

"Miniwatt"

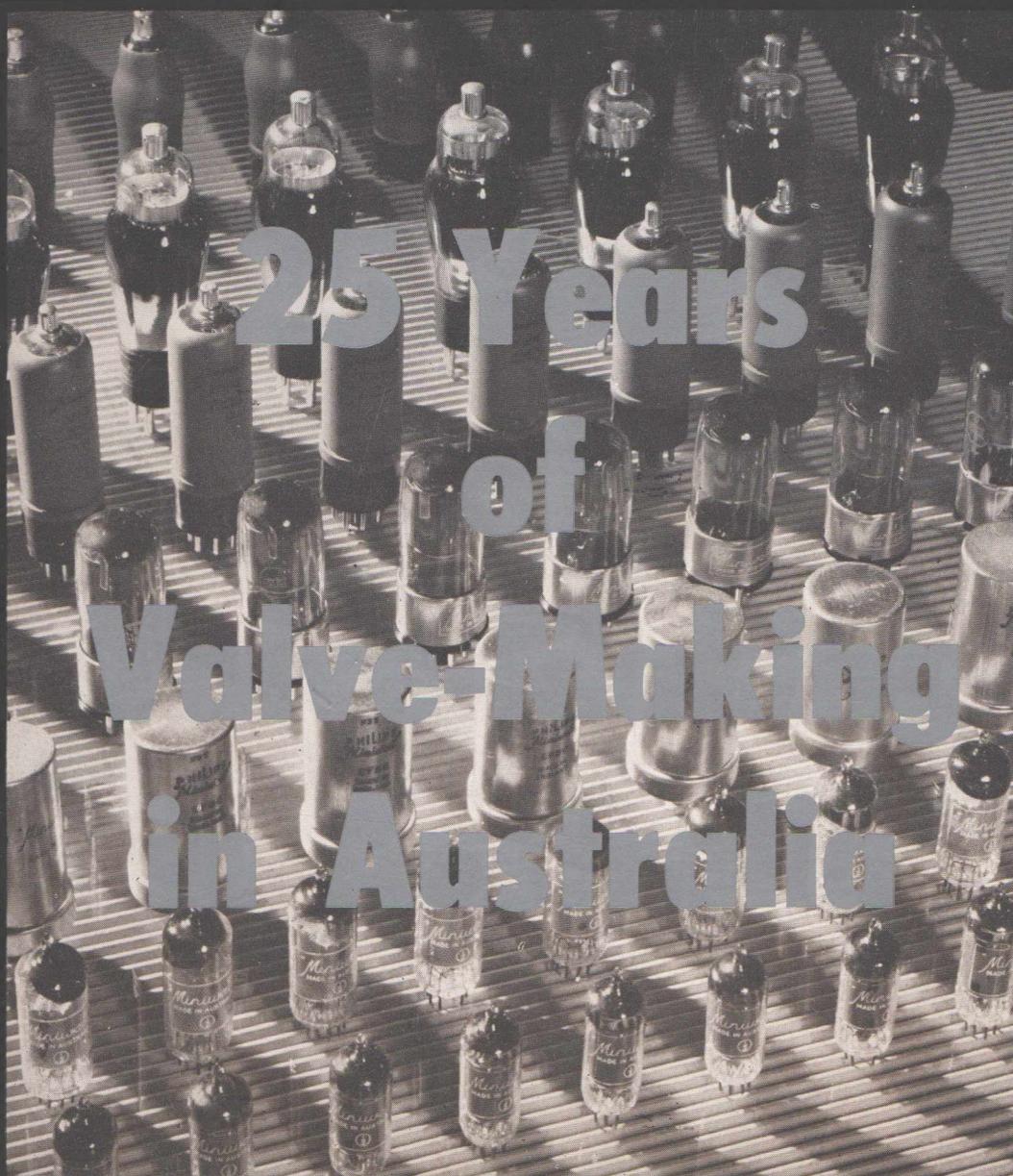
DIGEST

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TECHNICAL AND COMMERCIAL TOPICS OF
CURRENT INTEREST TO THE ELECTRONICS INDUSTRY

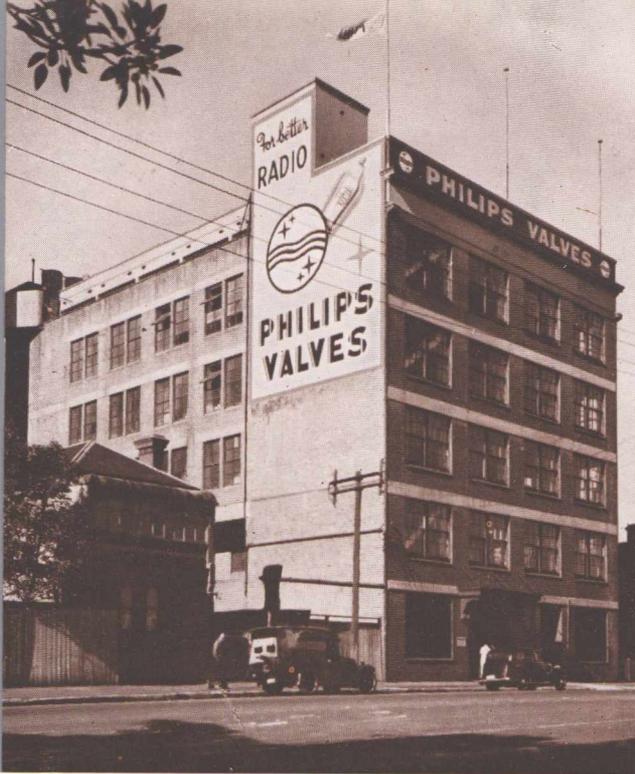
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Australia.

25 years



Camperdown — 1937



March 1937 saw the commencement of the production of Philips Miniwatt receiving valves in Australia. From a very modest production rate and an extremely restricted type range at the start, in the ensuing 25 years this enterprise has expanded to the extent that over 40 million valves have been manufactured in more than 130 individual types, ranging from large water-cooled transmitting valves to miniature all-glass receiving valves.

Our first Valve Factory was located at Camperdown, New South Wales, but in 1946, with the consolidation of Philips manufacturing activities, was transferred to Adelaide, South Australia.

Throughout the years, many changes have been made; new basic valve constructions have been introduced, new production techniques adopted, all designed to meet the increasingly more stringent demands created by the expansion of electronics into many new fields. During the War years, transmitting and industrial valves essential to the Nation's Defence Effort were added to the then already expanded range of receiving valves. More recently, with the introduction of television, a modern Picture Tube Manufacturing Plant was established.

Miniwatt receiving valves were the first of what has become a wide range of Australian made products merchandised by the Miniwatt Electronics Division of Philips. Today, side by side with receiving valves, manufacturing activities provide an impressive range of types of picture tubes, semiconductor devices, radio and television components, and fine copper wire, all manufactured under ideal conditions in the most modern of plants at Philips Hendon Production Centre.

