RADIOTRONICS

AMALGAMATED WIRELESS VALVE CO. PTY. LTD.

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In this issue:—

RESISTANCE-CAPACITY COUPLED DATA

6L5G, 6T7G and 6S7G

For convenience in reference a table has been arranged, giving recommended operating conditions for Resistance-Capacity Coupled operation of the Radiotron types 6L5G, 6T7G and 6S7G, all these being of the 6.3 volt 0.15 Amp. series. Reference should be made to previous issues of Radiotronics for general comments on resistance-capacity coupling, but in this table the major operating conditions are included. A variation in plate voltage of plus or minus 50% is permissible without any change in resistors, provided that cathode bias is used, and in the case of a pentode valve—that a screen dropping resistor is used. In cases where the plate supply voltage is varied, the output voltage will vary in approximately linear relationship. Fixed resistances may vary plus or minus 10% without much effect on the performance. The distortion for peak output voltage is approximately 5% in all cases.

Type	Total Supply Voltage	Plate Load Resistor (Megohms)	Following Grid Resistor (Megohms)	Cathode Bias Resistor (Ohms)	Screen Dropping Resistor (Megohms)	Voltage Gain at 4V. Rms Output	Peak Output Voltage at Grid Current Point
6L5G (triode)	90	0.1	0.5	5200	—	12	23
		0.25	0.5	10300	—	11.9	21.5
			1.0	12100	—	12	23.6
	180	0.1	0.5	4790	—	12.3	50
		0.25	0.5	9290	—	12.4	46
			1.0	10950	—	12.5	52
	300	0.1	0.5	4700	—	12.9	89
		0.25	0.5	9100	—	12.9	80
			1.0	10750	—	12.8	88
6T7G (duo-diode high-mu triode)	90	0.25	0.5	8300	—	30	10.2
			1.0	9000	—	31.6	11.5
	180	0.25	0.5	5220	—	36.4	33.8
			1.0	5920	—	38	38.5
	300	0.25	0.5	4580	—	40	69
			1.0	5220	—	41	80
6S7G (super-control R.F. pentode)	90	0.25	0.5	1520	1.6	66.5	18
			1.0	1560	1.7	77	19
	180	0.25	0.5	890	1.8	104	39.5
			1.0	950	1.9	118	44
	300	0.25	0.5	650	1.95	122	66
			1.0	700	2.1	136	76

TWO NEW CONVERTER VALVES

Mixer and Separate Oscillator in One Envelope

One of the most important factors in any radio set is the converter stage, and any improvement in this stage will undoubtedly result in an improvement in the receiver performance. Consequently any forward step in the design of converter valves will be of widespread interest.

The function of the converter stage in a superheterodyne receiver is to "mix" the input signal from the aerial with a locally generated "oscillator" frequency so as to produce a signal in the plate circuit which is of intermediate frequency. One well tried method consists of a separate oscillator valve whose output, together with the input signal, are fed into a separate mixer valve. In early designs, both signals were fed into the signal grid circuit, so that interlocking and other troublesome effects occurred. A distinct improvement was made in the release of the Radiotron 6L7 and 6L7G pentagrid (or heptode) mixer valves but these had the disadvantage that a separate oscillator valve was required.

For a number of years the pentagrid converter of the 6A7—6A8—6A8G class has been very widely used since it combines in one envelope both oscillator and mixer. Although not ideal in all respects it has given extremely good performance both on the broadcast band and on short-waves.

Both the new releases 6K8 and 6J8G differ from pentagrid converters in that they incorporate a separate oscillator in the same envelope although internally connected to a grid of the mixer unit. By means of the isolation of the plate of the oscillator from the electron stream of the mixer it has been possible to improve the stability of the oscillator so that its frequency is very little affected by variations in voltages applied to the mixer.

