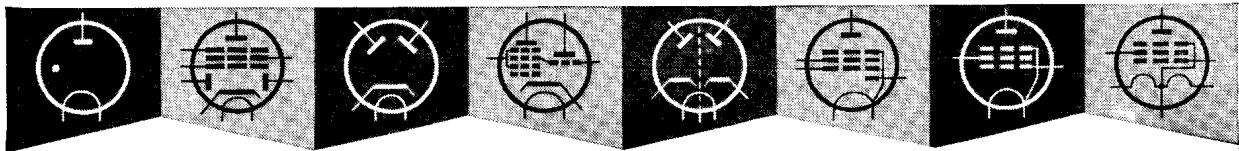


VALVES, TUBES & CIRCUITS

1. PREVENTION OF INTERFERENCE BY TELEVISION RECEIVERS



A television receiver is capable of producing interference with broadcast reception over a limited area. This interference is due in the main to induced electric fields and magnetic fields set up in the neighbourhood of the television receiver; re-radiation of parasitic oscillations from the receiver proper is less serious and will not be considered here. The electric field is the more troublesome since it will affect broadcast receivers having ordinary aerials; the magnetic field will influence only that minority of receivers having frame aerials.

The most important sources of interfering electric fields are the line output transformer and associated high potential points; the deflector coils; and high impedance circuits near these components. Since, in general, magnetic fields emanate from the same sources, the measures recommended below will reduce both causes of interference.

- (1) The E.H.T. transformer, booster diode and line output valve should be totally screened by a can which makes good contact with the chassis. Two-hole fixing of the can is not entirely satisfactory and it is advisable to make multiple connections between can and chassis. The difference in radiation between a good and a bad connection here may amount to as much as 8 dB for magnetic fields.
- (2) Any width or linearity controls of the inductor type should be screened separately if they cannot be accommodated inside the line output screening can.

The design of the line output screening involves problems of ventilation to avoid overheating of the components enclosed by the screen. As a general guide to designers, the maximum safe bulb temperature for the PL81 line output pentode has been determined at 185° C. (design centre rating).

- (3) The deflector coils should be screened as far as possible by an aluminium can or by metal foil wound coaxially around the coil and earthed to chassis. Care must be taken to ensure that there is no likelihood of voltage breakdown between the foil and the coils. This form of screening will give good reduction of electric fields and will also reduce magnetic fields but not to the same degree. To reduce the magnetic field still further, the deflector coil screening can should have endplates with holes only just large enough for the tube neck to pass through. This gives a further reduction of approximately 6 dB.
- (4) Care should be taken in the layout of the receiver to keep circuits of high impedance well away from the worst sources of interference.
- (5) The graphite coating of the cathode ray tube should be efficiently connected to earth—preferably from two separate points on the coating.
- (6) Both conductors of the mains supply should be connected to the earth terminal via 0.05 μ F paper capacitors rated for 600 V_{r.m.s.} working.
- (7) The use of a perforated foil screen at the back of the set will reduce radiation in that direction.



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A D D I T I O N A L N O T E S

PREVENTION OF INTERFERENCE BY TELEVISION RECEIVERS—contd.

The following tables indicate the interfering field strengths measured six feet from the back of a conventional 12-inch television provided with various forms of screening. At present there is no generally accepted standard for permissible radiation, but to give significance to these measurements suggested design figures are included in the tables.

FORM OF SCREENING	FIELD STRENGTH*	ATTENUATION
ELECTRIC FIELD STRENGTHS		
	(μ V)	(dB)
1 Simple screening can over line output transformer and line output valve.	330	0
2 As (1) but with additional screening at back of set.	102	10
3 As (2) but with simple screening of deflector coils.	60	15
4 As (3) but with multiple connections to line output screening can and end-pieces on deflector coil screening.	20	24
5 As (4) but with foil screening on deflector coils, and back top and sides of receiver screened.	20	24
6 As (4) but with non-graphite-coated picture tube.	46	17
7 Suggested design figure.	50	
* The aerial used was a 4-ft vertical rod located 6 feet from the back of the set		
MAGNETIC FIELD STRENGTHS		
	(μ V/m)	(dB)
1 Unscreened	9,000	0
2 Deflector coils only screened with foil wound coaxially around coils.	3,140	10
3 As (2) but with end-plates on deflector coils.	1,570	16
4 As (3) but with screening can over line output transformer and line output valve	800	21.5
5 As (4) but with multiple connections to line output screening can.	360	29.5
6 Suggested design figure.	400	

All measurements were made on a frequency of 162 kc/s (wavelength 2,000 metres). The reasons for this choice of frequency were:

(1) Freedom from broadcast interference

(2) The induced harmonic falls as the frequency increases. Thus, the worst case to be considered is the long-wave band. The programme which will be most affected by line timebase interference is the Droitwich Light Programme. The carrier frequency of this programme is 200 kc/s, and the 20th harmonic of the line timebase is normally 202.5 kc/s. This will produce a 2.5 kc/s beat with Droitwich. The field pattern around an unscreened television receiver is more or less uniform, but when the top, back and sides of the set are screened the field pattern assumes a cardioid shape due to the front of the tube being unscreened.

Fortunately this front radiation is not normally very serious because the front of the receiver is usually some ten to fifteen feet from an opposite wall and hence from a neighbour's broadcast set, whereas the back of the television receiver may be only two or three feet away from a party wall. Thus, under all domestic conditions, but more especially in flats, the back radiation is the more serious.



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ADDITIONAL NOTES

**A PUSH-PULL AUDIO OUTPUT STAGE
EMPLOYING TWO ECL80 TRIODE-PENTODES (continued)**

BLOCK DIAGRAM

A block diagram showing the functions of the separate sections of the two ECL80's is given in Fig. 2. The voltage amplifier and phase inverter stages utilise the two triode sections, V1A and V2A, respectively. The push-pull output is obtained from the two pentode sections V1B and V2B.

OUTPUT PENTODES

The output valves are operated in Class "A" in order to reduce to a minimum the change in current when a signal is applied. Cathode bias is employed and is obtained from a resistor R6 common to both valves. This resistor is by-passed by a capacitor C3. With an h.t. line voltage of 170V or 200V, the optimum value of anode load (R_{a-a}) is 15 k Ω and the cathode resistor R6 should be 180 Ω . The performance of the output pentodes is summarised below. The output power quoted in this table is the actual power output of the valves. Some loss will occur in the output transformer, T1, depending upon the design and the materials used in its construction. Grid stopper resistors are not included in the circuit as no trouble should arise from parasitic oscillations in the output stage.

Typical Operating Data for Output Pentodes

V_b	...	...	170	...	...200	V
$I_{a(o)}$	...	...	29	...	... 34	mA
$I_{g2(o)}$	...	...	6.0	...	... 7.0	mA
I_a (max. sig.)	...	...	30	...	... 37	mA
I_{g2} (max. sig.)	...	...	7.2	...	... 9.0	mA
V_{g-g} (r.m.s.)	...	...	2×4.2	...	2×5.0	V
P_{out}	...	...	2.0	...	... 3.0	W
D_{tot}	...	...	1.2	...	... 2.0	%

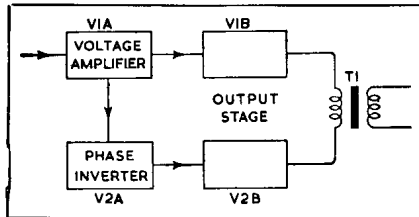


Fig. 2. Block diagram of amplifier.

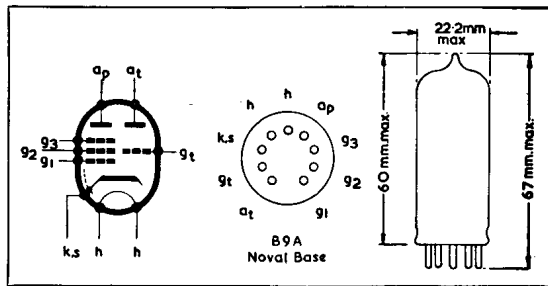


Fig. 3 Base connections of ECL80.

