RADIOTRONICS

AMALGAMATED WIRELESS VALVE CO. PTY. LTD.

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

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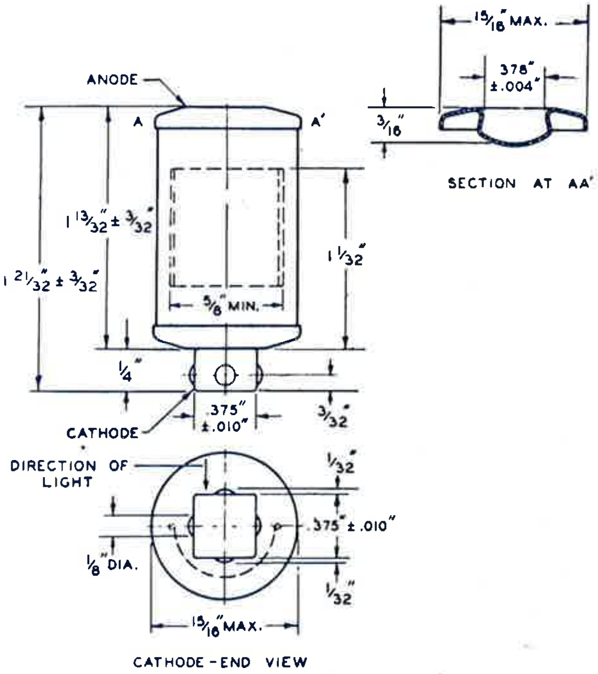
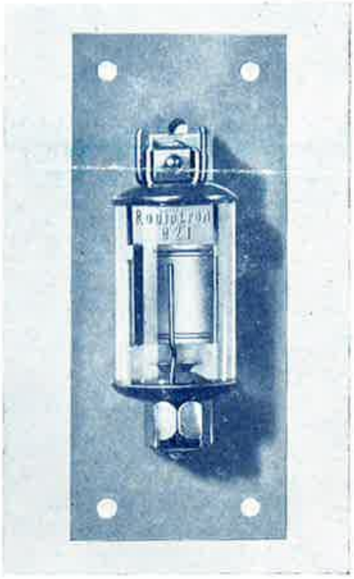
In this issue:—

RADIOTRONS 921 AND 922
NEW CARTRIDGE TYPE PHOTOTUBES

Radiotron 921 is a sensitive phototube of the gas-filled type while Radiotron 922 is of the vacuum type, both having similar overall dimensions. In place of the base employed with earlier type photo-tubes, these new types are of cartridge form with the cathode and anode at opposite extremities. This arrangement provides extremely high leakage paths together with low capacitances.

Type 921 is particularly suited for audio frequency reproduction or for relay operation.





Due to the characteristics of a gas-filled type not remaining absolutely constant with time or operating conditions, it is not advisable to use this type where accurate measurements and constant gain are necessary. The vacuum type 922 is to be preferred for all work involving a constant output and is particularly suitable for the measurement of illumination ratios or for matching. It may also be used for the measurement of small amounts of light.

Each of these types is available from stock at a special nett price of £1, including the special mounting socket.

Radiotrons 921 and 922

Characteristics

CATHODE	Semi-cylindrical, caesium coated
CATHODE WINDOW AREA	0.38 square inch
OVERALL LENGTH	$1\frac{21}{32}'' \pm \frac{3}{32}''$
MAXIMUM DIAMETER	$\frac{15}{16}''$
TERMINAL MOUNTING	Special

Tentative Maximum Ratings and Characteristics

	Type 921	Type 922†
DIRECT INTERELECTRODE CAPACITANCE	1.1	0.6 uuf.
ANODE-SUPPLY VOLTAGE (D.C. or Peak A.C.)	90	500 max. volts
ANODE CURRENT‡	20	30 max. microamps.
D-C RESISTANCE OF LOAD		
With 250-volt anode supply voltage	—	1 min. megohn
With 500-volt anode supply voltage	—	10 min. megohm
With 90-volt anode supply voltage:—		
For currents greater than 2 microamps.	4	— min. megohm
For currents less than 2 microamps.	1	— min. megohm
With 75-volt anode supply voltage or less:—		
For currents less than 3.5 microamps.	No minimum	—
AMBIENT TEMPERATURE	50	50 max. °C.
GAS AMPLIFICATION FACTOR§	Not over 10	—
SENSITIVITY	—	*20 Microamp./lumen
At 0 cycles	**100	— Microamp./lumen
At 1000 cycles	**97	— Microamp./lumen
At 5000 cycles	**90	— Microamp./lumen

† The light-response characteristic of the 922 is practically linear for light inputs up to 1.0 lumen, provided the anode voltage is relatively high and the load resistance relatively low.

