BRIMAR

WIDE ANGLE DEFLECTION CIRCUIT FOR C14BM

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DEFLECTION CIRCUITS FOR WIDE ANGLE CATHODE RAY TUBES

CIRCUIT I For C14BM

SUMMARY: This report describes a line and frame time base suitable for use with the Brimar C14BM wide angle deflection rectangular cathode ray tube. Operation is from a 200 volt HT rail, and the E.H.T. is supplied from the line fly-back pulses. An efficiency diode provides a boosted HT supply which is used for both frame and line output stages. An auto wound line output transformer is employed with an iron dust core material.

1.0 GENERAL: The advent of large screen wide angle deflection cathode ray tubes has increased the problems associated with the provision of adequate power for the line deflector coils and the required high value of E.H.T. from the fly-back pulses. In the case of the C14BM the deflection angle has been increased from some 50° to 70°, and in order to prevent the electron beam from striking the inside of the neck at the extreme ends of its scan the neck diameter has been increased from a nominal of 35 mm. to approximately 1-7/16 in. The centre of deflection of the beam is brought forward towards the screen to prevent corner cutting, so that a shorter length deflector coil is required than has hitherto been customary.

These factors all add to increase the scanning power required, and with the additional demands caused by a higher E.H.T. voltage mean that the C14BM requires nearly 2½ times the scanning power that was needed for the 12 in. tubes.

This situation is made more difficult by the requirements for AC/DC operation, which set a maximum limit of 200 volts to the HT rail for the receiver. The total power required for the line output stage scanning a C14BM is approximately 40 watts at 12 kV E.H.T. Assuming that the valves are 100% efficient this would mean an HT current of 200 mA for the line output stage alone, and this, in practice, would be much higher due to valve and circuit losses.

If the stored energy is recovered from the magnetic circuit of the line output transformer and deflector coils and fed back to the output stage, the time base has only to supply the losses; indeed a perfect circuit, once it had reached its operating condition, would require no power to maintain it. The scan energy contained in the overswing is allowed to flow back through the deflector coils before the output valve begins its cycle of operation and provides almost one half of the scan amplitude. Linearity is controlled by the efficiency diode and a linearity coil and associated condensers. As nearly half the scan can be obtained in this way the power requirements of the line output valve are reduced. The DC voltage appearing across the load of the efficiency diode may be added in series with the HT line to augment the voltage supply to the line output valve. Although the power requirements of the line output stage are greatly reduced by these means a large valve is still necessary as despite the great reduction obtained in the external power requirements, the internal 'circulating' power is the full amount, and has to be controlled by the output valve.

Scan amplitude, in the case of the line, is controlled by a variable inductor shunted across part of the line output transformer diverting some of the power from the scan coils.

E.H.T. voltage is obtained by half wave rectification of the positive fly-back pulses in the line output valve anode, which are stepped up by the overwinding on the output transformer.

The frame time base is conventional, and is operated from the boosted HT rail. This is desirable, as it is difficult to obtain the large linear current swing required when the output valve is operated from a 200 volt rail. A triode output valve is employed and very little power is required by this part of the circuit, so that the additional current can be readily supplied by the boosted HT rail.

2.0 THE LINE TIME BASE:

2.1 Line Oscillator: To obtain the maximum E.H.T. and boost voltages the fly-back should be as rapid as possible, and to ensure this the grid of the output valve must be cut off very rapidly and held at cut-off during the fly-back period. At this time the anode of the output valve is highly positive so that a considerable negative voltage is required for complete cut-off.

A multivibrator oscillator using a 12AU7 valve is employed to produce the drive voltage as this type of oscillator permits a sharper cut off to be obtained than with a conventional blocking oscillator. The circuit is shown on 426·1. A 12AU7 double triode is used in an unsymmetrical multivibrator circuit, the frequency of which is adjusted by R1 and the amplitude by R5. The output from the anode of V2 is fed to a peaking circuit C6 R8, which inserts a negative spike, so that the wave shape is of the form shown on 426·4. This is applied to the grid of the 6CD6G and is 130 volts peak to peak, the negative spike being 45 volts peak amplitude.