ADDITIONAL NOTES

A PUSH-PULL AUDIO-OUTPUT STAGE
EMPLOYING TWO ECL80 TRIODE-PENTODES (continued.)

VOLTAGE AMPLIFIER

In order to reduce the number of components to a minimum the voltage amplifier triode V1A is operated with the same bias as the output valves. This is achieved by returning the grid resistor R1 to earth instead of to a tap on the cathode resistor R6. With an h.t. of 200V, the bias developed across R6 is approximately 8V. The voltage gain of V1A with an anode load, R2, of 100 k Ω is 8 times. For an output of 5V r.m.s., required to drive the pentode section, the total harmonic distortion in this stage is 1%.

PHASE INVERTER

The conventional types of phase inverter, using cathode coupling, Fig. 4 (a) and (b), cannot be used because the triode and pentode sections have a common cathode. The anode follower circuit, as sketched in Fig. 4 (c), is not affected by this limitation and is therefore used in this stage. The resistors indicated in Fig. 4 (c) are shown as R3, R4 and R5 in Fig. 1. These resistors, together with C2 and R7, govern the performance of the phase inverter.

The values of R4 and R5 depend upon the voltage gain of the triode. For a gain of 8 times, R5 should be $1.3 \times R4$. If R4 is 270k Ω , then R5 should be 350k Ω . This is, however, specified as the nearest preferred value i.e. 330k Ω . The difference of 20 Ω causes some unbalance in the signal voltages applied to the two pentode grids, but the resulting distortion of the output waveform is small. Deviation of the values of the resistors from the recommended nominal ratings can also cause unbalance but tolerances of up to $\pm 10\%$ do not noticeably affect performance.

R7 functions as a grid resistor for V2A in order to complete the D.C. path to the valve. It is connected to the anode end of R5 rather than directly to the grid. Owing to the low output impedance of the anode follower this connection has negligible effect upon its operation. Connection to the grid would alter the feedback in the anode follower. This would change the gain of the stage.

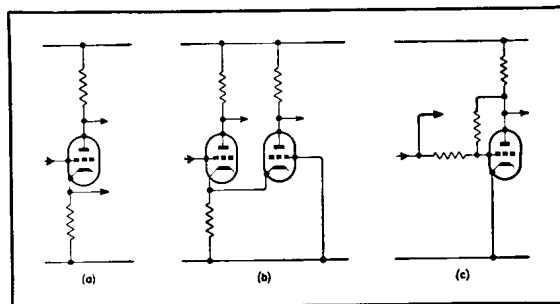
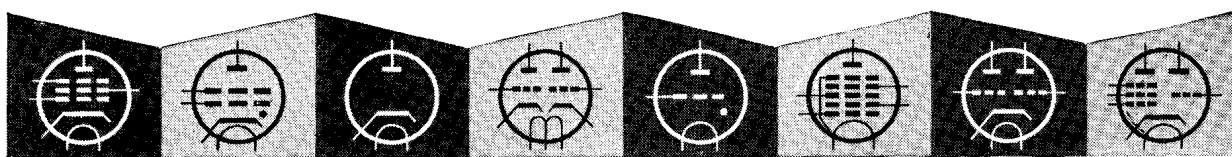


Fig. 4. Basic types of phase inverter stage.



VALVES, TUBES & CIRCUITS

4. "FLYWHEEL" SYNCHRONISATION OF TELEVISION LINE TIMEBASES

The problem of ensuring good line synchronism in the presence of large noise pulses has received more attention in the design of receivers for the negative modulation systems used in the U.S.A. and on the Continent of Europe than in the design of receivers for the British system which employs positive modulation. Nevertheless, a low signal-to-noise ratio in fringe areas in Great Britain also causes poor synchronism when direct synchronising of the line timebase is adopted. This is due, of course, to the timebase being triggered by noise pulses which occur just before the synchronising pulse.

One method of preventing this is to control the frequency of the timebase oscillator by a direct potential which varies with the tendency of the oscillator frequency to drift. The variation of the control potential is obtained by comparing the relative phase of the synchronising pulses with that of the flyback pulse from the timebase oscillator, and this is done by a so-called coincidence detector.

A typical circuit is shown in Fig. 1, and its operation is as follows:

The synchronising pulse input, of approximately 100 volts peak-to-peak, is differentiated and applied to the grid of the triode V1. The grid is so biased that only the negative portions of the differentiated synchronising pulses are amplified by the triode. The pulses appearing at the triode anode then have a leading edge corresponding to the leading edge of the synchronising pulses, but are of shorter duration than the synchronising pulses.

The pentode V2 is employed as the coincidence detector. The pulses appearing at the anode of V1 are applied to the screen grid of V2, and a series of pulses which correspond to the flyback period of the line timebase oscillator are applied to the control grid. The mean anode current of V2 will thus vary with the phase difference between these two sets of pulses, that is to say with the degree of coincidence between them, as illustrated in Fig. 2. The voltage at the anode of V2 will vary accordingly.

V3 and V4 operate as a multivibrator in the conventional manner and constitute the line timebase oscillator, the grid resistor of V3 being returned to the anode of the coincidence detector V2. A positive-going pulse corresponding to the line flyback pulse appears at the anode of V4, and it is this pulse which is applied to the grid of the coincidence detector as previously mentioned. The drive to the line output valve is taken from the anode of V3, being suitably shaped by R1 and C1.

The tuned circuit L1, C2 in the anode circuit of V4 is tuned to the line timebase frequency, and is inserted to improve the long-term stability of the oscillator.

The cycle of operation of this system is:

- (1) Line oscillator frequency falls
- (2) Line scanning time increases
- (3) Line flyback pulse is delayed
- (4) Degree of coincidence between flyback pulse and synchronising pulse at the coincidence detector is reduced
- (5) Anode current of coincidence detector falls
- (6) Anode voltage of coincidence detector rises
- (7) Line scanning time falls
- (8) Line oscillator frequency rises

For an initial rise in line oscillator frequency, the converse of the above stages occurs.

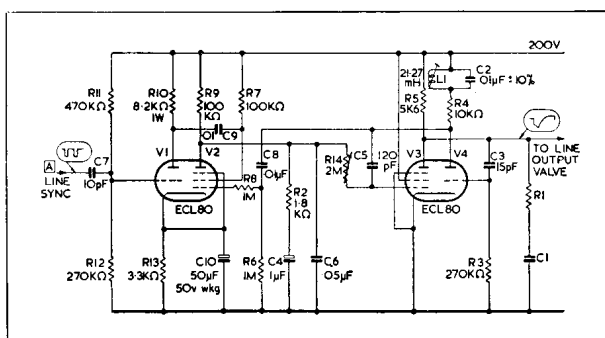


Fig. 1—Typical "Flywheel" Synchronising Circuit.

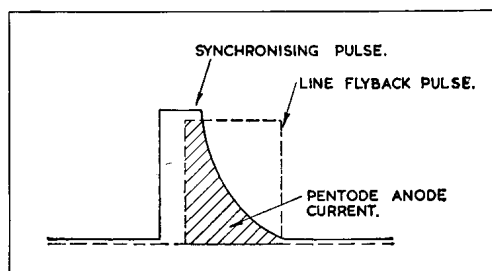


Fig. 2—Positive-going synchronising pulse and line flyback pulse applied simultaneously to the coincidence detector.



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4.— FLYWHEEL SYNCHRONISATION OF TELEVISION LINE TIMEBASES—Contd.

The effect of R1 and C1 on the output waveform is shown in Fig. 3. By adjusting the values of R1 and C1 the output waveform (Fig. 3b) can be made of any shape between a square pulse (as Fig. 3a) and a sawtooth. The main use of this is to permit the use of various output stages working under different conditions. In particular, with some output stages employing energy recovery circuits a variation of C1 alters the conduction periods of the output pentode and efficiency diode, thereby varying the amplitude of the output current and hence the width of the picture.

The tuned circuit L1, C2 in the anode circuit of the triode section of the oscillator is designed to improve the frequency stability of the oscillator. As can be seen from Figs. 3g and 3h, the addition of this tuned circuit increases the rate of rise of voltage at the grid of the pentode at the instant when the pentode starts to conduct. The effect of this is to reduce the variations in time of scan which result from random fluctuations in firing potential and peak negative excursion at the pentode grid.