Today, Miniwatt is a major supplier of these items, and takes pride in celebrating 25 years of achievement and service to the Australian Electronics Industry.

of valve manufacture in Australia



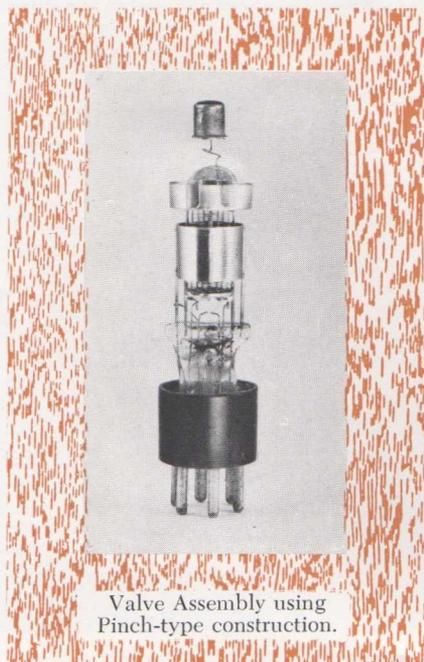
Hendon — 1962

25 Years of Valve Development in Australia

The evolution of the receiving valve to its present stage of development is the result of unceasing efforts by scientists, physicists and engineers during the last 60 years. Fleming's diode of 1904 made use of the phenomenon of electron emission observed by Edison in his lamp experiments towards the end of the nineteenth century. De Forest added a grid to the diode in 1906 to provide control of electron flow, thus creating the first prototype for the modern receiving valve. Until the mid 1920's, valves were virtually hand-made, and their construction and the manufacturing procedures adopted bore a great resemblance to those of the lamps from which they had sprung. Mass-production of valves followed closely on the establishment of a broadcasting service.

Pinch-type Valves

The first mass-produced valves retained the lamp's pinch-type construction, so called because of the pinching of the glass at the top of the centre stem to obtain a vacuum-tight seal around the connecting leads. This basic construction was used in the first Miniwatt



Valve Assembly using Pinch-type construction.

receiving valves manufactured in Australia in 1937, and many millions of pinch-type valves have been made since. At various times, constructional variations, such as changes in bulb size and shape, the use of the P-type side-contact bases and later octal bases, were made. These culminated in the single-ended GT construction—a parallel-sided bulb in which an overall reduction in valve height was achieved by using an extremely short stem for the pinch structure, and the bulb was seated within the base instead of on top of it.

Except for replacement purposes, the pinch-type construction is no longer used for valve production today. Indeed, the limitations it imposed on valve characteristics and manufacturing techniques were recognised early in its use, but at that time no satisfactory alternative construction had been developed.

Development of All-glass Construction

The development of high definition TV and the first serious experiments in VHF communications in the late 1930's again highlighted the need for the elimination of the pinch. The idealised type of construction then sought was one which would:

- (a) provide improved product quality with characteristic variations reduced to a minimum;
- (b) give improved performance in VHF and UHF applications;
- (c) be single-ended in construction and without a loss-producing base;
- (d) have reduced connecting-lead lengths to minimise lead inductance;
- (e) have increased spacing between lead wires, with low operating temperature in the region of the vacuum seals;
- (f) have a multi-planar support system, to reduce microphony;

- (g) have small dimensions and be of a standard construction suited to a very large variety of valve types.

Throughout the world, many attempts were made to solve this problem, but none was really successful until the introduction of the Philips "All-glass" construction, although even this construction was physically rather large.



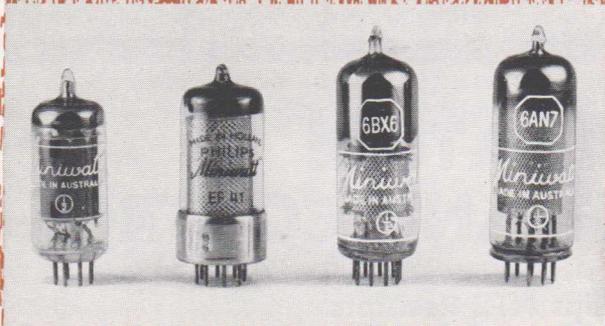
EF50 with can removed showing All-Glass construction

EF50 made in Australia

The all-glass construction was used initially for the valve type EF50 which, introduced first for TV, proved indispensable in the development of Radar and was subsequently made in Australia during the War Years. The EF50 so clearly established the superiority of the all-glass type of construction that all subsequent receiving valve development has been concentrated on retaining its advantages, but with a reduction in physical size.

Miniature All-glass Construction

In America, the 7-pin Miniature all-glass construction was developed, and first used in a range of battery-operated receiving valves. Many technological problems had to be solved before this construction reached the quality level that it enjoys today.



Valves having All-glass construction (left to right):
7-pin Miniature, Rimlock, Noval and Innoval.

In Europe, the problem was approached in a different manner in that not only was a reduction in physical size sought, but an attempt was made to eliminate production techniques that had deleterious effects on valve quality. These primarily resulted from the high temperature fusion of the glass base and bulb during the sealing operation. In the Miniature all-glass construction, not only had the effects of the products of combustion on the electrode structure to be tolerated, but also very soft base pins had to be used to prevent glass distortion and strain.

The European solution to these problems involved a technique wherein the bulb was joined to a moulded glass base fitted with rigid base pins by the use of a low-temperature glaze seal. This construction was employed in the "Rimlock" series, a small number of which were made in Australia for study purposes.

Innoval—An Australian Development

Contemporary American development at that time produced the all-glass Noval series, which were similar to the 7-pin Miniature series except for the slightly larger bulb diameter and the nine base-pin connections. One disadvantage of the European "Rimlock" series was the fact that the base incorporated eight equally spaced pins, requiring a base locating device and a fairly expensive socket. Both the American 7-pin Miniature and

the 9-pin Noval constructions employed uneven base-pin spacing, providing self-location with correspondingly cheaper sockets.

In Australia, the advantage of the 9-pin Noval base and the manufacturing techniques of the European "Rimlock" construction were combined to produce the now well-known "Innoval" series of valves introduced to this market in 1949. There is no doubt that, at that time, the Innoval construction offered the closest approach to the ideal valve construction then devised, and it is only in recent years that changes in production techniques and internal structures have improved the quality of the valves made in the 7-pin Miniature and 9-pin Noval techniques to a standard comparable with that first produced in the Innoval construction. At the present stage of development, these constructions are all utilised for the production of Miniwatt receiving valves at Hendon, South Australia.

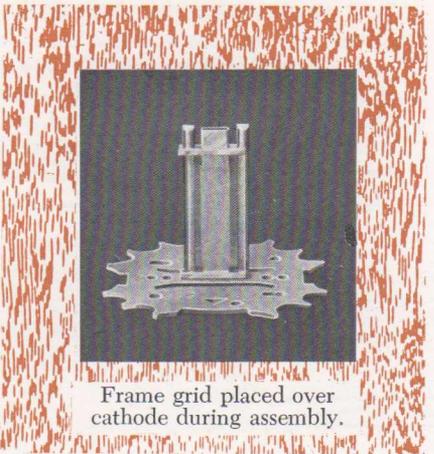
The Frame Grid

The Miniwatt range has always been recognised as providing valves with characteristics superior to those of its contemporaries. In the design and manufacture of such valves it will be obvious that to maintain uniformity of quality, great demands are made on the mechanical, electrical and chemical engineering aspects involved, and the production techniques employed. Typical of the many advances in valve production tech-

nology introduced into Australia during the past 25 years by Miniwatt is the recent introduction of the Frame-Grid construction.

