RADIOTRONICS

AMALGAMATED WIRELESS VALVE CO. PTY. LTD.

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

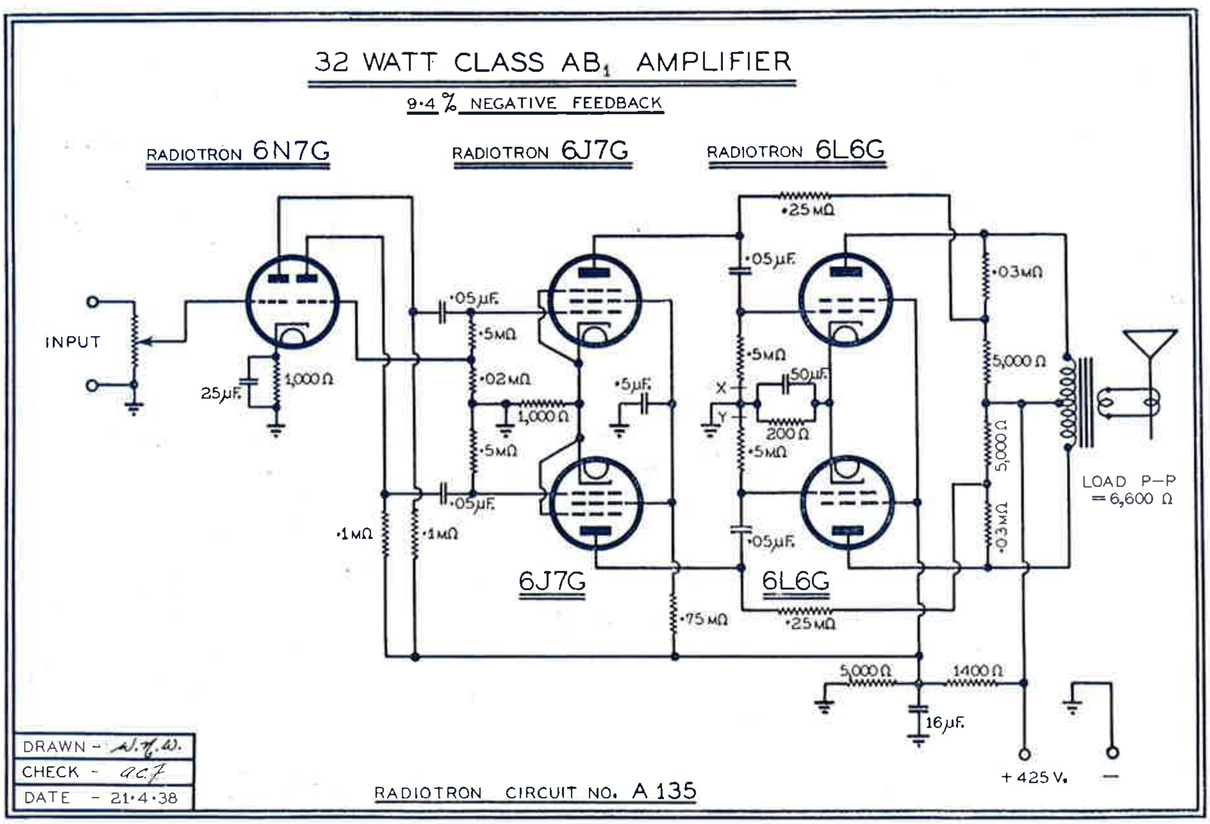
TECHNICAL BULLETIN No. 86 **16th MAY, 1938**

In this issue:—

32 WATT 6L6G AMPLIFIER

Negative Feedback with Resistance Coupling

For a considerable time past there has been a succession of enquiries for a satisfactory 30 watt amplifier which is free from any tendency towards instability or the development of high voltages in the plate circuit. Radiotron Circuit A135, shown on this page, should satisfy this demand and is also both simple and economical. It will be seen that the circuit employs Radiotron 6N7G as a first stage amplifier and inverter, exciting two 6J7G resistance coupled pentodes in push-pull. These in turn excite the final stage, consisting of two 6L6G valves in Class AB_1 push-pull. The input circuit to the first grid may be arranged in the most convenient manner, a simple form of volume control suitable for a pick-up being indicated in



