RADIOTRONICS

AMALGAMATED WIRELESS VALVE CO. PTY. LTD.

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In this issue:—

RADIOTRON 813 TRANSMITTING BEAM POWER TETRODE

Radiotron 813 is a Beam Power Tetrode for transmitting purposes, having a maximum plate dissipation of 100 watts. In Class C Telegraphy the 813 is capable of an output of 260 watts, while as a plate modulated amplifier it may be used to give a carrier output of 175 watts. The 813 may also be used as a Linear Class B or Grid Modulated R.F. Amplifier, an output of 50 watts being obtainable in either case. The driving power is very small and varies from 0.5 to 2.0 watts, depending on the class of service and applied voltages. The 813 also makes a very efficient frequency multiplier.

Neutralisation is unnecessary with adequately shielded circuits. Maximum ratings are permissible at frequencies up to 30 Mc., while the valve may be operated at reduced ratings up to 120 Mc.

Radiotron 813

Filament	10 Volts	5 Amps.
Plate Voltage (Max.)		
Plate—Modulated		1600 Volts
Other Applications		2000 Volts
Plate Dissipation (Max.)		100 Watts
Maximum Overall Length		$7\frac{1}{2}''$
Maximum Diameter		$2\frac{9}{16}''$
Base		Giant 7 Pin Bayonet
Cap (Plate)		Medium Metal

RADIOTRON 6K8-G INCORPORATION IN 6-VALVE CIRCUIT

The advent of Radiotron 6K8-G has made possible the construction of receivers of quite a simple character which nevertheless have extremely good performance, particularly on short waves. The special characteristics of the 6K8-G, which have the greatest appeal, are the stability of the oscillator frequency on all bands and the sensitivity and general satisfactory performance on the highest frequencies of the short wave band. As a result of these good characteristics, it is possible to apply A.V.C. to the 6K8-G without suffering from frequency drift due to fading and without any likelihood of flutter provided that reasonable precautions are taken.

Valves of the pentagrid type such as the 6A7 or 6A8-G have high sensitivity and good performance on the broadcast band, but when A.V.C. is applied to the converter on the short-wave band it is usually necessary to employ a fairly expensive filter in the anode-grid circuit in order to prevent flutter and, while this is reasonably effective as an anti-flutter device, it does not assist in any way towards preventing the receiver from coming off-tune when the signal fades severely. This effect on the short-wave band is well known to all who have handled such receivers and in the past good performance could only be achieved by removing A.V.C. from the converter for short-waves. For satisfactory receiver performance this would necessitate the use of an R.F. stage, not only as an amplifying stage, but also for the A.V.C. control. The stability of the 6K8-G makes the R.F. stage no longer essential in this regard since ample A.V.C. action may be obtained on the short-wave band by applying the controlling voltage to the grid of the converter. Receivers of the 5-valve variety, having no R.F. stage, are very popular in spite of the defects which have been enumerated, but the 6K8-G avoids the most serious of these defects, and therefore makes a considerable contribution to the performance of a typical small receiver. At the same time, it must be realised that the addition of an R.F. stage to any receiver improves its performance very markedly in many directions such as the reduction of background noise for a given sensitivity, improved A.V.C. characteristic, improved image ratio, and lessened liability to suffer from cross modulation. The receiver, which is described in this issue, is therefore shown with an R.F. stage, using Radiotron type 6U7-G as the R.F. amplifier. This R.F. stage may, however, be omitted entirely and the remainder of the receiver will have an excellent performance when compared with other rceivers having no R.F. stage. No additional circuit diagram has been shown, since the parts to be omitted are so obvious.

Tuning Indicator

A Magic Eye Tuning Indicator has been included in the circuit for ease of tuning and may be either type 6U5 or 6G5 as may be desired. Radiotron 6U5 is fitted with a space-charge grid in the target section which provides better uniformity of performance and longer life, due to the elimination of excessively high target currents. The newer types of Radiotron 6G5 are also fitted with a space charge grid, but the earlier construction 6G5's will not have such a satisfactory performance. A resistor of 20,000 ohms has been shown in the target circuit of the tuning indicator and this is intended only for use with the more modern type of tuning indicator employing a space charge grid. With the older type of tuning indicator it is advisable to decrease this resistance to 10,000 ohms and to decrease the target supply voltage to about 200 or 220 volts.