The dynamic impedance and Q factor of this tuned circuit are not critical, and the circuit can be constructed in a number of ways, each of which gives good results. The method adopted by the home constructor will depend upon the components which are to hand. Three suggestions are given below as a guide.

Tuned Circuit L1 and C2

Suggestion (1). Circuit as shown in Fig. 1, with L1 consisting of a pair of Neosid Cores Type T10B with adjustable slug and former I18 wound with 755 turns of 0.0052" diameter (39 S.W.G.) enamel-covered copper wire.

Alternative wire sizes—38 S.W.G. enamel, 40 S.W.G. enamel, or 40 S.W.G. enamel and single silk covered.

This assembly must be mounted about $\frac{1}{8}$ " from the chassis. The range of adjustment is only $\pm 7.5\%$, which will cover variation in mains frequency and compensate for the drift in the paper capacitor, but the number of turns will have to be adjusted initially to match the capacitor selected.

Suggestion (2). Circuit as shown in Fig. 1, with L1 wound on a pair of Ferroxcube cores Type FX.1073, the coil former being 0.42" outside diameter and approximately 0.375" inside diameter made by winding turns of paper on a $\frac{3}{8}$ " diameter mandrel and secured with distrene varnish.

The winding should consist of 400 turns of 0.0092" diameter (34 S.W.G.) enamel and single silk covered copper wire, wave wound in single bank, 5/16" wide, half wave per turn.

Gears on Douglas wave-winder: 40, 36, 44, 48, 40, 80

If wave-winding is not available, satisfactory results should be obtained by scramble winding.

The nominal gap between the halves of the core is 0.017", and tuning is achieved by adjusting this gap. Such an arrangement, while not appealing to the production engineer, is the cheapest arrangement, and provides a range of adjustment adequate for all purposes. In devising a mechanical adjustment it should be remembered that a movement of approximately 0.001" will change the frequency by 300 c/s.

Suggestion (3). L1 is increased to 75 mH and C2 reduced to 2,700 pF in parallel with a 1,000 pF compression type mica variable capacitor.

L1 may have the same core and winding as in Suggestion (2) but with the gap reduced to 0.004". With such a small gap the inductance will be very sensitive to gap variations, and it will be necessary to adjust the gap initially to tune roughly in the centre of the capacitance range. Furthermore, the temperature coefficient of inductance will be approximately one part in a thousand per degree centigrade, and so the assembly should be mounted in as cool a position as possible.

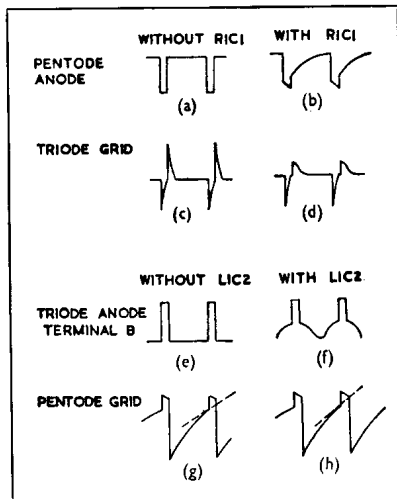


FIG. 3.—WAVEFORM IN LINE TIMEBASE OSCILLATOR.

- (a) (b) Waveform in anode circuit of pentode section.
- (c) (d) Waveform in grid circuit of triode section.
- (e) (f) Waveform in anode circuit of triode section.
- (g) (h) Waveform in grid circuit of pentode section.

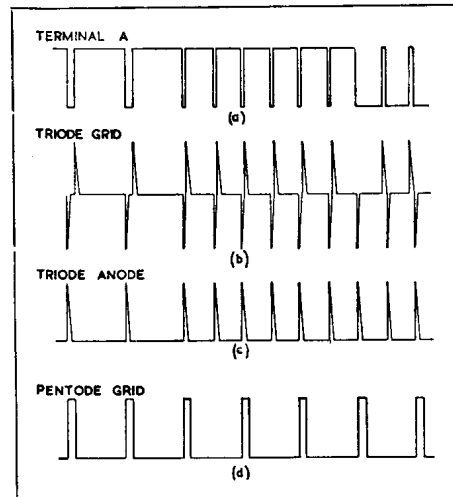
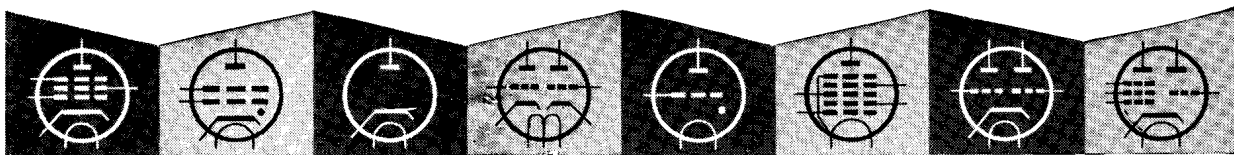


FIG. 4.—WAVEFORM IN COINCIDENCE DETECTOR

- (a) Incoming synchronising pulses at terminal A, Fig. 1.
- (b) Differential pulses applied to the grid of the triode section, Fig. 1.
- (c) Amplified synchronising pulses appearing at the triode anode and applied to the pentode section, via C9, Fig. 1.
- (d) Pulses derived from the line timebase and applied to the control grid of the pentode section, via C8, Fig. 1.





VALVES, TUBES & CIRCUITS

5. DM70—SUBMINIATURE TUNING INDICATOR FOR BATTERY OR MAINS RECEIVERS

An entirely new form of cathode ray tuning indicator, the Mullard DM70 is characterised by a compact subminiature bulb, a simple triode structure, a linear form of indication and a 1.4-volt 25mA directly-heated filament.

Whilst having electrical characteristics similar to a triode, the grid and anode together produce a visual indication of the voltage applied to the grid. These two electrodes consist of flat plates, the grid having an aperture shaped like an exclamation mark and the anode being coated with luminescent material on the face nearer the grid. The filament is located on the side of the grid remote from the anode and is parallel to the axis of the aperture. On viewing the anode through the grid aperture, a luminescent column is observed, the length of which is a maximum when approximately zero bias is present on the grid. Its length decreases from the "waist" of the aperture upwards as the bias becomes more negative. The valve is so constructed that the "dot" remains illuminated until the column has almost disappeared. The DM70 can be controlled by an undelayed a.g.c. voltage or by the demodulator circuit of a receiver to give maximum length of column when no signal is being received. On "tuning-in" to a carrier the length of column decreases, the minimum length indicating accurate setting of the tuning control.

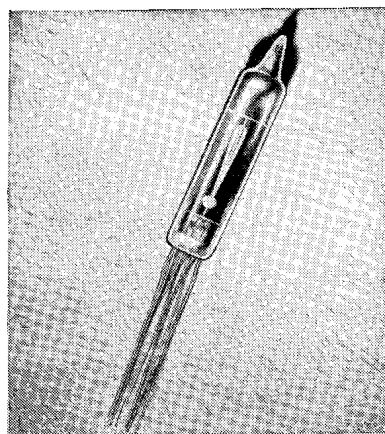


Fig. 1.—DM70, showing grid aperture.

In a particular receiver the h.t. voltage and the a.g.c. or demodulator voltage for maximum received signal are usually predetermined. Under these conditions control over the operating conditions of the DM70 may be obtained by correct choice of the filament voltage polarity. In the data given, the best method of filament connection has been indicated for each application, the "earthed" pin being at the same potential as the earthed side of the a.g.c. circuit. This is normally connected to the chassis of the receiver. The small bulb (10mm. diameter), solder-in leads and linear form of indication permit the valve to be mounted in several unconventional ways such as part of the moving cursor in the tuning dial. It then serves as an illuminated pointer, the "dot" assisting in this function and also acting as a pilot light in battery receivers. In a subsequent advertisement it is hoped to deal with the application of this valve in both mains and battery receivers.