2.2 Line Output Stage: The line output valve is the 6CD6G, which has a high peak anode current rating at low anode voltage. Abridged characteristics of this valve are given in Appendix 2. The screen grid is supplied from the 200 volt HT rail through a 5000 ohm dropping resistor, the actual screen voltage being 115 volts. A small amount of cathode bias must be provided to protect the valve in the event of failure of the drive voltage. In the circuit the anode dissipation of the 6CD6G without drive is approximately 25 watts, which although well over the maximum rating the valve has been found to withstand for short periods without harm. If desired, a fuse may be fitted in the HT line which will blow after some seconds if the drive fails.

When the fly-back pulse takes place the peak positive anode voltage rises to about 5 kV. Through the anode to grid capacity of the valve this appears as a positive pulse on the control grid which acts in opposition to the negative peaking pulse which is required to ensure that the valve is fully cut-off. To neutralise this positive pulse a negative pulse is obtained from tag 1 of the line output transformer and passed to the control grid through C8.

2.3 Efficiency Diode: The 6U4GT used as an efficiency diode has the advantage of a high peak heater to cathode voltage rating which renders unnecessary a separate highly insulated heater supply. A summary of the characteristics of this type is shown on Appendix 2.

This rectifier damps the overswing of the line scan, recovers the energy and delivers it to the circuit in two ways. Firstly it allows the energy to be passed into the deflector coils as a linearly decaying current which provides nearly half the scanning power. The action may be likened to a pair of valves operating in Class B push-pull where each valve supplies half the output, the operation passing from one to the other at the cut off point. Secondly the DC voltage appearing across the output of the efficiency diode is available for connection in series with the HT rail to the time base, and in this way operation from a higher HT voltage is possible. The boost voltage available is 180 volts, so that the total HT supply is 380 volts.

The peak heater to cathode voltage is 3·3 kV which is safely below the maximum of 3·85 kV. The 6U4GT employs a special type of heater assembly and insulation which permit such high peak heater to cathode voltages.

2.4 Linearity: Linearity is controlled by a coil with an adjustable dust core in conjunction with the condensers C11 and C12. In practice these condensers should be selected to a reasonable tolerance, say better than $\pm 10\%$, otherwise there may be insufficient inductance swing to cover production variations.

Linearity is also affected by the shape and amplitude of the drive voltage to the 6CD6G. Ideally, the drive amplitude should be adjusted so that the valve is working under full Class B conditions. If too much drive is applied the valve will run into Class C, and the position at which the scan transfers from the efficiency diode to the line output valve is affected. Overlap takes place and the centre of the picture is compressed into bright vertical bars.

The drive should be increased until the vertical bars appear and then reduced to just below the point at which they disappear.

2.5 Width Control: It is desirable to be able to control the width of the line scan without greatly affecting the E.H.T. voltage. This rules out the possibility of controlling by means of the voltages on the line output valve. A small part of the output transformer is shunted by a coil with an adjustable iron core, and this inductance shunts some of the current which normally would pass through the deflector coil.

A variation of about 10% in line amplitude is obtainable without any very significant change in E.H.T. voltage.

2.6 Line Output Transformer: A drawing showing the mechanical arrangement of the output transformer is shown on 426·3. The core material is Type U1, a dust iron manufactured by Messrs. Neosid Ltd. This material has not the exceptionally low losses of ceramic iron materials, nor is the permeability very high, being only of the order of 5. It has the advantage of being practically unsaturable so that no further sacrifice of permeability is lost through gapping.

Despite the apparent shortcomings of this material it has been possible to design a reasonably efficient circuit around it.

An auto-wound transformer is employed, the E.H.T. overwinding being a narrow wave wound coil over the wide output valve winding. The electrical specification and the winding details are given in Appendix 3.

The tapping for the cathode of the 6U4GT efficiency diode is selected to give optimum performance when an additional 15 mA is drawn from the boosted HT supply by the frame time base. If this additional current is not required the transformer turns ratio requires modification.

Great care must be taken with the construction of the transformer to prevent voltage breakdown and corona discharge. The voltage gradient across the windings is very high so that it is important that, particularly on the overwinding, no loose turns slip down the outside and cause breakdown between sections of the winding. Sharp bends or points on the connecting wires should be avoided or corona discharge to nearby bodies at low potential may take place. Such corona discharges not only place an additional load on the E.H.T. supply, reducing the available voltage, but give rise to interference spots on the picture which can only be satisfactorily removed by elimination of the discharge.

