The Neon Tube—Television's "Loud Speaker"

How This Marvelous Device Makes Possible the Distant Reproduction of Moving Scenes Simultaneously with Their Occurrence

*By D. E. Replogle**

ONE of the essential components of a television receiver is the glow-lamp; this and its associated scanning device serve the same purpose in the television apparatus that the loud speaker serves in the radio set.

This remarkable device, as most successfully developed, utilizes neon gas as the luminous element, and is the only lamp yet known which, without prohibitive cost, can be made, satisfactorily, to meet the requirements of the present television systems; in which there is required a light-source, of uniform intensity over a large area, which will instantaneously vary in brilliancy with variations in the television signals. The television lamp most strikingly differs from the familiar electric lamp, in that it gives off a soft orange "glow" from a large surface which may be looked at without hurting the eyes, rather than the dazzling white "spot" of an incandescent tungsten filament. The color of this glow may be readily controlled in manufacture by variation in the kind and quantity of gas employed within the bulb.

As will be seen from Fig. 1, the construction of the television lamp is apparently quite simple; although this simplified appearance has been secured only after a great deal of research work with gaseous-conduction tubes and neon lamps of all types and for many different uses. Indeed, the development and refinement of this device has involved a review of many rare gases, a deep study of atomic structure, and a long process of reasoning out the acrobatics of electrons. The highly intricate action taking place in the miniature universe of the gas contained in the television lamp is, therefore, not at all in keeping with the utter simplicity of the mechanism and electrical features of the device; yet we must master the first before we can enjoy the second.

ITS ACTION A PARADOX

The "glow" takes place uniformly over the surface of either one or the other of the two flat and parallel plates (P and P1, Fig. 1); the effect depending upon which plate is connected to the positive and which to the negative side of the power supply. The two parallel plates are so placed with respect to each other as to utilize the principle of "short-path" insulation in order to prevent "glow" *between* the plates which, of course, would not be very desirable.

The "short-path" principle is one of those scientific truths that are stranger than fiction. Briefly, in a gaseous conducting medium, if we have oppositely-charged metallic bodies of sufficiently high potential difference, the gas between will "break down" or "ionize," and conduction will take place from one to the other. However, move these same conductors *very close to each other,* and the gas between is no longer ionized; which is apparent from the fact that there is no longer a glow present in the tube. Current ceases to flow from one to the other. An excellent insulator is now presented by the intervening gas. Why?

The explanation is steeped in academic science, which is usually far beyond the realm of the layman. Furthermore, no one has ever seen atoms or electrons; hence cold logic steps in to explain things which man may never see for himself. However, if we may be permitted to make a free translation into lay language, of a theory by C. G. Smith, inventor of the "S" tube, the story runs about like this:

The facing charges of electricity are bound to produce action. Some loose electron in the gap between the charged conductors is coaxed toward one or the other, and rapidly accelerates its rate of travel until its speed is sufficient to smash those atoms obstructing its path. The collisions result in ionization, or the breaking down of the gas, which then becomes a fair conductor of electricity; or, to put it another way, there is now a wholesale movement of electrons. It is evident, then, that the electron needs a good running start, so to speak, in order to smash things up in general. Failing in a good running start, the electron does no smashing, ionization cannot take place, and there is no electrical conduction; the gas, under such circumstances is a good insulator. Some gases require a longer path for ionization than others, which is another important consideration. Helium is especially ideal in this respect, having an exceptionally long free path.

CONSTRUCTION OF THE GLOW LAMP

The "short-path" principle, then, is adopted merely to prevent electrons from getting a good running start; it is practically applied in insulating the inner surfaces of the two electrode plates most effectively.

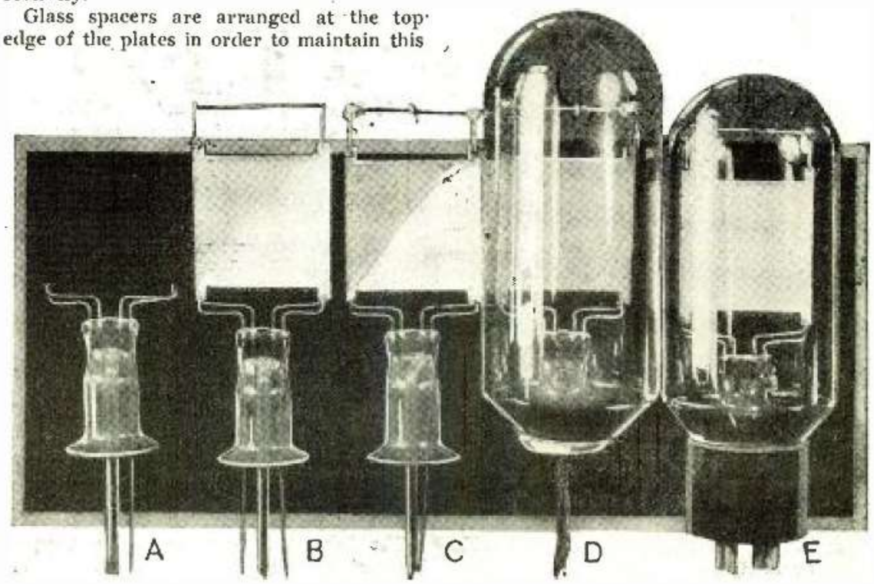
Glass spacers are arranged at the top edge of the plates in order to maintain this separation at just the right value, while the supporting rods between the stem and the lower edges of the plates serve the same purpose at the bottom. The cross rod at the top of the plates is merely to prevent the plates from being bent away from their normal vertical plane, as a result of jars during transportation. This brace serves also to prevent vibration of the plates when the tube is mounted on the same framework as the scanning-disc motor, as frequently is the case.

