

"Miniwatt"

DIGEST

VOL. 2 No. 1
OCTOBER 1962

— TECHNICAL AND COMMERCIAL TOPICS OF
CURRENT INTEREST TO THE ELECTRONICS INDUSTRY

CONTENTS

	Page
MINIWATT HIGH QUALITY AM TUNER	2
TRANSISTORISED DC/DC CONVERTERS, Part 1, Low-to-Medium Power Units	6
Higher Current Ratings for Miniwatt ASZ15-18	10
PRE-AMPLIFIERS FOR MAGNETIC PICK-UPS, Pt. 1 — Two Basic Equalising Units	11
CLASS B AMPLIFIER USING AC128 — Alternative 9 V and 14 V Operation	14

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



HIGH QUALITY AM TUNER

"Miniwatt" High Quality AM Tuner

The tuner described in this article satisfies a logical requirement arising from the description of two high quality amplifiers in previous issues of the "Miniwatt Digest"⁽¹⁾.

The limitations placed by the Australian AM Broadcasting system on the attainment of quality approaching acceptable concepts of high fidelity are severe; hence compromises are inevitable in any tuner design.

The unit described here produces highly acceptable quality within the limitations imposed.

1. Design Requirements

The following design requirements are postulated as specifying the tuner performance in broad outline:

- (i) Sensitivity sufficient for the reception of signals of worthwhile field strength.
- (ii) A selectivity characteristic adequate for good quality reception, without undue exposure to the possibilities of interference.
- (iii) A low level of harmonic distortion.
- (iv) The best audio frequency characteristic consistent with freedom from interference from unwanted stations.
- (v) Freedom from heterodyne whistles and other false responses.
- (vi) Ease of tuning.

2. Circuit Description

The tuner involves the use of two valves (a 6AN7 as mixer and a 6BH5 as IF amplifier), two germanium diodes (an OA74 as signal demodulator and an OA85 for the indicator channel) and a tuning indicator (type 6FG6). The circuit diagram is shown in Fig. 1.

Following are details of the circuit arrangement:

(i) *Station Selector.* A Miniwatt permeability tuner type AP1200 is used for this purpose. This unit is designed for use with the 6AN7 and shows practically constant sensitivity and negligible mistracking over the broadcast frequency range. The range covered is 1620 Kc/s to 520 Kc/s. The alignment is extremely simple.

The oscillator circuit has been particularly studied with a view to the reduction of oscillator harmonics which are conducive to the production of heterodyne whistles and other false responses⁽²⁾. In addition to the use of a relatively low value oscillator grid leak (R_5), which in itself tends to equalise oscillator strength across the band and minimise harmonics, use has been made of a series resistor (R_6) to the grid, which produces still further harmonic attenuation. While such practices may produce less than optimum conversion gain in the mixer, the reduction of oscillator harmonics with consequential improvements in other factors is of more than compensating value.

Performance Specifications

Frequency Range: (520-1620) Kc/s.

Sensitivity (Input voltage, with 30% modulation, for 200 mV^o audio output):

at 1500 Kc/s 65 μ V

at 1000 Kc/s 54 μ V

at 600 Kc/s 61 μ V

—adequate for modern high-fidelity amplifier equipment (including both "Twin 10" and "Twin 3").

Audio Response:

—3 dB at 4.4 Kc/s, with gradual roll-off
to—55 dB at 10 Kc/s (adjacent channel spacing).

Harmonic Distortion:

Barely discernible^o from inherent test generator distortion.

Power Supply Requirements:

HT 18 mA at 220 V. Heater supply 0.64 A at 6.3 V AC.

^o Refer to section 4.

(ii) *Signal Channel IF Amplifier.* The signal channel IF amplifier circuit consists of a pair of Miniwatt Micro 12 IF transformers type 4262 used in conjunction with a Miniwatt 6BH5 RF pentode valve. As supplied, these transformers are intended for ordinary radio receivers and feature narrow selectivity characteristics which, however, are unsuited to the wider band reception required. Consequently the first IF transformer (T_1) is damped with resistors (R_8 and R_{11}) across both primary and secondary, which, associated with valve damping, effectively halve the unloaded Q's of the circuits. Since such extra damping would reduce the coupling provided by the transformer design to less than half critical coupling, an additional coupling is provided by means of a 2.2 pF capacitor (C_{11}) connected from primary to secondary (in correct phase) as shown in the diagram. This somewhat overcouple the circuits, an effect which is necessary in order to secure an adequately wide passband. The overcoupling requires some additional care in the alignment procedure which will be described in due course.

The second IF transformer (T_2) is heavily damped by the diode circuit and, in consequence, requires considerably increased coupling. This is provided by means of a 5.6 pF capacitor (C_{16}) connected between primary and secondary. The extra coupling, however, does not overcouple the circuits and so alignment procedure is normal in this stage.

(iii) *Diode Detector.* The dimensioning of the detector circuit is perhaps the most critical part of the whole design. The diode detector circuit in a normal radio receiver is deficient in regard to both bandwidth and demodulation distortion — mainly arising out of high impedance diode loads, generous IF signal filtering and relatively poor AC/DC ratio.

To meet design requirements the diode load was made $22\text{ K}\Omega$ shunted by a capacitor of 47 pF (R_{16} and C_{17} respectively). This configuration provides constant loading for a fairly wide bandwidth. The range, however, is not unduly generous since the necessary filtering circuits reduce the frequency of the cutoff point. The heavy diode damping suggested a diode of higher permeance than those incorporated in valves such as the 6N8; hence a germanium diode type OA74 was used. This separate diode also had the advantages of reducing feedback in the circuit and minimising layout problems.

(iv) *Signal Output Circuit.* A $39\text{ K}\Omega$ resistor (R_{17}) was used in series with the capacitance of the output cable (approx. 12" long) to provide further IF filtering.

Since the nominal AM broadcast station separation in Australia is 10 Kc/s , a whistle filter (C_{18} , L_3) tuned to this frequency is used. The inductor L_3 is wound in a Philips pot-core assembly. This circuit alone provides over 40 dB attenuation at 10 Kc/s and is sufficiently selective to incur only 3 dB attenuation at 8 Kc/s .

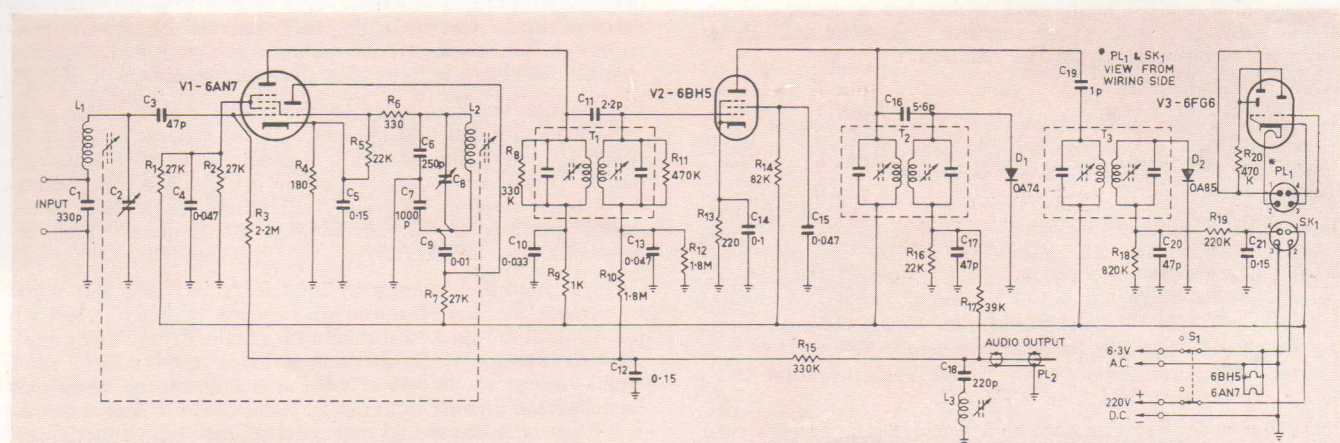
(v) *AGC.* A simple AGC is applied since this type introduces less distortion than other more sophisticated methods.

(vi) *Tuning Indicator Channel.* The flatness of the signal passband precludes reasonably precise tuning even when an indicator is connected to the signal circuits. Consequently a separate, more selective, IF circuit and a high impedance diode detector circuit are employed to operate the indicator, a 6FG6.

The IF circuit comprises an additional transformer type 4262 loosely coupled to the plate of the 6BH5 by a 1 pF capacitor (C_{19}). The improved selectivity of the indicator channel, providing as it does a peaked single response (Fig. 5) for the tuning indicator, considerably improves ease of tuning.

(vii) *Power supply.* The power requirements of the tuner are quite moderate: HT, 18 mA at 220 V ; heaters 0.64 A at 6.3 V . Frequently, this is available from the audio amplifier. Both the "Twin 10" and "Twin 3" will accommodate these requirements. However, the 6CA4 (alternatively specified rectifier) should then be used in the case of the "Twin 3". If, however, a separate power supply is needed, it may be built on a chassis similar in size to the tuner, mounted on a common base-plate and included in the tuner cabinet. In this case, however, the switch S_1 should be replaced by an approved ON-OFF switch suitable for 240 V mains switching.

The circuit of a suitable power supply is shown in Fig. 2. A valve type 6V4 is used as a rectifier with a resistance-capacity filter.