The self capacity of the windings must be kept to a minimum, particularly that of the overwinding. The rapidity of the fly-back pulse and the consequent value of the E.H.T. voltage depend on ensuring the lowest possible capacity across the line output.

The filament voltage winding for the IT2 E.H.T. rectifier consists of 4-3/4 turns of polythene covered wire wound directly on the side limb of the transformer core so that the ends of the winding may be brought up directly to the rectifier.

2.7 Deflector Coil: No constructional details are given for the deflector coils as this is a problem rather closely connected with individual manufacturing abilities. The circuit has been designed for line coils of some 30 to 40 mH inductance. This inductance is quite normal and representative of general practice.

In order to reduce, as far as possible, deflection defocussing which becomes more serious with wide angle deflection tubes it is necessary to provide a magnetic field which is as nearly uniform as possible, over the whole of the deflection angle, so that the spot is not distorted or out of shape. This can be accomplished by a cosine distribution of the turns, i.e. the number of turns varies as the cosine of the angle around the circumference of the neck, the reference plane being horizontal. The ends of the windings which are bent up do not greatly influence the shape of the field, but it is advisable to arrange for the back end to bend up as sharply as possible. The front end should be arranged to follow the shape of the flare of the funnel of the tube as defined by the reference gauge, but should not be extended far up the flare of the tube. The purpose of the front shaping is to allow the deflector coils to locate on the neck as close to the screen as possible, thus bringing forward the centre of deflection so that the beam does not strike the inside of the tube neck. To this end the coils must be as short as possible consistent with obtaining adequate sensitivity, and should not be allowed to exceed 2 ins. in length.

In practice the cosine law winding is not suited to the C14BM and similar tubes with semi-flat screen faces. Where the radius of curvature of the screen surface is greater than that of the deflected beam, pin cushion distortion occurs, and the field distribution of the deflector coils must be modified to reduce this. Quite a good compromise between deflection defocussing and pin cushion distortion may be obtained by winding the coils with a cosine squared distribution. This yields a winding tapering more sharply than the cosine distributed winding and it becomes so thin that in practice the last 20 or 30 degrees may be omitted.

The cosine squared law may be approximated by winding the outer section of the coils with a smaller gauge of wire than the inner section together with a little shaping of the windings. By the use of a greater number of wire sizes the distribution may be approximated without shaping. It has been found better to wind the coils in the shape finally required with the ends bent to shape and bonded, as attempts to shape up to a flat coil lead to untidy ends as the outside turns are not long enough and pull down into a bunch. Although requiring a more complex jig the practice of winding the coils in the exact shape required has much to recommend it as this prevents damage to the insulation during the forming process, and if self-bonding wire is used, by passing a current through the coil in the jig a rigid winding is obtained which is repeatable in production.

To improve the sensitivity a magnetic yoke is required around the outside of the deflector coils. This can consist of a ring of material similar to that used for the line output transformer core, or may even consist of a large number of turns of soft iron wire. The important thing is to obtain a fairly good Q so that the losses are as low as possible.

Another method of obtaining the necessary distribution of the magnetic field is to use a castellated yoke which encloses the coils and controls the field distribution by the shape of the pole pieces. It is necessary to design the yoke for the radius of screen curvature relative to deflection radius of the tube on which it is to be used, but this may be outweighed by the great increase in sensitivity and Q obtained by this method.

2.8 E.H.T. Supply: The 1T2 rectifies the fly-back pulses which are stepped up by the overwind on the output transformer. The reservoir condenser is formed by the capacity between the CR Tube anode and the external conductive coating on the tube, which is of the order 0·001μF.

A curve showing the regulation of the E.H.T. supply is shown on 426·2. Over the normal working range the effective impedance is approximately 7 MΩ, which is not unduly high. The average beam current of the CR Tube varies between 30 and 70 μamperes; only on some picture titles and plain rasters does it usually rise above 100 μamperes. The reservoir condenser holds sufficient charge to supply the beam current requirements of normal picture highlights.

