"Miniwatt"

DIGEST

VOL. 2 No. 8
MAY 1963

TECHNICAL AND COMMERCIAL TOPICS OF CURRENT INTEREST TO THE ELECTRONICS INDUSTRY

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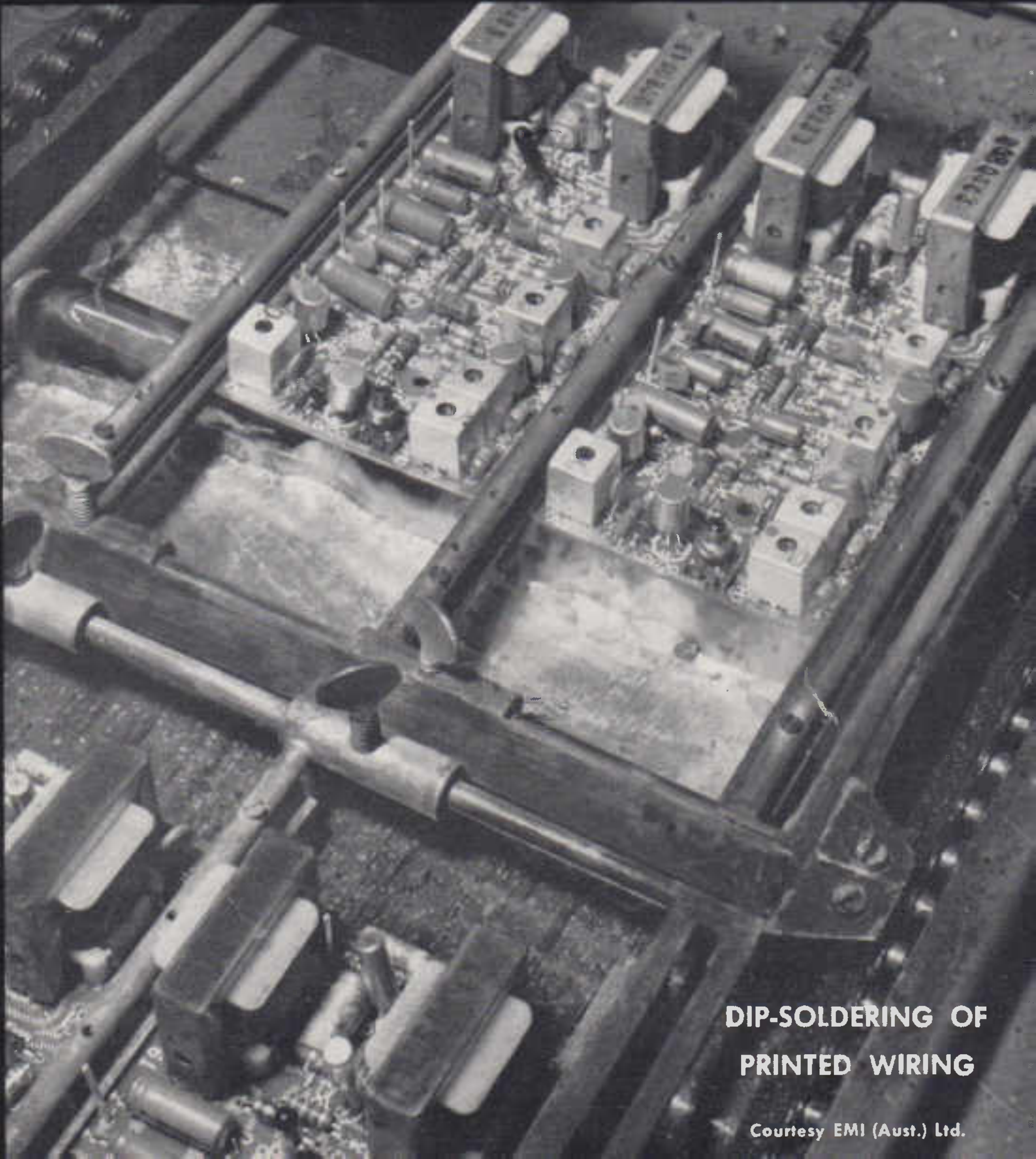
Published by the
"Miniwatt"
Electronics Division of
PHILIPS Electrical Industries
Pty. Limited,
20 Herbert Street,
Artarmon,
N.S.W., Australia

PHILIPS



DIP-SOLDERING OF PRINTED WIRING

Courtesy EMI (Aust.) Ltd.

Practical Aspects of the

INSTALLATION OF SEMICONDUCTORS

Based on experience obtained in the use of semiconductors in a wide variety of applications, some useful techniques are described for the mounting, soldering and care of Miniwatt transistors and diodes. Particular attention is given to the requirements for dip-soldering.

MOUNTING ACCESSORIES

Although low-power semiconductors are usually supported only by their leads, it is usually necessary to mount higher-power types using special accessories. The Miniwatt accessories listed on pp. 115-117 may have one or more of three functions:

(i) Mechanical attachment of the device to a support.

(ii) Improved thermal conductance between the semiconductor and free air.

(iii) Electrical insulation of the body of the semiconductor from its support.

Medium-power semiconductor devices having a cylindrical metal case are generally placed in a metal clip which acts as a cooling fin. Often this cooling fin is attached to a larger external heat sink to obtain even lower thermal resistance. In the latter case, good thermal contact can be achieved by ensuring that the areas of contact of the cooling fin and heat sink are both flat and by tightly screwing the fin to the heat sink.

High-power semiconductor devices normally require an external heat sink for adequate cooling[1]. They are designed to be readily bolted to the heat sink (often the chassis) using standard accessories available from Miniwatt. Among the accessories available are nuts, washers and screws for fixing, mica washers for electrical insulation, and lead washers for improved thermal contact. These lead washers, when compressed, fill in small gaps caused by any irregularities in the mating surfaces. Further improvement may be obtained by an application of silicone grease. However, it is essential to carefully remove any burrs or thickening from the edges of mounting holes made in the heat sink.

A recent addition to the Miniwatt accessories is a range of heat sinks designed for the BYZ10, BYY22 and BYZ14 series of silicon power diodes (see pp. 126-127 of this issue).

SOLDERING

The soldering rules given here have been derived from a combination of empirical values from the soldering technique and values that are appropriate to semiconductors. The main consideration is always to protect the semiconductor from thermal overload. The wire lengths stated are therefore always minimum values and soldering times are always maximum values.

For each of the soldering methods—by soldering iron and with dip soldering—several different combinations of soldering time and wire lengths are given.

Soldering by Soldering Iron

1. At a tip temperature not exceeding 245 °C, the permissible soldering time is 10 secs. provided that the point of soldering is at least a distance of $^7/_{32}''$ from the sealing on the bottom of the case. At a distance of $\frac{1}{16}''$ from the sealing, the maximum soldering time is 3 secs. for the same iron temperature. Solder should not be applied closer than $\frac{1}{16}''$ from the seal (see Fig. 1).

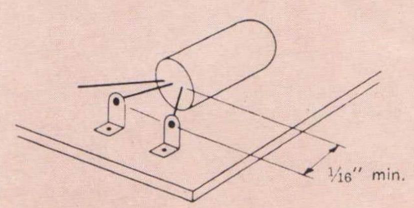


Fig. 1. Minimum lead length between semiconductor body and point of soldering using a soldering iron.

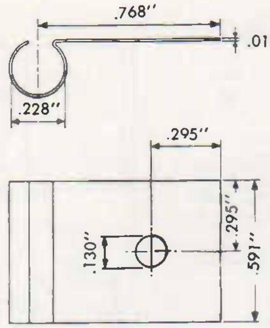
2. With a tip temperature between 245 °C and 400 °C, the permissible soldering time is 5 secs. with the point of soldering at least $^7/_{32}''$ away from the sealing.

Although the transistors can be soldered by means of small soldering irons having low powers, it is preferable to use an iron with some reserve in thermal capacity. Then a good soldered joint can be made more quickly, thus reducing the flow of heat into the semiconductor to a minimum.

