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CONTENTS

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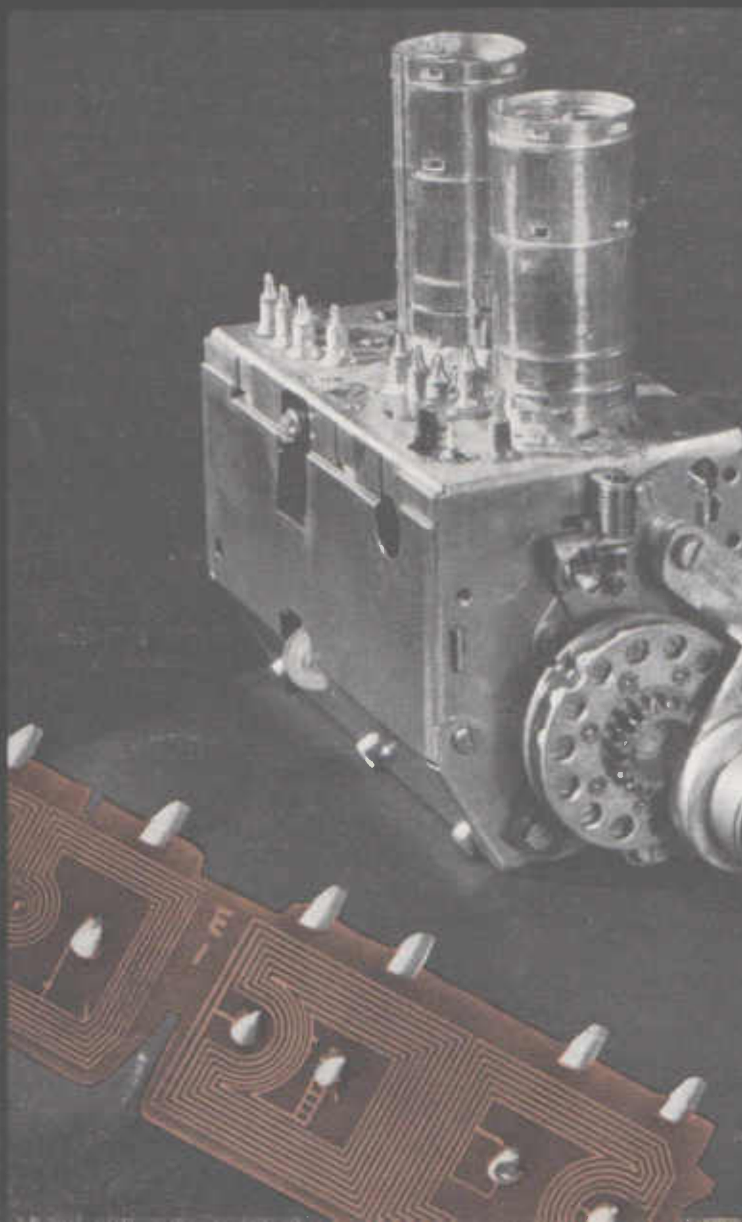


PRINTED COIL TUNER WITH "MEMOMATIC" FINE TUNING

PRINTED COIL TUNER

with "Memomatic" Fine Tuning

The Miniwatt 13-channel tuner type NT3009 just released, incorporates several important new features, all contributing to a superior performance compared with former types. These features are:

- ★ **All tuning coils for each channel are printed on a single-laminate wafer.**
- ★ **Increased gain—provided by new frame-grid converter valve 6HG8.**
- ★ **Optimum oscillator tuning—a mechanical memory arrangement reproduces the optimum fine oscillator tuning for each individual channel.**
- ★ **Light compact construction—the printed coil configuration permits a more compact construction of the tuner resulting in smaller dimensions and reduced weight.**

MECHANICAL CONSTRUCTION

The Rotor

The rotor consists of a main shaft supporting three specially shaped metal discs. Thirteen printed coil strips are fitted into grooves on the discs so that the strips are positioned along the shaft and extend radially towards the circumferences of the discs. The rotor has 14 indexed positions, leaving a vacant position available for use in case of developments not foreseeable at the present time. The rotor shaft is not driven directly, but is geared to a separate drive shaft which carries the selector knob. A rear extension of the rotor shaft enables it to be coupled to a drive motor if remote channel-changing operation is required.

As shown in Fig. 1, the coils necessary for the selection of a particular channel are printed side by side, so that one strip carries all the coils for this channel. The coil conductors are precision-etched from a copper-clad synthetic-resin-bonded paper laminate. This specially selected laminate is treated to ensure low moisture absorption and a low coefficient of thermal expansion. Thus readily reproducible and highly stable coils result, which provide excellent performance for all channels. Each strip is also fitted with robust silver-plated contacts which are soldered to the separate coil sections.

The Stator

Also contained within the housing is a stator strip carrying 10 silver-plated spring contacts and, for each indexed position of the rotor, the relevant coils are connected to the tuner circuitry through the stator spring contacts. In order to always ensure fully effective contact, the position of the stator strip relative to the rotor strip is individually factory adjusted.

"Memomatic" Fine Tuning

Under weak signal conditions, it is a well-known fact that the normal position of the vision carrier on the response slope (6 dB down) does not necessarily produce optimum picture quality. In the case of previous tuners, either a service adjustment of the oscillator slug had to be made, or the viewer had to reset his fine-tuning knob after each channel-changing operation if he were to obtain the best possible picture.

In the new tuner, a mechanical "memory" is used to reset a ceramic trimmer in the oscillator circuit. For this purpose the main rotor shaft carries a disc with 14 set-screws. The screw associated with each indexed position is mechanically linked to the trimmer in such a way that the capacity varies when the screw is turned. This ad-

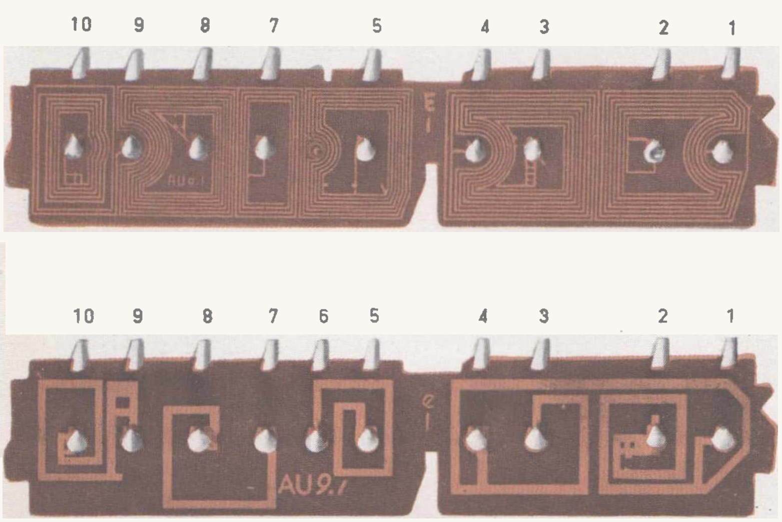


Fig. 1.

◀ Coil strip for Channel O.

(Contact numbers correspond to those shown in Fig. 3.)

◀ Coil strip for Channel 9.