‡ On basis of the use of a sensitive cathode area ½in. in diameter.

§ Gas Amplification Factor is given as a ratio of sensitivity at maximum anode voltage to the sensitivity at a voltage sufficiently low (approximately 25 volts) to eliminate gas ionization effects.

* The sensitivity value is given for conditions where a Mazda Projection Lamp operated at a filament color temperature of 2870 degrees Kelvin is used as a light source, with a load resistance of 1.0 megohms and a 250-volt supply. Light flux of 0.1 lumen was used.

** Sensitivity values are given for conditions where a Mazda Projection Lamp operated at a filament color temperature of 2870 degrees Kelvin is used as a light source. The method for determining sensitivity made capacitance effects negligible and employed a 90-volt supply. The voltage drop in the load was kept small. For the 0-cycle measurement, 0.02 lumen was used; for 1000 and 5000 cycles, a 100% modulated light having a mean value of 0.015 lumen was used.

RCA APPLICATION NOTE ON THE OPERATION OF PHOTOTUBES

The behaviour of a phototube for given operating conditions can be predicted from the anode characteristics of the tube. These characteristics, which correspond to the plate family of an amplifier valve, show the relation between anode current and anode voltage for different values of light input. It is the purpose of this Note to show how the anode characteristics of a phototube can be used to predict performance under given operating conditions.

The solid-line curves of Fig. 1 are the anode characteristics of a typical vacuum phototube having a caesium-oxide coated cathode. When a small amount of inert gas, such as argon, is admitted to the tube, the anode characteristics of the phototube change to those shown by the dashed-line curves of Fig. 1. The dashed-line curves are typical of gas phototubes. These two sets of curves will be used in this Note to illustrate the performance of gas and vacuum phototubes.

Steady-Light Operation

Fig. 2A is a typical phototube circuit in which the output voltage appears across resistor R_L. When light falls on the cathode of the phototube, a current flows through R_L and the phototube; at any instant, the sum of the voltage drops across R_L and the phototube equals E, the applied voltage. Hence, the voltage across R_L and the voltage across the phototube for any value of light input can be determined by the intersection of a load line and the anode characteristic of interest. For example, when $R_L = 10$ megohms, $E = 90$ volts, and $F = 0.04$ lumen, the voltage across R_L is 25 volts for the gas phototube and 8 volts for the vacuum phototube. When $R_L = 45$ megohms, the output voltage is 56 volts for the gas type and 37 volts for the vacuum type. Hence, as R_L is increased, the output voltage of the vacuum type approaches that of the gas type. The effect of load resistance on output voltage for a given value of light input is shown in Fig. 3.

The circuit of Fig. 2A is suitable for applications in which the d-c output voltage feeds a voltage amplifier which, in turn, actuates a relay. For this type of application, the gas phototube is more sensitive than the vacuum type with the same B-supply voltage and load. However, the sensitivity of gas phototubes changes with age, applied, voltage, and values of light input. Because of these factors, circuits for gas phototubes should not be critical to reasonable changes in sensitivity. In some applications, these changes in sensitivity can be compensated by an adjustment of the gain following the phototube. In the event that readjustment of the gain is not desirable, a vacuum phototube used with sufficient amplification to give the desired overall sensitivity will prove more stable.

Modulated-Light Operation

Many phototube circuits depend on modulated light for their operation. In a sound-motion-picture projector, for example, the amplifier following the phototube responds only to the modulated component of light input. In such applications, the criteria for sensitivity are not the same as those for steady-light operation.