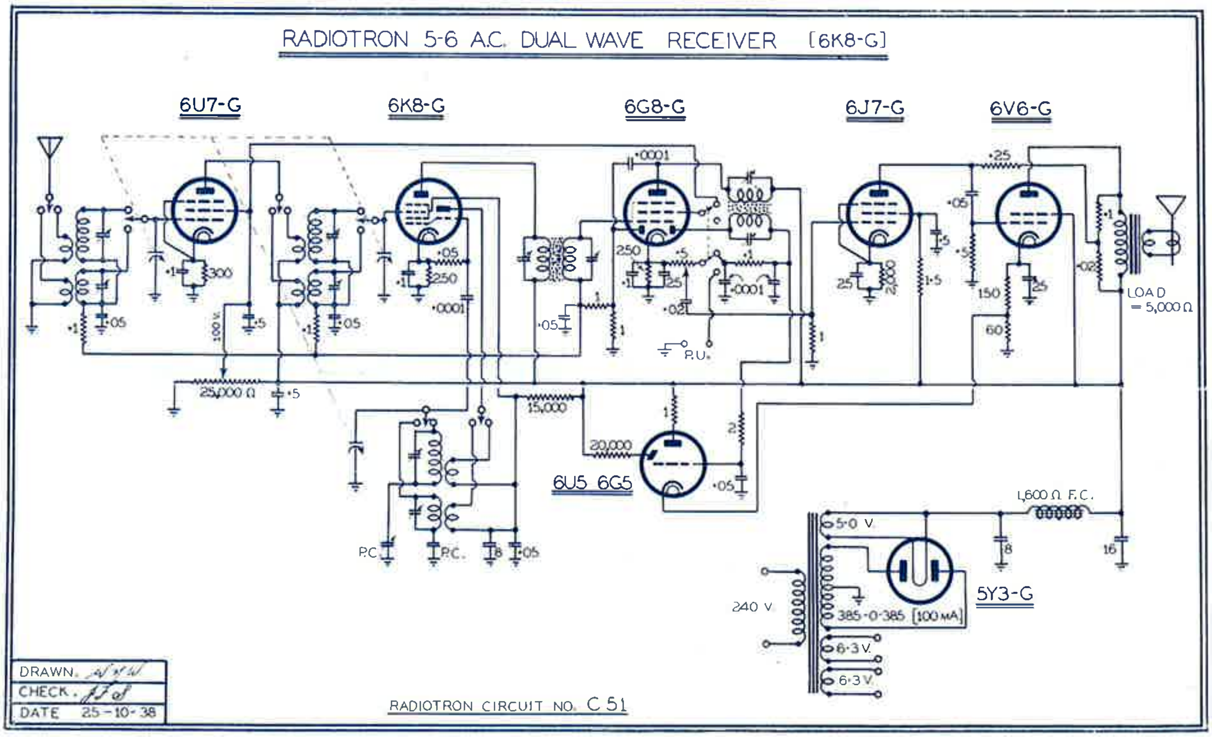
Circuit Arrangement

Radiotron 6U7-G is used as the **R.F. amplifier** and its screen supply is obtained from a 25,000 ohm voltage divider having a tapping at 100 volts which is used to supply the screens of the R.F. and I.F. stages.

Radiotron 6K8-G **converter** is operated with normal voltages on all electrodes. As recommended in the published data on this valve type, the screen grid of the mixer and the plate of the oscillator are supplied through a common 15,000 ohm dropping resistor from B+. The reason for this particular arrangement is that there is a slight frequency drift in one direction with a change of voltage applied to the oscillator plate and in the reverse direction with the same change of voltage applied to the mixer screen. Consequently, by combining these two in a common dropping resistor the tendency to drift is very much reduced and, since the drift in each section is of approximately the same dimensions, the nett drift very closely approaches zero.

In order to make sure that no flutter occurs even with the slight amount of drift that occurs with the 6K8-G, a comparatively small filter employing an 8 μF. electrolytic condenser is connected from the junction of the 15,000 ohm resistor and the primary of the oscillator coil to earth. This condenser may be omitted in many cases, and its inclusion depends on such characteristics of the receiver as audio gain, I.F. selectivity, steepness of selectivity curve and power supply regulation.