R ₁	27 K Ω , 10%, 1 W
R ₂	27 K Ω , 10%, 1 W
R ₃	2.2 M Ω , 20%, $\frac{1}{2}$ W
R ₄	180 Ω , 10%, $\frac{1}{2}$ W
R ₅	22 K Ω , 10%, $\frac{1}{2}$ W
R ₆	330 Ω , 20%, $\frac{1}{2}$ W
R ₇	27 K Ω , 10%, 1 W
R ₈	330 K Ω , 10%, $\frac{1}{2}$ W
R ₉	1 K Ω , 20%, $\frac{1}{2}$ W
R ₁₀	1.8 M Ω , 20%, $\frac{1}{2}$ W
R ₁₁	470 K Ω , 10%, $\frac{1}{2}$ W
R ₁₂	1.8 M Ω , 20%, $\frac{1}{2}$ W
R ₁₃	220 Ω , 10%, $\frac{1}{2}$ W
R ₁₄	82 K Ω , 10%, 1 W
R ₁₅	330 K Ω , 20%, $\frac{1}{2}$ W
R ₁₆	22 K Ω , 10%, $\frac{1}{2}$ W
R ₁₇	39 K Ω , 20%, $\frac{1}{2}$ W
R ₁₈	820 K Ω , 20%, $\frac{1}{2}$ W
R ₁₉	220 K Ω , 20%, $\frac{1}{2}$ W
R ₂₀	470 K Ω , 20%, 1 W

V ₁	Valve type 6AN7
V ₂	Valve type 6BH5
V ₃	Valve type 6FG6
D ₁	Diode type OA74
D ₂	Diode type OA85
L ₁	Aerial coil } Philips
L ₂	Oscillator coil } type AP1200
L ₃	Inductor, whistle filter } tuner
PL ₁	Teletron or McMurdo 4-pin plug
PL ₂	"Belling-Lee" coaxial plug
S ₁	2-pole 2-pos. Oak Series 20 switch
SK ₁	Teletron or McMurdo 4-pin socket
T ₁	Miniwatt Microband
T ₂	IF transformers
T ₃	type 4262

Resistors in the prototype tuner were Philips series B8 305 05 ($\frac{1}{2}$ W) and Philips series B8 305 06 (1 W).

C ₁	330 pF, 10% ceramic
C ₂ , C ₃	(3.5-58) pF, air trimmer
C ₃	47 pF, Pin-up
C ₄	.047 μ F, 20%, 400 V polyester
C ₅	.15 μ F, 20%, 125 V polyester
C ₆	250 pF, 10%, silvered mica
C ₇	1000 pF, 10%, 400 V polyester
C ₉	.01 μ F, 20%, 400 V, polyester
C ₁₀	.033 μ F, 20%, 400 V polyester
C ₁₁	2.2 pF, 10% ceramic
C ₁₂	.15 μ F, 20%, 125 V polyester
C ₁₃	.047 μ F, 20%, 125 V polyester
C ₁₄	.1 μ F, 20%, 125 V polyester
C ₁₅	.047 μ F, 20%, 400 V polyester
C ₁₆	5.6 pF, 10% ceramic
C ₁₇	47 pF, 10% ceramic
C ₁₈	220 pF, 10%, ceramic
C ₁₉	1.0 pF, 10%, ceramic
C ₂₀	47 pF, 10%, ceramic
C ₂₁	.15 μ F, 20%, 125 V polyester

Philips type number

C304AH/A330E
C005CA/60E
C322BC/P47E
C296AC/A47K
C296AA/A150K
—
C296AC/A1K
C296AC/A10K
C296AC/A33K
C304AB/N2E2
C296AA/A150K
C296AA/A47K
C296AA/A100K
C296AC/A47K
C304AB/L5E6
C304AB/A47E
C304AC/A220E
C304AH/N1E
C304AB/A47E
C296AA/A150K

Fig. 1. Circuit details of Miniwatt High Quality AM Tuner.

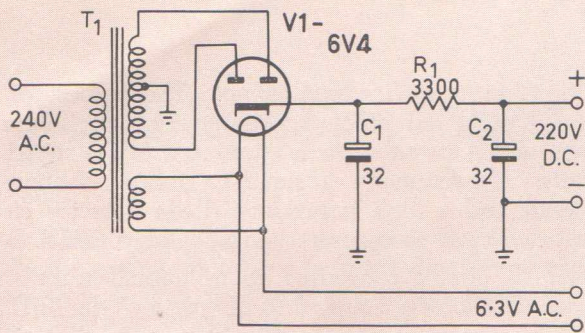


Fig. 2. Suitable power supply (should supply from power amplifier be inadequate).

- T₁ Power transformer: primary 240 V; secondaries 225/225 V at 50 mA, 6.3 V at 2 A; e.g., Ferguson PF201, etc.
- V₁ Miniwatt 6V4 valve.
- R₁ Resistor, 3300 Ω, 20%, 3 W.
- C₁, C₂ Electrolytic capacitor, 32 μF, 300 VW.

3. Construction and Adjustment

The cabinet and chassis construction was designed with two ideas in mind. Firstly, there had to be provision for housing the power supply, should the amplifier with which the tuner is used be incapable of providing the power requirements. Secondly, alternative provision has been made for incorporating a second tuner unit within the cabinet to satisfy the needs of stereo AM broadcast reception.

(i) *Mechanical Construction.* The tuner was constructed on a cadmium plated steel chassis measuring 3¾" wide, 6½" front to rear and 1¼" high. A similar sized chassis is suitable for a power supply if such is needed as an inclusive item. These chassis are mounted on their sides on a suitable base plate. Fig. 3 shows the tuner chassis assembled and mounted on the base. The ON-OFF switch is mounted on the front panel, while the tuning indicator mounts on a small sub-chassis, adjustable in position, so as to register correctly behind the opening provided in the front plate.

(ii) *Electrical Wiring.* This is shown in Fig. 4. Additional information, including metalwork details and point-to-point wiring diagram, is available on application to the Miniwatt Division, P.O. Box 34, Artarmon, N.S.W.

(iii) *Voltage Readings.* The following voltages were measured using a Philips P187 multimeter which has a sensitivity of 40,000 ohms per volt. (Less sensitive voltmeters will show lower values on some of the HT readings):

6AN7	Hexode plate	pin 7	211 V
	Hexode screen	pin 1	70 V
	Cathode	pin 3	1.8 V
	Triode plate	pin 8	92 V
6BH5	Plate	pin 6	220 V
	Screen	pin 1	82 V
	Cathode	pin 3	2 V
6FG6	Triode plate	pin 9	40 V
	Deflector plate	pin 7	
	Target plate	pin 6	220 V
	Cathode	pin 3	0 V

The total HT current was 18 mA at 220 VDC, while the total heater current was 0.64 A at 6.3 V AC.

(iv) *Alignment.* For this purpose a signal generator with correct frequency calibration, and some form of output indicator are needed. The magic eye incorporated in the tuner is not suitable entirely, since it will not give correct results when

tuning the transformer T₂. A sensitive DC or AC voltmeter may be used as a level device, being connected at the audio output.

Before switching the power on, connect a 100 K Ω, ¼ W resistor across the primary of T₁ (in addition to R_s). A 455 Kc/s signal should be applied to the input terminals through a 100 pF capacitor. After switching on and allowing for warm-up, tune the secondary of T₂ and then the primary of T₂ for maximum response. It should be noted that the primary of T₃, loosely coupled though it is, has some effect on the primary of T₂, acting as a loosely-coupled trap inclined to produce a "suck-out" at 455 Kc/s. The primary and secondary of T₃ should be adjusted to give maximum deflection on the magic eye, under which condition T₃ will produce a slight, but observable, dip in the response of T₂. Repeat the adjustments of T₂ and T₃ till no further improvement is possible.

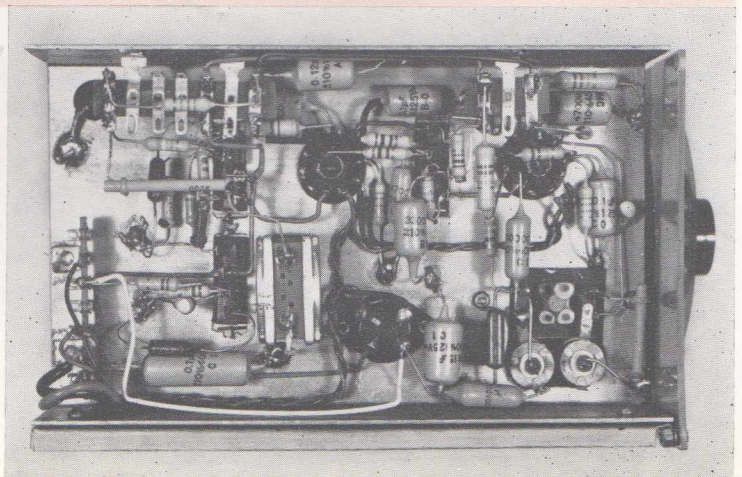
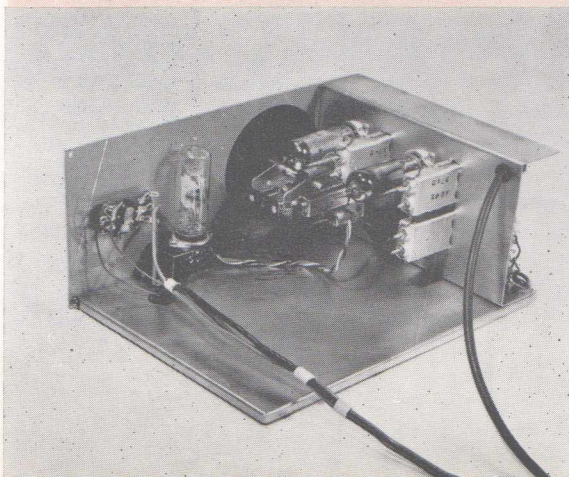
Next, tune the primary and secondary of T₁. During this adjustment, both the signal output and the magic eye deflection will both reach a maximum. Repeat tuning to ensure accuracy. Now remove the 100 K Ω damping resistor from the primary of T₁ and tune this circuit only to 448 Kc/s. Do not change the tuning of any of the other circuits. During this latter adjustment, ignore the magic eye deflection, using only the signal output maximum as criterion. This procedure is necessary because of the increased coupling in T₁ essential for a good bandwidth. When tuning is complete, the signal and indicator channels exhibit selectivity characteristics as shown in Fig. 5.