The rigid frame-like structure of the valve grid, with its centreless-ground side rods and welded rectangular-section cross-members of molybdenum, accurately determines the dimensions of the tension-wound tungsten grid winding wire to ensure:

- (a) higher mutual conductance;
- (b) lower equivalent noise resistance;
- (c) smaller spread in characteristics;
- (d) reduced microphony;
- (e) great reliability,



Frame grid placed over cathode during assembly.

resulting in improved circuit performance, particularly in VHF applications.

In the current range of Miniwatt Preferred Valves for TV applications, four types embody the Frame-Grid construction.

During the past 25 years, the Australian production of Miniwatt valves has kept abreast of worldwide developments in valve construction and production techniques, all of which have been aimed at making available a range of valves designed to satisfy the critical demands created by the spread of electronics into its many new fields of application. Australian engineering and production personnel can be proud of their contributions to the progress of receiving-valve technology over the past 25 years.

TEMPERATURE MEASUREMENT AND CONTROL

using Philips NTC Resistors

Negative Temperature Coefficient Resistors are composed of oxidic materials having highly temperature-dependent characteristics. Philips NTC resistors are particularly suitable for industrial applications where temperature is to be measured or controlled in the range -70°C to $+200^{\circ}\text{C}$. Two applications are described: (1) an accurate, linear, remote-indicating, direct-reading thermometer covering the range 0°C to 100°C ; (2) a fast-acting, continuously-variable, remotely-controlled electronic thermostat, with a switching accuracy suitable for all but the most critical of industrial temperature control applications, and an operating range of 20°C to 80°C .

INDUSTRIAL THERMOMETER

Simple in principle, this device incorporates an NTC resistor forming one arm of a Wheatstone bridge. Any increase in the temperature of the NTC resistor decreases its resistance value, thus unbalancing the bridge and causing a current to pass through a meter connected across it.

NTC resistors exhibit an approximately exponential temperature dependence which may be expressed by:

$$R = A e^{B/T}$$

where R = resistance value

at T = absolute temperature,

A, B = constants for a particular resistor,

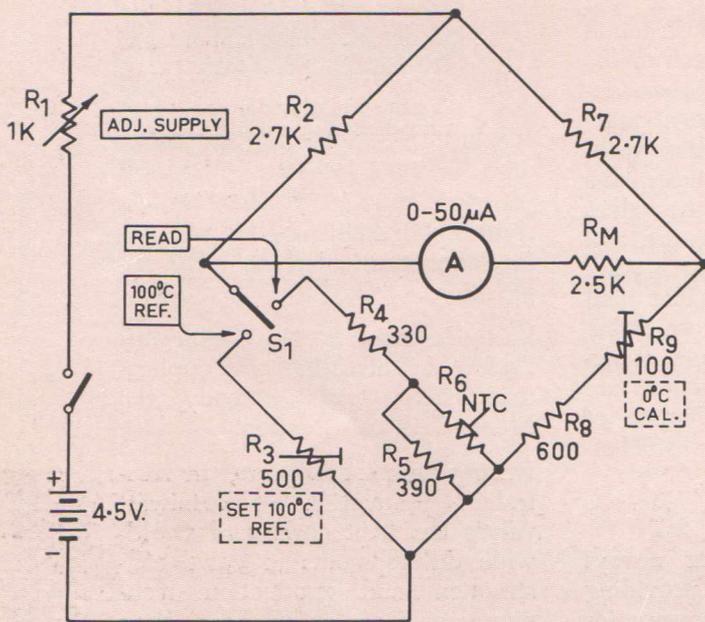
e = base of natural logarithms.

Thus the scale of any direct-reading instrument would be non-linear, and some form of compensation is desirable. A high degree of linearity can be obtained by suitable selection of shunt and/or series components in the NTC arm of the bridge, but the resulting improvement in linearity is obtained with some sacrifice in sensitivity.

The sensitivity of the circuit can be improved by increasing the battery voltage. However, care must be taken to ensure that the current flowing through the NTC resistor is kept low, as heat generated by excessive current can be a source of error in itself.

A practical circuit for the range 0°C to 100°C is shown in Fig. 1, and has an overall linearity within 2% referred to full scale deflection. A miniature glass-mounted bead-type NTC resistor is used to achieve a short thermal time constant. This NTC resistor has a nominal value of $1000\ \Omega$ at 25°C , and is shunted by a $390\ \Omega$ carbon resistor chosen to be equal in value to the nominal NTC resistance at 60°C . This choice was based on measurements involving many NTC samples.

A $50\ \mu\text{A}$ FSD meter, calibrated 0 to 100°C and having an internal resistance of $2500\ \Omega$, was used for indicating the temperature. At full-scale meter deflection, the total current drawn by the bridge is $3.9\ \text{mA}$. The use of a fairly sensitive meter was found to be necessary in order to obtain sufficiently large deflections with the low battery voltage used and the low value of resistance in shunt with the NTC.



- | | |
|--|----------------------------------|
| R_1 1 K lin. | R_4 330 |
| $R_2, 7$ 2.7 K | R_5 390 |
| R_3 500 lin. | R_6 NTC Philips miniature type |
| A 0-50 μA meter, $R_M = 2.5\ \text{K}$,
graduated 0-100 | E 205 CEP/1K |
| S_1 push-button change-over
switch | R_8 600 |
| | R_9 100 lin. |
- All resistors $\frac{1}{2}\ \text{W}$, 5% tolerance (Philips cracked carbon type B8 305 05B).

Fig. 1. Circuit details of industrial thermometer.

The function of the potentiometer R_1 in series with the battery is to set, and thereafter maintain, correct bridge supply by compensating for drop in battery voltage occurring with normal usage.

The bridge was calibrated against an accurate mercury thermometer, the initial setting-up procedure being as follows:

- (1) The NTC resistor is first placed in a bath at a temperature of 0°C and with switch S_1 set to "READ", the bridge is balanced by adjusting "0°C CAL." control R_9 . This preset potentiometer, which sets the lower limit calibration, should require no further adjustment in normal circumstances.
- (2) The NTC resistor is then placed in a bath at 100°C and the potentiometer R_1 adjusted to give full-scale deflection of the meter. This sets the upper limit calibration.
- (3) The procedures (1) and (2) should then be repeated to check the calibration.
- (4) The switch S_1 is then set to "100°C REF.", and with the NTC resistor placed in the bath at 100°C the meter is adjusted to full-scale by means of the preset potentiometer R_3 . The purpose of this preset adjustment is to provide a reference with which to check for inaccuracies arising from incorrect battery voltage. The bridge is now calibrated.

Before each set of readings, the switch S_1 should be set to "100°C REF." and the potentiometer R_1 adjusted to give full-scale deflection of the meter. With the switch changed over to the "READ" position the bridge is then ready for use.

The temperature range adopted for the present example is 0°C to $+100^\circ\text{C}$. However, other ranges can be provided within the limits -70°C to $+200^\circ\text{C}$, when using Philips NTC resistors.

ELECTRONIC THERMOSTAT

The unit described hereunder (Figs. 2 and 3) possesses several important advantages over a common thermal switch ("thermostat"):

- (i) Temperature control is accurate and continuously variable. Furthermore, the controlled temperature can be set at a remote point.
- (ii) The thermal time constant of the sensing element is small.
- (iii) The resistance of additional lead lengths in remote control applications is negligible compared with the NTC resistance.