The basing of both Radiotron 6K8 and 6J8G valves is arranged so as to be similar to that of the 6A8 and 6A8G. It is therefore possible to interchange any of these valves without any change in the chassis. Although this may be done without any detriment to the valves there will not normally be any improvement in performance. In order to obtain an improvement in performance on the broadcast band it will generally be necessary to fit I.F. transformers having high dynamic resistance, to improve the Q of the R.F. coil in the signal grid circuit and to make changes in the oscillator coil or circuit. Due to the higher input and output resistances of the new valves these changes in the tuned circuits will have a more pronounced effect than they would have with valves such as the 6A7.

It is expected that limited quantities of each of these new Radiotron types will be available about the date of this publication, and it is anticipated that receiver designers will obtain samples so as to conduct tests in order to satisfy themselves regarding their performance. No claim for revolutionary improvements in performance is made for either of these new types, and it is not expected that they will be adopted to any great extent during the current season. There is, however, good reason to believe that in receiver models designed in the future one or other of these new types will be adopted.

RCA APPLICATION NOTE

Radiotron 6K8

Triode - Hexode Converter

The pentagrid-converter type of valve now in general use is a good frequency-converting device at medium radio frequencies. However, the performance of this type is not as good in the high-frequency band as in the broadcast band because undesirable effects of interaction between oscillator and signal sections of the valve increase with frequency. Radiotron 6K8, a new all-metal converter valve, is designed for improved performance in the high-frequency band of all-wave receivers. Because the 6K8 combines the functions of oscillator and mixer, it retains the important advantage of low circuit cost; moreover, because of improved design, it gives optimum performance with a low value of oscillator amplitude.

A disadvantage of the present pentagrid converter is the large variation in the transconductance (g_m) of the oscillator section with signal-grid bias. In practice, this characteristic is evidenced by a shift in oscillator frequency with change in A.V.C. voltage. This shift in oscillator frequency is appreciable in the high-frequency band because of the large ratio of signal frequency to intermediate frequency.

Several undesirable effects have been traced to oscillator-frequency shift with A.V.C. voltage: (1) alignment of R.F. circuits may be difficult, (2) a receiver may motorboat when a

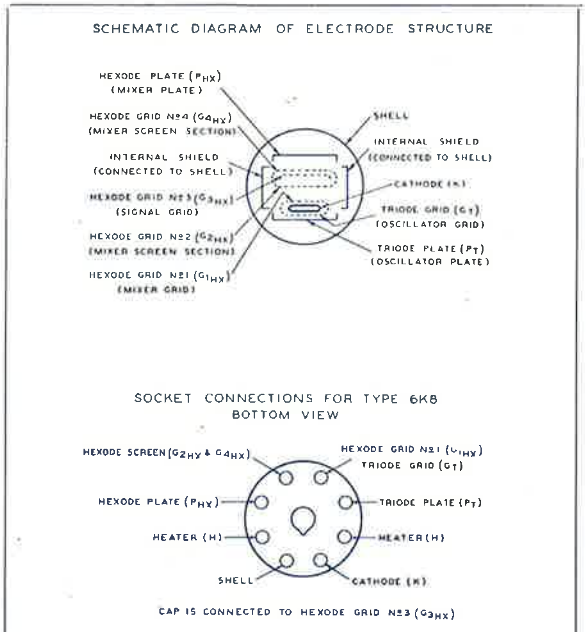


FIG. 1

strong signal is impressed, and (3) appreciable distortion may be introduced by the I.F. amplifier, because the intermediate frequency differs from that to which the I.F. transformers are tuned. Alignment difficulties which are encountered when A.V.C. voltage is applied to the signal grid of the converter is due to the dependence of oscillator frequency on A.V.C. voltage; the magnitude of the A.V.C. voltage, in turn, depends on oscillator frequency. Alignment difficulties which are experienced when no A.V.C. voltage is present may be traced to coupling between the oscillator grid and the signal grid. With the pentagrid-converter type of valve, a receiver may motorboat when a strong signal is impressed because of poor power-supply regulation or large oscillator-frequency shift with A.V.C. voltage. This effect is considerably reduced with the type 6K8, because oscillator frequency is not critical to changes in oscillator-plate voltage or signal-grid bias.

