Westinghouse ELECTRONIC TUBES

PHOTOTUBES

SR-50 , SR-51 , SR-53 , SR-58 , SK-60
SK-61 , SK-63 , SK-68 , WL-734
WL-735 , WL-737 , WL-770

WESTINGHOUSE LAMP DIVISION

WESTINGHOUSE

ELECTRIC & MANUFACTURING COMPANY

SPECIAL PRODUCTS SALES DEPARTMENT

BLOOMFIELD, N. J.

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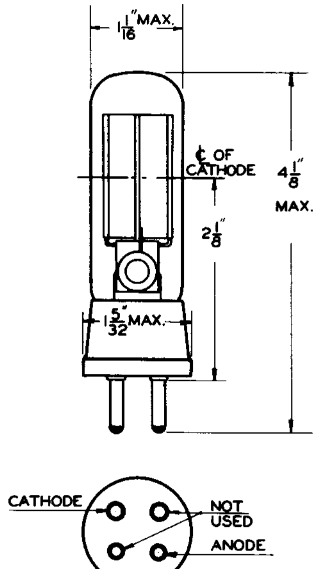
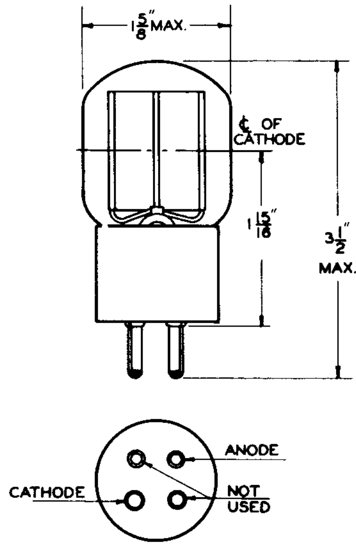
FEBRUARY 9, 1937