The bulb surrounding the two plates is of particularly clear glass, to permit the radiation of the maximum amount of light. The tube contains neon gas, at a low pressure, together with certain alkaline substances which increase the speed of operation and the intensity of illumination.

The tube is fitted with a standard UX base. The luminous plates are placed in a plane at right angles to the axis of the socket pin. In a television receiver, therefore, the pin should point directly either to or away from the scanning disc, in order that the glow-lamp's plates may be parallel to the disc. Connections are made to the plate, and one of the filament, prongs of the socket.

CIRCUIT CHARACTERISTICS

As with all types of gas-discharge tubes, the neon lamp has a very pronounced "negative-resistance" characteristic and a stabilizing resistor must always be used in series with the lamp and the supply voltages. (This is just a technical way of saying that the internal electrical resistance of the lamp decreases as the current through the lamp is increased. Thus, if no current-limiting resistor were to be used in series with the



The steps in the assembly of a glow lamp: A, glass stem and wire supports, ready for the plates. B, plates mounted in position. C, plates completely assembled, with top wire supports. D, tube ready for evacuation. E, completed tube ready to work.

* *Raytheon Manufacturing Company*

tube, the current would tend continually to increase and, as it increased, the resistance of the tube would automatically decrease, causing still further current increase and so on; until an excessive current value was reached and the lamp destroyed.) A resistor which is smoothly variable through a wide range (0-500,000 ohms) will be found very convenient for this purpose; as not only does it stabilize the tube operation, but it serves also as a ready means for adjusting the current through the lamp, and thus its brilliancy, to the desired value.

As will be seen from Figs. 2 and 3 a D.C. voltage of 180 is required for proper operation. By means of the series variable resistor, the current through the lamp may then be controlled between 5 and 20 milliamperes. With a current of less than 5 milliamperes, the glow on the plates is not uniform and, therefore, not satisfactory for television use. As the current is increased in intensity from 5 to 20 milliamperes, the glow remains very uniform and increases in intensity. Currents in excess of 20 milliamperes should not be passed through the tube or its life will be materially shortened.

As will be seen, either a separate D.C. source (which may be either batteries as in Fig. 3, or a good "B" power unit), or else, in some instances, the plate current of the power tube itself, as in Fig. 2, may be used to light the lamp. In case the regular power-tube plate supply is used, the plate-to-filament resistance of the power tube serves as the stabilizing resistor and the plate voltage must be increased from the normal value (180 volts in case of the UX-171 type) by an amount equal to the drop across the lamp (about 150 volts).

While the impedance of the neon lamp is quite low—500 ohms—it should be operated directly in the output circuit of the power tube (either UX-171 or UX-210) without using any impedance-adjusting device. Such an arrangement is used because the television lamp is *a current-operated device* rather than a power-operated device; therefore the most desirable output circuit arrangement is one which provides for a maximum of current change in the plate circuit of the power tube in which the lamp is connected.

REVERSING THE COLOR EFFECT

It has already been mentioned that changing the D.C. connections to the tube changes the "glow" from one plate to the other. Interchanging the A.C. connections, on the other hand, *reverses the character of the image,* in the reception of television. Thus one connection will give a *positive* picture, and the reverse a *negative.* That such a condition is possible will readily be seen if we consider the instant at which one A.C. lead is positive and the other negative. If these leads are so connected to the electrode plates that the A.C. "+" lead and the D.C. "+" lead are on one plate, and the A.C. "—" and the D.C. "—" lead on the other, the "*instantaneous*" current through the tube is equal to the instantaneous A.C. value *plus* the steady D.C. value and the instantaneous brilliancy of the illumination is greater than normal.

If, on the other hand, however, the A.C. leads have been interchanged with respect to the D.C. leads, the instantaneous value of the alternating current opposes the direct current and, as a result, the brilliancy of illumination will be below, rather than above, normal. See Fig. 4 on the next page.