MOUNTING ACCESSORIES FOR SEMICONDUCTORS

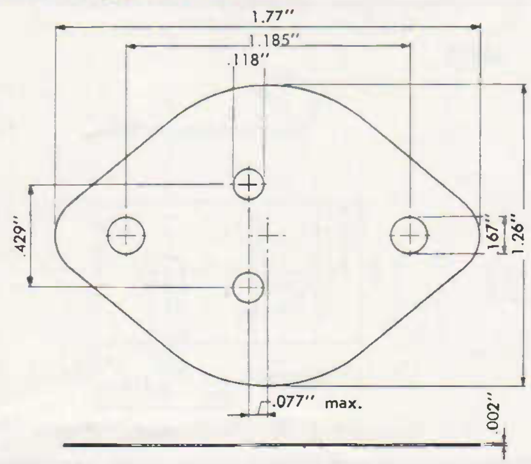
56200

(e.g. for AC128, BCZ10)

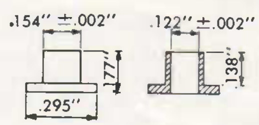


1 Cooling fin (nickel-plated copper)

56201 A (e.g. for OC26, ASZ15)



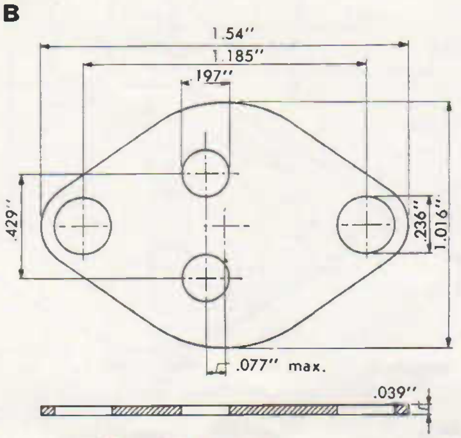
1



2

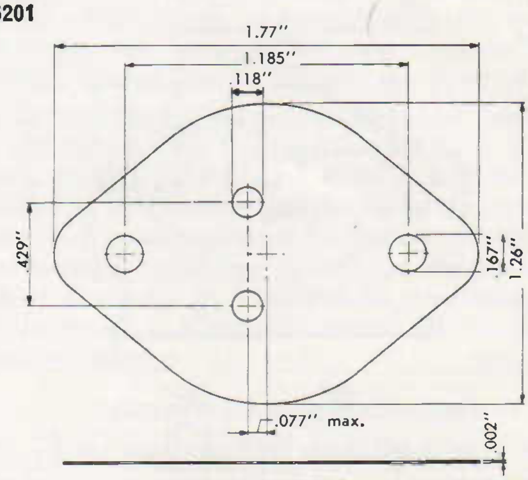
Quantity	Item	Figure
1	Mica insulator	1
2	Insulation washer	2

56201 B



1 Lead washer

56201



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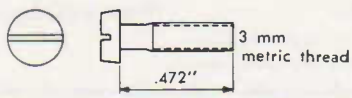

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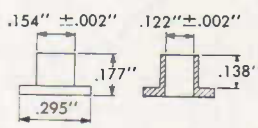

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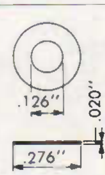

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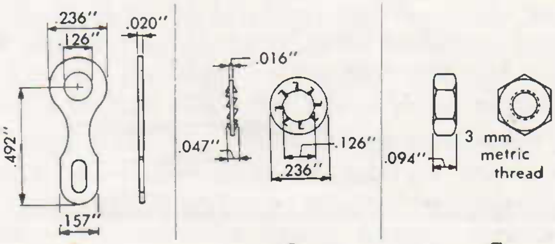
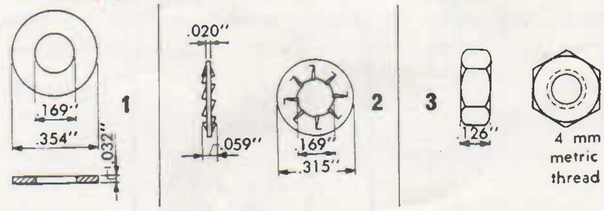


5 6 7

Quantity	Item	Figure
1	Mica insulator	1
2	Screw	2
2	Insulation washer	3
3	Washer	4
1	Soldering tag	5
2	Lock washer	6
2	Hexagonal nut (nickel-plated copper)	7

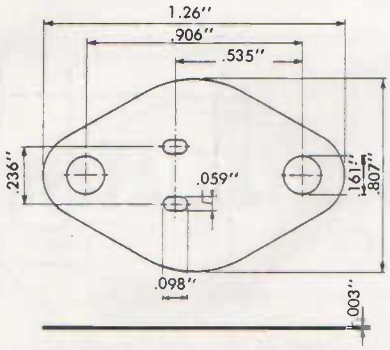
56202 (e.g. for OA214, OA31)



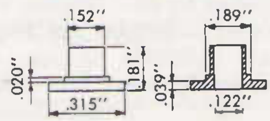
Quantity	Item	Figure
1	Washer	1
1	Lock washer	2
1	Hexagonal nut (nickel-plated copper)	3

56203

(e.g. for OC30)



1

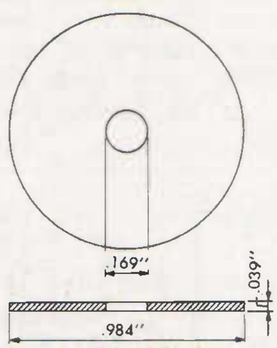


2

Quantity	Item	Figure
1	Mica insulator	1
2	Insulation washer	2

56204

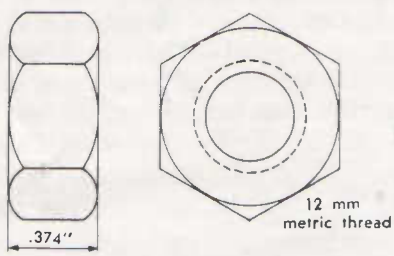
(e.g. for OA214)



1 Cooling plate (aluminium)

56206

(e.g. for BYY15, BYZ14)



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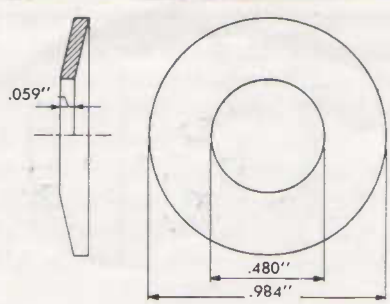
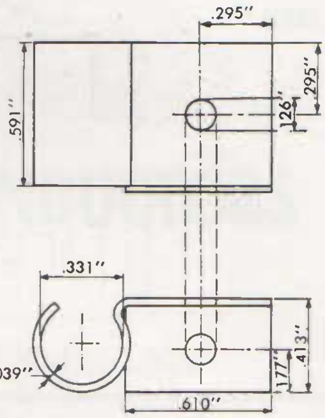


2

Quantity	Item	Figure
1	Hexagonal nut (nickel-plated copper)	1
1	Washer	2

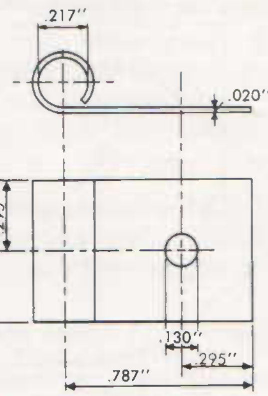
56207

(e.g. for AF118)



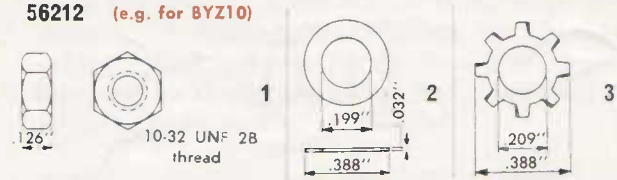
1 Cooling fin

56210



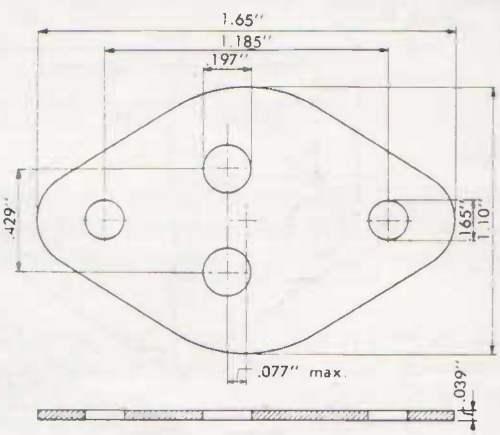
1 Cooling fin (nickel-plated copper)

56212 (e.g. for BYZ10)



Quantity	Item	Figure
1	Hexagonal nut (nickel-plated copper)	1
1	Washer	2
1	Lock washer	3

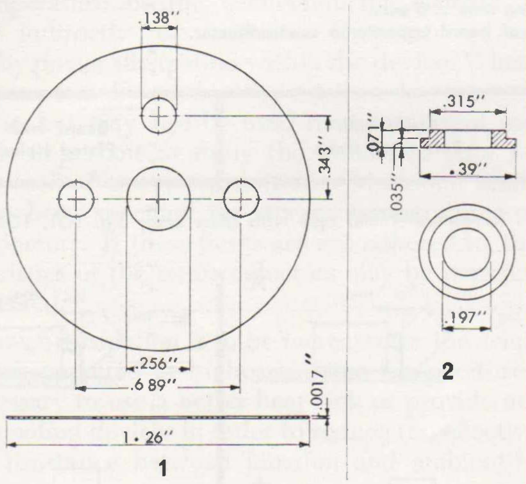
56214

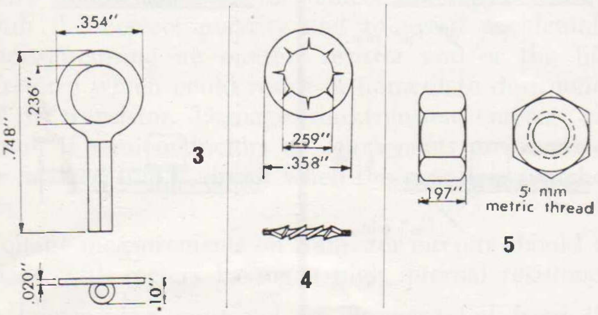


1 Lead washer

FOR SEMICONDUCTORS

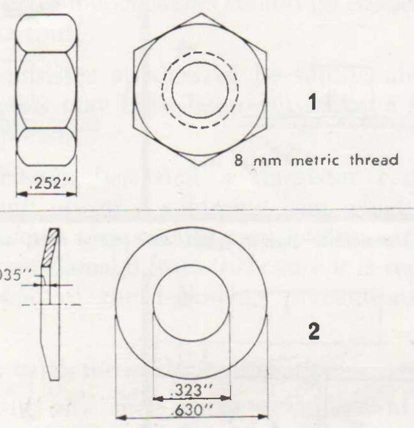
56213
(e.g. for ADZ11)





Quantity	Item	Figure
1	Mica insulator	1
1	Insulation washer	2
1	Soldering tag	3
1	Lock washer	4
1	Hexagonal nut (nickel-plated copper) ..	5

56215
(e.g. for BYY24)



Quantity	Item	Figure
1	Hexagonal nut (nickel-plated copper) ..	1
1	Washer	2

Dip Soldering

The widespread acceptance of printed circuits for the efficient production of electronic equipment has led to the establishment of special rules for mounting semiconductors and dip-soldering them to printed boards. Several suitable methods are given on p. 118.