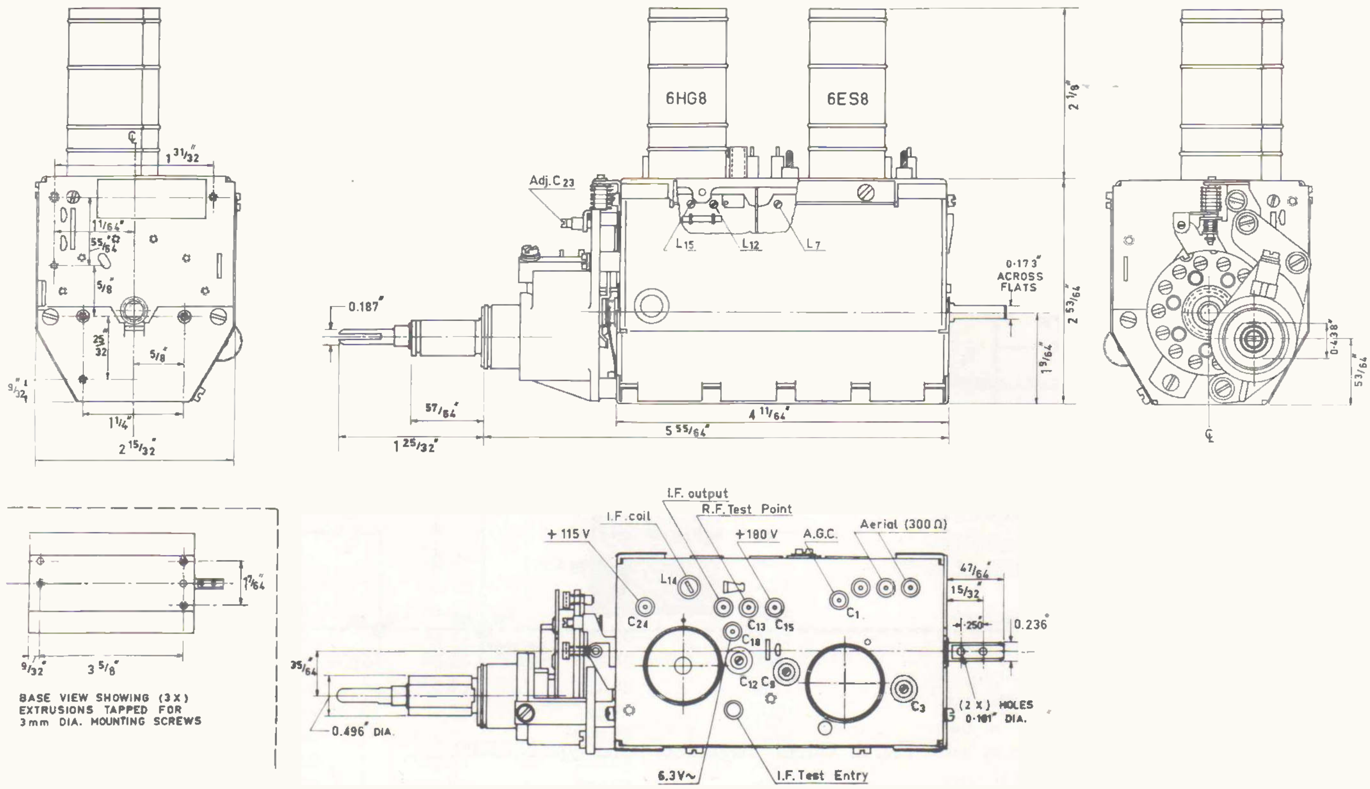


Fig. 2. Mechanical details of tuner type NT3009.

justment is made by means of a special spring-loaded adjustment knob mounted concentrically with the manual channel-changer control.

The separate adjustments for each channel should be carried out on installation to obtain the best picture quality, but once set, no further adjustment should be required. The adjustment is quite simple and can be readily carried out by the viewer. In addition, the present construction avoids inadvertent alteration of the fine-tuning control with channel changing, a common fault in conventional tuners.

Tuner Terminals and Test Facilities

All supply connections to the tuner are made via feed-through capacitors fitted to the top of the housing. All relevant supply, test, adjustment and signal points are clearly indicated on the drawing of Fig. 2.

CIRCUIT DESCRIPTION

The NT3009 tuner employs the frame-grid twin-triode 6ES8 as cascode RF amplifier, and the new frame-grid triode-pentode 6HG8 as oscillator-mixer. A complete circuit diagram is shown in Fig. 3.

The 6ES8 grid circuit is in the form of a bridge network consisting of the aerial coil assembly (C_2, C_3) and the effective valve capacitances C_{a-g} and C_{g-k}. In the balanced condition, the plate feedback is neutralised and oscillator radiation via the aerial minimised. However, with the tolerance on component values, etc., a virtual earth may not be established exactly at the centre of L_1. Thus to ensure effective coupling of the two aerial coil halves, the driving source must be "floating". It is to be remembered that the flat printed coils provide negligible mutual coupling.

The 300 Ω balanced aerial input is connected to the aerial coil (L_3, L_4, L_5) via a 1:1 transformer (L_1, L_2). This broad-band transformer is wound through a core of the new high-frequency ferrite, "Ferroxplana 1Z2". Its use ensures that input line balance is maintained, and provides a "floating" secondary winding in conformity with the above requirements.

In order to increase the stability margin on the lower frequency channels, a small amount of negative feedback has been introduced by means of an imperfectly bypassed cathode resistor (R_1, C_4) in the grounded-cathode section of the RF amplifier.

The standard cascode circuit is coupled to the mixer input by means of a special bandpass filter consisting of coils L_8 to L_{11}. Due to the inherently small degree of mutual coupling between the flat coils printed side by side, it is necessary to introduce an additional coupling element. Considera-

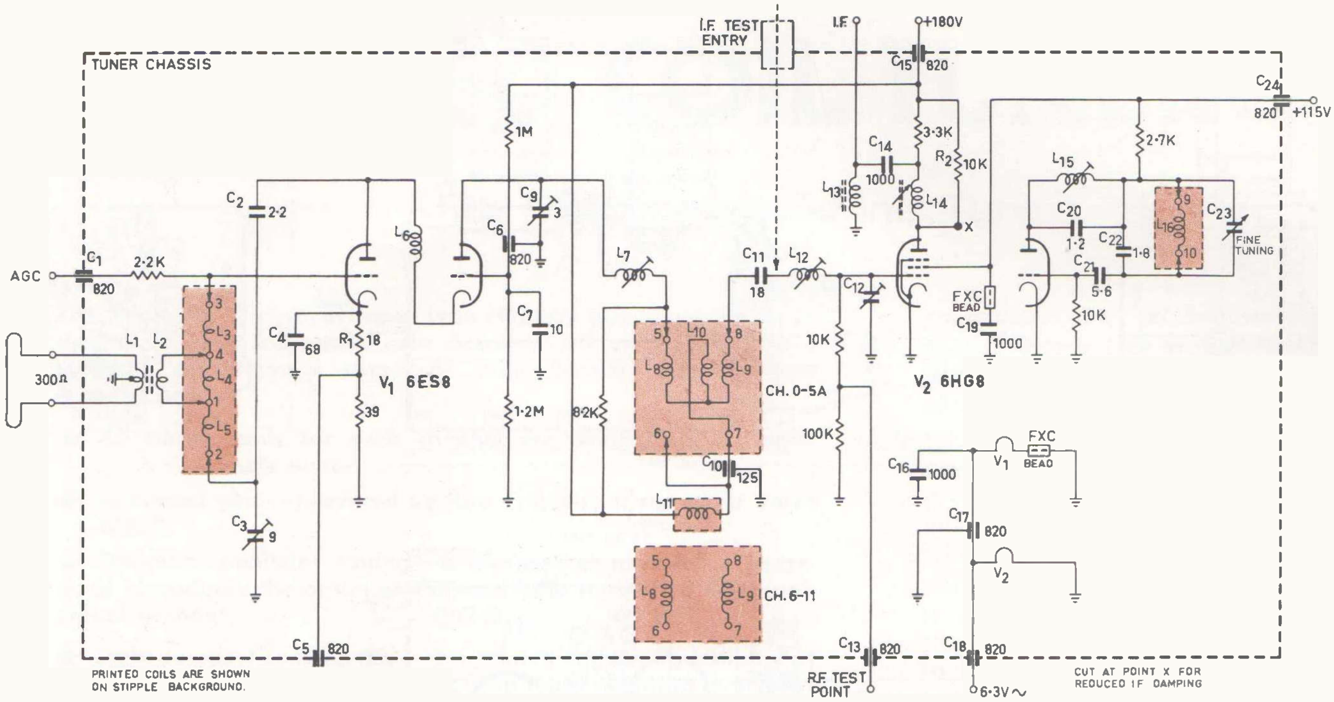


Fig. 3. Circuit diagram of tuner type NT3009.

tions of the response of such a bandpass filter outside its pass band make it desirable to use bottom inductive coupling on the lower channels and bottom capacitive coupling on the higher channels. For this reason the configuration of the bandpass filter differs for channels 0 to 5A from that for channels 6 to 11 (see also Fig. 1).