The 1T2 filament voltage cannot be measured in the normal way as it is of pulse waveform and is at high potential to earth. The correct operating condition is best determined by comparing the filament temperature with that of another valve operated from a 1·4 volt battery or other DC source.

3.0 Frame Time Base: The frame time base output valve may either be operated from the 200 volt HT rail or from the boosted HT line. In the first case a high slope valve is required which can supply a high peak anode current swing with only a low anode supply voltage. This indicates a pentode or tetrode valve of the output or large video class, and in fact suitable valves will give satisfactory operation under such conditions. Due to the low anode voltage, however, the valve swings out of the region of linear characteristics, and rather complex negative feedback arrangements are required to linearize the trace. Further, the high standing anode current through the output transformer primary makes it difficult and expensive to obtain the high primary inductance so necessary for efficient operation.

If, however, the time base is operated from the boosted HT supply the higher voltage enables the same power to be developed at a lower anode current, and, as in the case of the present circuit, quite a small triode is adequate for the output stage. The valve may be used over the linear portion of its characteristics, and the primary inductance of the output transformer may be high without the need for a bulky component.

3.1 Drive Circuit: A conventional blocking oscillator is used for this purpose supplying a 20 volts peak to peak signal to the output valve grid. One half of a 12BH7 is employed for this purpose. The other half of this double valve may be used for the frame output stage.

3.2 Output Stage: One half of a 12BH7 double triode will provide adequate frame scan, and the other half is used as the frame blocking oscillator. The alternative is a 12AU7 with both sections strapped in parallel to obtain a low impedance. A triode connected 6BW6 or 6V6 would serve equally well for this purpose, but these types are rather larger than necessary.

Vertical linearity is controlled by the variable cathode bias resistor R19, which is adjusted in conjunction with the amplitude control R16.

3.3 Output Transformer: The frame output transformer should have a primary inductance preferably greater than 30 Henries. The output valve anode current is less than 15 mA so that this inductance is not difficult to achieve. The required inductance may be obtained with Stalloy laminations, but a smaller and more efficient transformer can be made using a Permalloy or Mumetal core, providing it is gapped to prevent saturation by the DC anode current.

The transformer shown on the circuit has a turns ratio of 14 : 1 to match the specified inductance of the deflector coils.

3.4 Deflector Coils: The same remarks apply as in paragraph 2.7 where the line coils are described. The line coils are normally favoured as regards sensitivity, so the frame coils are wound over the line coils and consequently suffer from lower sensitivity than the line coils. The winding distribution of the frame coils should be the same as for the line to strike the best compromise between deflection defocussing and pin-cushion distortion.

The total coil inductance most suited for this circuit is between 10 and 15 mHenries. The largest possible wire gauge should be used, as at frame frequency the load appears predominately resistive, so that a low DC resistance reduces the copper loss which only goes to heat the coil.

3.5 Decoupling of Frame HT Supply: Adequate decoupling is required on the frame HT rail to prevent the appearance of line pulses on the frame supply which may interfere with the frame sychronisation and destroy the interlace. This decoupling must be isolated from the take off point on the boost HT rail which is not at ground potential to line frequency, but is part of the linearity control circuit. The 3·3 k resistor R23 is adequate for this purpose as the linearity circuit has a comparatively low Q.

4.0 Conclusions: This time base circuit is suitable for use with the C14BM, but the core material for the line output transformer does not enable the highest efficiency to be obtained. Further circuits are being developed around higher permeability and low loss core materials, which will enable higher E.H.T. voltages and scanning power to be obtained for the same power input.

For larger cathode ray tubes it will be necessary to use a higher efficiency line transformer core, and to pay more attention to suitable deflector coil shrouds to increase the scanning sensitivity.

In Appendix 1 are shown the operating conditions for this circuit in which are included the important peak voltage and current relationships. None of the valves is being operated at its maximum rating, although at first sight it would appear that the 12AU7 frame output valve is operating with excessive anode voltage. This valve is not overrun, as allowing for the volt drop in R23, R18 and R19 and in the transformer primary, the anode voltage is below the absolute maximum rating of 330 volts.

