"Miniwatt"

# DIGEST

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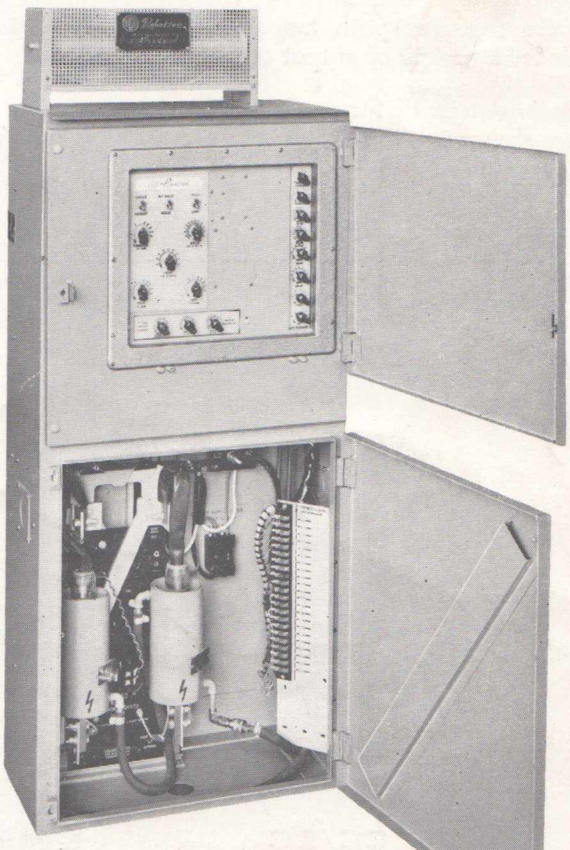
TECHNICAL AND COMMERCIAL TOPICS OF CURRENT INTEREST TO THE ELECTRONICS INDUSTRY

## CONTENTS





Universal Resistance Welding Control Equipment Incorporating Ignitrons Type PL 5552A

(Photograph courtesy Electric Control & Engineering Limited)

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

PHILIPS

# TRANSISTORISED DC/DC CONVERTERS

## PART 2 — Medium-to-High Power Units

**The range of DC/DC converters described in the previous issue of the "Miniwatt" Digest(1), has now been extended to include three medium-to-high power converter circuits. These cover a power range of (30-100) W and are capable of giving the rated power output with unselected transistors in the temperature range (0-55)°C.**

The circuits to be described are conservatively rated and will operate reliably with the normal variations in voltage encountered with accumulator operation. They will also "fail safe" should a heavy overload occur, as the oscillations will then cease, thus protecting the transistors and other components until the overload is removed. These laboratory units were designed with tapped output transformers to illustrate their use under a variety of output conditions.

Basic details of the medium-to-high power DC/DC converters described are shown in the following table (note the overlap in the available power ranges):

| Nominal Input Voltage (V) | Type of Circuit Used | Philips Transistor Type | Nominal Output Voltages (V) | Power Range Available (W) | Performance Curves Fig. No. | Ripple at Full Load (V P/P) |
|---|---|---|---|---|---|---|
| 12 | Push-pull transformer coupled with separate saturating transformer *(see Fig. 2)* | ASZ17 | 300<br>400 | **30-40** | Fig. 2 (a)<br>Fig. 2 (b) | 1.1<br>0.8 |
| 12 | Push-pull transformer coupled *(see Fig. 3)* | ASZ15 | 300<br>400 | **35-70** | Fig. 3 (a)<br>Fig. 3 (b) | 0.6<br>0.4 |
| 12 | Push-pull transformer coupled *(see Fig. 4)* | ADZ11 | 300<br>400<br>600 | **60-100** | Fig. 4 (a)<br>Fig. 4 (b)<br>Fig. 4 (c) | 0.5<br>0.4<br>0.3 |

### 40 W DC/DC CONVERTER

This Converter (Fig. 2) has been designed to use ASZ17 transistors in conjunction with two transformers constructed from standard silicon steel laminations. In this power range, such a construction is more economical (despite some increase in overall size) than those adopted for the higher-power converters described later in this article. A small saturating transformer $T_1$ is used to switch the transistors, whilst a second (larger) transformer $T_2$ is used in a linear fashion to step up the square-wave voltage developed in the collector windings to provide the required DC output.

An advantage of this circuit is that it is easily constructed without using special transformer materials or winding techniques. However, it should be noted that although only a moderate size of output transformer is incorporated in this circuit, larger sizes would be necessary should higher output power or efficiency be required.

The circuit gives good regulation with a choice of output voltage for powers of up to 40 W.

### Principle of Operation

Reference to the circuit (Fig. 2) shows that the transistor bases are switched by a saturating transformer $T_1$ in a fashion similar to the push-pull transformer-coupled operation described in Part 1(1). However this circuit differs in that the primary winding of $T_1$ is fed from the collector winding of $T_2$ via a feedback resistor $R_1$, and the switching process is as follows:

When the core of transformer $T_1$ reaches saturation, the rapidly increasing primary current produces an additional voltage drop across the feedback resistor $R_1$, thus reducing the drive and causing the collector current of the conducting transistor to decrease. This in turn reverses the voltage polarities at the base windings, thus turning the conducting transistor off and the non-conducting transistor on. This switching process is repeated every time the core of $T_1$ saturates, and so $T_1$ is cycled between its positive and negative saturation regions.

Although transformer $T_2$ supplies the current for $T_1$, it does not saturate, and hence the collector current, when either transistor conducts, consists of the feedback current through $R_1$ plus only a small magnetising current in $T_2$ in addition to the normal load current. The transistors therefore do not have peak currents very much in excess of their load currents and this fact enables more power to be obtained for a given transistor peak current rating when compared with a single transformer-coupled converter.

It should be noted also that the starting and driving conditions for the transistors are controlled by the voltage divider ($R_4$, $R_5$) and that the series base resistors ($R_2$, $R_3$) are used to minimise effects due to manufacturing spread in values of $V_{be}$ in the switching transistors. The other converters likewise incorporate such components.

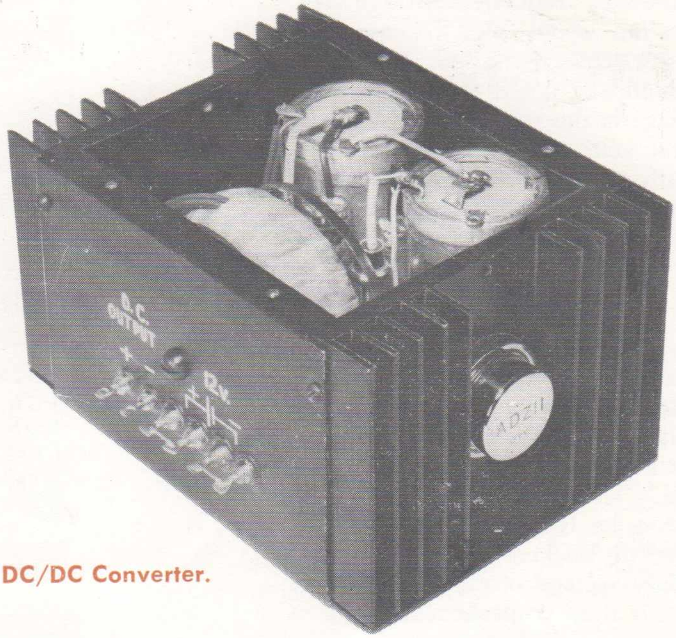



Fig. 1. 100 W DC/DC Converter.

## 70 W AND 100 W DC/DC CONVERTERS

The recently announced[2] current upratings of the "Miniwatt" ASZ15-18 series of power transistors have enabled higher output powers to be realised in DC/DC converters operated from low-voltage accumulator sources.

The 70 W DC/DC converter (Fig. 3) uses ASZ15 transistors and is designed to take advantage of these new ratings.

The 100 W converter (Fig. 4) uses the recently introduced ADZ11 15 A power transistors — the data for this series being listed on page 25 of this issue.

Typical applications of these converters are for HT supplies in communications equipment including AM and FM transmitters and in public address amplifiers.

### Principle of Operation

The 70 W and 100 W DC/DC converters both use the push-pull transformer-coupled operation described in Part 1 of this article[1]. This type of circuit has enabled compact units to be built with high output power and efficiency.

The transformers used in these converters have been constructed from HCR Alloy (50% nickel, 50% iron). This alloy has a square-loop characteristic with high saturating flux density and low hysteresis losses, and is most suitable for this type of switching application at these power levels.

Toroidal cores have been used as they provide low leakage reactance and relatively small dimensions for these higher powers. The cores are normally supplied by the manufacturer in moulded plastic cases which can act as winding formers, besides protecting the HCR alloy from any mechanical damage which could impair the magnetic quality.

The winding technique for these cores differs from that of normal transformers as the secondary, with its large number of turns, is normally machine-wound first, followed by the base and collector windings which should be bifilar wound. The reason for this particular winding order is that the collector windings consist of a small number of turns of heavy-gauge wire and, in most cases, the winding of these is more easily accomplished by hand.

The individual windings should be carefully insulated as high voltages are used, and polyester tape (0.0025″, half-lapped) is particularly suitable for this application. The secondary windings of the toroidal transformers have been tapped to provide variations in output voltage to suit particular applications.

## RECTIFICATION CIRCUITRY

The use of voltage-doubler circuits is recommended throughout for rectification purposes, and reference to Figs. 3 and 4 shows that in the voltage-doubler circuits used there, the silicon diodes are shunted with small capacitors ($C_2$ and $C_3$). These capacitors will slightly improve the switching waveforms as they eliminate any small effects due to hole storage which may be present when the diodes are switched with a combination of high power and higher-than-mains frequency. Bridge rectification could also be used in these circuits if desired. However, it should be noted that the output voltage in this case is only half that of the voltage-doubler circuits, and transformer winding space may preclude the use of bridge rectification for high voltage requirements.

## CONSTRUCTIONAL DETAILS

Because high-power DC/DC converters require large DC input currents, it is preferable to mount the unit as close to the supply as possible. The wiring and interconnecting leads must be short and of sufficient thickness to avoid unnecessary voltage drops and possible deterioration in performance.

A typical construction is shown in Fig. 1.

The converters can be positively or negatively earthed relative to the supply as the transistors are insulated from their heat sinks by mica washers.

