M.A.B.

THE RORT BROCHURE A COLLECTOR'S PIECE

Since the advice in the Editorial of Outlook Volume 8, No. 6, that the collector's piece—the Rort Leaflet—would be reproduced in this issue of Outlook, several of our readers have suggested that other than in leaflet form, it would lose some of its charm. We bow to the suggestion and thank these readers for their interest. We have had an original leaflet reprinted and copies are available on receipt of a stamped addressed envelope, no smaller than foolscap size endorsed "Rort". ■

Ed.

GREAT CIRCLE MAP OF THE WORLD

Readers may be interested to know that the wide acceptance of the recently released Mullard Great Circle Map has already necessitated a second printing.

Whilst this chart has been centred on Sydney as a compromise for N.S.W.. Southern Queensland, South Australia and Victoria, we regret that production costs at this time do not allow a similar comprehensive chart centred on Perth, however the Department of Lands of the Western Australian Government at one time prepared a great circle chart centred on Perth. This is now out of print unfortunately, and somewhat outdated.

For the benefit of our Perth friends and to be used in conjunction with the chart centred on Sydney, we have in preparation the artwork of a chart centred on Perth. In view of the quantities, the reproduction will be of dye line print technique. The chart will be available from our W.A. Distributors, Tedco Pty. Ltd., 579 Murray Street, Perth. ■

NEW COLD-CATHODE TRIGGER TUBE ZC1030

The ZC1030, a new, "smaller-than-subminiature" cold-cathode trigger tube, is faster than similar types previously offered, yet costs less.

Using ZC1030 tubes in a typical counter circuit, together with the numerical indicator, ZM1080, is probably now the cheapest method of decade counting.

The ZC1030 could be used in electronic desk calculators, small computers and most indexing counter and switching circuits.

The ZC1030 has a recovery time of 100μs which allows it to operate at speeds much faster than those normally obtained by cold-cathode trigger tubes.

Accelerated life tests show that the new tube has a life expectancy of some tens of thousands of hours—similar to that of its forerunner, the Z700U.

The small size (20mm long by 6mm diameter excluding leads) and sturdy wire-ended construction make the ZC1030 suitable for printed wiring boards. As an added advantage it gives visual indication of the state of operation during maintenance and testing routines.

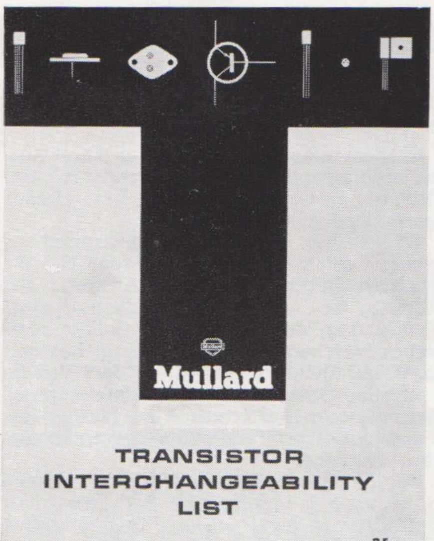
Typical applications of the ZC1030 will include electronic desk calculators, small computers and most indexing, counting and switching circuits. ■

Abridged Advanced Data:

Anode supply voltage	250 V
Anode maintaining voltage	102 V
Trigger ignition voltage	130 V
Cathode current	2 mA
Recovery time	100 μs
Operating temperature range	-55 to $+70$ °C

TRANSISTOR INTERCHANGEABILITY LIST LATEST EDITION

One of the most sought-after Mullard publications is the "Transistor Interchangeability List" which is regularly revised and amended. The eighth edition, just to hand, tabulates in excess of 2,350 transistor types in the first part of the publication while the latter features the "Broadcast Receiver Transistor Replacement Guide". (Approximately 1000 transistor listings.) This section is compiled to provide service organisations with a ready reference of transistors in the Mullard range which are suitable replacements for many Japanese and other imported transistors.