Change the test frequency to 1620 Kc/s and turn the permeability tuner dial till the tuner is in the extreme out of mesh position. Adjust the oscillator trimmer C₈ to give maximum output (signal level meter or magic eye). Since the permeability tuner requires no padder adjustment, on turning to the "all-in" position it will respond to a low frequency limit between 520 and 525 Kc/s.

Change the test frequency to 1500 Kc/s and tune this signal by turning the dial till maximum response is shown. Now adjust C₂ until the greatest maximum is obtained: no other adjustment is necessary. If the unit is to be used with a small aerial—say up to 40 feet of wire used indoors, the aerial may be connected directly to the input terminals. For longer aerials, a 100 pF capacitor should be connected between the aerial and the input. In any case, alignment may be satisfactorily checked with the actual aerial used, by tuning the station nearest to 1500 Kc/s which is to be received, and readjusting C₂ if neces-

Fig. 3. Rear view of tuner (removed from case) showing tuner chassis and indicator on common base plate.

Fig. 4. Tuner chassis wiring details.



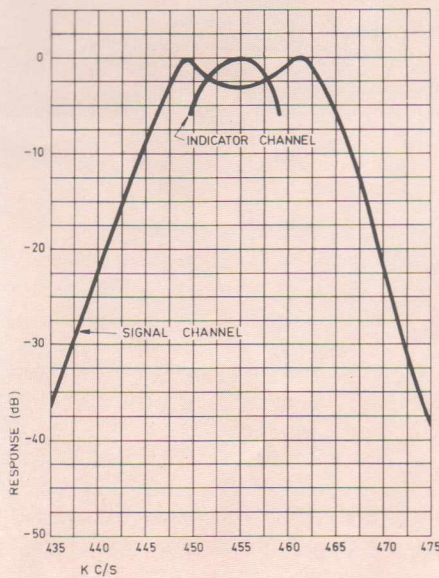


Fig. 5. Signal and indicator channel IF responses.

Fig. 6. Audio response showing effectiveness of 10 Kc/s whistle filter.

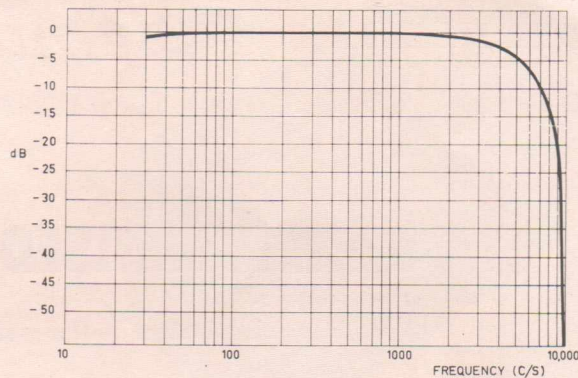
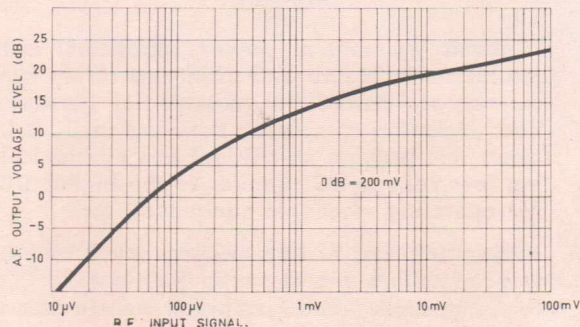


Fig. 7. AGC characteristic.



sary to give maximum deflection on the magic eye. When this is done, the alignment will be correct throughout the band for the particular aerial used.

4. Test Results

(i) *Sensitivity.* In a device such as this, the first need is to agree on a suitable output level. Since the tuner is intended to give high quality reception it is perhaps expedient to agree on a reference level high enough to excite a prospective amplifier to substantially full output. The Miniwatt "Twin Ten" Amplifier requires 350 mV for 10 W single channel output, while the "Twin Three" requires 200 mV for 3 W output. Since these levels show approximately equal power sensitivity (200 mV capable of producing 3 W from either amplifier) this figure was selected as the target level.

Following are the measured sensitivities for 200 mV RMS output from an input signal with 30% modulation.

1500 Kc/s	65 μ V
1000 Kc/s	54 μ V
600 Kc/s	61 μ V

These figures correspond to sensitivity of the order of 8 μ V for 50 mW amplifier output which compares favourably with ordinary radio receiver sensitivities. It is thus clear that any signal capable of providing high quality reproduction will provide full output from a modern hi-fi amplifier.

(ii) *Selectivity.* This was measured at 1000 Kc/s. The effect of the signal frequency circuit of the permeability tuner, if correctly adjusted, is to substantially eliminate the dip shown in the signal channel IF passband (Fig. 5) thus rendering the overall signal passband much flatter, while the added selectivity of the input circuit improves the sharpness of indication of the magic eye. Following are the results obtained:

Attenuation dB	Total Bandwidth (Kc/s)	
	Signal Channel	Indicator Channel
3	12	7.5
6	17	
20	25	17.0
40	42	26.0
60	66	49.0

(iii) *Audio Frequency Response.* For this purpose, the signal generator was externally modulated by an audio oscillator, the audio frequency output of the tuner being measured for a constant modulation depth of 50%. The results are shown in Fig. 6. The rapid fall beyond 8 Kc/s is intentional, being pro-

duced mainly by the whistle filter tuned to provide maximum rejection at 10 Kc/s.

(iv) *AGC Characteristic.* The AGC characteristic is shown in Fig. 7.

(v) *Harmonic Distortion.* This was difficult to assess with good accuracy due to the distortion inherent in the signal generator itself. Results indicated a low level of distortion in the tuner. With a modulation frequency of 400 c/s, the total distortion at 30% modulation was 2.38% while the generator itself showed 2.3%. Similarly at 70% modulation, the total was 4.71% with the generator showing 4.6%. It was not possible to obtain reasonably reliable figures at other frequencies. The tuner, however, could accept signal modulated by any frequency up to 9 Kc/s to depths over 90% without showing clipping effects in the output.

Conclusion

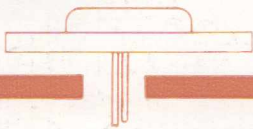
The results describe a tuner meeting the requirements for high quality AM reception. It may be objected that the frequency response for constant modulation depth is not sufficiently flat for quality reproduction, but this apparent shortcoming (imposed by requirements for spurious signal rejection) is easily compensated for.

It is not unusual in tuner unit design to provide a frequency-correcting audio stage to equalise the response. However, modern high quality amplifiers, such as the two mentioned, have in themselves the means to correct the response. For this reason, such an equalising stage, with its added complexity and cost, was considered superfluous.

(This investigation has been carried out in the "Miniwatt" Electronic Applications Laboratory by F. C. N. Smith.)

References:

1. P. Heins & J. Clark, Miniwatt "Twin Three" and Miniwatt "Twin Ten", *Miniwatt Digest*, Vol. 1, No. 2, p. 23, and Vol. 1, No. 3, p. 38, respectively.
2. K. R. Sturley, *Radio Receiver Design*, Pt. 1, p. 206 (Chapman & Hall 1945).



TRANSISTORISED DC/DC CONVERTERS

Part I—Low-to-Medium Power Units

Miniwatt germanium power transistors, with their very low saturation resistance and ability to safely switch high levels of current, are particularly suitable for general switching applications including specifically their use in DC/DC converters. These converters provide an efficient and economical means of converting low voltage DC supplies to the higher DC voltages required for operating electronic equipment, etc.

In this, the first of two articles, converters are described in the low-to-medium power range 300 mW to 30 W which use the "ringing choke" and "push-pull transformer coupled" principles of operation.

Basic details of the lower-power DC/DC converters to be described are as follows:

Nominal Input Voltage	Type of Circuit Used	Philips Transistor Type	Nominal Output Voltage	Power Range Available
6 V	Push-pull transformer coupled	2 × OC76	90 V	300 mW to 900 mW
12 V	Push-pull transformer coupled	2—AC128	250 V	900 mW to 5 W
12 V	Ringing choke	OC26	250 V	5 W to 9 W
12 V	Push-pull transformer coupled	2—OC26	300 V	9 W to 30 W

These converters are designed to operate in the temperature range 0-55° C and care has been taken to ensure that maximum power can be achieved with the normal manufacturing spreads of transistor parameters. These units have been conservatively rated, and will operate safely with the normal fluctuations of accumulator voltage, etc.

PRINCIPLES OF OPERATION

(a) Push-Pull Transformer Coupled Converter⁽¹⁾ (Figs. 3, 4 and 6)

Two transistors used as controlled switches and a saturating transformer are the basis of the push-pull

converters described in this article. Referring to Fig. 3 (representative of this type) the transistors Tr_1 and Tr_2 alternately conduct, causing the flux in the core to be cycled between positive and negative saturation, thereby inducing a square-wave voltage across the transformer secondary.

