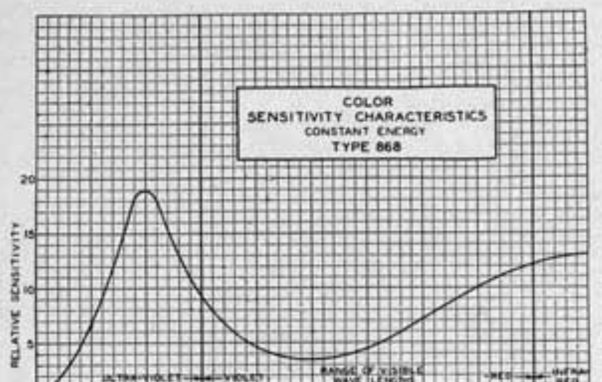
A New Phototube for Ho

Circuits for Using the Cell Su

By William



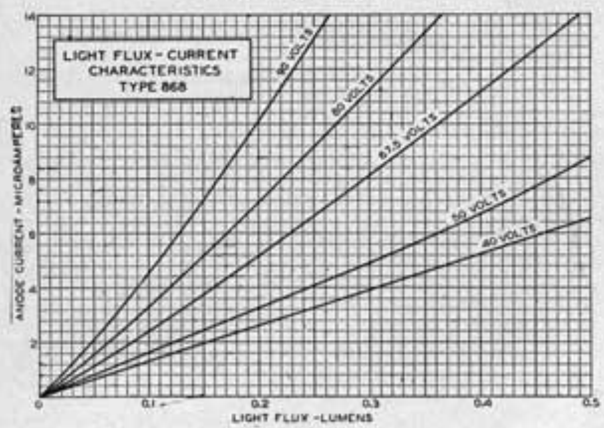


Fig. 1
Color sensitivity characteristic of the new Type 858 phototube.

Fig. 2
Light flux-current characteristic of the Type 868 phototube.

A NEW phototube, the 868, has been announced by RCA and Cunningham. This new tube is designed for use as light sensitive cell in home talking movie reproduction of the sound-on-film type and for many other applications where a light sensitive cell is required.

The new cell is of the caesium type and is sensitive throughout the entire visible spectrum, as well as in the ultra-violet and the infra-red. Its high sensitivity in the red and infra-red makes this cell particularly valuable when the source of light is in incandescent lamp, which is rich in the lights of longer wavelengths.

In Fig. 1 is a reproduction of the color sensitivity characteristic of the new cell, the curve having been taken under conditions of constant light energy entering the cell. As will be noted, the sensitivity is zero at 2,500 angstrom units, which is far into the ultra-violet. Then as the wave-length increases the sensitivity increases rapidly up to 3,500 angstrom units, where it reaches a maximum. Then it falls gradually to 5,000 angstrom units, where it reaches a minimum. This is in the blue-green region of the visible spectrum. As the wave-length increases still further the sensitivity increases again and reaches another maximum somewhere in the infra-red region.

Explanation of Variation

The increase in the sensitivity as the wave-length decreases beyond 5,000 angstrom units is due to the fact that short waves are more active photo-electrically than the long waves, just as the shorter waves are more active photographically than the long waves. The rapid drop in the sensitivity beyond 3,500 angstroms is undoubtedly due to the absorption of the light by the glass of the tube, as ordinary glass will not pass ultra-violet light. When it is necessary to utilize the ultra-violet in phototubes it is customary to use a quartz tube. For the same reason quartz lenses are used in photography by ultra-violet light.

The rise in the sensitivity characterized beyond 5,000 angstrom units is due to the peculiar responsiveness of the caesium coating on the cathode. When other alkaline metals, such as sodium and potassium, are used on the cathode, the maximum sensitivity falls at shorter frequencies, the sodium placing it near 6,000 angstroms and the potassium placing it in the violet.

Light Flux-Current Characteristic

In Fig. 2 are several curves showing the variation in the photo-electric current with light flux entering the 868 cell. They are for five different anode voltages. It will be noticed that the curves are very nearly linear, especially for the lower anode voltages. The linearity indicates that the tube will not introduce any distortion in the output of the cell and that the current is proportional to the quantity of light that enters the cell.

There is practically no time lag between the light entering the cell and the current and for that reason the cell is applicable to cases where the light fluctuates with extreme rapidity. It is rapid enough to follow faithfully the high audio frequencies in sound movie reproduction and also to follow the variations of light encountered in scanning a scene for television.

Rating and Characteristics of the Phototube

Anode supply voltage, maximum	90 volts
Anode current, maximum	20 microamperes
Static sensitivity	45 microamperes per lumen
Dynamic sensitivity at 1,000 cycles	40 microamperes per lumen
Dynamic sensitivity at 5,000 cycles	38 microamperes per lumen
Gas amplification factor	Not over 7.
Load circuit resistance	0.1 to 5 megohms
Maximum overall length	4.125 inches
Maximum diameter	1 3/16 inches
Window diameter	0.9 square inches
Bulb	T-8
Base	Small four prong
Cathode surface coating	Caesium

The sensitivity characteristics were taken with a Mazda projection lamp as the source, operated at a filament temperature of 2,870 degrees Kelvin, and one megohm load resistance in the test circuit. The sensitivity varies with the type of light because the color sensitivity curve is not uniform and because the energy distribution of the light depends on the type of lamp and on the temperature at which it is operated. The phototube has a small quantity of gas in the envelope, as this increases the sensitivity.

