RADIOTRONICS

AMALGAMATED WIRELESS VALVE COMPANY LIMITED

BOX No. 2516 BB G.P.O., SYDNEY

TECHNICAL BULLETIN No. 73

24th FEBRUARY, 1937

In this issue:—

Items of General Interest:

For the Radio Engineer:

Experimenters' Section:

ITEMS OF GENERAL INTEREST.

PRICE ANNOUNCEMENT *(Australian Prices)*

Radiotron 807	£2 2 0 nett
Radiotron 808	£4 5 0 nett
Radiotron 913	£2 2 0 nett

Stocks of Radiotron 808 are due to arrive on 1st March, and stocks of 807 and 913 are due on 15th March. Further shipments are following later.

HIGH VOLTAGE RECTIFIER

Radiotron 866 (mercury vapour rectifier) fulfils all the requirements of a heavy duty high voltage rectifier. It is extensively used in transmitters, but is useful for all heavy duty requirements including low voltage high current applications. Two Radiotron 866's may be used to convert 240 volts A.C. to 200 volts D.C., with a maximum D.C. current of 1.0 ampere.

In order further to popularise this robust and versatile valve the Australian price has recently been reduced to 25/- nett. Continuity of supplies is guaranteed.

RADIOTRON DESIGNER'S HANDBOOK

The second edition of the Radiotron Designer's Handbook has had a very wide circulation, but queries are frequently received from those not possessing a copy of this useful publication. Every radio engineer, service man, home constructor and experimenter should have a copy available for reference. Tables, formulae and information on many radio matters are given in a handy form.

Available at 1/- each (1/1 post free).

ITEMS OF GENERAL INTEREST (Continued)

READING "I.F. SENSITIVITY" WITH SIGNAL GENERATOR

True I.F. sensitivity must be measured with an input to the primary of the first I.F. transformer, but unfortunately, such is not convenient. The only two convenient points to which the signal generator can be connected are the control grids of the pentagrid converter and of the first I.F. valve. The first arrangement measures more than the true I.F. sensitivity through the use of the pentagrid valve as an additional I.F. amplifier. This additional I.F. amplification is approximately proportional to the conversion gain *with a low impedance grid circuit,* but bears no definite relation to the conversion gain with a tuned grid circuit. In other words, valves having similar conversion gain under conditions of tuned grid circuits, will not necessarily have similar gain as I.F. amplifiers.

It seems preferable to call the sensitivity measured at the grid of the converter valve with a low impedance input at intermediate frequency the "Converter Valve I.F. Sensitivity."

The second arrangement measures less than the true "I.F. Sensitivity" by the gain of the first I.F. transformer. It seems preferable to call such a reading the "I.F. Valve Sensitivity."

SPECIAL CAUTION: *Never test a converter valve unless the oscillator is oscillating normally.*

HEATING TIME WITH SERIES OPERATION

Valves operated with the heaters in series (as in an A.C.-D.C. receiver) are always found to take a longer time to heat than when they are operated in parallel (as in a normal A.C. receiver). The reason, once it has been pointed out, is quite obvious.

When valves are operated in parallel, each valve is supplied with current directly from the secondary of the transformer and is not appreciably affected by any of the other valves in the set. Due to the thermal resistance characteristics of the heater wire, its resistance when cold is considerably less than when heated. The result is that immediately the transformer is switched on it supplies a nearly constant voltage (e.g., 6.3 volts) which causes a heavy current to flow through the low resistance heater. This heavy current causes rapid heating, but as the heater increases in temperature, so its resistance rises and finally a state of equilibrium is reached with normal temperature, resistance and current.

With series heater operation it is usual to employ a fixed resistance or barretter in series with the heaters. This resistance effectively prevents a serious rise in current before the heaters reach their normal temperature, and the result is that the heating time is very much prolonged. A barretter produces an even slower heating time than a fixed resistance, due to its constant current characteristic.