The **I.F. stage** uses Radiotron 6G8-G, duo-diode super control R.F. pentode, the amplifier being employed in conventional fashion and the output from the plate circuit passing through the second I.F. transformer to one of the diodes for detection. The second diode is used for A.V.C. and the exciting voltage is applied through a .0001 μF. condenser from the plate of the I.F. valve directly to the diode. The cathode bias resistor of this stage carries both R.F. and A.F. components and is therefore bypassed by a 0.1 and a 25 μF. condenser in parallel. The diode load resistor is 0.5 megohm and the R.F. filter consists of a 0.1 megohm resistor and .0001 μF. filter as with preceding Radiotron circuits. Due to the special A.V.C. arrangement which has been adopted, the increase of distortion due to the operation of A.V.C. is quite small, and occurs only at a very low input voltage to the aerial. There is no shunting of the diode load by the A.V.C. network, although there is a slight loading due to the 2 megohm resistor to the grid of the Tuning Indicator.



The **audio system** comprises Radiotron 6J7-G as a resistance coupled pentode feeding into the grid of a 6V6-G beam tetrode with negative feedback applied by the series method. Although the percentage of output voltage which is applied to the plate circuit of the 6J7-G is 16.6%, the effective percentage at the grid of the 6V6-G is 10.7%, giving a gain reduction factor of 2.93.

The cathode of the 6U5 is returned to a tapping on the 6V6-G cathode bias resistor in order that deflection of the tuning indicator may occur even with small signals and on short waves. The same effect could be obtained quite readily by returning the cathode to a suitable point on a separate voltage divider.

The **power supply** comprises a standard 385-385 volt 100 mA. transformer and Radiotron 5Y3-G rectifier. The filter system incorporates a 1600 ohm field coil and condensers of 8 and 16 μF. capacitance.

Coil Details

The **coils** which were used in this receiver are of conventional pattern and are regarded merely as examples of average design. It is not claimed that the highest possible efficiency has been obtained, especially since this might result in difficulties in other directions. In order to assist designers in obtaining a satisfactory conventional type of coil for use with the Radiotron 6K8-G, the data on the coils is tabulated in full and two diagrams are shown, illustrating the aerial and R.F. coils on one and the oscillator coils on the other diagram. The aerial and R.F. coils may be used with any type of converter or R.F. valve, but the oscillator coils are particularly suited to the Radiotron 6K8-G and are not suitable for any other type of converter.

The short wave coils are shown for alternative bands, either the usual short-wave coverage for a dual wave receiver (16 to 51 metres) or the 3 band receiver arrangement with ranges from 13 to 39 and from 35 to 105 metres. It is unfortunate that, due to lack of standardisation in the short wave band coverage, there are so many arrangements on the short wave band and it is not possible to give coil details for each and every arrangement. The coils which are given, however, are intended to be a guide towards suitable design and similar types of winding could be adopted for other wave bands. It will be seen from the diagrams and data that the **oscillator coils** for 13-39 and for 16-51 metres are interwound, while those for 35-105 metres as well as for the broadcast band, are of the close-wound solenoid type. On the broadcast band the primary of the oscillator coil is wound over the bottom end of the secondary winding. The **aerial and**

