

# RADIOTRONICS

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In this issue:—

	Page		Page
Audio Frequency Amplifiers .....	57	Radiotron 6J7-G and 6B8-G as Small Power Triodes .....	63
Radiotron 809—Photograph .....	59	Grid Resistor for 6V6-G .....	63
New Valve Import Restrictions .....	61	Radiotron 6J8-G as I.F. Amplifier .....	64
Power Transformer Impedance .....	62	New Valve Data Sheets .....	64
Replacement for 5U4-G or 5Z3 .....	62	Radiotron News .....	64
Replacement for 2A3 .....	63		
Radiotron Amplifier A501 .....	63		

### AUDIO FREQUENCY AMPLIFIERS

A number of requirements must be satisfied before an audio frequency amplifier can be claimed to be satisfactory in all respects. The important characteristics include not only frequency response and distortion but also loudspeaker damping, stability and freedom from hum.

In any treatment of an amplifier it is desirable to consider the loudspeaker as forming part of the amplifier rather than as a separate unit. In this case the design should begin with the loudspeaker and the amplifier itself should be designed from the output end and finishing at the input end.

When it is not possible to design an amplifier to suit a particular loudspeaker it is generally assumed that the loudspeaker will have a level frequency characteristic. If this is not the case some form of tone compensation may be required, but it is far more satisfactory for this to be incorporated into the original design of the amplifier or to form a completely separate unit, rather than to be added to the main amplifier at a later date. There are many difficulties in adding any form of tone compensation to a completed amplifier and the procedure is one which is not recommended.\*

If an amplifier is considered apart from the loudspeaker it is possible for all the tests

\* The addition of a special tone compensation stage at the input end of the amplifier is to be commended. This stage should not be relied upon for gain, since the gain at certain frequencies may be about unity. It is hoped to describe such a tone compensation stage in a future issue of Radiotronics.

(except perhaps that for hum) to be carried out with suitable measuring instruments and there is no point in making a further test under actual operating conditions. The design of audio frequency amplifiers has now reached a stage where an amplifier can be rated accurately and compared on paper with any other amplifier without any test being made by ear. In fact the latter may prove misleading if amplifiers not having level frequency characteristics are applied to loudspeakers not having level characteristics. For example, if an amplifier incorporating bass boosting is used in conjunction with a loudspeaker which is deficient in the bass, the overall result may be pleasing. On the other hand the same amplifier, used with a speaker having a prominent bass response, is likely to give an overall reproduction which is badly out of balance with a preponderance of bass. Allowance should also be made for the acoustics of the room when two amplifiers are being compared by ear, since a heavily damped room requires a preponderance of highs for an apparently balanced reproduction.

The major characteristics of an amplifier are treated briefly in the following paragraphs.

#### STABILITY.

With good design an amplifier may be made completely stable under all conditions. Any instability which may be present in a poorly designed amplifier may result in audible motor-boating or high-pitched oscillation, or alternatively may have an adverse effect on the



tone without being otherwise evident.

The only really satisfactory test for incipient instability is the use of a Cathode Ray Oscillograph with a sine-wave input of variable voltage and frequency as may be obtained from a Beat Frequency Oscillator.

The cure for instability in a simple amplifier is generally obvious, and readily applied. With push-pull amplifiers employing negative feedback, or single-sided amplifiers employing negative feedback over more than a single stage, the problem may be much more difficult. For references to articles on instability see the Bibliography at the end of this article.

### HUM.

Hum is one of the more difficult problems of an amplifier since it is affected not only by circuit design but also, to some extent, by layout. A simple test for hum is that of operating the amplifier on a loudspeaker load under normal operating conditions. The hum level for good fidelity should be so low that it is inaudible even at a short distance from the loudspeaker. It may be found preferable to feel, with the finger, the vibration of the loudspeaker cone itself, since this may be a more sensitive test than the hearing test. All efforts towards a decrease of the hum level will be repaid in the performance of the amplifier.