the diagram. The 6N7G cathode bias resistor is by-passed by a condenser, principally in order to reduce hum caused by leakage between the heater and cathode of this valve. In a number of cases it may be found possible to omit this condenser. The grid input to the second unit of the 6N7G is taken from a tapping point on the grid resistor following the first unit. Although this is indicated in the diagram as a fixed tapping point, it is highly desirable for the correct resistances to be found by trial, in order to give perfect balance between the two sides. Since this balance is also affected by the 6J7G stage, it is desirable to check the balance in the grid circuit of the final stage. The method suggested is to insert a microammeter or 0-1 milliammeter at the points X and Y in turn, and to note the input at which grid current just commences to flow. The input should be identical for each of the two sides and if not so at the first attempt, the tapping point should be suitably adjusted. If so desired, a variable resistance could be used in place of fixed resistors, but in general it is preferable to employ fixed resistors as being less inclined to cause drift or noise. It will be seen that the cathode resistor of the two 6J7G valves is 1,000 ohms and is unby-passed, by-passing being normally unnecessary, since any hum present in this stage would not be apparent. The values of screen dropping resistor and cathode bias resistor are exactly half those specified for a single valve under resistance coupled pentode conditions. Both 6J7G valves are used with series feedback arranged from a voltage divider across each side of the output load. Each voltage divider is arranged with resistances of 5,000 and 30,000 ohms which, in conjunction with the shunting effect in the grid circuit of the valves, gives an effective negative feedback of 9.4%. The load on the 6L6G valves is 6,600 ohms, plate to plate, this being the normal load for Class AB_1 operation with self-bias. No resistance capacity filter is necessary across the loudspeaker, owing to the use of feedback, and for the same reason a tone control on the 6L6G stage will not be effective. The grid resistors of the 6L6G valves are both 0.5 megohm, this being the maximum permissible with self-bias. The self-bias resistor of 200 ohms is by-passed by a condenser of 50 μF., the effective bias being 25 volts. The plate voltage is 400 volts and therefore the supply voltage, which provides not only the plate voltage, but also the grid bias, must equal 425 volts. The screen voltage should be 300 volts and this is obtained by means of a heavy voltage divider or bleeder across the 425 volt supply. It will be seen that this divider draws a current of approximately 65 mA., this being in addition to the currents drawn by the valves in the receiver. A 16 μF. condenser is used to give by-passing and stability to the screen voltage. A voltage divider drawing less current will not maintain the screens at such a steady potential, and will therefore introduce distortion and tend to decrease the output. The total current from the 425 volt supply is approximately 213 mA. with maximum signal.

The power supply should be one giving 425 volts at 213 mA. and this supply must have good regulation. A simple form of supply would be Radiotron 83 with a transformer 500 volts R.M.S. each side, a choke input filter with 20 henries inductance and a suitable smoothing condenser. The voltage delivered by the 83 valve will be a $0.9 \times 500 = 450$ volts, less 15 volts drop in the valve or 435 volts actual. From this must be subtracted the drop in the filter choke, and if a choke of 100 ohms resistance is used, this will be about 20 volts. The output voltage under these conditions would then be approximately 415 volts, a satisfactory approach to the maximum. Due to the slight decrease in voltage, the power output will be somewhat reduced and a further reduction would be caused by any additional resistance in the filter circuit.

In certain circumstances the 5,000 ohm resistor forming part of the bleeder could be replaced partly or wholly by the field coil of a loudspeaker, so as to avoid unnecessary waste of power. Two field coils, each of 2,500 ohms, should be connected in series and each would then receive approximately 10 watts. Care should be taken in this case to see that the voltage drop from screens to earth is 325 volts maximum.

Since this circuit uses resistance coupling throughout, it is suggested as being a particularly attractive arrangement for a large amplifier, particularly when weight is a consideration. The fidelity and frequency response are considerably better than would be the case in an amplifier without feedback.

RADIOTRON 902

continued from page 123

The 902 is based so that the trace produced on the screen by deflecting plates D_1 and D_2 is essentially parallel to the line passing through pins No. 3 and No. 7. The 902 should not be used with less than 400 volts applied to anode No. 2 in order to obtain satisfactory operation.

Supplies of the 902 are not yet available, but are expected in the near future. The price of the 902 has not yet been announced.

RADIOTRON 902 2in. Cathode Ray Tube

Radiotron 902 is a cathode ray tube, having a 2in. screen and electro-static deflection. The screen is of medium persistence, and the tube operates with comparatively low voltages. This type forms an intermediate size between the 913 with a 1in. screen and the 906 with a 3in. screen, and is particularly valuable, owing to its size being suitable for portable oscillographic equipment. An advantage over larger tubes lies in the lower plate voltage. The screen is considerably larger than that of the 913 and the deflection sensitivity is greater.