In circuits which depend on steady-light input for operation, phototube sensitivity is simply $S = I_a/F$, where I_a is the anode current in microamperes and F is the light flux in lumens received by the cathode. In circuits which depend on modulated-light input for operation, phototube sensitivity is defined as

$$S_d = \frac{dI_a}{dF}$$

S is the static sensitivity and S_d is the variational sensitivity of the phototube. Variational sensitivity is analogous to the transconductance (g_m) of an amplifier valve. Because the output of the phototube usually feeds a voltage-operated amplifier, it is important to know the voltage sensitivity of the phototube and its associated circuit. Voltage sensitivity (S_v) in this Note is defined as the ratio of the alternating voltage output to the alternating light-flux input. In symbols,

$$S_v = \frac{dE_a}{dF}$$

where E_a is the output voltage in volts. Now,

PHOTOTUBE ANODE CHARACTERISTICS

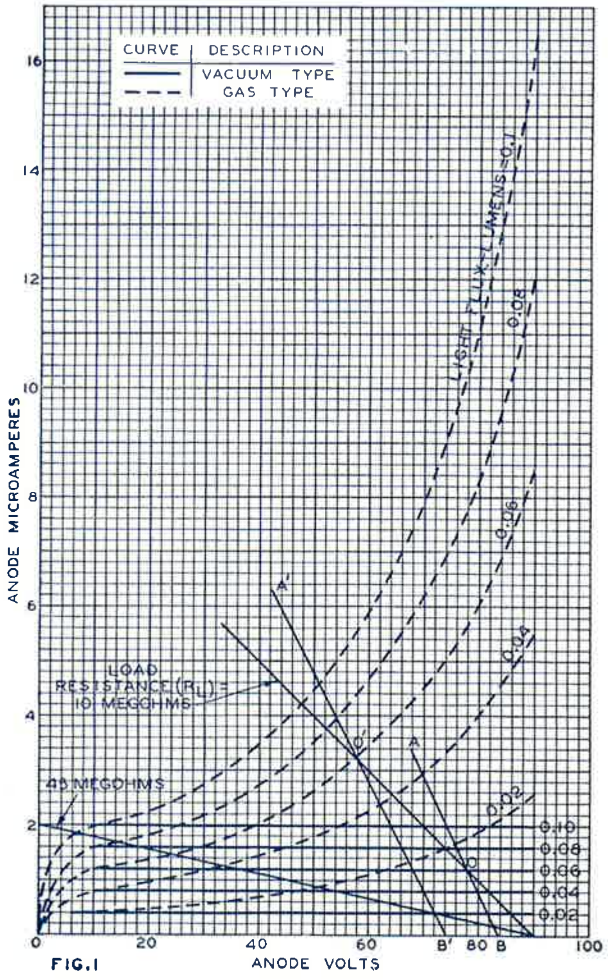


FIG. 1

PHOTOTUBE OPERATING CHARACTERISTICS

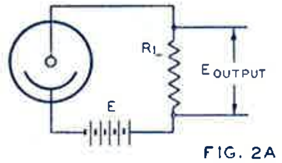


FIG. 2A

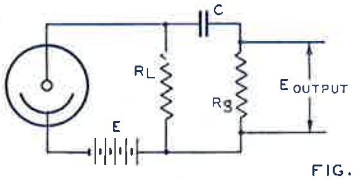


FIG. 2B

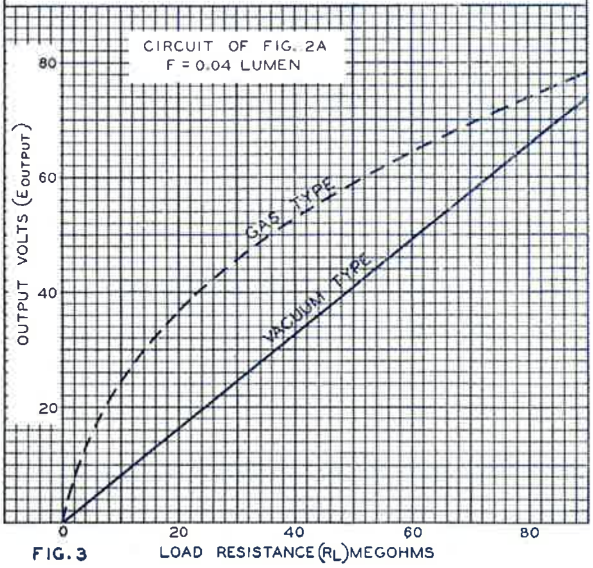


FIG. 3

the action of the circuit of Fig. 2A is analogous to that of an amplifier valve; the cathode is a source of electrons and the anode collects these electrons; the varying light input on the cathode is analogous to an alternating voltage applied to the grid of an amplifier valve. Therefore, the alternating output voltage of a phototube is

$$dE_a = dF \, . \, S_d \frac{r_p R_L}{r_p + R_L}$$

where r_p is the variational resistance in ohms of the phototube and is equal to the slope (dE/dI) of the anode characteristic at the operating point. Since voltage sensitivity is the output voltage per unit of light-flux input,

$$S_v = S_d \frac{r_p R_L}{r_p + R_L}$$

The physical interpretation of this last equation is important. The internal resistance of the phototube shunts the load resistance R_L; the change in current due to a change in light flux causes a voltage drop across the parallel combination of r_p and R_L. Thus, the output voltage may be low, even though S_d is high, because the internal resistance of the phototube reduces the generated voltage.