Thus, in the first instance, a signal impulse results in the illumination of the tube getting dimmer, and in the other brighter; which in turn, results in a positive picture in the first instance, and a negative in the second, providing the polarity of the signal voltage is the same as it was at the transmitting end. In the case of some amplifiers, however, the instantaneous polarity of the signal voltage may be reversed by the time it reaches the television lamp; this is the case with a "grid leak-condenser" detector working into an *even* number of resistance-coupled audio stages. In such an instance, a reversed or negative image would always be obtained if it were not possible to correct matters simply by reversing the lamp connections.

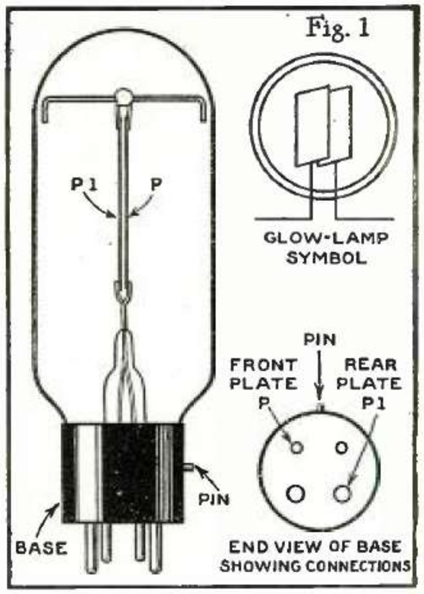


Fig. 1

The details here show more clearly the arrangement of the neon tube's elements. The article explains why the glow is on the outside of the plates—not between them, as might be expected.

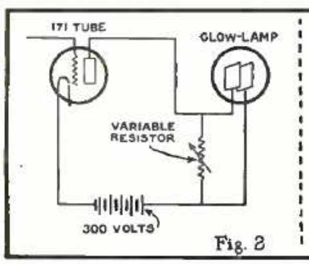


Fig. 2

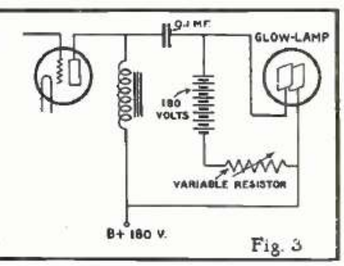


Fig. 3

A higher "B+Max" voltage is needed in Fig. 2, where the power tube's plate current lights the neon tube; while in Fig. 3 the additional batteries are across the latter only (See page 423). The value of the coupling condenser is not critical.

How to Adjust the Television Receiver for Operation

THE first step in the reception of a television image is the locating of the signal on the receiver dials. This is best done with the aid of headphones or a loud speaker connected in place of the neon tube. Do not fail, however, to have a fixed condenser of about 1 mf. capacity in series with the phones when connected in place of the neon tube or across its terminals.

The television signal has a distinctive sound but, unfortunately, the short-wave band contains several signals that may easily be mistaken for television. For instance, the high-speed code transmissions of such stations as WIZ and WQO are quite like a television signal because of the "flutter," or what may be called a "group frequency." On the broadcast band, in which WRNY operates, this trouble will not be experienced.

In addition to a low "group frequency," which is the rate at which complete pictures are transmitted and which is around 18 to 20 cycles (per second), the television signal contains high-frequency notes whose character depends upon the nature and the position of the subject before the transmitter pick-up.

The experimenter will hear a signal which sounds at first like a flutter and will then note that this flutter is really the rapid repetition of a high-frequency note. The nature of this note and its loudness constantly change as the subject before the transmitter moves or is changed. For instance, a newspaper rolled up and held in a vertical position produces a distinct note which is very clean cut. A hand does not produce so clear a note, yet the signal is of the same general nature.

"CRAZY" IMAGES

The television experimenter may, upon his first attempts, be puzzled to find his received images either turned upside down, or else reversed as when looking through a photographic negative the wrong way. Both of these faults can be corrected quite easily.

It is quite obvious when an image is upside down, and the correction of this fault is equally obvious. The subjects before the transmitters at most stations broadcasting television are scanned from top to bottom during one rotation of the disc. Accordingly, if the receiving disc is so rotated that the plate of the neon tube is scanned from the bottom to top, the picture will be inverted. To reverse the manner in which the neon lamp plate is scanned vertically, it is necessary either to reverse the rotation of the disc or to remove the disc from the driving motor and turn it around. The latter operation may involve the removal of the hub and remounting on the opposite side of the disc.

Whether or not the received image is reversed horizontally, is impossible to tell unless one happens to know the scene being transmitted, or unless distinctive characters are held before the transmitter pick-up. For example, one of the objects often