The choice of a Philips Premium Quality twin-triode, type ECC186, for switching the relay which controls the heaters was based on the following:

- (a) The extremely close control on the characteristics of all Philips Premium Quality tubes—especially in relation to the cutoff bias.
- (b) Emission is not impaired by long periods in the cutoff condition.

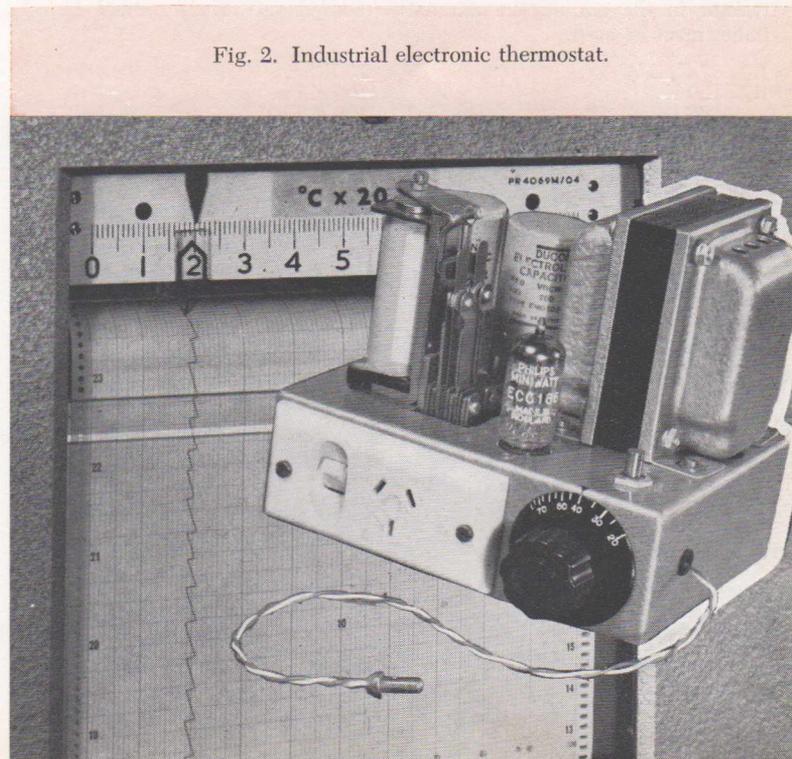
- (c) High input resistance, reducing additional loading on the sensing and control network containing the NTC to negligible proportions.
- (d) 240 V AC will normally be available in the remote control centre.
- (e) The relay operating current is easily handled, and in an economical fashion.
- (f) The regenerative switching of the Schmitt Trigger results in "snap-action" of the relay, reducing arcing at its contacts arising from any inductive effects in heater elements. Also, the performance of the controller is essentially independent of that of the relay.
- (g) The Schmitt Trigger circuit is independent of supply voltage over a wide range.

The standard relay chosen is fitted with two 240 V, 8 A contacts, and can be used to switch small heating elements directly. For switching larger powers these contacts can be used to switch heavy-duty contactors. The control setting of the thermostat described is readily adjustable within the range 20°C to 80°C . The controlled system or switching accuracy is $\pm 2^\circ\text{C}$ for normal conditions, and $\pm 4^\circ\text{C}$ under adverse conditions when using a standardised scale. For an individually calibrated scale the accuracy is approximately $\pm 1^\circ\text{C}$ under normal conditions.

Principle of Operation

The control circuit proper consists of a resistive combination in shunt with the DC voltage supply. The NTC resistor forms part of this, and it constitutes the temperature sensing element. As the temperature applied to the NTC resistor varies, the voltage division across the elements in the resistive combination varies. This actuates the Schmitt Trigger, which operates the relay when the temperature falls below a preset level, and releases it when the temperature rises above another preset level. In the steady state, the controlled temperature will thus cycle between corresponding limits (the "temperature differential").

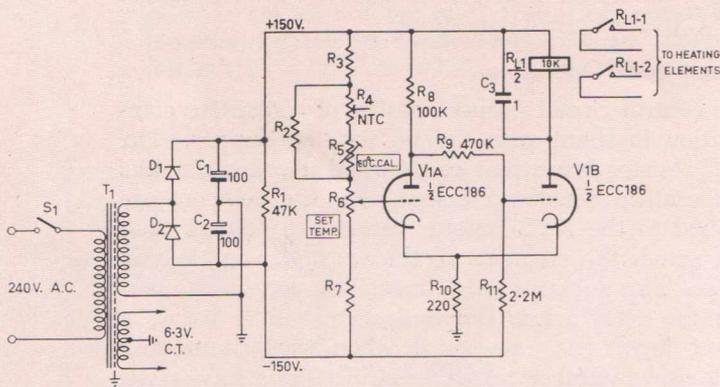
Fig. 2. Industrial electronic thermostat.



The differential is controlled by R_{10} chosen as a compromise between control accuracy and other practical considerations. If now a step change in the setting of R_6 is introduced, the voltage applied to the grid of V_{1A} will fall outside the above limits and heating or cooling will be introduced (via R_{L1}) until the NTC resistor has adjusted its resistance sufficiently for cycling to be resumed. The potentiometer R_6 incorporates a scale calibrated in controlled temperature.

The operation of the Schmitt Trigger is briefly as follows:

Assume initially that V_{1A} is cut-off by the input potential applied to its grid. Maximum current is then flowing in V_{1B} and the plate current of V_{1A} is held cut off by the resulting potential drop across the common cathode resistor R_{10} . When the input voltage at the grid of V_{1A} rises sufficiently to overcome the cutoff bias level established by R_{10} , plate current will start to flow in V_{1A} , applying bias to the grid of V_{1B} . This causes a reduction in the plate current of V_{1B} , which in turn lowers the common cathode potential, driving V_{1A} further into conduction and V_{1B} further into cutoff. This regenerative switching action results in an extremely rapid change from one state to another. The relay R_{L1} acts as the plate load of V_{1B} .



Parts List

If the miniature bead-type NTC resistor replaces the rod-type NTC resistor in the circuit, the alternative component values printed in italics must be used.

R_1 47 K, 3 W	R_5 20 K lin.
R_2 100 K	100 K lin.
220 K	R_6 100 K lin.
R_3 82 K, 1 W	R_7 100 K, 1 W
680 K	820 K
R_4 NTC, Philips rod-type	R_8 100 K, 1 W
B8 320 07P/150K	R_9 470 K, 5%
NTC, Philips miniature	R_{10} 220, 1 W, 5%
type E 205 CEP/680 K	R_{11} 2.2 M, 5%

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

$C_{1,2}$ 100 μ F, 200 VW, UCC type ETD155 or Ducon type EMC 10145

C_3 1 μ F, 125 V, Philips polyester C 296 AA/A1M

D_1, D_2 OA210

T_1 Power transformer: 115 V secondary, e.g. A & R 2062

R_{L1} Relay: 10 K coil; 55 V operation; two sets 240 V, 8 A contacts; e.g. Relays Pty. Ltd., type 6R.

Fig. 3. Circuit details of electronic thermostat.