Construction of the 6K8

The electrode arrangement and socket con-

Electrical Characteristics of the 6K8

Direct Interelectrode Capacitances (Approx):*			
Hexode Grid No. 3 to Hexode Plate		0.03	μμf
Hexode Grid No. 3 to Triode Plate		0.01	μμf
Hexode Grid No. 3 to Triode Grid and Hexode Grid No. 1		0.1	μμf
Triode Grid and Hexode Grid No. 1 to Triode Plate		1.1	μμf
Triode Grid and Hexode Grid No. 1 to Hexode Plate		0.05	μμf
Hexode Grid No. 3 to All Other Electrodes = R.F. Input		6.6	μμf
Triode Plate to All Other Electrodes (except Triode Grid and Hexode Grid No. 1) = Osc. Output		3.2	μμf
Triode Grid and Hexode Grid No. 1 to All Other Electrodes (except Triode Plate) = Osc. Input		6.0	μμf
Hexode Plate to All Other Electrodes = Mixer Output		3.5	μμf
Hexode Plate Voltage		250 max.	Volts
Hexode Screen (Grids No. 2 and 4) Voltage		100 max.	Volts
Hexode Control-Grid (Grid No. 3) Voltage		–3 min.	Volts
Triode Plate Voltage		200 max.	Volts
Total Cathode Current		16 max.	Milliamperes
Typical Operation:			
Heater Voltage	6.3	6.3	Volts
Heater Current	0.3	0.3	Ampere
Hexode Plate Voltage	100	250	Volts
Hexode Screen Voltage	100	100	Volts
Hexode Control-Grid Voltage	–3	–3	Volts
Triode Plate Voltage	100	100	Volts
Triode Grid Resistor	50000	50000	Ohms
Hexode Plate Resistance (Approx.)	0.3	0.3	Megohms
Conversion Transconductance	360	400	Micromhos
Hexode Control-Grid Bias (Approx.) for Conversion Transconductance = 2 μmhos	–30	–30	Volts
Hexode Plate Current	2.3	2.7	Milliamperes
Hexode Screen Current	6.9	6.5	Milliamperes
Triode Plate Current	3.5	3.5	Milliamperes
Triode Grid and Hexode Grid No. 1 Current	0.15	0.15	Milliamperes

The transconductance of the oscillator unit (not oscillating) of the 6K8 is approximately 2400 micromhos when the Triode Plate Volts = 100, and the Triode Grid Volts = 0.

* With shell connected to cathode.

nections of the 6K8 are shown in Fig. 1. Cathode (K), triode grid (G_T), and triode plate (P_T) form the oscillator unit of the valve; cathode (K), hexode mixer grid (G_{1HX}), hexode double screen (G_{2HX} and G_{4HX}), hexode signal grid (G_{3HX}), and hexode plate (P_{HX}) constitute the mixer unit. Note that a single cathode sleeve serves both oscillator unit and mixer unit. The oscillator voltage on G_{1HX} modulates the transconductance of the mixer unit to produce the intermediate frequency.

These data show that the recommended value of hexode screen voltage for 100- or 250-volt operation is 100 volts. The use of 100 volts on the hexode screen accounts for the comparatively high conversion transconductance of the 6K8 in A.C./D.C. receivers. With the pentagrid-converter type of valve, screen voltage should be lower than the plate voltage to obtain high plate resistance, because of secondary-emission effects. This restriction is not imposed on the 6K8, because the internal shield plates act as a suppressor to raise the plate resistance of the hexode unit at low values of hexode plate voltage.

Another point of interest is the recommended value of 100 volts for the oscillator (triode) plate. With the pentagrid-converter type of valve, oscillator-anode voltage should be greater than the screen voltage to obtain sufficient oscillator-anode current. This condition does not obtain in the 6K8, because its oscillator-plate current is substantially independent of the voltage on its hexode screen, due to the geometry of the valve structure.

The recommended value of 100 volts for the screen of the hexode unit and for the plate of the oscillator unit is practical, because this value is also applied to the screens of R.F. and I.F. valves, and may be taken from the same point in the power-supply system in series-feed oscillator circuits. In shunt-feed oscillator circuits, a separate resistor or choke is, of course, required in the oscillator-plate circuit. When oscillator-plate and screen voltages are taken from one point in the power-supply system, this point should be adequately by-passed to ground.