## FURTHER INFORMATION

*The "Miniwatt" Electronic Applications Laboratory would be pleased to supply any further information required, especially if specific designs are required which are not covered by either this or the previous[1] article.*

***(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. C. Denne and H. R. Jones, Transistorised DC/DC Converters, Part 1 — Low-to-Medium Power Units; *Miniwatt Digest*, Vol. 2, No. 1, 1962, pp. 6-10.
2. *Miniwatt Digest*, Vol. 2, No. 1, 1962, p. 10.


**ERRATUM (Regulated 6.3 V Supplies)**

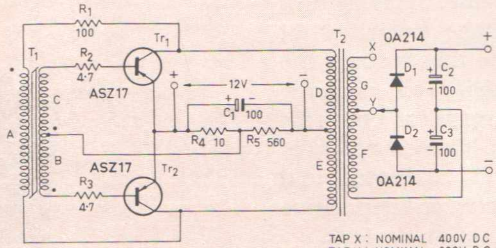
In Vol. 1, No. 10, p. 157, Figs. 1 and 2:

—the return of the output potential divider chain is shown connected to the centre-tap of $R_2$, whereas it should be taken to point B.

—the base of the OC44 is shown connected to the base of the OC74, whereas it should be taken to the end of $R_2$ opposite from B.

### Circuit Details

**Fig. 2. 40 W DC/DC CONVERTER.**



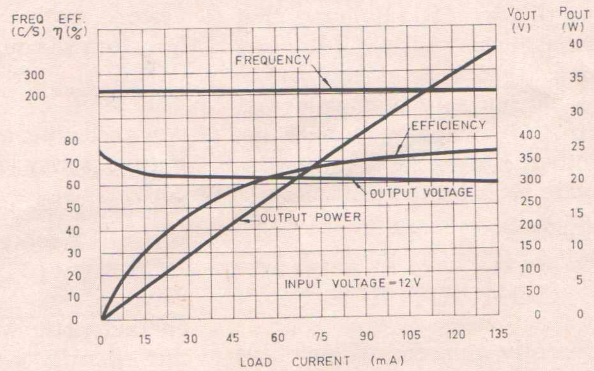

| TRANSFORMER WINDING DETAILS | | | |
|---|---|---|---|
| WINDING | | Nº OF TURNS | ENAMELLED COPPER WIRE GAUGE |
| $T_1$ | A | 60 | 23 B&S |
| | B | 50 | 23 B&S |
| | C | 50 | 23 B&S |
| $T_2$ | D | 28 | 2×19 B&S |
| | E | 28 | 2×19 B&S |
| | F | 380 | 28 B&S |
| | G | 130 | 28 B&S |

TAP X : NOMINAL 400V DC OUTPUT
TAP Y : NOMINAL 300V DC OUTPUT

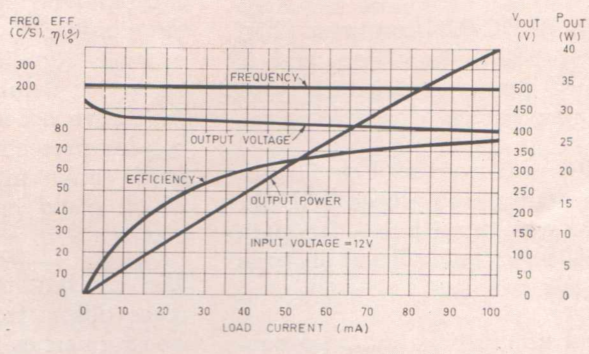
| Components | | Philips Type Numbers |
|---|---|---|
| $Tr_1$, $Tr_2$* | Power transistors | ASZ17 |
| 2 sets of mounting and insulating accessories | | 56201 |
| $D_1$, $D_2$ | Silicon diodes | OA214 |
| $R_1$ | 100 Ω, 10 W, 5%, ww | 83542B/100E |
| $R_2$, $R_3$ | 4.7 Ω, 5.5 W, ww | 83540A/4E7 |
| $R_4$ | 10 Ω, 1.5 W | B8 305 07B/10E |
| $R_5$ | 560 Ω, 1.5 W | B8 305 07B/560E |
| $C_1$ | 100 µF, 16 VW, electrolytic | C426 AM/E100 |
| $C_2$, $C_3$ | 100 µF, 250 VW, electrolytic | — |
| $T_1$ | 19 EI laminations, .020" thick, of Stalloy 130 with 9/16" tongue, interleaved. | |
| $T_2$ | 49 EI laminations, .020" thick, of Stalloy 120 with 7/8" tongue, interleaved. | |

* Each transistor vertically mounted on heat sink of 12 sq. ins. 18 SWG blackened mild steel.
Required tolerance on resistors ± 10%, unless otherwise stated.

### Typical Performance Curves

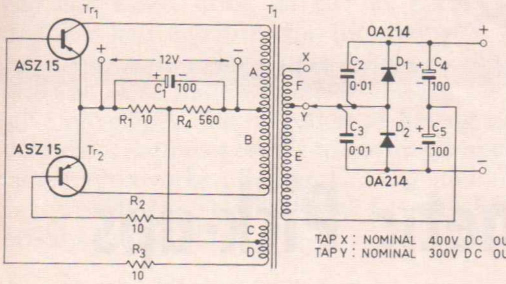



(a) Nominal output voltage 300 V.




(b) Nominal output voltage 400 V.

## Fig. 3. 70 W DC/DC CONVERTER.

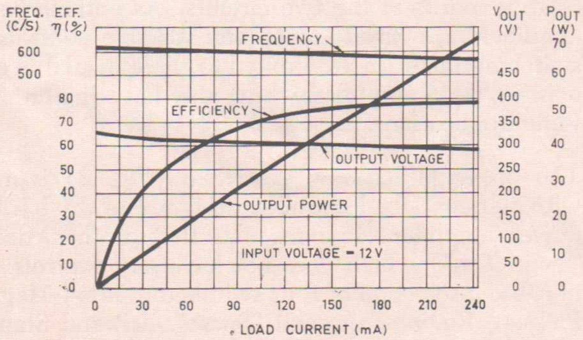



TAP X : NOMINAL 400V DC OUTPUT
TAP Y : NOMINAL 300V DC OUTPUT

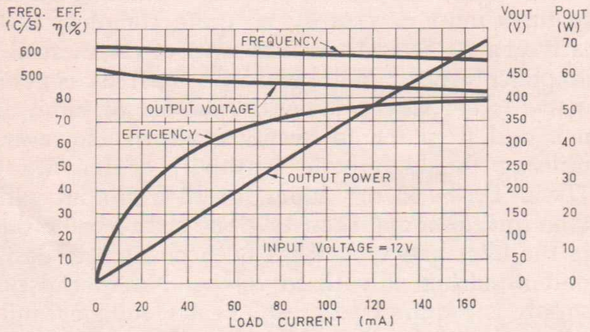
| TRANSFORMER WINDING DETAILS | | |
|---|---|---|
| WINDING | Nº OF TURNS | ENAMELLED COPPER WIRE GAUGE |
| A | 36 | 15 B&S |
| B | 36 | 15 B&S |
| C | 40 | 22 B&S |
| D. | 40 | 22 B&S |
| E | 500 | 25 B&S |
| F | 200 | 25 B&S |

| Components | | Philips Type Numbers |
|---|---|---|
| $Tr_1$, $Tr_2$* | Power transistors | ASZ15 |
| 2 sets of mounting and insulating accessories | | 56201 |
| $D_1$, $D_2$ | Silicon diodes | OA214 |
| $R_1$ | 10 Ω, 10 W, ww | 83542A/10E |
| $R_2$, $R_3$ | 10 Ω, 5.5 W, ww | 83540A/10E |
| $R_4$ | 560 Ω, 3.0 W | B8 305 08B/56OE |
| $C_1$ | 100 μF, 16 VW, electrolytic | C426 AM/E100 |
| $C_2$, $C_3$ | .01 μF, 700 V, polystyrene | C297AC/B10K |
| $C_4$, $C_5$ | 100 μF, 250 VW, electrolytic | — |
| $T_1$ | HCR Alloy Toroid, Telcon type 6D, tape thickness .002″ (dimensions of basic core excluding case, $1\frac{7}{8}$″ OD × $1\frac{1}{4}$″ ID × $\frac{1}{2}$″ depth). | |

* Each transistor vertically mounted on heat sink on 12 sq. ins. 18 SWG blackened mild steel.
Required tolerance on resistors ± 10%.

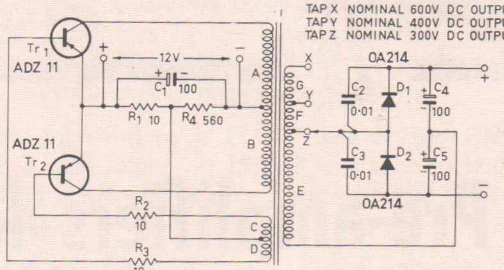



(a) Nominal output voltage 300 V.




(b) Nominal output voltage 400 V.

