RCA RADIOTRON COMPANY, INC.
HARRISON NEW JERSEY

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UNIFIED SALES--ENGINEERING SERVICE
TO
EQUIPMENT MANUFACTURERS

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HARRISON, NEW JERSEY

APPLICATION NOTE No. 34
February 15, 1934.

APPLICATION NOTE ON CHARACTERISTICS OF THE 868 PHOTOTUBE

The RCA-868 is a phototube of the gaseous type. It has two elements, a semi-cylindrical, caesium-coated, silver cathode, and a central-wire anode. A small amount of argon gas is used in this phototube, its function being to increase the sensitivity.

CHARACTERISTICS

Anode Supply Voltage	90 max.	Volts
Anode Current	20 max.	Microamperes
Static Sensitivity	55	Microamperes per Lumen
Dynamic Sensitivity (1000 Cycles)	50	Microamperes per Lumen
Dynamic Sensitivity (5000 Cycles)	48	Microamperes per Lumen
Gas Amplification Factor*	Not over 7	
Load Circuit Resistance	0.1 to 5.0	Megohms
Window Area of Cathode		0.9 Square Inch
Maximum Overall Length		4-1/8"
Maximum Diameter		1-3/16"
Bulb		T-8
Base		Small 4-Pin

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

When light falls on the cathode of the 868, electrons are emitted. These electrons are attracted to the anode made positive by the application of an external voltage, and thus permit current to flow in the external circuit. Under recommended operating conditions, the number of electrons emitted by the cathode, and consequently the photo-electric current, depends not only on the amount of light falling on the cathode, but also on the color of the light as well as on the frequency of light modulation.

Spectral Sensitivity

The 868 is sensitive over the entire visible spectrum and has sensitivity peaks in the infra-red and ultra-violet regions. From the spectral sensitivity curve shown in Fig. 4, it will be observed that the 868 is light-sensitive at wavelengths from 3000 to 10000 angstrom units.* Cut-off at 3000 angstrom units is due to the glass bulb. The large response of the 868 to wavelengths in the infra-red region of the spectrum makes this tube particularly useful in sound reproduction and television applications where tungsten-filament lamps are employed as light sources.

The light source to be used depends upon the requirements of the system. Since the response of phototubes is greater for certain colors of light, the color of the light source is important. For some special applications the response of the 868 can be altered by means of a suitable color filter. The light source used to obtain the characteritics is described under "Conditions for Testing".

Operation of the 868

During operation, the cathode of the 868 should never be permitted to reach too high a temperature nor should it be subjected to an excessive amount of light. Too high a temperature will result in the volatile cathode coating being deposited on the insulating surfaces of the bulb with consequent impairment of the sensitivity and life. A 10% increase in temperature reduces the sensitivity of the 868 about 15%. It is recommended that operating temperatures do not exceed 50° C. If the cathode is subjected to an excessive amount of light during operation, the sensitivity of the phototube may be appreciably reduced. If subjected to direct sunlight during operation, it will probably be permanently damaged. When subjected to sunlight, although not in operation, the 868 will have its sensitivity temporarily reduced by an amount, and for a period of time, dependent upon the length of exposure.

The amount of light and the anode voltage on the 868 should be adjusted to values which do not cause the maximum anode current to exceed 20 microamperes. Excessive light or anode voltage will cause the gas to become conductive, a condition indicated by a slight blue glow. If the glow is allowed to persist for more than a few seconds, or occurs frequently, the tube loses sensitivity and ability to respond uniformly to modulated light. The anode voltage should never exceed 90 volts. For large amounts of light, it is recommended that the anode voltage be decreased to the lowest value which will give the desired output.

Conditions for Testing the 868

The average characteristics of the 868 are determined with a tungsten-filament lamp as a light source. The lamp is operated at a

* The angstrom is a unit of wavelength and is equal to 10^{-10} meters.

color temperature of 2870° Kelvin. In testing practice, the lamp is rechecked for color temperature and candlepower at least every 100 hours of operation. The light falling on the cathode of the phototube is restricted to a spot one-half inch in diameter. The center of the spot is located on the cathode at 2-7/16" measured from the bottom of the shoulder on the contact pins. An incident light of 0.1 lumen, an anode potential of 90 volts, and a load resistor of one megohm is used by us in making all tests on this phototube except where other conditions are specified.