RADIOTRON COILS

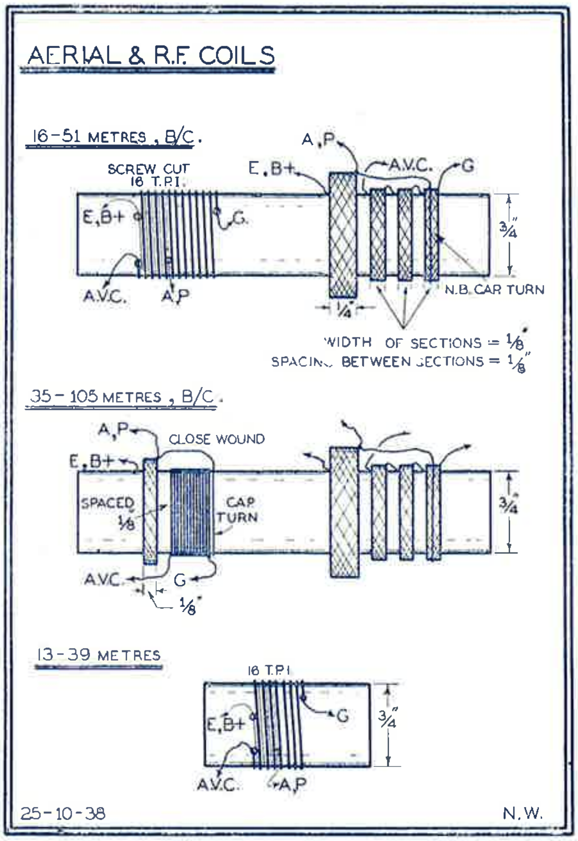
WINDING DETAILS

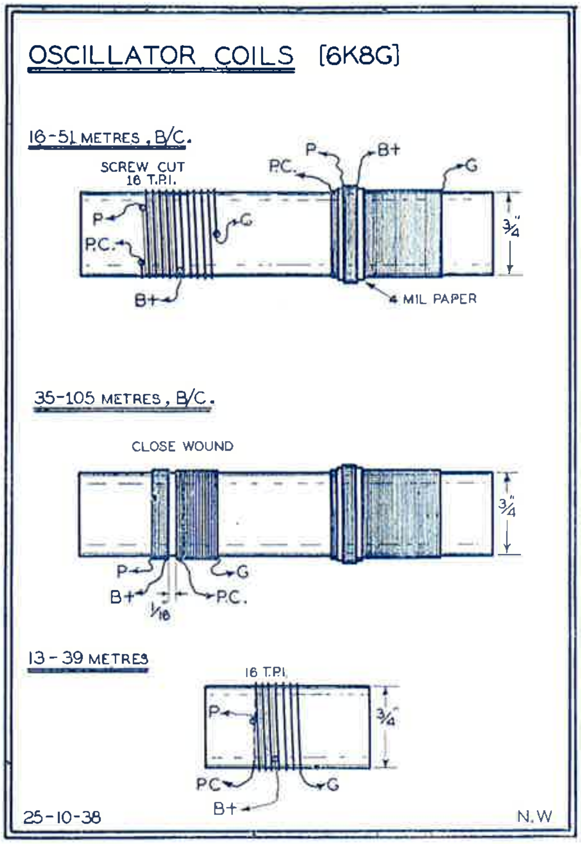
(Oscillator Coils for 6K8-G only)

COIL.	PRIMARY.	SECONDARY.
Aerial. 550-1500 Kc.	375 turns 40 S.W.G. S.S.E. with one turn over hot end of secondary.	120 turns 5/44 Litz in three equal sections.
Aerial. 35-105 m.	55 turns 40 S.W.G. D.C.C. wound in one section ⅛" wide, with one turn over hot end of secondary.	20 turns 27 B & S Enam. close wound.
Aerial. 16-51 m.	4.25 turns 34 B & S Enamel interwound from bottom of secondary.	11.7 turns 22 B & S Enam. wound in screw cuts. 16 T.P.I.
Aerial. 13-39 m.	3.2 turns 34 B & S Enamel interwound from bottom of secondary.	7.75 turns 22 B & S Enam. wound in screw cuts. 16 T.P.I.
R.F. 550-1500 Kc.	950 turns 40 S.W.G. S.S.E. with one turn over hot end of secondary.	120 turns 5/44 Litz in three equal sections.
R.F. 35-105 m.	110 turns 40 S.W.G. D.C.C. wound in one section ⅛" wide, with one turn over hot end of secondary.	20 turns 27 B & S Enam. close wound.
R.F. 16-51 m.	8.75 turns 34 B & S Enamel interwound from bottom of secondary.	11.45 turns 22 B & S Enam. wound in screw cuts. 16 T.P.I.
R.F. 13-39 m.	6 turns 34 B & S Enamel interwound from bottom of secondary.	7.75 turns 22 B & S Enam. wound in screw cuts. 16 T.P.I.
Oscillator 550-1500 Kc.	10 turns 34 B & S Enamel wound over bottom of secondary.	100 turns 31 B & S Enam. close wound
Oscillator 35-105 m.	8.5 turns 34 B & S Enamel wound 1/16" from cold end of secondary.	18.25 turns 27 B & S Enam. close wound.
Oscillator. 16-51 m.	4.5 turns 34 B & S Enamel interwound from bottom of secondary.	10.9 turns 22 B & S Enam. wound in screw cuts. 16 T.P.I.
Oscillator. 13-39 m.	3.25 turns 34 B & S Enamel interwound from bottom of secondary.	7.5 turns 22 B & S Enam. wound in screw cuts. 16 T.P.I.

