RADIOTRONICS

AMALGAMATED WIRELESS VALVE CO. PTY. LTD.

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

TECHNICAL BULLETIN No. 102 **20th February, 1940**

In this issue:—

OVERBIASED OPERATION OF RADIOTRON 1Q5-GT

Radiotron 1Q5-GT, owing to its sensitivity and high power output, is likely to be very popular in 1.4 volt receivers. As this type is planned for Australian manufacture later in the year there need be no anxiety regarding its availability. There are, however, smaller receivers which do not require the full power output of 270 milliwatts and in which the cathode current of 11.1 mA. would be unduly high.

Fortunately, this valve type is particularly amenable to operation with over-bias, and practically any output from 50 to 270 milliwatts may be obtained with reasonably good plate circuit efficiency. The efficiency falls slightly as the bias is increased, but the loss is not very serious.

In order to obtain a comparative basis it was decided to select operating conditions for a total harmonic distortion of 10% in all cases, and the load resistance was selected so that both second and third harmonics were close to 7%. Owing to the limitation of third harmonics to about 7% the tone is considerably better than would be the case with 10% third harmonics and zero second harmonic. The results of these tests are shown in tabular form for self-bias operation. They may be taken as being very closely correct for back-bias operation since the rise of cathode current is comparatively small.

Owing to differences between individual valves, which tend to become more marked as the bias is increased, extreme overbiasing is inadvisable in commercial receivers. The use of self- or back-bias assists in obtaining uniformity of performance; fixed bias with over-bias voltages is not recommended.

(See Table on next page)

THE CALCULATION OF TRIODE CONSTANTS

Those who are interested in the calculation of plate current, amplification factor and mutual conductance from the geometrical structure of a valve with a saturated space charge are referred to an article by J. H. Fremlin entitled "Calculation of Triode Constants" in Electrical Communication, July, 1939. An abstract of this article, with sufficient detail to be of interest, was given in Radiotronics for November, 1939, on pages 76-81.

This treatment is more exact than that at present in common use, and is based on the direct consideration of a triode instead of an equivalent diode. Formulae are given for plane and cylindrical constructions and corrections are given for the effect of grid wire diameter and initial electron velocity.

(*Continued from Page 1*)

Self-bias Operation of Radiotron 1Q5-GT with over-bias Voltage

In the first three columns the first value gives the reading at no signal input, and the second at maximum signal input.

These readings were obtained on a single valve having characteristics close to the published characteristics.

Negative Grid Bias. (Volts).	Plate Current. (mA.).	Screen Current. (mA.).	Load Resistance. (Ohms).	Power Output. (mW.).	Harmonic Distortion. 2nd Harmonic. (%).	3rd Harmonic. (%).	Total. (%).
7.04-7.40	3.63-3.05	0.36-1.14	25,000	97	—	—	10
6.53-6.84	4.57-3.85	0.48-1.41	20,000	135	—	—	10
6.33-6.63	5.00-4.43	0.53-1.39	15,000	146	—	—	10
6.02-6.36	5.62-5.12	0.63-1.50	12,500	168	6.7*	7.6*	10.2*
5.71-6.04	6.02-5.53	0.70-1.59	11,000	184	7.1*	7.7*	10.5*
5.61-5.95	6.42-5.97	0.76-1.64	10,000	204	7.0*	7.7*	10.4*

* Readings taken with Wave Analyser.

RADIOTRON 7AP4

7″ KINESCOPE (CATHODE RAY TUBE) SHORT BULB AND MAGNETIC DEFLECTION

Radiotron 7AP4, a high-vacuum cathode-ray tube designed for black-and-white reproduction of television pictures, employs magnetic deflection of the electron beam. Its screen accommodates a picture 4½ inches by 6 inches in size, or slightly larger. A special feature of this tube is its relatively short overall length of approximately 13½ inches.

TENTATIVE CHARACTERISTICS AND RATINGS.

Heater Voltage (A.C. or D.C.)	2.5 Volts
Heater Current	2.1 Amperes
Fluorescent Screen:	
Material	Phosphor No. 4
Color of Fluorescence	White
Direct Interelectrode Capacitance:	
Grid to all other Electrodes	12 max. $\mu\mu$F.
Overall Length	13½″ ± ⅜″
Maximum Diameter	7⅛″
Bulb	J-56
Base	Medium 5-Pin

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS.

High-Voltage Electrode (Anode No. 2) Voltage	3500 max. Volts
Focusing Electrode (Anode No. 1) Voltage	1000 max. Volts
Control Electrode (Grid) Voltage	Never Positive
Fluorescent-Screen Input Power per sq. Cm†	2.5 max. Milliwatts
Typical Operation:	
Heater Voltage	2.5 Volts
Anode No. 2 Voltage	3500 Volts
Anode No. 1 Voltage (Approx.)*	675 Volts
Grid Voltage#° adjusted to give suitable luminous spot	
Grid Signal-Swing Voltage▭	15 Volts

* Adjustable to ± 20%.

\# Approximately 10% of Anode No. 1 voltage is required for current cut-off if the maximum permissible resistance is used in the grid circuit.

▭ Peak-to-peak value for good brilliance with good resolution. For greater brilliance, up to twice this value should be available.

° Maximum resistance in the grid circuit should be limited to 2 megohms.

† This value applies to the brightest portion of a stationary pattern. Approximately double this value is permissible with a moving pattern.

RADIOTRON SENIOR AMATEUR RECEIVER

Nearly three years ago we described a receiver which had been constructed in our laboratory and which was then believed to be ideal for amateur reception of 'phone and C.W. During the past few months we have received many requests for information on this receiver, together with any comments which we could make to bring it more up-to-date. Since we have not yet been able to carry out the necessary extensive development work for a new receiver we are pleased to describe in this article the features which we would consider desirable in such a new design. At some future date we hope to complete this design and describe the receiver in Radiotronics.