PRELIMINARY DATA

OPERATING CONDITIONS				FILAMENT	
Battery-operated receivers				V_f	1.4 V
	Pin 4 earthed	Pin 5 earthed		I_f	25 mA
V_b	90	67.5	V	LIMITING VALUES	
V_a	85	60	V	$V_{b(0)}$ max.	450 V
V_g	0	0	V	V_b max.	300 V
I_a	170	105	μA	** V_a max.	90 V
*Length	11	10	mm	V_a min.	45 V
V_g (for complete extinction)	-10	-7	V	† p_a max. ($V_a < 90$ V)	25 mW
Mains-operated receivers (Pin 5 earthed)				† p_a max. ($V_a \approx 200$ V)	10 mW
V_b	110	170	250	I_k max.	300 μA
R_{p_a}	0.47	1.0	1.8	R_{g-f} max.	10 M Ω
V_g	0	0	0	BASE B8D	
I_a	105	110	105		
*Length	10	10	10		
V_g (for complete extinction)	-15	-23	-34		

*Length of fluorescent column observed, measured from the top of the aperture. The maximum value is approximately 14 mm.

**In circuits without anode series resistor.

†Values of p_a max. for intermediate values of V_a may be determined by linear interpolation.



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ADDITIONAL NOTES

SELECTION OF OPERATING CONDITIONS

The best use can be made of the variation of the length of the luminescent column with different input signals by careful selection of the operating conditions of the DM70. The recommended conditions for the more usual values of h.t. voltage in both battery and mains receivers have been given in the data panel on this reprint. The factors involved in the selection of these conditions can be listed as follows:—

- (a) The grid voltage at which maximum column length occurs for a specific anode voltage must be more positive than any value likely to be applied in the receiver.
- (b) Normally, the steady voltage developed across the demodulator or a.g.c. diode when no signal is received lies between $-0.2V$ and $-0.6V$. The grid voltage for maximum column length should exceed this, but not to such an extent that the column length at this grid bias is greatly reduced.
- (c) The value of grid voltage at which the column is completely extinguished should approximate to the maximum potential likely to be produced across the demodulator or a.g.c. diode.

The value of the grid voltage at which maximum column length occurs is governed by the potential difference between the grid and filament in the region where the aperture is narrowest—the “waist” of the exclamation mark. This point is not the same distance from each end of the filament so that the potential difference between grid and filament will change if the polarity of the filament voltage is reversed. In the same way the use of alternating instead of direct filament voltage affects the potential difference.

For this reason it has been found that for battery receivers with a 90V supply it is preferable to earth pin 4 of the DM70, whilst with a 67.5V battery pin 5 should be earthed. With a.c. mains receivers the only satisfactory arrangement is with pin 5 earthed.

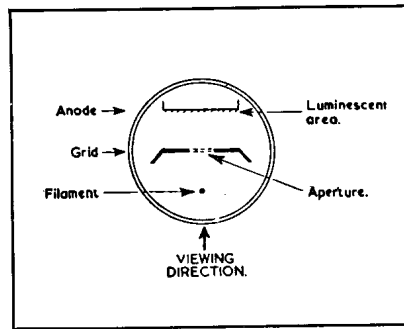


Fig. 2. Cross-section showing electrode structure.

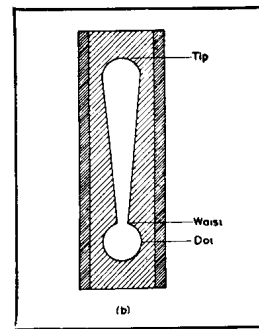


Fig. 3. Detail of grid aperture.

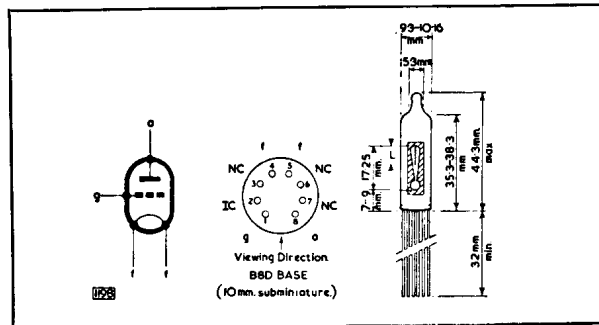
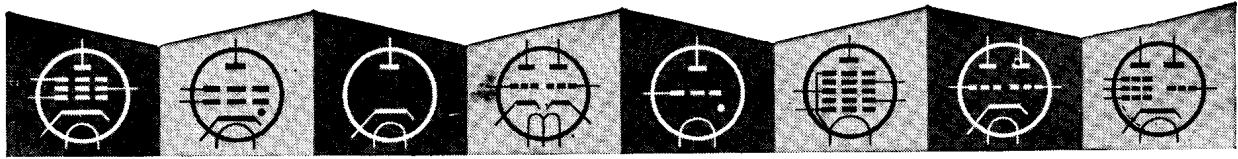


Fig. 4. Pinning and dimensions.



VALVES, TUBES & CIRCUITS

6. DM70—SUBMINIATURE TUNING INDICATOR FOR BATTERY OR MAINS RECEIVERS (Contd.)

APPLICATION IN VARIOUS TYPES OF RECEIVERS

Battery Receivers Those receivers provided with a 90-volt battery operate with an h.t. of about 85V after deducting the negative grid bias required for the output valve. In such a receiver a DM70 connected with pin 4 earthed has a cut-off voltage of -10V , which is adequate to indicate the strongest signal likely to be encountered. Similarly for a 67.5V battery, the h.t. is of the order of 60V giving a cut-off voltage of -7V when connected with pin 5 earthed.

A.B.C. Receivers In an A.B.C. receiver it is usually necessary to connect the filament of the DM70 in series with the filaments of the other valves. With a chain of valves having 50mA filament the 25mA filament of the DM70 should be shunted by a 56Ω resistor. The positioning of the DM70 in the filament chain needs careful consideration to ensure that the values of grid voltage at zero and at maximum signal give the optimum amount of indication on the DM70.

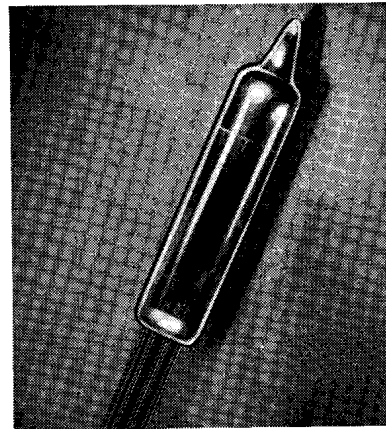
A.C. Mains Receivers The filament of the DM70 can usually be fed from a 6.3-volt transformer winding through a series resistor of $220\Omega \pm 5\%$. Alternatively, a 3.15V centre-tap on the heater supply can be used, the value of the series resistor then being $82\Omega \pm 10\%$.

It is not recommended that the filament of the DM70 be fed with a direct current from the cathode resistor of the output valve owing to the possibility of wide variations in this current resulting in reduced life of the indicator.

The recommended anode voltage for the DM70 in mains receivers is 60V, which can be obtained from the h.t. line by means of a series resistor. This results in a sliding anode voltage dependent upon the current of the valve and so extends the range of grid control to deal adequately with strong signals in a very sensitive receiver.

As the filament is supplied with an alternating voltage it is necessary to take precautions to prevent hum being introduced into the a.g.c. circuit from the grid of the DM70.

A.C./D.C. Receivers The filament of the DM70 shunted by a suitable resistor may be connected in series with the heaters of the other valves in an A.C./D.C. receiver provided a surge current limiting device is also included in the series circuit. For mains voltages above 160V the shunt resistor should be $18\Omega \pm 10\%$ when included in a 100mA heater chain.



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MVM 230

ADDITIONAL NOTES

TYPICAL OPERATION IN AN A.B.C. RECEIVER

The sequence of valves in the filament chain of an A.B.C. receiver is governed primarily by the following requirements:—

- (a) Provision of adequate grid bias for the output valve
- (b) Reduction of hum
- (c) Derivation of optimum a.g.c. voltage for those valves to be controlled.