The manner in which this happens is as follows. Assume that Tr_1 has commenced switching towards a saturated condition: the changing collector current of Tr_1 flows through half (N_1) the primary of transformer T_1 which besides establishing a secondary (N_5) voltage also induces voltages in the feedback windings (N_3, N_4) and the other primary half (N_2). A regenerative switching action ensues which causes increased conduction of Tr_1 and switches Tr_2 off. The collector current of Tr_1 continues rising in an almost linear fashion until the transformer saturates.

At this point the magnetic field collapses, rapidly decreasing the voltage fed back to the base of Tr_1 . The collector current of Tr_1 subsequently decreases as its drive has been removed, and this reduction of current causes the flux to build up in the opposite direction, thus inducing voltages of opposite polarities in the various windings. Again the action is regenerative and Tr_1 is rapidly switched off, whilst Tr_2 is rapidly switched on. The cycle then repeats.

Relatively large amounts of power can be switched by this method compared with sine wave operation of transistors. The transistor in the saturated condition has only a small voltage drop across it, whilst in the non-conducting state the voltage across the transistor is high (approximately twice the supply voltage) and only leakage current flows. It can thus be seen that the dissipation could become high only for the intervals during which the transistors are switching. In the



Fig. 1. 900 mW DC/DC Converter.

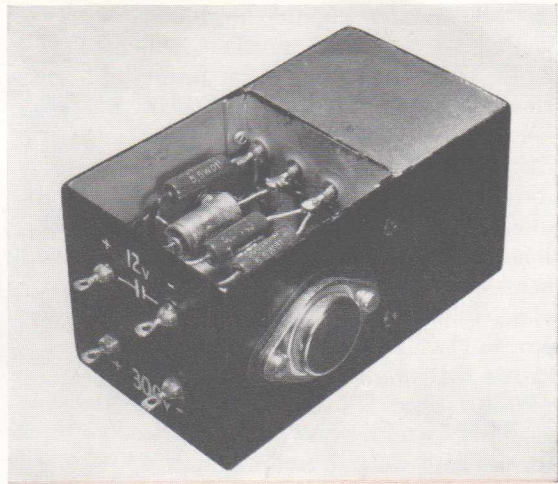


Fig. 2. 30 W DC/DC Converter.

circuits to be described switching losses are minimised by careful attention to design.

(b) Ringing Choke Converter⁽²⁾ (Fig. 5)

The "ringing choke" converter in Fig. 5 uses a single power transistor and operates as a relaxation oscillator generating a rectangular waveform. When the input voltage is applied, the oscillation is first initiated by means of small negative voltage derived from voltage divider R_1 , R_2 and applied to the transistor base. The transistor is thus made to conduct and is maintained in the saturated condition by constant voltage induced in the feedback winding (N_2) whilst the collector current rises linearly to a maximum value βI_b ; where β is the common emitter current gain and I_b is the constant value of base current.

At this point the stored energy in the transformer primary inductance reaches its maximum value. The transistor can now no longer maintain a constantly increasing collector current and the rate of current increase falls off, thereby inducing voltages of opposite polarity in all windings, which changes the operating point of the transistor and drives it towards cutoff. The resonant circuit formed by the inductance and transformer plus

stray capacitance in the secondary winding now commences "ringing". When the induced secondary voltage rises to a value greater than that previously established across the filter capacitor, the diode D_1 conducts, causing a transfer of the energy stored in the primary winding to the load. The ringing continues after the diode has stopped conducting and the reverse half cycle causes regenerative switching on of the transistor, and the cycle is thus repeated.

In a ringing choke converter the available power depends on the driving conditions for the transistor, and the primary current is largely independent of the actual load. The voltage regulation is comparatively poor, and as there is only a limited amount of energy per cycle that can be stored in a given core size the use of this circuit is restricted to relatively low power levels.

TRANSFORMER CORE CONSIDERATIONS

The choice of transformer material largely depends on the output power and the frequency of operation. This particular range of converters has been designed using Ferroxcube ferrite "E" cores as they present an efficient and economical solution for the output powers involved. This core material is in-

expensive, and transformers are easy to construct and fast to wind. High core resistivity results in low eddy current losses. Operation is possible at frequencies higher than most magnetic materials, providing more economical use of filtering components with better space utilisation. The comparatively low saturation flux density of Ferroxcube ferrite results in a relatively large cross-sectional area for a given power, although this effect can usually be offset by the higher operating frequencies permitted. The BH curve does not present well defined switching points which means that, where operation requires core saturation, the drive for the transistor must be somewhat higher, resulting in higher peak currents for a given core size. Although this is unimportant here, special rectangular hysteresis loop core materials will be specified for the higher powered range to be described in the next issue of the *Digest*. This will ensure full transistor rating utilisation at these higher powers.

TRANSFORMER CONSTRUCTION

These transformers are constructed with all windings wound on the centre leg of the ferrite "E" cores. The windings should be insulated with .005" paper and, in the case

of the primary should be bifilar wound to minimise transient voltages. The cores should be firmly clamped together and no air gap is necessary except in the case of the ringing choke converter. Transformer noise can be effectively reduced by potting it in suitably selected epoxy resins, and this has been described in detail in a previous issue of the *Digest* (Vol. 1, No. 11). Reference to Fig 2 shows that miniature glass lead-ins (Philips type 88014/03) are particularly useful for both transformer and output terminations.

CIRCUIT DESCRIPTIONS

900 mW DC/DC Converter

This low power converter (Fig. 3) uses miniature components throughout, with a voltage doubler circuit connected to the secondary winding of the miniature transformer. Winding details are shown in Table 2, and it should be noted that adequate winding space has been allowed, should full wave rectification or increased output voltage be required. In both cases the ratings of components in the rectifying section should be checked to ensure safe operation. Reliable starting is accomplished by a negative voltage applied to the bases of the transistors via resistor R₃.

The regulation of this supply has been improved at little expense in regard to full load efficiency by placing a voltage dependent resistor across the load.

Typical performance curves for a nominal 6 V input are given in Fig. 3. The measured peak to peak ripple voltage is 220 mV in the full load condition.

5 W DC/DC Converter

This push-pull circuit (Fig. 4) with its high efficiency and good regulation will find application in portable and test equipment, etc. The converter uses the recently introduced 2-AC128 matched audio transistors. The operation of the circuit is essentially the same as that in Fig. 3 except that the starting and drive conditions for the transistors are controlled by the

Fig. 3. 900 mW DC/DC Converter.

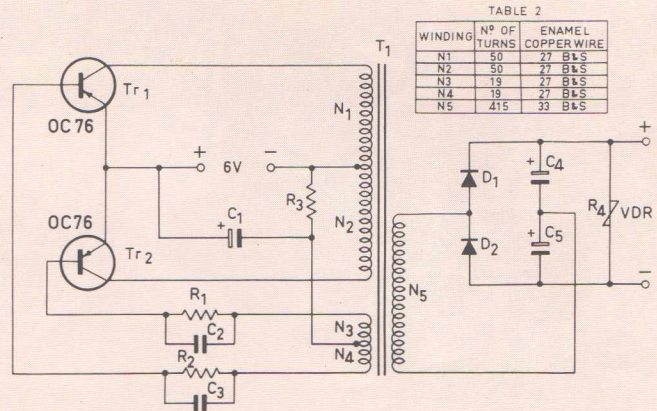


TABLE 2

WINDING	Nº OF TURNS	ENAMEL COPPER WIRE
N1	50	27 B & S
N2	50	27 B & S
N3	19	27 B & S
N4	19	27 B & S
N5	415	33 B & S

Fig. 4. 5 W DC/DC Converter.

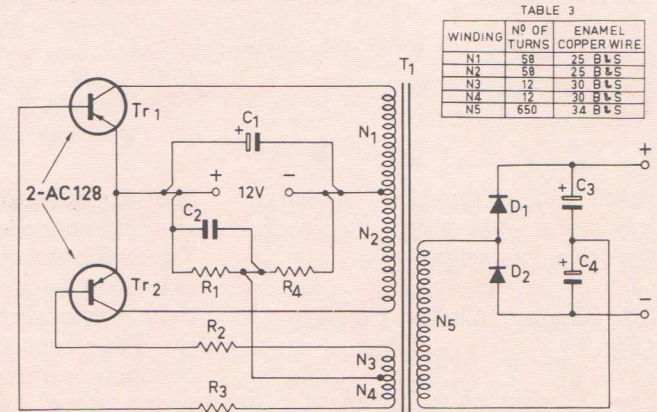


TABLE 3

WINDING	Nº OF TURNS	ENAMEL COPPER WIRE
N1	58	25 B & S
N2	58	25 B & S
N3	12	30 B & S
N4	12	30 B & S
N5	650	34 B & S

Fig. 5. 9 W DC/DC Converter.

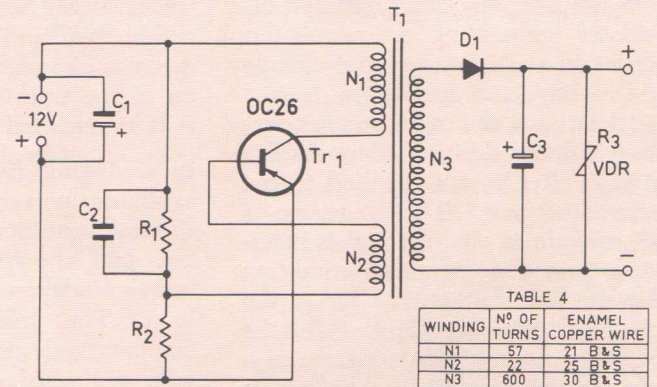


TABLE 4

WINDING	Nº OF TURNS	ENAMEL COPPER WIRE
N1	57	21 B & S
N2	22	25 B & S
N3	600	30 B & S

Fig. 6. 30 W DC/DC Converter.