In all cases the highest permissible solder temperature is 245 °C and the longest soldering time is 5 secs. Some methods of mounting allow heat to be readily conducted to the semiconductor body, e.g., where the outside of a semiconductor touches the printed board, and where a metal case is used. In those cases (see table), care must be taken that no point on the body of the device is allowed to exceed 115 °C for more than two minutes.

GENERAL PRECAUTIONS

The points mentioned in this section may be well known to most readers, but have been added here for the sake of completeness.

Mechanical

Transistors and diodes are generally enclosed either in all-glass cases or in hermetically-sealed metal envelopes. The internal electrodes are attached to connecting wires which respectively either pierce the glass bulb or pass through glass-to-metal seals. When the semiconductor is being wired into the circuit, the external flexible connecting leads should not be bent at the glass as this bending could eventually weaken the seal. Right-angle bends in the leads must be made at least $\frac{1}{16}$" distance from the glass seal, and it is advisable to hold firmly the lead adjacent to the seal.

Although transistors and diodes are particularly resistant to shock, they must not, however, be subjected to such rough treatment as to cause mechanical problems. Semiconductors having all-glass construction are coated with a black lacquer which is resistant to normal handling (photo-devices are left unlacquered). This varnished surface should not be damaged because the semiconductor materials in the device are light-sensitive. Exposure to strong radiations of X and γ rays may influence unfavourably, and sometimes irreversibly, the properties of the semiconductor.

When equipment incorporating semiconductors is subjected to severe vibration during use, the container should be suitably supported in order to prevent mechanical fatigue of the connections and to avoid any undesirable effects caused by excessive vibration of the container.

Thermal

During all operations, it is imperative that the published permissible operating temperatures of the devices should not be exceeded.

If the permissible junction temperature is exceeded, the transistor may suffer permanent damage from such causes as:

(a) Loosening of the internal connections causing complete failure.

DIP-SOLDERING SEMICONDUCTORS TO PRINTED BOARDS

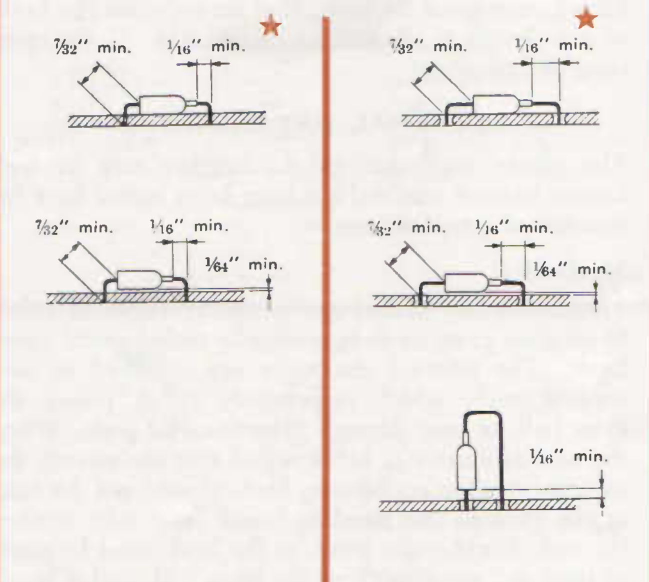
(limiting conditions for mounting and soldering)

Conditions to be observed in all cases

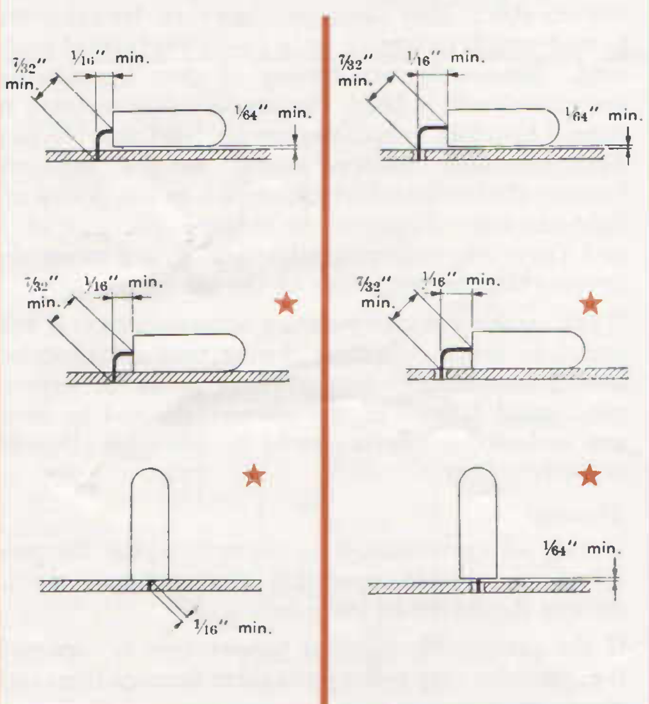
1. **Max. permissible solder temperature = 245 °C.**
2. **Max permissible soldering time = 5 secs.**
3. **Soldering only on side of board opposite to semiconductor.**

Board with Perforated Holes	**Board with Plated Holes**

Diodes—Miniature all-glass construction

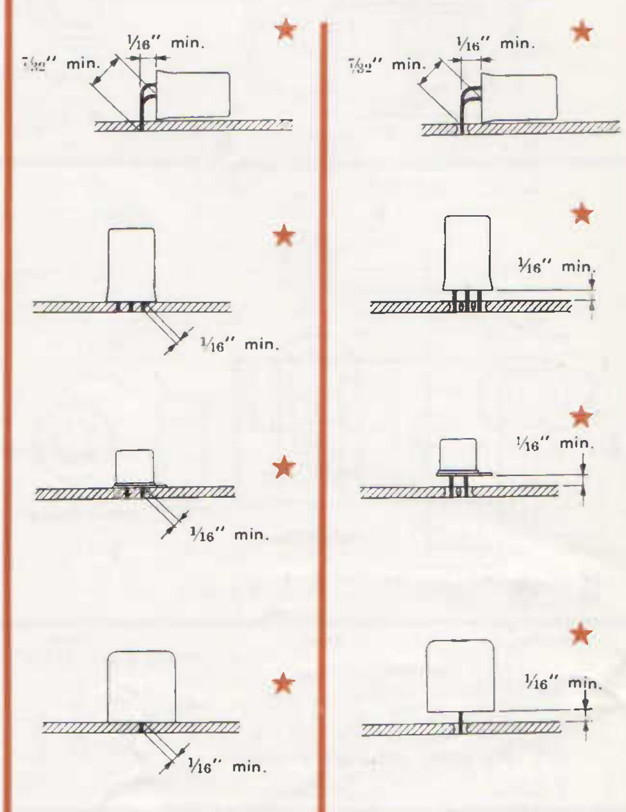


Transistors—all-glass construction or all-glass + metal cover

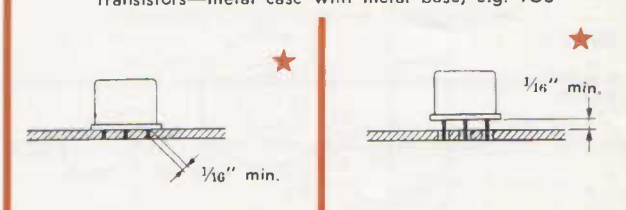


Board with Perforated Holes	**Board with Plated Holes**

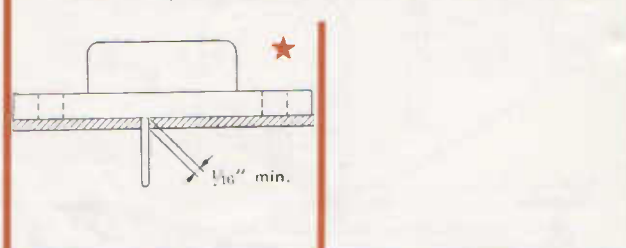
Transistors—metal case with glass base, e.g. TO1, TO7, TO18



Transistors—metal case with metal base, e.g. TO5



Transistors—power types wtih metal case, e.g. TO3, TO36



★ No part of the glass or metal case should exceed 115 °C for more than 2 mins.