The Radiotron Senior Amateur Receiver was described in Radiotronics 75 (30th April, 1937), pages 30 to 34. For the benefit of those who do not have this copy* available the valve arrangement is listed below:—

R.F. Amplifier	Radiotron 956
Mixer	Radiotron 6L7
H.F. Oscillator	Radiotron 6D6
Noise Silencer	Radiotron 6L7
Noise Amplifier ...	Radiotron 6C6
Noise Rectifier	Radiotron 6H6
1st I.F. Amplifier ..	Radiotron 6D6
2nd I.F. Amplifier, Diode Detector & BFO Mixer	Radiotron 6B7S
Beat Frequency Oscillator	Radiotron 6J7
A.V.C. Diode and Audio Amplifier .	Radiotron 75
Power Output	Radiotron 42
Magic Eye Tuning Indicator	Radiotron 6G5
Power Rectifier	Radiotron 80

When the Senior Amateur Receiver was in the process of design it was realised that a single R.F. stage using type 6D6 did not have sufficient gain to give low noise level on the highest frequency band (30 Mc/s). Consequently a single Acorn valve (type 956) was adopted as giving improved gain under these conditions without necessitating the use of a four-gang condenser. Subsequent experiments with regeneration, either in the mixer or in the R.F. stage, showed that, as a means of increasing the R.F. sensitivity it was subject to certain disadvantages in that it had a serious effect on the tuning and on the image ratio as well as necessitating an additional control. It became obvious that, for a receiver of high sensitivity, two R.F. stages are highly desirable. If a suitable four-gang condenser is not available it should be possible to make use of a combination of two 2-gang condensers suitable for ganging. If two R.F. stages are used there is no necessity for using Acorn valves, since type 6U7-G will give reasonable gain at all frequencies, having the additional advantage of being Australian made.

* Radiotronics, No. 75, is now out of print, but copies of the circuit diagram are available on request.

The frequency converter stage is one which may be arranged in many ways. The original receiver used type 6L7 with a 6D6 oscillator; this was quite satisfactory and may be used with confidence. It has the disadvantages that the 6L7 is not Australian made and that a separate oscillator valve is essential.

Types 6J7-G and 1851 are both excellent as mixer valves, but are critical with regard to oscillator voltage; they also introduce complications in the circuit design.

Type 6K8-G is excellent in many respects and does not require a separate oscillator. With two R.F. stages the somewhat higher noise level of this type would probably not be noticeable. A further advantage is that full A.V.C. may be applied with negligible frequency shift during fading.

Type 6A8-G may be used with a separate oscillator.

Type 6J8-G has many good features and, all factors considered, would probably be our first choice in a new design. It is now Australian made, it does not need a separate oscillator (except perhaps below 13 metres), it has excellent oscillator frequency stability provided that A.V.C. is not applied to its signal grid, and has a very low noise level. It has the disadvantages of being degenerative and of introducing loading on the tuned grid circuit, although with two R.F. stages these effects should not prove serious. Plate tuning of the oscillator would probably be justified.

Type 6J8-G is in principle the same as the 6L7 with a separate oscillator, but the grid of the oscillator is internally connected to the third grid of the mixer. The performance is comparable with that of the 6L7 and some slight advantage over the 6L7 exists at the highest frequencies owing to the short leads and direct connection of the oscillator to the mixer section. The conversion conductance is slightly lower than that of the 6L7.

Crystal Filter and Noise Silencer

The crystal filter is highly desirable for C.W. reception under difficult conditions but, as much listening is done on 'phone only, some users may prefer to omit the crystal altogether and thereby to save one valve. If the crystal filter is omitted the noise silencer as originally used may also be omitted, since its principal intention is to prevent "ringing" of the crystal due to transient peaks. An audio frequency "level limiter" of satisfactory design is considerably cheaper and may be equally as efficient as the noise silencer operating at intermediate frequency. A satisfactory level limiter would require to be adjustable so as to cut at any required depth of modulation, and should ideally be automatically controlled by the A.V.C. so that its action is not affected by the strength of carrier. Limiting circuits using a valve such as the 6H6-G are well known but at the present time we are investigating one which does not require the use of such a valve. If this is successful it will be described at a later date.

If the crystal filter is required for C.W. reception it is desirable for it to be protected by a noise silencer operating at I.F. In the original circuit the gain in the single stage noise amplifier was not sufficient to give operation on weak impulses such as the ignition interference from cars. A higher gain in this channel, or a circuit rearrangement to give the same effect if this is possible, would be desirable.

The I.F. Amplifier (apart from the noise silencer stage which has very little gain) consists of two stages and experience has shown that the gain was unnecessarily high. Some form of flat-topping the I.F. transformers is very helpful when high selectivity is not required. A tertiary coil which may be switched in or out of circuit is simple to add to existing I.F. transformers, but its adjustment requires the use of a frequency modulated oscillator (wobbulator). If a two position selectivity switch is used, it is helpful to arrange matters so as to adjust the gain of the I.F. Amplifier as the switch is moved, giving uniform gain in both positions. A subsidiary continuously variable I.F. gain control is an additional worth-while feature.

The A.V.C. system as used in the original receiver could be improved by using a three or four position switch control of the time constant giving a very long time constant for C.W., a medium value for general use and a very short one for very rapid fading. The same switch could also be used for switching off the A.V.C.

A more elaborate tone control than that used in the original receiver appears to be desirable. One having independent control of bass and treble attenuation and three positions on each (including one with zero attenuation) should satisfy all requirements.