The eighth edition, available from Mullard Offices throughout the Commonwealth, is priced at 25 cents, post free. ■

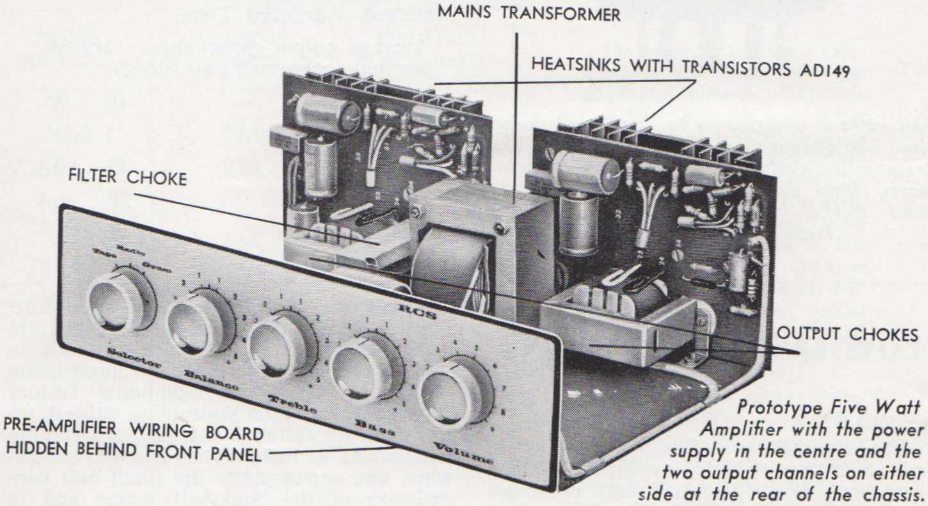
ADDITIONS TO THE FIVE-WATT TRANSISTOR AMPLIFIER

The latest additions to the range of wound components approved for use with the Five Watt Amplifier are the A & R mains transformer PT5755 and the output choke Z3200.

The Ferguson mains transformer, PF2440 and the output choke TRS236, were used in the construction of the prototype amplifier and are discussed in the original article in Outlook, Vol. 8 No. 4 on page 58*.

Power Supply

The power supply circuit shown on page 59* of the abovementioned publication, was originally designed to be used with a dropping resistor R which had to be adjusted to a value of approximately 6.8Ω to obtain —22V for the monaural version of the Five Watt Amplifier. In the stereo version a resistance of somewhat less than 3.4Ω is recommended (two 6.8Ω wire-wound resistors in parallel).



Prototype Five Watt Amplifier with the power supply in the centre and the two output channels on either side at the rear of the chassis.

If a filter choke such as the R.C.S. 57 or its equivalent is used instead of the dropping resistor, improved regulation is obtained and voltage adjustment may not be necessary for one or two channel operation.

When assembling the power supply it should be noted that the electrolytic capacitors should be returned directly to the centre tap of the mains transformer secondary as indicated in the circuit diagram. This common return ensures a low hum level.

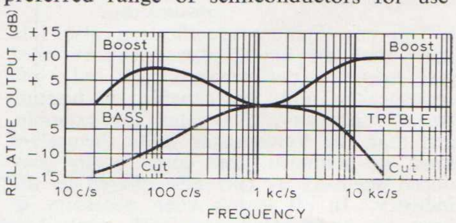
The four main sections of this amplifier (pre-amplifier, left hand channel, right hand channel and the power supply), are shown assembled on a common chassis with the power supply in the centre and the two output channels on either side of the pre-amplifier. Complete kit sets for this high quality amplifier are available from:

R.C.S. Radio Pty. Ltd.,
651 Forest Road,
BEXLEY. N.S.W.

Improved Performance

The original Five Watt Amplifier was designed around the germanium power output transistor AD140. An improved high frequency performance may be obtained by using an AD149, which supersedes the AD140. No circuit changes are necessary to accommodate this new transistor.

The AD149, which now belongs to the preferred range of semiconductors for use in entertainment applications in Australia is also available in matched pairs (Type 2—AD149). ■



Tone control characteristics.

Additional information: Transistor Stereo Pre-amplifier*, Outlook Vol. 8, No. 5, page 70.

* *Reprints of the original articles are available from Mullard Offices upon receipt of a stamped addressed envelope, no smaller than foolscap size, endorsed "Five Watt Amplifier" and/or "Transistor Stereo Pre-amplifier".*

FERROXCUBE TOROIDS
WITH NYLON COATING

Mullard Ferroxcube, a non-metallic ferrite, is now widely used in industry as a core material for inductors and transformers. It is also finding ever increasing use in applications as diverse as electronic computers, aerial rods and magnetostriction devices. The tables below have been compiled to assist designers with a selection of the most appropriate grades of material as well as the correct physical size. Design information on ferroxcube toroids as well as the comprehensive range of magnetic components may be found in Volume 6 of the Mullard Technical Handbook. The Technical Service Departments in Mullard Offices are always available to amplify any particular point and give technical assistance with any special problem.