The internal resistance of a vacuum phototube is very high, while that of a gas phototube is low over a large portion of its operating range. The value of r_p at a point on any anode characteristic can be determined by measuring the slope at the point of interest. S_d is constant for vacuum phototubes over their operating range, but is not constant for gas phototubes. For this reason, it is desirable to calculate the performance of phototubes by graphical methods. However, it should be noted that for vacuum phototubes the output voltage can be calculated with fair accuracy by the relation

$$E_a = F \; S_d \; R_L$$

where F is the alternating component of the light input in lumens and E_a is the alternating voltage output in volts.

Consider the typical phototube circuit of Fig. 2B. The load is R_L for steady-light input and is the parallel combination of R_L and R_g for alternating-light input, provided the reactance of C is negligible at the lowest frequency of interest. To predict the operation of the phototube when the light input is modulated, draw the load line R_L from the B-supply voltage, as shown in Fig. 1. For a steady-light input of 0.06 lumen, the operating point is O for the vacuum-type phototube and is O′ for the gas-type phototube.

A convenient value of R_L = 10 megohms is assumed. When $R_g = R_L$ and the amplitude of the sinusoidal light input is constant, load lines AB and A′B′ represent the operating lines for the vacuum and gas phototubes, respectively. Now, when the steady-light input is modulated 66-2/3%, for example, the peak value of light input is 0.1 lumen and the minimum value is 0.02 lumen; the corresponding changes in voltage across R_g are (67.5 — 51) = 16.5 volts for the gas phototube and (82 — 74) = 8 volts for the vacuum type. These values are the total changes in output voltage; the peak values of the fundamental components are approximately half these values.

For a sinusoidal variation in light input, the distortion is negligible for the vacuum phototube and is appreciable for the gas phototube. The second-harmonic distortion may be calculated from the relation

$$\text{Per Cent Second Harmonic} = \frac{(I_{max} + I_{min} - 2\,I_o)}{2(I_{max} - I_{min})} \times 100$$

where I_{max} and I_{min} are the maximum and minimum instantaneous values of current, respectively, and I_o is the current at the operating point. Substituting the values obtained from Fig. 1 for the gas phototube, we have

$$\text{Per Cent Second Harmonic} = \frac{4.6 + 1.3 - (2 \times 3.2)}{2(4.6 - 1.3)} \times 100 = -7.5\% \quad \text{(approx.)}$$

The sign of a harmonic indicates its phase; the negative sign in this example signifies that the average value of the anode current is less with modulation than without modulation. This simple analysis shows that for chosen values of R_L, R_g, and E, and with the same B-supply voltage, the gas-type phototube furnishes about twice as much output as the vacuum type; however, the output of the gas type may contain too much distortion for some purposes.

A comparison of the anode characteristics of the two types of phototubes shows that for very large values of load resistances corresponding to the light flux on the cathode, the performance of both types is identical, because the sensitivity of the gas phototube approaches that of the vacuum phototube at low values of anode voltage. When R_g is infinite, the calculations for output voltage and distortion are made along the load line corresponding only to R_L.

The recommended maximum anode voltage for a gas phototube is 90 volts. When the anode voltage rises above 90 volts, a glow discharge takes place and the active emitting surface of the cathode sputters off. Thus, the peak value of the maximum alternating output voltage from a gas phototube is limited to a little less than 90/2, or 45 volts.

The recommended maximum d-c anode-supply voltage for a vacuum phototube is 500 volts. In order to obtain the maximum voltage output from a vacuum phototube supplied with modulated light, it is necessary to adjust the anode voltage under static conditions to a value approximately one-half of the maximum d-c supply voltage. This adjustment permits the modulated voltage output to have a peak value of nearly 250 volts.