APPENDIX 1

OPERATING CONDITIONS OF LINE AND FRAME TIME BASE

HT Supply Voltage 200 volts DC

6CD6G	$V_{a\ (pk)}$	5·0 kV	$I_{k\ (dc)}$	94 mA
	$I_{a\ (dc)}$	76 mA	$I_{k\ (pk)}$	340 mA
	$I_{g2\ (dc)}$	17 mA	$V_{a\ (dc)}$	380 volts
	V_{g2}	115 volts		
6U4GT	$V_{h,\ k\ (pk)}$	3·3 kV	$I_{k\ (pk)}$	350 mA

Total HT current, line and frame = 112 mA at 200 volts
Frame time base current = 15 mA at 380 volts
Frame output valve anode current = 14·3 mA
Frame output valve cathode voltage = 15 volts DC

APPENDIX 2

ABRIDGED CHARACTERISTICS OF TIME BASE VALVES

6CD6G and 50CD6G

Ratings (Design Centre)

	6CD6G	50CD6G
V_h	6·3 volts	50 volts
I_h	2·5 amperes	0·3 ampere
$V_{a\ (max)}$	700 volts	
*$V_{a\ (pk)\ max}$	6,000 volts	
$p_{a\ (max)}$	15 watts	
$p_{g2\ (max)}$	3 watts	
$V_{g2\ (max)}$	175 volts	
*$V_{g1\ (pk)\ max}$	-150 volts	
C_{in}	26 pF	
C_{out}	10 pF	
$C_{g1,\ a}$	1.0 pF	

6U4GT and 25U4GT

Ratings (Absolute Values)

	6U4GT	25U4GT
V_h	6·3 volts	25 volts
I_h	1·2 amperes	0·3 ampere
$I_{a\ (pk)}$	660 mA	
$V_{h,\ k\ (pk)\ h+}$	500 volts	
*$V_{h,\ k\ (pk)\ h-}$	3,850 volts	
*P.I.V. (max)	3,850 volts	
$I_{k\ (dc)\ max}$	138 mA	
$C_{h,\ k}$	8·5 pF	

* The duty cycle must not exceed 15% of the scanning cycle, which is normally approximately 15 μseconds for a 405 line 25 frame interlaced system.

1T2

Ratings (Design Centre)

V_f	1·4 volts	$I_{a\ (pk)\ max}$	12 mA
I_f	0·14 ampere	$I_{a\ (dc)\ max}$	2 mA
P.I.V. (max)	15 kV	$C_{a,\ f}$	0·65 pF

12AU7

Ratings (Design Centre) Frame Scan Service

V_h	6·3 volts or 12·6 volts
I_h	0·3 ampere or 0·15 ampere
$V_{a\ (max)}$	300 volts
$p_{a\ (max)}$	2·75 watts each section
$I_{k\ (pk)}$	60 mA each section

12BH7

Ratings (Design Centre) Frame Scan Service

V_h	6·3 volts or 12·6 volts
I_h	0·6 amperes or 0·3 amperes
$V_{a\ (max)}$	500 volts
$p_{a\ (max)}$	3·5 watts each section
$I_{k\ (pk)}$	60 mA each section

APPENDIX 3

WINDING DETAILS OF LINE OUTPUT TRANSFORMER

Core Material: 2 Type U1 dust cores by Messrs. Neosid Ltd., Welwyn Garden City.