Sensitivity and Fidelity Characteristics

Figs. 1 and 3 show families of characteristic curves for the 868 at different anode voltages and anode currents with various values of load and light flux. A variation in output of less than 4 decibels may be expected if the cathode is scanned with a very small beam. When a high degree of uniformity is required, it can be obtained by spreading the incident light over as large a portion of the cathode as possible.

When used with light sources varying at audio frequencies, the 868 has a response at 10000 cycles per second only 17 per cent less than that at 100 cycles per second (see Fig. 5). This is a loss of two decibels. The fidelity of this phototube at 25 volts is assumed to be 100 per cent throughout the frequency range of Fig. 5. At 25 volts, ionization of the argon gas is at minimum, and the 868 behaves like a vacuum type of phototube. At voltages above 25 volts, greater amplification is obtained because of the increased current produced by the ionized gas.

Load

The load resistance used with the 868 depends upon the application. In general, the larger values of load resistance give larger outputs up to the limiting values of tube resistance and distortion (see Fig. 2). The resistance of this phototube is a function of the anode voltage and the incident light, and varies from one or two megohms up to 1000 megohms. The resistance decreases with the amount of incident light and increases with anode voltage up to the point at which gas amplification takes effect, after which it decreases. For a given value of load resistance, distortion will depend upon the phototube current.

Insulation Requirements

Since the 868 is a high-resistance device, it is extremely important that the insulation of associated circuit parts and wiring be good. Insulation resistances which are high compared to that of the tube must be employed if good operation and low distortion are to be obtained. For the same reason, the capacities between the various associated circuits should be kept as low as possible. It is essential that the base and socket of the 868 be kept clean in order to minimize leakage conductance.

Stability

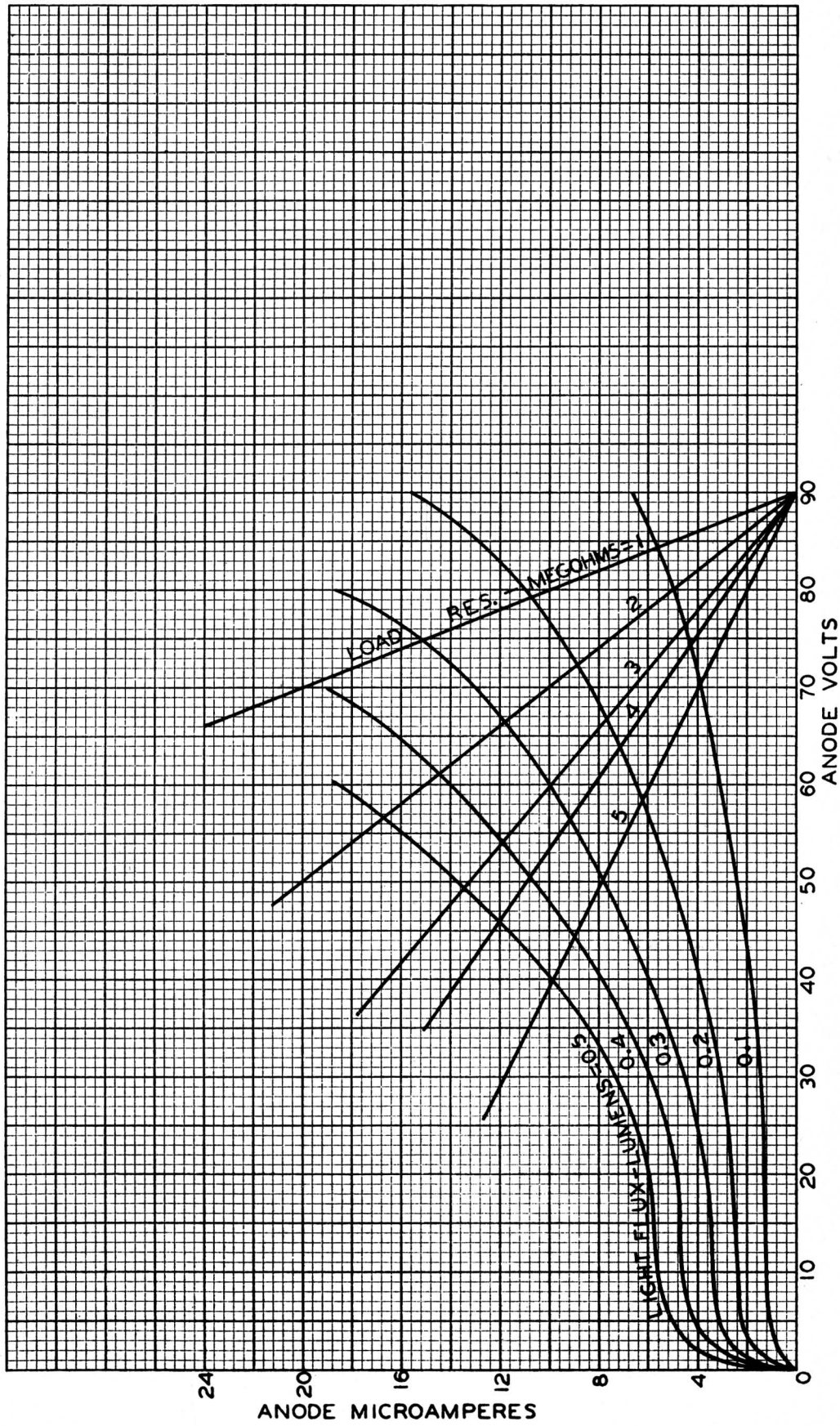
Stability is a very important characteristic of phototubes. All our 868's are aged for a number of hours prior to final test. This process insures good stability during their useful life. Un-aged tubes may vary over 6 decibels in the first two hours of use; aged tubes should not show over 2 decibels variation.