The **layout** of such a receiver is one of the most important factors in its satisfactory operation. The original receiver which was built in our laboratory was on a single chassis, and was rather cramped for space. As a separate loudspeaker is almost essential in any case (in order to avoid microphony) one practicable arrangement with many good features is to use one chassis for the tuner and a separate chassis for the A.F. Amplifier, Power Pack, etc., and Loudspeaker. Alternatively a single chassis and external loudspeaker may be used. Rigidity of the tuning chassis is essential for satisfactory operation, and nickel plated steel with solid brass bar reinforcement (as used in the original receiver) is recommended.

The **coil switching arrangement** presents some difficulties. If listening is restricted largely to one or two bands it may be practicable to use plug-in coils. Those who have experienced the pleasure of multi-band switching will not relish the work involved in changing four coils each time the frequency band is changed. A multi-band switching system is often regarded as being too ambitious for the average amateur constructor, although in our opinion it is quite practicable. A compromise may be adopted in the combination of the two systems. For example, a three position switching system may be used, switching to either of two sockets for plug-in coils or to a fixed set of broadcast coils. By this means either of two short wave bands or the broadcast band may be switched in without any changing of coils. Various other arrangements could be adopted to suit the requirements of the individual constructors such as for example a three position switch covering short wave bands, of which one could be a plug-in coil and the other two popular bands such as the 20 and 40 metre bands, the coils of which could be permanently in circuit.

A satisfactory band spreading arrangement is essential for such a receiver. In the original receiver the band setting condensers were not ganged, but this arrangement has been found to be rather unsatisfactory and a ganged control will be used in any future design. This introduces additional complications, particularly if four tuned sections are required, as would be the case with two R-F stages. In spite of these difficulties we are of the opinion that such an arrangement is desirable and practicable provided that the constructor is prepared to take the necessary trouble. We hope to say something further about a method of band-spreading for this receiver at some future date.

Comments regarding this receiver would be welcomed and should be addressed to the Unified Sales-Engineering Service.

SOME SPECIAL APPLICATIONS OF PHOTOTUBES

Although gaseous phototubes are widely used in the reproduction of sound-on-film, vacuum phototubes are preferable for applications where constancy of output is required. Radiotron vacuum phototubes include the following types:—

Type.	Surface.	Principal Use.
917	Caesium	Relays and measurements
919	Caesium	Relays and measurements
922	Caesium	Relays and measurements
925	Caesium	Relays
926	Rubidium	Colorimetry

Types 917 and 919 are fitted with the older type of 4 pin base and top cap, the former having the top cap connected to the anode and the latter to the cathode. Type 925 is more compact and is fitted with an octal base without a top cap. Types 922 and 926 are of the cartridge type similar in dimensions to the 921 and provide high insulation for both electrodes. They are therefore desirable types for accurate measurement purposes.

The choice between types 922 and 926 is merely dependent upon the **desired spectral sensitivity characteristic.** Type 922 has a maximum sensitivity at a wavelength of 8000 Angström Units (infra-red region) while type 926 has its maximum at 4400 Angström Units (violet-blue region). Reference to the Radiotron Phototube Chart will give the curves and other data.

Special Applications

Special applications of phototubes include the operation of relays by light, the measurement of light intensity, the counting of objects passing a beam of light and the matching of candlepower, colour and turbidity.

The information to follow is derived from the R.C.A. Radiotron instructional leaflet on type 917, but is equally applicable to types 922 and 926. In cases where both types 917 and 919 are specified they may both be replaced by two type 922 or two type 926 since these more recent types have good insulation for both electrodes.

SPECTRAL SENSITIVITY CHARACTERISTIC

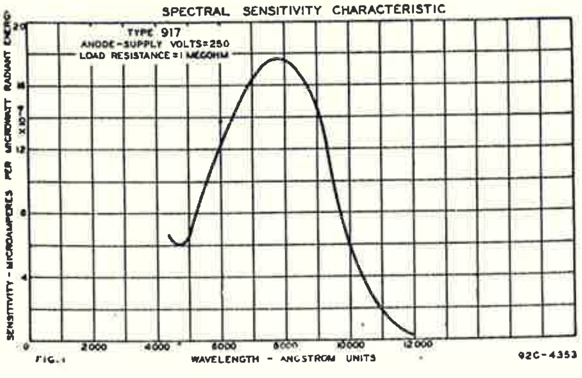


FIG. 1

* The angström unit is a unit of wavelength and is equal to 10-10 metres.

"The maximum ambient temperature rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface to evaporate with consequent decrease in the life and sensitivity of the tube.

"The spectral response of the 917 is shown in Fig. 1. This phototube is sensitive over the entire visible spectrum. The large response in the infra-red region makes the tube particularly useful where tungsten-filament lamps are employed as light sources. **In the ultra-violet region, cut-off occurs at 3000 angström units* due to the absorption of the glass bulb.** For some special applications, it may be desirable to alter the spectral-response characteristic. This can often be done by the use of a suitable color filter.

"The anode-current versus light-input characteristic of the 917 is practically linear for light inputs up to 1.0 lumen, provided the anode voltage is relatively high and the load resistance relatively low.

AVERAGE ANODE CHARACTERISTICS

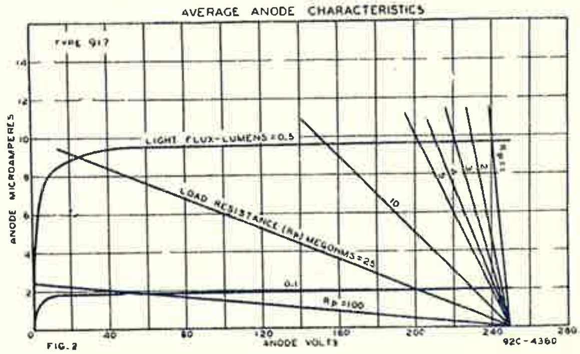


FIG. 2

"When maximum sensitivity of phototube circuits is important, the leakage resistance of circuit parts and of wiring insulation should be high. Leakage currents from anode to cathode over the external surface of the bulb can be made very small by cleaning the glass with a cloth dampened in alcohol to remove all traces of dust and grease, and then coating the bulb with a non-hygroscopic wax, such as pure white ceresin wax. When an amplifier valve is used in the circuit, the tube should preferably be a type having the grid brought out to a cap at the top of the bulb; with such a valve, similar steps can be taken to minimize its surface leakage.