A third point of interest is the low value of oscillator grid current (I_5) required for high conversion transconductance (g_c) and high hexode plate resistance (r_p). Curves of g_c, r_p, and total cathode current I_a vs I_5 through 50000 ohms for 100- and 250-volt operation are shown in Fig. 2. These curves indicate that nearly maximum conversion transconductance is obtained over a wide range of oscillator grid current and that r_p increases with oscillator grid current.

The recommended minimum value of oscillator grid current is 100 microamperes, and the recommended design value is 150 microamperes. The recommended minimum value is selected on the basis of low r_p and high I_a. The cathode current varies inversely with the oscillator grid current. The recommended maximum value of cathode current (16 milliamperes) is reached at a value of oscillator grid current a little less than 100 microamperes. The recommended design value of 150 microamperes is comparatively easy to obtain in practice. Inductive (tickler) feed-back circuits are usually designed for the proper value of oscillator grid current at the low-frequency end of a band; the oscillator grid current then increases with frequency over that band. It it possible to obtain substantially uniform oscillation amplitude over an entire band by using a shunt-feed oscillator circuit. In such a circuit, the series padding condenser provides electrostatic coupling at the low-frequency end of the band and the tickler provides inductive coupling at the high-frequency end of the band.

It should be noted that oscillator coils intended for use with the pentagrid converter type of valve may not be suitable for use with the 6K8, because of the possibility of over-exciting the oscillator unit of the valve. In order to use such coils, it may be necessary to reduce the oscillator plate voltage, the number of tickler turns, or the mutual inductance between tickler and secondary so as to reduce the oscillator grid current to a good value. The R.F. input capacitance of the 6K8 is 6.6 μμf. Because this value is approximately half that of a pentagrid converter, a higher tuning ratio can be obtained with a converter stage employing a 6K8 than with a converter stage employing a pentagrid converter.

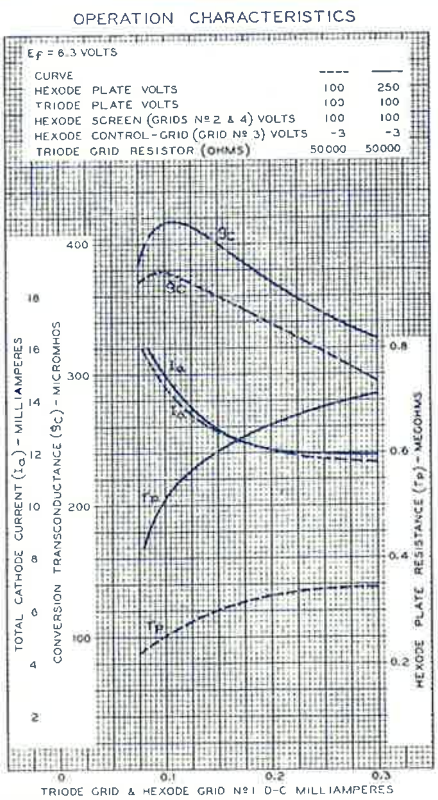


FIG. 2

Operating Characteristics of the 6K8

The curves of Fig. 3 show the variation in oscillator transconductance with signal-grid bias for the 6K8 and for a pentagrid converter. These curves indicate the effect of A.V.C. voltage on oscillator performance. As previously mentioned, one practical effect of the improved performance of the 6K8 indicated by the curves of Fig. 3 is a reduction in oscillator-frequency shift with A.V.C. voltage. This is shown by the curves of Fig. 4. The data of Fig. 4 were taken in a radio receiver of typical design after a suitable micrometer condenser was installed to permit accurate determination of frequency shift. It is seen that a frequency shift of approximately 50 k.c. can be obtained in practice with a pentagrid-converter type of valve and that the frequency shift was reduced to approximately 2 k.c. when the 6K8 was installed; these data were taken at 18 megocycles.