The 868 gives best results under constant use. In case the tube is not in service for one month or more, the normal characteristics of the tube may change somewhat but can be restored by a short period of operation (usually about one hour) under normal operating conditions.

RCA Radiotron
RCA-868

Cunningham RADIO TUBES
C-868

AVERAGE ANODE CHARACTERISTICS



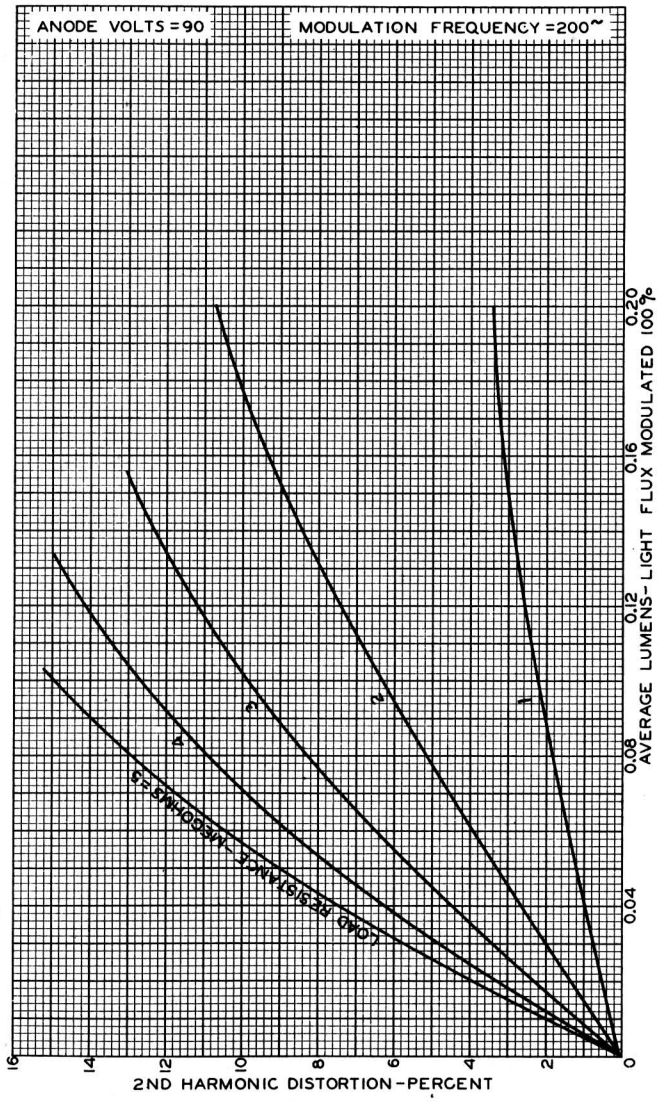
NOV. 15, 1932

FIG. 1

925-5217

RCA Radiotron RCA-868 Cunningham RADIO TUBES C-868

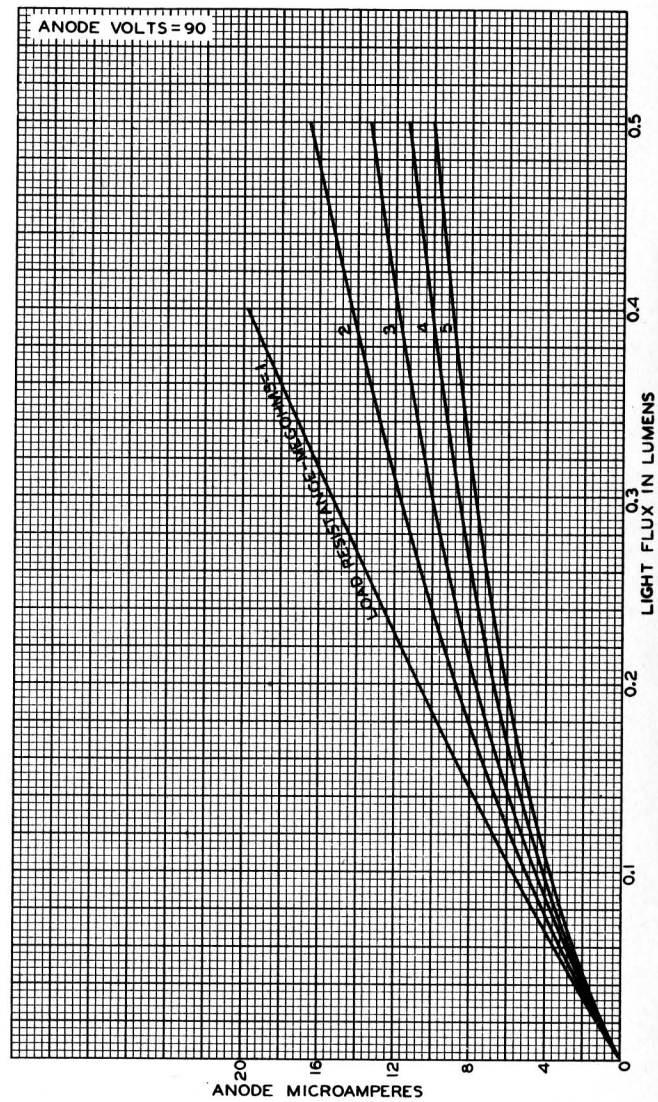
AVERAGE OPERATION CHARACTERISTICS



NOV. 15, 1932 FIG. 2 925-5215

RCA Radiotron RCA-868 Cunningham RADIO TUBES C-868

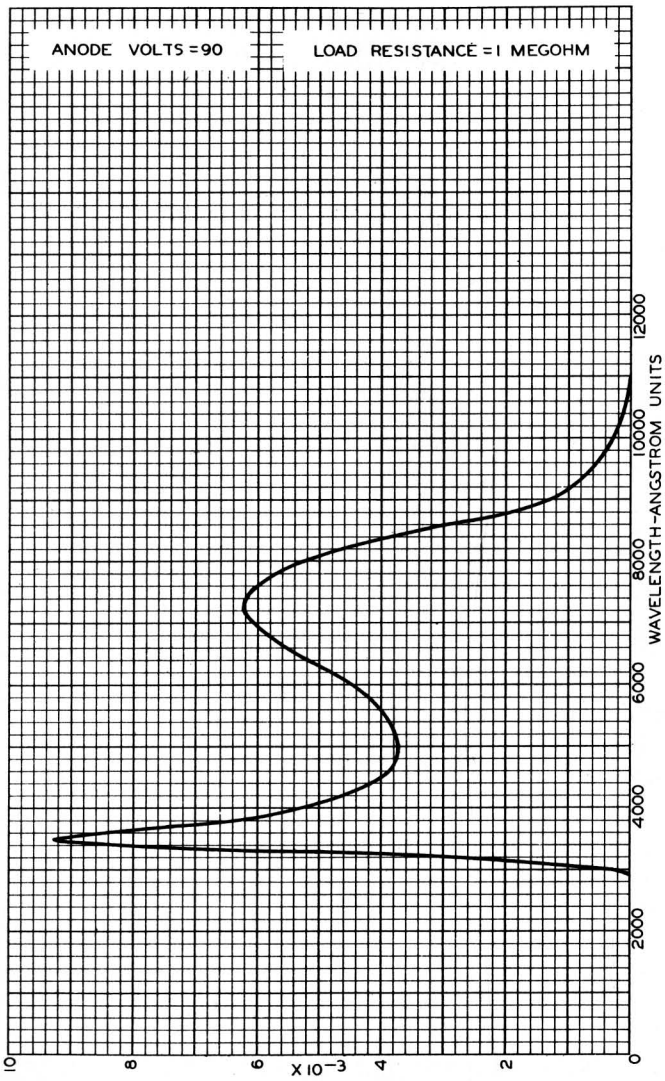