(b) Damage to the element itself, resulting in changes in the value of current gain and sometimes an increase in noise. Such a fault is obviously more difficult to trace.

The temperature of the semiconductor element is affected indirectly by ambient temperature and directly by power dissipation within the device. Where a device is normally used under continuous operating conditions, but may also be used for intermittent service, it is important to study the published data relating to each of the two conditions. Minimum limits have also been specified for storage temperatures of semiconductors. If these limits are not adhered to, the characteristics of the semiconductors may be permanently affected.

If the power dissipation is to be increased or the semiconductors operated at higher ambient temperatures, it is necessary to use a better heat sink or provide additional cooling devices in order to reduce the effective thermal resistance between junction and ambient[1].

Electrical

Care should be taken to connect the supply voltage with the correct polarity and to avoid accidentally short-circuiting an emitter resistor and/or the bias circuitry which could result in immediate destruction of the transistor. Damage from transient currents can result if semiconductors or components are removed or inserted into a circuit when the supply is switched on.

Voltage measurements on transistor circuits should be made with meters having a high internal resistance.

A loudspeaker must not be disconnected from the secondary of the speaker transformer without taking the precaution of turning the volume control of the receiver right down.

Reducing the load resistance (and particularly short-circuiting it) is very likely to damage a transistor, especially in the output stages. Consequently, care should be exercised in taking measurements with bare probes, and no extra loudspeakers should be connected directly to the output.

Finally, if a transistor appears to be faulty, always check whether this may have been caused by a fault in another component.

It is a well known fact that a transistor can be damaged through use of a soldering iron which has appreciable leakage (especially any mains voltage type). To prevent damage from this cause it is recommended that one of the following precautions be taken:

(i) Effectively earth the soldering iron tip.

(ii) Short circuit any such leakage voltage at the transistor itself, using clip leads.

Reference

1 Hancock, D. J., Heat Sinks for Power Transistors, *Miniwatt Digest*, Vol. 2, No. 3, pp. 40-44.

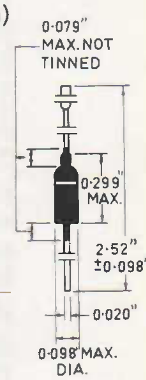
Miniwatt AA119
2-AA119 Detector Diodes

As the successor to the popular detector diode OA79, the miniature version AA119 can be used either as a direct replacement or as a preferred type in new equipment. When the matched pair 2-AA119 is used in ratio detector circuits, the operating characteristics are identical to those previously published by Miniwatt for the 2-OA79.

The AA119 belongs to the Australian-made range of miniature diodes which are being supplied by Miniwatt at the same prices as the previous "OA80" series which they replace and to which they are electrically equivalent—see *Digest*, Vol. 2, No. 4.

The small size of the AA119 is in keeping with the growing trend to use miniature parts in present-day portable radios. Also, the 2-AA119 can be easily built into a ratio detector can.

TECHNICAL DATA (Abbreviated tentative data)



GENERAL DATA

Type	Germanium point contact
Construction	All-glass
Connections	White band indicates cathode end

Thermal Resistance

Junction to ambient in free air	K	max. 0.45° C/mW

MAXIMUM RATINGS (Absolute Maximum)

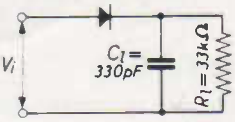
		T_{amb} = 25	60 °C
Inverse voltage			
Average (averaging time max. 50 msec)	$-V_D$	30	30 V
Peak	$-V_{DM}$	45	45 V
Forward current			
Average (averaging time max. 50 msec)	I_D	35	15 mA*
Peak	I_{DM}	100	100 mA*
Surge (max. 1 sec)	I_{Dsurge}	200	200 mA
Temperatures			
Storage	T_s	—55 to +75 °C	
Operating ambient	T_{amb}	—55 to +60 °C	

CHARACTERISTICS, Range Values for Equipment Design

	T_{amb} = 25 °C typ.	T_{amb} = 25 °C max.	T_{amb} = 60 °C typ.	T_{amb} = 60 °C max.
Forward voltage (V_D)				
at I_D = 0.1 mA	0.23	0.30 V	0.16	0.25 V
at I_D = 1 mA	0.56	0.88 V	0.50	0.80 V
at I_D = 10 mA	1.5	2.2 V	1.4	2.1 V
at I_D = 30 mA	2.8	4.0 V†	2.6	3.8 V†
Reverse current ($-I_D$)				
at $-V_D$ = 0.1 V	0.35	1.0 μA	4.5	12 μA
at $-V_D$ = 1.5 V	0.8	2.8 μA	6	25 μA
at $-V_D$ = 10 V	4.5	18 μA	16	60 μA
at $-V_D$ = 30 V	35	150 μA	60	300 μA
at $-V_D$ = 45 V	90	350 μA	170	500 μA

In the circuit below at V_i = 3 V_{rms}, f = 10.7 Mc/s and T_{amb} = 25 °C:

		typ.	min.	max.
Efficiency	η	85		%
Damping resistance	r_D	15	13.5	19 kΩ



* A derating must be applied, depending on the value of $-V_{DM}$.
† Measured with current pulses to prevent excessive dissipation.

new

FREQUENCY CONVERTER TYPE 6AN7A
has 300 mA heater current

The 6AN7A has been introduced to the Miniwatt preferred range of radio valves to supersede type 6AN7.

The new type is identical to the 6AN7 in all respects except that it has a heater current of 300 mA, whereas the 6AN7 requires 225 mA. Thus the 6AN7A may be used as a direct replacement for the 6AN7 in all cases except where the 6AN7 may have been used in a series heater chain. In this instance, the heater current must be determined and the values of shunt resistance altered to suit.

Availability
Ex-stock.

VHF MEDIUM-POWER TRANSISTOR TYPE AFY19

The AFY19 is a PNP alloy-diffused germanium transistor primarily intended as a power amplifier in small-power transmitters at frequencies up to 180 Mc/s.

The transistor has a TO5 metal case.

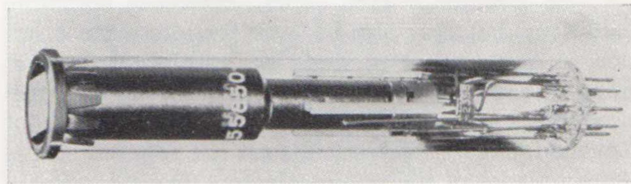
Brief Specifications

Thermal Resistance from junction to:			
ambient, mounted on heat sink of at least 2 sq. ins.	K_{j-a}	0.08	°C/mW
case	K_{j-c}	0.035	°C/mW
Absolute Maximum Ratings include:			
Collector-base voltage	$-V_{CB}$	32	V
Peak collector current	$-I_{CM}$	300	mA
Total dissipation	P_{tot}	800	mW
Frequency at which $\lvert h_{fe} \rvert = 1$ at $I_E =$ 100 mA, $-V_{CB} = 5$ V, $T_{amb} = 25$ °C	f_t	350 (min. 225	Mc/s Mc/s)

Availability

Sample quantities ex-stock.

VIDICON TUBE TYPE 55850
has only 0.6 W heater consumption



The low heater power required for this 1″ vidicon TV camera tube makes it particularly suitable for all-transistorised cameras where heat dissipation must be kept at a minimum.

Three grades are available:

55850 N for industrial use
55850 S for TV studio use
55850 F for film scanners.

The three grades vary only in the degree of uniformity of the photoconductive layers.

The 55850 can replace all standard types of 1″ vidicons.

Applications
The 55850 is for use in black-and-white or colour cameras in TV studios, medical or industrial applications, and also in film scanners.

Brief Specifications

Resolution capability	600 to 900 TV lines
Photoconductive layer	Antimony-trisulphide
Heater voltage	6.3 V (± 10%)
Heater current	90 mA
Length	6¼″ (158 mm.)
Diameter	1″

Availability
Ex-stock for all grades.

MAGNETRON TYPE YJ1060
for Weather Radar Equipment

The YJ1060 is a convection-cooled light weight packaged magnetron for pulse service at high altitudes, operating at a fixed frequency within the range 9345 to 9405 Mc/s and delivering a peak output power of 20 KW.

The Philips YJ1060 is electrically and mechanically interchangeable with the 6027H, differing in mechanical outline in that only one magnet is used instead of two. Thus the YJ1060 weighs only 3 lbs 4oz. compared with 5 lbs. for the 6027H—an obvious advantage for airborne equipment.

Availability
Ex-stock.

FURTHER INFORMATION IS AVAILABLE ON APPLICATION TO ANY OF THE ADDRESSES ON THE BACK COVER OF THE *Digest*.

Selection and Use of

PHILIPS HIGH VOLTAGE RECTIFIER TUBES

Five configurations provide the basis for 53 individual circuits covering the present range of Philips High Voltage Rectifiers.

Charts and Tables are provided to enable the user to find circuit details for rectifier installations delivering up to 280 KW from single-phase systems or up to 630 KW from 3-phase systems.