RADIOTRON 5 VALVE FIDELITY CIRCUIT D41

MODIFICATION TO CIRCUIT

It has been found desirable to add to the circuit D41 (as published in Radiotronics Nos. 71 and 72) an audio frequency bypass condenser across the cathode bias resistor of the 6B7S I.F. amplifier. The condenser C5 (0.1 μF) is still required to bypass I.F. and needs to be paralleled by an electrolytic 25 μF condenser C11.

An error occurred in the reference number of the volume control resistance which was shown as R12 and which should be R13. Would you please make these two alterations in the original circuits in order to avoid possible oversight at a later date?

FOR THE RADIO ENGINEER

DISTORTION IN DIODE DETECTORS

One of the most common fallacies in radio is to believe that a diode is distortionless. Undoubtedly there are applications in which the distortion introduced by a diode is reduced through correct design to a fairly low percentage, but most conventional arrangements give very severe distortion at great depths of modulation.

First of all, consider the case where R1 (fig. 1) has an infinite resistance. Each positive half wave will then tend to charge the condenser C1, making the point H negative with respect to the cathode of the valve. During the negative half waves no current will flow in either direction. The half wave charges thus become cumulative, and build the voltage across C1 up to the *peak* value of the I.F. supply voltage. When such a condition is reached, no more current will flow through the valve, until the peak I.F. voltage is increased, when it will again charge C1 to the new peak voltage. If, however, the I.F. voltage is reduced, the condenser cannot discharge back through the valve, and would remain charged at the higher peak value.

Such a circuit would not, therefore, rectify a modulated I.F. input to give a voltage across C1 varying with the modulation envelope.

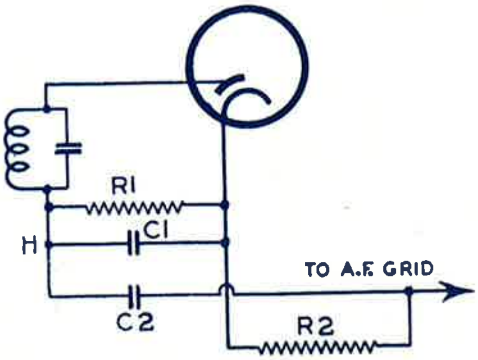


FIG. 1.

OUTLINE CIRCUIT OF FUNDAMENTAL DIODE DETECTOR

When a finite load resistance R1 is shunted across C1, there is a certain discharge during the cycle, which enables the circuit to deal with modulation. It must not be forgotten, however, that a certain charge remains, and for that reason there will be fairly constant D.C. voltage across R1C1 for any value of I.F. voltage we may choose. Its value is dependent on R1 and C1. It is convenient to plot the plate *current* in terms of the voltage across R1C1. This has been done for the 6B7S diode (single section) in Fig. 2. The (D.C.) current in the circuit is plotted against (D.C.) plate voltage for various values of unmodulated peak input voltage. C1 is taken to be 100 $\mu\mu$F.

On the family of curves load lines may be plotted for any specified load, such as that for .5 megohm, OA. The D.C. voltage across the load is seen to vary almost linearly with the peak input voltage over the entire range of the curves. If the (I.F.) signal voltage is equal to 10 V. peak the D.C. voltage is seen to be 8.8 V. across R1C1. On 100% peaks of modulation it will swing from .8 to 18.4 volts, about the 8.8 V. mean.

A negative potential of the order of 8.8 V. applied to the grid of a valve is liable to shift its working point enough to cause serious distortion. It is customary, therefore, to couple the diode load to the grid of the first audio stage with a condenser C2 in fig. 1, making necessary the use of a grid resistor R2, and imposing an A.C.

shunt across R1. Presupposing a 10 V. peak input, we may plot the resulting load line through X on OA as shown in BC. It is seen that a plate current cut-off condition is reached with an input voltage of 2.8 volts peak. Further decrease in input causes no reduction in grid voltage of the audio stage, and there is, in consequence, serious distortion at depths of modulation greater than 70%. Distortion is plotted against modulation percentage in Fig. 3.