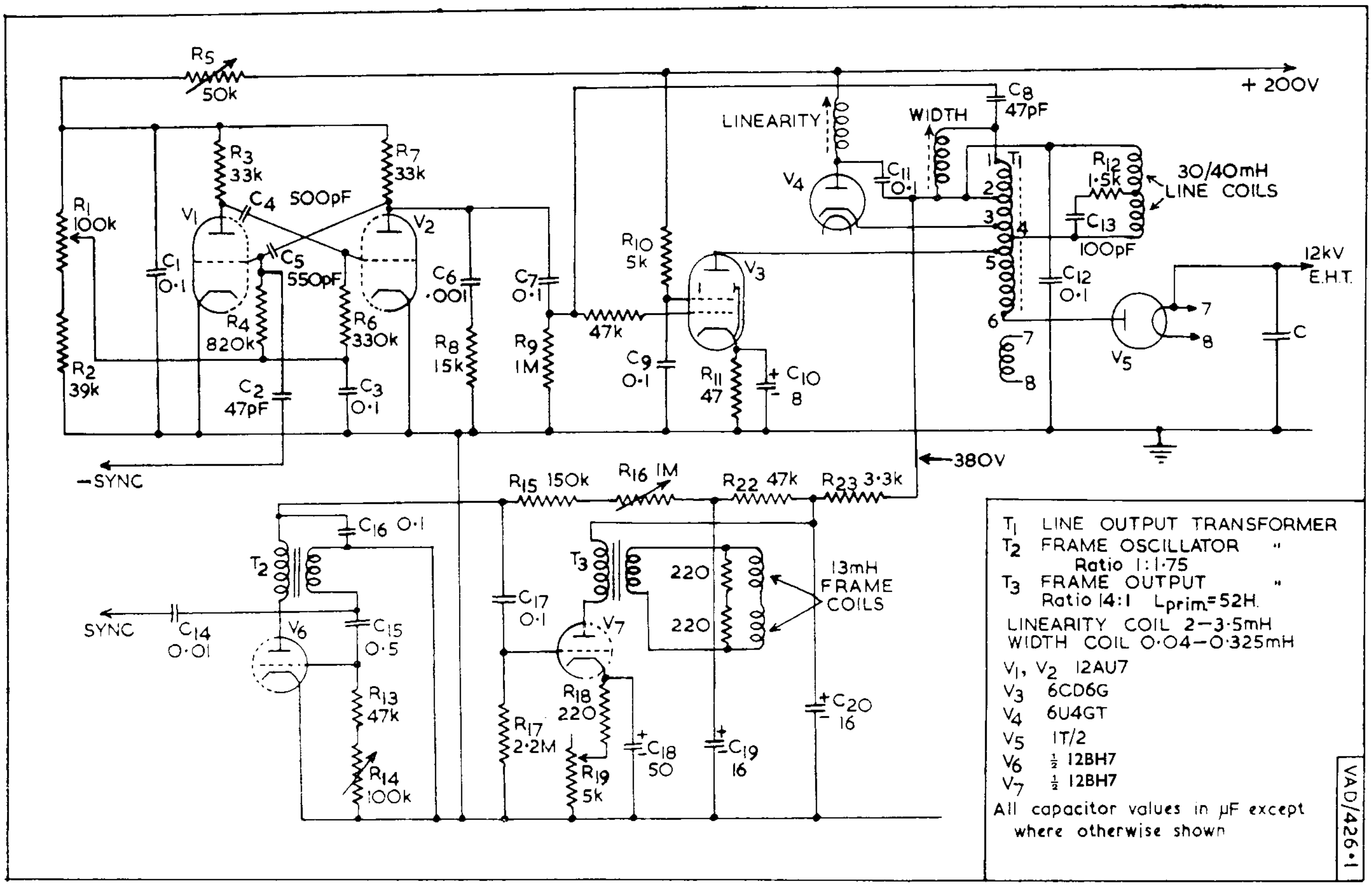
Former: Paxolin Tube 3/4 in. internal diameter, outside diameter 7/8 in. approx.