Definition of Units

Many terms which may not be familiar to radio fans have been used in this description of the new phototube, and for that reason it will not be out of place to define them.

An angstrom is a unit of length which is used for expressing very short lengths, especially those of wave-lengths of light. There are 100 million angstrom units in one centimeter, or ten billion in one meter. Hence a wave 5,000 angstrom units long is 0.0005 centimeter long.

Ultra-violet light is light having shorter waves than the shortest visible violet light wave. **Infra-red** light is light having waves longer than the longest visible red light.

Anode has the same sinificance in the phototube as it has in the thermionic vacuum tube. It is the positive or electron gathering element. **Cathode** also has the same significance, being the electron emitter.

Static sensitivity is the sensitivity measured with extremely slow changes in the light, or so slow that capacity effects have no chance to affect the current.

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gested, Operation Explained

A. Jaffe

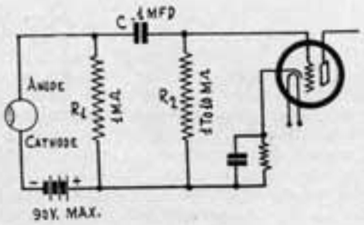

Fig. 3

A method of coupling the phototube to a thermionic amplifier when a separate battery is used in the phototube circuit.

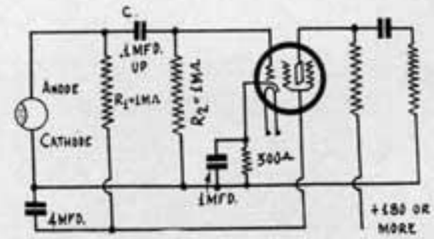

Fig. 4

The votage used on the amplifier tubes may be used to actuate the phototube if the circuit is arranged in this manner.

Dynamic sensitivity is the sensitivity measured with rapidly varying light.

The difference between static and dynamic sensitivity is the same as the difference between static and dynamic amplification of a thermionic vacuum tube.

Light flux, or **luminous flux,** is the quantity of light energy. The **lumen** is the unit of luminous flux. It is the light flux through one square centimeter on a sphere one meter in diameter when a source of unit intensity is located at the center of the sphere. The source of unit intensity is the standard candle. There is another definition of the lumen which makes it 10,000 times greater. This is the light flux from a source of unit intensity that flows through unit solid angle.

Practical Circuit

In Fig. 3 is a tpical circuit connecting a phototube and a vacuum tube amplifier. R1 is the load resistance on the phototube, in this case one megohm. C is a stopping condenser to isolate the grid from the high voltage and R2 is the usual grid leak. If the voltage drop in R1 is suitable for bias on the tube that follows it is not necessary to use C and R2, but the drop not only depends on the voltage of the battery in series with the load resistance and the phototube, but also on the light flux that enters the cell.

Suppose that the voltage in series with the tube is 40 volts and the load resistance is one megohm. If the flux that enters the cell is 0.2 lumen, the current is 2.6 microamperes, according to Fig. 2. The drop in R1 is then 2.6 volts, which would be satisfactory for a screen grid tube of the 224 type, or for almost any screen grid tube with the other voltages on the tube as usually recommended. With 90 volts in the phototube circuit and the flux the same as before, the drop in R1 would be 10 volts, which would be suitable for a 227 tube. Thus it is practical to choose such anode voltage and flux that would make the bias correct for almost any amplifier tube without the use of C and R2.

In case it is desired to use the same source of voltage for the phototube as for the amplifier tubes, the stopping condenser and grid leak should be used. Then R1 should be connected to B plus just as any plate coupling resistance, provided that the voltage does not exceed 90 volts. The return of R1 could be connected to the screen of an amplifier tube, on which the voltage is usually 90 volts or less. Fig. 4 shows a suitable circuit.

How Circuits Work

The manner in which the light values are converted into equivalent electric values can be explained by means of the curves in Fig. 2. Suppose we apply a voltage of 67.5 volts in series with a one megohm resistor and the phototube and that we arrange the components as in Fig. 4. Let the normal intensity of the light flux entering the phototube be 0.2 lumen and let this vary between 0.1 and 0.3 lumen. The light fluctuation amplitude, therefore, is 0.1 lumen. When the flux is 0.1 lumen the photo-electric current is 2.4 microamperes. The voltage drop in R1 is then 2.4 volts. At 0.2 lumen the current is 5.2 microamperes. Hence the change of 0.1 lumen changes the current 2.8 microamperes. The corresponding change in the voltage drop in R1 is 2.8 volts, which is the amplitude of the signal voltage resulting from the light variation.

On the other side we have a current of 8.1 microampere when the light flux is 0.3 lumen. Hence the change in the current due to a change in the light of one lumen is 2.9 microamperes. The corresponding change in the voltage across R1 is 2.9 volts. It will be noticed that the amplitude on increase is very nearly the same as the amplitude on decrease, the difference being only 0.1 volt.

This signal voltage would be sufficient to load up a screen grid tube. However, in the reproduction of home talkies it is not likely that such wide fluctuation in the light flux is possible. Hence the output voltage would be much less, and this would have to be compensated for by additional amplification in the electrical stage of the signal.

Volume Control Trouble

THE volume control in my set consists of a 500,000 ohm potentiometer in the grid circuit of the first audio tube. When the potentiometer is at full-on position everything is all right, but just so soon as I turn the control at all, using less resistance, I hear a howl, and no signal.—E. F. W., Seattle, Wash.

The potentiometer is defective. Try another one, or replace it with a fixed resistor to confirm the diagnosis.