Tests in a typical receiver of oscillator-frequency shift for line-voltage changes were conducted. A 6K8 was installed and electrode voltages adjusted for 250-volt operation at 18 megacycles. When the line voltage was varied from 200 to 250 volts, the oscillator frequency shifted approximately 6 k.c. A pentagrid converter was installed in the same receiver under proper operating conditions and the line voltage was varied from 200 to 250 volts; the oscillator frequency shifted approximately 27 k.c. The ratio of 6/27 represents a very worthwhile improvement.

At frequencies of the order of 18 megacycles, effects of the time of transit of electrons through the valve cannot be neglected. One important transit-time effect is observed in the nature of the input conductance of the mixer unit (R.F. input conductance). At 18 megacycles, the R.F. input conductance of the 6K8 is negative. The effect of a negative input conductance is to improve the Q-ratio of the tuned circuit connected to the 6K8. This improvement in circuit Q was evidenced in one test by a higher image ratio. A valve type in which the input grid is adjacent to the cathode exhibits positive input conductance, and this decreases the effective Q of a circuit connected to the input grid.

The conversion transconductance of the 6K8 is 400 micromhos under the 250-volt operating conditions. The conversion gain, which is the ratio of the I.F. voltage across the load to the R.F. voltage input, is given by the relation:

$$\text{Conversion Gain} = \frac{g_c\ r_p\ R_L}{r_p + R_L}$$

where R_L is the resonant impedance of the I.F. transformer measured across the primary

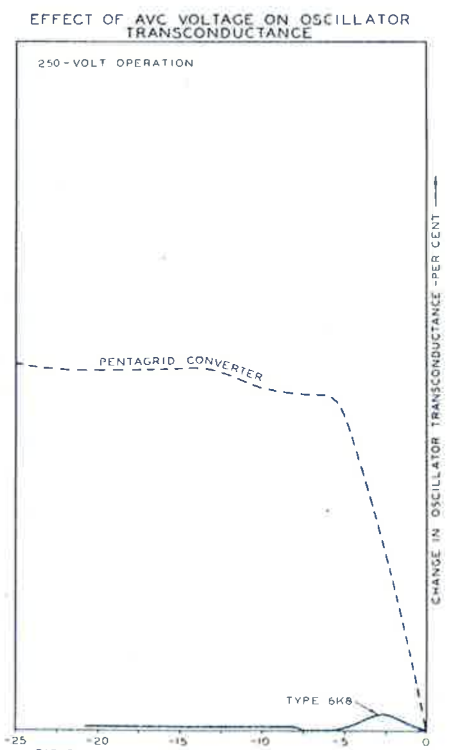


FIG. 3

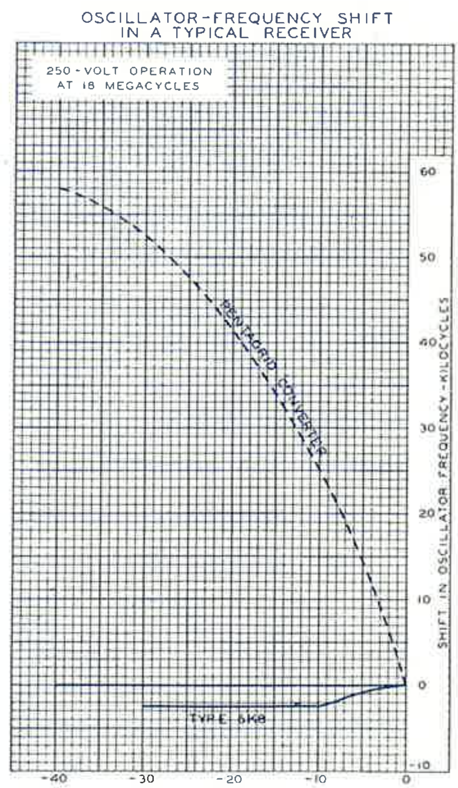


FIG. 4

terminals. The conversion gain for different values of R_L is shown by the curve of Fig. 5. It is seen that for values of R_L less than 0.35 megohm the gain obtained from a 6K8 is only slightly less than that obtained from a pentagrid converter. More gain is obtained from the 6K8 than from a pentagrid converter at values of R_L greater than 0.35 megohm.