## Fig. 4. 100 W DC/DC CONVERTER.

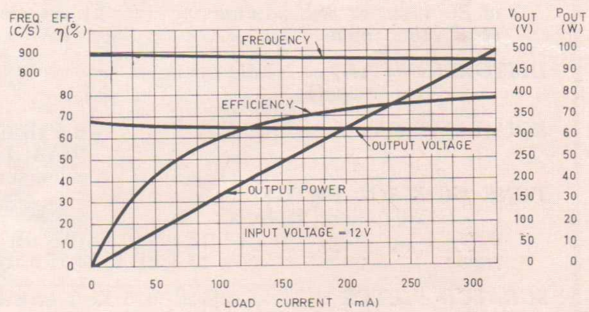



| TRANSFORMER WINDING DETAILS | | |
|---|---|---|
| WINDING | Nº OF TURNS | ENAMELLED COPPER WIRE GAUGE |
| A | 24 | 2×16 B&S |
| B | 24 | 2×16 B&S |
| C | 30 | 22 B&S |
| D | 30 | 22 B&S |
| E | 325 | 25 B&S |
| F | 100 | 25 B&S |
| G | 205 | 25 B&S |

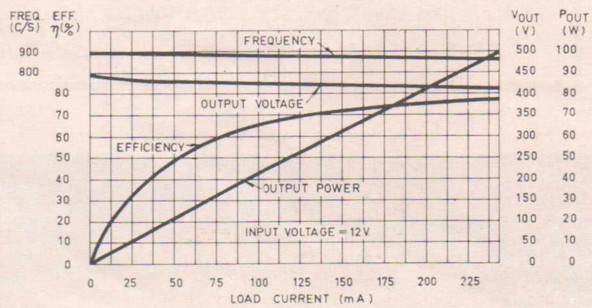
| Components | | Philips Type Numbers |
|---|---|---|
| $Tr_1$, $Tr_2$* | Power transistors (incl. mounting and insulating accessories) | ADZ11 |
| $D_1$, $D_2$ | Silicon diodes | OA214 |
| $R_1$ | 10 Ω, 10 W, ww | 83542A/10E |
| $R_2$, $R_3$ | 10 Ω, 5.5 W, ww | 83540A/10E |
| $R_4$ | 560 Ω, 5.5 W, ww | 83540B/56OE |
| $C_1$ | 100 μF, 16 VW, electrolytic | C426AM/E100 |
| $C_2$, $C_3$ | .01 μF, 700 V, polystyrene | C297AC/B10K† |
| $C_4$, $C_5$ | 100 μF, 350 VW, electrolytic | † |
| $T_1$ | HCR Alloy Toroid Telcon Type 7C, tape thickness .002″ (dimensions of basic core excluding case, $2\frac{1}{4}$″ OD × $1\frac{1}{2}$″ ID × $\frac{1}{2}$″ depth). | |

* Each transistor with $4\frac{1}{4}$″ square heat sink, either blackened 16 SWG copper vertically mounted, or stacked fin (e.g., Ferris Bros. Type 7001).
† These components are specified for a 600 VDC output unit only.

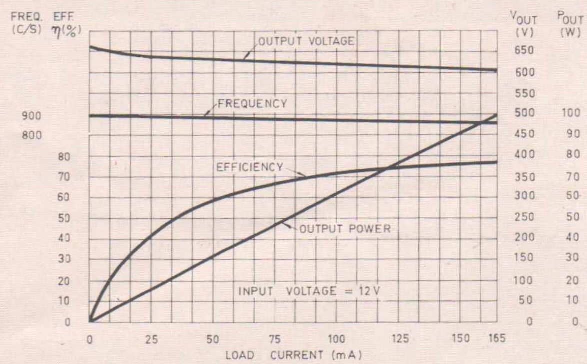
(a) Nominal output voltage 300 V




(b) Nominal output voltage 400 V




(c) Nominal output voltage 600 V



# Pre-amplifiers for Magnetic Pick-ups

## PART 2 — A Comprehensive Control Unit

**In Part 1 of this article[1], the requirements of equaliser pre-amplifiers were discussed and two circuits were described. Part 2 now presents a comprehensive pre-amplifier having extended and self-contained controls, designed specifically to operate a modified version of the Miniwatt "Twin Ten" Amplifier[2] in which the tone controls are omitted.**

### Performance Specifications

| | |
|---|---|
| *SENSITIVITY for 45 mV* output:* | |
| *at PU input in LP position* | 5.0 mV |
| *at PU input in Std. position* | 3.1 mV |
| *at all other inputs* | 50 mV |
| *DISTORTION (THD at 1 Kc/s for rated power output)* | 0.1% |
| *EQUALISATION* | better than ± 1 dB of RIAA LP and Std. characteristic |
| *TONE CONTROL RANGE (at 20 c/s and 20 Kc/s):* | |
| *bass* | + 15 dB to —12.5 dB |
| *treble* | + 15.5 dB to —15.5 dB |
| *SCRATCH FILTER* | roll-off at 5 Kc/s or 8 Kc/s |
| *RUMBLE FILTER* | —3 dB points at 40 c/s or 90 c/s |
| *CURRENT DRAIN* | 8.2 mA at 300 VDC and 0.7 A at 6.3 VAC |

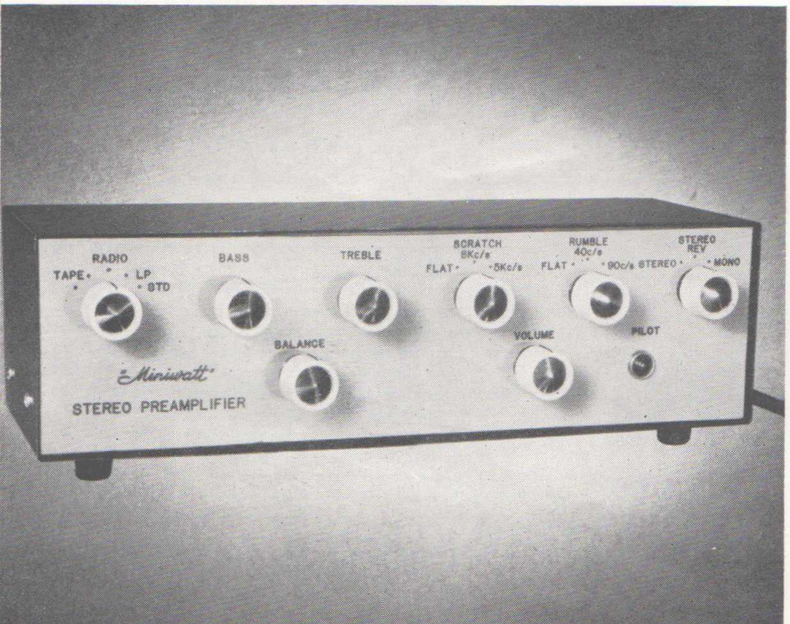
* *Sufficient to drive Miniwatt "Twin-Ten" to full output*

The two simple equaliser pre-amplifiers described in the last issue of the *Digest* were designed to allow the use of a magnetic pick-up with an amplifier originally intended for crystal pick-up input (e.g., the Miniwatt "Twin Ten"[2]). The reasons and requirements for equalising were discussed, together with the relative merits of the two circuits. As both these pre-amplifiers are "fixed" units, any variable controls and switching facilities are limited to those available on an existing main amplifier, which may have limitations in some applications.

The pre-amplifier now described (Fig. 2) is a unit with self-contained controls, designed to drive a basic power amplifier (in particular that of the Miniwatt "Twin Ten") which does not have any controls. The unit has a selection of four switched inputs—Magnetic Pick-up, Radio, Tape and "Spare". LP and Standard (78) RIAA equalising is provided for magnetic pick-up together with bass and treble tone controls, filters for "scratch" and "rumble", stereo-mono switching and a wide range balance control. (See Figs. 3, 4 and 5 for characteristics).

It will be obvious that a unit containing all these features must necessarily be quite complex, particularly in a stereo system. A number of commercial pre-amplifier control units available overseas contain as many as ten valves, a similar number of input channels and from ten to twenty controls. However, by utilising the high basic sensitivity of the Miniwatt "Twin Ten" (45 mV input for 10 W output without tone controls), and accepting one or two compromises in the filter network, it has been possible to design a unit requiring only three valves. No special power supply is required (e.g., DC heater voltage) and the whole unit occupies the relatively small space of 12″ × 3½″ × 4″.

Fig. 1. Complete unit showing controls.



## Circuit Description

The first stage, using an EF 86, operates as a pre-amplifier and equaliser for the magnetic pick-up input. Although a 7025 twin triode would have provided an extra stage without increasing the number of valve envelopes, the objection of having to provide a DC heater supply was felt to outweigh any advantage gained. Networks ($R_5$, $R_6$, $C_4$, $C_6$) and ($R_8$, $R_9$, $C_7$, $C_8$) provide the standard and LP equalising characteristics respectively.

No tape equalising is included as most recorders provide an equalised output for an external amplifier, and the sensitivity of both the tape and radio channels is more than adequate for most applications. (To maintain uniform input levels on all channels, it may sometimes be necessary to provide output attenuation in the radio tuner).

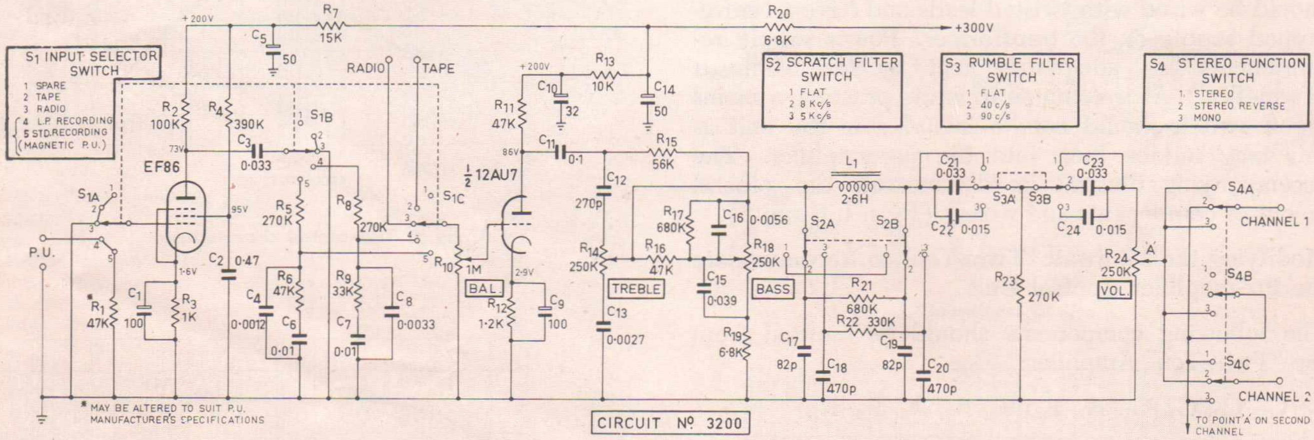
The "spare" position on the input selector may be wired according to individual requirements, providing microphone or crystal PU input, etc.

The balance control is of the conventional type, consisting of log. and antilog. tapered elements in the dual control. Correctly connected these give approximately 1 dB loss in the centre position. Maximum rotation in each direction will produce zero and maximum output for the respective channels.

This is followed by a 12AU7, which drives the tone controls and filters. A 12AU7 was chosen because it provides a low impedance source for the tone-control networks.