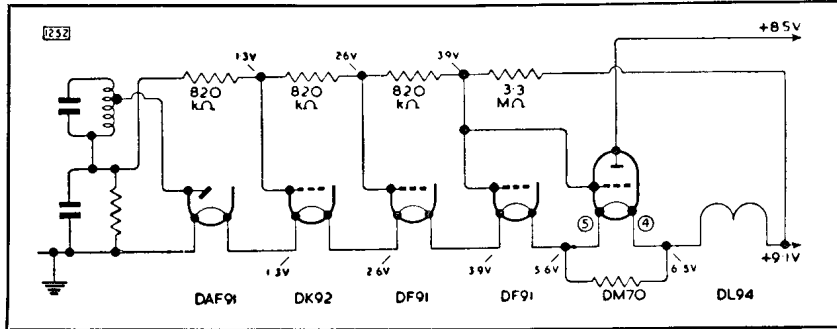


Fig. 5. Typical heater chain for A.B.C. receiver

As a result it is not always possible to include the DM70 in the most suitable position in the chain to ensure correct cut-off voltage on the grid at the operating anode voltage. Fig. 5 shows a recommended filament chain for a typical five valve receiver having two stages of I.F. amplification with a.g.c. applied to both these valves and to the frequency changer. The a.g.c. voltage is provided by a potential divider network between the demodulation diode and the positive end of the filament chain. This potential divider is designed so that with zero signal the bias of each of the valves is zero. As the taps on the divider approach the positive end of the network the proportion of the total control voltage which can be applied to each valve becomes less. If the grid of the DM70 were connected to a tap with the same potential as the negative side of its filament the control voltage would not be sufficient to almost extinguish the luminescent column when strong signals are received.

This may be overcome as shown in Fig. 5 by applying the same voltage to the grid of the DM70 as to the second I.F. valve and at the same time reversing the polarity of the filament connection from that normally recommended for use with a 90-volt battery. This ensures that the best use is made of the full range of indication provided by the DM70.

PREVENTION OF HUM IN A.C. MAINS RECEIVERS

(a) The anode of the DM70 should not be connected to the screen grid of any of the other valves in the receiver. Not only might this result in more than 60V being supplied to the DM70 but it would probably result in a hum voltage from the directly-heated filament of the indicator being fed to the screen grid of the valve concerned.

(b) The introduction of hum into the a.g.c. circuit from the grid of the DM70 may be prevented by the use of the circuit shown in Fig. 6. In this circuit R1 represents the load of the demodulator or a.g.c. diode of the receiver. The decoupling network, R2, C1 is also present in receivers having normal undelayed a.g.c., so that the 6.8MΩ resistor R3 is the only additional component required. In receivers having delayed a.g.c. the DM70 is fed from the demodulator resistor, in which case the complete network R2, R3, C1 should be included in the circuit.

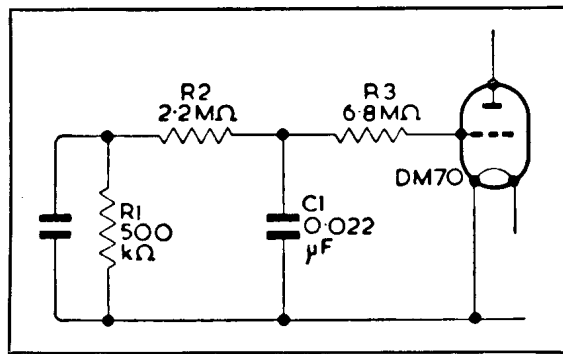
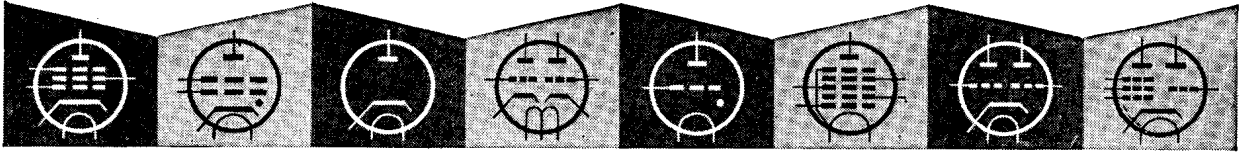


Fig. 6. Circuit for prevention of hum in A.C. receiver



VALVES, TUBES & CIRCUITS

7. WIRING CONSIDERATIONS WHEN USING HIGH GAIN VALVES AT HIGH FREQUENCIES

The published figures for input damping usually refer to the valve alone; for instance, for the EF80 the input damping is $10k\Omega$ at 50 Mc/s. The effective input damping of an EF80 in the lay-out illustrated is, however about $3.9k\Omega$ at 50Mc/s, due to the inevitable small reactances introduced by leads and by the inductive reactances of the decoupling components. At frequencies above 20-30 Mc/s leads even $\frac{1}{4}$ " in length form appreciable reactive elements. Reduction of lead lengths cannot however be pursued indefinitely, so that a compromise is usually adopted between unnecessarily long leads and lead lengths which would involve difficulty during mass production and servicing of the equipment.

DESIGN HINTS. The cathode and screen electrodes should be well decoupled for optimum results. Furthermore, the cathode capacitor can be made to resonate with its own series inductance and the inductance of the cathode lead so as to offer a negligible impedance at the frequency under consideration. This method, however, is likely to depend critically upon the type of capacitor used; for instance, the performance with a 500 pF mica capacitor might be different from that experienced with a ceramic capacitor of the same value.

In some cases it is desired to vary the grid-to-cathode bias on the valve in order to achieve a measure of gain control. Unfortunately, as the gain is reduced there is a simultaneous increase in the effective parallel input damping resistance. The input capacitance is also reduced in value. The bandwidth and the resonant frequency of the grid tuned circuit may therefore change as the gain is altered. This effect can be minimised, however, by the introduction of a critical amount of negative feed-back in the cathode circuit of the valve. This is usually achieved by leaving a portion of the bias resistor undecoupled. For the EF80 it is suggested that an undecoupled 33Ω resistor should be connected to the cathode pin of the valve-holder, the remainder of the cathode resistive load, i.e. a 150Ω resistor being decoupled to chassis in the usual way. This circuit introduces a loss of approximately 2 dB per stage.

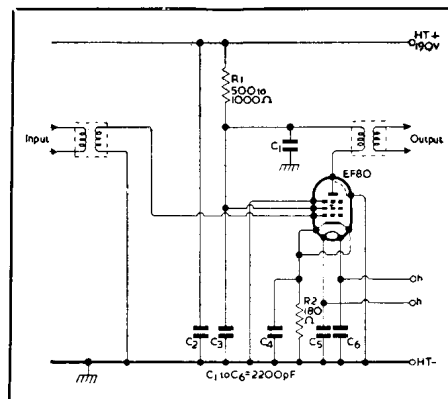
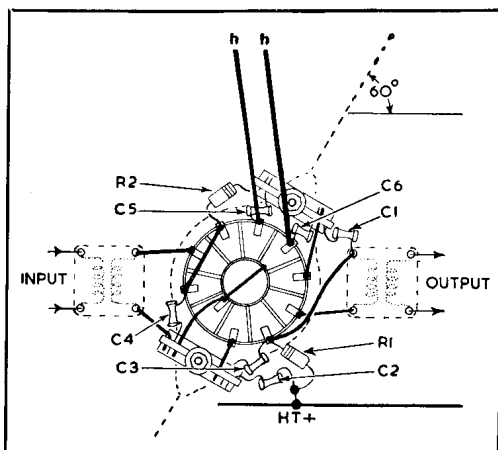


Fig. 1. Example of Wiring Layout.

Fig. 2. Circuit Diagram corresponding to Fig 1.

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WIRING CONSIDERATIONS WHEN USING HIGH GAIN VALVES AT HIGH FREQUENCIES

A NOTE ON PUBLISHED VALVE DATA

As pointed out overleaf the published figures for input damping of a given valve usually refer to the valve alone.

The performance of an R.F. amplifier valve is measured in the laboratory on equipment in which every possible care is taken to ensure that the results will not be affected by factors which have nothing to do with the valve. By this means figures can be obtained which relate solely to the valve, and these are the published data which are made available to the circuit designer.