BULLETIN TD-76

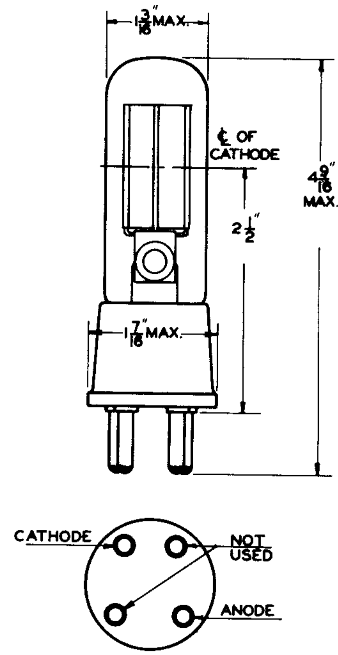
OUTLINE DIMENSIONS



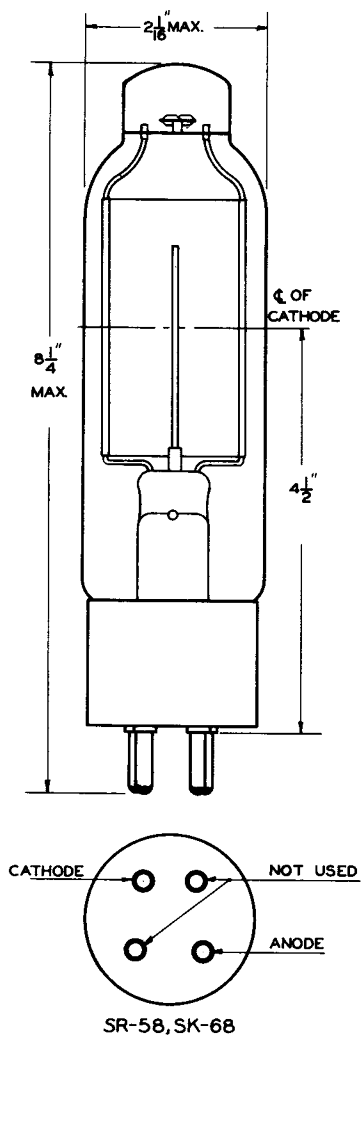
WL-734, WL-735



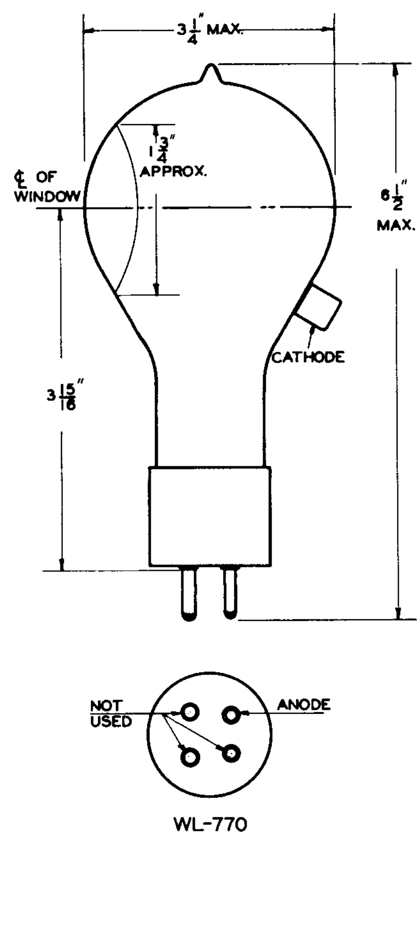
WL-737



SR-50, SR-51, SR-53,
SK-60, SK-61, SK-63



SR-58, SK-68



WL-770

WESTINGHOUSE LIGHT SENSITIVE PHOTOTUBES

DESIGN DATA AND RATINGS

Type	Descript.	Spectral Region of Max. Response	Typical Sensitivity Microamps. Per Lumen	Maximum Operating Volts	CATHODE Surface	CATHODE Aperture (Inches)	Maximum Current Microamps. per sq.in.	Socket Style#	Top Connector Style#
SR-50	Vacuum	Deep red--near u-v*	15.0	500	Cs-O	13/16x1-3/8	20	766732	....
SR-51	"	Violet	15.0	500	Cs-O	13/16x1-3/8	20	766732	....
SR-53	Vacuum	Deep red--near u-v	25.0	500	Cs-O	13/16x1-3/8	20	766732	....
SR-58	"	" " " "	15.0	500	Cs-O	1-5/8x3-1/2	20	766732	....
SK-60	Gas	Deep red--near u-v	60.0	90	Cs-O	13/16x1-3/8	20	766732	....
SK-61	"	Violet	60.0	90	Cs-O	13/16x1-3/8	20	766732	....
SK-63	Gas	Deep red--near u-v	125.0	90	Cs-O	13/16x1-3/8	20	766732	....
SK-68	"	" " " "	60.0	90	Cs-O	1-5/8x3-1/2	20	766732	....
WL-734	Vacuum	Deep red--near u-v	15.0	500	Cs-O	13/16x1-3/8	20	684379	....
WL-735	Gas	" " " "	60.0	90	Cs-O	13/16x1-3/8	20	684379	....
WL-737	"	" " " "	60.0	90	Cs-O	1x1-1/4	20	684379	....
WL-770	Vacuum	Near u-v	0.75	500	Cs-Mg	1-3/4 diam.	25	684379	829334

* Ultra-Violet

GENERAL INFORMATION

The phototubes listed in this bulletin are essentially two electrode tubes consisting of a semi-cylindrical cathode and a central anode sealed in a glass envelope. The cathode consists of a base metal such as silver with a light sensitive surface, usually caesium oxide, and is the larger element of the two. The anode consists of a straight wire electrode mounted along the axis of the cathode. The action of light upon the cathode results in the emission of electrons from the light sensitive surface, and the electrons which are released by this action are drawn to the anode by virtue of the voltage which is applied between the cathode and the anode. These phototubes are made in two different types, namely, vacuum and gas-filled. The two designs are identical as to structure, but differ in that there is a high vacuum in the vacuum type and an inert gas at a very low pressure in the gas-filled type. The SR-50, SR-51, SR-53, SR-58, WL-734 and WL-770 phototubes are all of the high vacuum type, and the SK-60, SK-61, SK-63, SK-68, WL-735 and WL-737 phototubes are of the gas-filled type.

In the gas-filled type, greater effective response is obtained due to gas amplification and secondary emission. When the applied voltage is above 25 or 30 volts, the electrons traveling from cathode to anode have sufficient velocity to knock out electrons from gas atoms with which they collide, thus splitting up the atoms into positive ions and free electrons. The electrons are, of course, attracted to the anode and the positive ions to the cathode, which they may strike sufficiently hard to knock out several "secondary" electrons. Thus these two factors produce an additional current which at higher voltages may be several times the value of the primary electron current.

The gas ratio of a phototube, that is, the ratio of its response at the operating voltage to its response at the voltage where gas amplification begins, for a given illumination, is a measure of the gas and secondary emission amplification. The gas ratio is often taken as the ratio of its response at 90 volts to that at 25 volts with a constant illumination. Care must be taken with gas-filled tubes not to exceed a certain maximum voltage (the value of which depends on the type of tube and the illumination on the tube) or a glow discharge will result which will ruin the sensitive surface. The limits are shown in the accompanying curve of lumens plotted against anode voltage. Anode voltages to the left of this curve are safe values.