The measurement of hum is comparatively simple, but the results require a certain amount of interpretation. The usual method of measurement with a copper-oxide output meter does not distinguish between the fundamental ripple frequency (100 c/s.) and its harmonics. Unless elaborate testing equipment is available the harmonics can only be identified by ear. If the hum sounds rough or rasping it may safely be concluded that the higher harmonics of the hum frequency are present. If the higher harmonics are relatively weak it is satisfactory to rely on the output-meter test; as a guide for fidelity amplifiers for the home, it may be accepted that the hum level should be not less than 50 db below the maximum output of the amplifier. For example with a 10 watt amplifier the hum level should not be above 0.1 milliwatt.

If an amplifier is to be used at a level considerably below the maximum output, the hum level should be reduced in proportion. If an amplifier is to be used out-of-doors or if the loudspeaker has a relatively weak bass response (100 c/s.), the hum level may be higher.

It is desirable to cut down the hum level primarily by improving the filtering in the conventional manner rather than by the use

of neutralisation or a hum bucking coil. The latter methods may be used for getting rid of the final traces of hum, but should not be relied upon without first incorporating an efficient filtering system. Hum is generally severe with resistance coupled pentodes owing to the high plate resistance. Such a stage should, therefore, have more complete filtering than other stages. A suitable filter may readily be incorporated in the form of a "decoupling" resistance and condenser combination in the plate circuit.

In amplifiers having high overall gain it is essential to isolate the early stages from the magnetic fields of the power transformer or chokes. This is particularly difficult where a single steel chassis is used, and where possible it is desirable to use two entirely separate chassis. For example, the power supply and output stage may be accommodated on one chassis and the voltage amplifying stage on the other. Much trouble may be caused by hum if transformers are used in the early or intermediate stages of a compact amplifier; resistance coupling is to be preferred for this reason.

Push-pull operation is beneficial in reducing the effects of hum, but it is not usually necessary to use push-pull throughout the amplifier unless an unusually low level of hum is desired. For normal use it is usually sufficient to adopt a single sided amplifier in the early stages. For further information see the Bibliography at the end of the article.

Tests on frequency response and distortion should not be carried out until the amplifier is completely stable and free from audible hum.

### FREQUENCY RESPONSE.

The frequency response of an amplifier may be measured with the aid of a Beat Frequency Oscillator and Output Meter. This test is an extremely easy one to carry out, and needs no description. The output meter may be replaced, if desired, by a cathode ray oscillograph. The frequency response may be calculated (using the formulae given in the Radiotron Designer's Handbook), but the process is somewhat laborious. When an amplifier is constructed exactly in accordance with a description in Radiotronics there should be no necessity for measuring the frequency response, which should agree very closely with the published data, provided that every effort is made to reduce to the minimum all stray capacitances.

The test for frequency response of an amplifier is frequently carried out with an equivalent resistive load in place of the loud-

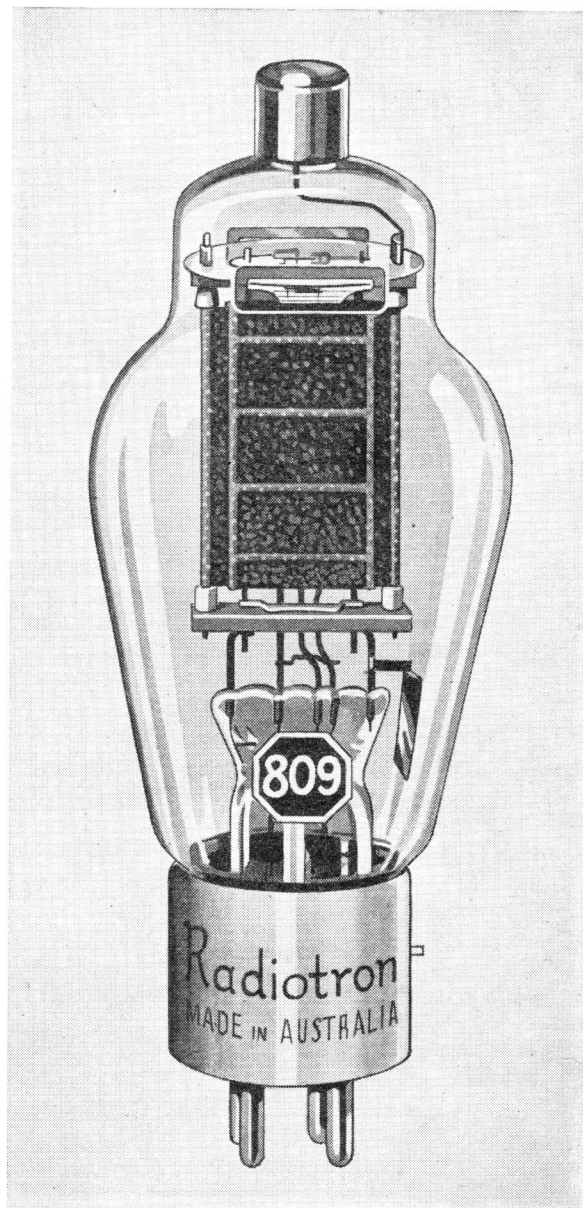
speaker. This does not give all the information which is required for a complete test, and the method which has been adopted in the A.W.V. laboratory is to measure the voltage across the primary of the speaker transformer with the field at normal excitation. Although this improved test is not comprehensive, it brings in the effect of variation in speaker impedance with frequency, including the shunting effect of the primary inductance.