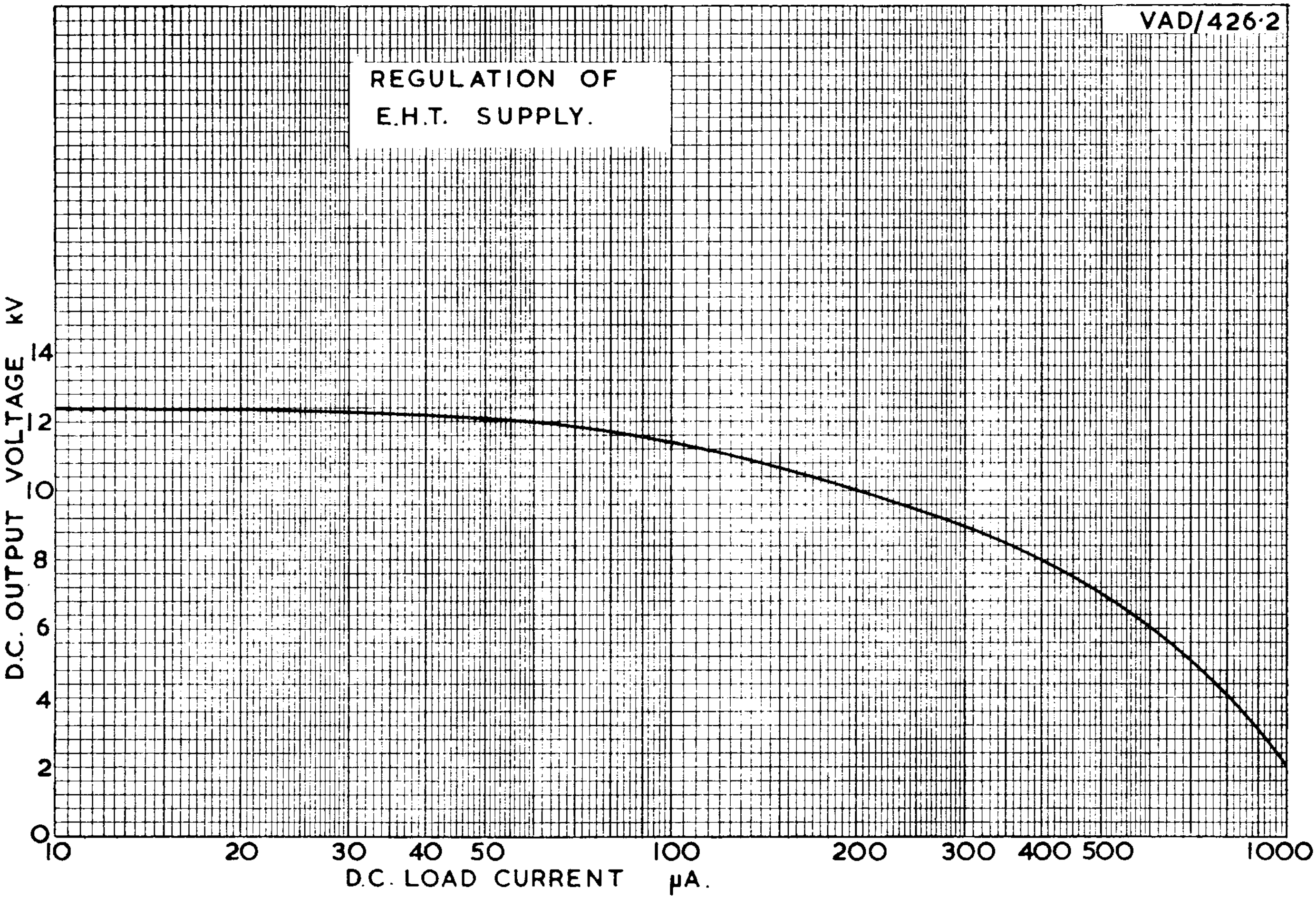
First Winding: 1 in. wide, 1/4 wave—1,400 turns of 36 SWG single silk enamelled, tapped at 80, 850 and 950 turns.
Douglas Wave Winder Gears 37—28/36—48 // 24—76.

Overwinding: 1/4 in. wide, single wave. 1,600 turns of 40 SWG double silk covered.
Douglas gears. 48—38/28—36 // 60—60.
No air gap in core.