APPLICATION

WESTINGHOUSE vacuum and gas-filled phototubes have a high instantaneous speed of response, which makes it practically impossible for any change in intensity of light to escape their reaction.

Phototubes are inherently suited to the control of artificial lighting for schools, factories, public buildings, streets and signs. They may be employed in starting, stopping or controlling mechanical operations, and for counting such objects as cartons, sheets of paper, steel ingots, vehicles or pedestrians. They may be so arranged as to have the objects intercept a beam of light. They may be arranged to record density of smoke, fumes and solutions or to detect the presence of smoke or fire. Materials can be graded in size, thickness or color or to a mechanical precision by the use of a phototube.

Since light is used as the controlling medium instead of mechanical or electrical contact, operations where friction should not be introduced or where mechanical contact cannot be made and which would otherwise be difficult to obtain, are readily and conveniently governed by phototube control.

INSTALLATION

Mechanical

Although these tubes may be mounted in any position, it is recommended that they be installed in a vertical position with the base of tube either up or down. It is, of course, imperative that the cathode emitting surface face the light source upon which the functioning of the tube is dependent. The SR-50, SR-51, SR-53, SR-58, SK-60, SK-61, SK-63 and SK-68 types are supplied with the specially designed and rugged industrial bases which have been widely adopted for tubes used in the industrial field. Several types are equipped with the UX type of base, namely, the WL-734, WL-735, WL-737 and WL-770. The industrial socket style #766732 is made of especially high quality moulded insulating material, and is recommended for use with the phototubes having the industrial bases. This socket has a high resistance which remains constant with an increase of temperature up to 70 degrees centigrade and humidity up to 90 percent. UX type of sockets made of high quality material should be used with the tubes which are supplied with UX bases.

While WESTINGHOUSE phototubes are uniformly rugged in all mechanical respects, they should be protected from unnecessary vibration. If they are mounted in locations where vibration exists, it is recommended that the sockets be cushioned properly. These tubes are not particularly sensitive to temperature changes although the maximum recommended operating temperature should not exceed 50 degrees centigrade. This refers to the ambient air temperature or the temperature of the air which comes in contact with the bulb. Operation of the phototube at too high a temperature may cause a change in the sensitivity of the light sensitive surface due to the evaporation of the volatile materials with consequent decrease in sensitivity and an adverse effect on life. In general, higher temperatures may slightly decrease the sensitivity. To cite an example, there is very little change in sensitivity with the WL-735 gas filled phototube operated within the temperature range of minus 20 degrees Centigrade to plus 20 degrees Centigrade, while from 20 degrees Centigrade to 50 degrees Centigrade there may be a decrease in sensitivity of about 0.4% per degree Centigrade. If it is necessary to mount the tubes in a place where natural ventilation is poor, best operating results will be secured if forced air cooling is provided by means of an electric fan or a stream of cool dry air.

Care should always be taken to avoid any extraneous or undesired light from reaching the phototube, otherwise erratic results may be obtained. In addition to the light shield, it is also desirable to shield the circuit carefully from stray fields. In extreme cases it may even be necessary to shield the leads to any external source of power.

The sensitivity values given in the accompanying table were taken when a Mazda projection lamp operating at a filament color temperature of 2870 degrees Kelvin was used as the light source. The test circuit includes a one megohm load resistance in series with a 90 volt supply source. The standard light flux value of 0.1 lumen was used.

Electrical

It is essential to minimize the detrimental shunting effects of leakage between electrode connections and capacitance between the leads. It is, therefore, important to use only high quality sockets and to properly insulate the leads, particularly the one connected with the anode or positive voltage supply.

For both steady and pulsating light, the sensitivity of gas filled phototubes within their normal operating range, is practically independent of the amount of light. However, sensitivity is affected by the frequency of light modulation. This is characteristic of gaseous phototubes and is due to the relatively large mass of the positive ions and their correspondingly sluggish motion. Because there is a time lag between the disruption of a gas atom and the increase in current due to the resultant positive ion, fluctuations in the gas component of current lag slightly behind fluctuations in the primary photo-emission component. For high frequency of modulation, this lag tends to smooth out the pulsations in phototube current, thus decreasing the alternating component of the current and, to some extent, the sensitivity. For low frequencies, however, the effect is not important and the low-frequency sensitivity is practically equal to the static sensitivity.

The sensitivity of the gas-filled phototube for pulsating light is measured with a light input that is varied sinusoidally about a specified mean value from zero to a maximum of twice the mean. Sensitivity values for the audio-frequency range give a sensitivity at 10000 cycles which is down approximately 17% or only about 2 decibels from the value at 100 cycles. The gas content is such that the tubes combine high sensitivity with good audio-frequency fidelity.