A fidelity amplifier should have a frequency response from about 40 to 10,000 c/s. within  $\pm 2$  db. Such an amplifier is described as "flat", and is suitable for use with a loudspeaker having a "flat" characteristic. When an amplifier having a more or less level frequency response is used in combination with an ordinary type of speaker, the overall frequency response is usually an unknown quantity, and in some cases tone compensation is applied until a pleasing tone results. It is at this stage that many users of amplifiers go far astray. Lacking instruments, they frequently cut the response above say 3,000 or 5,000 c/s. in an endeavour to obtain the desired balance between bass and treble, whereas the correct step might be to introduce bass boosting below say 250 c/s.

In obtaining "balance" it is desirable to include, not only the amplifier proper, but all other essential units. For example, in the reproduction of records it is desirable to include the pickup, tone compensation unit, amplifier and loudspeaker *in situ*. A "gliding-tone" record provides the only really satisfactory means of judging overall frequency response. The main difficulty is the basic one of the discrimination of the human ear, or lack of discrimination in most cases. Even trained observers differ widely in their observations of the extremes of frequency. The measurement of frequency response by means of a calibrated microphone and amplifier is difficult, particularly in an enclosed space, owing to the occurrence of "standing waves". These are well known to those who have had any experience in this class of work, but may be demonstrated very easily. A Beat Frequency Oscillator may be set to a frequency in the region of 2,000 c/s. and the output applied through an amplifier to a loudspeaker in a closed room. If the observer stands some distance away from the speaker, and moves his head a short distance to one side or the other he will observe a change in apparent volume from a maximum to a minimum. This is due to the "standing waves" brought about by reflection from the walls.

The effects of standing waves on the frequency response may be eliminated by a "warbling tone" or by a moving microphone, but both these methods are too complicated

## RADIOTRON 809



*Radiotron 809 is a transmitting triode with a plate dissipation of 25 watts. It may also be used as an audio frequency Class B Amplifier or modulator with a power output up to 100 watts from two valves. Radiotron 809 is Australian-made.*

for use outside properly equipped acoustic laboratories. In the normal case it is necessary for the observer to make an allowance for the presence of standing waves.

An amplifier equipment which is adjusted in one room may be out of adjustment in another room, or even if the location of the loudspeaker is changed in the one room. It is for this reason that a loudspeaker should always be tested *in situ*.

[Continued overleaf]

The final adjustment for balance between bass and treble may be made on a selection of records, judged by ear. This test should be carried out under normal listening conditions with the normal number of persons present, and with the observer in the normal listening position. There is usually a pronounced focussing of the high frequencies so that the high frequency response on the axis of the speaker is much greater than that at an angle to the axis. In some cases special means are taken to cause dispersion of the high frequency waves, either in the form of a fitting on the speaker or a reflecting and dispersing surface facing the speaker and situated on the axis. If no high-frequency dispersion is used, the tonal balance will vary considerably with the location of the listener.