"Also, for maximum sensitivity, it is desirable to use a high resistance connected in series with the phototube and coupled to the grid circuit of an amplifier valve. It should be noted that, in general, the grid-circuit resistance for an amplifier valve is limited by the valve's ratings to a value not more than 1 or 2 megohms. With larger values of grid-circuit resistance, the bias voltage on the grid may become so small that the plate and screen currents become excessive. Therefore, when a grid-circuit resistance larger than rated value is used, precautions should be taken to limit the plate and screen currents to safe values. Such precautions include the use of a low-voltage supply for plate and screen, or the use of current-limiting resistors in the plate and screen-voltage leads. In some cases, it may be found that the use of a high grid-circuit resistance causes the plate current to vary erratically. This effect can usually be eliminated by operation of the heater or filament at less than rated voltage.

"For constant calibration of high precision devices using the 917, the phototube should be operated at an anode voltage of about 20 volts. Higher anode voltages may cause ionization of minute traces of residual gas within the tube. The gas current resulting from this ionization may produce slow changes in the tube's characteristics which would change calibration.

"A further consideration for the maintenance of constant calibration is that the light incident on the phototube should be spread over as large a portion of the cathode surface as possible. This will minimize any variations in sensitivity that might be caused by a shift in the position of the light spot on the cathode.

"High-resistance relays and output meters, in general provide better sensitivity when they are operated from a pentode amplifier valve rather than from a triode. The reason is that a pentode provides a larger current swing than does a triode working into a load resistance of several thousand ohms.

SIMPLE CIRCUIT FOR RELAY OR MEASUREMENT OPERATIONS

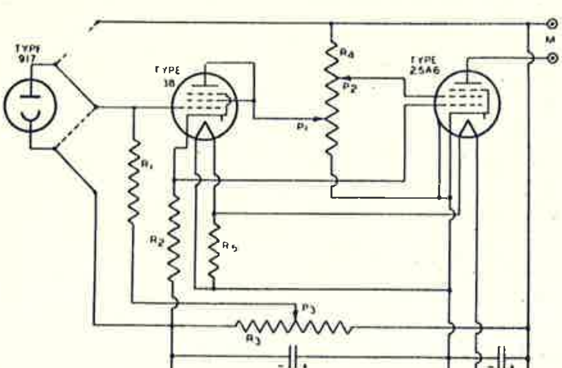


FIG. 3

C = 8 μf
M = D C MILLIAMMETER OR RELAY (0-25 MA.)
R_1 = 100 MEGOHMS
R_2 = 0.5 MEGOHM
R_3 = 0.1 TO 2.0 MEGOHM
R_4 = 0.1 MEGOHM
R_5 = 50 OHMS (1 WATT)
R_6 = 200 OHMS (20 WATTS)

"Radiotron 917‡ is especially suited for use in circuits intended for precise light measurements and light-controlled relay operations. Because of its top-cap anode connection, the tube can be used in such circuits, either alone or with its companion type, the Radiotron 919‡ phototube, to give extremely small leakage currents and high sensitivity. The 917‡ is to be used in circuits where the phototube anode is connected to the top-cap of an amplifier valve. In circuits where the cathode of the phototube is to be connected to the top-cap of the amplifier valve, Radiotron 919‡ should be used. The important requirement in choosing between the 917 and the 919, is that the input lead to the amplifier valve should be connected from top-cap to top-cap, rather than to a base terminal. By this method of connection, leakage currents can be made extremely small.

"In the circuits of Figs. 3, 4, 6 and 7, the grid-circuit resistance of the first amplifier valve is much larger than the maximum recommended value. In order that this high resistance may not cause instability of plate current, the heater of the first amplifier valve is operated at considerably less than rated voltage. Because of this large voltage reduction, it may be found that some individual amplifier valves do not give satisfactory operation in these circuits.

Relay or Measuring Operations

"Relay or measuring operations can be performed by means of the simple circuit shown in Fig. 3. This circuit responds to rapid variations in light and is, therefore, especially well-suited for use in high-speed counting devices, or in the measurement of rapid light fluctuations. In applications where speed of response is not of primary importance, a circuit requiring fewer parts can be used.†

"In the circuit shown in Fig. 3, when the phototube is connected as shown in solid lines, an increase in illumination on the phototube causes a decrease in the plate current of the 25A6. When the phototube is connected as shown in dotted lines, an increase in illumination produces an increase in plate current. Since in this dotted-line connection it is the cathode of the phototube that is connected to the grid of the 38, less leakage and higher sensitivity can be obtained in this connection by the use of Radiotron 919‡ phototube.

"For maximum sensitivity to be obtained from this circuit, it should be adjusted so that the potential of the 25A6 grid varies over a range whose upper limit is slightly more

‡ Radiotron types 922 and 926 are equally suitable for this application.

† See Fig. 2 in "Some Unconventional Vacuum Tube Applications", F. H. Shepard, Jr., RCA Review, October, 1937.