The sensitivity of a phototube is determined by the amount of current which the tube will pass with an applied potential of 90 volts d.c. across the tube in series with a one megohm resistor when the amount of light falling on the cathode is one lumen. The lumen is a standard unit of light flux equivalent to a luminous intensity of one foot-candle upon a projected area of one square foot. To obtain the value of the light flux in lumens, multiply the projected area of the illuminated aperture in square feet by the intensity in foot candles. A light source of one candle power will illuminate a surface one foot distant with an intensity of one foot-candle. The light intensity on a surface from a given small source varies inversely as the square of the distance. Thus:

$$F = \frac{CA}{D^2}$$

Where F is the flux in lumens, C is the candle power of the light source, A is the area in square inches of the surface or aperture and D is the distance in inches of the light source from the surface, D and A being in corresponding units. Mazda "C" lamps of 50 to 100 watts are rated approximately at 1.0 candle power per watt at marked voltages. For example, approximately one lumen of light flux strikes the cathode of a WL-735 phototube when placed 10 inches from a lighted 100 watt lamp.

The cathode sensitivity of these phototubes is of such uniformity that a beam of light projected upon a very small area of the cathode is quite effective. However, best uniformity is obtained when the incident light is projected over as large a portion of the cathode as possible.

When a phototube is used with a relay, the highest sensitivity is obtained by the use of a relatively large load resistance. The phototube may be used with any of the usual amplifier tubes as long as the grid circuit is not too high, say less than one or two megohms. When higher resistances are used in the coupling circuit, it is desirable to use one of the WESTINGHOUSE low grid current amplifier tubes and to take precautions to properly insulate the grid circuit.

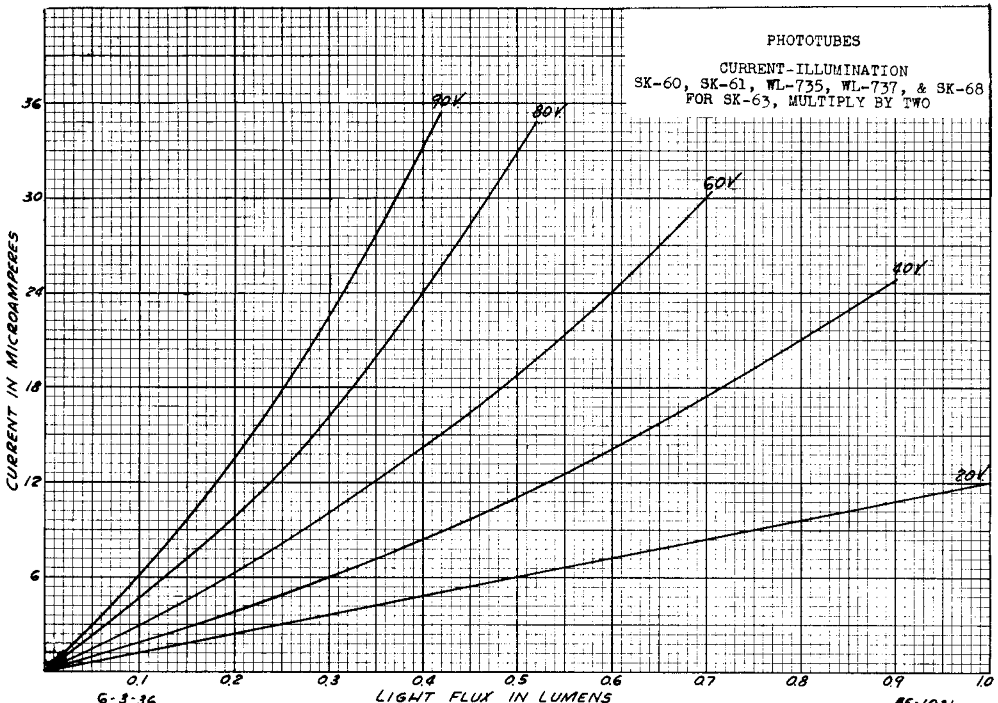
OPERATION

The current rating of a gas filled phototube depends upon the operating conditions, hence it is important to avoid the combination of too much current with too high a voltage. The reason is that these two factors govern the number of positive ions striking the cathode per second and their velocity. Too many ions bombarding the cathode with excessive velocity may disintegrate the cathode surface and cause the tube to lose its sensitivity.