USE OF SELECTION CHARTS

For convenience, the selection charts are divided into two groups, one for operation from single-phase mains supplies, the other from three-phase supplies. In order to avoid confusion between types with similar ratings some types have been listed separately so that Fig. 2 overlaps Fig. 1 and Fig. 5 overlaps Fig. 4. Figs. 3 and 6 apply to grid-controlled rectifiers operating from single-phase and three-phase mains supplies respectively.

If the required conditions fall within the overlapping area of two charts the final choice between the alternatives will depend on the relative cost and performance.

When using the charts, first select the group number corresponding to the required voltage and current from the appropriate chart and then refer to the Table 1 for details of the circuit. Tables 1 and 2 list the reference letter of the appropriate circuit diagram; the type and required number of rectifier tubes; the maximum permissible transformer voltage, and maximum DC output figures. *These values are all absolute maxima and no allowance has been made for mains voltage fluctuations, tube drop, or transformer regulation.* For this reason, if the desired operating point falls close to the upper limit of a particular group, it is advisable to select the next highest group in order of voltage. All groups may, of course, be used at voltages and currents below the maximum limits indicated.

If for any reason it is necessary to use a circuit configuration other than that recommended, the appropriate voltage and current relationships may be found in Table 5. This table applies specifically to rectifiers with resistive load (e.g. in industrial oscillators without filter) but may be used for choke input filters (as in broadcast transmitters) with the exception that in the latter case the peak anode currents will be lower than indicated by the table.

LIMITING CONDITIONS

From Tables 3 and 4 will be found the maximum permissible values of peak inverse voltage, average and peak currents and surge current together with applicable temperature limits. Before designing equipment, it is imperative to consult the complete published data for the tube chosen to ensure that all limitations are observed (e.g. warm-up time, filament voltage limits and special derating conditions, etc.).

Temperature

Tubes Filled with Mercury Vapour

Unless otherwise specified in Tables 3 and 4, the tubes are mercury vapour filled.

In the technical data of these tubes types temperature limits for condensed mercury are given. During operation, the condensed mercury should only be visible within the neighbourhood of the socket or the lower part of the bulb. Care should be taken to ensure that the condensed mercury temperature during operation is between the published temperature limits. Too low a temperature gives low gas pressure which results in a low current carrying capability, high arc drop and consequent shortening of life. Too high a temperature gives high gas temperature which results in a reduction of the permissible peak inverse and forward voltage.

The temperature measurements should be made at the coldest part of the bulb where the mercury vapour condenses, which in general will be just above the base.

Table 1—Rectifiers Operating from Single-Phase Supply

Group	Circuit	Rectifiers Type	Rectifiers Qty.	V_{tr}	V_o	I_o	W_o
1	A	DCG4/1000G	2	3·5 0·71	3·2 0·63	0·5 1	1·6 0·63
2	A	DCX4/1000	2	3·5 1·8	3·2 1·6	0·5 1	1·6 1·6
3	A	DCX4/5000	2	3·5	3·2	2·5	8·0
4	A	DCG5/5000GB	2	4·15 1·75	4·15 1·6	3 3·5	12·3 5·6
5	A	DCG9/20	2	7·4	6·7	5	33·5
6	A	857-B	2	7·75	7·0	20	140
7	B	DCG4/1000G	4	7·1 1·4	6·4 1·3	0·5 1·0	3·2 1·3
8	B	DCX4/1000	4	7·1 3·5	6·4 3·2	0·5 1·0	3·2 3·2
9	B	DCX4/5000	4	7·1	6·4	2·5	16
10	B	DCG5/5000GB	4	9·2 3·5	8·3 3·2	3 3·5	24·9 11·2
11	B	DCG9/20	4	14·8	13·4	5	67
12	B	857-B	4	15·5	14·0	20	280
13	A	DCG4/5000	2	4·6	4·1	2·5	10·3
14	A	575A	2	5·3 3·6	4·8 3·2	3·0 5·0	14·4 16·0
15	A	DCG6/18	2	5·3 0·9	4·8 0·8	6·0 10·0	28·8 8·0
16	B	DCG4/5000	4	9·2	8·3	2·5	20·8
17	B	575-A	4	10·6 7·1	9·6 6·3	3·0 5·0	28·8 31·5
18	B	DCG6/18	4	10·6 1·8	9·6 1·6	6·0 10·0	57·6 16·0
19	A	DCG6/6000	2	4·6	4·1	2·0	8·2
20	A	ZT1000	2	7·4 5·3	6·7 4·8	5·0 6·0	33·5 24·8
21	A	DCG7/100	2	5·3	4·8	20	96
22	B	DCG6/6000	4	9·2	8·3	2·0	16·6
23	B	DCG7/100	4	10·6	9·6	20	192
24	B	ZT1000	4	14·8 10·6	13·4 9·6	5·0 6·0	67 57·6
25	B	DCG12/30	4	19·1	17·2	5·0	86

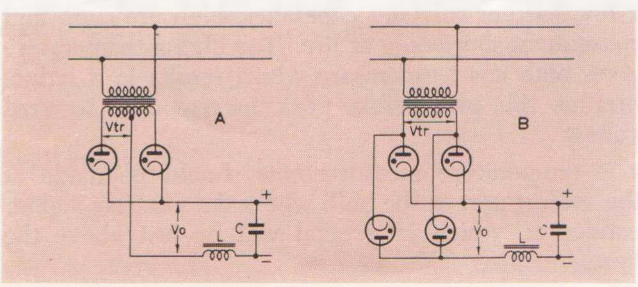


Table 2—Rectifiers Operating from Three-Phase Supply

Group	Circuit	Rectifiers Type	Rectifiers Qty.	V_{tr}	V_o	I_o	W_o
26	C	DCG4/1000G	3	4·1 0·82	4·8 0·96	0·75 1·5	3·6 1·44
27	C	DCX4/1000	3	4·1 2·0	4·8 2·4	0·75 1·5	3·6 3·6
28	C	DCX4/5000	3	4·1	4·8	3·75	18
29	C	DCG5/5000GB	3	5·3 2·0	6·2 2·4	4·5 5·25	27·9 12·6
30	C	DCG9/20	3	8·6	10	7·5	75
31	C	857-B	3	10·3	10·5	30	315
32	E	857-B	6	7·8	9·1	60	546
33	D	DCG4/1000G	6	7·1 1·41	9·6 1·91	0·75 1·5	7·2 2·87
34	D	DCX4/1000	6	7·1 3·5	9·6 4·8	0·75 1·5	7·2 7·2
35	D	DCX4/5000	6	7·1	9·6	3·75	36
36	D	DCG5/5000GB	6	9·2 3·5	12·4 4·8	4·5 5·25	55·8 25·2
37	D	DCG9/20	6	14·8	20	7·5	150
38	D	857-B	6	9·0	21	30	630
39	C	DCG4/5000	3	5·3	6·2	3·75	23·3
40	C	575-A	3	7·04 4·715	7·14 4·8	4·5 7·5	32·2 36·0
41	C	DCG6/18	3	6·1 1·02	7·2 1·19	9 15	64·8 17·9
42	E	DCG6/18	6	5·3 0·88	6·2 1·03	18 30	112 30·9
43	D	DCG4/5000	6	9·2	12·4	3·75	46·5
44	D	575-A	6	6·1 4·1	14·3 9·7	4·5 7·5	64·4 72·8
45	D	DCG6/18	6	10·6 1·76	14·4 2·38	9 15	130 35·8
46	C	DCG6/6000	3	5·3	6·2	3	18·6
47	C	ZT1000	3	8·5 6·1	10 7·2	7·5 9	75 64·8
48	C	DCG7/100	3	6·1	7·2	30	216
49	E	DCG7/100	6	5·3	6·2	60	372
50	D	DCG6/6000	6	9·2	12·4	3	37·2
51	D	DCG7/100	6	10·6	14·4	30	432
52	D	ZT1000	6	14·8 10·6	20 14·4	7·5 9	150 130
53	D	DCG12/30	6	19·1	25·8	7·5	194

Where V_{tr} = maximum permissible transformer voltage (KV r.m.s.)—see circuit.

V_o = maximum DC output voltage (KV) obtainable with V_{tr}.

I_o = maximum permissible DC (average) output current (A).

W_o = maximum DC output power (KW) — ($V_o \times I_o$).

RECTIFIER SELECTION GROUPS (see Tables 1 and 2)

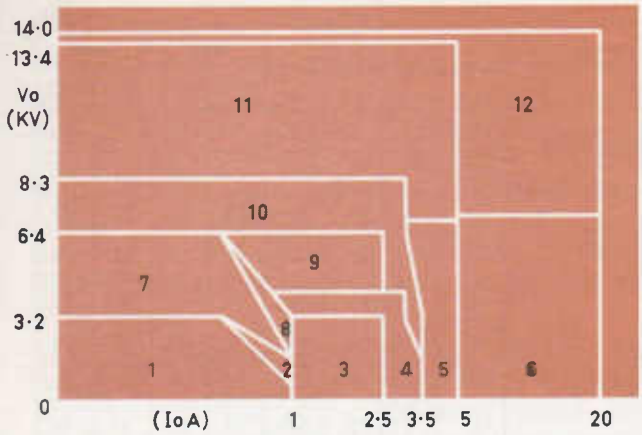


Fig. 1. Single-phase supply.