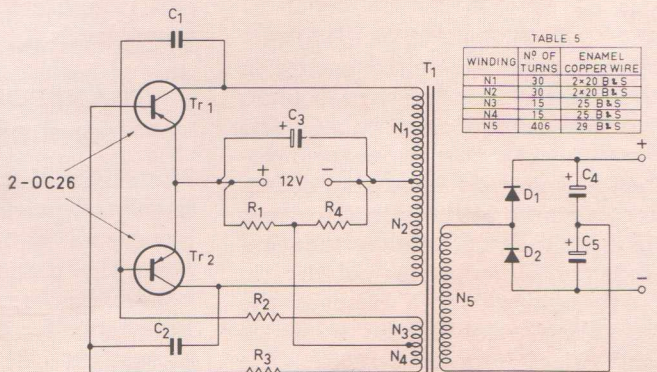
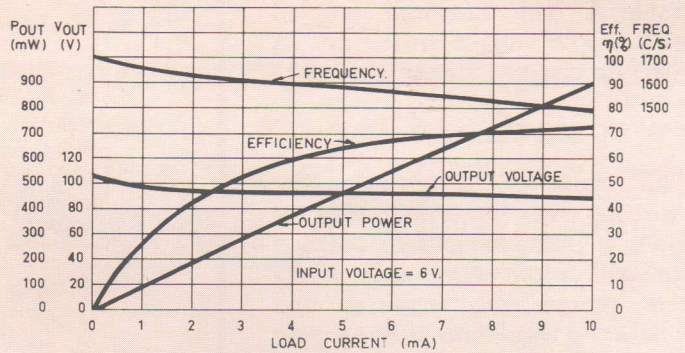


TABLE 5

WINDING	Nº OF TURNS	ENAMEL COPPER WIRE
N1	30	2x20 B & S
N2	30	2x20 B & S
N3	15	25 B & S
N4	15	25 B & S
N5	406	29 B & S

Component	Philips Type number
Tr ₁ , Tr ₂	Switching Transistors OC76
R ₁ , R ₂	270 Ω ½ W B8 305 05B/270E
R ₃	820 Ω ½ W B8 305 05B/820E
R ₄	Voltage dependent resistor E299DC/P342
C ₁	16 μF, 10 VW electrolytic C426AM/D16
C ₂ , C ₃	.047 μF, 33 V, flat foil polyester C280AA/P47K
C ₄ , C ₅	6.4 μF, 64 VW electrolytic C426AM/H6.4
D ₁ , D ₂	Diodes OA85
T ₁	(2 X) Ferroxcube ferrite "E" cores (refer Table 2) 56907.47/3A
	Coil former to suit above cores VA 901.11

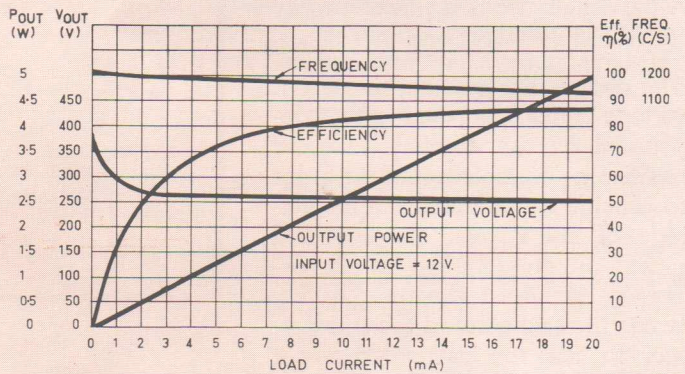
Required tolerance on fixed resistors 10%.



Component	Philips Type number
Tr ₁ , Tr ₂ *	Matched transistors 2-AC128
R ₁	100 Ω ½ W B8 305 05B/100E
R ₂ , R ₃	220 Ω ½ W B8 305 05B/220E
R ₄	4.7 K Ω ½ W B8 305 05B/4K7
C ₁	40 μF, 16 VW electrolytic C426AM/E40
C ₂	1 μF, 125 V, polyester C296AA/A1M
C ₃ , C ₄	8 μF, 200 VW electrolytic AC8125/8
D ₁ , D ₂	Silicon diodes OA210
T ₁	Ferroxcube ferrite "E" core 56907.13/3A
	Ferroxcube ferrite "I" core (refer Table 3) 56010.33/3A

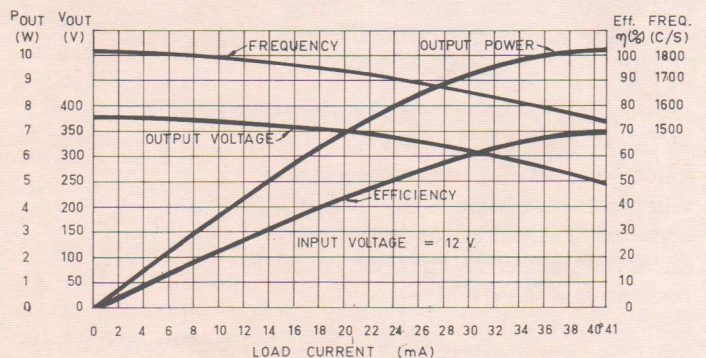
* With cooling fins 56200.

Required tolerance on fixed resistors 10%.



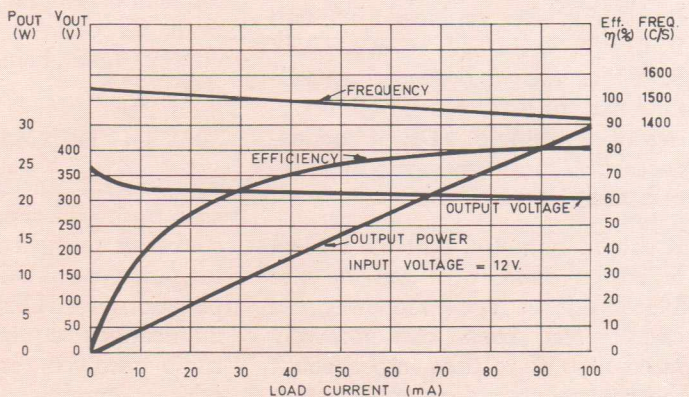
Component	Philips Type number
Tr ₁ *	Power Transistor OC26
R ₁	220 Ω 1.5 W B8 305 07B/220E
R ₂	39 Ω 1.5 W B8 305 07B/39E
R ₃	Voltage dependent resistor E299DH/P350
C ₁	100 μF, 16 VW electrolytic C426AM/E100
C ₂	1 μF, 125 V, polyester C296 AA/A1M
C ₃	40 μF, 450 VW electrolytic
D ₁	Silicon diode OA211
T ₁	(2 X) Ferroxcube ferrite "E" Cores (refer Table 4) 56907.49/3E1
	Coil former to suit above cores VA 901.21

* Transistor vertically mounted with insulating mica washer on 12 sq. ins. 18 SWG blackened mild steel heat sink.



Component	Philips Type number
Tr ₁ , Tr ₂ *	Matched Power Transistors 2-OC26
R ₁	10 Ω 5.5 W 83540A/10E
R ₂ , R ₃	6.8 Ω 5.5 W 83540A/6E8
R ₄	560 Ω 5.5 W 83540A/560E
C ₁ , C ₂	0.27 μF, 125 V, polyester C296AA/A270K
C ₃	100 μF, 16 VW electrolytic C426 AM/E100
C ₄ , C ₅	32 μF, 200 VW electrolytic AC8125/32
D ₁ , D ₂	Silicon diodes OA210
T ₁	(2 X) Ferroxcube ferrite "E" cores (refer Table 5) 56907.49/3E1
	Coil former to suit above cores VA901.21

* Each transistor mounted with insulating mica washer on 15 sq. ins. of 18 SWG blackened mild steel.



voltage divider R_1 , R_4 . Transformer winding details are given in Table 3. The measured peak to peak ripple voltage is 480 mV in the full load condition.

9 W DC/DC Converter

This converter operates on the "ringing choke" principle. It provides a most economical solution for applications where only moderate powers are required, and where the regulation of the supply is not of prime importance, such as in fixed load applications.

A particular use is a power supply for AC/DC shavers (up to 9 W).

The circuit in Fig. 5 has an output voltage which is to some extent dependent on the applied load and transistor parameters, and in order to provide the nominal output voltage of 250 V over the specified power range (5-9 W) it is necessary to adjust the air gap between the two cores in the transformer to suit the particular power used. It was found that approximately 0.012" gap provided 250 V at full load, whilst for lower powers this spacing would have to be progressively decreased (0.0045" at 5 W) in order to maintain 250 V.

A voltage dependent resistor (VDR) type E 299DH/P350 is placed across the output to provide protection should the load become open circuited, as in this condition the induced voltages could become excessively high, damaging the transistor. It should be noted that in applications where the supply is to remain lightly loaded for a considerable length of time, R_3 should be replaced by two VDR's in series (type E299DH/P246) as the high secondary voltage may cause the dissipation rating of the single VDR to be exceeded. Transformer winding details are given in Table 4.

It should be noted that the typical transistor used provided a safe 10.2 W output level. However, the circuit has been conservatively rated at 9 W to take into account the somewhat wider variations experienced with a ringing choke

converter. The measured peak to peak ripple voltage is 550 mV in the full load condition.

"Philishave" Application

(e.g., "Philishave" models 7800, 7911G, 7911S, 7743, 7735 and 7737.)