Characteristics and Ratings

Heater Voltage (A.C. or D.C.)	6.3 volts	
Heater Current	0.6 Ampere	
Fluorescent Screen Material	Phosphor No. 1	
Direct Interelectrode Capacitances:		
Control Electrode to all Other Electrodes	8.0 max. $\mu\mu$F.	
Deflecting Plate D_1 to Deflecting Plate D_2	3.0 max. $\mu\mu$F.	
Deflecting Plate D_3 to Deflecting Plate D_4	2.8 max. $\mu\mu$F.	
Overall Length	$7\frac{7}{16}$in. $\pm$ $\frac{3}{16}$in.	
Maximum Diameter	$2\frac{1}{16}$in.	
Base	Medium Shell Octal 8 Pin	
High Voltage Electrode (Anode No. 2)	600 max. volts	
Focussing Electrode (Anode No. 1)	175 max. volts	
Control Electrode (Grid)	Never positive	
Grid Voltage for Current Cut-Off with Maximum Voltage applied to Anodes Nos. 1 and 2	—80 approx. volts	
Peak Voltage between Anode No. 2 and any Deflecting Plate	350 max. volts	
Fluorescent Screen Input Power per sq. cm.	5 max. mW.	
Typical Operation:		
Heater Voltage	6.3	6.3 volts
Anode No. 2 Voltage	400	600 volts
Anode No. 1 Voltage (Approximately)	100	150 volts
Grid Voltage adjusted to give suitable luminous spot.		
Deflection Sensitivity:		
Plates D_1 and D_2	0.28	0.19 mm/volt D.C.
Plates D_3 and D_4	0.33	0.22 mm/volt D.C.

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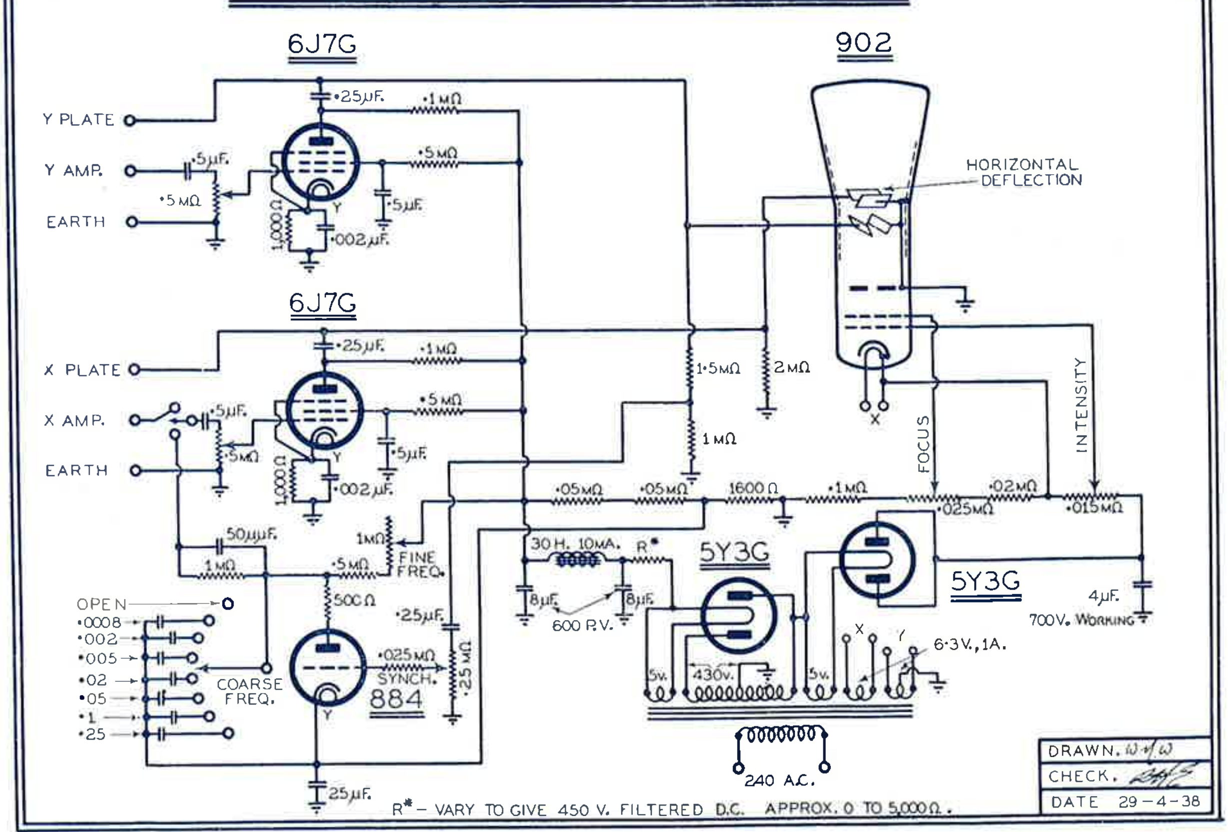
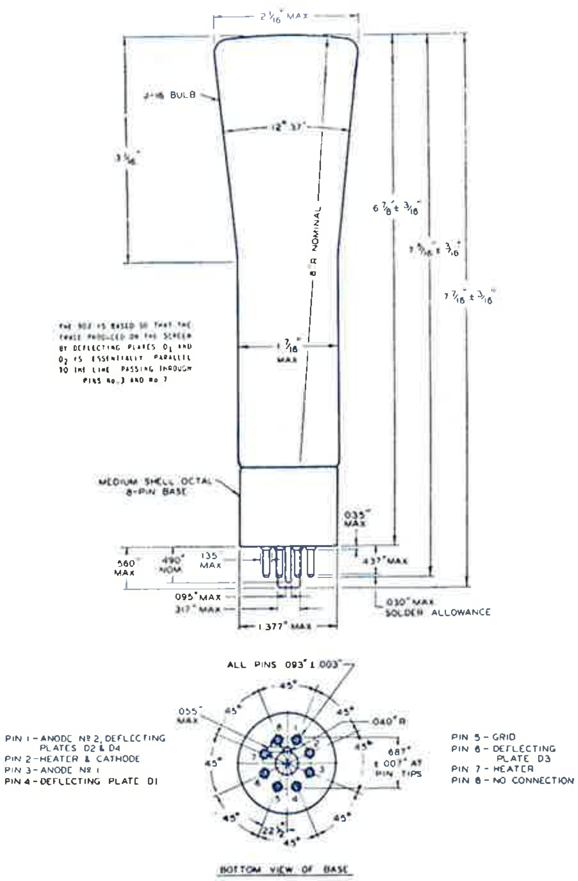
OSCILLOGRAPH CIRCUIT FOR RADIOTRON 902