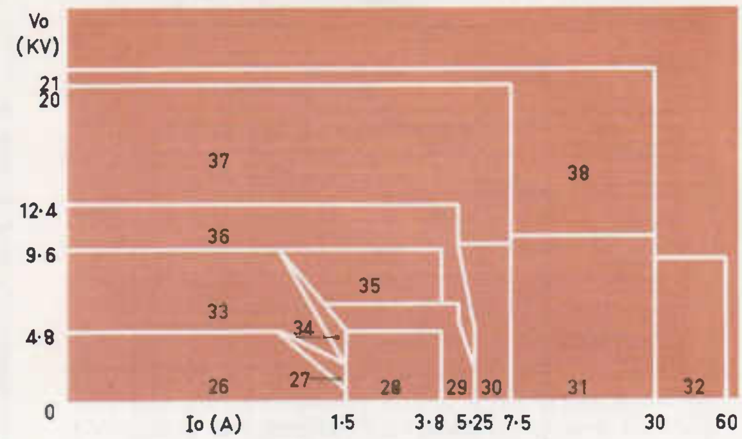


Fig. 4. Three-phase supply.

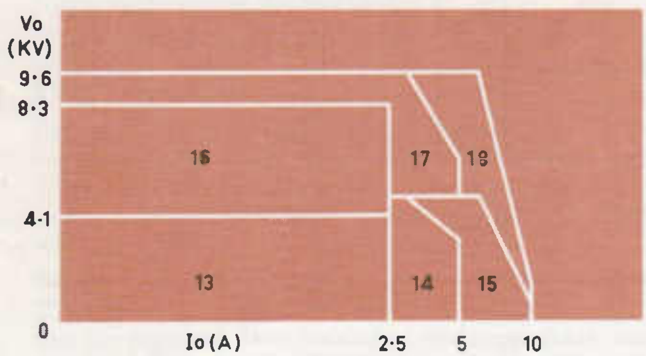


Fig. 2. Single-phase supply.

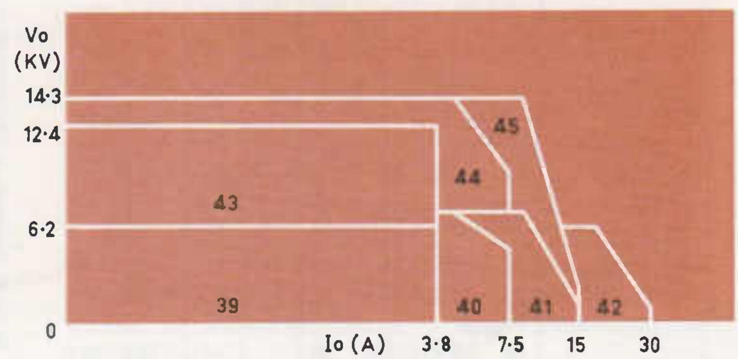


Fig. 5. Three-phase supply.

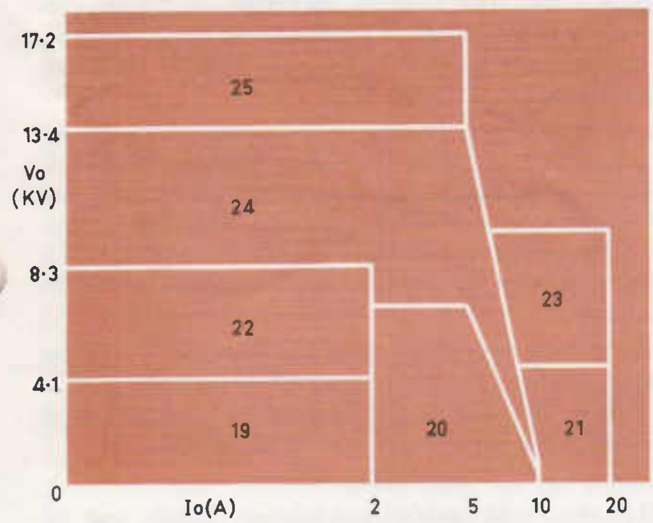


Fig. 3. Single-phase supply (grid-controlled types).

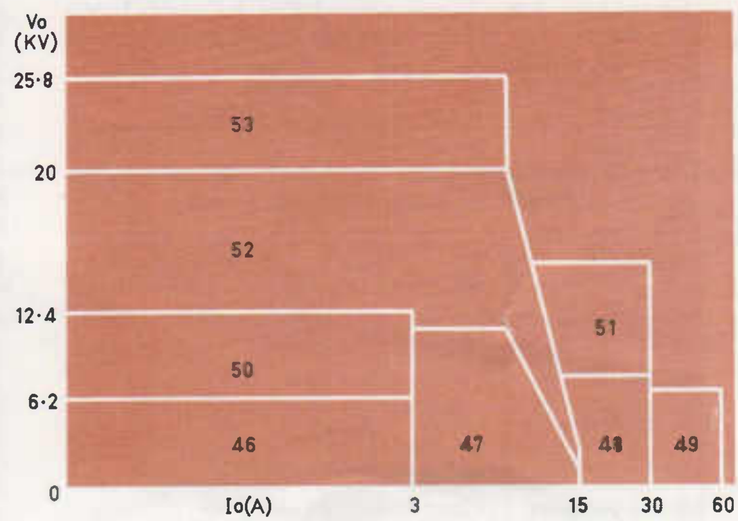


Fig. 6. Three-phase supply (grid-controlled types).

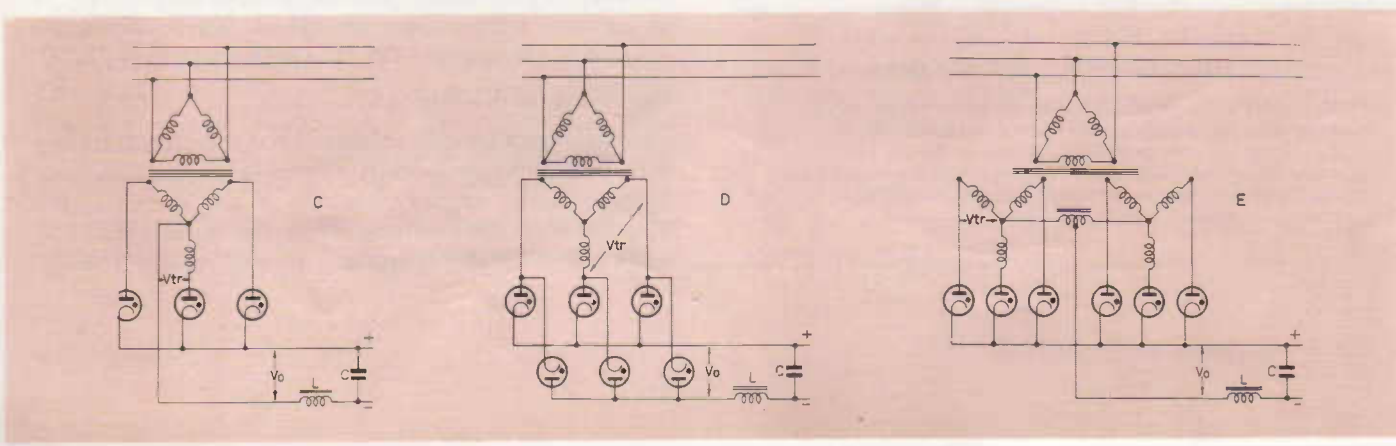


Table 3—Philips High Voltage Rectifiers (Types and Ratings)

Tube Type	$V_{a\ invp}$	I_a	I_{ap}	I_{surge}	t_{Hg} min.	t_{Hg} max.	T_{amb} min.	T_{amb} max.
DCG4/1000G	10	0·25	1·0	—	25	60	15	40
	2	0·5	2·0	—	25	70	15	50
DCG4/5000	13	1·25	5·0	40	25	55	10	35
	10	1·25	5·0	40	25	60	10	40
DCG5/5000GB	13	1·5	6·0	40	25	55	15	40
	10	1·5	6·0	40	25	60	15	45
	5	1·75	7·0	40	25	70	15	55
DCG6/18	15	3·0	12	120	25	55	15	35
	10	—	—	—	25	60	15	40
	2·5	5·0	20	200	25	75	15	55
DCG9/20	21	2·5	10	100	25	45	15	30
	15	2·5	10	100	25	50	15	35
	10	2·5	10	100	25	60	15	45
575-A	15	1·5	6·0	60	20	50	—	—
	10[1]	2·5	10	60	20	60	—	—
857-B	22	10	40	400	30	40	—	—
	10[2]	10	40	400	25	60	—	—
DCX4/1000[3]	10	0·25	1·0	20	—	—	−55	+75
	5·0[4]	0·5	2·0	20	—	—	−55	+75
DCX4/5000[3]	10	1·25	5·0	50	—	—	−55	+70

(1) Filament current out of phase. (2) Forced air cooling.
(3) Xenon filled. (4) f_{max} = 500 c/s.