COIL FORMERS	All coils wound on ¾ inch diameter bakelite former.
SHIELD CAN DIMENSIONS	550-1500 Kc. } 35-105 m. } **Shield Can**—Internal Diameter, 2⅛". 16-51 m. } 13-39 m. } **No Shield Can**—Placed between gang switch shield plates which are 2⅜" apart.
TUNING CONDENSER	A :—10—390 μμF. } B :— 9—398 μμF. } See note below.
PADDING CONDENSERS	550-1500 Kc. :— 410 μμF. 35-105 m. :—2000 μμF. 16-51 m. :—4000 μμF. 13-39 m. :—4500 μμF.
MAX. EFFECTIVE STRAY CAPACITANCES	A :—34 μμF. } B :—35 μμF. } including valve input, trimmer, wiring and coil capacitances.
INTERMEDIATE FREQUENCY	465 Kc.

NOTE.—These coil data apply only to particular conditions, and adjustment will normally be required in differing layouts. The effective inductance of the coils is affected by the length of the leads, the shield cans, and proximity to other components in the case of unshielded coils. The band coverage is affected by the total stray capacitances as well as by the capacitance of the gang condenser. Using gang condenser B, the band-coverage will be wider than with condenser A. Any minor adjustment in the coils should be made in the same proportion to both primary and secondary.





R.F. coils on the broadcast band employ high impedance primaries and sectional Litz wound secondaries. The aerial coil for the 35-105 metre band is also of the high impedance type, although the secondary is a single layer close-wound solenoid. In all cases where high impedance primaries are employed a capacitance turn is added to improve the gain at the high frequency end of the band.

In the design of the coils for the receiver it is necessary to consider the effects of variation of gain over the wave band, the coil gain, and the necessity for matching the high impedance primary to an aerial; also for the oscillator coil the production of the desired oscillator grid current within fixed limits over the band. As a guide towards oscillator coil design with the 6K8-G, it may be stated that the oscillator grid current should be between 100 and 200 μA. on all wave bands. The variation over the band should be reduced as far as possible by suitable coil design since either too high or too low oscillator grid current causes unsatisfactory performance.

RECEIVER TEST RESULTS

Comparison of receiver measurements at the Aerial Terminal, using Radiotron Receiver No. C51 with representative samples of 6K8-G and 6A8-G both working under optimum voltage and oscillator conditions.

Absolute Sensitivity

Band.	*Frequency or Wavelength.*	*6K8-G.*	*6A8-G.*
550-1500 Kc.	1400 Kc.	1.5 μV.	1.0 μV.
	600 Kc.	1.3 μV.	1.1 μV.
35-105 m.	37.5 m.	6.0 μV.	3.0 μV.
	90 m.	6.5 μV.	4.5 μV.
16-51 m.	17 m.	6.3 μV.	9.0 μV.
	45 m.	8.5 μV.	6.0 μV.
13-39 m.	14 m.	3.5 μV.	22 μV.
	35 m.	6.4 μV.	7.5 μV.

Image Ratio

Band.	*Frequency or Wavelength.*	*6K8-G.*	*6A8-G.*
550-1500 Kc.	1400 Kc.	10,000:1	10,000:1
	600 Kc.	100,000:1	80,000:1
35-105 m.	37.5 m.	260:1	190:1
	90 m.	1560:1	1200:1
16-51 m.	17 m.	100:1	80:1
	45 m.	330:1	240:1
13-39 m.	14 m.	22:1	12:1
	35 m.	330:1	260:1

NOISE LEVEL

Measurements made in Radiotron Receiver No. C51 with signal fed to Aerial terminal at 600 Kc. and 1400 Kc. on average samples of 6K8-G and 6A8-G.

INPUT = 5 μV., 30% Modulation.

Milliwatts Noise in 50 Milliwatts Output

Type	*600 Kc.*	*1400 Kc.*
6A8-G/1	3.5 mW.	3.0 mW.
6A8-G/2	3.8 mW.	3.2 mW.
6K8-G/1	3.8 mW.	3.5 mW.
6K8-G/2	4.5 mW.	4.0 mW.