Because the filter and tone control networks are not separated by valve stages, it was necessary to effect a satisfactory compromise between several conflicting requirements.

The starting point in design was the "scratch" filter, which is a simple $\pi$-section low-pass network. This filter is designed such that its terminating resistance ($R_{23}//R_{24}$) has a minimum loading effect on the tone control networks. $L_1$ is therefore fairly large (2.6 H) and is realised in a compact unit by using a Philips pot-core assembly type S25/16. $R_{21}$ and $R_{22}$ are




| | |
|---|---|
| $R_{1,\ 101}$ | 47 KΩ, ½ W |
| $R_{2,\ 102}$ | 100 KΩ, ½ W |
| $R_{3,\ 103}$ | 1 KΩ, ½ W |
| $R_{4,\ 104}$ | 390 KΩ, ½ W |
| $R_{5,\ 105}$ | 270 KΩ, ½ W |
| $R_{6,\ 106}$ | 47 KΩ, ½ W |
| $R_7$ | 15 KΩ, 1 W |
| $R_{8,\ 108}$ | 270 KΩ, ½ W |
| $R_{9,\ 109}$ | 33 KΩ, ½ W |
| $R_{10,\ 110}$ | 1 MΩ, log./antilog 2-gang pot. |
| $R_{11,\ 111}$ | 47 KΩ, ½ W |
| $R_{12,\ 112}$ | 1.2 KΩ, ½ W |
| $R_{13,\ 113}$ | 10 KΩ, 1 W |
| $R_{14,\ 114}$ | 250 KΩ, log. 2-gang pot. |
| $R_{15,\ 115}$ | 56 KΩ, ½ W |
| $R_{16,\ 116}$ | 47 KΩ, ½ W |
| $R_{17,\ 117}$ | 680 KΩ, ½ W |
| $R_{18,\ 118}$ | 250 KΩ, log. 2-gang pot. |
| $R_{19,\ 119}$ | 6.8 KΩ, ½ W |
| $R_{20}$ | 6.8 KΩ, 1 W |
| $R_{21,\ 121}$ | 680 KΩ, ½ W |
| $R_{22,\ 122}$ | 330 KΩ, ½ W |
| $R_{23,\ 123}$ | 270 KΩ, ½ W |
| $R_{24,\ 124}$ | 250 KΩ, log. 2-gang pot. |

Resistors used in the prototype were Philips cracked-carbon series B8 305 05 (½ W) and B8 305 06 (1 W), unless otherwise stated. Tolerance required is ± 10%.
Components with 100 added to the subscript are for the second channel.

| | |
|---|---|
| $C_{1,\ 101}$ | 100 μF, 4 VW electrolytic (C425AL/B100) |
| $C_{2,\ 102}$ | .47 μF, 400 V, 10% polyester (C296AC/A470K) |
| $C_{3,\ 103}$ | .033 μF, 400 V, ± 10% polyester (C296AC/A33K) |
| $C_{4,\ 104}$ | .0012 μF, 400 V, ± 10% polyester (C296AC/A1K2) |
| $C_5$ | 50 μF, 300 VW, electrolytic |
| $C_{6,\ 106}$ | .01 μF, 125 V, polyester (C296AA/A10K) |
| $C_{7,\ 107}$ | .01 μF, 125 V polyester (C296AA/A10K) |
| $C_{8,\ 108}$ | .0033 μF, 400 V polyester (C296AC/A3K3) |
| $C_{9,\ 109}$ | 100 μF, 4 VW electrolytic (C425AL/B100) |
| $C_{10}$ | 32 μF, 300 VW electrolytic |
| $C_{11,\ 111}$ | .1 μF, 400 V polyester (C296AC/A100K) |
| $C_{12,\ 112}$ | 270 pF, N150, ± 5% ceramic (C304AC/B270E) |
| $C_{13,\ 113}$ | .0027 μF, 400 V, ± 10% polyester (C296AC/A2K7) |
| $C_{14}$ | 50 μF, 300 VW electrolytic |
| $C_{15,\ 115}$ | .039 μF, 125 V, ± 10% polyester (C296AA/A39K) |
| $C_{16,\ 116}$ | .0056 μF, 400 V, ± 10% polyester (C296AC/A5K6) |
| $C_{17,\ 117}$ | 82 pF, NPO, ± 5% ceramic (C304AB/B82E) |
| $C_{18,\ 118}$ | 470 pF, N750, ± 5% ceramic (C304AH/B470E) |
| $C_{19,\ 119}$ | 82 pF, NPO, ± 5% ceramic (C304AB/B82E) |
| $C_{20,\ 120}$ | 470 pF, N750, ± 5% ceramic (C304AH/B470E) |
| $C_{21,\ 121}$ | .033 μF, 125 V, ± 10% polyester (C296AA/A33K) |
| $C_{22,\ 122}$ | .015 μF, 125 V, ± 10% polyester (C296AA/A15K) |
| $C_{23,\ 123}$ | .033 μF, 125 V, ± 10% polyester (C296AA/A33K) |
| $C_{24,\ 124}$ | .015 μF, 125 V, ± 10% polyester (C296AA/A15K) |

| | |
|---|---|
| $L_{1,\ 101}$ | 2.6 H pre-adjusted pot-core type S25/16—K 300061/3B2, wound with 2500 turns 39 B&S enamel |
| $S_1$ | 3-bank, 5-position, 2-pole wafer switch |
| $S_{2,\ 3}$ | 2-bank, 3-position, 3-pole wafer switches |
| $S_4$ | 1-bank, 3-position, 3-pole, wafer switch |

3 screened valve sockets type 5908/35
10 "Belling-Lee" coax. sockets
1 chassis, housing and front panel (as available from Heating Systems Pty. Ltd., 97 Marriott Street, Redfern, N.S.W.)

**Fig. 2. Circuit details of "Miniwatt" Stereo Pre-amplifier.**

placed in parallel with $L_1$ in the "8 Kc/s" and "5 Kc/s" positions respectively, to assist in maintaining a flat frequency response below the cutoff frequency of the filter. The overall performance of this filter (Fig. 5) is very satisfactory. The tone controls are quite conventional and are of comparatively low impedance, so that the "scratch" filter terminating impedance may be reasonably low without affecting control operation.

Two simple RC sections comprise the "rumble" filter. It has a fairly gradual slope, due partly to the choice of a simple filter and partly to the increased impedance it presents at low frequencies (in its operative positions) at the output of the tone control. Listening tests have shown it to be quite effective. A volume control and stereo function switch complete the unit.

The output impedance is sufficiently low to allow the usual few feet of cable to be taken to the main amplifier without excessive loss in high frequency response.

### Construction

The observations on construction and layout made in the previous issue of the *Digest* apply equally here. It is most important to wire a heavy "bus-bar" around the chassis for all earth connections. The heaters should be wired with twisted leads and have a centre-tapped supply on the transformer. Power supply requirements are adequately met by the Miniwatt "Twin-Ten". As is common in audio practice, a mains on-off switch should not be included in the unit as this may induce hum into the pre-amplifier. The accompanying illustrations demonstrate the general layout of components and wiring (Figs. 1, 6 and 7).

### Modifying the Miniwatt "Twin-Ten" to Accommodate the Pre-amplifier Control Unit

The following components should be omitted from the "Twin-Ten" Amplifier:

$S_1$, $C_1$, $C_2$, $C_3$, $C_4$, $R_1$, $R_2$, $R_3$, $R_4$, $R_5$, $R_6$, $R_7$.

$R_7$ should be replaced with a 1 MΩ ½ W cracked carbon resistor and the control unit connected across this resistor.

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

**References:**

1. J. Clark, Pre-Amplifiers for Magnetic Pick-ups—Part 1, Basic Equalising Unit, *Miniwatt Digest*, Vol. 2, No. 1, p. 11.
2. P. Heins and J. Clark, Miniwatt "Twin-Ten", *Miniwatt Digest*, Vol. 1, No. 3, p. 38.

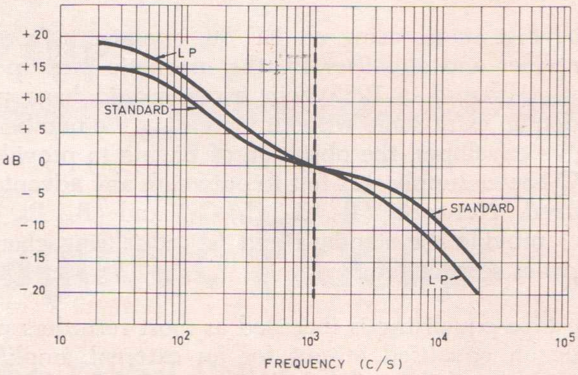



**Fig. 3. Equalising characteristics.**

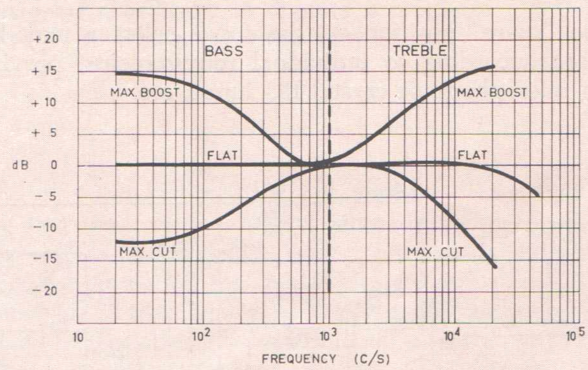



**Fig. 4. Tone-control characteristics.**

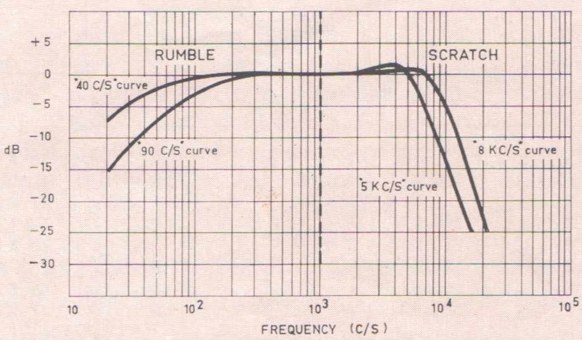



**Fig. 5. Response of "scratch" and "rumble" filters.**

Fig. 6. Top view of chassis (cover removed).