It is evident that the greater R2 is made, the less will be its shunting effect on R1, and less distortion will occur. On account of grid emission it is necessary to keep R2 down to 1 megohm maximum. The ratio R1/R2 may be kept low, however, by making R1 small. If one carries such a practice to extreme, distortion may be introduced at low signal levels due to curvature of the diode's characteristic. Another way out of the difficulty is to feed C2 from a tap on R1, by making it the volume control. As the tapping approaches the cathode, the distortion becomes less and less.

(To be continued)

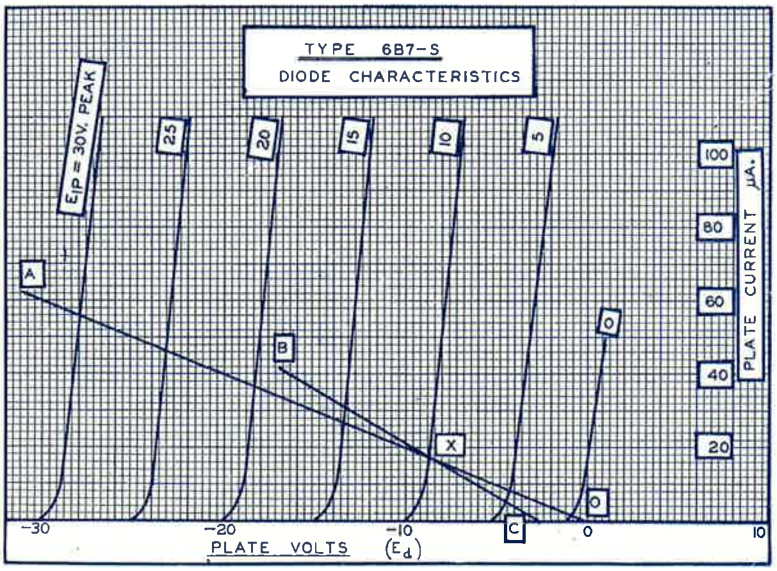


FIG. 2.

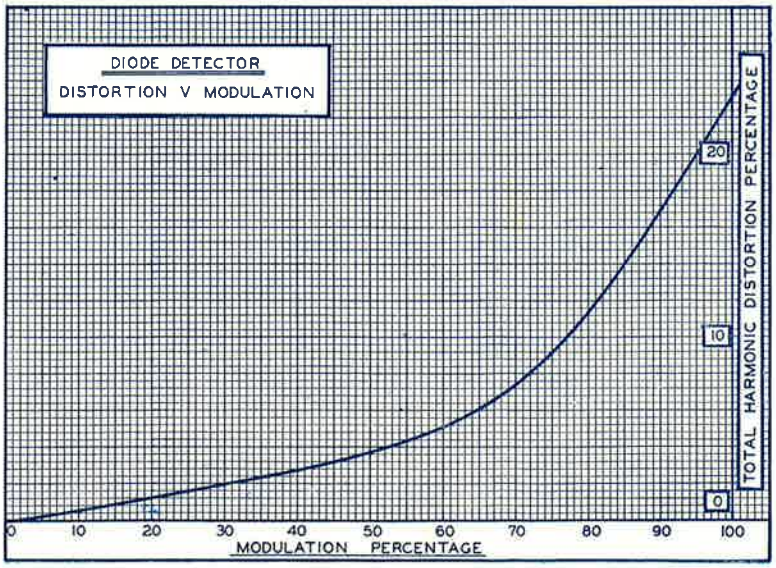


FIG. 3.

PRECAUTIONS NECESSARY WITH TYPE 75

INABILITY TO GIVE HIGH VOLTAGE OUTPUT

It is frequently forgotten that the maximum voltage output of a resistance coupled amplifier is severely limited. High-mu triodes are much more limited in voltage output than general purpose or low-mu triodes. This is on account of two important characteristics. Firstly due to the high plate resistance there is only a very short length of comparatively straight dynamic characteristic. In other words, the "bottom bend" and point of cut-off are reached at quite small negative bias voltages. The grid must not therefore be allowed to swing into this region or distortion will be experienced.