SENSITIVE CIRCUIT FOR MATCHING MEASUREMENTS

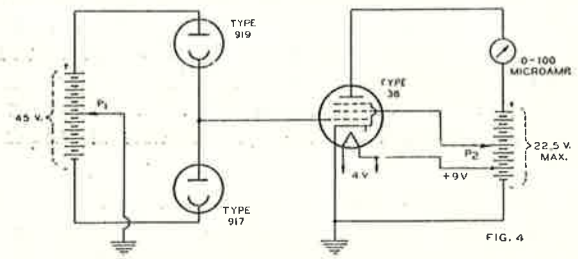


FIG. 4

negative than zero bias. For the connection shown in solid lines, the adjustment can be made as follows: Set P_3 at the positive end of R_3, P_1 and P_2 at the positive end of R_4, and the illumination on the phototube at the minimum value it will have in the use of the circuit. Then move P_1 toward the negative end of R_4 until the IR drop across R_2 due to cathode current of the 38 brings the 25A6 to zero bias. The correct setting of P_1 can be determined with the aid of the meter M. When the movement of P_1 begins to affect the meter reading, the 25A6 is approximately at zero bias and P_1 has the correct setting. Then adjust the screen voltage of the 25A6 by means of P_2 to give the desired value of maximum output current. If the circuit is to operate a relay, the maximum output current should be just large enough to hold the relay closed. Next move P_3 toward the negative end of R_3 to the position where the movement begins to produce a decrease in the plate current of the 25A6. The circuit is then ready for operation and is adjusted so that a small increase in illumination above the minimum value will produce a comparatively large decrease in plate current of the 25A6.

"For the connection shown in dotted lines, the procedure for adjusting the circuit is the same except that the adjustments are made with illumination at its maximum value. When the adjustments have been made, a small decrease in illumination below the maximum value will produce a comparatively large decrease in plate current of the 25A6.

Matching Measurements

"Matching measurements of photometric qualities such as candle-power, color and turbidity can be made with high precision by means of the circuit shown in Fig. 4. This circuit can be used, for example, to determine whether the candlepower of a lamp is precisely equal to that of a standard lamp. For this use, the circuit is first adjusted so that the microammeter reads mid-scale when one phototube is exposed to light from the standard lamp and the other phototube is exposed to light from a comparison lamp. The standard lamp is then replaced by the unknown lamp. If the unknown lamp supplies exactly the same amount of light to the first phototube that the standard lamp did, the meter reading will be the same as for the standard lamp. However, if there is a difference, even though very small, between the amounts of light supplied by the standard lamp and the unknown lamp, the bias applied to the 38 will be much different than it was for the standard lamp. The meter reading will therefore be much different. Thus, the circuit can be used to detect a very small mismatch between the lamps. By exposing the phototubes to light reflected from materials or transmitted by liquids, the circuit can also be used to match or measure color, turbidity, and other photometric qualities.

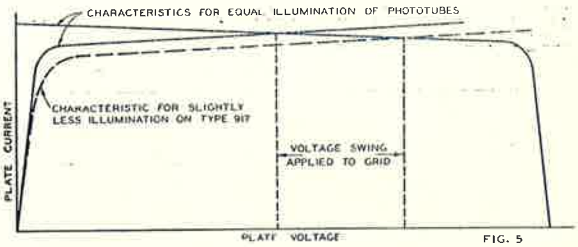


FIG. 5

"An easy way to understand the theory of this circuit is to consider one phototube as the load for the other, as in Fig. 5. In this figure, the 919 is considered as the load for the 917 and a reversed 919 current-voltage characteristic is drawn as a load line on the 917 current-voltage characteristic. The intersection of the two curves gives the distribution of voltage across the phototubes because the phototubes, being in series, must pass the same current. When the circuit is so adjusted that the intersection is on the flat portion of the curves, a small change in the illumination on one phototube produces a large shift of the point of inter-section. This is shown by the dotted line which represents the current-voltage characteristic for the 917 under slightly decreased illumination. The wide shift in the intersection means a large change in the bias on the grid of the 38. Consequently, the circuit has high sensitivity.

"The circuit can be adjusted for operation as follows: Short circuit the grid to the cathode of the 38 and adjust contact P_2 so that the microammeter deflection is slightly less than full scale. This adjustment assures that, during the operation of the circuit, the plate current of the 38 will not exceed the meter's full-scale value. Then remove the shorting connection from the grid and, with zero illumination on the phototubes, adjust P_1 so that the microammeter deflection is approximately midscale. Next set the illumination on one phototube at a convenient value and adjust the illumination on the other phototube so that the meter deflection is again midscale. The circuit is then ready for operation. This adjustment procedure compensates for differences in insulation resistance and sensitivity of individual phototubes.

"For high sensitivity, it is important that grid current in the 38 be small. Emission current from the heater to the grid can be minimized by a positive bias of 9 volts applied to the heater, as indicated in Fig. 4. Leakage currents to the grid can be made small by means of the precautions described above. The response of the meter to a change in illumination may be slow, especially at low light levels. The reason is that the dynamic resistance between the grid and cathode of the 38 may be so large that this resistance, when multiplied by the input capacitance of the 38, gives a large time constant.