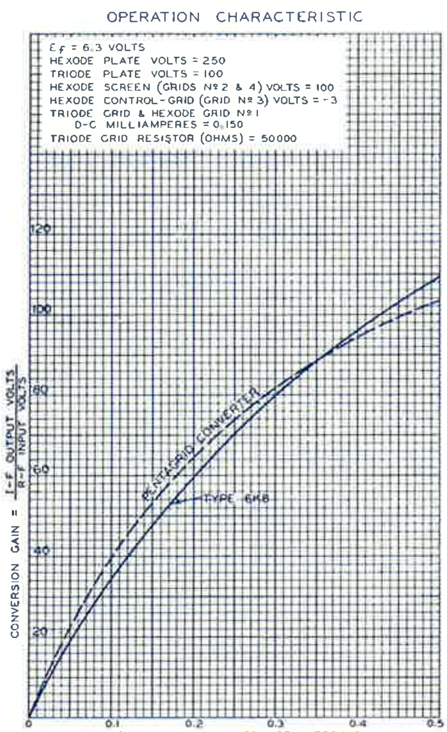


FIG. 5

RADIOTRON 6J8G

Triode Heptode

Radiotron 6J8G is a glass valve on an octal base, incorporating a separate triode oscillator and a heptode (or pentagrid) mixer unit. The grid of the triode oscillator is internally connected to the **third** grid of the mixer which very closely resembles the 6L7G in its electrical characteristics. The oscillator is of approximately the same strength as that of the 6A7 and 6A8G, and, in many circumstances, the valve can be treated as being very similar to these two types. Although the conversion conductance (290 micromhos) is comparatively low, the very high plate resistance results in a gain with average I.F. transformers which is approximately the same as that of the pentagrid converters. With high dynamic resistance I.F. transformers, there may be an advantage in gain through using the 6J8G. Two important advantages provided by the 6J8G are firstly, the improved selectivity due to the high plate resistance of the mixer and, secondly, the stability of the oscillator due to its isolation from the electron stream of the mixer. In operation the 6J8G may be considered as being similar to two separate valves having a common cathode and having the grid of the oscillator connected to the third grid of the mixer. Since there is no other appreciable coupling between them the oscillator stability is extremely good. The effect of this stability is that the oscillator frequency is very little affected by a variation in the A.V.C. voltage applied to the control grid of the mixer. The oscillator frequency is also remarkably stable even when large variations are made in the voltages applied to the plate of the oscillator or the screen of the mixer, and in this respect it is a distinct improvement on the pentagrid converter.

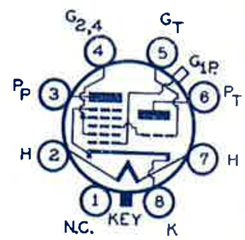
Due to the extremely low capacitance between the R.F. input grid and the plate of the mixer, there is very little "Miller Effect" to cause loading on the signal grid circuit and there is consequently less damping at the low frequency end of the broadcast band where the signal frequency approaches the intermediate frequency. The sensitivity of the 6J8G is therefore more constant over the broadcast band in receivers employing an intermediate frequency of about 465 K.C.

An improvement in performance may be expected with the 6J8G due to the application of plate tuning in the oscillator circuit in place of the usual grid tuning. An examination of vector diagrams indicates that with grid tuning the plate and grid voltages of the oscillator are not 180 degrees out of phase and therefore the effective oscillator voltage is considerably reduced. By the simple expedient of placing the tuned circuit in the plate circuit and the reaction winding in the grid circuit, a marked improvement may be obtained in the phase between grid and plate voltages and the effective oscillator voltage is thereby increased. Certain other minor advantages are claimed to follow as a result of the use of plate tuning. The oscillator harmonic content is comparatively low and the harmonics which are present are directly bypassed to earth due to the low impedance of the tuned circuit to all frequencies except that of the fundamental. Evidence is also available to show that a tuned plate oscillator has greater frequency stability than is commonly obtainable with the tuned grid type, this advantage being particularly important on the short-wave bands. With a tuned plate circuit the oscillator is less affected by the space charge coupling to the injector (No. 3) grid of the mixer, and for this reason also plate tuning is an advantage. A still further advantage is the greater band coverage obtainable with plate tuning on the short-wave band.