MIXING SYSTEMS

In carrier-modulation equipment, it is generally necessary to provide some convenient method of changing the source of input. The simplest method is to use a change-over switch (Fig. 1), which may have as many contacts as desired. Rotating such a switch, however, gives rise to voltage surges, which if not injurious to the output valves, at least cause objectionable "thumps" in the reproduction. Hence it is usually necessary to insert a volume control after the switch, which may be turned down during the change-over.

When it is desired to "mix" the inputs in controllable proportions, more complicated circuits become necessary.

The simple series mixer of Fig. 2 has three serious drawbacks. (a) Both sides of input B are above earth. (b) Stray capacities to earth of channel B tend to by-pass the high frequencies of channel A. (c) Any hum picked up in channel B is fed without appreciable attenuation to the following grid. With care the system may be made to give reasonable results, but is limited in its usefulness.

A more satisfactory circuit is shown in Fig. 3. The inputs are really in parallel and one side of each is returned directly to earth. The series resistors R_3 and R_4 prevent either control short-circuiting the other. Too low a value will reduce their effectiveness. The upper limit is set both by the maximum permissible grid resistance and the input capacitance of the following valve.

For very high-Mu triodes, such as type 75, which have a comparatively large input capacity, frequency attenuation becomes serious if R_3 and R_4 exceed 0.25 megohm. For most other valves, 0.5 megohm may be considered a practical limit.

If R_3 and R_4 be each 0.5 megohm, then the potentiometers R_1 and R_2 may have any values up to 0.5 megohm, which is the correct load for high impedance or crystal pick-ups. Under these conditions the maximum loss is 6 db.

Figs. 4 and 5 show two methods widely used in communication engineering. The first uses a pair of T-attenuators, which provide constant input and output impedances for all settings. The second is a bridge circuit. Both circuits are intended for use with low impedance lines, and are too costly for the average experimenter.

Possibly **the most satisfactory arrangement** is to feed the two inputs to the grids of two valves which have a common plate load. In this way the input circuits are quite isolated and the setting of one control can have no effect on the other.

Fig. 6 shows the simplest possible arrangement, using a 6A6 (6N7G) twin triode valve. It is obvious that the plate resistance of the two sections are in parallel, so that each triode works into an A.C. load less than its own plate resistance. Under such conditions the voltage output for a given percentage of distortion is seriously limited.

The effect is greatly reduced by the insertion of isolating resistors as in Fig. 7. With this arrangement a stage gain of 10 may be obtained with a peak voltage output capability of 35 volts.

The performance of such a mixer may still further be improved by replacing the two triode units with a pair of pentodes. The plate resistance of Radiotron 6J7G as a resistance coupled amplifier is in the order of 3 megohms, so that the isolating resistors of Fig. 7 are not necessary, and very nearly the full gain of the pentode stage may be realised. With the circuit as Fig. 8 the stage gain will be 120, with a peak voltage output of approximately 45 volts. Omission of the cathode by-pass condenser reduces the gain by one half, but improves the linearity of the stage.