When the converter is used for the operation of AC/DC shavers it will be found that with the reservoir capacitor C_3 initially uncharged, the regulation of the supply will result in insufficient starting torque for the motor. This, however, can be easily overcome by providing a push button to momentarily open circuit the load, until C_3 charges up, the stored energy then being available for starting.

30 W DC/DC Converter

The circuit in Fig. 6 operates as a push-pull transformer-coupled converter using a matched transistor pair type 2-OC26. Typical applications are HT supplies for communications equipment, domestic radio receivers and small public address amplifiers, etc. Reference to Fig. 2 shows a suggested

Higher Current Ratings for Miniwatt ASZ15, ASZ16, ASZ17, ASZ18

The Miniwatt power switching transistors ASZ15, ASZ16, ASZ17 and ASZ18 have been released for higher collector and emitter currents. All other limits, characteristics, curves, etc., remain as published on 3/3/1960 in the Philips Electronic Tube Handbook, Semiconductor Volume. The new current ratings should greatly increase the flexibility of these transistors and extend their application.

The new Current Ratings are:—

Collector Current

Peak $I_{CM} = 10 \text{ A max.}$
Average* $I_C = 8 \text{ A max.}$

Emitter Current

Peak $I_{EM} = 12 \text{ A max.}$
Average* $I_E = 9 \text{ A max.}$

* Averaging time = max. 20 msec.

These new ratings apply to all transistors at present in stock in Australia.

mechanical construction. Transformer winding details are given in Table 5.

SUMMARY

The power supplies described in this article are easily constructed from readily available components. The circuitry has been designed to accommodate the normal manufacturing spreads in transistor characteristics and provides efficient conversion in the power range specified.

Extensive use has been made of voltage doubler circuits in the push-pull converters as this achieves more effective use of (a) transformer winding space (b) diode and capacitor voltage ratings.

(This article is based on work carried out in the "Miniwatt" Electronic Applications Laboratory by A. C. Denne, assisted by H. R. Jones).

References:

1. A New Self-excited Square-wave Oscillator, G. Uehrin and Taylor, *Proc. IRE*, Vol. 43, No. 1 (Jan. 1955), p. 99.
2. "The Design of Transistor DC Converters", *Electronic Applications*, Vol. 16, No. 2 (1955/56), pp. 59-79.



Pre-amplifiers for Magnetic Pick-ups

Part 1—Two Basic Equalising Units

It is generally agreed that a magnetic pick-up is necessary to obtain the highest quality from recordings, and that its use places some additional requirements on a high-fidelity amplifier. The following discussion outlines these requirements, and shows that an equalised pre-amplifier is necessary when a magnetic pick-up is used with an amplifier such as the Miniwatt "Twin Ten" which is intended for a crystal pick-up. Three pre-amplifiers have been designed, two of which are described here, with the third, which incorporates variable controls, to follow in the next issue.

The use of a magnetic pick-up, compared with a crystal pick-up, places certain additional requirements on a high-fidelity amplifier. These are due to the low output voltage of the magnetic pick-up, and the need to modify the overall amplifier frequency response.

In the process of recording, the groove excursions would become progressively greater as frequency decreases, were all frequencies to be passed through the recording amplifier with equal amplitude. The lowest frequency would therefore limit the maximum amplitude recorded and only minute amounts of high frequency information would appear on the recording. To overcome this, recording amplifiers have a standard frequency response or "equalisation" which provides low frequency attenuation and high frequency boosting around specified frequencies according to a standardised curve (Fig. 1, curve A). However, playback of records with this characteristic will produce different results from crystal and magnetic pick-ups. The output voltage of a crystal pick-up is approximately proportional to the amplitude of stylus excursion and tends to be self equalising. Magnetic pick-up voltage on the other hand, is proportional to the stylus velocity and for a given stylus excursion the velocity will decrease with decreasing frequency. Its output voltage therefore follows the same frequency response as the recording amplifier. To produce equal output voltage at all frequencies, the playback amplifier must then have a frequency response which is the "mirror image" of the recording characteristic (Fig. 1, curve B) and under this condition the pick-up is equalised.

The output voltage of modern magnetic stereo pick-ups varies (amongst the main manufacturers) from about 1 to 3 mV/cm/sec and the average recorded velocity of 33 $\frac{1}{3}$ LP "Classical" recordings is around 7 cm/s. A suitable amplifier would therefore require an input sensitivity of better than 7 mV for rated power output, to be satisfactorily driven by currently available pick-ups.

From the foregoing discussion it is obvious that a high-fidelity amplifier designed to be driven by a crystal pick-up (e.g. the Miniwatt "Twin Ten"⁽¹⁾) will require an equalising pre-amplifier.

The low signal levels and high gain encountered in pre-amplifiers dictates a choice of valves which have low hum, noise and microphony: the Miniwatt types EF86 low noise pentode, 7025 (special quality audio version of the 12AX7) high μ triode and 12AU7 low μ triode satisfy these requirements. Three circuits, which fall into two basic types, have been designed to examine the main possibilities in valve and circuit configuration. The first type of pre-amplifier, two examples of which are presented here, has fixed equalisation, no external controls, and is intended to drive the crystal pick-up inputs of an amplifier having its own gain and tone controls. The second type of

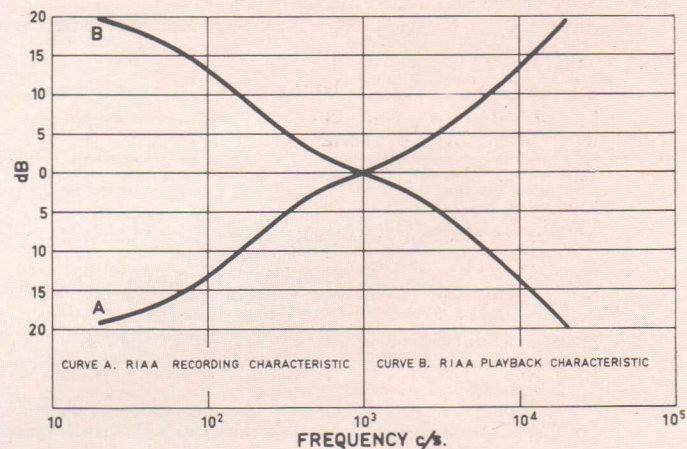


Fig. 1: RIAA recording and playback characteristics.

pre-amplifier (to be presented in the next issue of the *Digest*) contains switched equalising, tone, rumble, scratch, volume and balance controls, and is intended to drive a basic power amplifier with no external con-

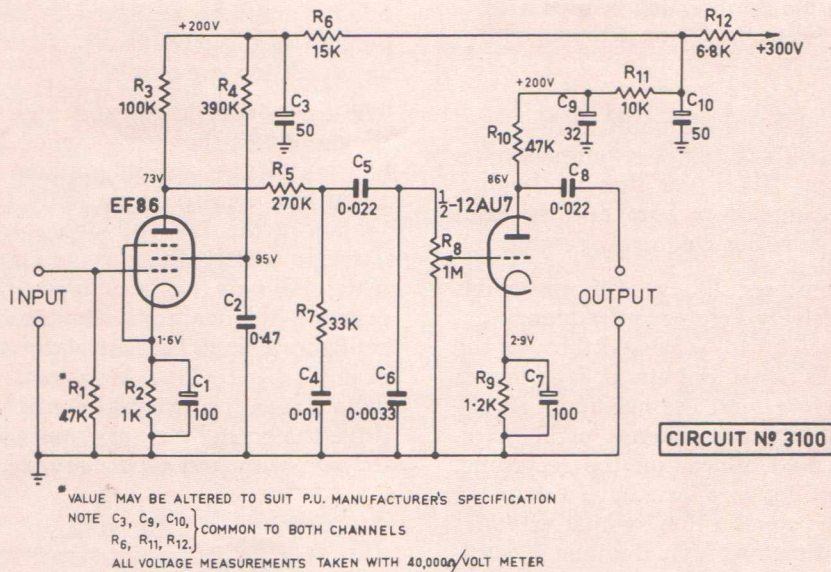
trols of its own. It should be noted that although the present circuits have been designed with the Miniwatt "Twin Ten" specifically in mind, they may be used with any other amplifier having comparable sensitivity.

PRE-AMPLIFIER USING EF86 CIRCUIT

This consists of an EF86 and one section of a 12AU7 per channel, with the equalising network (R_5, R_7, C_4, C_6) placed between the two valves. A pre-set gain control in the grid of the second valve provides sensitivity adjustment and gain balance for each channel. Due to the use of an EF86 in the first stage, hum and noise generated within the pre-amplifier is extremely low making a DC heater supply unnecessary. Critical listening tests with a Miniwatt "Twin Ten", operated with maximum gain and bass boost, revealed no audible increase in hum level when the pre-amplifier (with open circuit input) was connected.

Performance Specifications

Gain	125 times.
Sensitivity	3.0 mV input for rated 10 W output from Miniwatt "Twin Ten".
Hum and Noise	58 dB below 1 V with input grid open.
Distortion	0.15% THD for 1 V output at 1 Kc/s.
Equalisation	Better than ± 1 dB of R.I.A.A. characteristic from 20 c/s to 20 Kc/s.
Channel separation	Better than 50 dB between 20 c/s and 20 Kc/s for 1 V output one channel (open circuit on other channel).
Current drain	8.2 mA.



R _{1, 101}	47 K Ω	R _{5, 105}	270 K Ω	R _{9, 109}	1.2 K Ω
R _{2, 102}	1 K Ω	R ₆	15 K, 1 W	R _{10, 110}	47 K Ω
R _{3, 103}	100 K Ω	R _{7, 107}	33 K Ω	R ₁₁	10 K Ω , 1 W
R _{4, 104}	390 K Ω	R _{8, 108}	1 M Ω Miniature pre-set pot. E097A/1M	R ₁₂	6.8 K Ω , 1 W

Resistors required: 10% $\frac{1}{2}$ watt cracked carbon unless otherwise stated (resistors used Philips series B8 050 05 ($\frac{1}{2}$ W) and B8 305 06 (1 W)).