ELECTRICAL CHARACTERISTICS

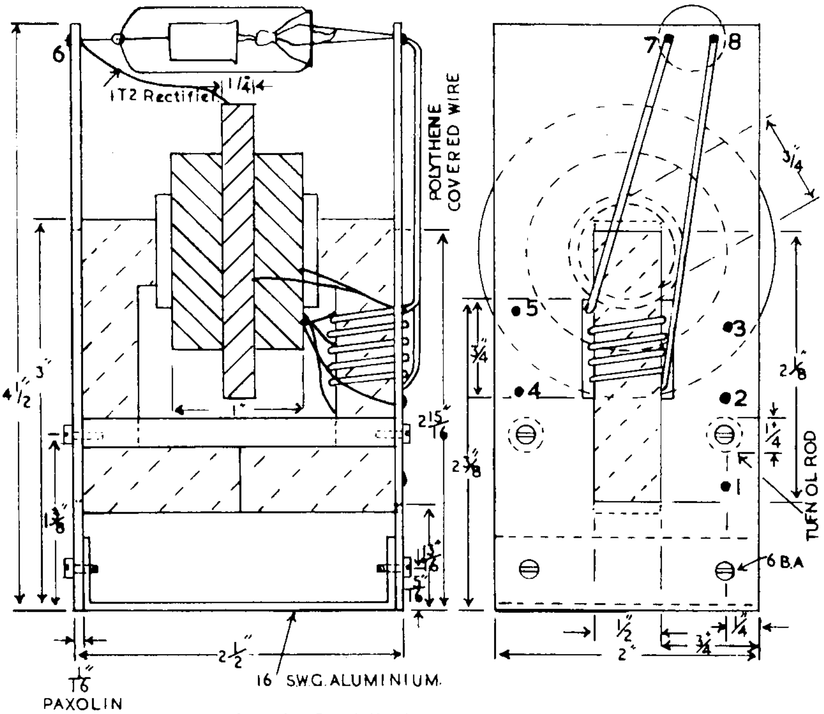
Tag No.	DC Resistance ohms	Inductance mH
2	5	0·4
3	45	45
4	50	56
5	78	140
6	380	650


R5 50k
+ 200V
C8 47pF
LINEARITY
WIDTH
R1 100k
R2 39k
R3 33k
R7 33k
C4 500pF
C5 550pF
V1
V2
C1 0·1
R4 820k
R6 330k
C2 47pF
C3 0·1
C6 ·001
C7 0·1
R8 15k
R9 1M
47k
R10 5k
C9 0·1
V3
R11 47
C10 8
V4
C11 0·1
T1
R12 1·5k
C13 100pF
30/40mH LINE COILS
C12 0·1
12kV E.H.T.
V5
C
-SYNC
380V
R15 150k
R16 1M
R22 47k
R23 3·3k
C16 0·1
T2
T3
220
220
13mH FRAME COILS
SYNC
C14 0·01
V6
C15 0·5
C17 0·1
V7
R13 47k
R14 100k
R17 2·2M
R18 220
R19 5k
C18 50
C19 16
C20 16
T1 LINE OUTPUT TRANSFORMER
T2 FRAME OSCILLATOR "
Ratio 1:1·75
T3 FRAME OUTPUT "
Ratio 14:1 Lprim=52H.
LINEARITY COIL 2–3·5mH
WIDTH COIL 0·04–0·325mH
V1, V2 12AU7
V3 6CD6G
V4 6U4GT
V5 1T/2
V6 ½ 12BH7
V7 ½ 12BH7
All capacitor values in μF except where otherwise shown
VAD/426·1

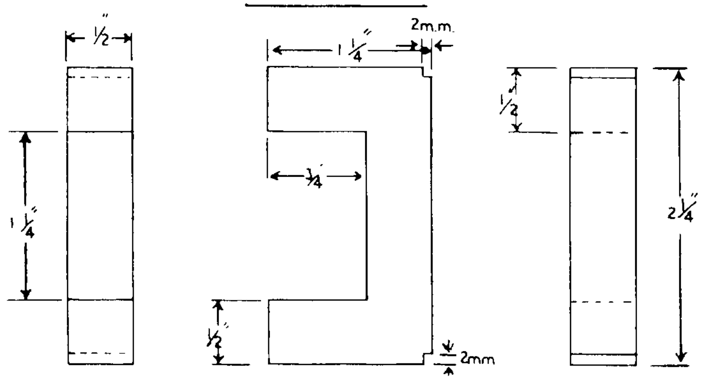


VAD/426·2
REGULATION OF
E.H.T. SUPPLY.
D.C. OUTPUT VOLTAGE kV
14
12
10
8
6
4
2
0
10
20
30
40
50
100
200
300
400
500
1000
D.C. LOAD CURRENT μA.

LINE OUTPUT TRANSFORMER DETAILS



NEOSID DUST CORE TYPE U.1.



WAVEFORM OF GRID DRIVE OF 6CD6G