Compensation for the frequency response of the pick-up and loudspeaker may perhaps be most satisfactorily applied by the use of a filter unit between the pick-up and the main amplifier. This tone compensation device may or may not include amplifying valves. In the latter case there will normally be attenuation of certain frequencies, and a reserve of gain is required in the amplifier.

### HARMONIC DISTORTION.

Harmonic distortion above a reasonable limit is one of the most objectionable features found in amplifiers. At the same time there seems to be much misunderstanding regarding the degree of distortion which can be tolerated. An amplifier which distorts badly owing to incorrect design or adjustment may give 20% or even 30% total harmonic distortion before an ordinary listener complains of bad tone. In extreme cases the distortion may reach over 50% and yet speech may still be (just) intelligible.

In ordinary amplifiers making no claim to fidelity the distortion may reach 10% to 15% or more at full volume, but will normally be much less at lower volume. The percentage which may be tolerated by a critical listener depends upon the percentages of the individual harmonics. For example, a larger percentage of second harmonic may be tolerated than that of third, more third than fifth and more fifth than seventh. The following table, which is given on page 32 of the Radiotron Designer's Handbook, will give some idea of the maximum permissible distortion under specified conditions:—

	Good Fidelity Wide Range Critical Listener.	Fair Fidelity Restricted Range Less Critical Listener.
2nd Harmonic	5%	10%
3rd "	2.5%	5%
4th "	Not important since small	
5th "	0.5%	1%
7th "	(say) 0.1%	(say) 0.2%

Merely to say that "an amplifier has 5%

distortion" does not convey much useful information. If this is almost entirely second harmonic the amplifier may be one having good fidelity. If it is largely composed of third, fifth and seventh harmonics the reproduction may be very poor. A push-pull amplifier usually has only a very small percentage of second harmonic and allowance should be made for this fact in interpreting the percentage distortion.

The total distortion is obtained by taking the square root of the sum of the squares of the individual harmonics. Thus the column in the table above corresponding to Good Fidelity gives a total distortion of 5.61%. If the second harmonic is omitted, as for push-pull operation, the permissible maximum total distortion is only 2.55%. Both arrangements come within the definition of good fidelity and yet one has a total distortion more than twice that of the other.

With due regard to the dominant harmonic in each case, the following approximate guide may be used in the classification of amplifiers having good fidelity:—

	Max. Total Distortion.
Single power triode . . . . .	5%
Single power pentode . . . . .	2.5%
Single 6L6-G . . . . .	5%
Single 6V6-G . . . . .	2.5%
All push-pull amplifiers . . . . .	2.5%

Any attempt to decrease the harmonic percentages below these limits is unlikely to be apparent to a listener. It must be remembered, however, that individual harmonics in separate stages should be added when in phase or subtracted when out of phase. Thus 5% second harmonic in a pick-up or preamplifier, when applied to an amplifier giving 5% second harmonic, may give 10% second harmonic if the two are in phase or zero second harmonic if they are out of phase.\* From 5% to 10% total harmonic distortion is frequently found in the cheaper class of magnetic pick-ups, but the better class of magnetic, moving coil or crystal pick-ups gives much lower percentages. Modern high-quality studio pick-ups have less than 3% total harmonic distortion over the whole audible frequency range.

Loudspeakers are far from being free from harmonic distortion, but the percentage varies enormously as the frequency is changed, and in any case is very difficult to measure. An aural test is all that is practicable in most cases.

### LOUDSPEAKER DAMPING.

Adequate damping in a loudspeaker is necessary to give faithful reproduction of transients and to prevent "hang-over" effects. There are few more distressing sounds than

\* These percentages are given only for illustration, and are not typical.



a loudspeaker with very small damping and a pronounced resonance at about 100 c/s. Any strong bass impulses result in a monotonous succession of "booms" like a drum, all of the same frequency irrespective of the frequency of the original sound. The decay period of each "boom" may last for an appreciable time and thus lose all resemblance to the original sound.

A loudspeaker is similar in principle to a moving coil instrument, and in both cases the damping is small when the terminals of the moving (or voice) coil are open-circuited while the damping is considerable when these terminals are short-circuited. The better class of loudspeaker operates with a higher magnetic flux density and has better damping than the cheaper and lighter types.