From this discussion, it is seen that when the respective maximum anode voltages are applied to each type of phototube, and when the value of the load on the vacuum phototube is increased until the minimum instantaneous anode voltage (E_{min}) is the same for both types, the voltage sensitivity of the vacuum phototube can be much higher than that of the gas type. In the limiting case when maximum output voltage is obtained from each type for the same value of light input, the voltage sensitivity of the vacuum phototube is approximately 250/90, or 2.7 times that of the gas phototube.

The static and variational sensitivities of gas phototubes vary with age, temperature, light-flux, and anode voltage. In applications where changes in sensitivity necessitate readjustments of circuit conditions, consideration should be given to the use of vacuum phototubes. It is easy to compensate for the comparatively low gain of vacuum phototubes under certain operating conditions by increasing the gain of the succeeding amplifier.

A good frequency characteristic is desirable in many cases. When a vacuum phototube is used, the anode-cathode capacitance of the phototube and the equivalent shunt capacitance of the associated circuit determine the high-frequency response characteristic. When a gas phototube is used, the time necessary to deionize the gas is also a factor in determining high-frequency response. The relative magnitudes of the effects of capacitance and gas on high-frequency response depend on the physical placement of the components and their electrical characteristics.

Hiss Output

The absolute value of hiss output is in general not as important as the signal-to-hiss ratio. The data in Fig. 4 show the relation between signal-to-hiss ratio and light flux for typical vacuum and gas phototubes. When it is desirable to have a large signal-to-hiss ratio, the use of a vacuum phototube may be preferable.

Determination of Light Flux

The success of any method for predicting the performance of a phototube depends on the accuracy with which the light flux received by the cathode is known. The light flux in lumens on the cathode can be determined when the candlepower of the light source, the distance between light source and cathode, and the area of the light spot on the cathode are known. The light flux, F, in lumens, is

$$F = \frac{(CP)\ A}{144\ R^2}$$

where (CP) is the average candlepower in candles of the light source; A, the area of the light spot on the cathode in square inches; and R the distance in feet between the light source and the phototube. This formula should be used only when R is much greater than the largest dimension of the light source.

In most applications, it is necessary to shield the phototube from extraneous light; a small aperture, about 0.5-inch in diameter, admits the light that actuates the tube. For a light spot of this size, the value of F becomes

$$F = 0.00137 \frac{(CP)}{R^2}$$

The following table lists the approximate candlepower rating of a number of standard inside-frosted Mazda lamps which are not surrounded by reflecting surfaces.

Watts	Bulb Designation	Initial Cp (Approx.)
15	A-17 I.F.	—
25	A-19 I.F.	—
40	A-19 I.F.	34
50	A-19 I.F. (Rough Service)	35
60	A-21 I.F.	60
75	A-21 I.F.	82
100	A-23 I.F.	120
150	A-25 I.F.	200

Under "bulb designation," the first letter indicates the shape of the bulb, the following number is the maximum diameter of the bulb

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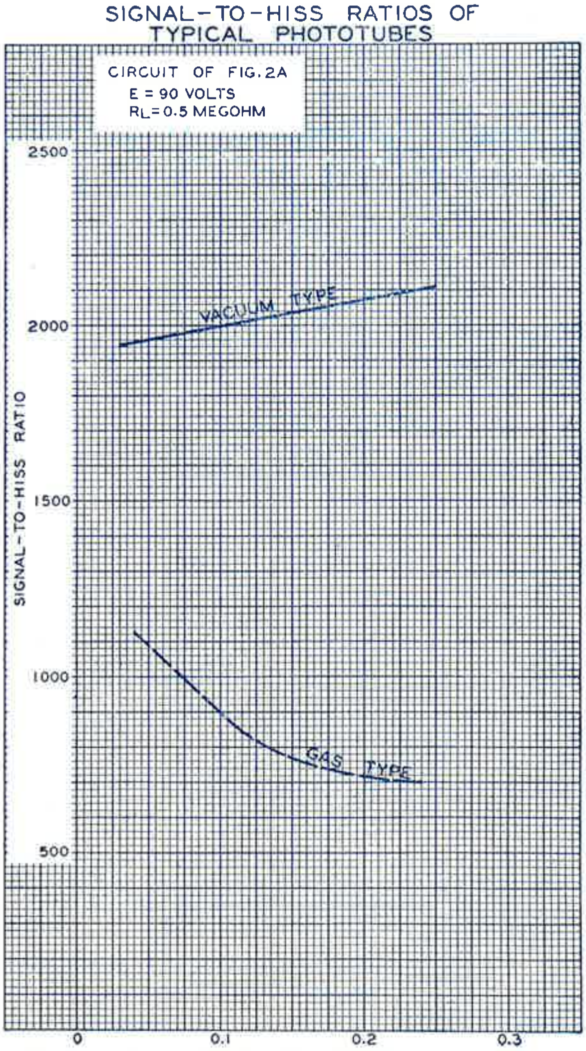