On the lower channels, the requisite coupling between L_8 and L_9 is provided by the series combination of L_{10} and C_{10} which appears slightly inductive. At a frequency somewhat lower than the channel frequency, actual series resonance of L_{10} and C_{10} will occur, and this fact is used to provide an IF trap for the lowest channel. Coil L_{11} is provided in order to ensure that series resonance occurs at exactly the IF frequency.

On the higher channels (6 to 11), L_{10} has been omitted, and coupling is achieved primarily by means of the low inductance feed-through capacitor C_{10}. To compensate for the decreasing reactance of C_{10} at the highest channel frequencies, some top capacitive coupling has been introduced between points 5 and 8, this being built into the printed coil assembly.

The triode section of the 6HG8 is used as a Colpitts oscillator, the output of which is capacitively coupled to the mixer control-grid by means of valve and wiring capacitances, and additionally by a "printed capacitance" between oscillator coil L_{16} and bandpass coil L_9. Compensation for frequency drift is achieved by means of negative temperature coefficient capacitors C_{20}, C_{21} and C_{22}.

The triode plate and pentode screen supply is brought out separately from the cascode HT supply, so that it is possible to connect those sections more sensitive to voltage variation to a separate supply point which will not be affected by AGC fluctuations.

"Ferroxcube" ferrite beads are used in the mixer screen-grid decoupling circuit and in the heater wiring of the 6ES8 in order to prevent possible parasitic oscillations.

For the same reason, C_7 has been included in the 6ES8 grounded-grid section.

The IF output is obtained via a high-pass filter (C_{14}, L_{13}) which prevents external signals close to the oscillator frequency from producing significant output at the IF output terminal.

L_{14} forms part, together with the input coil of the first IF stage, of a capacitively bottom-coupled bandpass filter. The magnitude of the total coupling capacitance (between 50 and 100 pF) depends on the required degree of coupling, and it includes the capacity of the cable connecting the tuner to the IF strip. This form of coupling has the advantage of providing good oscillator radiation suppression, and for this reason the lumped coupling capacitor external to the tuner should have a minimum value of 24 pF. It should be mounted, with short leads, as close as possible to the IF output terminal. Provision is made so that the primary of the bandpass filter may be operated with or without the 10 K Ω damping resistor R_2, depending on the preference of the designer of the IF strip. The tuner is supplied with the damping resistor R_2 in circuit, but if required, this can be disconnected by severing the link denoted "X" in Fig. 3. This link is accessible through a hole in the cover plate.

TECHNICAL DATA OF TUNER TYPE NT3009

Channel Frequencies

TV Channel	Channel Limits Mc/s	Vision Carrier Mc/s	Sound Carrier Mc/s	Marking on Coil Strip
0	45–52	46.25	51.75	AUO
1	56–63	57.25	62.75	AU1
2	63–70	64.25	69.75	AU2
3	85–92	86.25	91.75	AU3
4	94–101	95.25	100.75	AU4
5	101–108	102.25	107.75	AU5
5A	137–144	138.25	143.75	AU5A
6	174–181	175.25	180.75	AU6
7	181–188	182.25	187.75	AU7
8	188–195	189.25	194.75	AU8
9	195–202	196.25	201.75	AU9
10	208–215	209.25	214.75	AU10
11	215–222	216.25	221.75	AU11

Position 12 in reserve

Valves

RF amplifier . . . . 6ES8.
Oscillator-mixer . . . . . . 6HG8.

Position of Rotor Shaft

When the flats on main and drive shafts are in a horizontal position, and the smaller of the two adjacent cut-outs in the memory screw disc is in the topmost position, the blank channel (No. 12) is indexed.

HT Supplies

Cascode and mixer plate supply
180 V at 25 mA (with zero AGC).

Oscillator plate and mixer screen supply . . . . . . 115 V at 10 mA.

Operating Temperature

Maximum operating temperature . . 70°C.

Intermediate Frequencies

Vision IF . . . . 36.75 Mc/s.
Sound IF . . . . 31.25 Mc/s.

The oscillator frequency is higher than the signal frequency.

The centre frequency of the fine tuning control is preset in the factory to give the above intermediate frequencies at the tuner output. It is possible to adjust the oscillator frequency to produce any vision IF frequency in the recommended range of 36.00 to 36.875 Mc/s. The procedure is described below.

RF 3 dB Bandwidth

Channels 0 to 3 . . . . 7-10 Mc/s.
Channels 4 to 5A . . . . 7-12.5 Mc/s.
Channels 6 to 11 . . . . 7-15 Mc/s.

(Measured at the RF test point with an AGC voltage of —1.2 V.)

Voltage Gain

Gain between aerial terminals and control grid of first IF valve at zero AGC voltage is at least 70 times on all channels.

Aerial Input Impedance

300 Ω balanced.

Noise Factor

Channels 0 to 3 . . . . < 5 dB.
Channels 4 to 5A . . . . < 6 dB.
Channels 6 to 11 . . . . < 7 dB.

Fine Tuning Range, Δf

Ch's. 0 to 3 . . ±900 to ±2500 Kc/s.
Ch's. 4 to 11 . . ±1250 to ±4000 Kc/s.

Reproducibility of Oscillator Frequency

The frequency deviation of a channel after switching away and switching back is $\Delta f \leqq \pm 100$ Kc/s.

Oscillator Injection Voltage

The DC voltage at the mixer control grid, measured at the RF test point, is —1.7 V minimum.

IF Rejection

Channels 0 to 5A . . . . > 150 times
Channels 6 to 11 . . . . > 1000 times

Oscillator Adjustment

If the tuner is to be used with a receiver requiring a vision IF frequency other than 36.75 Mc/s, the fine tuning trimmer can be adjusted by means of the following procedure:

Switch tuner to Channel 2 and check that the "memory" screw for channel is set to the middle of its travel. Adjust trimmer C_{23} by means of the adjustment screw above the memory disc (see Fig. 2) to obtain the appropriate local oscillator frequency. Reseal this screw with sealing lacquer and then set the oscillator frequency for all other channels by means of the "memory" screws.

IF Alignment

Since the RF test point is decoupled by C_{13}, it is not possible to use this point for the injection of IF test signals. A special IF test entry provides access, through a brass tube, to the junction of C_{11} and L_{12}. It is recommended that the IF test signal be injected into this point through a 1000 pF blocking capacitor, to avoid shunting the mixer grid with the low generator output resistance.

Service and Adjustment

It is recommended that service of the tuner be carried out only by personnel familiar with this kind of work, and equipped with the necessary high quality test gear. Where these are not available, the defective tuner should be returned to the receiver manufacturer, who will then arrange for its repair.

For those Service Organisations equipped for complete service, detailed alignment instructions are available on request.

Reference

P. T. Rudge—Turret Tuners with Printed Coils—*Proc. IRE (Aust.)*, Vol. 22, No. 12, Dec. 1961, pp. 748-751.

PHILIPS Small Synchronous Motors

FEATURES

Quick starting
High torque/volume ratio
Slow running speed (1/12th synchronous speed)
—reduced wear
—only simple gear boxes required
Speed insensitive to voltage variation
Choice of direction of rotation
—units available for clockwise, anti-clockwise, or reversible rotation
Stepping operation possible
Automatic braking
—stops virtually instantaneously when stator de-energised
Wide range of gearing available
—for all motors, 50 reduction ratios available in standard casings
Maintenance low
—units run for years without any maintenance
Subjected to rigid tests
—besides the normal quality control tests, samples are subjected to impact tests, and damp-heat tests simulating extremes of environmental conditions

SOME APPLICATIONS

Time
—electric clocks
—masterclock systems
—attendance control clocks
—elapsed time indicators
Programmed timers for
—domestic appliances
—laboratories
—industrial furnaces
—photographic darkrooms
—X-ray equipment
—ultra-violet and infra-red lamps
—control of street lights
—industrial automatic control
Sequence switching for
—neon lighting
—traffic signals
—railway signalling
—automatic switchgear
Constant speed drives for
—recording instruments
—film and TV projection
—professional film and TV
—programmed instruments
—bookkeeping machines
—computers
General
—remote-controlled TV tuners
—general remote control and actuation
—display turntables
—stoker controls
—fire alarm systems
—time delay relays

Based on a 24-pole rotor field system constructed of high coercive-force Ferroxdure, Philips synchronous motors possess unusually high torque/volume ratios at the comparatively low running speed of 250 rpm. Both unidirectional and reversible types are available, all additionally being capable of stepping operation. The above factors, coupled with the availability of standard gear boxes providing a wide selection of gearing ratios, yield drive combinations suitable for numerous applications in Industry and Technology.