In a practical case the voice-coil can never be short-circuited when used to reproduce sound, but a close approach to this ideal can be obtained if the plate resistance of the power valve is small compared with the impedance of the loudspeaker at the primary of the transformer. This holds in the case of Class A triode valves, or pentodes or beam tetrodes with a considerable degree of negative voltage feedback. A pentode or beam tetrode

valve with no feedback or with negative current feedback gives negligible damping and cannot be considered for an amplifier required to give good fidelity.

### BIBLIOGRAPHY.

References are to the Radiotron Designer's Handbook, Third Edition, except where otherwise stated.

**Hum.**

Chapter 24.

**Frequency Response.\***

Of resistance coupled triode, pages 3, 4, 61-62.

Of resistance coupled pentode, pages 5, 6.

Affected by grid coupling condenser, pages 4, 63.

Affected by cathode resistor bypassing, pages 25-28.

Affected by screen dropping resistor bypassing, page 28.

Of whole amplifier, calculation, pages 53-56.

Testing for, pages 237-238.

**Stability.**

Of multi-stage amplifier, pages 28-30.

See also Radiotronics 75, pages 27-29.

**Harmonic Distortion.\***

Chapter 5.

**Loudspeaker Damping.\***

Page 22.

\* See also "The Relationship between the Power Output Stage and the Loudspeaker" by F. Langford Smith, Proc. World Radio Convention, Sydney, 1938; reprinted in the Wireless World, February 9 and 16 (1939), and in A.W.A. Technical Review, Vol 4, No. 4 (1939).

## NEW VALVE IMPORT RESTRICTIONS THE PRESENT POSITION IN AUSTRALIA

Under recent Customs (Import Licensing) Regulations\*, further restrictions have been placed on the importation of receiving valves from non-sterling sources. As a result of these restrictions:—

1. The total value of imported receiving valves from non-sterling sources is limited to 25% of the value of the importations during the base year.
2. Such receiving valves as are imported from non-sterling sources are permitted only on condition that they are used solely for replacement purposes and are not to be used for radio set manufacture.
3. No importations from non-sterling sources are permitted in the case of types manufactured in Australia.

The effect of these restrictions is to limit receiver equipment manufacturers to the use of Australian-made valves, or valves from sterling sources, and to reduce the number of replacement valves imported from non-sterling sources.

A wide range of Australian-made valves is available for 1.4 volt, 2 volt and 6 volt battery receivers as well as for A.C. receivers,

\* Licensing Instructions No. 260.

and these have already been adopted to a very wide extent by receiver manufacturers. Very little disturbance should therefore be experienced in the change-over to 100% Australian-made equipment valves.

Manufacturers of equipment, other than radio receivers, using receiving type valves are similarly obliged to avoid the use of valves imported from non-sterling sources.

A number of receiving types which are required for replacement purposes are also manufactured in Australia. The restrictions on the importation of replacement types will make it necessary for certain types to be replaced by near-equivalent Australian-made types and in this connection the Radiotron "Equivalent Type Chart" will be found most useful. Types for which no Australian-made near-equivalents are available, and which have been used in commercial receivers during the past 10 years will be imported by this Company, consistent with Customs quota allocations.

Any enquiries regarding valve types and characteristics should be addressed to the Unified Sales-Engineering Service, Box 2516-BB, G.P.O., Sydney.

## POWER TRANSFORMER IMPEDANCE

### THE EFFECT ON RECTIFIERS

Curves published for rectifier valves only apply to cases in which the testing conditions are reproduced exactly. The effect of the capacitance of the first filter condenser with a condenser-input filter is well known. Curves for types 5V4-G and 5Y3-G, as given in the Radiotron Loose Leaf Valve Data Book, are for a filter input capacitance of 8  $\mu$ F., which is widely used.

The effect of the transformer impedance, however, is not generally appreciated. With a condenser-input filter the peak current may be three or more times the average (D.C.) current, and the voltage drop in the transformer windings at the instant of peak current may be considerable. For this reason it is not sufficient merely to measure the voltage at the secondary of the transformer under loaded conditions.