FIG. 4

TESTING FOR MUTUAL CONDUCTANCE

One of the most important tests which can be made on a valve in order to determine whether it is capable of satisfactory operation is that for Mutual Conductance. A test of this kind is usually far more comprehensive than one for emission, although each serves a useful purpose and both tests are desirable. The reading of Mutual Conductance may be obtained under normal working conditions and is therefore quite definite and free from ambiguity.

Mutual Conductance is the valve characteristic which determines amplification and power output in receiver operation. A certain minimum of emission is necessary in any valve to give normal mutual conductance. Emission currents above this value do not improve the performance any further, and the mutual conductance remains constant. Similarly, the emission of a valve must fall to this minimum value, before the valve performance begins to be impaired. Below this value, falling emission indicates decreasing performance. For this reason, in an emission test, the fact that the emission exceeds the minimum emission is more important than the actual value of emission, while in a mutual conductance test the result obtained is a direct indication of valve performance.

Mutual Conductance (also known as Transconductance) is the relationship between the signal voltage and the plate current for zero load resistance, and is measured in micromhos (microamperes per volt) or millimhos (milliamperes per volt). It is actually the slope of the plate current-grid voltage characteristic of the valve.

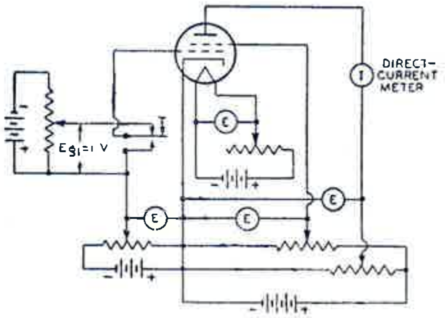

FIG. 5.

There are two common methods of testing for mutual conductance, the static (or "grid shift method") and the dynamic method. The **static** test may be carried out without any special instruments beyond those usually employed for measuring electrode voltages and plate current, the circuit being shown in Fig. 5. The filament should be operated at the rated voltage, this being measured right at the valve pins in order to eliminate errors due to voltage drop in the wiring. The plate voltage of triodes and the screen voltage of pentodes are critical, and care should be taken to adjust them accurately. The plate voltage of screen grid, tetrode or pentode valves is less critical than that of the screen grid. The control grid voltage is particularly critical and every effort should be made towards the highest accuracy.

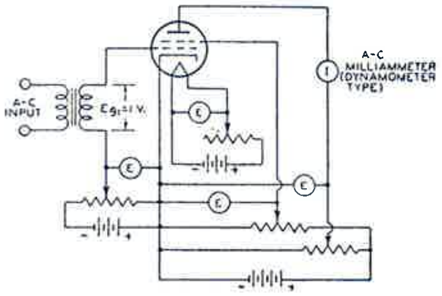

FIG. 6.

The static test is accomplished by taking a reading of plate current with a grid bias say 0.5 volt **less** than the rated bias, followed immediately by a reading of plate current with a bias 0.5 volt **greater** than the rated bias. By this means a "grid shift" of 1 volt is produced, and the difference between the plate current readings is equal to the mutual conductance. For example, if the readings of plate current are 6.5 and 5.0 mA. respectively, the difference is 1.5 mA. and the slope is 1.5 mA. per volt or 1500 micromhos.

It is important to choose the two bias voltages so that they are situated equidistant on each side of the rated bias voltage since otherwise the inevitable curvature of the characteristic will introduce an error. The change in voltage may be accomplished by means of a steady voltage supply as shown in the diagram, together with a second supply which is adjusted to give a voltage of 1.0 volt which is switched in or out of circuit as desired. This arrangement requires two separate voltmeters for accurate measurements, and a simpler although slightly less accurate arrangement would be to adjust the voltage divider to the two voltages in succession.

This static test does not enable very rapid tests to be made since the plate and screen voltages need resetting for each reading, owing to the varying drain on the voltage dividers.