Constructional Details of Probes

Two different probes have been constructed for the circuit of Fig. 3. The first is a glass-mounted miniature bead-type NTC Resistor (E 205 CEP/680K) "thermometer type". It responds rapidly to changes in temperature and can be used without additional precautions, even in corrosive and conducting environments.

The second type of probe is a small rod-type NTC resistor (B8 320 07P/150K) mounted in an oil or silicone-grease filled copper tube as shown in Fig. 4. An alternative mounting method would be to place the NTC resistor inside a drilled brass screw which could then be filled with silicone grease (which provides low thermal resistance). This would then allow direct mounting to the wall of a metal container. The rod type of NTC resistor is cheaper and more robust than the bead type, but has a slightly longer response time.

Each NTC resistor requires an individual resistive network with which to actuate the Schmitt Trigger. The series-parallel arrangements of resistors in these networks are used to linearise the scale, and also to provide a means of compensating for the resistance spread of each type of NTC resistor ($\pm 20\%$ at 25°C).

The practical construction of the complete unit is shown in Fig. 2.

Thermostat Calibration

Initial calibration of the scale is carried out against an accurate mercury thermometer. Upper temperature calibration is set by potentiometer R_5 which is in series with the NTC resistor. This control has sufficient adjustment so that a standard scale can be used for all NTC resistors within the two extreme manufacturing tolerance limits. For example, if an NTC resistor with a resistive characteristic which is the mean of the two extreme manufacturing tolerances is placed in the circuit, then the potentiometer R_7 will be at about the centre of its rotation.

The full procedure for scale calibration is as follows:

- (1) R_5 is set to its mid position.
- (2) The probe is placed in a bath at 20°C .
- (3) R_6 is rotated until the relay just closes and the lower limit of the scale (20°C) is marked at this point.
- (4) A resistor is substituted for the NTC, its value being equal to the nominal value of the NTC at 80°C . (10K Ω for B8 320 07P/150K or 100K Ω for E 205 CEP/680 K).

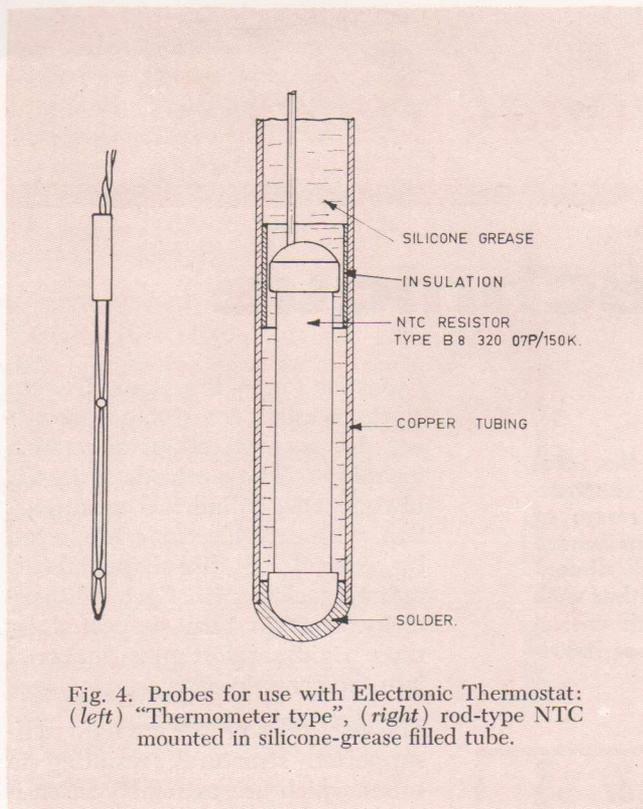


Fig. 4. Probes for use with Electronic Thermostat: (left) "Thermometer type", (right) rod-type NTC mounted in silicone-grease filled tube.

- (5) R_6 is rotated until the relay just closes and the upper limit of the scale (80°C) is marked at this point.
- (6) The NTC resistor is then replaced, and inserted in a bath at 80°C .
- (7) With R_6 in the same position as determined in (5), R_5 is adjusted until the relay just closes.
- (8) The procedures in (2), (3), (6) and (7) are repeated to ensure accurate setting of the two limits, since the lower limit calibration will be changed slightly by the adjustment of R_5 , perhaps necessitating a slight orientation of the scale in the process.
- (9) The scale can then be calibrated within the two set limits by varying the bath temperature and setting R_6 to just close the relay.

With the circuit calibrated in this way, the relay controlling the heating element will operate whenever the temperature falls below the predetermined value on the scale.

The differential between relay pull-in and relay drop-out is about 3°C for the bead-type NTC resistor circuit, and about 4°C for the circuit using the rod type of NTC resistor. The differential for both types of NTC resistor will increase near the upper temperature limit, because the change in absolute value of resis-

tance is smaller at higher temperatures. It is this factor which places a practical upper limit on the operating range of the thermostat. The differential is also affected by variations in supply voltage. However, if the variations do not exceed $\pm 6\%$ the effect is negligible.

Power Supply

The power supply is a conventional voltage-doubling circuit, with the centre-tap of the capacitive network earthed to provide the desired positive and negative voltages. The circuit arrangement results in a slight unbalance of current, because the positive voltage side will have to provide the plate current for V_{IA} and V_{IB} . The effect is negligible, however, as the total current drain is small. A bleed resistor (R_1) is placed across the supply to improve regulation.

Thermal Time Constant

The following tests have been carried out to find how the accuracy of control is influenced by thermal time constant.

With the probe inserted in a bath at 35°C , the potentiometer R_6 is adjusted to the calibrated value of 40°C . The probe is then quickly removed from this bath and immersed in a bath at 45°C . The time from the change of baths to the time of relay operation is measured. The delay times obtained in this way are checked by changing from the baths in the opposite direction. The delay times should be the same in both directions.

The following times have been measured according to this method:

Miniature NTC type E 205 CEP/680K	... < 0.5 secs.
Rod NTC type B8 320 07P/150K	... 4.5 secs.

Summary

The versatile electronic thermostat described above is easily constructed and calibrated. It is suitable for use in many industrial applications, especially those involving temperature control of fluids.

The controlled temperature can be adjusted remotely using a continuously-variable calibrated dial. This is particularly important when the sensing element is in an inaccessible position.

(This investigation was carried out in the "Miniwatt" Electronic Applications Laboratory by A. C. Denne, with acknowledgment to earlier unpublished work carried out in overseas Concern laboratories.)

References

1. Design of Thermistor Thermometer with Linear Calibration, *Journal Scientific Instruments*, Vol. 28, No. 6, June 1951, pp. 176-179.



Professional Tubes

A New Valve Technique

—Philips Nuvistors

Philips industrial Nuvistors, types 7586 and 7587, are the forerunners of a range of electron tubes differing radically in construction from the conventional. They extend the Philips range of established Premium-Quality Tubes in critical applications where circumstances demand very low power drain and small dimensions (approaching those of comparable transistors), together with the advantages of premium-grade electron tubes. Such critical circumstances are frequently encountered in the design of industrial, medical, military and communications equipment.

Nuvistors are Premium-Quality electron tubes constructed according to a new all-metal-ceramic technique. The electrode system is of concentric cylindrical construction, with each electrode supported by conical or disc-shaped heat-radiating elements. Each of these elements is in turn supported by three rigid support pins anchored into the ceramic base.