The effective impedance of a transformer may be measured by what is known as a "short-circuit test". In this test the secondary (or one side of the secondary if full-wave rectification is used) is short-circuited, with an A.C. ammeter in circuit to indicate the secondary current. The primary voltage is then increased by some convenient continuously-variable control from zero upwards until the secondary current reaches some convenient value, preferably approaching the full load current. The primary voltage is then noted.

If  $I_2$  = secondary current

$E_1$  = primary voltage

$N_2$

$\frac{\quad}{N_1}$  = turns ratio secondary to primary

$N_1$

then the primary voltage referred to the secondary will be

$$E_1 \cdot \frac{N_2}{N_1}$$

and the impedance referred to the secondary will be

$$\frac{E_1 N_2}{I_2 N_1}$$

For example if the primary is rated at 240 volts and the secondary delivers 385 volts at no load the turns ratio will be

$$\frac{N_2}{N_1} = \frac{385}{240}$$

If the primary voltage ( $E_1$ ) is 5 volts for a secondary current ( $I_2$ ) of 100 mA. the impedance of the secondary will be

$$\frac{E_1 N_2}{I_2 N_1} = \frac{5 \times 385}{0.1 \times 240} = 80 \text{ ohms.}$$

#### Equivalent Resistance.

The equivalent resistance of the transformer

may readily be calculated from measurements of the D.C. resistance of primary and secondary and knowledge of the turns ratio.

If  $R_1$  = D.C. resistance of primary

$R_2$  = D.C. resistance of secondary

$N_2$

$\frac{\quad}{N_1}$  = turns ratio secondary to primary

$N_1$

then the equivalent resistance referred to the secondary will be

$$R_1 \left\{ \frac{N_2}{N_1} \right\}^2 + R_2.$$

For example if  $R_1$  = 15 ohms

$R_2$  = 36 ohms

$N_2$  = 385

and  $\frac{N_2}{N_1} = \frac{385}{240}$

then the equivalent resistance referred to the secondary will be

$$15 \left\{ \frac{385}{240} \right\}^2 + 36 = 74.4 \text{ ohms.}$$

The equivalent resistance will necessarily be less than the equivalent impedance since the impedance is the square root of the sum of the squares of the resistance and the reactance. If it is not convenient to make a short-circuit test for impedance, the impedance may be taken as being somewhat greater than the resistance.

The equivalent impedance of the transformer, reflected on to one half of the secondary, is the "supply impedance per plate" as shown on the Data Sheets and Curves.

### REPLACEMENT FOR 5U4-G OR 5Z3 Radiotron 5V4-G with Series Resistors

Radiotron 5V4-G is an Australian-made low-impedance indirectly-heated rectifier. It cannot be used as a direct replacement for type 5U4-G in equipment designed for the latter, but by the insertion of a small resistance in series with each plate the electrical characteristics may be made almost identical. A resistance of 125 ohms in series with each plate is the correct value—not 50 to 75 ohms as given on page 55 of Radiotronics 106.

Under these conditions the maximum voltage per plate is 450 volts RMS and the D.C. current should not exceed 200 mA. for a first filter condenser of 4  $\mu$ F. or 175 mA. for a capacitance of 8  $\mu$ F.

Similar remarks apply to type 83V, which is also Australian-made, as a replacement for type 5Z3.

## REPLACEMENT FOR 2A3

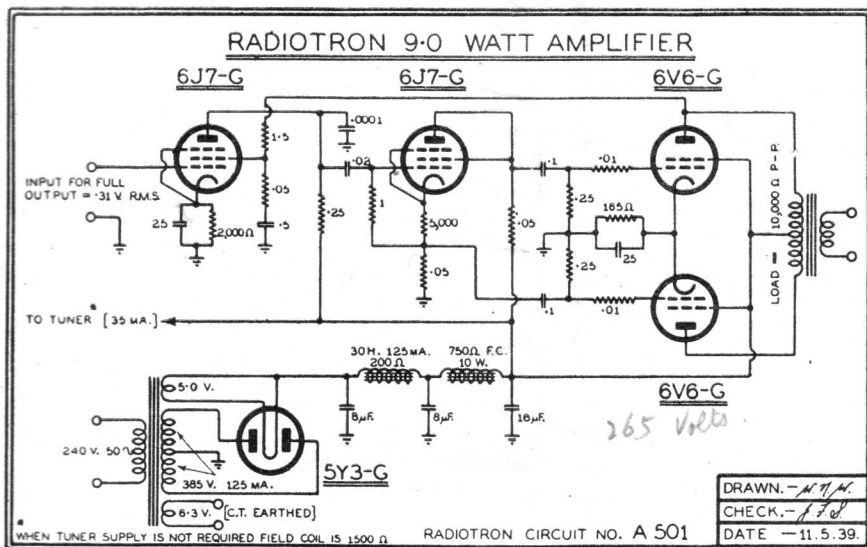
Type 2A3, being an imported type, is no longer available for new equipment although limited quantities are being imported for replacement purposes. It is suggested that manufacturers of equipment previously using type 2A3 should consider the following arrangements using Australian-made valves.