The dynamic test, of which a circuit is given in Fig. 6 is preferable since the valve is tested under conditions more nearly those of actual operation. It will be seen that a signal input of 1.0 volt R.M.S. is applied to the grid, and the alternating component of plate current is read by means of a dynamometer-type of milliammeter. With this arrangement the

(*Continued on Page* 144)

THE PHON

The Unit of Loudness

During the past year or so some readers may have been puzzled by references in articles dealing with acoustics to the "Phon." This name is of very recent origin and was standardised about two years ago by the British Standards Institution as a **unit of loudness.** There tends to be confusion between the Decibel which is not a loudness unit but a unit of change of power, and the Phon which is a true loudness unit. If the ear were equally responsive to all frequencies, the Phon and the Decibel would be identical. The Decibel bears no relation whatever to the frequency response of the ear but rather to the conditions existing in an electrical circuit. The Phon being a unit of loudness is directly affected by the characteristic of the ear and therefore there is no direct relationship between Decibels and Phons over the audio range.

For convenience the frequency of 1,000 c/s has been taken as a common basis so that at this frequency the level in Decibels is identical numerically with the level in Phons provided that the same zero reference level is used in each case. At other frequencies due to the non-linear frequency response of the ear, the level in dB and the level in Phons will be different. The definition of the measure of loudness may be given as: "**The loudness of a sound in Phons is numerically equal to the sound intensity in Decibels of an equally loud 1,000 c/s pure tone.**" It is therefore possible to compare different sounds for loudness by comparing each with a pure 1,000 c/s tone from an oscillator fed to a head phone and controlled by an attenuator calibrated in Decibels. The attenuator is adjusted until the loudness from the head phone at one ear is judged to be equally loud as the noise entering the uncovered ear. The loudness of the noise in Phons is then said to be numerically equal to the intensity of the reference tone in Decibels.

Zero reference level is taken as the average limit of audibility which has been standardised as 0.0002 dynes per sq. cm. (10^{-16} watts per sq. cm.).

Taking as a typical case a level of 70 Phons which is somewhat like the average loudness from an ordinary radio set, it will be obvious from the definition that at 1,000 c/s the power level in relation to the standard zero will be 70 dB. At 100 c/s. 70 Phons will be equivalent to 80 dB while at 50 c/s it will be equivalent to 84 dB. (Fig. 7). At the most sensitive frequency for the human ear, which is between 3,000 and 4,000 c/s, the equivalent level is 67 dB while at 10,000 c/s where the ear is less sensitive, the level is 83 dB. From this it will be evident that a loudspeaker which is to give equal loudness at all frequencies will need to handle greater power at very low frequencies and at very high frequencies than it does at 1,000 c/s. In practice it is rarely found that a high level exists at the higher frequencies but it does very frequently occur at the lower audio frequencies. An amplifier of the type mentioned which is to give equal loudness at 50 and 1,000 c/s will need to deliver 14 dB more power at 50 cycles than it does at 1,000 c/s.

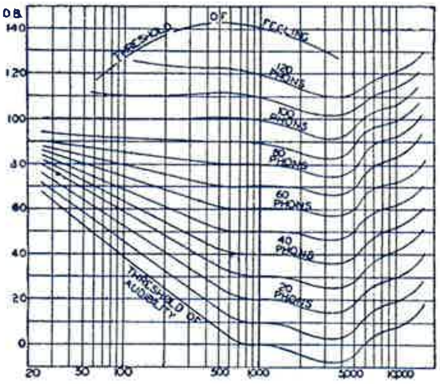

FIG. 7.

The real value of the Phon is as a measure of loudness and the following table, which has been compiled in England, will give an interesting comparison.

No. of phons.	
130	Threshold of feeling or pain.
110-120	Vicinity of aeroplane engine.
105-110	Vicinity of pneumatic drill.
100-105	Vicinity of loud motor horn.
90-95	Interior of tube train, windows open.
90	Interior of noisy motor vehicle; loud radio set.
80	Interior main-line train, windows open.
70	Interior of quiet motor car; medium radio set.
60-75	Conversation (average to loud).
40-50	Suburban residential district.
20-30	Quiet country residence.
0	Threshold of audibility.

In this table zero level corresponds to an RMS pressure of 0.0002 dynes per sq. cm. (10^{-16} watts per sq. cm.).

The use of Phons will be more familiar to the Sound Engineer than to the Radio Engineer but a knowledge of this unit is essential if some of the literature on the subject is fully to be understood.