Plate tuning of the oscillator has been widely used in England for a considerable time past, and the success which it has attained appears to have confirmed the original claims made. It may, of course, be applied to any type of separate oscillator or converter but is particularly useful in the case of the 6J8G. With plate tuning it is usual to employ parallel feed to the plate of the oscillator so that the tuned circuit may be at earth potential. The additional components are therefore a resistance between B+ and the plate, and a coupling condenser from the plate to the hot end of the tuned circuit.

Radiotron 6J8G appears to offer certain advantages due to its high plate resistance, high input resistance and oscillator stability which should attract the attention of receiver designers. In order to take advantage of its performance, it is necessary to employ high impedance I.F. transformers, high impedance grid circuits and suitable oscillator circuits, but with these requisites the performance on the broadcast band should be comparable so far as a stage gain is concerned with existing types of converters, while on the short-wave band its performance should be distinctly improved. Experience alone will show the advantages of the various types of converters in their true perspective, but the 6J8G opens a wide field for experimental work.

SOCKET CONNECTIONS



G-8H

RADIOTRON 6J8G

TRIODE HEPTODE CONVERTER

Tentative Characteristics

Heater Voltage A.C. or D.C.	6.3	Volts
Heater Current	0.3	Ampere

Operating Conditions and Characteristics

Heater Voltage	6.3	6.3	Volts
Plate Voltage (Heptode)	100	250	Volts Max.
Control Grid Voltage (Heptode)	–3	–3	Volts
Screen Voltage (Heptode)	100	100	Volts Max.
Oscillator Plate Voltage (Triode)*	100	250	Volts Max.
Oscillator Grid Resistor (Triode)	50,000	50,000	Ohms
Plate Current (Heptode)	1.4	1.3	mA.
Screen Current (Heptode)	3.0	2.9	mA.
Oscillator Plate Current (Triode)	3.0	5.0	mA.
Oscillator Grid Current (Triode)	0.3	0.4	mA.
Plate Resistance (Heptode)	0.9	4.0	Megohms Approx.
Conversion Conductance	250	290	µmhos
Control Grid Voltage (Heptode) for 2 µmhos Conversion Conductance	–20	–20	Volts

* Applied through 20,000 ohm dropping resistor.

Triode Section

Plate Voltage	100	Volts
Grid Voltage	0	
Plate Current	7	mA.
Plate Resistance	10,600	ohms
Mutual Conductance	1,600	µmhos
Amplification Factor	17	

Capacitances (with standard shield)

R.F. input grid to Heptode plate	.01 max.	µµF.
R.F. input grid to Oscillator plate	.015	µµF.
R.F. input grid to Oscillator grid	.13	µµF.
R.F. input grid to all other electrodes (R.F. input)	4.4	µµF.
Heptode plate to all other electrodes (Mixer output)	8.8	µµF.
Oscillator grid to Oscillator plate	2.2	µµF.
Oscillator grid to all other electrodes (Oscillator input)	11.7	µµF.
Oscillator plate to all other electrodes (Oscillator output)	5.5	µµF.

TRANSMITTING RADIOTRONS

891-R & 892-R

Two new types which have been added to the Radiotron range are the 891-R and the 892-R which are essentially similar to the water cooled types 891 and 892 but which, in place of the water jacket, are fitted with a special radiator which is cooled by means of forced air. Due to this air cooling the ratings on these two types are somewhat lower than the ratings on the similar water cooled types. Both valves have 2-unit filaments, each unit operating at 11 volts 60 A. These filaments may be operated with either single or two-phase connection. Under class C telegraphy conditions these valves may be operated with a maximum plate voltage of 10,000 volts, a maximum plate input of 18 KW and maximum plate dissipation of 5 KW. Under typical operating conditions the power output is 10 KW for class C telegraphy and 3.5 KW for plate modulated class C telephony.