SENSITIVE CIRCUIT FOR MATCHING MEASUREMENTS
A-C OPERATED

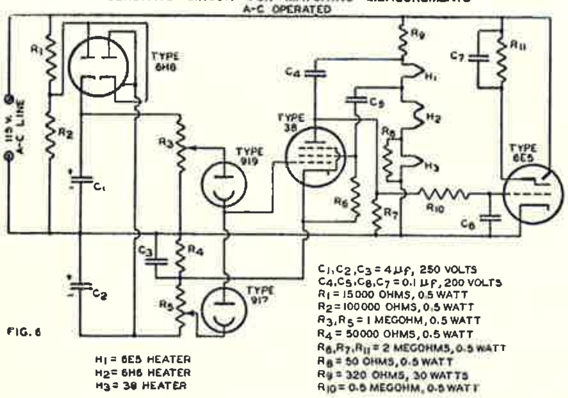


FIG. 6

A.C. Operated Circuit for Matching Measurements

"An a-c operated circuit for matching measurements is shown in Fig. 6. This circuit employs a 917‡, 919‡, and 38 connected in the high-sensitivity arrangement of Fig. 4, but requires no battery or microammeter. Anode voltage is supplied to the phototubes by the 6H6 connected as a voltage-doubler rectifier. Positive plate and screen voltages are supplied to the 38 and 6E5 on alternate half-cycles of the a-c line voltage. The magnitude of the plate current of the 38 is indicated by the 6E5. The applications for this circuit are the same as those for the circuit of Fig. 4. The procedure for adjusting the circuit is similar to that for Fig. 4. First, with zero illumination on the phototubes, set potentiometer R_3 at about the middle of its range 6E5 is half closed. Then apply a convenient value of illumination to one phototube and adjust the illumination on the other phototube so that the 6E5 shadow angle is again half closed. The circuit is then ready for operation. **For illumination levels as low as 0.0001 lumen, an unbalance of $\frac{1}{4}$ of 1% in the light on the phototubes will cause the 6E5 shadow angle to open to 90° or close to 0°.** This sensitive response is obtained only when leakage currents are made small as described above. At higher illumination levels the sensitivity is even better because the ratio of photoelectric current to leakage currents is larger.

‡ These may be replaced by either type 922 or 926.

CIRCUIT FOR MEASUREMENT OF ILLUMINATION RATIOS

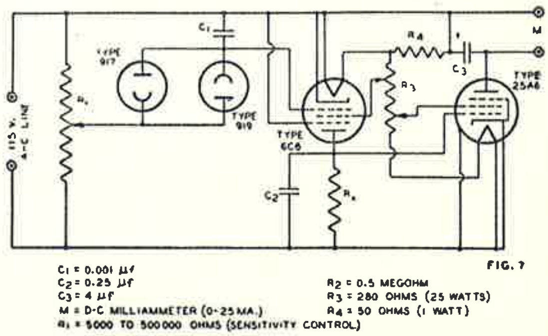


FIG. 7

Ratios of Light Intensities

"Ratios of light intensities can be measured directly by means of the a-c operated circuit shown in Fig. 7. Condenser C_1 is charged during one half-cycle through one phototube. On the next half-cycle, the condenser is charged in the opposite direction through the other phototube. If the phototubes are equally illuminated, they feed equal charges into the condenser and the net d-c voltage across the condenser is zero. When, however, the phototubes are unequally illuminated, there is set up across the condenser a d-c voltage whose magnitude is a function of the ratio of illuminations. This condenser voltage, amplified by the 6C6 and the 25A6, is read on the output meter which can be calibrated to show directly the intensity of one source as a multiple or a fraction of that of the other.

Phototube References

"Campbell and Ritchie: Photoelectric Cells; Sir Isaac Pitman and Sons, Ltd. Gulliksen and Vedder: Industrial Electronics; John Wiley and Sons, Inc. Henney, Keith: Electron Tubes in Industry; McGraw-Hill Book Co., Inc. Hughes and DuBridge: Photoelectric Phenomena; McGraw-Hill Book Co., Inc. Zworykin and Wilson: Photocells and Their Applications; John Wiley and Sons, Inc.

"For further information on the phototube circuits in this bulletin, see 'Miscellaneous Applications of Vacuum Tubes', F. H. Shepard, Jr., Proc. Radio Club of America, June, 1935, 'Application of Conventional Vacuum Tubes in Unconventional Circuits', F. H. Shepard, Jr., Proc. I.R.E., Dec., 1936, and 'Some Unconventional Vacuum Tube Applications', F. H. Shepard, Jr., RCA Review, October, 1937."

NEW MINIATURE VALVES

The following is for information only and does not imply that these valves will be available in Australia. Owing to existing restrictions on imports it may be assumed that these valves will not be available in Australia until further notice.

A new series of Miniature Valves has recently been added to the Radiotron range. These valves have no bases, and fit a special 7-pin socket. They have parallel-sided envelopes and are single-ended in all cases, but have an exhaust tip at the top of the bulb.

These valves have 1.4 volt filaments and are intended for operation from a 45 volt B Battery, this being the maximum voltage which may be applied to the power pentode (1S4). Under these conditions the power output is 65 milliwatts with a total harmonic distortion of 12%, but on back bias this power output is reduced to about 50 milliwatts. This is very small compared with the 200 to 270 milliwatt output obtainable with valves used in existing portable receivers, and the volume obtainable from the loudspeaker would necessarily be very small.

The converter (1R5) operates on the same principle as the 6SA7, that is to say, it has no anode-grid electrode and a special coil arrangement is required for the oscillator. A conversion conductance of 235 μmhos. is obtained with a 45 volt supply and a cathode current of 2.75 mA. The valve has a super-control characteristic of relatively short grid base.

The diode-pentode (1S5) has a single diode, and a gain of about 30 times is available from the pentode section as an A.F. amplifier.

The super-control R.F. pentode (1T4) has a mutual conductance of 700 μmhos., with a plate resistance of 0.25 megohm on a 45 volt supply. A short grid base (10 volts) is employed.

All these types with the exception of the output pentode operate at zero minimum bias. All four types have the same external dimensions: 2⅛in. overall length and ¾in. maximum diameter.