Table 5—Voltage and Current Relationships in Rectifiers with Resistive Load

Circuit	$\frac{V_{tr}}{V_o}$	$\frac{V_{a\ invp}}{V_o}$	$\frac{I_a}{I_o}$	$\frac{I_{ap}}{I_a}$	Ripple Freq. / Mains Freq.
A. Full Wave	1·11	3·14	0·5	3·14	2
B. Bridge	1·11	1·57	0·5	3·14	2
C. 3 ϕ Half-wave	0·86	2·09	0·33	3·63	3
D. 3 ϕ Bridge	0·74	1·05	0·33	3·14	6
E. 6 ϕ Half-wave (with inter-phase transformer)	0·86	2·42	0·17	3·14	6

SYMBOLS USED IN TABLES 3, 4 AND 5

$V_{a\ invp}$ is recurrent peak inverse voltage on rectifier (KV).
I_a is DC (average) anode current in rectifier (A).
I_{ap} is recurrent peak anode current in rectifier (A).
I_{surge} is surge (fault) current (A), maximum duration 0.1 sec.
t_{Hg} is condensed mercury temperature range (°C).
t_{amb} is ambient temperature range (°C).

Table 4—High Voltage Grid-Controlled Rectifiers

Tube Type	$V_{a\ invp}$	I_a	I_{ap}	I_{surge}	t_{Hg} min.	t_{Hg} max.	t_{amb} min.	t_{amb} max.
DCG6/6000[1]	13	1·0	4·0	40	25	55	15	30
	10	1·0	4·0	40	25	60	15	35
DCG7/100[2]	15	10	45	400	25	60	10	30
	10	10	45	400	25	65	10	35
DCG12/30[3]	27	2·5	10	100	30	40	20	25
	21	2·5	10	100	30	45	20	30
	15	2·5	10	100	25	50	15	35
	13	2·5	10	100	25	55	15	40
	10	2·5	10	100	25	60	15	45
ZT1000[4]	21	2·5	10	100	25	45	15	30
	15	3·0	12	100	25	55	15	35
	10	—	—	—	25	60	15	40
	2·5	5·0	20	200	25	75	15	55

(1) R_g = max. 0·1 MΩ (2) R_g = max. 20 KΩ
(3) I_g = max. 25 mA (I_{av} = max. 30 sec). (4) R_g = max. 0·1 MΩ

Some tube types are provided with an external cap surrounding the upper part of the tube, which keeps the temperature of this part higher than that of the bottom when the tube is switched off. This cap ensures that the mercury condenses in the lower part of the tube and must always be mounted on the tube, even during pre-heating.

Limits for ambient temperature are sometimes given. If a lowering of the local ambient becomes necessary in order to remain within ratings this can be achieved by directing a low velocity air flow of ambient temperature, or less, to the glass just above the base. *The condensed mercury vapour temperature is decisive in all cases.*

The ambient temperature can be measured by a thermometer which has been screened against direct heat radiation. The measurements should be carried out at various points around the lower part of the tube.

Tubes with Inert Gas Filling

Tubes filled with an inert gas (usually xenon) may be used at temperatures beyond those permissible for mercury vapour tubes. For these tubes only the limits of ambient temperature are given. These limits are in general minimum —55 °C and maximum +75 °C.

Peak Inverse Voltage ($V_{a\ inv\ p}$)

The maximum inverse voltage that a mercury tube can handle without arc-back is a function of the tube configuration, the vapour pressure of the mercury, the magnitude of the current density during a conductive half-cycle and the frequency of the supply voltage.

As can be seen from Tables 3 and 4, when working at higher temperatures it is necessary to reduce the PIV due to the reduced vapour pressure.

Maximum Peak Plate Current (I_{ap})

The maximum peak plate current rating represents the highest instantaneous value of current that may safely be carried through the tube during its conductive half-cycle. This value depends upon the total electron emission available from the filament and upon the phase of the filament excitation with respect to the phase of the plate supply and on the filament operating voltage.

With the filament supply in phase with the plate supply, the instant of maximum plate current demand coincides with that of the maximum voltage across the filament, with the result that the maximum current density and therefore maximum emission, occurs at the positive end of the filament.

A more uniform distribution may be obtained by exciting the filament out of phase with respect to the plate supply. With the ideal of 90° phase difference between the plate and filament supplies, the instant of peak current, and therefore *peak emission*, coincides with the instant of zero voltage across the filament, and therefore gives best uniformity. With the 60° and 120° phase difference readily available with three-phase power supplies, the voltage across the filament at the instant of maximum current demand, though not zero, is nevertheless low enough to result in a close to optimum uniformity in distribution of current density.

The normal rating (I_{ap}) shown in Tables 3 and 4 assumes in-phase excitation unless otherwise stated, although it is recommended to use out of phase excitation and/or a centre-tapped filament transformer.

Maximum Average Plate Current (I_a)

In general, more than one limiting value is specified for average plate current. It will be seen from Tables 3 and 4 however, that for higher values of current the allowable inverse voltage rating is reduced due to the increased operating temperature of the tube.

Maximum Surge Current (I_{surge})

In order to prevent the tube from being damaged by passing too high a fault current a value for the maximum permissible surge current is given. It indicates the maximum value of a transient current resulting from a sudden overload or short circuit which the rectifier can pass for a period not exceeding 0.1 sec. Several overloads of this nature will considerably reduce the life of the tube.

The equipment designer has to take into consideration this maximum surge current rating when calculating the short circuit impedance of the equipment. *This surge current is not intended as a peak current that may occur on switching*, or during operation.

A simple method of limiting the surge current to the maximum rating is to put a series resistance in the anode circuit which in most cases will also be necessary because the relation between the resistive and reactive impedance of the short circuit path should be at least 0.3.

Grid Controlled Rectifiers

When a thyratron is conducting, a positive ion current of magnitude proportional to the cathode current is generated. This current will, in general, flow to that electrode which is at the most negative potential during conduction (e.g., the grid). In order to prevent damage to the tube it is necessary to ensure that the voltage of this electrode is more positive than —10 V during this phase. This precaution will prevent an increase in the electrode emission due to excessive electrode dissipation, sputtering of electrode material, changes in the control characteristics caused by shift in contact potential and, in the case of inert gas filled tubes, a rapid gas clean-up.

In circuits where the anode potential changes from a positive to a negative value and the control grid has a positive potential, thereby drawing grid current, a small positive ion current flows to the anode. At high negative anode voltages it is therefore essential to limit the magnitude of the positive ion current by severely restricting the current flowing from cathode to grid. This may be effected by using fixed negative grid bias and narrow positive firing pulses. However, for bridge circuits the minimum width of these pulses should be sufficiently large to secure "take-over" of the discharge.

The minimum allowable value of the grid resistor is 0.1 times that recommended.

Maximum Frequency

Unless otherwise stated, the maximum frequency at which the tubes may run under full load conditions is 150 c/s. Under special conditions (derating of voltage and current) higher frequencies may be used; details should be obtained from the manufacturer.

SCREENING AND INTERFERENCE

In order to prevent unwanted ionisation of the gas-filling (and consequent flash-over) due to strong RF fields, it may be necessary to enclose the rectifier in a separate earthed screening box. RF should be prevented from reaching the rectifier by RF chokes and capacitors.

Oscillation can occur in circuits with gas-filled tubes, especially in grid-controlled circuits. These oscillations should be damped by suitable networks as excessive peak inverse voltages may occur, causing arc-back. The use of two parallel RC circuits is advisable. An air choke of the order of 100 μH should be connected in series with, and close to, the anode connection. This choke can advantageously be wound from resistance wire in order to help short circuit protection.

Special attention should be paid to the damping circuits for the primary of the HT transformer when connected to HT mains.

Heat Sinks for Silicon Power Diodes

Three types of heat sinks have just been released by the Miniwatt Division designed for use with BYZ10, BYY22 and BYZ14 series of power diodes respectively. The heat sinks are available with or without an insulated terminal.

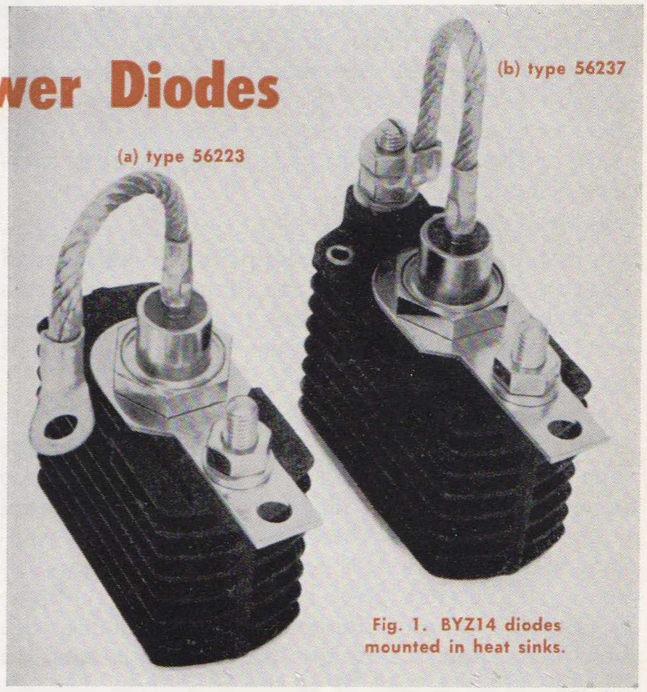


Fig. 1. BYZ14 diodes mounted in heat sinks.