On the other hand the grid must not be allowed to swing to a point less negative than 1.0 volt or grid current will flow. If the working bias is -1.35 volts and the stage gain is 59 times, the peak output voltage is limited to just over 20 volts. This is sufficient to excite a single 42, but is not sufficient to excite push-pull 42's or an inverse feedback 42, nor is it sufficient to excite a triode valve such as the 2A3 or 45. It is possible to use a higher bias than -1.35 volts in order to obtain higher voltage output. With a plate supply of 250 volts the bias should not exceed -1.75 volts, and even with this voltage the second harmonic distortion is becoming appreciable due to the proximity to the "bottom bend." Under these conditions and with a plate load resistor of 0.25 megohm, and the following grid resistor 0.5 megohm, the maximum peak output voltage is just over 28 volts.

If the plate supply voltage can be increased above 250 volts, a considerably greater peak output voltage may be obtained. Plate supply voltages up to 400 volts may be used with Radiotrom 75, in conjunction with a plate load resistance of 0.25 megohm.

Radiotron 6C6 operated as a resistance coupled triode gives a peak output voltage more than twice that of a 75 under similar conditions. The following table makes an interesting comparison.

Type	Plate Load Resistor.	Following Grid Resistor.	Peak Output Voltage*.
75	0.1 megohm	1 megohm	35.3
		0.5 megohm	32.5
		0.25 megohm	27.7
	0.25 megohm	1 megohm	34.4
		0.5 megohm	28.7
		0.25 megohm	21.5
6C6 Triode	0.1 megohm	1 megohm	78.0
		0.5 megohm	71.6
		0.25 megohm	61.5
	0.25 megohm	1 megohm	74.5
		0.5 megohm	62.0
		0.25 megohm	46.5

* 5% harmonic distortion.

HIGH INPUT CAPACITY

Due to the "Miller effect," the effective grid input capacity of a valve is very much greater under dynamic conditions than is shown by static tests. The effective grid-cathode capacity of an amplifying valve is given by the formula:

$$C_{input} = C_{gk} + (M + 1)\, C_{gp}$$

where C_{gk} = static capacity grid to cathode
C_{gp} = static capacity grid to plate
M = stage gain (numerical value)

In the case of the 75 used under typical conditions the effective input capacity is over 100 $\mu\mu$f even without allowing for any stray capacities in either grid or plate circuits. This high input capacity is unavoidable with high gain triodes but is reduced to practically negligible proportions in the case of resistance coupled pentode valves such as the 6C6 or 6B7S.

BASS BOOSTING

In Radiotronics Technical Bulletin No. 72, two typical methods of bass boosting were described. Tests have been conducted on the second method there described the circuit of which is reproduced in the form in which measurements were made (Fig. 4). It is again emphasized that the method is only really effective when applied to a resistance-coupled pentode and is not satisfactory for use with a triode. The results obtained are shown in Fig. 5 in which curve A refers to a capacity C = 0.01 μF and curve B to a capacity C = 0.02 μF. It appears as though curve A (C = 0.01 μF) gives a very close approximation to the ideal compensation at low volume.

If it is preferred to use a continuously variable control, a 0.25 megohm potentiometer may be used in place of the two fixed resistors. With a setting corresponding to the resistance ratio shown in the figure the arrangement will act as a bass booster. With a setting nearer the plate end of the potentiometer, the arrangement will act rather as a "tone control" by reducing the high note response. There would appear to be advantages obtained through ganging this control with the volume control, but practical difficulties are obvious.

There is always danger in the application of Bass Boosting due to its possible use at full volume. Bass Boosting of the type herein described is intended only for use at low volume so as to bring the bass almost from inaudibility to an apparently natural level. If applied at full volume, it will inevitably result in bad distortion and in an unnatural preponderance of bass.

Bass Boosting is not a means for obtaining more bass response than the power valve is capable of giving.