Two type 45 valves in parallel are almost identical electrically to one type 2A3, while they have the advantages of a more robust construction and longer life. Two type 2A3 in push-pull may be replaced by four type 45 in push-pull parallel.

Beam tetrode valves with negative feedback have characteristics almost identical to those of triode valves for distortion, plate resistance and loudspeaker-damping. They

have the further advantage of greater plate-circuit efficiency. Two type 6V6-G beam tetrode valves are capable of an output of 9 watts in Class A<sub>1</sub> from a plate supply voltage of 265 volts and cathode bias, with less than 3% second harmonic and negligible higher harmonics over three stages. Such an amplifier has all the advantages of a push-pull triode amplifier and is less expensive to construct. A complete description of this amplifier (A140) was given in Radiotronics 89, page 149 (15th August, 1938), but the circuit as then published did not include any power supply.

On this page is published a similar circuit (A501), including a power supply with provision for adding an R.F. tuner.



*This circuit gives a power output of 9 watts with a total overall harmonic distortion less than 3% second harmonic and negligible higher order harmonics. The input voltage for maximum power output is 0.31 volt RMS, and the gain reduction due to feedback is 3.98.*

### SMALL POWER TRIODES TYPES 6J7-G AND 6B8-G

It is not always realised that general purpose triodes and triode-connected pentodes are capable of an output of several hundred milliwatts when used as Class A<sub>1</sub> power amplifiers. Types 6J7-G and 6B8-G are both capable of being operated as triodes with the screen connected to the plate and under these conditions may be used with transformer coupling or as power amplifiers. The power output obtainable is quite sufficient to operate the loudspeaker of a small receiver.

#### TENTATIVE OPERATING CONDITIONS.

(Screen connected to plate)

	6J7-G	6B8-G	
Heater	6.3	6.3	volts
Plate	250	250	volts
Grid	-8	-20	volts
Cathode Bias Resistor	1,230	2,500	ohms

Amplification Factor	20	8.3	
Plate Resistance	10,500	7,500	ohms
Transconductance	1,900	1,100	μmhos
Plate Current	6.5	8	mA
Load Resistance	22,000	20,000	ohms
Power Output	275	350	mW.
Second Harmonic	5	5	%

### RADIOTRON 6V6-G Grid Resistor Ratings

When Radiotron 6V6-G is operated with a screen voltage of 100 volts\* the plate current at zero grid voltage is less than the typical operating current with 250 volts on plate and screen and with normal grid bias. There is therefore no restriction on the grid bias voltage which is thus rated as "0 minimum".

Under these operating conditions the grid resistor may safely be increased to 1.0 megohm with either self- or fixed-bias.

\* See Radiotronics 103, p. 21.



## RADIOTRON NEWS

**Radiotrons 1K4 and 1K5-G:** A new Data Sheet has been issued, giving new maximum ratings and 90 volt operating conditions.

**Radiotron 2A3:** The question of Australian-made equivalents is discussed elsewhere in this issue.

**Radiotrons 5U4-G and 5Z3:** The use of Australian-made types 5V4-G and 83V with series resistors in each plate circuit as replacements for types 5U4-G and 5Z3 is discussed elsewhere in this issue.

**Radiotron 5V4-G:** Three Data Sheets have been issued with the new maximum ratings and a complete set of curves. Curves are also given for the condition with a resistance of 125 ohms in series with each plate to simulate the characteristics of type 5U4-G and for use in circuits where frequent switching is to be expected.