The heat sinks are made of an aluminium alloy and are painted black. When the diodes are fixed to the heat sinks, reference should be made to the limiting values of mounting torque given in the diode data.

When free convection cooling or forced air cooling of less than 0.5 m/sec. is used, the heat sinks should be mounted as shown in Fig. 2. If forced air cooling of more than 0.5 m/sec. is applied, the heat sinks may be orientated in any position. However, to prevent air turbulence the heat sinks should not be mounted one immediately behind the other in the direction of air flow. For bridge constructions, etc., the minimum distances between heat sinks are given in Fig. 3.

A chart for obtaining the thermal resistance of a heat sink under specified conditions is given in Fig. 4.

To simplify calculation where the average current is known, the curves of Fig. 5 have been drawn for 3 and 6-phase operation using the chart of Fig. 4 in conjunction with the published data. In both these figures it is assumed that the direction of air flow is along the length of the cooling fins.

Table 1—Selection of Heat Sinks

Diode Types	Heat Sink Type Numbers			Max. overall dimensions of (a) + (b)
	(a) Heat sink + fixing items	(b) Insulated terminal assembly	(a) + (b) Complete heat sink assembly	
BYZ10/16 BYZ11/17 BYZ12/18 BYZ13/19	56219	56220	56235	$2\frac{5}{32}'' \times$ $\frac{13}{16}'' \times$ $1\frac{9}{16}''$ high
BYY22/23 BYY24/25 BYY67/68 BYY69/70 BYY71/72	56228	56229	56238	$3\frac{7}{32}'' \times$ $1\frac{13}{32}'' \times$ $3\frac{3}{32}''$ high
BYY15/16 BYY73/74 BYY75/76 BYY77/78 BYZ14/15	56223 [Shown in Fig. 1 (a)]	56224	56237 [Shown in Fig. 1 (b)]	$3\frac{29}{32}'' \times$ $1\frac{19}{32}'' \times$ $3\frac{21}{32}''$ high

Table 2
Heat Sinks for Rectifier Circuits

(Recommended number of items)

Circuit	Heat sinks without insulated terminal	Heat sinks with insulated terminal
Half-wave	—	1
Full-wave	1	1
Bridge	2	2
3ϕ half-wave	—	3
3ϕ bridge	3	3
6ϕ half-wave	—	6
6ϕ half-wave (with interphase transformer)	—	6

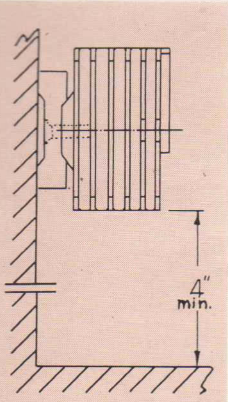
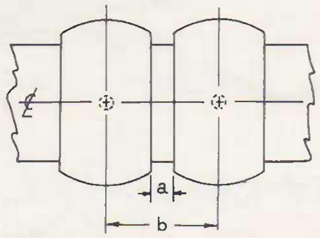


Fig. 2. Mounting for free convection cooling.



Heat Sink	a	b
56219/35	7/32"	1"
56228/38	7/32"	1 5/8"
56223/37	13/32"	2"

Fig. 3. Min. distances between heat sinks.

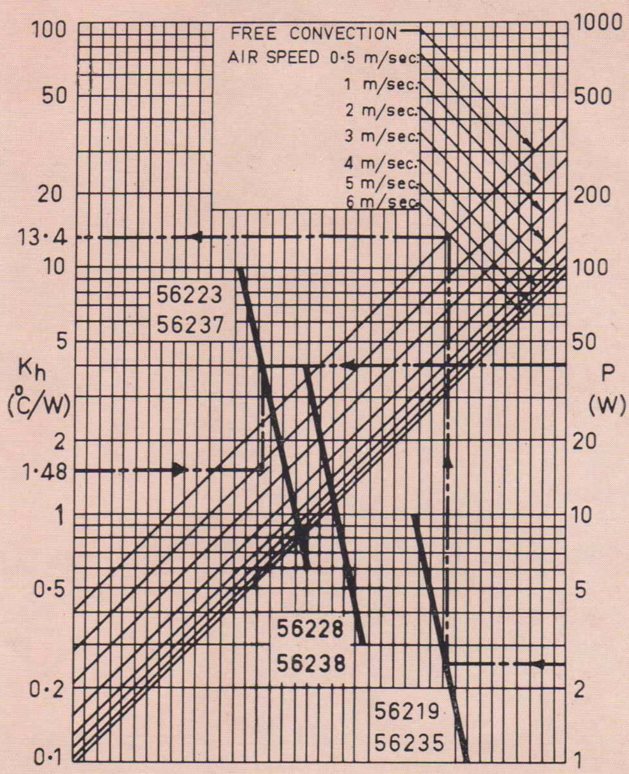


Fig. 4. Chart relating thermal resistance (K_h) of the heat sinks to dissipation (P) and air speed.

Diode Dissipation and Heat Sink Considerations

The maximum permissible total dissipation ($P_{tot\ max}$) of a diode mounted in a heat sink is

$$P_{tot\ max} = \frac{T_j - T_{amb}}{K_{j-amb}} \quad \ldots \quad (1)$$

The total thermal resistance from junction to ambient is
$K_{j-amb} = K_{j-mb} + K_{mb-h} + K_h$ .. .. (2)

K_{mb-h} is the contact thermal resistance for minimum torque as given in the published data for the particular diode.

K_h is the thermal resistance of the heat sink to ambient air.

Use of Fig. 4 to Determine K_h

The thermal resistance (K_h) of a heat sink varies with the power dissipated by the diode, and also with the air speed if forced-air cooling is used.

The procedure is as follows:

1. Determine the dissipated power (P) of the diode and mark this on the scale on the right of the chart.
2. Trace horizontally until this meets the heavy line for the particular heat sink.
3. Trace vertically to meet the line for air speed.
4. Trace horizontally to find the value of thermal resistance (K_h) of the heat sink on the left-hand scale.

Two examples of calculations using Fig. 4 are worked out below and shown by chain-dotted lines.

Example 1

Calculation of permissible ambient temperature for a BYZ10 diode mounted on a heat-sink type 56219/35 and dissipating 2.5 W with free convection cooling.

From the BYZ10 series published data:

$T_{j\ max} = 150°C$, $K_{j-mb} = 6°C/W$, $K_{mb-h} = 0.6°C/W$.

Use of Fig. 4 shows that K_h for heat sink type 56219/35 and 2.5 W dissipation with free convection is 13.4°C/W.

Using Eqn. (2), $K_{j-amb} = (6 + 0.6 + 13.4)°C/W = 20°C/W$.

Using Eqn. (1), $T_{amb} = 150 - (2.5 \times 20) = 100°C$ max.

Example 2

Calculation of air speed required to cool a BYZ14 diode mounted on a heat sink type 56223/37. The BYZ14 dissipates 40 W and $T_{amb} = 45°C$.

From the BYZ14 published data
$T_{j\ max} = 150°C$, $K_{j-mb} = 1.0°C/W$, $K_{mb-h} = 0.15°C/W$.

Using Eqn. (1),
$K_{j-amb} = 2.63°C/W$.

Using Eqn. (2),
$K_h = 1.48°C/W$.

From Fig. 4 the chain dotted line shows that an air speed of about 0.7 metres/sec must be applied.

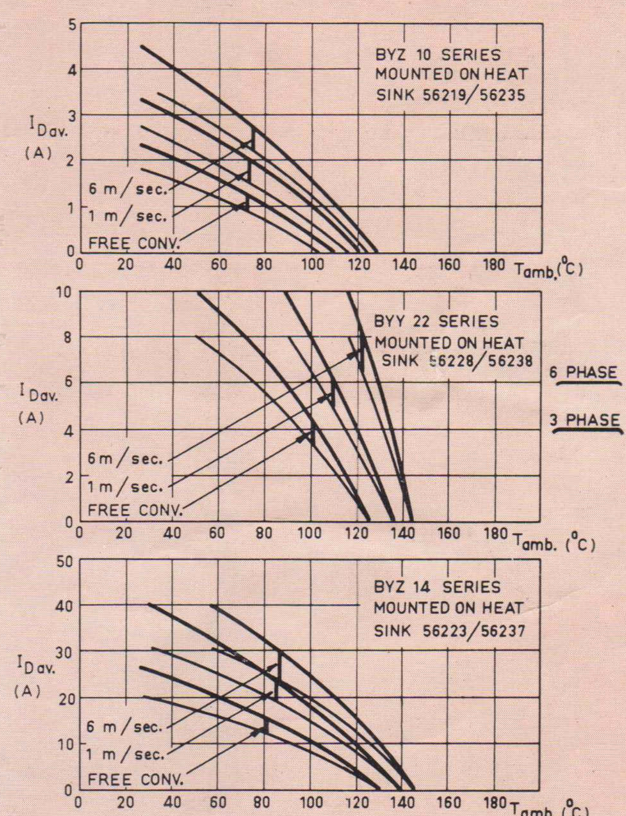


Fig. 5. Maximum permissible average current ($I_{Dav.}$) as a function of T_{amb} for 3 and 6-phase operation.

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