C _{1, 101}	100 μ F, 4 V, electrolytic C425-AL/B100	C _{6, 106}	0.0033 μ F, 400 V, polyester C296AC/A3K3
C _{2, 102}	0.47 μ F, 400 V, polyester C296AC/A470K	C _{7, 107}	100 μ F, 4 V, electrolytic C425AL/B100
C ₃	50 μ F, 300 V, electrolytic	C _{8, 108}	0.022 μ F, 400 V, polyester C296AC/A22K
C _{4, 104}	0.01 μ F, 400 V, polyester C296AC/A10K	C ₉	32 μ F, 300 V, electrolytic
C _{5, 105}	0.022 μ F, 400 V, polyester C296AC/A22K	C ₁₀	50 μ F, 300 V, electrolytic

3 screened valve sockets (5908/35)

2 plugs and sockets ("Belling-Lee" co-axial type)

1 screened box and chassis (as available from Heating Systems Pty. Ltd., 97 Marriott Street, Redfern, N.S.W.)

Fig. 2. Circuit details of pre-amplifier using EF86.

PRE-AMPLIFIER USING 7025

The second circuit uses a 7025 twin triode in each channel and is rather simpler than the one using the EF86. The equalising network (R_4, R_6, C_3, C_4, C_6) is again placed between the valve sections although the pre-set gain control has been omitted in the interests of simplicity. To compensate for excessive slope in the treble roll-off between 12 Kc/s and 20 Kc/s caused by Miller capacitance in the triodes, C_3 has been added to the equalising network. On initial inspection this circuit would appear to be a more acceptable configuration than the previous one. However, the internal hum limits given for the 7025 are greater than those of the EF86 and to realise hum levels comparable with the first circuit, a DC heater supply is necessary, involving extra expense and difficulty. In making a choice between the two circuits it should be realised that the

7025 version will operate satisfactorily under average "listening conditions" with an AC heater supply, but it will not withstand the more critical listening test conditions described for the EF86 version. Although 12AX7's have proved to be quite satisfactory in this circuit, there is no firm guarantee that the hum and noise figures quoted for this pre-amplifier will be consistently duplicated.

Performance Specifications

Gain	145 times.
Sensitivity	2.5 mV for rated 10 W output from Miniwatt "Twin Ten".
Hum and Noise	47 dB below 1 V with input grid open (AC heater supply).
Distortion	0.16% THD for 1 V output at 1 Kc/s.
Equalisation	Better than ± 1 dB of R.I.A.A. characteristic from 20 c/s to 20 Kc/s.
Current Drain	3.2 mA.

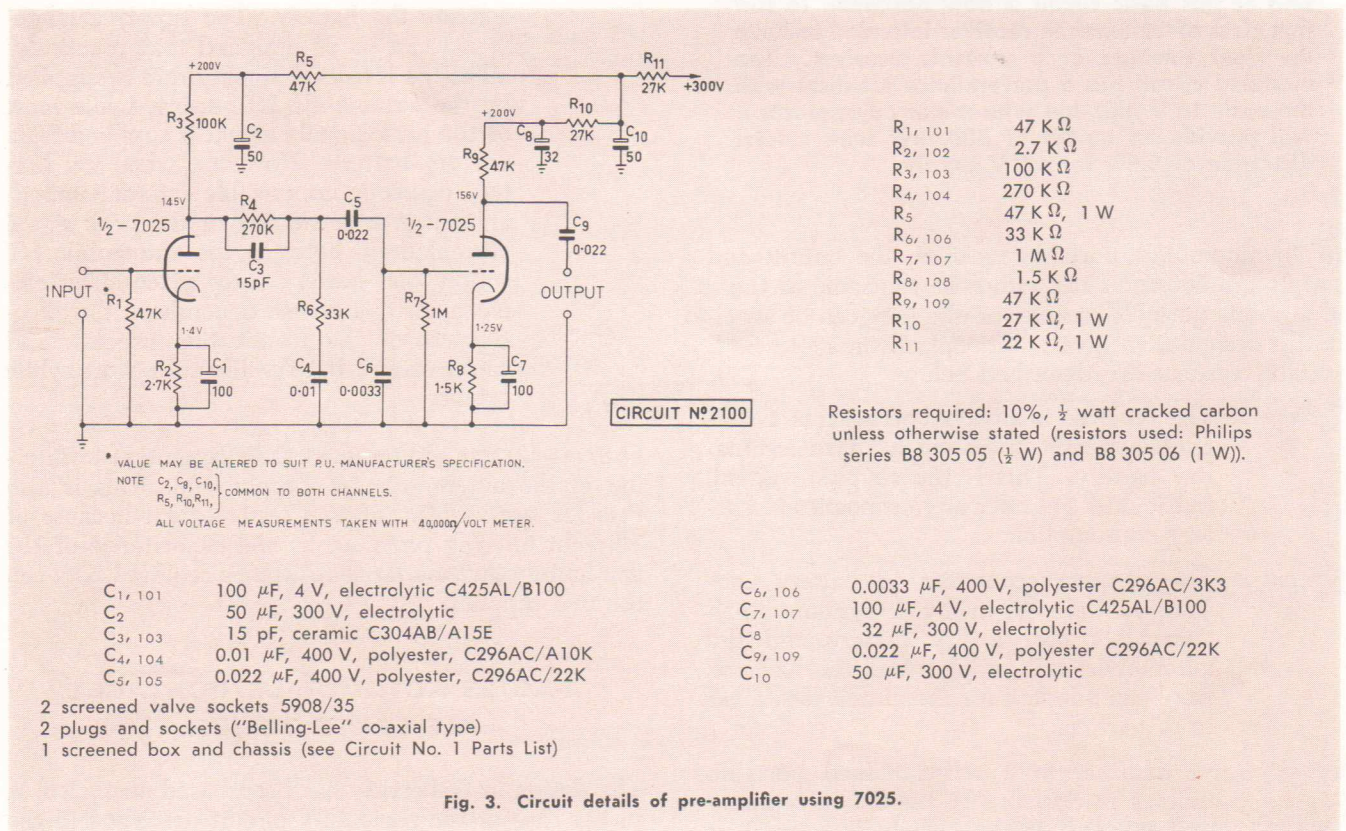


Fig. 3. Circuit details of pre-amplifier using 7025.

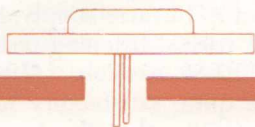
Both pre-amplifiers have a generous margin of gain for any currently available magnetic pick-up. Should the available gain in the 7025 amplifier be excessive, the cathode bypass capacitor C_7 may be omitted, reducing the gain by about half. Each stage is individually decoupled to ensure low frequency stability, and the time constants of the coupling networks have been designed to attenuate the low frequency response below 15 c/s. This protects the main amplifier and speakers from large low-frequency disturbances which may appear at input of the pre-amplifier. Care should be taken in construction to run a common earthing busbar around the chassis: the heater leads

should be twisted and have a grounded centre tap at the transformer, and all unshielded signal leads kept to a minimum length. The use of cracked carbon resistors, skirted valve sockets and polyester capacitors is advised in the interests of low hum, noise and long term circuit reliability. The HT and heater supplies can be conveniently taken from the main amplifier (e.g. Miniwatt "Twin Ten").

(This article is based on work carried out in the "Miniwatt" Electronic Applications Laboratory by J. Clark.)

Reference

1. P. Heins and J. Clark, Miniwatt Twin Ten Amplifier, *Miniwatt Digest*, Vol. 1, No. 3, December 1961.



CLASS B AMPLIFIER USING AC128

—alternative 9 V and 14 V operation

In the previous issue of the *Miniwatt Digest* a Class B output stage using 2-AC128 was described⁽¹⁾, which provided 2 W output with 5% distortion for a supply of 14 V. A modified version of this basic circuit is now described to suit that class of automobile receiver intended to have the dual function of a portable receiver. The modified circuit has a performance identical with the basic 14 V unit, but with minor adjustments it will provide an output of 580 mW with a total distortion of 4.5% for a 9 V supply.

In an automobile/portable receiver, the output and supply arrangements can either be the same as those of a simple portable receiver or else they can be specifically designed to give additional advantages. Four possible systems are described below:

- System 1.* The receiver is always operated as a self-contained unit operating from an internal dry battery. This is the simplest system, but it does not offer any economies in battery consumption.
- System 2.* The greatest economies in battery consumption are given by a system which alternately uses a dry battery and the automobile LT supply, and this scheme has been adopted for the circuit described in this article.
- System 3.* In addition to a self-contained portable unit as in *System (2)*, there is a separate unit installed in the vehicle for providing higher-powered audio output. For automobile use, the portable receiver is plugged into a cradle housing and connected simultaneously to a higher-power output stage, a larger fixed speaker and the LT supply of the vehicle.

The connections are so arranged that the output stage of the portable unit then becomes the driver stage of the higher-powered amplifier. The power output requirements for both functions are easily satisfied with this system. However, the complicated interconnection adds an additional expense, with reduced reliability.

System 4. The receiver is always connected to the internal dry battery, but some economy in battery consumption is achieved by using the LT supply of the automobile to reactivate the battery. The supply arrangements can be so designed that practically all of the low-level signal drain is supplied by the automobile LT supply, while most of the peak signal current is supplied from the dry battery. However, when the battery develops appreciable internal impedance, a greater sharing of the peak signal current drain between the automobile LT supply and battery takes place. The efficiency of this system depends on the effectiveness of the reactivation process, and could extend battery life to a worthwhile extent.