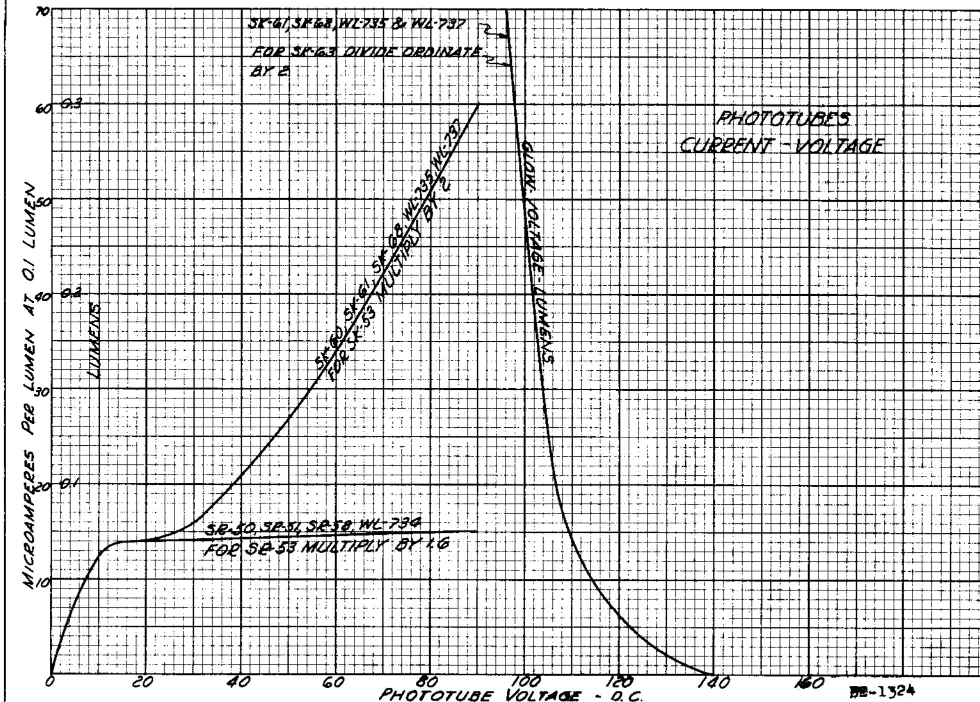
The voltage across the tube can be computed by subtracting the voltage drop through the load resistance from the supply voltage.

A gas discharge, evident as a faint blue glow, may occur if the current and especially the rated voltage of a gas-filled phototube is exceeded. If such a glow occurs, the anode voltage should be removed from the tube immediately in order to prevent permanent damage to the tube.

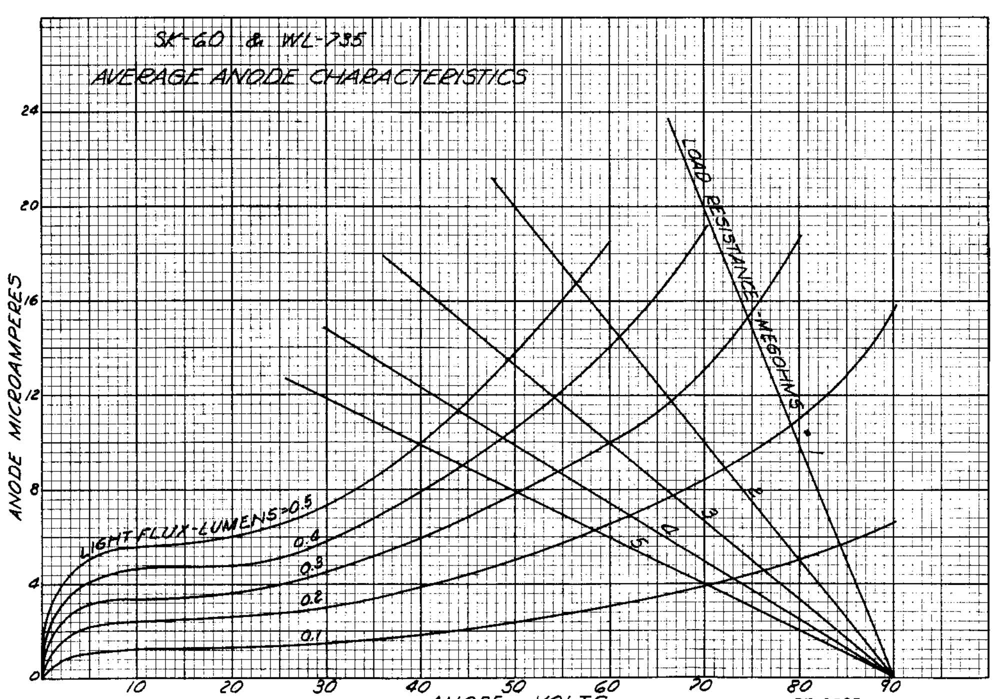
A phototube generally gives best results under constant use. The characteristics of a phototube which has not been used for a month or more may change somewhat, but can