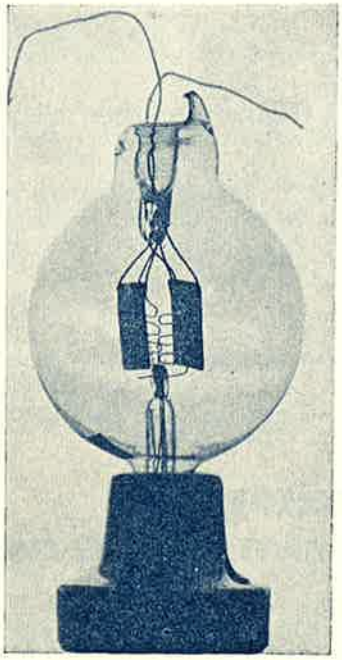
6V6-G TRIODES AS MODULATORS OR DRIVERS

Single or push-pull 6V6-G triodes may be found very convenient for use as modulators or driver stages for Class B systems. Operating data on type 6V6-G as a triode with screen tied to plate were given in Radiotronics 100, page 50. Although the power output is limited, this type has the advantage of an indirectly heated cathode. If two are used in push-pull the power output will be more than double, and the distortion and hum will be reduced. This type has certain advantages over type 6F6-G as a triode, and it is probable that it will be widely used. A loose-leaf data sheet on the triode operation of this type is now in preparation.

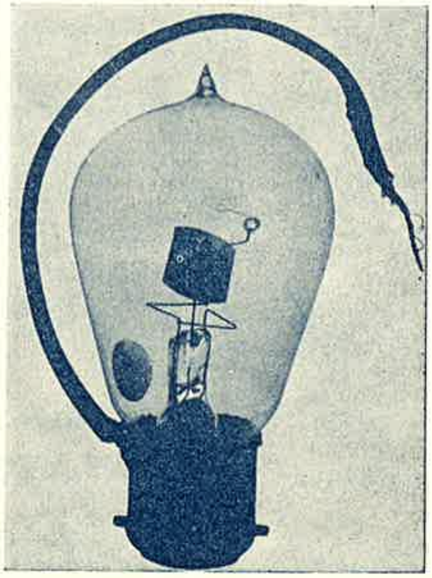
REVISED PAGE SIZE FOR RADIOTRONICS

Commencing with this issue, the first for 1940, Radiotronics is being printed on Australian-made paper in order to patronise Australian industry and to ensure continuity of supply. The Australian paper is supplied in a size slightly different from what has been used in Radiotronics during preceding years, and for this reason the Bulletins in future will be of a size similar to this issue. This change will not affect the binding since it has been made on the first issue of a new year.

The index, enclosed as a supplement to this Bulletin, is of the same size as the issues for the preceding twelve months so that it may be bound with them into a permanent record.



FLEMING VALVE



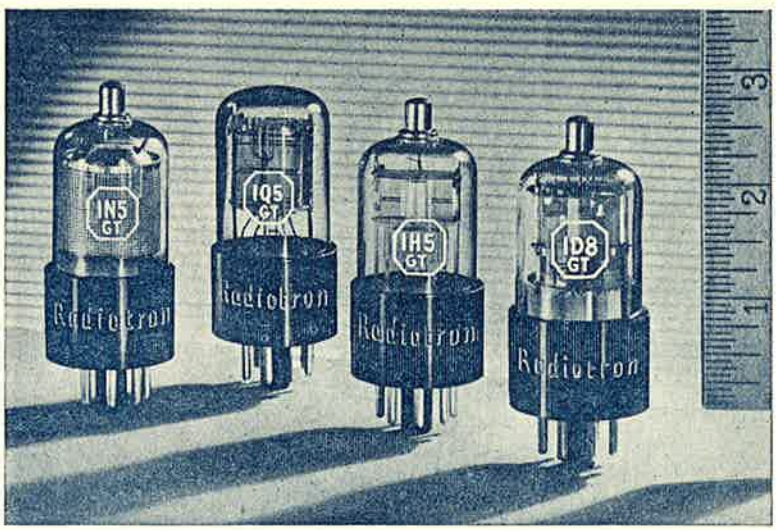
de Forest AUDION

Valves of Yesterday

It is only a short time ago, and within the memories of most of us, that Fleming constructed the first radio valve (a diode), one of which is shown in the picture on the left. The first triode was constructed by de Forest and called the "Audion," one of which is shown in the illustration on the right.

And To-day

Both Professor J. Ambrose Fleming and Dr. Lee de Forest have lived to see the marvellous development of the thermionic valve to the mass-produced instrument of precision which we use to-day. The illustration on the right shows four of the popular 1.4 volt Bantam Valves used in portable radios of to-day.



MAXIMUM RATINGS

A NEW METHOD FOR RECEIVING VALVES

In the past all receiving valves have been given "maximum" ratings which were absolute maxima, not to be exceeded under any circumstances. Although these ratings were satisfactory in cases where the power was supplied from a battery, they have led to some misunderstandings in cases where the power was derived from the mains. In the latter case the voltage may rise as well as fall, and thereby exceed the rating if the equipment is designed on the basis of the nominal mains voltage. A similar problem exists in the case of automobile receivers.

A new method of rating receiving valves has been standardised by the Radio Manufacturers' Association (U.S.A.). Under these new ratings the plate and screen power supply has been divided under three sources:—

1. A.C. or D.C. Power Line.
2. Automobile Storage Batteries.
3. "B" Batteries.

For cases in which the power supply is from the power line, new maximum ratings have been formulated which are designated "Design Maxima". These correspond to the **nominal** voltage of the line and are chosen so as to allow for normal line voltage fluctuations (± 10%). The name "Design Maximum" indicates that the rating given may be used for design purposes on the assumption that the voltage applied to the receiver is at its nominal value.

With automobile battery-operated equipment the voltage fluctuations are greater, and the procedure is to design on a basis of 6.6 volts from a 6 volt accumulator under which conditions the plate and screen voltage, the plate and screen dissipation and the rectifier load current should not exceed 90% of the design maxima.

When "B" Batteries are used as a source of plate and screen power, an allowance of + 10% above the nominal voltage is given, since dry batteries when new give about 10% above the nominal voltage. When using "B" batteries, therefore, the nominal voltage should not exceed the Design Maximum for the particular valve type. The specifications for these new ratings are given below.