Noise expressed as Percentage on Voltage Basis

Type	*600 Kc.*	*1400 Kc.*
6A8-G	27.2%	24.8%
6K8-G	28.6%	27.3%

BANDWIDTH

Comparison of Bandwith between 6K8-G and 6A8-G measured at converter grid, at Intermediate Frequency = 465 Kc., with various I.F. Transformers.

I.F. Transf.	*Input off Res. / Input at Res.*	*Bandwidth.* *6K8-G.*	*6A8-G.*
A	1,000	47 Kc.	65 Kc.
	10,000	120 Kc.	117 Kc.
B	1,000	42 Kc.	43 Kc.
	10,000	69 Kc.	76 Kc.

A. Z_d = 0.25 M. Q = 125. C = 115 $\mu\mu$F.
B. Z_d = 0.25 M. Q = 220. C = 200 $\mu\mu$F.

Second I.F. transformer and I.F. stage identical in each case.

OSCILLATOR GRID CURRENT

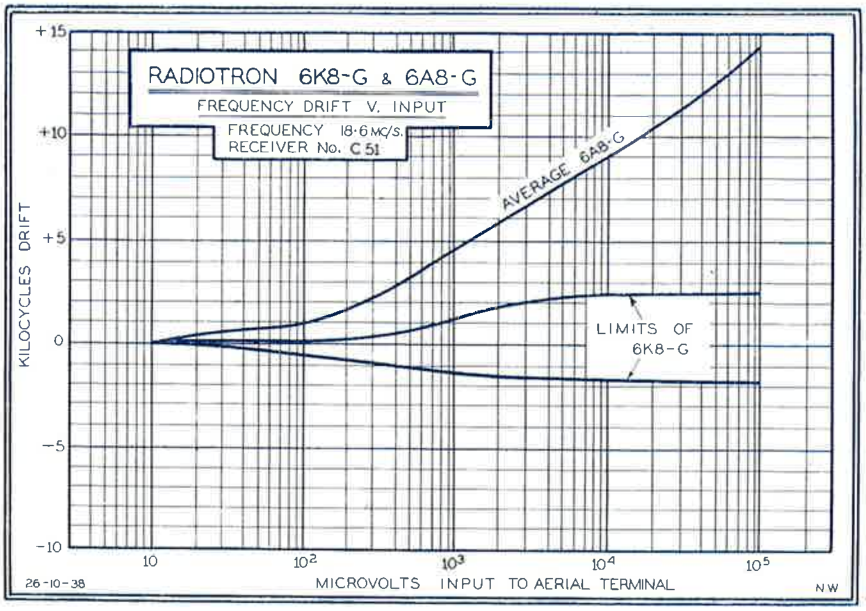
Oscillator Grid Current of average sample 6K8-G having Oscillator G_m = 3000 μmhos over the four bands and using coils as specified.

Band.	*Point.*	*Osc. Grid Current.*
550-1500 Kc.	550 Kc.	130 μA.
	1000 Kc.	150 μA.
	1500 Kc.	150 μA.
35-105 m.	35 m.	250 μA.*
	50 m.	210 μA.*
	90 m.	130 μA.
	105 m.	110 μA.
16-51 m.	16 m.	180 μA.
	30 m.	180 μA.
	51 m.	110 μA.
13-39 m.	13 m.	180 μA.
	20 m.	190 μA.
	39 m.	110 μA.

* Although these values are above those normally recommended, no appreciable loss of sensitivity or other defect was found in this particular case.

FREQUENCY DRIFT

The frequency drift of a converter valve depends upon many factors and no absolute curves which are of much value to the receiver designer can be given for a particular valve. It has been found that there are differences in the frequency drift due to A.V.C. between different types of receivers, even when employing the same valve. Consequently, in connection with this receiver, which may be regarded as a typical one, the total frequency drift due to A.V.C. and other effects is plotted against aerial input voltage for the receiver as a whole. On the diagram are shown two curves giving the upper and lower limits of individual 6K8-G valves and any Radiotron 6K8-G should be within these limits. It will be seen that the upper limit is +2.5 Kc. and the lower limit —1.8 Kc. For the purposes of comparison the curve for an average 6A8-G is shown and the improvement due to the use of the 6K8-G is evident. These curves were taken at a frequency of 18.6 megacycles.