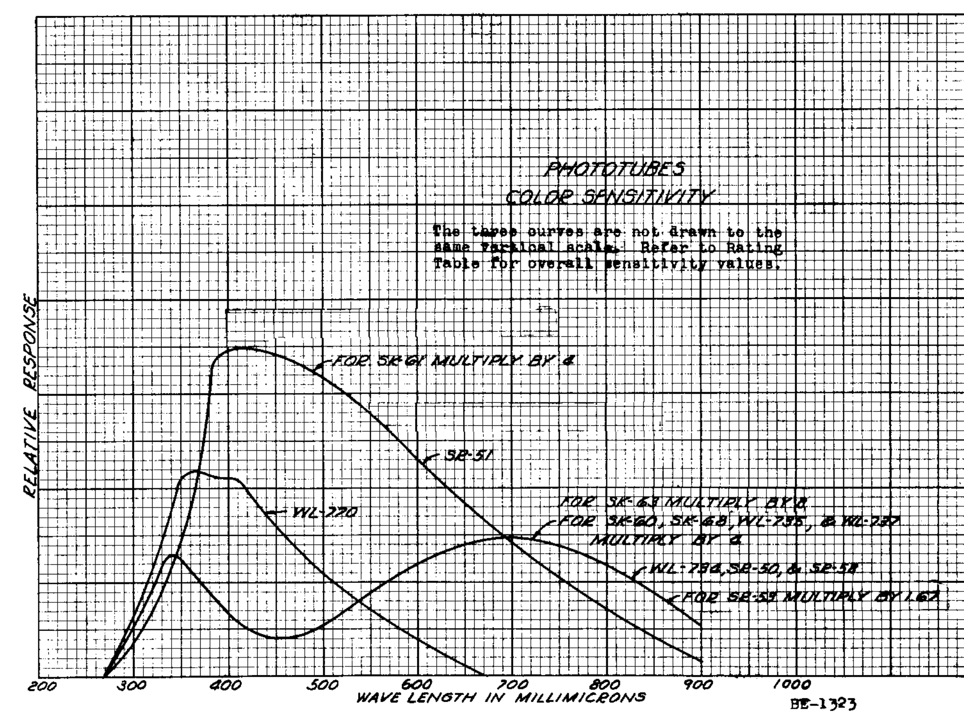
PHOTOTUBES
CURRENT-ILLUMINATION
SK-60, SK-61, WL-735, WL-737, & SK-68
FOR SK-63, MULTIPLY BY TWO
90V
80V
60V
40V
20V
CURRENT IN MICROAMPERES
LIGHT FLUX IN LUMENS
G-3-36
BE-1031



PHOTOTUBES
CURRENT - VOLTAGE
SK-61, SK-68, WL-735 & WL-737
FOR SK-63 DIVIDE ORDINATE BY 2
SK-60, SK-61, SK-68, WL-735, WL-737
FOR SK-53 MULTIPLY BY 2
SR-50, SR-51, SR-58, WL-734
FOR SR-53 MULTIPLY BY 1.6
GLOW-VOLTAGE-LUMENS
LUMENS
MICROAMPERES PER LUMEN AT 0.1 LUMEN
PHOTOTUBE VOLTAGE - D.C.
BE-1324



SK-60 & WL-735
AVERAGE ANODE CHARACTERISTICS
LOAD RESISTANCE-MEGOHMS
LIGHT FLUX-LUMENS
ANODE MICROAMPERES
ANODE - VOLTS
BE-1325



PHOTOTUBES
COLOR SENSITIVITY
The three curves are not drawn to the same vertical scale. Refer to Rating Table for overall sensitivity values.
FOR SK-61 MULTIPLY BY 4
SR-51
WL-770
FOR SK-63 MULTIPLY BY 8
FOR SK-60, SK-68, WL-735, & WL-737 MULTIPLY BY 4
WL-734, SR-50, & SR-58
FOR SR-53 MULTIPLY BY 1.67
RELATIVE RESPONSE
WAVE LENGTH IN MILLIMICRONS
BE-1323

be restored to normal by a short period of operation (about one or two hours) with the usual current and illumination. Exposure to large amounts of light, such as direct sunlight, may temporarily decrease the sensitivity of the tube even though there is no voltage applied. The magnitude and duration of this decrease depend upon the length of over-exposure