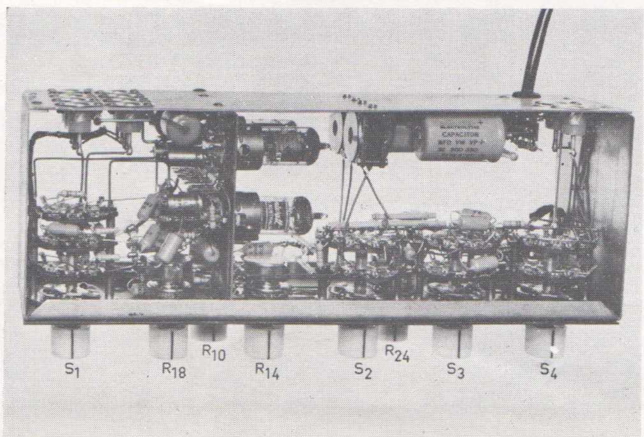
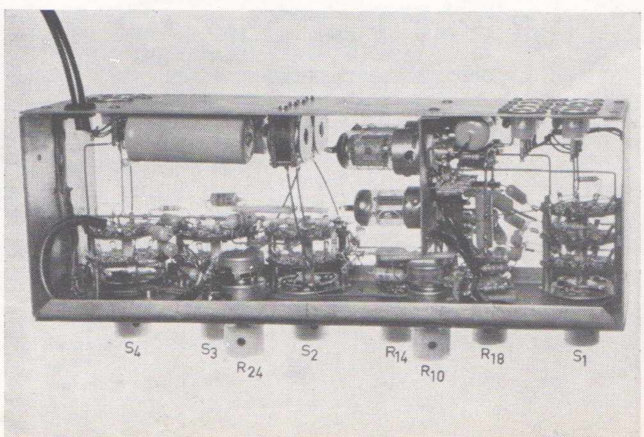



Fig. 7. Underchassis view (cover removed).



# Semiconductors

## "Miniwatt" ADZ11 & ADZ12

## High-Power Transistors for Industrial Applications

**Designed specifically for AF industrial applications, the ADZ11 and ADZ12 are high power transistors with a peak collector current rating of 20 A.**

### MINIWATT ADZ11 and ADZ12 (Abbreviated Data)

**General Data**

Outline .................................................. TO36

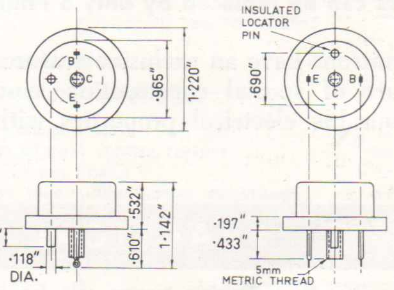
Thermal resistance:
junction to mounting base $K_{j-mb}$ ................. 0.8 °C/W

**Maximum Ratings**
**(Absolute Maximum)**

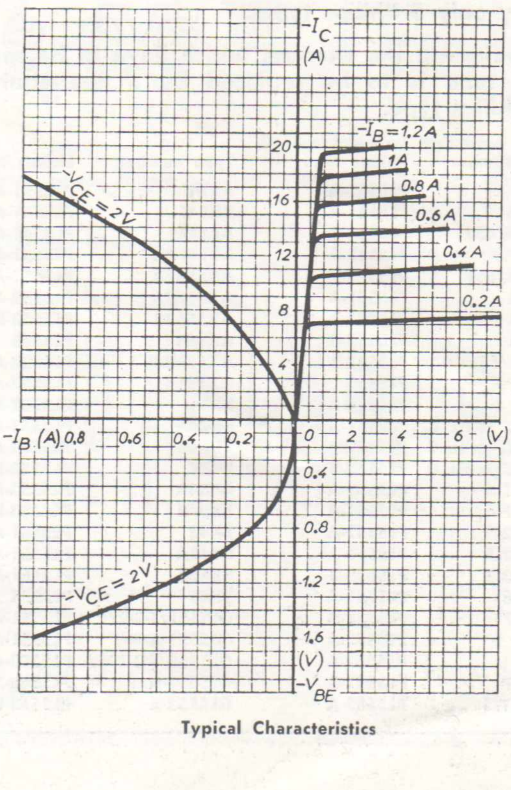
| | | ADZ11 | ADZ12 | |
|---|---|---|---|---|
| Collector-to-base voltage | $-V_{CB}$ | 50 | 80 | V |
| Collector-to-emitter voltage | $-V_{CE}$ | 40 | 60 | V |
| Peak collector current | $-I_{CM}$ | 20 | 20 | A |
| Collector current | $-I_C$ | 15 | 15 | A |
| Emitter-to-base voltage | $-V_{EB}$ | 30 | 50 | A |
| Peak emitter current | $I_{EM}$ | 22 | 22 | A |
| Emitter current | $I_E$ | 17 | 17 | A |
| Peak base current | $-I_{BM}$ | 4 | 4 | A |
| Base current | $-I_B$ | 2 | 2 | A |
| Collector dissipation at $T_{mb} \leq 55°C$ | $P_C$ | 45 | 45 | W |
| Junction temperature | $T_j$ | 90 | 90 | °C |
| Storage temperature | $T_s$ | −55 to +75 | | °C |

**Characteristics** (Range Values for Equipment Design at $T_{mb} = 25°C$)

| | | ADZ11 | ADZ12 | |
|---|---|---|---|---|
| Collector-cutoff current at: | | | | |
| $-V_{CB} = 2$ V, $I_E = 0$ | $-I_{CBO}$ | 0.2 max. | 0.2 max. | mA |
| $-V_{CB} = 50$ V, $I_E = 0$ | $-I_{CBO}$ | 8 max. | — | mA |
| $-V_{CB} = 80$ V, $I_E = 0$ | $-I_{CBO}$ | — | 8 max. | mA |
| Emitter-cutoff current at: | | | | |
| $-V_{EB} = 2$ V, $I_C = 0$ | $-I_{EBO}$ | 0.2 max. | 0.2 max. | mA |
| $-V_{EB} = 30$ V, $I_C = 0$ | $-I_{EBO}$ | 8 max. | — | mA |
| $-V_{EB} = 50$ V, $I_C = 0$ | $-I_{EBO}$ | — | 8 max. | mA |
| Floating potential at: | | | | |
| $-V_{CB} = 50$ V, $I_E = 0$ | $-V_{EB}$ | 1 max. | — | V |
| $-V_{CB} = 80$ V, $I_E = 0$ | $-V_{EB}$ | — | 1 max. | V |
| Collector knee voltage at: | | | | |
| $-I_C = 15$ A, $-I_B = 2$ A | $-V_{CEK}$ | 1 max. | 1 max. | V |
| Base voltage at: | | | | |
| $-V_{CE} = 2$ V, $-I_C = 1.2$ A | $-V_{BE}$ | 0.7 max. | 0.7 max. | V |
| $-V_{CE} = 2$ V, $-I_C = 5$ A | $-V_{BE}$ | 1.2 max. | 1.2 max. | V |
| $-V_{CE} = 2$ V, $-I_C = 15$ A | $-V_{BE}$ | 2 max. | 2 max. | V |
| Common-base cutoff frequency at: | | | | |
| $-V_{CB} = 12$ V, $I_E = 1$ A | $f_{hfb}$ | 80 min. | 100 min. | Kc/s |
| DC current gain at: | | | | |
| $-V_{CE} = 2$ V, $-I_C = 1.2$ A | $h_{FE}$ | 40 min. / 120 max. | 40 min. / 120 max. | |
| $-V_{CE} = 2$ V, $-I_C = 5$ A | $h_{FE}$ | 25 min. | 25 min. | |
| $-V_{CE} = 2$ V, $-I_C = 15$ A | $h_{FE}$ | 15 min. | 15 min. | |




Dimensional Outline




Typical Characteristics

# *Professional Tubes*

## PHILIPS IGNITRONS

### FOR NEW EQUIPMENT OR REPLACEMENT

**Whichever category applies and whatever the application, those contemplating ignitron purchase should consider the special advantages to be gained by a choice of Philips tubes. The most severe and rigid tests are carried out during all phases of manufacture, and finally each tube is subjected to operational tests far in excess of normal requirements.**

**The interchangeability chart below shows that nearly 100 different ignitron types of other manufacturers can be replaced by only 5 Philips types.**

Philips ignitrons have an exclusive feature in that the ignitors are of special construction, combining the most favourable electrical properties with very long life. The thermostatically-controlled versions show marked improvement with respect to water economy and protection against over-heating of tubes and equipment.

Special features of Philips ignitrons are:

- ☐ Thoroughly power tested at maximum load.
- ☐ Absolutely vacuum-tight.
- ☐ Internationally dimensioned thermostat mounting material.
- ☐ Improved ignitor action ("2-fix" contact block) precluding lead-through leakage.
- ☐ 5 Philips ignitrons can fully replace more than 100 types of other makes.