Fundamentals of Philips Synchronous Motors

Although the motors to be described are multi-polar (for low speed operation), the fundamentals of operation are best considered on a simple two-pole basis. These motors consist of a permanent magnet rotor and a wound single-phase stator.

The alternating stator field set up in the air gap as a result of the single-phase energising current can be resolved into two fields of half-magnitude, revolving in opposite directions at synchronous speed.

The permanent-magnet rotor could now be caused to follow either the field rotating in a clockwise, or that rotating in an anti-clockwise direction. For example, should the rotor be driven by the field rotating clockwise, then the field rotating anti-clockwise would exert a vibration with double the frequency of the main field. However, if the unwanted field is cancelled, a predetermined direction of rotation can be achieved and vibration problems eliminated. During a half-cycle of mains frequency the rotor would move through 180° (the peripheral distance between adjacent poles—or the "pole-pitch") and a unidirectional torque would be maintained.

Suppression of Unwanted Rotating Field

To this end a compensating field has been introduced, the field vector relationships being as illustrated in Fig. 1. The North and South poles denote instantaneous magnetic polarities, the auxiliary field structure being offset relative to the main field by an angle $\alpha°$.

The main stator field H, which changes sinusoidally, is represented by the rotating vectors H_l and H_r, whilst the compensating (or auxiliary) stator field F, also sinusoidal, is represented by F_l and F_r which also rotate at synchronous speed.

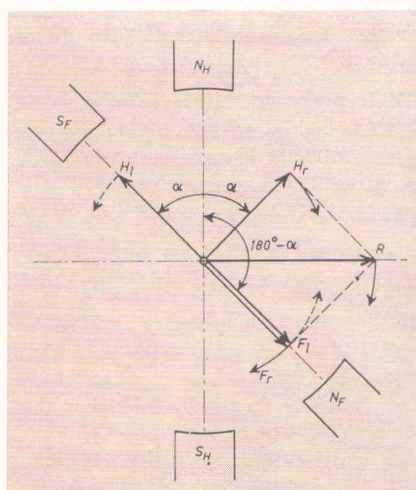


Fig. 1. Vector representation of technique whereby unwanted rotating field is eliminated. (N_F S_F represent an auxiliary stator field system.)

For clockwise shaft rotation, the field F_1 should always be equal and opposite to the field H_1 rotating in the same anti-clockwise direction. This condition will be satisfied when the fields H and F are equal in magnitude, but with phasing such that F leads H by $(180-a)°$. The resulting field is then a clockwise one, R, the resultant of H_r and F_r.

This system has been adopted for Philips reversible motors.

When two stator windings are incorporated within the one casing, the required phase shift between the fields, $(180-a)°$, can be obtained by means of a capacitor which can be connected in series with either winding. This is depicted in Fig. 2.

Current I_1 in coil L_1 lags the voltage by a certain angle (45°). With the aid of the capacitor, current I_2 in coil L_2 can be made to lead the voltage by 45°, and thus lead I_1 by 90°. The total stator current I_t will be approximately in phase with the voltage (unity power factor) resulting in maximum efficiency and low power consumption.

If the connections are reversed, the direction of rotation will also be reversed.

Besides the circuit of Fig. 2, another configuration is possible in which the two windings are connected in series (suitable for higher voltage operation).

Motors with Fixed Direction of Rotation

For these motors, the creation of a unidirectional field again depends on the production of an auxiliary stator field. In this case copper rings are fitted around each of the auxiliary poles, as depicted in simplified form in Fig. 3.

A portion of the total stator flux is shunted through the auxiliary flux path. This alternating flux results in currents through the rings, and additional magnetic flux ϕ_r associated with these currents. The resultant auxiliary flux ϕ_F is thereby caused to lag the main field flux ϕ_H, as required.

Speed Reduction Using 24-pole Ferroxdure Rotor

In extending the theory to multi-pole motors, one has simply to consider that unidirectional torque is maintained provided that, once again, a pole-pitch is traversed in a half-cycle of mains frequency. Expressed mathematically this becomes:

$$n = \frac{60\,f}{p}$$

where n is rotational speed (rpm)
f is synchronous frequency (c/s)
p is number of pole pairs.

The introduction of additional pole pairs thus reduces the rotor speed. However, the number of pole pairs which can be incorporated on a magnet ring depends on its diameter (space available on periphery) and the properties of the magnetic material. The magnetic material Ferroxdure is characterised by a high coercive force. This means that a large number of strong poles can be accommodated around the periphery. In the Philips range of synchronous motors, as many as 24 poles (12 pole pairs) could be incorporated, with a resulting rotor speed of 250 rpm for 50 c/s mains, and 300 rpm for 60 c/s mains.

This low motor speed demands only slight gearing reduction for most applications. This results in gear boxes of simple design with reduced wear.

Starting of High Torque Type

A high torque synchronous motor of necessity possesses a relatively heavy permanent-magnet rotor. The associated large mass moment of inertia, in conjunction with the load, can cause starting difficulties as the rotor-ring has to be rapidly accelerated from rest to full speed.

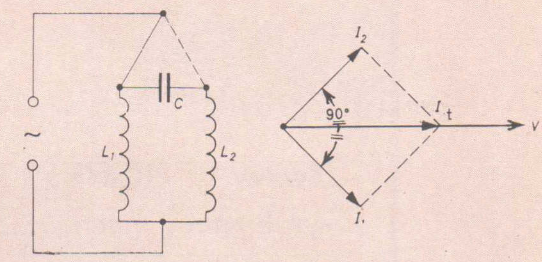


Fig. 2. System for obtaining auxiliary field for reversible motors.

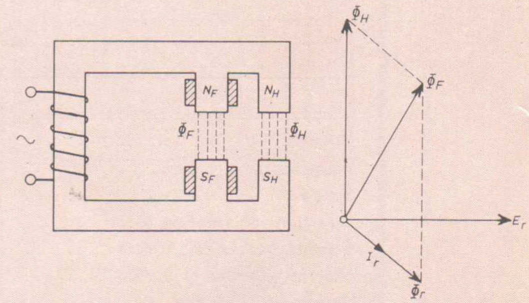


Fig. 3. Derivation of auxiliary field from main stator field, for unidirectional motors.

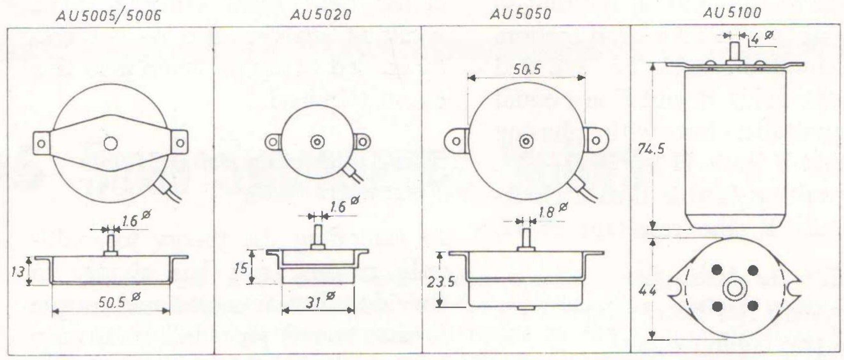
In the case of the high-torque motor type AU5100, this problem has been solved by the use of a flexible connection between magnet-ring and spindle. This patented "resonance rotor" enables the magnet-ring to be accelerated from rest to full speed at a rate determined by its own resonance frequency and independent of the connected load.