Systems (2) and (3) require careful attention to filtering of the automobile LT supply lead. This is also true for *system (4)*, but to a lesser extent because of inherent filtering provided by the capacitance of the dry battery and the series resistance required between the two supplies.

2-AC128 AUTOMOBILE/PORTABLE AF STAGE DESIGN

The design in this article has been based on *system 2*. In the case of the basic 14 V circuit described in the last issue of the *Digest*⁽¹⁾, the maximum output power was limited by the permissible collector dissipation. It is possible with a 9 V supply to obtain an output from the 2-AC128 of up to 1.6 W, the limitation being permissible peak collector current. However, with a 9 V supply the available drive from the unmodified driver stage limited the maximum output power. The output transformer was retapped to provide a modified load line for the output transistors such that the drive was sufficient to overdrive the output stage. It was considered that a maximum power of 500 mW would be ample for a portable receiver, and could be obtained from the 14 V basic circuit with only minor alterations. The 9 V circuit described actually delivers 580 mW.

The necessary switching for alternate 9 or 14 V operation is incorporated in Fig. 1. The frequency response, sensitivity and distortion for 9 V operation are shown in Figs. 2, 3 and 4 respectively.

The curves for 14 V operation will be found in the previous issue of the *Digest*, together with data for the driver transformer.

Output Transformer Data

Full primary resistance 1.8 Ω
 Full secondary resistance 0.4 Ω
 Self inductance of the full primary winding at $f = 100$ c/s and $V_{(RMS)} = 1$ V, $L = 280$ mH
 Turns ratio:
 (2.65 + 2.65)/1—for 14 V operation
 (2.85 + 2.85)/1—for 9 V operation.

(This article is based on work carried out in the "Miniwatt" Electronic Applications Laboratory by T. Davis.)

References

1. T. Davis, The AC128, New High-gain Germanium PNP Transistor for AF Output Stages, *Miniwatt Digest*, Vol. 1, No. 12, pp. 187-190.

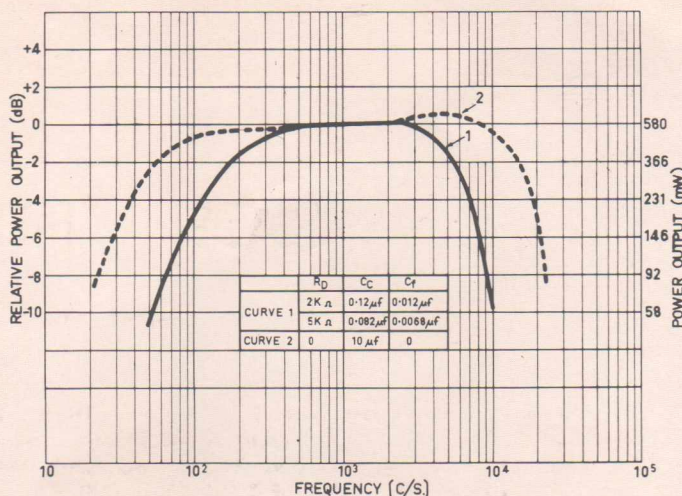
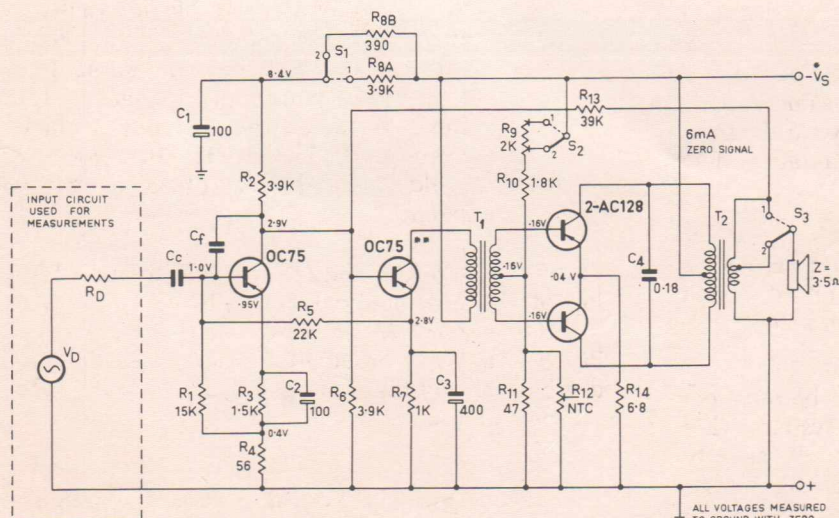


Fig. 2. Frequency response



R_D	C_C	C_F
2K Ω	0.12 μ F	0.012 μ F
5K Ω	0.082 μ F	0.0068 μ F

CIRCUIT NO 412/07

* $V_S = -14$ V OR -9 V SWITCHES S_1, S_2, S_3 SHOWN IN POSITION FOR $V_S = -9$ V
 ** 13V FOR $V_S = -14$ V & 9.3V FOR $V_S = -9$ V

- | | | | |
|----------------------------|-------------------------|-----------------------------------|------------------------|
| R_1 15 K Ω , 5% | R_7 1 K Ω | R_{11} 47 Ω | R_{13} 39 K Ω |
| $R_2, 3.9$ K Ω , 5% | R_{8A} 3.9 K Ω | R_{12} NTC, Philips type B8 320 | R_{14} 6.8 Ω |
| R_3 1.5 K Ω | R_{8B} 390 Ω | 01 A/130E, 130 Ω at 25°C | |
| R_4 56 Ω | R_9 2 K Ω lin. | | |
| R_5 22 K Ω , 5% | R_{10} 1.8 K Ω | | |

All resistors 10%, $\frac{1}{2}$ W cracked carbon, unless otherwise stated (Philips series B8 305 05)

- C_1 100 μ F, 16 VV electrolytic (Philips type C426 AM/E100)
 C_2 100 μ F, 4 VV electrolytic (Philips type C425 AL/B100)
 C_3 400 μ F, 4 VV electrolytic (Philips type C435 AL/B400)
 C_4 0.18 μ F (Philips type C296 AA/A180K)

- T_1 Driver transformer e.g., Ferguson TRD216
 T_2 Output transformer e.g., Ferguson TRS219

Fig. 1. Circuit details of automobile/portable audio amplifier using 2-AC128.

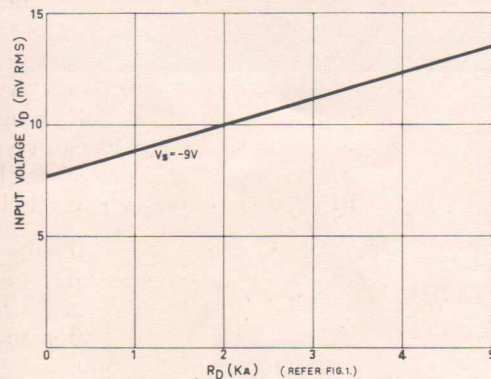


Fig. 3. Sensitivity for maximum output.

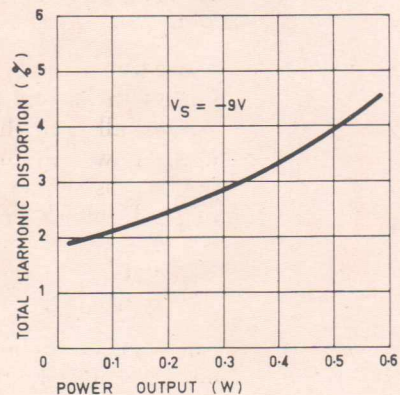


Fig. 4. Distortion characteristics at 1 Kc/s.

PHILIPS

- ELECTRONIC VALVES AND TUBES
 - SEMICONDUCTOR DEVICES
- CATHODE-RAY TUBES
 - LIGHT-SENSITIVE DEVICES
- TEMPERATURE-SENSITIVE DEVICES
 - FERRITES
- RADIATION-SENSITIVE DEVICES
 - FINE WIRES
- SPECIALIZED COMPONENTS AND DEVICES
 - SPECIALIZED MATERIALS
- TECHNICAL PUBLICATIONS

For Use in the Fields of—

ENTERTAINMENT — COMMUNICATIONS — INDUSTRY
COMMERCE — MEDICINE — SCIENTIFIC RESEARCH
AND DEFENCE



THE *Miniwatt* ELECTRONICS DIVISION

of

Philips Electrical Industries Pty. Limited
20 Herbert Street, Artarmon, N.S.W.
Phone 43 2171

Branches at:—

ADELAIDE	11-13 West Terrace, Adelaide, S.A., phone 51 6051
BRISBANE	56-58 Cordelia Street, South Brisbane, Qld., phone 42 47
CANBERRA	C.B.C. Chambers, Petrie Street, Civic Centre, Canberra City, A.C.T., phone J 4498
HOBART	73 Brisbane Street, Hobart, Tas., phone 3 3038
MELBOURNE	252 Sturt Street, South Melbourne, Vic., phone 69 0141
NEWCASTLE	194 Parry Street, Newcastle West, N.S.W., phone MA 5001
PERTH	672 Murray Street, Perth, W.A., phone 21 3131
SYDNEY	67 Mars Road, Lane Cove, N.S.W., phone 42 1261

Production Centre—

HENDON WORKS Tapley's Hill Road, Hendon, S.A., phone 4 5021

The information given in this publication does not imply a licence under any patent. Further information on the products described in this publication may be obtained on application to any of the addresses listed above.