The electrodes proper are light, self-supported structures, resulting in tubes which are extremely insensitive to shock and vibration, and which maintain good inter-electrode insulation throughout life.

All connections are brazed at temperatures in excess of 1000°C in an atmosphere of hydrogen. Evacuation of the tube, and brazing of the envelope to the metallised ceramic base wafer, is carried out at approximately the same elevated temperature. By such means an extremely high degree of degassing is achieved, meeting an important condition for long-life operation. Furthermore, since all parts of the Nuvistor are simultaneously exposed to the same high temperature, a stress-free assembly results.

High Ambient Operation

Good thermal conduction, via brazed connections, allows the large-area heat-radiating electrode supports to become fully effective. Thus thermal loading of plate and grids remains low, making it possible to operate the Nuvistor at relatively high ambient temperatures, the steel construction of the envelope contributing towards this.

Low Heater-Power Requirements

The cathode cylinder, constructed of "low interface" nickel, is supported by the cathode cone via a

PHILIPS 7586

Premium-Quality Medium-Mu Nuvistor Triode

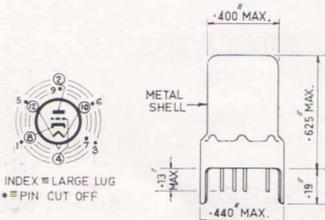
(Abbreviated Data)

General Electrical Data

Heater voltage $6.3 \pm 10\% \text{ V}$
Heater current .. 140 mA



Actual Size



Direct Interelectrode Capacitances

Grid to cathode, heater and shell .. 4.0 pF
Plate to cathode, heater and shell .. 1.4 pF
Plate to grid .. 2.2 pF
Plate to cathode .. 0.2 pF
Heater to cathode .. 1.4 pF

Maximum Ratings (Absolute maximum)

Plate voltage .. 110 V
Plate dissipation .. 1 W
Plate current .. 20 mA

Typical Characteristics

Supply voltage ..	26.5	75 V
Plate current ..	2.8	10.5 mA
Cathode resistor ..	—	130 Ω
Mutual conductance ..	7.0	11.5 mmho
Grid voltage at plate current 10 μA ..	—	—6.5 V
Amplification factor ..	31	33

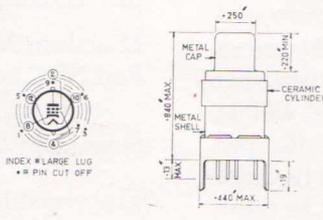
PHILIPS 7587

Premium-Quality Sharp-Cutoff Nuvistor Tetrode

(Abbreviated Data)

General Electrical Data

Heater voltage $6.3 \pm 10\% \text{ V}$
Heater current .. 150 mA



Direct Interelectrode Capacitances

Grid No. 1 to cathode, grid No. 2, heater and shell .. 6.5 pF
Plate to cathode, grid No. 2, heater and shell .. 1.4 pF
Plate to grid No. 1 .. 0.01 pF
Heater to cathode .. 1.4 pF

Maximum Ratings (Absolute maximum)

Plate voltage .. 250 V
Plate dissipation .. 2.2 W
Cathode current .. 20 mA

Typical Characteristics

Plate supply voltage ..	125 V
Grid No. 2 supply voltage ..	50 V
Plate current ..	10 mA
Grid No. 2 current ..	2.7 mA
Cathode resistor ..	68 Ω
Grid No. 1 voltage at plate current 10 μA ..	—4.5 V
Mutual conductance ..	10.6 mmho

length of thin-walled nichrome tubing. This results in low end-cooling of the cathode, providing a uniform cathode temperature with substantially reduced heater requirements. Further, a coiled-coil heater construction has been adopted in order to obtain a thick, reliable, heater element.

Uniformity and Reliability

The structure of the Nuvistor permits automatic assembly of parts made to extremely close tolerances. The heat-forming operation on the assembled electrode structure is carried out with the precision assembly jig still in place. This, together with the fact that all parts are uniformly exposed to the same elevated temperature, ensures the production of strain and distortion-free assemblies, possessing a high degree of uniformity from tube to tube. Furthermore, this will be maintained over a wide range of temperature.

The high degree of degassing, together with high order insensitivity to shock and vibration and ability to withstand elevated ambients, all combine to ensure long-life expectancy.

Performance

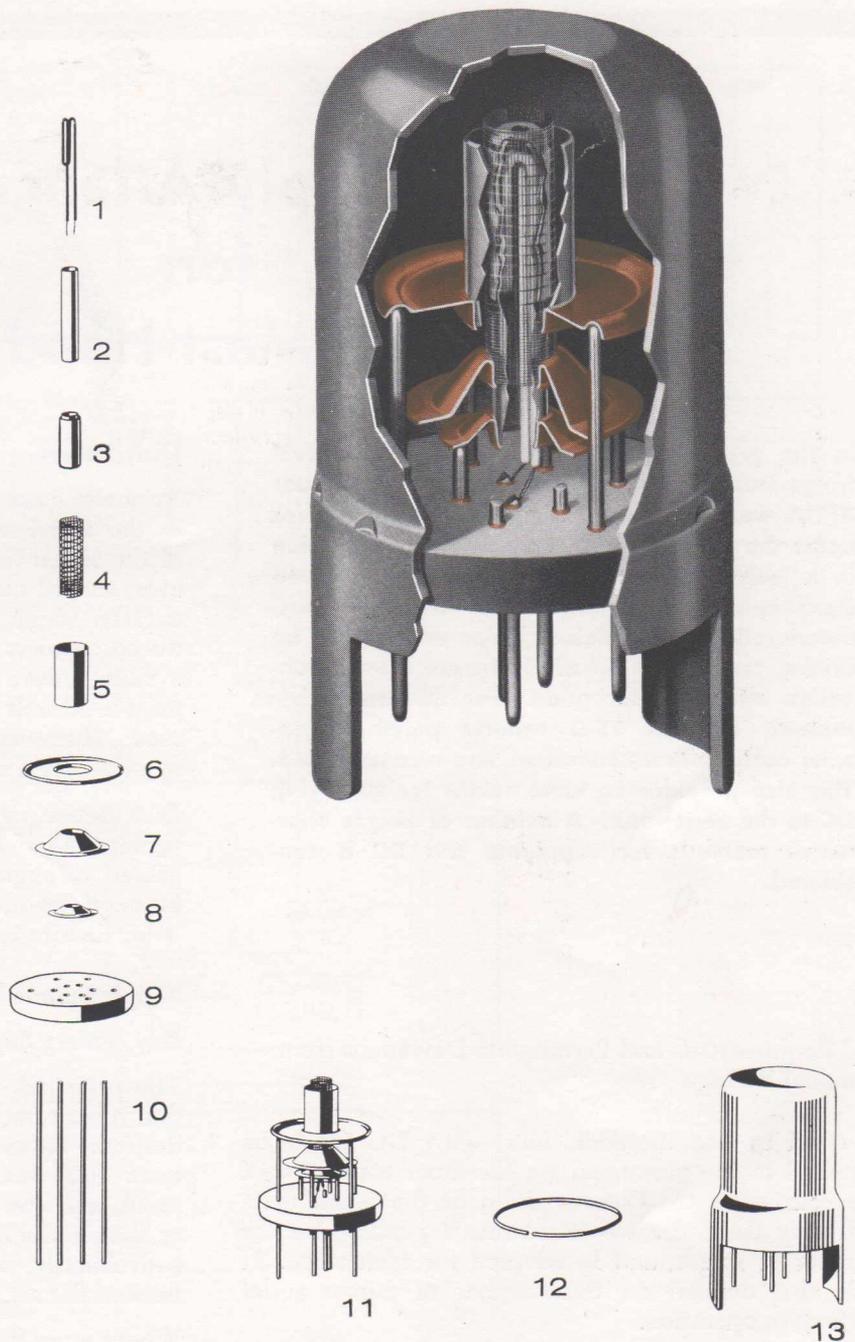
Additional features, resulting from the basically new design, are high mutual conductance at low plate currents and voltages, and the ability to operate at full ratings at any altitude. Low noise factor and good high-frequency performance are also obtained.