Types and Performance of Philips Synchronous Motors

Philips synchronous motors are available in voltages ranging from 24 V to 240 V in both 50 and 60 c/s versions. Fixed direction types are available for either clockwise or counter-clockwise rotation. A survey of all types is given in Table 1. All motors are additionally available with spindles fitted with pinions suitable for adaption to the

Table 1

Survey of PHILIPS synchronous motors



All dimensions in mm.

	AU 5005	AU 5006	AU 5020	AU 5050	AU 5100	
Voltage	220 [1]	220 [1]	24 [3]	220 [1]	220 [1]	V
Frequency	50 [2]	50	50 [2]	50 [2]	50 [2]	c/s
Speed	250 [4]	250	250 [4]	250 [4]	250 [4]	rpm
Direction of rotation	clockwise [5]			electrically reversible		
Starting torque at 1 rpm [6]	3,750	6,250	6,250	25,000	75,000	gcm [7]
Working torque at 1 rpm [6]	3,750	6,250	6,250	25,000	100,000	gcm [7]
Power consumption	1.1	1.1	0.38	1.4	5	W
Temperature rise	20	20	10	20	45	°C

[1] Also available for other voltages.
[2] Also available for 60 c/s.
[3] Available with suitable series resistor or capacitor for all voltages from 24 V to 240 V.
[4] Speed for all types is 300 rpm for 60 c/s supply.
[5] Also available for anti-clockwise rotation.
[6] The efficiency of the gear box is not taken into account.
[7] 100 gcm = 1.39 oz-in; 1 oz-in = 71.9 gcm.

standard gear box range, type AU5300, as described hereunder. When pressing a pinion onto a spindle the end thrust should be taken up at the free end.

Performance curves for randomly selected units of all types are given opposite.

Braking Torque

Philips synchronous motors produce considerable braking torque because when the energising current is interrupted, the strong rotor magnets move across, and within close proximity to, the stator windings. The resulting retarding fields produced, cause the motor to stop almost instantaneously.

The small angle through which the rotor continues to move after switching off depends on both the magnitude and mechanical inertia of the load. However, in the majority of applications additional external braking is unnecessary.

Motor Bearings

All Philips motors are fitted with bearings requiring no maintenance. Two types of bearings are used:

—Sintered bronze iron slide bearings. These self-lubricating type bearings are used in the high-torque motor type AU5100.

—Plastic slide bearings. These low friction coefficient bearings are used in all motor types except AU5100. The bearing material is a high-quality polyamide incorporating a very fine-grained emulsion of molybdenum disulphide providing self-lubricating properties. The surface of the bearing material is specially treated to obtain a coarse crystalline structure making it extremely resistant to wear. Moreover, this treatment reduces the water absorption to less than 1.5%.

As the coefficient of friction is very small (< 0.05), the losses due to friction are low.

These bearings are chemically resistant to such normal organic solvents as esters, ketones, lubricating oil, petrol, paraffin and solutions of organic salts.

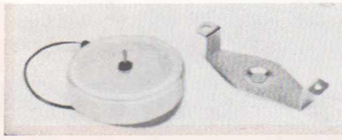
Standard Gear-Box Range Type AU5300

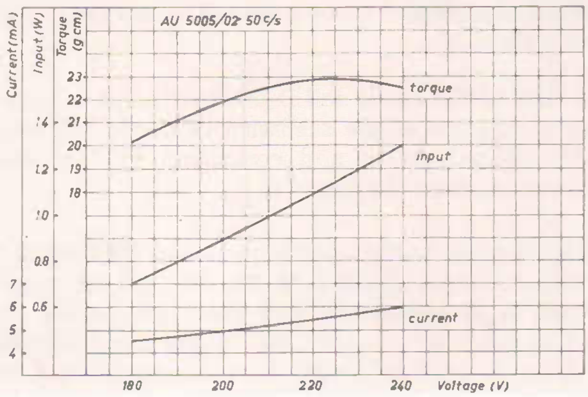
Reduction gearing in standard casings, is available in more than 50 types ranging from 25/6 to 360,000/1, specific details being available upon request.

For 50 c/s operation (250 rpm spindle speed) the above range corresponds to a final shaft speed range of 1 rev/sec to 1 rev/24 hrs. Performance curves for drive combinations comprising synchronous motors and type AU5300 gear box, are given in Fig. 4.

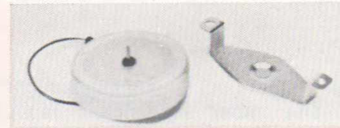
Performance of Synchronous Motors (units selected at random)