Ferroxcube toroids are available in a number of materials and sizes. They are primarily intended for use as transformer cores in pulse and wideband applications. Toroids are available with outside diameters approximately of:—
2, 5.0, 5.2, 8.4, 12.7, 25.4, 38.1, 89 and 108mm.

The eight grades of toroids are well as the physical sizes are tabulated.

Initially three sizes in the range of ferroxcube toroids, 12.7, 25.4 and 38.1mm diameter, are available with a nylon coating. Unlike other insulating materials employed to coat toroids, nylon will not chip, flake, or crack, thus the insulation between the toroid and the winding remains permanently intact.

The toroids are primarily intended for use as transformer cores in pulse and wideband applications. The nylon coating can withstand a voltage of 1000V DC, thereby eliminating the need for additional insulating before winding. The nylon coating effectively prevents abrasion of the insulation around the winding wire. The colour of the nylon coating is consistent with the colour coding of the range of Mullard toroids.

FERROXCUBE GRADES FOR TOROIDS

Grade A1. For tuned circuit applications up to 500kc/s and for wide-band and high frequency transformers when lowest frequency to be transmitted is greater than about 1Mc/s.	Grade B2. For tuned circuit applications over the range 0.5 to 2.0Mc/s and for wide-band and high frequency transformers over the range 1 to 50Mc/s.
Grade A4. For tuned circuit applications up to 500kc/s and for high flux density applications, wide-band low power transformers (10kc/s to 20Mc/s) and low power pulse applications.	Grade B3. For tuned circuit applications over the range 2.0 to 5.0Mc/s and for wide-band and high frequency applications over the range 1 to 50Mc/s.
Grade A5. For tuned circuit applications up to 200kc/s and for communication transformers up to approximately 1Mc/s.	Grade B4. For tuned circuit applications over the range 5.0 to 20.0Mc/s and for wide-band and high frequency applications over the range 20 to 100.0Mc/s.
Grade B1. For tuned circuit applications over the range 0.5 to 1Mc/s and for wide-band and high frequency transformers over the range 1 to 20Mc/s.	Grade B5. For tuned circuit applications over the range 20 to 50Mc/s and for wide-band and high frequency applications over the range 20 to 100Mc/s.

MULLARD RANGE OF FERROXCUBE TOROIDS

diameter (mm)	A1	A4	A5	B1	B2	B3	B4	B5
2	—	—	FX1969	—	—	—	—	—
5	—	—	FX2073	—	—	—	—	—
5.2	—	—	—	—	—	—	FX2270	FX1886
8.4	—	—	FX2072	—	—	—	—	—
12.7	**FX1322**	**FX1593**	**FX2691**	**FX1594**	**FX1595**	**FX1596**	**FX1597**	**FX1598**
25.4	**FX1230**	**FX1582**	—	**FX1583**	**FX1231**	**FX1299**	**FX1358**	**FX1584**
38.1	**FX1585**	**FX1586** **FX2395**	—	**FX1587**	**FX1588**	**FX1589**	**FX1590**	**FX1591**
89	—	—	—	—	FX1108	—	—	—
108	—	FX1076	—	—	—	—	—	—

Toroids available with nylon coating are printed in bold type.

HOW MUCH DO MARGINS MATTER?

When Einstein summed up a whole realm of concentrated thought in the equation $e = mc^2$ (energy and matter are interchangeable), he was stating a fact that had always existed but had never before been realised. There is a parallel for dealers that can be expressed in the equation $P = s \times m$. Or Profit = stock turnover rate × margin.

"So what? I knew that already" may well be the retailer's response. But although the idea behind this equation is widely known, it is surprising how few dealers fully realise the implications. Yet they are fundamental to profitable retailing.

Let's take a simple example:

A slow moving line selling at £100 may carry a 50% margin and turn over on average twice a year. A fast mover selling at the same price may carry only a 25% margin but turn over on average once a month. The profit to the shopkeeper at the end of the year from the big-margin line is £100 (£50 × 2), but from the lower-margin product it is £300 (£25 × 12).

Clearly, here is the first truth: Profit margins by themselves are no guide at all to profit. What matters is margin, considered in relation to speed of stockturn.

It is unfortunate that the phrase "profit margin" has linked so closely the two separate ideas of "profit" and "margin". Let's take another example: If a £100 product carries a 30% margin and turns over ten times a year, the profit from the line is £300. Assume that the margin is raised to 31% without the need to increase the selling price, then the profit is £310 — a gain of £10. Now take the same product, with its original margin of 30%, and assume that the retailer makes just one more sale during the year. The resulting profit is £330—a gain of £30, or three times as much with the original margin as when the margin was actually widened.