Further details on methods of Bass Boosting will be given in later Bulletins.

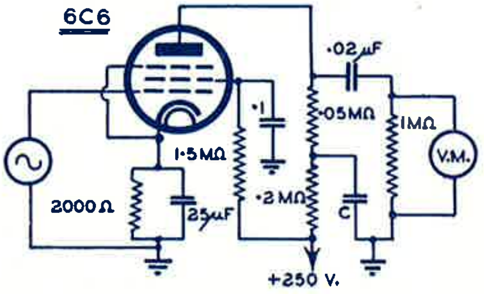


FIG. 4.

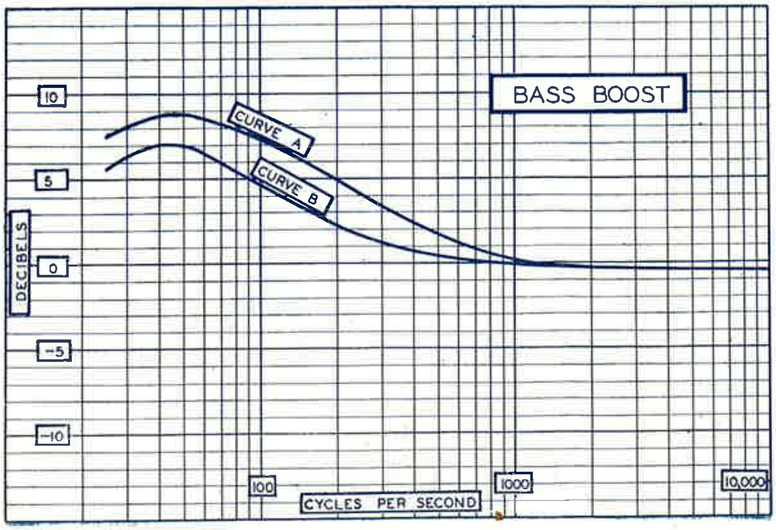


FIG. 5.

TESTS FOR ABSOLUTE SENSITIVITY

(2) OSCILLOGRAPHIC METHOD

The basis of tests for absolute sensitivity was given in Radiotronics Technical Bulletin No. 72 page 8. Briefly this method distinguishes between noise output and signal (400 c/sec) output and measures sensitivity on the basis of 50 milliwatts pure signal output.

The oscillographic method is illustrated in Figures 6 and 7. In the application of this method the Cathode Ray Oscillograph is firstly connected across both speaker transformer and output meter and its gain control is adjusted until a pure 400 c/sec. signal showing 50 mW on the output meter also shows 1in. deflection at the peak of the wave on the oscillograph (Fig. 6). This means that the oscillograph is now calibrated and may be used as an accurate indication of 50 mW output. Tests made with an R.C.A. Oscillograph Model 122B using a 906 cathode ray tube and a 57 as vertical amplifier have indicated that such a calibration remains constant over the period of a working day, the oscillograph remaining switched on continuously. The output meter may now be taken away and the speaker load (voice coil) brought into circuit. The receiver is then aligned using the speaker as an audible indication and the oscillograph as a visual indication. Finally the attenuator of the Signal Generator is adjusted so as to bring the peak of the wave on the oscillograph to a height of 1in. If a considerable amount of noise is present the line on the oscillograph will be "furry" as shown in Fig. 7 and it will be necessary to judge the mean. Even with high noise levels this method enables the 400 c/sec. signal to be distinguished from the noise output. The method is very rapid and easily applied. An assumption is made which it is advisable to check namely that the loudspeaker impedance at 400 c/sec. agrees with its nominal impedance. This will generally be found to be reasonably accurate.

FIG. 6.