It is, of course, possible to obtain performance figures in circuits which are known to have a general appeal and this is done in special cases. In these circumstances, however, the exact circuit must be defined in detail and even if this is done it is a difficult matter to ensure that all copies of the circuit will have the same performance. It is for this reason that the valve manufacturer is reluctant to issue performance data taken when the valve is used in circuits where the layout can influence the results. It is a better principle to issue data for the valve alone and so provide the circuit designer with basic figures from which he can work.

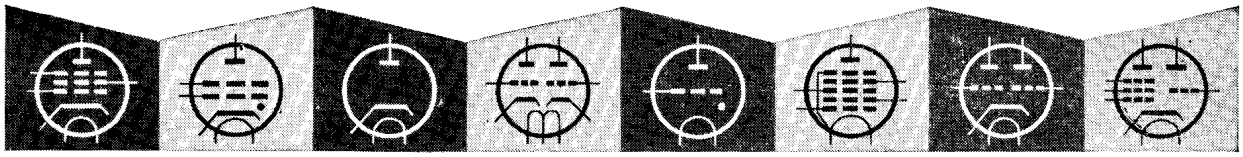
INSTABILITY

In high gain amplifiers where several stages are cascaded there is a risk of instability if feed-back between stages occurs. The H.T. line and the heater line are two very common causes of this fault. The H.T. line should preferably be decoupled at each take-off point to the individual stages, and a 500Ω — 1000Ω decoupling resistor for each stage is recommended. The heater line should be decoupled at each valve, and heater chokes may be required for frequencies above 20 Mc/s.

THE CHASSIS

Opinions are divided on the best material to be used for the chassis. There is probably little to choose provided good connections *can* be made to the chassis. A brushed cadmium-plated steel chassis is known to give good results up to 250 Mc/s. The various leads from the valve and decoupling components to the chassis can usually be accommodated on two double solder tags connected under the valve-holder retaining screws. These solder tags should not be too long and thin, otherwise their own inductance will prevent an effective connection being made to the chassis. The valve-holder itself should preferably be of the type which has a metal mounting shroud around the insulating material. Rigid mounting to the chassis is then possible, and the insulating material is not held in compression as the fixing screws are tightened up. As a result of this the solder tags are not liable to come loose if any shrinkage in the insulating material should occur in course of time.

It is bad practice to join all the earthed points together on the valve-holder and then connect them to chassis by a single wire. This tends to encourage coupling between electrodes. A far better scheme is to take separate wires down from each electrode to the nearest chassis tag, using 22 SWG tinned copper wire.



VALVES, TUBES & CIRCUITS

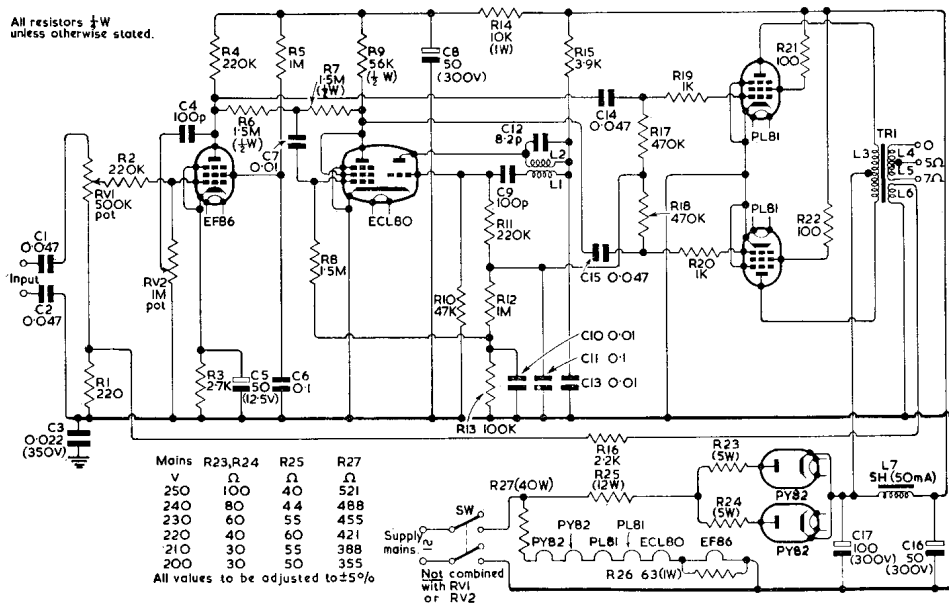
8. 15-WATT D.C./A.C. AUDIO AMPLIFIER

An amplifier suitable for use with D.C. or A.C. mains to give about 15 watts power output can be constructed with Mullard miniature noval-based valves. Two PL81 valves, used as a Class "B" push-pull output stage, are preceded by an ECL80 triode-pentode, the triode section of which operates as an R.F. oscillator at a frequency of about 2Mc/s. The direct voltage developed across its grid leak is used to bias the output valves and also the pentode section of the ECL80. The input signal is amplified by an EF86 and is fed direct to the control grid of one PL81. In addition, a portion of the signal voltage is applied to the pentode section of the ECL80 operating as a triode-connected phase inverter preceding the other PL81.

The power supply consists of two PY82's connected in parallel as a half-wave rectifier. The heaters of all the valves are connected in a 300 mA series chain, the 200 mA heater of the EF86 being shunted by a 63Ω resistor.

The potentiometer, RV2, acts as a treble tone control. An additional secondary winding L6 on the output transformer supplies a negative feedback voltage which is injected into the grid circuit of the EF86 via resistors R16 and R1. As the volume control RV1 is connected to R1, the feedback is minimum at maximum sensitivity of the amplifier and increases when the sensitivity is decreased. Care must be taken, as with all D.C./A.C. equipment, to avoid direct connection between the chassis and earth. In addition the chassis (H.T.—) line should be connected, where possible, to the neutral side of the mains.

An output of 16.2 W is measured at the primary side of the output transformer when the input at the grid of the EF86 is 220 mV. Without feedback the distortion is 6%, this being reduced to 1.8% by the application of feedback. The hum and noise level is 42 dB below at 16.2 W.



BIAS OSCILLATOR COILS L1, L2.

Standard M.W. local oscillator coil (mains). With no input, current through R10 should be 0.7 mA at 220V mains. Current increased by adding turns to L1 and decreased by removing turns.

OUTPUT TRANSFORMER, TRI.

Shell type core $1\frac{1}{4}$ in. wide. "No waste" series laminations

0.02 in. thick. 1 in. stack without air-gap. Overall dimensions: $3\frac{1}{2} \times 3\frac{1}{2}$ in.

L3 :	2 x 880 turns of 33	S.W.G.
L4 :	88 turns of 18	S.W.G.
L5 :	16 turns of 18	S.W.G.
L6 :	120 turns of 29	S.W.G.



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ADDITIONAL NOTES

PRECAUTIONS WITH DC/AC WORKING

THIS AMPLIFIER IS DESIGNED FOR DC/AC WORKING AND HAS NO TRANSFORMER TO ISOLATE THE CHASSIS FROM THE MAINS SUPPLY. THIS CAN BE DANGEROUS UNLESS ADEQUATE PRECAUTIONS ARE TAKEN TO ELIMINATE ALL POSSIBLE SOURCES OF DANGER.

The chassis must not be connected directly to earth and it is recommended that the amplifier be fitted in an insulating case. All external metal parts of the equipment must be connected to a good earth and isolated from the chassis. This applies particularly to a metal pick-up arm and the screening braid on the input lead. Any grub screws on control knobs should be covered with insulating tape or the holes filled with wax. Alternatively, non-conducting extension shafts may be fitted to the potentiometer spindle.

COMPONENTS

The stopper resistors, R19, R20, R21 and R22 are included to reduce the possibility of parasitic oscillations. They should be connected as close to the valve holder tags as possible.

The values of R23, R24, R25 and R27 given in the table on the circuit diagram should be adjusted to within $\pm 5\%$. This is necessary to ensure the same output voltage across C17 at full drive current for either D.C. or A.C. mains input.

The reservoir capacitance, C17, should be capable of passing a ripple current of 300 mA.

The mains switch, SW, should *not* be combined with either of the potentiometers, RV1 or RV2.