This illustrates the second basic truth: that profits normally depend far less on margins than on speed of stockturn. This must be so because each time a sale is made the whole margin is earned, whereas any widening of a margin can, at best, be only very small if the product is to remain competitive and saleable. Thus, the quickest way to higher profits is to raise stockturn rates. Some of the more important ways to do this are use of direct mail and local advertising, improving salesmanship, stocking a balanced range of merchandise, giving sound free advice, making full use of shop and window display, and offering better-than-average service.

Overheads

Let us now look at the margins themselves. The net profit margin is always smaller than the gross profit margin because there are overheads to be allowed for. But if the dealer is to know his true position, he should be a little more scientific.

Overheads are either fixed (they do not fluctuate with the volume of trade) or they are variable (they are incurred in some proportion to the amount of business done). An example of a fixed overhead is rent, which has to be paid at a predetermined level whether the shop is packed with customers or empty.

Other examples are shop equipment, insurance, rates, and the minimum sum the retailer expects to pay himself each week as wages.

Variable overheads include such items as assistant's wages and the cost of running the service van. They increase as the volume of business increases, although not necessarily in direct proportion.

Every article sold or service provided must bear its share of the fixed overheads of the business, but the shopkeeper is misleading himself if he does not add the variable costs only to those items that incur them. Failure to do this means that he may be providing something at less than the real cost to himself, thereby making a loss instead of a profit.

In practice, it is too time-consuming to work out the detailed net profit margin on every article and service, but it is important to consider which are the major items involving variable costs and then ensure that the price charged is adequate. Engineers' time and cost of transport are typical sectors where the full cost is not always fully appreciated.

The Lines to Promote

The commonplace short-cut calculation of apportioning total overheads evenly over total sales gives an inaccurate result which is particularly false for the fast-moving no-trouble lines, where gross margins are normally smaller than elsewhere. On the face of it, these lines may appear to produce little net profit, yet it is quite likely that they are the real money-spinners of the business, simply because the true net profit margin is reasonable, while at the same time these are the very lines whose rate of stockturn it is easiest for the shopkeeper to boost.

Which lines, then, should be promoted, in over-the-counter salesmanship, in window and shop-display, and by other means? It is amazing how many dealers put enormous efforts into trying to speed the stockturn rates of lines in little demand. If too great a supply of an article has been bought, it is of course necessary to clear the excess stock as quickly as possible, but in more normal circumstances it is the best selling lines that should be promoted hardest.

In general this is particularly so for products for which the shop has become known in the district. A little advertising of specialized lines can do wonders in speeding stockturn rates.

This is one of the keys to better business: a certain degree of specialization. Margins tend to decrease with the ease of sale, averaged out over the whole country, the resulting lower price being one reason for the quicker rate of sale. By specializing in lines that are more popular for the retailer's own particular business than the national average, the dealer is able to reap a profit bonus.

This is where sales promotion, such as direct mail and local press advertising can be particularly effective. It makes known the shop's specialities as well as its existence. Of course advertising involves some outlay, but the resulting extra business can bring back far more net profit, even after allowing for the additional variable cost involved.

Wise Spending

It can be seen that margins are not necessarily widest when overheads, fixed or variable, are kept to the lowest possible. What matters is that money invested in the shop's range of stock, appearance, advertising, etc., should be spent wisely in relation to its business. The extent to which they speed stockturn and thus earn more profit is the criterion, not the total outlay.

Slow moving stock, in terms of dealer's capital tied up, is far more expensive than is often realised. A shop with £3,000-worth of stock, at selling prices bringing in an average of, say, 10% net profit and five stockturns a year makes £1,500 p.a. net profit.

If the average speed with which stock is turned over can be increased to six times a year with the same rate of net profit, £1,800 p.a. will have been earned. Not a pennyworth of additional capital is being employed, but it is being worked more intensively to produce an extra £300 each year.

To sum up, many retailers mislead themselves by paying too much attention to the apparent profit on a line through looking at its gross margin and, even worse, by deducting a percentage representing total fixed and variable costs of the whole business to arrive at a supposed net margin. Their more shrewd counterparts take into account the rate of stockturn and the extent to which this might be increased for their particular shop, as well as the true net profit margin. They also bear in mind the reliability of the product and the degree of satisfaction it will give, for this is the foundation of their goodwill and many future profitable sales. ■

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