Although valves of this type are not yet used in Australia, it is interesting to note the trend of design among the leaders of valve technique.

THE RADIOTRON FIDELITY TUNER

In Radiotronics 84 a tuner having continuously variable selectivity was described. In this circuit the variation in selectivity is given by two ganged differential condensers of special design, and no coil movement is necessary to give symmetrical expansion. The test results on this receiver are given in figures 6 and 7, and it will be seen that the selectivity is at maximum in figure 6B, while the fidelity is a maximum in figure 6A. The expansion is symmetrical on both sides of the most selective position. Figure 7 shows the overall R.F. response at these two extreme positions. It will be seen that in the most widely expanded position, the R.F. response is very nearly perfect. Due to the design of the amplifier in which the control is effected on a buffer stage, the final I.F. amplifier operating on fixed bias, the distortion is extremely small, while the A.V.C. control is excellent. It is considered that this circuit arrangement has distinct advantages over alternative arrangements in which movable coils are used and the results which have been obtained indicate a very satisfactory performance.

RADIOTRON 50 WATT TRANSMITTER

The 50 watt transmitter circuit No. T125 given on page 110 of Radiotronics 84 has been found to have an error in the modulator circuit. The grid resistor of the 6J7G phase splitter should be returned not to earth as shown in the diagram, but to the cathode circuit at the junction of the 5,000 ohm bias resistor and the 0.05 megohm cathode load resistor. Would you please make the necessary correction in your earlier copy in order to avoid any misunderstanding.

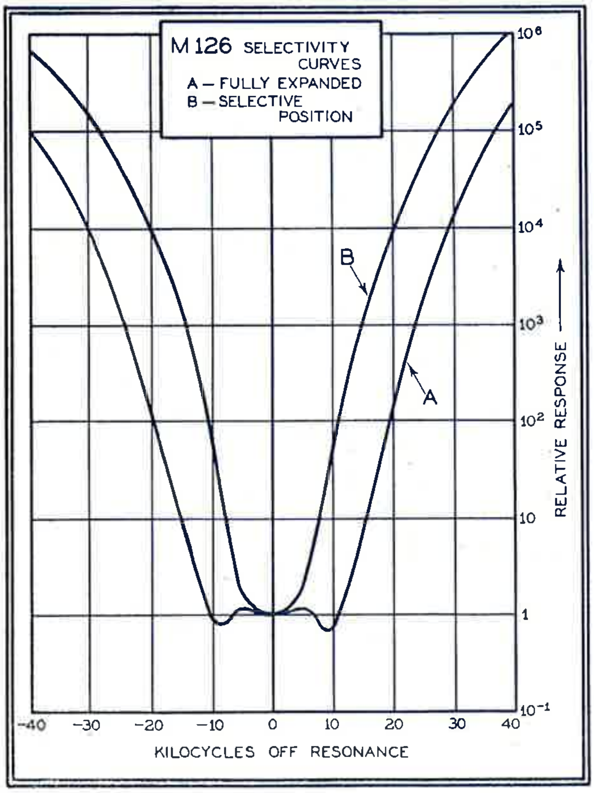


Fig. 6

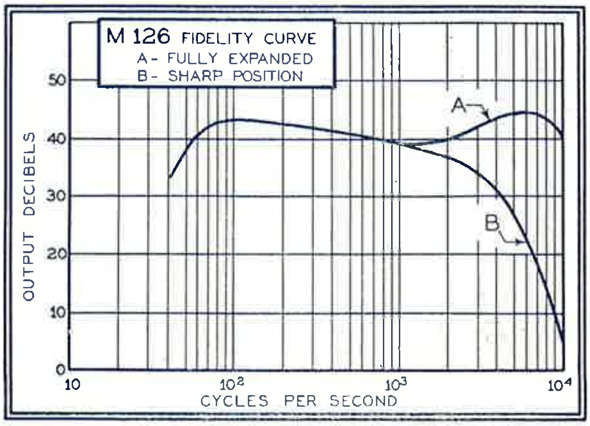


Fig. 7