BIAS OSCILLATOR

The coils for the oscillator providing the bias for the output valves can consist of a standard medium-wave local oscillator coil assembly as used in a mains receiver. In order to obtain the required oscillator grid current it may be necessary to rewind the grid coil L1. With no input signal applied, the current through R10 should be 700 μ A at a mains voltage of 220 V. To increase the current through the coil, turns should be added, and removed to decrease it.

FEEDBACK

The winding, L6, on the output transformer supplies a negative feedback voltage which is injected into the grid circuit of the EF86 through the resistors R16 and R1. The volume control RV1 has one side connected to R1 thus giving minimum feedback at maximum sensitivity (RV1 at maximum setting). On decreasing the sensitivity of the amplifier by means of RV1 the amount of feedback is increased. This ensures that considerable feedback can be obtained with large signals whilst at maximum sensitivity the performance of the amplifier equals that obtained with no feedback. If feedback is desired at all levels of input signal an alternative connection can be made by returning the tone control potentiometer RV2 to the junction of R1 and RV1 instead of to the negative H.T. line.

TYPICAL VALUES OF VOLTAGES AND CURRENTS

For 220 V. mains

(All voltages measured with respect to negative H.T. line)

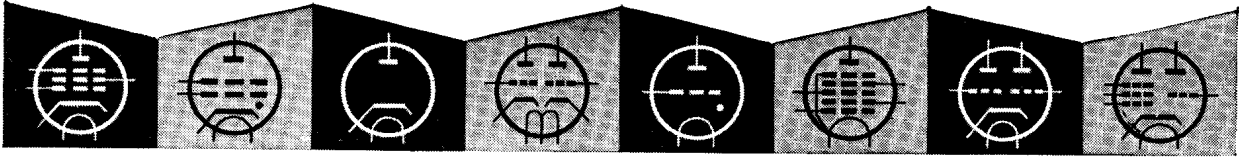
	A C Mains		D C Mains	
	No Input	Max. Output	No Input	Max. Output
C17 voltage (V)	250	185	215	190
C16 voltage (V)	240	165	208	175
C8 voltage (V)	205	145	175	150
Total D.C. (mA)	78	195	70	188
PL81's Va (V)	245	180	205	185
Vg2 (V)	240	170	200	175
Vg1 (V)	-32	-23	-27	-24
la (mA)	2 \times 32.5	2 \times 82.5	2 \times 30	2 \times 80
Ig2 (mA)	2 \times 2.5	2 \times 11.5	2 \times 2.25	2 \times 10.75
Ra-a (k Ω)	2.0	2.0	2.0	2.0
ECL80 Vap (V)	55		45	
Vg1 (V)	-3.3		-3	
Vat (V)	225		190	
Iat (mA)	2.8		2.2	
EF86 Va (V)	66		54	
Vg2 (V)	92		74	
Vk (V)	2.0		1.8	

SENSITIVITY

Output measured on primary side of output transformer	Signal on gl of PL81 (V r.m.s.)	Signal on gl of EF86 (V r.m.s.)
16.2 W	16	220
0.5 W	5.5	70
50 mW	1.8	23

BASE CONNECTIONS OF VALVES

TYPE	BASE	PIN NO.								TOP CAP	
		1	2	3	4	5	6	7	8		9
EF86	B9A	g2	s	k	h	h	a	s	g3	gl	—
ECL80	B9A	at	gt	k,s	h	h	ap	g3	g2	gl	—
PL81	B9A	IC	gl	k	h	h	IC	IC	g2	g3	a
PY82	B9A	IC	IC	k	h	h	IC	IC	IC	a	—



VALVES, TUBES & CIRCUITS

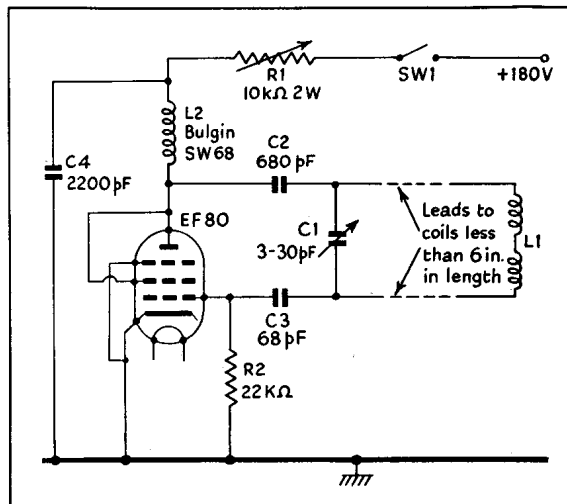
9. AN EXPERIMENTAL SPOT-WOBBLE CIRCUIT

The line structure of a television picture is an unpleasant feature, and is emphasized to the point at which it may become intolerable as the focus becomes sharper. The high horizontal definition achieved by good focus can be retained and at the same time the line structure removed by elongating the spot vertically. The most convenient way of doing this is by deflecting the spot vertically at a frequency which is high compared with the line frequency. This is called "spot wobble".

The best circuit arrangement for producing spot wobble depends upon the picture tube used, its associated components, and the layout of the receiver. A good starting point for experiments in this field is provided by the circuit described below. It should be appreciated, however, that if the interlace is not good, or if the spot is astigmatic, or if there is appreciable deflection defocusing, spot wobble is unlikely to effect any considerable improvement. These points should therefore be looked into before attempting to apply spot wobble.

The diagram shows a simple oscillator in which the spot-wobble deflector coils form part of the oscillatory circuit. An EF80 pentode is employed, connected as a triode, and the total drain on a 180 volt H.T. line is about 12 mA.

The amplitude control R1 is used to adjust the elongation of the spot to the condition in which the lines just merge. The switch SW1 permits the spot wobble to be switched off while the normal focus is being adjusted. The spot-wobble deflector coils consist of a pair of saddle windings similar to conventional deflector coils. There is, however, no yoke, and the windings are much smaller, each coil consisting of five turns of 0.018" diameter (26 S.W.G.) enamelled copper wire. These should be wound on a rectangular former $1\frac{1}{2}'' \times 1\frac{3}{4}''$. When removed from the former the flat winding is applied to the tube by folding the longer sides round the neck, i.e., with the $1\frac{1}{8}''$ width parallel to the axis of the tube. The two coils are mounted on opposite sides of the tube neck directly behind the normal deflection coils and are connected in series in such a way that their magnetic fields assist each other.



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ADDITIONAL NOTES

PRACTICAL HINTS

As explained overleaf, the spot-wobble coils should be mounted on the tube immediately behind the normal deflector coils. This means that part of the spot-wobble coils will have to be inside the focus and centering assembly, and the method of mounting them must permit this.

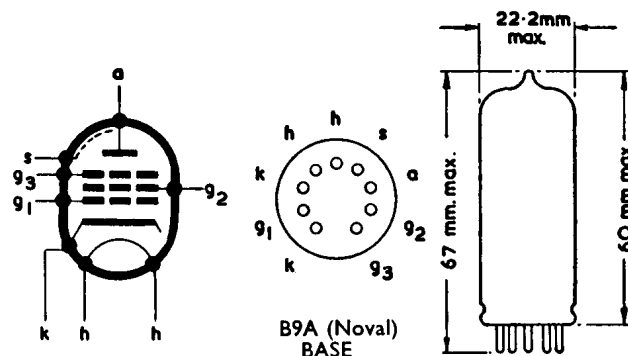
A simple temporary arrangement is to make a sliding former from two or three turns of Empire cloth $1\frac{1}{2}$ " wide to fit the tube neck, and to bend the spot-wobble winding over this while it is on the tube, retaining the windings in position with two turns of $1\frac{1}{2}$ " wide P.V.C. adhesive tape.

The leads from the spot-wobble coils to the oscillator should not be longer than 6 inches.