Fields of Application

Philips Nuvistors are eminently suited to professional applications where combinations of the following circumstances apply:

- extremes of ambient temperature and pressure.
- conditions of extreme shock or vibration.
- limited space availability.
- supply limited to low voltage and low power-handling capacity.
- applications where long life, interchangeability and stability (characteristics of the Philips Premium-Quality range) are essential factors.

CUT-AWAY VIEW OF A NUVISTOR TRIODE



Component parts from which a Nuvistor triode is built up. The cylindrical structure can be clearly seen:

- | | |
|--------------------|--|
| 1. Heater | 8. Cathode flange |
| 2. Cathode support | 9. Ceramic base wafer |
| 3. Cathode | 10. Connecting pins |
| 4. Grid | 11. Electrode system mounted on ceramic base wafer |
| 5. Plate | 12. Brazing ring |
| 6. Plate flange | 13. Mounted Nuvistor with metal shell |
| 7. Grid flange | |

Power Supply Arrangements for Transistorised Mast-Head Amplifiers

In the previous issue of the "Digest", several fringe-area mast-head units using the transistor AF102 were described⁽¹⁾. These low-noise devices boost the signal before it undergoes attenuation in a long down-lead, resulting in an improved signal-to-noise at the tuner input. In certain cases, deterioration of unshielded balanced line can be severe, resulting in greatly increased signal attenuation and poor reception. For this and other reasons, low-loss $75\ \Omega$ cellular polythene coaxial cable output connection was recommended. This also provides an ideal means for supplying DC to the aerial unit. A number of simple alternative methods for supplying this DC is considered.

DC Requirements and Permissible Deviations from Nominal Voltage

In order to feed the aerial unit, $+9\ \text{V}$ DC has to be supplied to the mast-head via the inner conductor of the coaxial cable. Current drain of the aerial units will vary from about 5 to 10 mA, depending on the number of stages, and I_E adopted for each stage. It will also depend on the number of fringe aerial systems in operation.

A variation in supply voltage produces variations in the AF102 admittance parameters—both directly, arising from the altered collector voltage, and indirectly, due to the changed I_E . Resulting fluctuations in g_{22} and C_{22} will tend to affect the bandpass and tuning. However, both parameters fall with decreasing I_E , and rise with decreasing voltage. Thus a compensation results, and $\pm 20\%$ fluctuation in the nominal $+9\ \text{V}$ DC produces insignificant changes in response. The supply arrangements of Fig. 3 yield a nominal $9.2\ \text{V}$ DC, the limits being well within the above tolerance.

Distribution

As power gains greater than 20 dB have been achieved in the aerial units previously described, distribution of the signal to about four TV sets is feasible. However, should more than one TV set be operated from a given fringe aerial installation, a problem is introduced. Unless special arrangements are adopted, if a viewer were to switch off his set (controlling the mast-head unit) he would disrupt viewing at all other sets. However, the majority of installations will involve only a single set.

Distribution on a $75\ \Omega$ unbalanced basis has the advantage that the separate coaxial feeders can be passed through conduit, etc. However, should there be only two sets served, and these within one household, distribution on a $300\ \Omega$ basis may be preferred.

Supply Source External to a Set

Dry Battery Supply

The principal disadvantage of using a 9 V battery is that it may not be disconnected when reception is not desired. However, a battery which will provide at least 1000 hours of continuous operation is fairly small, and can be incorporated in an "adapter unit" as shown schematically in Fig. 1. Such a unit can be conveniently, and inconspicuously, hung on to the back of the set.

Where more than one TV set is used, the signal arriving via the $75\ \Omega$ down-lead is distributed, and converted to balanced signals at each set by means of "balun" transformers (T_2) as previously described⁽¹⁾. A low-inductance earthing connection between adapter unit and tuner is provided by means of the braid of a short length of $75\ \Omega$ coaxial aerial cable.

For simplicity, switching from local station to fringe installation is depicted as a simple plugging operation. However, suitable switches can be devised, which would also make allowance for strapping R_2 ($82\ \Omega$) between an unbalanced terminal of T_2 and ground when the tuner is disconnected from "A".

DC Supply Arrangements for Mast-Head Amplifier

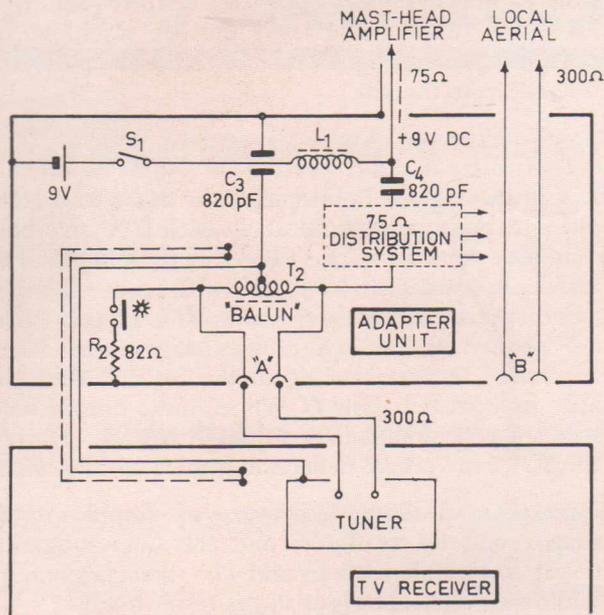


Fig. 1. Supply arrangements when dry battery used.

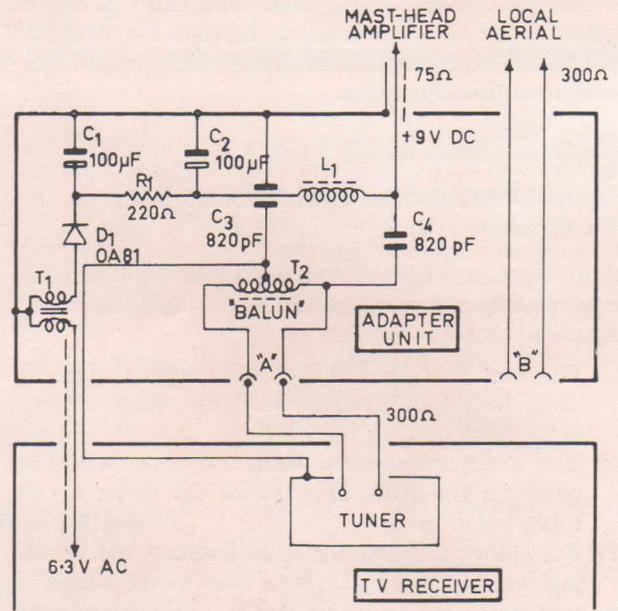


Fig. 2. Supply arrangements when 6.3 V AC (within set) is utilised.