## PRACTICAL INTERCHANGEABILITY LIST

- **Showing that Philips types can be substituted for ignitrons of all important brands in the world. Approximately 100 different types can be replaced by only 5 Philips types.**
- **Indicating the changes which have to be made if a tube is to be replaced by a near-equivalent Philips type.**

| Type number | Philips type | Type number | Philips type |
|---|---|---|---|
| 5551 | PL5551-A | AR14 | PL5551-A |
| 5551-A | PL5551-A | AR14T | PL5551-A [1] |
| 5551-A/652 | PL5551-A | AR14TP | PL5551-A [2] |
| 5552 | PL5552-A | AR14TWS | PL5551-A [3] |
| 5552-A/651 | PL5552-A | AX5551A | PL5551-A |
| 5552-A | PL5552-A | AX5552A | PL5552-A |
| 5553-A | PL5553-B | AX5553B | PL5553-B |
| 5553-B | PL5553-B | AX5555 | PL5555 |
| 5553-B/655 | PL5553-B | AX5822A | PL5822-A |
| 5555 | PL5555 | AX7585 | PL5552-A |
| 5822 | PL5822-A | BK24 | PL5552-A |
| A C E C taille B | PL5551-A | BK24A | PL5552-A [4] |
| A C E C taille C | PL5552-A | BK24B | PL5552-A [1] |
| A C E C taille D | PL5553-B | BK34 | PL5553-B |
| AJ5551 | PL5551-A | BK34A | PL5553-B [4] |
| AJ5551-A | PL5551-A | BK34B | PL5553-B [1] |
| AJ5552 | PL5552-A | BK42 | PL5551-A |
| AJ5552-A | PL5552-A | BK42A | PL5551-A [4] |
| AJ5553-B | PL5553-B | BK42B | PL5551-A [1] |
| AJ6346 | PL5551-A [4] | BK46 | PL5555 |
| AJ6347 | PL5552-A [4] | GL5551/FG-271 | PL5551-A |
| AR10 | PL5552-A | GL5551-A | PL5551-A |
| AR10T | PL5552-A [1] | GL5552/FG-235A | PL5552-A |
| AR10TP | PL5552-A [2] | GL5552-A | PL5552-A |
| AR10TWS | PL5552-A [3] | GL5553-A | PL5553-B |

| Type number | Philips type | Type number | Philips type |
|---|---|---|---|
| GL5553-B | PL5553-B | TH7021 | PL5551-A [5] |
| GL5555/FG238B | PL5555 | TH7030 | PL5552-A |
| GL5555 | PL5555 | TH7031 | PL5552-A [5] |
| GL5822-A | PL5822-A | TH7040 | PL5553-B |
| GL6346 | PL5551-A [4] | TH7041 | PL5553-B [5] |
| GL6347 | PL5552-A [4] | VJ5551-A | PL5551-A |
| GL6348 | PL5553-B [4] | VJ5552-A | PL5552-A |
| GL6511 | PL5822-A [4] | VJ5553-B | PL5553-B |
| NL1022-A | PL5822-A | WL5551 | PL5551-A |
| NL1051-A | PL5551-A | WL5551/652 | PL5551-A |
| NL1052-A | PL5552-A | WL5551-A | PL5551-A |
| NL1053-A | PL5553-B | WL5551-A/652 | PL5551-A |
| NL5551 | PL5551-A | WL5552 | PL5552-A |
| NL5552 | PL5552-A | WL5552/651 | PL5552-A |
| NL5553 | PL5553-B | WL5552-A | PL5552-A |
| PL2052-A | PL5552-A | WL5552-A/652 | PL5552-A |
| SBS | PL5551-A | WL5553 | PL5553-B |
| SCS | PL5552-A | WL5553-B | PL5553-B |
| SCS3 | PL5822-A | WL5553-B/655 | PL5553-B |
| SDR | PL5555 | WL5555 | PL5555 |
| SDS | PL5553-B | WL5555/653-B | PL5555 |
| TH7020 | PL5551-A | WL5822-A | PL5822-A |

[1] DIRECT equivalent, provided that internationally dimensioned thermostat mounting material is used.

[2] DIRECT equivalent, provided that internationally dimensioned thermostat mounting material and protective thermostat no. 55306 is used.

[3] DIRECT equivalent, provided that internationally dimensioned thermostat mounting material and water-saving thermostat 55305 is used.

[4] DIRECT equivalent, provided that internationally dimensioned thermostat material is used and all the tubes in the same equipment are replaced.

[5] DIRECT equivalent, provided waterflow switch and thermostat material are replaced.

### Two Basic Types

Ignitrons are of two basic types—those designed for high peak anode currents at comparatively low voltages of the order of (250 to 600)V, and those designed to deliver high average currents at high anode voltages up to 2400 V. The former are for "AC control" (resistance welding equipment, furnace control, etc.), whilst the latter are intended for industrial rectifier service where continuous control of the output power can be obtained by phased-back operation.

Basic considerations in the application of ignitrons to the field of resistance welding have been set out by Ciancaglini[1], who has dealt with all facets including sequence control. Summarised welding control application data is given in Table 1. However, the complete published data should be consulted for conditions other than those stated here.

Rectifier service includes use in power supplies for rolling mills, conveyer belt installations and electric locomotives, etc. However, as the conditions imposed on a tube for power rectification are usually much more severe than those for a tube connected in inverse-parallel (the normal connection in resistance welding), a tube of special construction has normally to be utilised. Philips PL5555 ignitron has been specially designed for such purposes. Two PL5555's connected in inverse-parallel can also be used in welding equipment. Similarly, it is possible for welding control ignitrons to be used for rectification provided that the ratings are observed.

### Excitation Schemes

Two systems of excitation are commonly used:

(a) Anode excitation (resistance welding and similar applications).

(b) Separate excitation (rectifier and certain AC control applications).

## Table 1—AC WELDER CONTROL SERVICE

**Two Tubes Connected in Inverse-parallel**
**(Frequency range: 25-60 c/s)**

| Type | Mains Voltage ($V_{rms}$) | Demand Power (kVA) | Average Current (A) | Current Demand ($A_{rms}$) | Duty Cycle (%) | Maximum aver. time (sec) | Max. fault current (0.15 sec) (A) |
|---|---|---|---|---|---|---|---|
| PL 5551A | 220 | 530<br>180 | 30.2<br>56 | 2400<br>800<br>125 | 2.8<br>15.6<br>100 | 18 | 6720 |
| | 250 | 600<br>200 | 30.2<br>56 | 2400<br>800<br>125 | 2.8<br>15.6<br>100 | 18 | 6720 |
| | 380 | 600<br>200 | 30.2<br>56 | 1580<br>527<br>125 | 4.3<br>23.7<br>100 | 11.8 | 4400 |
| | 600 | 600<br>200 | 30.2<br>56 | 1000<br>333<br>125 | 6.7<br>37.5<br>100 | 7.5 | 2800 |
| PL 5552A | 220 | 1060<br>350 | 75.6<br>140 | 4800<br>1600<br>311 | 3.5<br>19.5<br>100 | 14 | 13400 |
| | 250 | 1200<br>400 | 75.6<br>140 | 4800<br>1600<br>311 | 3.5<br>19.5<br>100 | 14 | 13400 |
| | 380 | 1200<br>400 | 75.6<br>140 | 3160<br>1050<br>311 | 5.3<br>29.6<br>100 | 9.4 | 8800 |
| | 600 | 1200<br>400 | 75.6<br>140 | 2000<br>667<br>311 | 8.4<br>46.7<br>100 | 5.8 | 5600 |
| PL 5553B | 220 | 2120<br>705 | 192<br>355 | 9600<br>3200<br>790 | 4.4<br>24.7<br>100 | 11 | 27000 |
| | 250 | 2400<br>800 | 192<br>355 | 9600<br>3200<br>790 | 4.4<br>24.7<br>100 | 11 | 27000 |
| | 380 | 2400<br>800 | 192<br>355 | 630<br>2100<br>790 | 6.7<br>37.5<br>100 | 7.3 | 17800 |
| | 600 | 2400<br>800 | 192<br>355 | 4000<br>1330<br>790 | 10.6<br>59.3<br>100 | 4.6 | 11200 |

## IGNITOR RATINGS AND CIRCUITS

### Ignitor maxima

| | | |
|---|---|---|
| max. positive ignitor peak voltage | = | max. pos. anode voltage |
| max. negative ignitor peak voltage | = | 5 V |
| max. peak forward current | = | 100 A |
| max. RMS current | = | 10 A (15 A for PL5555) |
| max. average current ($T_{av}$ 5 sec*) | = | 1 A ( 2 A for PL5555) |

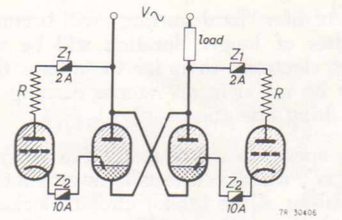
* $T_{av}$ = 10 sec. for PL5555

### Anode excitation

a. Ignitor characteristics

| | | |
|---|---|---|
| peak firing voltage (max.) | = | 200 V |
| typical value of peak ignitor current | = | 6 to 8 A |
| peak firing current (max.) | = | 12 A |
| max. ignition time (under above conditions) | = | 100 μsec |

b. Ignition circuit requirements




Recommended value of R

| Mains Voltage | R |
|---|---|
| 220 $V_{rms}$ | 2 Ω |
| 250 $V_{rms}$ | 2 Ω |
| 380 $V_{rms}$ | 4 Ω |
| 500 $V_{rms}$ | 5 Ω |
| 600 $V_{rms}$ | 6 Ω |

Fig. 1 ● **recommended thyratron: PL 5684**

peak ignitor voltage required to fire = min. 200 V

peak ignitor current required to fire:

| | | |
|---|---|---|
| PL 5551A | = min. | 12 A |
| PL 5552A | = min. | 12 A |
| PL 5822A | = min. | 25 A |
| PL 5553B | = min. | 30 A |

### Separate excitation

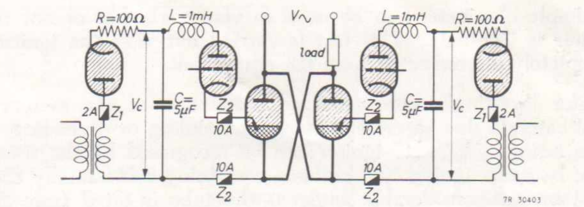



Fig. 2

| | | |
|---|---|---|
| ● **recommended thyratron** | : | **PL 106** |
| ● **recommended rectifier tube** | : | **DCG4/1000** |
| ohmic resistance of series inductance (1 mH) | : | max. 2 Ω |
| $V_c$ under operating conditions | = | 650 ± 50 V |
| peak value of closed-circuit current | = | 40 to 50 A |

These schemes are presented in Figs. 1 and 2 respectively: relevant data for both excitation schemes appear in the tabulations accompanying these figures. The ignitor maxima have been included for all five ignitron types.

With separate excitation, ignition of the ignitron is independent of the anode circuit parameters. This system is therefore suitable for rectifiers and for AC control circuits in which the available mains voltage at the desired ignition angle is, or may be below, the required minimum value for proper excitation. This system is also applicable for low mains voltage. The minimum anode voltage at which the tube will fire with separate excitation is about 30 to 40 V provided that the current through the ignitron is higher than approximately 10 A.

**Ratings**

In selecting an ignitron for a particular installation it is important that the tube be operated within its published ratings, *which are Absolute Maximum.* Thus care should be exercised to ensure that these ratings are not exceeded *under the most unfavourable conditions.* That is, the total effect of spread in transformer and components, and mains voltage fluctuations must be taken into account.