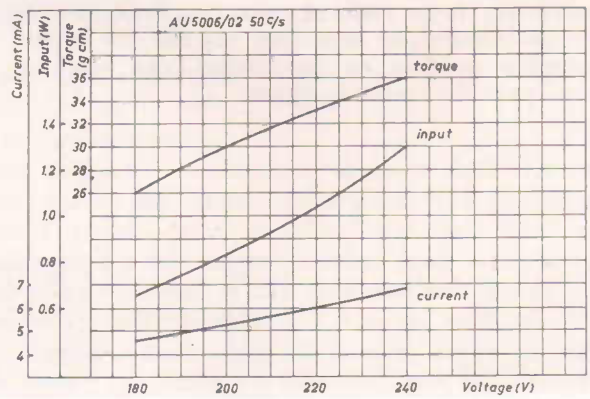
AU 5005



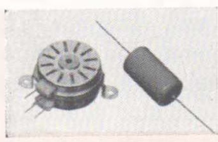


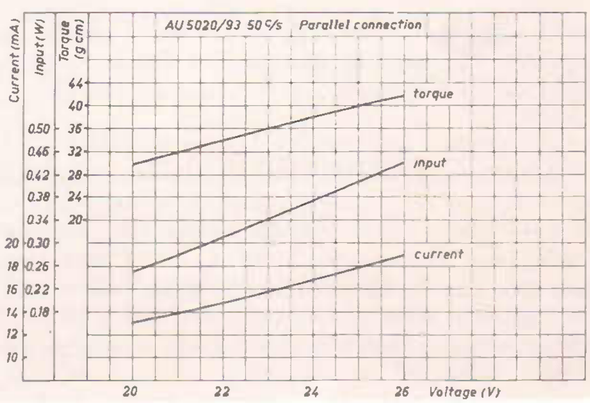
AU 5006



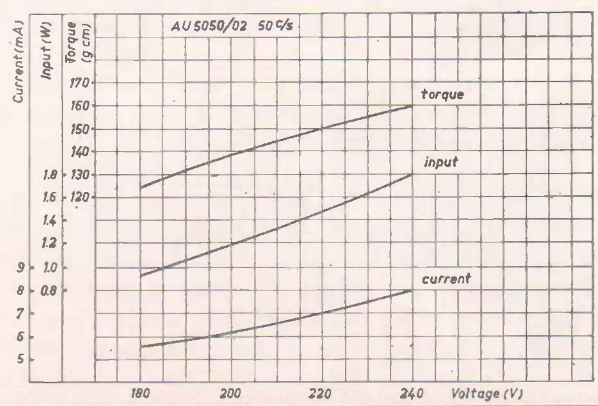


AU 5020

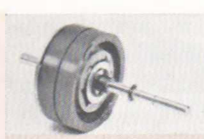




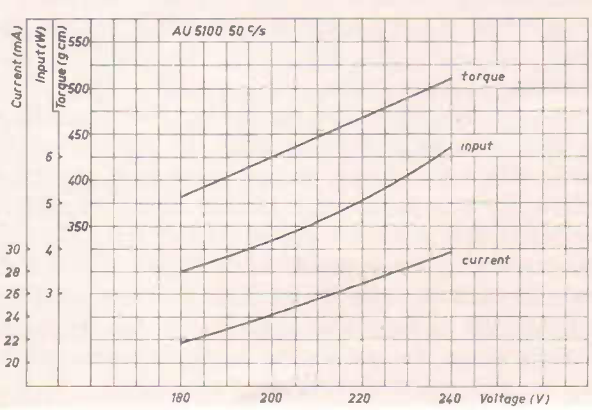
AU 5050



AU 5100



"Resonance" Rotor



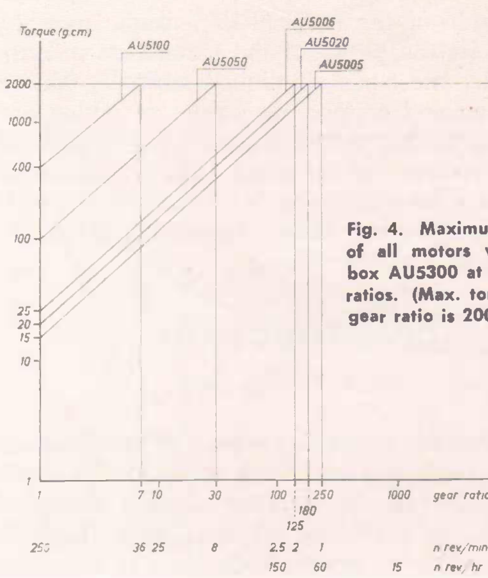


Fig. 4. Maximum torque of all motors with gear box AU5300 at various gear ratios. (Max. torque for any gear ratio is 2000 gm. cm.)

PHILIPS Electrolytic Capacitors

The most significant feature of the electrolytic capacitor compared with other varieties is the extremely large ratio of capacitance to volume. Philips electrolytic capacitors feature the largest possible product of capacitance and working voltage in the smallest volume.

Certain metals such as Aluminium, Tantalum and Magnesium, to mention a few, are readily coated with an oxide film when subjected to an electrolytic "forming" process. Such oxide films possess a high resistance in one direction with almost conductive properties in the other, and it is this oxide film that forms the dielectric in all electrolytic capacitors. Aluminium being readily available and comparatively cheap is best suited for use in the manufacture of electrolytic capacitors with Tantalum also used for special types.

The forming process consists of immersing an aluminium anode in a tank filled with electrolyte and containing a suitable cathode such as aluminium or stainless steel. On the application of a positive direct voltage between anode and cathode a critical value is reached at which aluminium ions are liberated from the anode material and combine with electrolytically produced oxygen ions to form a film of aluminium oxide on the surface of the metal.

For any constant voltage applied above the critical value for ion movement, the initial current is high then gradually decreases as the oxide film is deposited on the surface of the anode. The process is completed when the current has decreased to a constant residual value. Thus the thickness of the oxide layer may be accurately controlled by selecting the value of the "forming" potential applied.

The amplitude of the residual or leakage current is determined by the purity of the aluminium foil used as the anode, and since aluminium normally contains traces of iron and copper, the oxides of which have very poor insulating properties, only the most highly refined aluminium can be used. Philips electrolytic capacitors are manufactured from 99.998% pure aluminium and as a result these components possess the lowest leakage current available.

CONSTRUCTION

(refer to Fig. 1)

Philips electrolytic capacitors consist of an aluminium foil anode (positive plate) with an oxide film dielectric, preformed in the manner already described. Layers of porous paper are saturated with electrolyte paste and positioned against both faces of the anode. The electrolyte is the true cathode (negative plate) of the system; however for convenience of electrical connection a second aluminium foil is used as a contacting electrode.

The start of the anode foil is crimped on to a central aluminium pin and the sandwich of anode foil, electrolyte soaked paper, and contacting foil are then interwound about the pin.

A disc of resin bonded paper covered with a layer of special rubber is located at one end of the pin to provide a firm and effective basis for sealing the winding into the can. The end of the contacting foil winding is provided with a small aluminium tag which is secured between the resin paper disc and the inside of the aluminium can during the sealing process. The corrosive effects of heat and moisture are precluded by providing an hermetic seal for the container and by the use of aluminium piece-parts. This seal also prevents the electrolyte from drying out, so ensuring a long-life component.

Tinned copper connecting leads are welded into receptacles provided at each end so that intermittent contact or open circuits are virtually impossible.

CHARACTERISTICS

The equivalent circuit of an electrolytic capacitor consists of a capacitance with a series and shunt resistance. The series resistance is principally formed by the internal resistance of the electrolyte, while the shunt resistance represents the leakage current.

Capacitance Variation

The actual capacitance however, is not constant but decreases with rising frequency. This may be explained by reference to Fig. 2 which shows an exaggerated cross section through one winding of an electrolytic capacitor. The complete equivalent circuit (disregarding leakage current for the moment) is composed of a large number of parallel capacitances distributed along the length of the winding, each having a different series loss resistance. One of the techniques available for increasing the capacitance per unit area of foil is to etch the surface of the anode. The more deeply etched portions of the anode surface are associated with thicker layers of electrolyte between it and the cathode contact foil. Thus the capacitances at these points have higher series resistance, so that at high frequencies the corresponding contributions to the total capacitance are much less effective since the resistance is then much greater than the capacitive reactance.

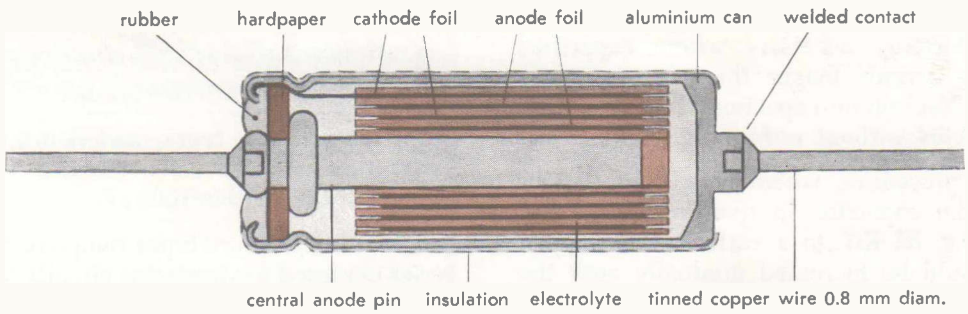


Fig. 1. Cross-section through Philips electrolytic capacitor.

Fig. 3 shows the variation of capacitance with frequency for Philips electrolytic capacitors at two specified temperatures. It may be clearly seen that no fall-off in capacitance is suffered at 20° C throughout the entire frequency range given, whilst at 0° C the capacitance at 10 Kc/s has fallen by less than 20% of its low frequency value. It has been known for poorer quality electrolytic capacitors to exhibit such a high capacitance drop at low temperatures as to render the component unsuitable for use under such conditions.

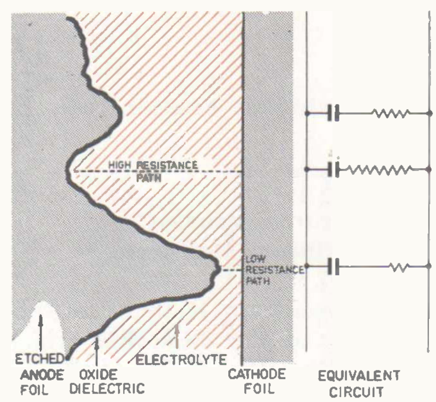


Fig. 2. Exaggerated cross-section through one winding, showing the effective variation in electrolyte thickness.

Leakage Current

Leakage current is composed of two components, one fixed, one variable.

The fixed component is governed by the purity of the aluminium used for the anode foil and primarily sets the minimum possible leakage current attainable with a new fully formed capacitor.

The variable component is determined by slight chemical activity which exists between the electrolyte and the oxide. This action tends to gradually deteriorate the dielectric properties of the oxide, which is counterbalanced in part by the constant forming of the oxide, provided by normal operation.

At elevated temperatures of operation both components of leakage current increase causing dielectric heating. This in turn increases the leakage current further so that a runaway condition could exist whereby the capacitor is eventually destroyed.