In any mixing system it is desirable that the input voltages to all channels be as nearly equal as possible, so that similar settings of the controls will produce similar output voltages. Hence where the output from a pick-up is to be mixed with that of a low-level microphone, it will generally be desirable to incorporate one stage of amplification after the

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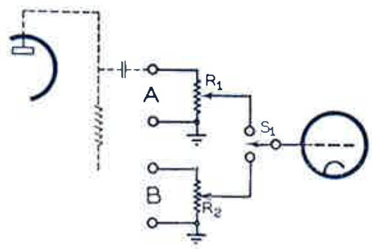


Fig. 1

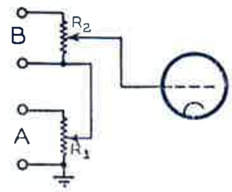


Fig. 2

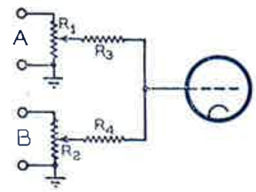


Fig. 3

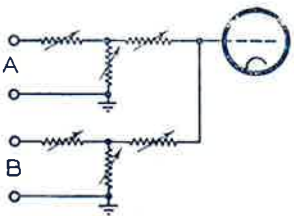


Fig. 4

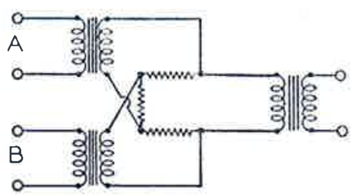


Fig. 5

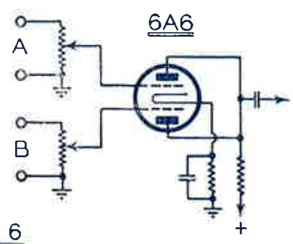


Fig. 6

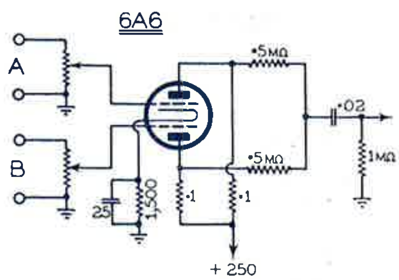


Fig. 7

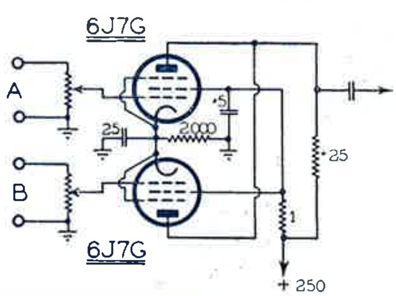


Fig. 8

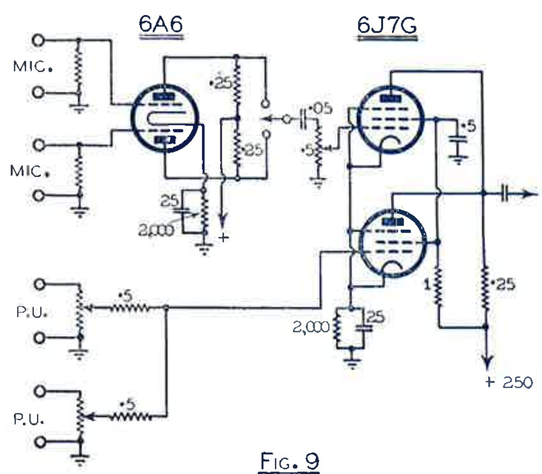


Fig. 9

RADIOTRON 1851

Television Amplifier Pentode

Radiotron 1851 is a heater-cathode type of metal valve intended for use by the amateur and experimenter in experimental television receivers. It is recommended for use in the R.F. and I.F. stages of the picture amplifier of such receivers, as well as in the first stages of the video amplifier, when several video stages are employed. The 1851 can also be used as a mixer and makes a good oscillator in low voltage applications.

In addition to applications for television, the 1851 also opens up interesting possibilities in U.H.F. receivers.