RADIOTRON 902.

2in. Cathode Ray Tube

Radiotron 902 is now available in limited quantities from stock at an Australian price of £2/15/- nett.

MEASURING R.F. BY ILLUMINATION

A simple method of measuring the R.F. output of an oscillator or transmitter is to couple a pick-up coil to a suitable lamp which should be chosen so that good brilliancy is obtained. It is more accurate to employ a smaller lamp operating at a greater brilliancy than to employ a larger lamp operating at low temperature.

An identically similar lamp operated from a D.C. supply and having a voltmeter connected across its terminals should be placed in close proximity to the first, and its brilliance adjusted by varying the D.C. voltage applied to it until the two lamps are of equal brilliancy as judged by eye. With good brilliancy this judging is reasonably accurate and the adjustment is readily made. Greater accuracy may however be obtained by the use of a light meter. Differences between lamps can be checked by interchanging the two lamps and by noting the difference in reading. A calibration curve may be drawn for a particular lamp showing the watts against volts used in the illumination of the checking standard, so that once the calibration has been completed only the voltage across the lamp need be measured. For obtaining this calibration it will be necessary to use a D.C. ammeter or milliammeter.

The lamp used for this application should have as small an inductance as possible and one of the zigzag filament type is to be preferred to a coiled filament. If such a lamp is used the error due to inductance is reduced to the minimum. For small oscillators a small pea lamp, having a single loop filament, could be used but in such a case it may be necessary to select two lamps which are suitably matched.

As an alternative method, a photographic exposure meter or illumination meter may be used under suitable conditions to measure the illumination given by the lamp supplied by R.F., the reading of the meter being calibrated under known conditions by the first method described above. This method is of less accuracy but for certain purposes may be more convenient since it provides a direct reading output. It is possible to calibrate the meter to read directly in watts if so desired.

A still further variation is to use only a single lamp which must first be calibrated for watts against volts. This is then used as a resistive load on the transmitter, and the voltage across it is read by means of a suitable diode valve voltmeter. An indirectly heated valve having a grid brought out to the top of the bulb may be used as the diode, the remaining electrodes being connected to the cathode, or alternatively any valve having diodes may be used. A 0.35 megohm load resistance is suitable, and should be shunted by a mica condenser about .001 μF. With this load resistance the peak R.F. voltage is approximately 350 volts per 1.0 mA. D.C., and on the assumption of good waveform this is equivalent to 245 volts R.F. (RMS) per 1.0 mA. D.C. This voltage range is suitable for a 240 volt lamp and a milliammeter reading 1.0 mA. full scale. A tapping on the coil in the tank circuit may then be arranged to give a suitable load on the transmitter. It should be noted that this method does not actually utilise the illumination of the lamp for measurement purposes, the lamp acting as a resistive load of high dissipation and low inductance. This method is reasonably accurate at frequencies up to 15 M.C. but should not be used at higher frequencies.

Testing for Mutual Conductance

(*Continued from Page* 142)

mutual conductance in micromhos is equal to 1000 times the A.C. plate current in milliamperes. That is to say that a reading of 2.0 mA. (A.C.) represents a mutual conductance of 2000 micromhos. With this test it is essential for the plate and screen circuits to be of low resistance in order to avoid errors. The dynamometer type milliammeter may, if desired, be replaced by an audio frequency choke of low D.C. resistance, across which is connected a large blocking condenser and a rectifier type milliammeter. The accuracy of this arrangement is less than that with the dynamometer instrument, and it is usually necessary to calibrate it from a more accurate instrument. It does, however, make a very valuable comparative test.

Valves are usually capable of operating satisfactorily until the mutual conductance falls to 65% of the rated value for voltage amplifier valves, and 50% for power valves.

The Operation of Photo Tubes

(*Continued from Page* 141)

in eighths of an inch, and the letters I.F. signify inside frosted.

In the case of automobile headlight lamps, the rated value of candlepower obtains for the direction which is perpendicular to the plane of the filament.

A value of light flux obtained from these data is approximate and should serve only as a guide. Final values of circuit constants should be based on tests with the equipment operating over the expected range of line-voltage variation.

REMINDER.

Australian subscribers to Radiotronics are reminded that this issue is the first in the new subscription year. Those who intend to renew their subscriptions should forward the sum of 2/- at the earliest opportunity since the availability of back numbers cannot be guaranteed.