The maximum leakage current applicable to all Philips electrolytic capacitors at 20° C, five minutes after the working voltage has been applied, is 0.08 CE (μA) where C is the nominal capacitance (μF) and E is the working voltage: it will usually be less than 20% of the limit quoted.

Re-forming

From the above considerations it is apparent that after extended periods of storage or non-use the dielectric may deteriorate sufficiently to produce an excessive leakage current and warrant re-forming.

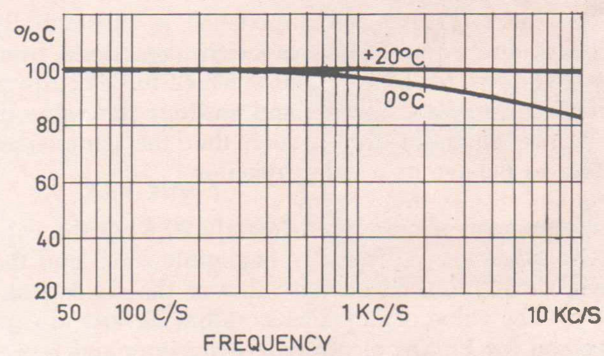


Fig. 3. Variation of capacitance with frequency at two specific temperatures.

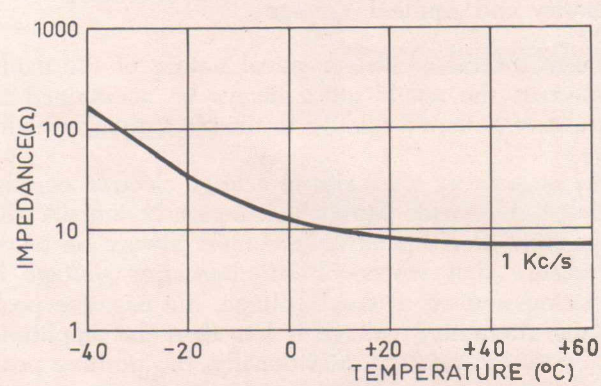


Fig. 4. Variation of impedance with temperature of Philips 25 μF capacitor at 1 Kc/s.

Although it has been common practice in this country to consider re-forming necessary where capacitors were stored for periods longer than three to four months, Philips electrolytic capacitors may be stored for up to two years without re-forming.

The re-forming procedure, where necessary, consists of connecting the capacitor in question through a series resistor, e.g. 82 KΩ, to a variable DC supply. The voltage should be increased gradually until the working voltage is reached without the leakage current at any stage exceeding twice the rated value. The working voltage should then be applied for approximately 4 hours during which time the oxide dielectric will have re-formed, reducing the leakage current to normal.

Impedance

The impedance of an electrolytic capacitor may be expressed by the equation

$$Z = \sqrt{X_c^2 + R_s^2}$$

where X_c = capacitive reactance
R_s = resistance of electrolyte

At low temperatures the resistance R_s increases substantially due to freezing of the electrolyte which impedes the ionic mobility. The graph of Fig. 4 indicates the impedance change with temperature of a Philips 25 μF 10 V capacitor at a frequency of 1 Kc/s.

It will be seen that the impedance is substantially constant and equal to the capacitive reactance from +60° C down to +10° C below which the electrolyte resistance rapidly increases and swamps the value of X_c in the equation above, such that the component ceases to behave as a true capacitor.

At frequencies above approximately 20 Kc/s the capacitive reactance X_c becomes negligibly small and the impedance is limited by the value of the series resistance. The value of impedance at 100 Kc/s is always specified for Philips electrolytic capacitors and represents a means of assessing and comparing the quality.

Polarity and Applied Voltage

Because of the electro-chemical nature of the oxide dielectric, the anode must always be maintained at a positive potential relative to the electrolyte cathode.

Reverse polarity gives rise to a large electron current through the oxide film which seriously impairs the capacitor. Consequently, care must always be taken to ensure that whenever an alternating voltage is superimposed on a direct voltage, the negative peak of the alternating voltage is less than the amplitude of the direct voltage. Additionally, the positive peak of the alternating voltage plus the direct voltage must not exceed the specified peak working voltage of the capacitor.

SELECTION

The Philips range of electrolytic capacitors may be broadly classified into two groups:

High temperature types comprising the C425, C435 series designed for valve circuits, with capacitance values available up to 1000 μF.

Medium temperature types comprising the C426, C436 series designed for transistor circuits, with capacitance values available up to 2000 μF.

Capacitance and Tolerance

A rationalised range of capacitance values and working voltages has been provided to conform with IEC Standards as adopted by NATO. Ten capacitance values per decade are supplied to —10%, +50% tolerance (except for can size 1 where —10%, +100% applies).

Working Temperature

The temperature rating for capacitors in the medium temperature range is 60° C continuous, except in the instance of the smallest can size where the limit is set at 50° C continuous. Where the components are operated for less than 12 hours in every 24, the temperature may be increased to 70° C and 60° C respectively. The high temperature range is rated at 70° C continuous which may be increased to 85° C where the components are operated for less than 12 hours in every 24.

Maximum Working Voltage

The maximum working voltages available at full rated temperature may be obtained from the chart opposite. A peak working voltage of ($1.25\ E_{max} + 0.5\ V$) may be applied at the maximum temperature for 1 minute per hour.

Where the continuous maximum temperature is under-rated by not less than 20° C, the maximum working voltage may be increased by 10%.

General

Once the requirements relating to the application of an electrolytic capacitor are known, reference should be made to the chart shown opposite. Within the range however, there may not be a type available to exactly meet the requirements of capacitance or working voltage. Thus two alternatives exist:

—To select a capacitor with higher nominal capacitance at the required working voltage.

—To select a capacitor with the required capacitance and a higher working voltage.

The second alternative is recommended as it will provide worthwhile advantages in most applications.

Where a Philips electrolytic capacitor is operated at less than the rated working voltage the leakage current is considerably reduced and the capacitance has a tendency to increase in value with age—a highly desirable characteristic.

Medium Temperature Electrolytic Capacitors
Maximum Working Temperature 60°/70° C

E_{max} (V) →	2.5	4	6.4	10	16	25	40	64
C_n (μF) ↓	Can size							
0.32								1
0.5							1	
0.8						1		
1.25					1			
1.6								2
2				1				
3.2			1				2	
4		1						
5	1							
6.4						2		3
10					2			
12.5							3	
16				2				4
20			2					
25		2				3		
32	2						4	5
40					3			
64				3		4	5	01
80			3					
100		3			4		01	02
125	3					5		
160				4		01	02	03
200			4		5			
250		4			01	02	03	
320	4			5				
400			5	01	02	03		
500		5	01					
640	5	01		02	03			
800	01		02					
1000		02		03				
1250	02		03					
1600		03						
2000	03							

High Temperature Electrolytic Capacitors
Maximum Working Temperature 70°/85° C

E_{max} (V) →	4	6.4	10	16	25	40	64
C_n (μF) ↓	Can size						
0.64							3
1						3	
1.6					3		
2							
2.5				3			
3.2							
4							3
5							
6.4						3	
8							
10					3		4
12.5							
16				3		4	
20							5
25			3		4		00
32		3				5	
40	3			4		00	01
50					5		
64			4		00	01	02
80		4		5			
100	4			00	01	02	03
125			5				
160		5		01	02	03	
200	5						
250			01	02	03		
320		01					
400	01		02	03			
500		02					
640	02		03				
800		03					
1000	03						

Selection Guide
for
Philips Electrolytic Capacitors

Can Size 1

Can Size 2

Can Size 3

Can Size 4

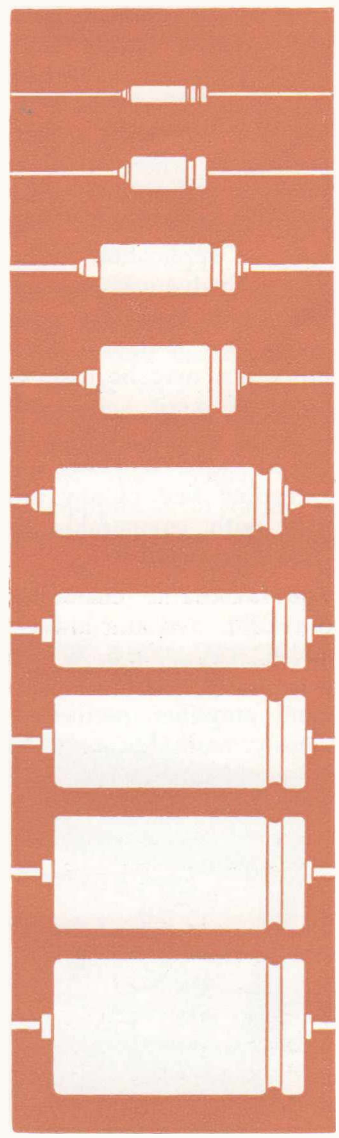
Can Size 5

Can Size 00

Can Size 01

Can Size 02

Can Size 03



Actual Sizes of Cans

The E55L Wideband Output Pentode

The combination of high slope and high power output in the Premium Quality pentode E55L enables the construction of simpler and more economical wideband amplifiers.