Tentative Characteristics and Ratings

HEATER VOLTAGE (A.C. or D.C.)	6.3 Volts
HEATER CURRENT	0.45 Ampere
DIRECT INTERELECTRODE CAPACITANCES: §	
Grid to Plate	0.02 max. μμF.
Input	11.5 μμF.
Output	5.2 μμF.
MAXIMUM OVERALL LENGTH	$3\frac{3}{8}$in.
MAXIMUM DIAMETER	$1\frac{5}{16}$in.
CAP	Pin Cap
BASE	Small Wafer Octal 7-Pin

Maximum Ratings and Typical Operating Conditions

PLATE VOLTAGE	300 max. Volts
SCREEN VOLTAGE	150 max. Volts
SCREEN-SUPPLY VOLTAGE	300 max. Volts

TYPICAL OPERATION and CHARACTERISTICS:

	Condition I*	Condition II**	
Plate Voltage	300	300	Volts
Suppressor Voltage	0	0	Volts
Screen-Supply Voltage†	150	300	Volts
Screen Series Resistor	—	60000	Ohms
Cathode-Bias Resistor‡	160	160 min.	Ohms
Amplification Factor (Approx.)	6750	6750	
Plate Resistance (Approx.)	0.75	0.75	Megohm
Transconductance	9000	9000	Micromhos
Plate Current	10	10	Milliamperes
Screen Current	2.5	2.5	Milliamperes

§ With shell connected to cathode.

† Screen-supply voltages in excess of 150-volts require use of a series dropping resistor to limit the voltage at the screen to 150 volts when the plate current is at its normal value of 10 milliamperes.

* Condition I with fixed screen supply gives a sharp cut-off characteristic.

** Condition II with series screen resistor gives an extended cut-off characteristic for applications where gain is controlled by variation of grid bias.

‡ The d-c resistance of the grid circuit should not exceed 0.25 megohm.

The pin cap terminal for the grid minimises input capacitance. To obtain full advantage of this arrangement, it is essential that the clip and lead to the open cap be kept away from the shell. Do not attempt to solder any connection to the pin cap. The heat of the soldering operation is almost certain to crack the glass seal beneath the bakelite insert holding the pin cap. A terminal from an octal socket makes a satisfactory clip for the pin cap.

Control grid bias for the 1851 may be obtained by means of a cathode-bias (self-bias) resistor adjusted to give a plate current of 10 mA. In valves such as the 1851 with an exceedingly high value of mutual conductance, there are pronounced changes of input capacitance and input conductance with plate current. In order to minimise these changes when the 1851 is used as an R.F. or I.F. amplifier, a portion of the cathode bias resistor may be left unby-passed. Reducing these changes in this manner, however, is accomplished with some sacrifice in effective mutual conductance and with some increase in effective grid-plate capacitance. To prevent excessive effective grid-plate capacitance, precautions should be observed to keep the external capacitance between plate and cathode leads at a minimum. It should be observed that with this method of minimisation, the cathode is not at A.C. earth potential. Because of this effect, the most favourable connection of the valve electrodes will be obtained when screen and suppressor are at A.C. earth potential, as shown in the circuit for R.F. or

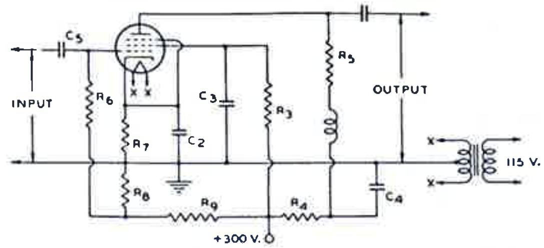
I.F. amplifier, Figure 14.

In some installations having automatic bias control which provides a fixed minimum bias, adequate to limit the plate current to 10 mA., and also using a 60,000 ohm series screen resistor, the cathode may be connected directly to earth or it may be connected through an unby-passed resistor to earth. This resistor may conveniently form a portion of the fixed minimum bias. Such an arrangement serves to minimise changes of input capacitance and input conductance as explained above.

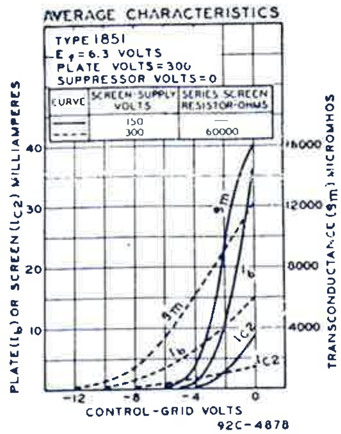
In video stages the cathode bias resistor should not be by-passed if it is desired to have degeneration and freedom from distortion. When, however, no degeneration and maximum amplitude are desired, the cathode bias resistor should be by-passed with a large condenser (350 μF.).

When minimisation of changes in input capacitance and input conductance is not accomplished by leaving a portion of the cathode bias resistor unby-passed, it will be found advisable to operate the 1851 with circuits heavily loaded by resistance and capacitance. Although such circuits minimise the effect of the relatively small variations in valve capacitance and conductance, they also cause some sacrifice in gain. Several schematic circuits, illustrating the use of the 1851 are shown in Figures 14 to 17.