**Radiotron 6B8-G:** Operating conditions as a Class A<sub>1</sub> Power Triode with a power output of 350 mW. are given elsewhere in this issue.

**Radiotron 6J7-G:** Operating conditions as a Class A<sub>1</sub> power triode with a power output of 275 mW. are given elsewhere in this issue.

**Radiotron 6J8-G:** Operating conditions as an R.F. or I.F. Amplifier are given elsewhere on this page.

**Radiotron 6V6-G:** An increase of the maximum grid circuit resistance to 1.0 megohm with 100 volt screen operation is announced in this issue.

**Radiotron 12A6** is a metal beam power amplifier with a 12.6 volt 0.15 ampere heater for use in A.C./D.C. receivers, which gives a power output of 2.5 watts. This type is not available from stock.

**Radiotron 809:** A photograph of this Australian-made 25 watt transmitting valve is given elsewhere in this issue.

**Radiotron 833A** is an improved type 833 with identical characteristics except that it may be operated at higher ratings with forced-air cooling. Further details on this type are available on request.

**Radiotron 1627** is a transmitting triode similar to type 810 in all respects except that the filament is rated at 5 volts 9 amperes.

**Radiotron 8003** is a transmitting triode having a maximum plate dissipation of 100 watts for operation at maximum ratings up to 30 megacycles.

## RADIOTRON 6J8-G AS I.F. AMPLIFIER

Radiotron 6J8-G may be used as an R.F. or I.F. amplifier in a similar manner to type 6L7-G. In this class of service the triode grid, which is internally connected to No. 3 grid of the mixer, may be operated at a fixed

negative bias of 3 volts. For certain special applications this use of type 6J8-G may be preferred to the use of the more conventional type 6U7-G. The following tabular comparison of types 6J8-G and 6L7-G used as Class A voltage amplifiers shows the differences between them.

### APPROXIMATE CHARACTERISTICS.

	6J8-G	6L7-G	
Heater	6.3	6.3	volts
Plate	250	250	volts
Screen	100	100	volts
Grid No. 3	-3	-3	volts
Control Grid (No. 1)	-3 min.	-3 min.	volts
Plate Resistance	1.9	0.6	megohm
Transconductance	915	1100	μmhos
Plate Current	2.6	5.3	mA.
Screen Current	2.4	6.5	mA.

In many cases in this type of service the 6L7-G may be directly replaced by the Australian-made type 6J8-G, the socket connections being identical. In cases where the screen supply is a series dropping resistor or high resistance potentiometer some adjustment may be required to allow for the lower screen current of type 6J8-G.

When the heptode section of the 6J8-G is used as an R.F. or I.F. amplifier it may be found possible to make some use of the triode section as a beat oscillator, detector or audio-frequency amplifier.

### VALVE DATA SHEETS

Twelve Radiotron Loose Leaf Valve Data Sheets are being released concurrently with this issue. These are:—

1C6/1C7-G	.. ..	1 sheet (data)
1D5-GP	.. ..	1 sheet (data)
1K4/1K5-G	.. ..	1 sheet (data)
1K6/1K7-G	.. ..	1 sheet (data)
1L5-G	.. ..	1 sheet (data)
5V4-G	.. ..	sheets 1, 2, 3
6B6-G	.. ..	1 sheet (data)
6H6-G	.. ..	1 sheet (data)
6K7-GT	.. ..	1 sheet (data)
85	.. ..	1 sheet (data)

Existing sheets for types 1C6, 1K4 (data), 1K6 (data), 5V4-G, 6B6-G and 6H6-G should be removed from the Data Book.

### REPLACEMENT TYPES.

Valve Data Sheets for the following replacement types are available on request (2d. posted):—1A4-P, 1B5/25S, 1C4, 1D4, 2A5, 2A6, 2A7, 2B7, 6C6, 6D6, 19, 24A, 30, 32, 34, 35, 42, 45, 47, 57, 58, 75, 77, 78, 80, 83V.

Your attention is drawn to the List of Contents which was issued as a supplement to Radiotronics 106 (30th September, 1940). Any sheets which may be missing from your Valve Data Book are available on request.