Advantages of the E55L

The new high-slope power pentode E55L with a maximum plate dissipation of 10 W is designed for applications requiring both a large plate current swing and a high value of mutual conductance. Such requirements arise in a wideband amplifier supplying a low impedance load, where a large current swing is required in order to develop a high output voltage. In such an application, high g_m and minimal valve capacitances are desirable to keep the number of stages to a minimum. These latter properties may be expressed as a figure of merit (*gain—bandwidth factor*) which is as high as 194 Mc/s for the E55L, a value far exceeding that of any other pentode with comparable maximum plate dissipation.

The favourable characteristics of the E55L and the lower-powered E810F ($P_{a\ max} = 5$ W) can now provide, in cascaded stages, wideband amplifier performance previously realisable only with distributed technique.

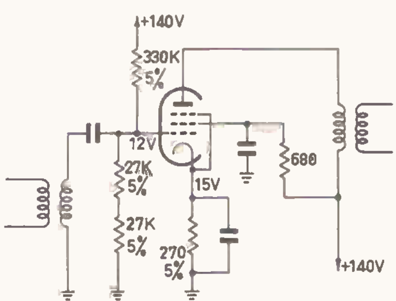


Fig. 1. Recommended DC operating conditions of a tuned RF amplifying stage with E55L.

Such excellent performance is made possibly only by employment of the Philips frame-grid technique of valve construction. In common with the above mentioned type E810F, the E55L is a dual frame-grid valve; that is, both control grid and screen grid are of frame-grid construction. The control grid structure results in the high figure of merit whilst the screen grid structure, using thinner wire than is possible with conventional self-supporting grid windings, permits the attainment of an I_a/I_{g2} ratio as high as 9/1, whilst still maintaining a very low value of C_{a-g1}.

Further advantages of the dual frame-grid construction are a low spread in characteristics, as well as stability of characteristics when switching from low to high plate current.

Recommended Bias Arrangements

It is recommended that very high-slope valves such as the E55L be operated with a large amount of DC feedback provided by the cathode resistor in order to stabilise the operating point. It is then necessary to apply a potential to the control grid which is positive with respect to ground. A typical circuit arrangement is shown in Fig. 1.

Typical Applications

Applications for wideband amplifiers include: pulse amplifiers, vertical deflection amplifiers in oscilloscopes, TV signal distribution amplifiers, TV studio equipment, repeaters in coaxial cables, microwave links and radar systems.

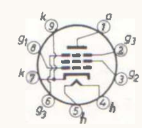
PHILIPS E55L

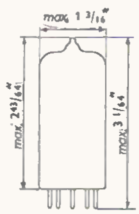
Premium Quality Wideband Output Pentode

(Abbreviated data)

General Electrical Data

Heater voltage	6.3 V
Heater current	600 mA
Base: Novar (B9D)	





Direct Interelectrode Capacitance (unshielded)

Input capacitance (I_k = 55.5 mA)	28	pF
Output capacitance	4	pF

Maximum Ratings (Absolute Maximum)

Plate dissipation	10	W
Grid No. 2 dissipation	1.5	W
Cathode current	75	mA

Typical Characteristics

Plate voltage	125	V
Grid No. 2 voltage	125	V
Grid No. 3 voltage	0	V
Grid No. 1 voltage	—3	V
Plate current	50	mA
Grid No. 2 current	5.5	mA
Mutual conductance	45	mmho
Amplification factor	30	
Input resistance (f=50 Mc/s)	1	KΩ

Typical Operating Conditions

Plate voltage	140	V*
Grid No. 2 voltage	140	V*
Grid No. 3 voltage	0	V
Grid No. 1 voltage	+12	V*
Cathode resistor	270	Ω
Plate current	50	mA
Grid No. 2 current	5.5	mA
Mutual conductance	45	mmho

* With respect to ground.

Novar Envelope

The performance specifications of the E55L require all-glass construction. A Premium Quality valve structure with 10 W plate dissipation cannot be built into a Noval type envelope, and the larger Novar envelope was therefore chosen for the E55L.

Commercial Comment

CONTINUITY

To technical readers the word "continuity" is immediately associated with continuity in an electrical circuit. Indeed, it is fundamental knowledge to all those connected with the electronics industry that continuity must be maintained for an electric current to continue to flow.

By analogy, it is equally true, although perhaps not so obvious, that continuity is essential in all facets of commercial activity to ensure the flow of profits.

Few successful business ventures are based on short-term non-repetitive operations. Most businesses are dependent on continuity of customer, supplier and employee goodwill for profitability and the expectation of a continuance of that profitability.

The direction and management of most large business enterprises concern themselves more deeply with continuity than most other business activities.

The setting up of memoranda and articles of association dealing with objectives, deal explicitly with continuity. Capital, production, sales, publicity and depreciation budgets are all set up on a programme of continuity.

Additionally, long - term plans usually based on from five to fifteen years, deal extensively with the possibilities of market saturation, the possibility of change in customer habit, choice, or motivation. The influence of technological change or advancements and even gimmicks must all be considered by the progressive company, giving proper regard to continuity.

Continuity in the small or medium-size business is no less important than in the large business undertaking. Moreover, the planning and application of methods for continuity can be better controlled with shorter and more strict lines of communication and control.

A simple but fundamental fact of business life in the average moderately successful retail or service business is the known customer turnover of approximately 15-20% per annum. This percentage of old customers is lost, to be replaced by approximately the same percentage of new customers.

Obviously, improvement in business activity will follow the successful implementation of any scheme to reduce the loss of old customers, whilst maintaining the same high rate of absorption of new customers.

Continuity of contact with customers has been proved the best method to achieve this end. Do not forget to keep an efficient customer follow-up file showing details of last sale or service, condition of all appliances, and so on, and follow up at regular intervals after the last transaction to ensure satisfaction.

Whilst it may be uneconomical to make personal calls at customers' homes, letters or other printed matter can be used to maintain a continuity of contact. The information mailed should preferably be of a type that will invite the customer to keep it for future reference.

Much more use could also be made of the telephone as an economical means of making person-to-person contact in a follow-up campaign. Provided that the art of salesmanship by 'phone is mastered, this method can be used to obtain further sales and to arrange for regular overhauls of radio and TV sets.

Even a low-budget publicity programme can be effective if well planned, developed and placed. Never overlook the value of word of mouth. Publicity from one well-satisfied customer develops another.

It is essential to use every means to keep your name continually before your customers. In this regard the "Miniwatt" Service Stickers will prove invaluable — supplies of Stickers are available through your wholesaler or at your nearest "Miniwatt" office.

Of course, in order to be able to demonstrate to customers that you are really up-to-date instead of just trying to appear so, it is essential to make adequate allowances for depreciation, replacement and augmentation of your vehicles and technical equipment in order to keep abreast of latest developments.

"Miniwatt" Service Sticker available on request.

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