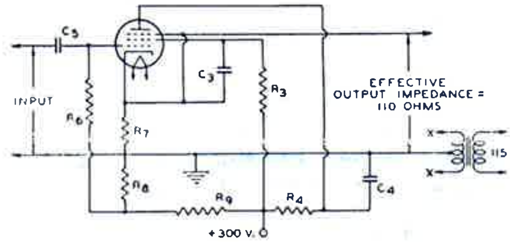
VIDEO AMPLIFIER
WITH HIGH-RESISTANCE INPUT COUPLING



NOTE: THE USE OF R_6 = 1.0 MEGOHM IS PERMISSIBLE IN THIS CIRCUIT BECAUSE OF THE REGULATING EFFECT PRODUCED BY R_7. THE BIAS VOLTAGE APPLIED TO THE GRID BY MEANS OF THE CATHODE RESISTOR R_7, AND THE BLEEDER RESISTORS R_8 AND R_9 SHOULD BE ADJUSTED TO GIVE A PLATE CURRENT OF 10 MA. NOTE THAT THE VOLTAGE ACROSS R_8 BUCKS A PORTION OF THAT ACROSS R_7.

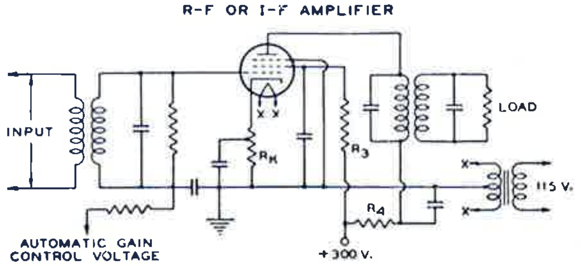


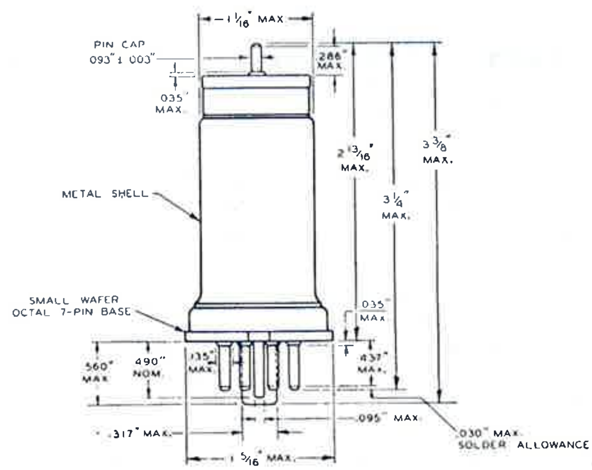
IMPEDANCE TRANSFORMER
FOR USE BETWEEN HIGH-IMPEDANCE CIRCUIT AND LOW-IMPEDANCE CIRCUIT



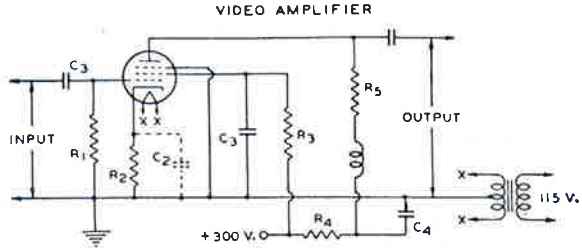
C_1 = 0.1 μf	R_K = 160 OHMS, WITH TAP AT APPROXIMATELY 35 OHMS FROM CATHODE END	R_4 = 5000 OHMS
C_2 = 350 μf	R_1 = 0.25 MEGOHM	R_5 = 2000 OHMS
C_3 = 1.0 μf	R_2 = 160 OHMS	R_6 = 1.0 MEGOHM
C_4 = 12 μf	R_3 = 60000 OHMS	R_7 = 1000 OHMS
C_5 = 0.25 μf		R_8 = 8000 OHMS
		R_9 = 290000 OHMS

R-F OR I-F AMPLIFIER



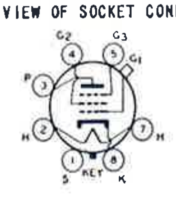


VIDEO AMPLIFIER



NOTE: THE CATHODE BY-PASS CONDENSER C_2 IS USED WHEN MAXIMUM SIGNAL AMPLITUDE AND NO DEGENERATION ARE DESIRED. OMISSION OF C_2 PROVIDES DEGENERATION AND GIVES LESS DISTORTION.