CHOICE OF OSCILLATOR FREQUENCY

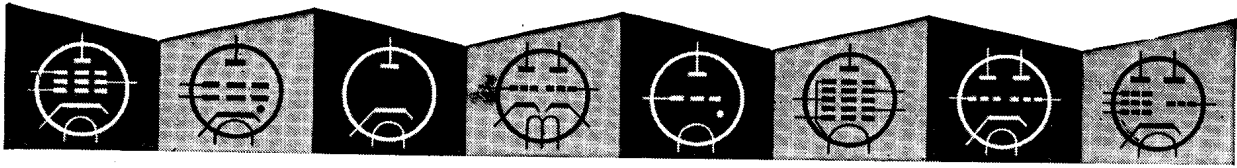
The spot-wobble frequency should be greater than 8 Mc/s; otherwise, with a finely focused spot, the sinusoidal pattern becomes apparent. The frequency should ideally be chosen so that neither this frequency nor its harmonics fall within the I.F. or R.F. channel of the receiver. If the whole of Band I and all the I.F. channels that are in use are taken in consideration, the lowest ideal frequency available for the spot-wobble circuit is 40 Mc/s. The losses at this frequency are prohibitively great, and a nominal frequency of 12.5 Mc/s has been selected. Provision has been made for adjustment of this frequency by means of C_1 so that harmonics can be moved out of the receiver channels.

EF80 ABRIDGED DATA					
HEATER					
Suitable for series or parallel operation A.C. or D.C.					
V_h	6.3	V	I_h	0.3	A
LIMITING VALUES			CHARACTERISTICS		
$V_{a(b)}$ max.	550	V	V_a	170	V
V_a max.	300	V	V_{g2}	170	V
p_a max.	2.5	W	V_{g3}	0	V
$V_{g2(b)}$ max.	550	V	I_a	10	mA
V_{g2} max.	300	V	I_{g2}	2.5	mA
p_{g2} max.	0.7	W	V_{g1}	-2.0	V
I_k max.	15	mA	g_m	7.4	mA/V
			r_a	400	k Ω



BASE CONNECTIONS AND DIMENSIONS OF EF80

MULLARD LTD., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2



VALVES, TUBES & CIRCUITS

10. NOVAL-BASED VALVES FOR AUDIO AMPLIFIERS

The designer of audio amplifiers must have at his disposal valves of several different types—valves suitable for use in the pre-amplifier stages; output valves capable, singly or in combination, of delivering the requisite amount of audio-frequency power to the loudspeaker; voltage amplifying valves of moderate gain for use in the driving stage preceding the output stage; and power rectifiers for providing the high tension supply to the amplifier.

There is everything to be gained when valves for all these functions form a complete range, designed for operation in combination. For many years a complete range of Mullard valves suitable for audio-frequency applications has been available. From time to time developments in the techniques of valve design and manufacture, or the emergence of new requirements in amplifier performance, have provided the impetus for the introduction of improved or even entirely new valves.

Quite recently audio-frequency amplification has assumed still greater importance, both by reason of comparatively new applications and on account of greatly extended use of amplifier equipment for all applications. The rapidly increasing use of 16mm. sound film equipment in the domestic, educational and advertising fields; the growing popularity of tape recording; the high quality sound accompaniment transmitted by the B.B.C. Television Service—these are but a few of the factors in the increased demand for valves especially designed for audio amplification and in the need for modification or extension of the existing range of valves.

In satisfying these requirements an opportunity is presented for incorporating in each type all relevant improvements which have been developed over a period of time; for planning ahead so that the new range will also meet foreseeable requirements for some time to come; and for adopting in each case the latest manufacturing techniques, including the use of the now preferred base—the Noval (B9A) nine-pin base.

The new range of Mullard valves for audio amplifiers comprises the following types:—

EF86—pentode pre-amplifier, incorporating all the improvements with respect to low microphony, low noise and low hum level associated with the EF37A and EF40 which it now replaces.

ECC81 } double-triode voltage amplifiers for such applications as dual input circuits,
 ECC82 } phase splitters, equalisation circuits etc. The range offers a choice of impedance
 ECC83 } to suit particular circuits; each triode section has an independent cathode.

EL84—output pentode rated for 12W anode dissipation. A single valve gives an output of 4 to 5 watts into the speaker load and 16W can be obtained from a pair of EL84's operated in Class AB push-pull.

EZ80—full-wave power rectifier having a maximum output of 90mA.



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 MYM246

ADDITIONAL NOTES

EF86

HEATER

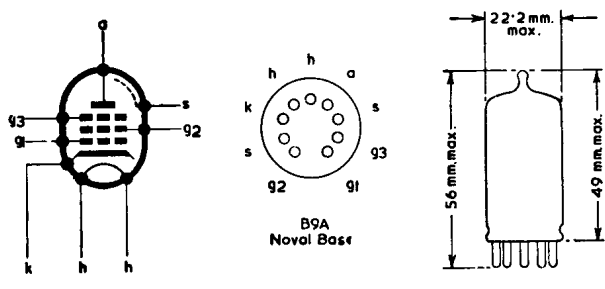
V_h	6.3	V
I_h	0.2	A

CHARACTERISTICS

V_a	250	V
V_{g3}	0	V
V_{g2}	140	V
I_a	3.0	mA
I_{g2}	0.6	mA
V_{g1}	-2.0	V
g_m	1.8	mA/V
r_a	2.5	M Ω

LIMITING VALUES

V_a max.	300	V
p_a max.	1.0	W
V_{g2} max.	200	V
p_{g2} max.	0.2	W
I_k max.	6.0	mA
V_{h-k} max.	100	V



ECC81, ECC82, ECC83

HEATER

(Parallel connection, applied between pin 9 and pins 4 and 5 connected together)

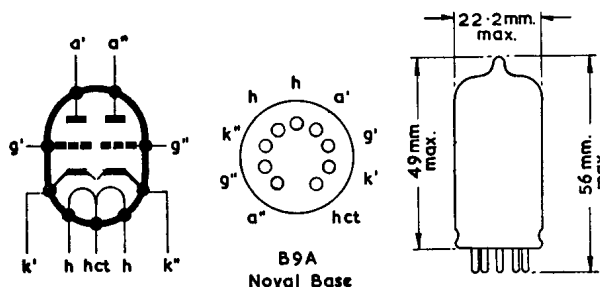
V_h	6.3	V
I_h	0.3	A

CHARACTERISTICS (each section)

	ECC81	ECC82	ECC83	
V_a	250	250	250	V
I_a	10	10.5	1.2	mA
V_g	-2.0	-8.5	-2.0	V
g_m	5.0	2.2	1.6	mA/V
μ	60	17	100	
r_a	12	7.7	62.5	k Ω

LIMITING VALUES (each section)

V_a max.	300	300	300	V
p_a max.	2.5	2.75	1.0	W
I_k max.	15	20	8	mA
V_{h-k} max.	150	180	180	V



EL84

HEATER

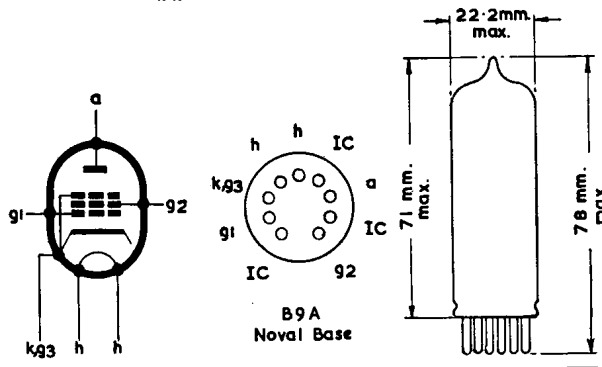
V_h	6.3	V
I_h	0.76	A

CHARACTERISTICS

V_a	250	V
V_{g2}	250	V
I_a	48	mA
I_{g2}	5.5	mA
V_{g1}	-7.3	V
g_m	11.3	mA/V
r_a	38	k Ω

LIMITING VALUES

V_a max.	300	V
p_a max.	12	W
V_{g2} max.	300	V
p_{g2} max.	2.0	W
I_k max.	65	mA
V_{h-k} max.	100	V



EZ80

HEATER

V_h	6.3	V
I_h	0.6	A

OPERATING CONDITIONS

V_a (r.m.s.)	2 x 250	2 x 350	V
C	50	50	μ F
*R lim min.	125	300	Ω
I_{out}	90	90	mA
V_{out}	265	360	V

*Per anode

LIMITING VALUES

V_a (r.m.s.) max.	2 x 350	V
I_{out} max.	90	mA
C max.	50	μ F
V_{h-k} (pk) max.	500	V