The ratings of ignitrons for AC control involve a considerable number of factors. To both clarify the terms used and to ensure that full advantage be taken of the devices without risk of damage to either them or the equipment, reference is given to a comprehensive treatment[2].

Two important considerations are the temperature and rate of flow of the cooling water, for these not only determine the amount of power which can be dissipated, but also the mercury vapour pressure within the tube. Moreover, high current peaks cause a rapid rise of vapour pressure within the tube. Thus cooling must be adequate to safeguard against arc-back or loss of control (the mercury vapour pressure is roughly doubled for each 10°C rise in temperature).

**When to consider replacement**

Generally, towards the end of life, "hard-starting" will become evident (larger current pulses of longer duration will be required through the igniting electrode in order to initiate the main discharge). This may be noted in an intense flashing of the thyratrons during each firing operation.

Failure or faulty or sporadic operation is frequently due to ignitor failure, air leakage or "gas", which can usually be attributed to inadequate water flow, failure of the ignitor circuit blocking rectifiers, or operation outside the ratings. When replacing a faulty ignitron it is advisable to check the rectifiers in the ignitor circuit.

The proper functioning of an ignitron can be checked using a number of standard tests as outlined below. It is emphasied that due safety precautions be exercised throughout testing.

***Ignitor Tests***

A simple ohmmeter can be used to verify whether or not the ignitor is "wetted". This test is carried out with the ignitron completely disconnected from the equipment.

Ignitor "wetting" arises from contamination of the mercury-pool cathode due to either inadequate cooling or exceeding of tube ratings. A "wet" ignitor can be recognised by the resistance between ignitor and cathode remaining substantially constant over a considerable angle as the tube is tilted from the vertical.

A burnt ignitor will result in sporadic firing or complete failure. This can be checked best by using a dynamic resistance test (employing CRO technique) with the ignitron cathode grounded, but with the firing circuit operating. The cold resistance in a good tube is usually between (10 to 150) Ω, but may be as low as approximately 5 Ω or as high as 500 Ω.

***Vacuum Tests***

Simple preliminary tests employing a low-frequency spark coil can be used to check for air leakage and "gas". Both of these frequently result in arc-back which is usually accompanied by severe flashing, or showers of sparks visible through the anode seal. The tube should be cool before testing.

If a tube has passed the spark coil test it is not necessarily satisfactory, and a standard HV test should then be applied after the tube has been out of service for at least one week. A voltage of approximately 10 KV rms should be applied between cathode and anode, a series resistor being included to limit the current from 5 to 10 mA. If the tube passes current for more than one minute, "gas clean-up" may be attempted by operating the tube carefully under reduced load. If on repetition of the HV test the tube again passes current, it should be replaced.

**Operational Aspects**

The following is centred around (and expands on) the information contained in the booklet which accompanies each Philips ignitron purchase. This enumerates directions for stand-by procedures, mounting details, placing in service, checks during operation and switching off procedure. These directions should be rigidly observed and, where any doubt exists, the Miniwatt Division can be contacted.

The booklet includes diagrams illustrating water-cooling arrangements. These incorporate both an adjustable valve and a solenoid valve together with a pair of thermostats and a shorting switch. The solenoid valve is actuated by means of a water-saving thermostat (type 55305) which in turn can be shorted out by the switch. The second thermostat (type 55306) operates only when the cooling water temperature becomes excessive, and then acts to interrupt the ignitron circuits or to remove power from the installation.

The purpose of the 55305 is to open the solenoid valve when the water temperature within the tube jacket reaches a certain magnitude and to close it when the tube becomes sufficiently cool. This results in a considerably reduced water consumption and further, eliminates the risk of condensation on the tubes under conditions of high humidity.

The purpose of the shorting switch is to enable the tube jackets to be filled initially and to enable periodical checkes to be made on the solenoid valve operation. Further, when large powers are being switched at high duty cycle, the thermostat reaction time may be too slow, in which case this switch can be operated in conjunction with the pedal switch in order to obtain water circulation. A further refinement is to incorporate a time-delay relay to minimise solenoid switching when the number of welds per hour becomes high.

Specific points which should be satisfied in a cooling system are:

(a) no greater than three tubes to be cooled in series.
(b) the cooling installation should be such that the water jackets are not emptied when the solenoid valve is closed.
(c) water pressure in tube jackets should never exceed 45 psi.
(d) when no thermostat can be mounted (namely for the PL5555) a water-flow switch should be set up at the end of the water circulation system.
(e) consult the Miniwatt Division if in doubt as to suitability of available cooling water.

In considering the mounting of thermostats it must be realised that in general the water jackets are at mains potential.

**References:**


1. H. Ciancaglini, The Application of Electronics in Spot and Seam Welding, *Electronic Appl. Bulletin*, Vol. 14, No. 12, Dec. 1953, pp. 177-92.
2. P. van der Ploeg, Ratings of Ignitron Tubes for AC Control, *Electronic Appl. Bulletin*, Vol. 15, No. 11, Nov. 1954, pp. 153-66.

# APPLICATION OF PHILIPS CIRCUIT BLOCKS in Ring Counters and Shift Registers

**Ring Counters and Shift Registers, with their associated driving circuits, are further applications[1] showing how Philips Circuit Blocks can be utilised to perform logical functions encountered in digital computer and industrial control applications.**

## RING COUNTER

A ring counter comprises a number of bistable stages in which the last stage is connected to the first stage. On the application of successive input pulses, a specified state ("1" or "0") moves progressively around the loop. General pulse counting, frequency division and pulse sequencing are typical uses.

An example of a ring counter with decimal decoding is now described, which has an input frequency range of 0-100 Kc/s. Reference to Fig. 1 shows the basic ring counter using five FF2 bistable mutivibrator Blocks which individually operate at one tenth of the applied input frequency. It should be noted that the inter-

TABLE 1. OPERATION OF RING COUNTER

| Input Pulse Number | State of Flip-Flops | | | | |
|---|---|---|---|---|---|
| | f1 | f2 | f3 | f4 | f5 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1 | 0 | 0 | 0 |
| 3 | 1 | 1 | 1 | 0 | 0 |
| 4 | 1 | 1 | 1 | 1 | 0 |
| 5 | 1 | 1 | 1 | 1 | 1 |
| 6 | 0 | 1 | 1 | 1 | 1 |
| 7 | 0 | 0 | 1 | 1 | 1 |
| 8 | 0 | 0 | 0 | 1 | 1 |
| 9 | 0 | 0 | 0 | 0 | 1 |
| 10 | 0 | 0 | 0 | 0 | 0 |

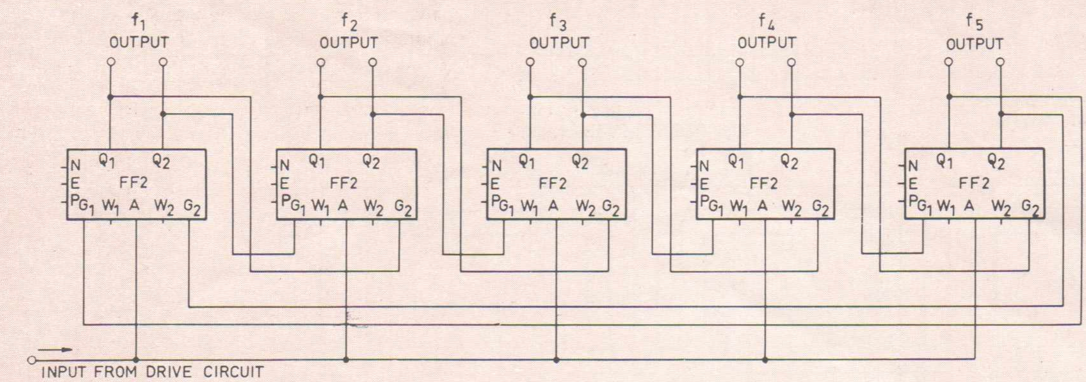



**Fig. 1. Basic Ring Counter**

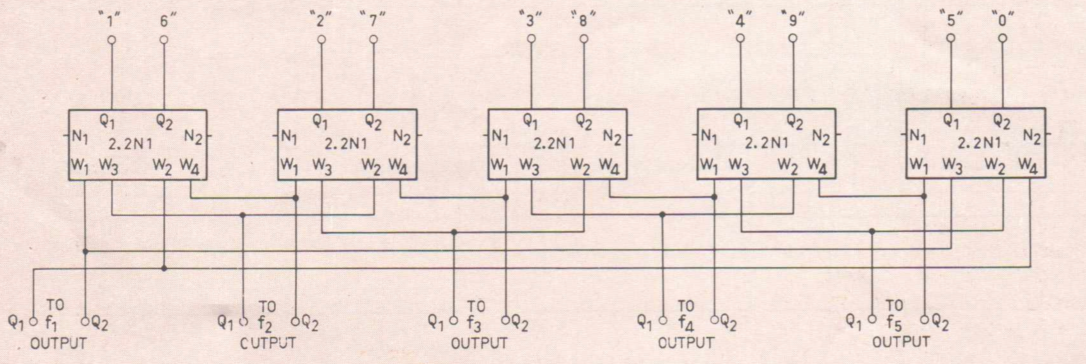



**Fig. 2. Decoding gates for Decimal Output (the loadability of the gates is as indicated in the data sheets and loading table available on application).**

connections between the FF2 Blocks are made crosswise ($Q_1$ to $G_2$ and $Q_2$ to $G_1$) except for the connections between the first and last units. The manner in which this counter works is illustrated in Table 1, which shows how the binary information changes from the initial reset condition. The designations "0" and "1" refer to the right-hand ($Q_2$) outputs of the FF2 Blocks. "0" is taken as being 0 V—that is, transistor fully conducting; and "1" is greater than 3.8 V negative, that is, transistor in non-conducting state. It can be seen that ten different conditions occur, which can be decoded to suit decimal output by using two inputs for each gate. The decoding circuit is shown in Fig. 2.

## SHIFT REGISTERS

Shift registers are used in digital pulse applications for storing coded information. The shift registers described (Figs. 3 and 4) can convert coded information, presented to the input in serial form, into a parallel code which is stored by means of the FF2 bistable multivibrator Blocks. The output can be decoded by means of gates attached to the $Q_1$, $Q_2$ terminals.