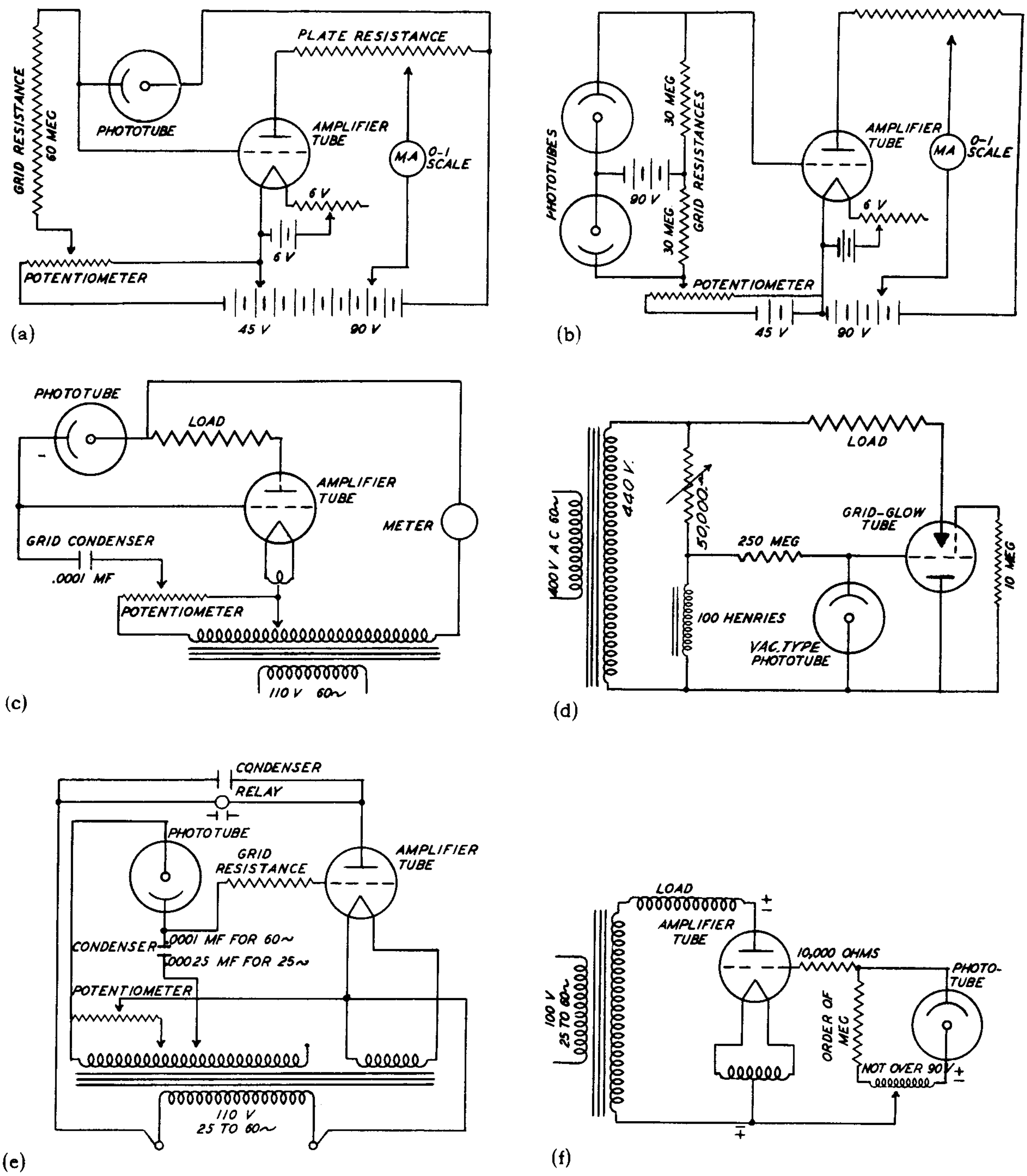
CHARACTERISTICS

The accompanying curves of anode current versus light flux for constant plate voltages are quite similar to the curves of anode current versus anode voltage for constant light flux values in that the two curves represent the same data plotted in two different forms. These curves show that the current output in all vacuum phototubes is exactly proportional to the light flux when saturation voltage is applied, whereas, in gas-filled phototubes the current output is only proportional to the light flux for low illuminations and low voltages, but not for high illuminations and high voltages. However, for a given gas-filled phototube a load resistance can always be chosen so that the current output becomes linear with the light flux over the permissible range of illumination.