RECEIVING VALVE RATINGS

ACCORDING TO RMA SYSTEM

It shall be standard to interpret the ratings on receiving types of valves according to the following conditions:—

Cathode

The heater or filament voltage is given as a normal value, unless otherwise stated. This means that transformers or resistances in the heater or filament circuit should be designed to operate the heater or filament at rated value for full-load operating conditions under average supply-voltage conditions. A reasonable amount of leeway is incorporated in the cathode design so that moderate fluctuations of heater or filament voltage downward will not cause marked falling off in response; also, moderate voltage fluctuations upward will not cause marked falling off in response; also, moderate voltage fluctuations upward will not reduce the life of the cathode to an unsatisfactory degree.

Plate and Screen

In the case of plate voltage and screen voltage, however, recommended maximum values are given. The interpretation of this maximum value depends on the power source, as follows:—

A-C or D-C Power Line: The maximum ratings of plate and screen voltages and dissipations given on the valve type data sheets are Design Maxima.

Automobile Storage Batteries: When a valve is used in automobile receivers and other equipment operated from automobile storage batteries, consideration should be given to the larger percentage range over which the battery voltage varies as compared with the power-line voltage. The average voltage value of automobile batteries has been established as 6.6 volts. Automobile-battery-operated equipment should be designed so that when the battery voltage is 6.6 volts, the plate voltage, the plate dissipation, the screen voltage, the screen dissipation, and the rectifier load current will not exceed 90% of the respective recommended design maximum values given in the data for each valve type.

"B" Batteries: Equipment operated from "B" batteries should be designed so that under no condition of battery voltage will the plate voltage, the plate dissipation, the screen voltage, and the screen dissipation ever exceed the recommended respective maximum values shown in the data for each type by more than 10%.

Other Electrodes

When a valve is of the multigrid type, the voltage applied to the additional positive electrodes will be governed by the considerations stated under Plate and Screen.

(Continued on next page)

Typical Operation

For many receiving valves, the data show typical operating conditions in particular services. These typical operating values are given to show concisely some guiding information for the use of each type. They are not to be considered as ratings, because the valve can be used under any suitable conditions within its rating limitations.

RADIOTRON MANUALS

Limited quantities of the Radiotron Receiving Valve Manual RC13 are still available and can be obtained at the special price of 1/- (plus 2d. postage).

Small quantities of the Radiotron Transmitting Valve Manual TT3 and the Cathode-Ray Manual TS-2 are on order and are expected to arrive in the near future. As stocks will be kept to the minimum, it would be appreciated if those requiring any of these manuals would place orders immediately so that they may be sure of obtaining a copy.

Complete Radiotron loose leaf Valve Data Booklets are available in flexible board covers at a cost of 2/- each (plus 2d. postage). These include all data sheets now available and may be kept up to date in the future by adding to them the data sheets issued as supplements to Radiotronics. No radio engineer should be without a copy of this Data Book.

Loose leaf covers for Radiotronics Bulletins are available at 1/- (plus postage). These binders will hold up to 24 issues, and each bulletin may readily be inserted when received.

Copies of the Radiotron Characteristic Chart are available free of charge (one penny posted). These charts are of handy size, being only 8¾in. x 5⅝in. with 20 pages of valve data.

All enquiries for any of these manuals and charts should be addressed to Amalgamated Wireless Valve Co. Pty. Ltd., Box No. 2516 BB, G.P.O., Sydney.

INDEX FOR 1939

A comprehensive index for Radiotronics Technical Bulletins issued during 1939 is supplied as a supplement to this issue. It has been found by experience that certain subjects frequently become of greater interest after a period of time, and that a review of recent literature is beneficial. As an aid in this direction, the Radiotronics Index has been made unusually comprehensive and a rapid glance through it should prove helpful to all readers. The individual valve type entries include all references to each type, even though

RADIOTRON NEWS

Radiotron 1R5 is a 1.4 volt miniature converter valve. See description and photograph elsewhere in this issue. This type is not at present available from stock.

Radiotron 1S4 is a 1.4 volt miniature power pentode valve. See description and photograph elsewhere in this issue. This type is not at present available from stock.

Radiotron 1S5 is a 1.4 volt miniature diode-pentode valve. See description and photograph elsewhere in this issue. This type is not at present available from stock.

Radiotron 1T4 is a 1.4 volt miniature super-control R.F. pentode valve. See description and photograph elsewhere in this issue. This type is not at present available from stock.

Radiotron 5V4-G, an indirectly heater full wave rectifier, is now being manufactured in Australia, and ample stocks are available.

Radiotron 6B5, a direct coupled power amplifier, has been added to the Radiotron range, but is not available from stock.

Radiotron 6N6-G, a direct coupled power amplifier with characteristics identical to those of type 6B5 but which is fitted with an octal base, has been added to the Radiotron range, but is not available from stock.

Radiotron 991, a glow discharge voltage regulator tube, has been added to the general list of miscellaneous types. It is fitted with a bayonet candelabra double contact base and has an operating voltage from 55 to 62.5 volts with a current of from 0.3 to 2.0 milliamperes respectively. The peak current is 3 mA. and the starting-supply voltage 87 volts minimum. This type is not normally available from stock.

RADIOTRON DESIGNER'S HANDBOOK

The third edition of the Radiotron Designer's Handbook is now available at 3/- per copy. Readers who have not yet obtained a copy may do so by sending 3/4d. (to cover packing and postage) to Amalgamated Wireless Valve Co. Pty. Ltd., 47 York Street, Sydney, Australia.

Copies will shortly be available through principal booksellers in Australia.

BACK NUMBERS OF RADIOTRONICS

Certain back numbers of Radiotronics are available and readers who need these issues to complete their files may obtain them by sending one penny postage for each two bulletins. The numbers available are 89, 90, 91, 92, 93 and 101.

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