AVERAGE SENSITIVITY CHARACTERISTICS



NOV. 15, 1932 FIG. 3 925-5216

RCA Radiotron RCA-868 Cunningham RADIO TUBES C-868

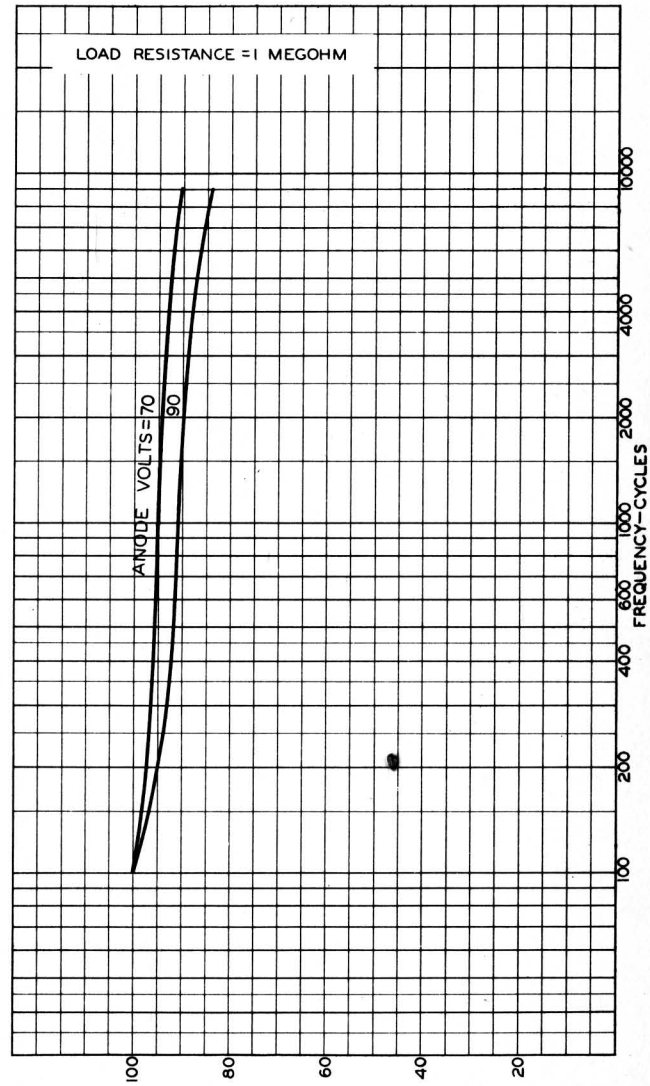
SPECTRAL SENSITIVITY CHARACTERISTIC



JAN. 3, 1934 FIG. 4 92S-5214RI

RCA Radiotron RCA-868 Cunningham RADIO TUBES C-868

AVERAGE FIDELITY CHARACTERISTICS



NOV. 11, 1932 FIG. 5 92S-5213