CALCULATION OF GRID BIAS RESISTANCE COUPLED AMPLIFIERS

It sometimes happens that the value of the cathode bias resistor is quoted and it is necessary to determine what is the particular grid voltage to which this corresponds. The method used is illustrated in the two diagrams, Figures 1 and 2. Figure 1 shows the plate characteristics of the valve and on these curves the supply voltage, which in this case is 300 volts, is selected and the load line R_L is drawn with an inverse slope equal to the resistance in the plate circuit. The intersection of the load line with each of the grid bias curves is noted as *a*, *b*, *c*, *d*, etc. The second diagram, Fig. 2, is then constructed from information obtained from Fig. 1. At point *a* the bias is zero and thus the position of point *a* is settled. The remaining points in Fig. 2 may be added by applying Ohms Law, i.e.

$$\text{Bias Voltage} = \frac{R_c \times I_p}{1000}$$

where I_p is in milliamperes.

Through these points *a*, *b*, *c*, *d*, etc., a smooth curve is then required to be drawn and the point on this curve corresponding to the specified value of R_c is noted and its bias voltage read. In the case shown in Fig. 2, where R_c = 2600 ohms, it is evident that the bias voltage will be slightly greater than −1.4 volts. It is usual to specify the value of cathode bias resistor rather than the grid bias voltage since the voltage will vary somewhat with different valves, whereas the cathode bias resistor value is selected to give satisfactory operation with all valves. In any calculations it is necessary to bear in mind the fact that the published curves are for average valves and that slightly higher or lower values may occur with certain valves.

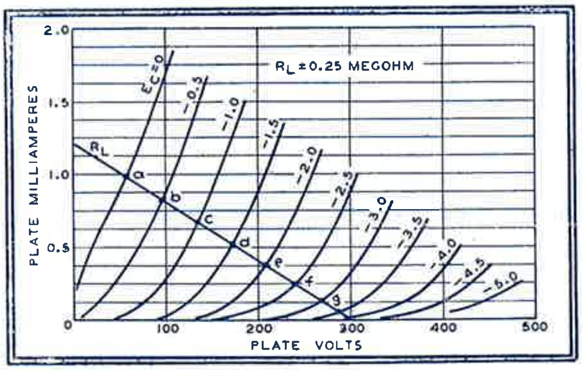


Fig. 1. *Method of Determining Bias Voltage from Plate Family and Load Line.*

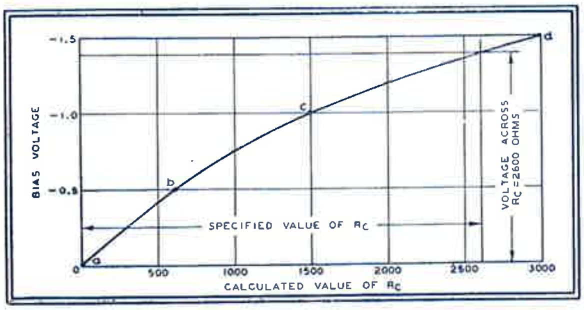


Fig. 2. *Calculated Values of Cathode Bias Resistor—Bias Voltage Curve obtained from Plate Family and Load Line.*

LOW VOLTAGE OPERATION OF RADIOTRON 913

A Trouble and its Cure

The use of voltages as low as 250 volts requires the exercise of certain precautions, the nature of and reasons for which are not generally understood. Fluorescent screens commonly used in cathode-ray tubes are composed of combinations of various chemical elements in a crystalline state. The No. 1 Phosphor screen used in the 913 is made by mixing certain forms of zinc, silica, and manganese together and heating the mixture to a high temperature. The resulting mass is ground to a fine powder, mixed with liquid and applied to the end of the tube with an air pressure spray gun.

Such fluorescent screens are quite good insulators. Unless a means of discharging the screen is provided, negative electrons from the beam may build up a negative charge on the screen material to the point where it eventually becomes so negative that the electrons of the beam are repelled and cannot reach the screen. Fortunately, a discharging means is provided by the phenomenon of secondary emission. Primary electrons in the beam knock one or more secondary electrons out of the screen when they strike, providing the velocity of the primary electrons is great enough. These secondary electrons are collected by the shell of the 913. In actual operation, the screen assumes a potential such that the ratio of primary to secondary electrons is one.