BOTTOM VIEW OF SOCKET CONNECTIONS



S = SHELL
H = HEATER
P = PLATE
G_2 = SCREEN
G_3 = SUPPRESSOR
K = CATHODE
G_1 = CONTROL GRID

RCA APPLICATION NOTE ON WIDE-ANGLE TUNING WITH RADIOTRON 6E5, 6G5, OR 6U5

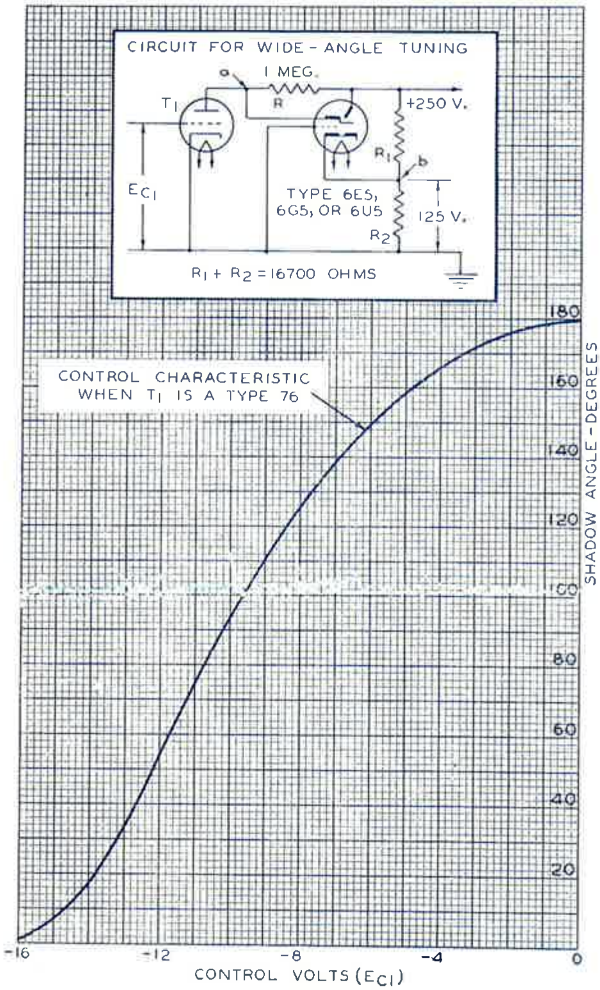
It is possible to increase the shadow-angle sensitivity of the 6E5, 6G5, or 6U5 as a tuning indicator by increasing the maximum shadow angle from the usual value of 90 degrees to approximately 180 degrees. This improvement is obtained by using a separate triode in a new circuit to control the action of the ray-control electrode in the tuning-indicator. The cost of using this new circuit is but little more than the cost of the additional valve.

The circuit for obtaining wide-angle tuning is shown in the accompanying diagram. When a high negative bias is applied to T_1, the plate current of T_1 is nearly zero and the voltage drop across R is nearly zero. Under this condition, the shadow angle is zero. When the grid of T_1 is at zero potential, the plate current of T_1 is high and the potential of point (a) is nearly —125 volts with respect to the cathode of the 6E5, 6G5, or 6U5. The shadow angle under these conditions is approximately 180 degrees. In the usual circuit, the maximum shadow angle is only 90 degrees because the potential of the ray-control electrode (a) does not become negative with respect to cathode.

The accompanying curve shows the relation between shadow angle and control voltage when T_1 is a type 76. Other valve types may be used in place of the 76; the shadow-angle characteristic with the 76 is shown merely to illustrate the performance of the circuit. For example, when T_1 is a 6J5, the cut-off voltage is approximately —12 volts; when T_1 is a 6K7, the cut-off voltage is approximately —40 volts, provided the suppressor is connected to control grid and screen voltage is obtained from the 250-volt source through a 5-megohm resistor.

A well-defined shadow angle is not obtained over the entire range of 180 degrees. The edges of the pattern are sharp for shadow angles from 0 to approximately 150 degrees; from 150 degrees to 180 degrees, the edges of the pattern are not sharp. However, by reducing the potential of point (b) with respect to ground, the maximum shadow angle is reduced and the edges of the pattern are sharp over the entire range. A suitable compromise can be made easily. In order to stabilize the potential of point (b), it is suggested that the bleeder current through R_1 be approximately 15 milliamperes.

OPERATION OF THE 6E5, 6G5, OR 6U5



Correction

Improved Audio A.V.C.

In the article under this heading in Radiotronics 84, the stage gain given on Page 109, Column 2, should read: "Maximum gain approximately 26 times." The full gain of 45 times is obtainable with a bias of —6 volts on No. 3 grid, but in order to obtain this without affecting the bias on No. 1 grid, a more complicated circuit is necessary.

MIXING SYSTEMS

(Continued from page 125)

microphone to bring its level up to that of the pick-up (cf. Fig. 1).

Fig. 9 illustrates a fairly large mixing system which provides adequate control of two microphones and two pick-ups and has sufficient gain to provide from them an output of about 30 volts. Note that no controls have been used in the grid circuits of the 6A6, since the low level microphones can never overload that valve.