As will be seen by the accompanying curves of current versus phototube voltage for the various tubes, the current in the vacuum type reaches saturation at approximately 14 volts, and any further increase in potential gives only a slight increase in the saturation current. This slight increase is due to geometrical construction of the tube. In a gas-filled tube, the same saturation value is reached at 14 volts, but this condition is temporary since the output current rises rapidly when the voltage is increased still further due to the effect of ionization of the gas in the tube. The sensitivity of the gas-filled phototubes may be several times the corresponding value of a vacuum tube of similar construction. This augumented sensitivity is due to gaseous ionization and is the chief merit of gas-filled phototubes.

Some curves are included which show the color sensitivity of the phototubes plotted as relative response versus wave length in millimicrons. These curves show the sensitivity characteristics of these various tubes due to light of various wave lengths. The cutoff of all of the curves to zero at wave lengths at a little less than 300 millimicrons is due to the absorption of shorter wave length light by the glass bulbs. Some types possess a large response in the longer wave length or infra-red region which make such tubes particularly useful for operation where Mazda lamps are employed as light sources. If desired, color filters may be used to alter the color sensitivity response of the phototube.

Several circuits are shown which illustrate typical methods of using the various phototubes. In most cases operating voltages and circuit constants are recommended. However, it will often be found that these do not represent the optimum condition for any particular installation, and the values which produce the best results should be used. The publication of these circuits does not imply or carry a license to use them. In several of the circuits the phototube controls the grid bias of a vacuum amplifier tube while one circuit is shown in which the phototube controls the grid bias of a thyratron. This latter circuit is particularly useful in that it operates entirely from alternating current and the controlled current may be relatively large.



(a) Flexible d-c amplifier with neutralized anode current

(b) Differential d-c circuit with neutralized anode current

(c) Simple amplifier for straight a-c operation

(d) Grid-Glow relay circuit a-c operation

(e) Simple amplifier for straight a-c operation

(f) Negative control Grid-Glow relay circuit for a-c operation

Fig. 4-19 - Typical phototube circuits

GUARANTEE

Westinghouse tubes are guaranteed to be free from electrical and mechanical defects. They have been designed and built to withstand reasonable service conditions and have passed rigid tests before shipment. Their performance will depend, to a large extent, upon the kind of equipment in which they are used and the care with which they are handled. In case of doubt as to the proper operating conditions, information should be secured from the Special Products Sales Department, Westinghouse Lamp Division, Westinghouse Electric & Manufacturing Company, Bloomfield, New Jersey.

If a tube is received with apparent defects or evidence of abuse in transit, suitable notation should be made on the receipt required by the transportation company. If, after a clear receipt has been given, acceptance tests reveal that the tube is inoperative or has been abused in transit, immediate steps should be taken to notify the transportation company, at the same time requesting inspection by the carrier's agent. Claims for concealed damage will be accepted by carriers only when such damage has been reported to them within fifteen days after delivery. Purchasers desiring the assistance of the manufacturer in filing such claims must report them to the manufacturer within a reasonable time to insure compliance with the common carriers' requirements.

The manufacturer assumes no responsibility for tubes which may become defective during re-shipment or handling by the user. If a tube shows a defect or trouble is experienced in its operation, a careful check should be made to see that the circuit or other equipment is not at fault. It is advisable to recheck the tube in another socket or replace it in the set in which it gave trouble as a check on its operability before it is returned to the manufacturer. The service report form must be completely filled in with the information concerning actual life obtained and the conditions of operation so that proper consideration may be given to the claim. This sheet must accompany the request for permission to return the tube.

No claim for adjustment, except obvious manufacturing defects, will be considered when a tube has been used for experimental purposes, or where the conditions of operation have not been in accordance with the electrical rating and accompanying operating instructions. If examination and test of the tube indicate a defect of quality, workmanship, or material, an adjustment will be allowed based upon the merit of each individual claim. Upon receipt of the authorization for return, the user should pack the tube for shipment as carefully as when it was originally received, since damage in shipment will make proper examination impossible. Complete shipping instructions are given on the return tag. This guarantee applies only within the period of one year after the tube is shipped from the factory.

LICENSE NOTICE

The sale of this device carries a license under patent claims of the device itself for power, therapeutic, medical, railway signalling, and x-ray purposes; for communication (not including programs) on, between, or with, and signalling, directing, or controlling land vehicles in connection with their operation; for communication by the owner or operator of apparatus for power purposes, but only in the business of such owner or operator involving such apparatus; for use on aircraft, for communication (not including public service or programs) on, between, or with, and in signalling, directing, or controlling aircraft in connection with their operation; for wireless telephony and wireless telegraphy transmitting apparatus for use by municipal, county, or state governments, solely or primarily for rendering an official service; and for laboratory use.