(*Continued on page 176*)

CLASS A$_1$ OPERATION

An Interesting Observation

The plate dissipation of a valve is the difference between the D.C. plate power input and the power output. Consequently when a valve is being operated with no signal input, there will be no power output, and the whole of the D.C. plate power input must be dissipated by the plate. When a signal voltage is impressed on the grid, a certain power output will be obtained, and on the assumption that the D.C. plate current remains constant, the plate dissipation will be less than in the static case. Since at full output the plate efficiency of a Class A$_1$ triode is about 20%, the plate dissipation at full output will be approximately 80% of the D.C. input power. Actually, due to even harmonic distortion, the D.C. plate current increases slightly with full grid excitation, and consequently the plate dissipation is slightly over 80% of the static plate power input.

The interesting result is that a Class A$_1$ triode operates with the highest plate dissipation under no signal conditions, and at full power output is not being operated at its maximum rating.

LOW VOLTAGE OPERATION OF RADIOTRON 913

(*Continued from page 175*)

In this dependence on secondary emission for maintaining the screen potential, we find the explanation of the fact that sometimes no light can be obtained from the 913 screen. When the power switch on an oscillograph unit is turned on, all the cathodes become heated. As the rectifier filament gradually warms up, voltage builds up slowly on Anode No. 2 of the cathode-ray tube. In the meantime, the cathode of the cathode-ray tube has begun to emit electrons which are drawn to the screen. Because the anode voltage has not reached its minimum rating of 250 volts, the velocity of these electrons is so low that they cannot release secondary electrons from the screen. Thus the screen is driven negative and the velocity of succeeding electrons is reduced despite the fact that the anode voltage is increasing. In this manner the velocity of the beam electrons is kept so low that no light can be produced.

The cure for this difficulty is simple and is effective in a majority of cases. The potentiometer controlling the voltage on No. 1 grid should be turned to the position which would completely bias off the beam under operating conditions before the power is turned on. Thus the negative bias on the control grid will build up as the cathode-ray tube starts to emit, and will prevent any electrons from reaching the screen. After sufficient time has been allowed for Anode No. 2 to reach its full potential the bias may be reduced, and since only high velocity electrons reach the screen, the tube will operate normally.

RADIOTRON NEWS

A new series of 1.4 volt filament valves has been announced, and limited stocks are expected early in December. These valves are intended for operation from a single large dry cell A Battery and a 90 volt B Battery, and comprise—

RADIOTRON 1A5-G, Small Power Pentode, 115 milliwatts maximum output, filament 1.4 V., 0.05 A.

RADIOTRON 1A7-G, Pentagrid Converter, sharp cut-off, 250 micromhos conversion conductance, filament 1.4 V., 0.05 A.

RADIOTRON 1C5-G, Power Pentode, 240 milliwatts maximum output, bias —7.5 V., filament 1.4 V., 0.10 A.

RADIOTRON 1H5-G, Single Diode High-Mu Triode, filament 1.4 V., 0.05 A.

RADIOTRON 1N5-G, R.F. Pentode, sharp cut-off, filament 1.4 V., 0.05 A.

A new metal-envelope series of valves has been announced, in which the grid connection normally taken to the top cap is taken to one of the base pins. This series comprises:—

RADIOTRON 6SF5, High-Mu Triode.
RADIOTRON 6SJ7, R.F. Pentode.
RADIOTRON 6SK7, Super-Control R.F. Pentode.
RADIOTRON 6SQ7, Duo-Diode High-Mu Triode.

These valves have applications similar to those of types 6F5, 6J7, 6K7 and 6Q7, and the addition of the "S" is to indicate the "single-ended" construction. The electrical characteristics, apart from capacitances, of types 6SF5 and 6SQ7 are identical to those of the 6F5 and 6B6-G (75) respectively, but the mutual conductances of types 6SJ7 and 6SK7 are higher than those of the 6J7 and 6K7.

RADIOTRON 6W7-G, a sharp cut-off R.F. Pentode with characteristics approximately similar to the 6J7-G, but having a heater operating at 6.3 volts 0.15 ampere, has been announced and stocks are expected early in December.

RADIOTRON 813, Transmitting Beam Tetrode with 100 watts maximum plate dissipation, is described elsewhere in this issue. Further information will be given later regarding price and availability from stock.