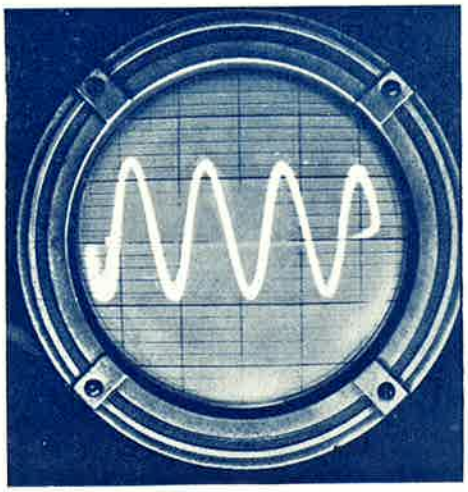
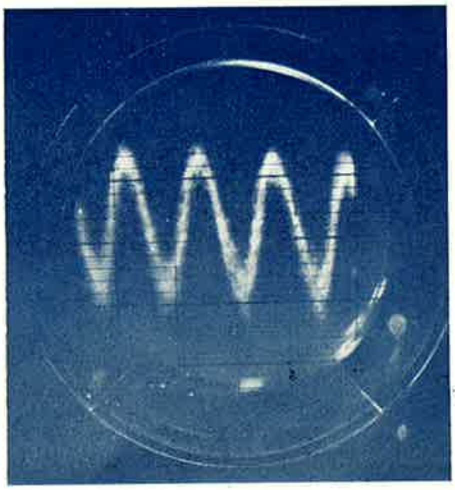


FIG. 7.



EXPERIMENTERS' SECTION

AMATEUR RECEIVER

The problem of a good Amateur Receiver is a difficult one not so much on account of its design as in limiting the number of "extras" to the minimum without seriously detracting from its value. It is proposed, therefore, to describe two models, the first a Senior model, employing 13 valves and including crystal filter, noise silencer, beat oscillator and Magic Eye tuning and at a later date a Junior model with about 8 valves which should be capable of good results at a considerably lower cost.

Both models will cover the 10, 20, 40 and 80 metre bands and will have an Intermediate Frequency of 465 K.C. Plug-in coils have been chosen in preference to band switching on account of greater flexibility, lower cost and simplified wiring.

The valve arrangement of the Senior Model is as follows:—

6D6 or 6K7	Radio Frequency Amplifier.
6L7	Mixer.
6C6 or 6J7	Electron coupled Oscillator.
6L7	Noise silencer muting.
6C6 or 6J7	Noise silencer amplifier.
6H6	Noise silencer diodes.
6D6 or 6K7	First I.F. Amplifier.
6B7S	Second I.F. and diode detector.
6J7	Beat frequency Oscillator.
75 or 6Q7	Audio amplifier and A.V.C. diode.
42 or 6F6	Power Pentode.
6G5	Magic Eye.
80	Rectifier.

In cases where either all-metal or glass valves may be used without affecting the circuit the alternative type numbers are given. In other cases no alternative is available.

The circuit diagram and coil specifications will be given in the next issue of Radiotronics to be published on 31st March, 1937.

RADIOTRON 808

Radiotron 808 is a high-mu triode with a maximum plate dissipation of 50 watts, arranged with the plate brought out to a cap on the top of the bulb and the grid to a cap on the side. A tantalum plate is employed and under maximum dissipation conditions the colour of the plate is dull red. Maximum ratings may be employed up to 30 megacycles. The maximum plate voltage and plate input must be reduced to 75% for 60 megacycles and 50% for 130 megacycles. The resonant frequency of the grid-plate circuit is approximately 272 megacycles.

Brief technical data is given below:—

RADIOTRON 808.

Filament voltage (A.C. or D.C.)	7.5 volts
Filament Current	4 amperes
Amplification Factor	47
DIRECT INTER-ELECTRODE CAPACITANCES (approx.)	
Grid-Plate	3 μμF
Grid-Filament	5 μμF
Plate-Filament	0.2 μμF
Base	Medium 4 pin Bayonet
MAXIMUM OUTPUT.	
As Class B Audio Amplifier (2 valves)	185 watts
As Class B Linear Amplifier	22 watts
As Plate Modulated Amplifier	105 watts
As Oscillator or Class C Amplifier	140 watts
MAXIMUM PLATE VOLTAGE	1500 volts