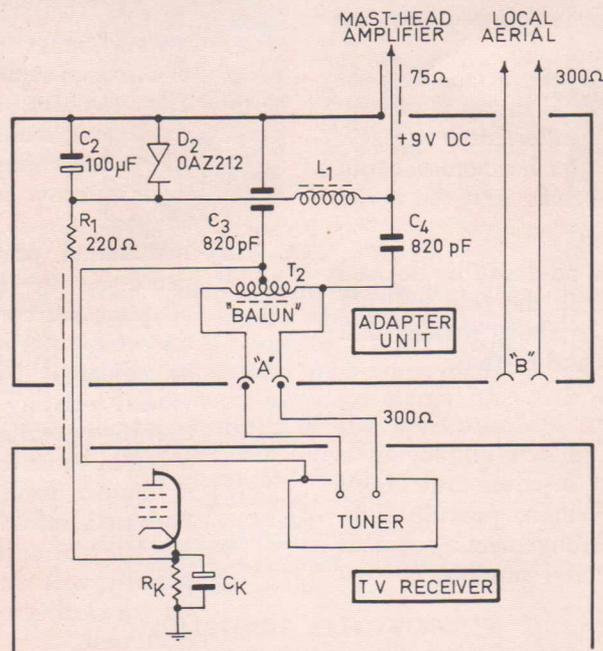


Fig. 3. Supply arrangements when voltage drop across cathode resistor is utilised.

PARTS LIST

- C₁ 100 μ F electrolytic, 40 V peak working.
- C₂ 100 μ F electrolytic, 16 V working, Philips type C426A. M/E100.
- C_{3,4} 820 pF Philips ceramic feed-through type C309BB/R820E.
- D₁ Germanium diode type OA81.
- D₂ Silicon Zener diode type OAZ212.
- L₁ Philips Ferroxcube-cored choke type VK200.10/4B.

- R₁ 220 Ω , $\pm 5\%$, Philips type B8 305 05B/220E.
- R₂ 82 Ω , $\pm 5\%$, Philips type B8 305 05B/82E.
- T₁ Blocking oscillator type transformer: e.g. Ferguson type TBB 117, wdg. 3½/1 with resistances 210 Ω and 80.6 Ω respectively.
- T₂ 10 t 24 B/S enam. copper, centre-tapped, wound bifilar on Ferroxcube bead-type 56.390.31/4B.

Decoupling of the DC supply is achieved by means of the low-pass filter (L_1, C_3) and capacitor C_4 . These components are all wide-band, L_1 being a Ferroxcube-cored choke, the capacitors being Philips tubular ceramic feed-through types.

Supply Source from Within a Set

(a) Turns Overwound on Horizontal Output Transformer

Even in the case of stabilised horizontal systems this arrangement is not very practical for the following reasons:

- (i) The fact that an EHT point is approached in order to obtain the required low-voltage supply is far from ideal.
- (ii) The exact number of turns required will depend on the particular set, of the order of 10 turns being usual.
- (iii) For safety reasons, the wire forming the winding would have to be insulated to withstand a voltage of the order of 18 KV. This introduces additional problems in that a thick winding will not tend to "lie", and so may come within close proximity to the EHT overwind itself. Corona disturbances may then be introduced into the aerial supply unit.
- (iv) Because of the low duty cycle, a more expensive diode with a higher PIV rating would be essential for rectifying the alternating voltage. This waveform, rich in higher harmonics, could also introduce spurious signals into the aerial supply unit.

A satisfactory arrangement could no doubt be devised in the laboratory, but conditions in the field will not be as favourable, and it is for the above reasons that this possibility will not be considered further.

(b) 12.6 V AC Heater Supply

This is usually only available in sets employing a special type of picture tube. A separate 240/12.6 V transformer would, after rectification, provide sufficient DC voltage. However, arrangements (c) and (d) described below are considered superior.

(c) 6.3 V AC Heater Supply

This is almost universally available, but if not stepped-up will be of insufficient magnitude to supply the 9 V DC required. However, a small inexpensive standard blocking-oscillator transformer can be used for such a purpose, and such has been utilised in Fig. 2. However, the nominal 9 V DC figure is obtained with a current drain of 5 mA (single-stage amplifier), and for currents in excess of this a larger transformer will be required. With normal mains fluctuations, the 9 V figure holds to within $\pm 10\%$.

Adequate supply filtering is provided by the RC pi-filter (R_1, C_1, C_2) and decoupling of the signal from the supply is achieved by means of low-pass filter (L_1, C_3) and capacitor C_4 as described above.

A short length of 75Ω coaxial aerial cable is recommended for interconnecting the adapter unit to the 6.3 V AC supply. This will provide shielding from possible spurious signals which could enter the adapter unit from the set.

(d) Voltage Developed across a Cathode Resistor

In considering a suitable point, the audio and vertical output stages appear most suitable. A number of existing sets employ the 6BM8 in these applications, and from +12 to +17 V DC will be available at a valve cathode. However, heavy 50 c/s peak currents are present in vertical output stages, and filtering additional to that existing in the set will then probably be essential. The 6GW8 in audio output service will not provide a sufficiently high voltage. However, the 6GV8 in vertical deflection service will be suitable.

Generally speaking, however, a suitable cathode source will be available, and this will range from about 10 to 19 V with 13 and 17 V being common for audio and vertical output stages respectively.

The adapter unit presented in Fig. 3 employs similar decoupling arrangements to those used in Fig. 2. However, it possesses several advantages:

- (i) No additional transformer is required, and an electrolytic capacitor is saved.
- (ii) The OAZ212 Zener diode, an inexpensive $\pm 16\%$ unit, maintains a DC supply of $9.2 \pm 16\%$ for source voltages enumerated above, and for load currents within the above 5 to 10 mA range.
- (iii) Installation problems are eased. It is only necessary to disconnect R_K and, with the adapter unit connected, insert a variable resistor set to approximately the correct value, and to adjust it for the cathode potential previously existing. All that is then required is that the potentiometer be replaced by a resistor equal in value to its final setting.
- (iv) A known fixed degree of additional supply filtering is introduced (R_1, C_2).
- (v) Inadvertent application of voltage of incorrect polarity will cause the OAZ212 to conduct in the forward direction, thus protecting the mast-head unit.
- (vi) C_2 and C_3 provide low- and high-frequency bypassing respectively for noise introduced by the Zener diode (such being common to all discharge-type regulating devices).

The adapter units described in Figs. 2 and 3 can be provided in small compact assemblies which can be fitted to the rear of the set. However, if potting is employed, the potting compound should be chosen so as not to affect the RF performance.

Reference

1. A. J. Erdman and N. A. Steadson, Transistor Operation at 200 Mc/s, the AF102 in Mast-head Amplifier Design, *Miniwatt Digest*, Vol. 1, No. 5, Feb. 1962.

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