The binary information is applied serially to the input terminals of Fig. 3 from either an FF1 or FF2 Block (the FF1 Block is recommended where a single input line is used). This information is shifted bit after bit into the register by means of a shift pulse applied (from the drive circuit) in between each pulse applied to the input. After each new shift pulse, the contents of the register are moved one position to the right until all the information is stored. The outputs of the last FF2 Block can be connected crosswise to the gate inputs of the first FF2 ($Q_1$ to $G_2$ and $Q_2$ to $G_1$), and in this case any information stored in the register will now circulate through it by means of the shift pulses.

### Bi-directional Shift Register

The circuit in Fig. 3 can be easily converted into a bi-directional shift register (Fig. 4) by adding additional input gates as incorporated in the Blocks type 2.PL1. The information in the register can be shifted in either direction dependent on the input to which the shift is applied.

A *bi-directional decimal counter* could also be made by modifying Fig. 4 so that the input and output are interconnected according to the ring counter arrangement shown in Fig. 1.

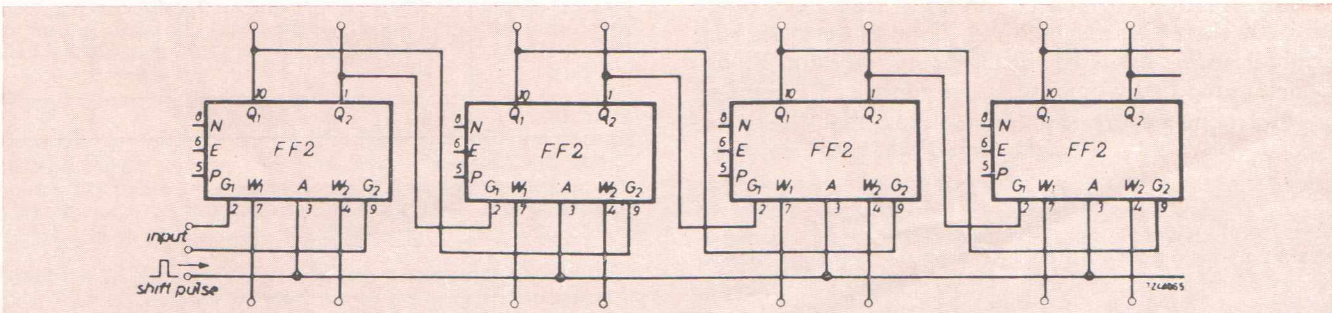



Fig. 3. Shift Register.

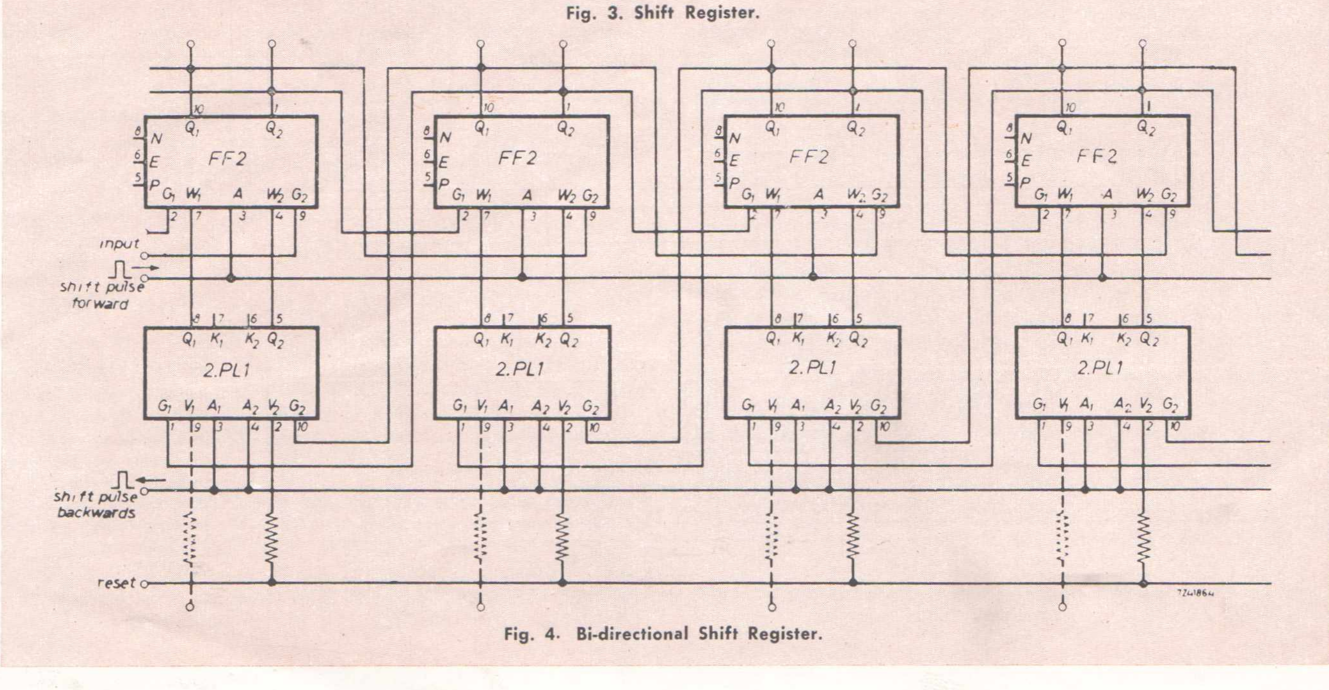



Fig. 4. Bi-directional Shift Register.

## DRIVE CIRCUITS FOR RING COUNTERS AND SHIFT REGISTERS

The circuits shown in Figs. 5, 6 and 7 can be used with the circuits of Figs. 1, 3 and 4 to supply the drive or shift pulses for the required number of FF2 blocks.

## RESET CIRCUITS

The reset circuits for all Circuit Block configurations have been published previously[1] and can be applied to the appropriate $W_1$ or $W_2$ terminals as required.

In the case of the bi-directional shift register, the diodes incorporated in the 2.PL1 Blocks (inputs $V_1$ and $V_2$) can be used for negative set or reset signals to clear the store.

***Further Information***

*The "Miniwatt" Electronic Applications Laboratory will be pleased to advise on Circuit Block combinations to suit particular requirements. An announcement will be made in the* Digest *in the near future concerning additional types and any information regarding the operating characteristics of the entire range of Circuit Blocks is available on request.*

**References:**


1. A. C. Denne and N. A. Steadson, Applications of Philips Circuit Blocks, *Miniwatt Digest*, Vol. 1, No. 12, 1962.

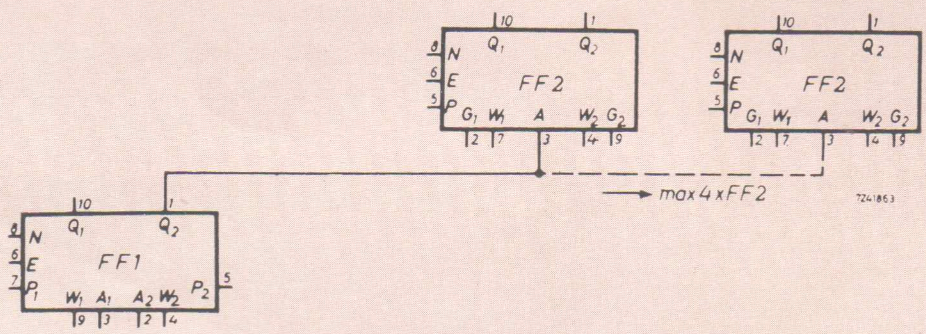




**Fig. 5.**

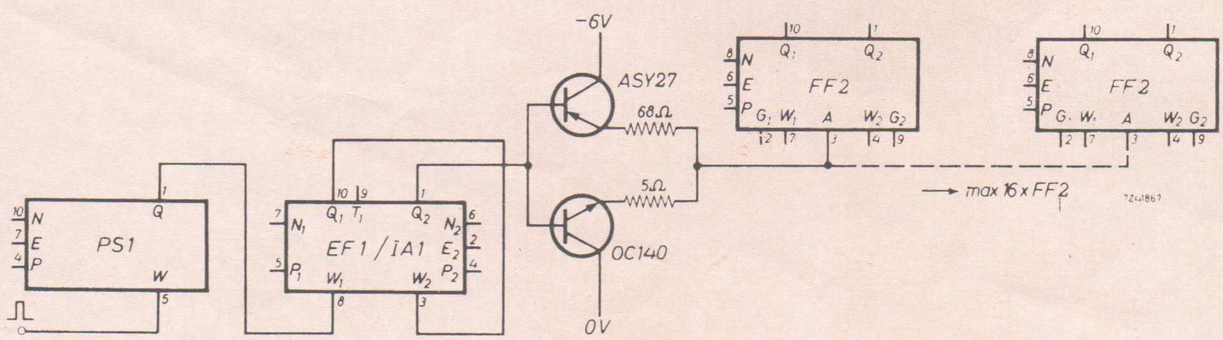



**Fig. 6.**

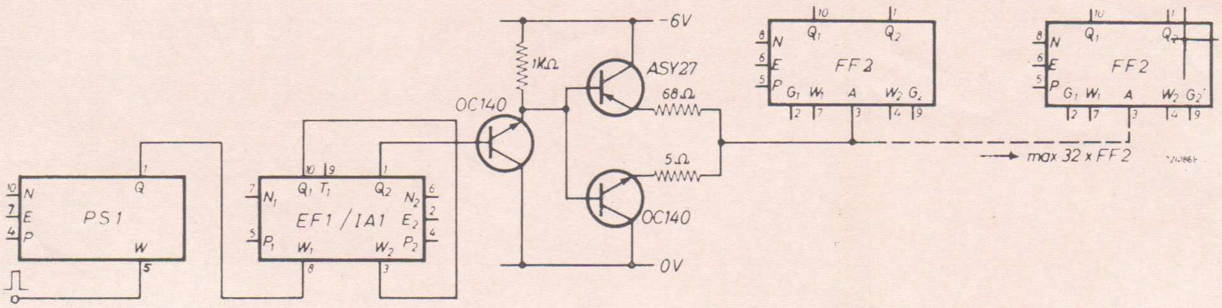



**Fig. 7.**

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