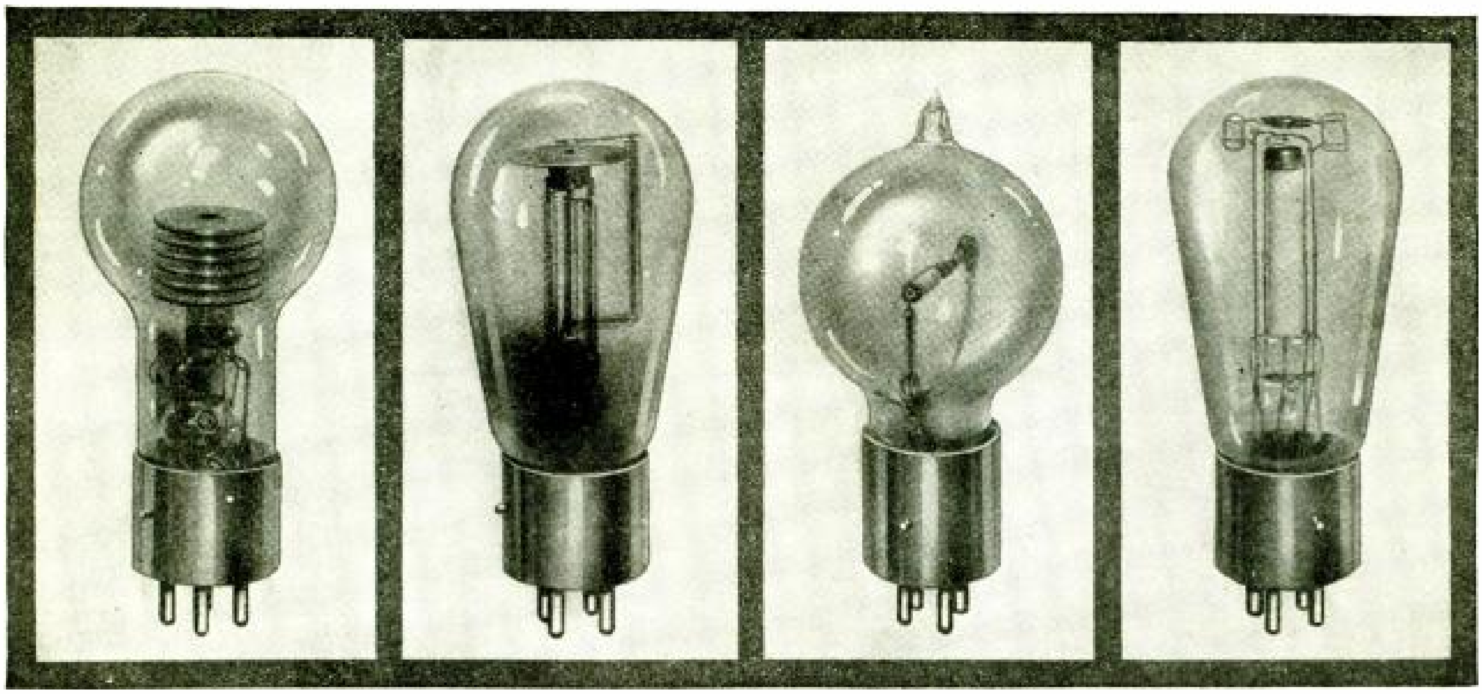


The photograph above shows several different styles of "neon crater" tubes: Fig. 2 at the extreme left shows an air-cooled crater tube, with fins on the cathode to help dissipate the heat; the tube next to that has a large cathode plate and is viewed end-on; the third crater tube shown is viewed from the side, while the tube at the extreme right is viewed from the end. The feature of all crater tubes is to obtain a highly concentrated discharge in a small area, so as to have a bright point of light, instead of a widely diffused light.

THE CRATER TUBE

EARLY in the development of television, it became apparent that the light source is the "bottle neck" through which the results of a television receiver must pass. Since the very beginnings of the art, we have been searching for a light-source that will respond to the high frequencies that light transmission demands, and at the same time give sufficient illumination for the production of pictures. Until just recently, the best that the lamp art had to offer was the so-called *flat-plate neon glow-lamp*, which is now well known to the television experimenter. While the present glow-lamp works well for the purposes of the amateur enthusiast, who is satisfied with the very thought of actually reproducing living images by radio, we must realize that the ultimate judge of the television image will be Mr. Layman, a hundred million strong, who is interested in "entertainment"; and the Mr. Layman will require that his sight reception be at least comparable with the early motion pictures. That ultimate criticism sooner or later standing in our path, it is apparent that we must develop a better light-source as the next step in improving the television image. Why the flat-plate glow-lamp will not lend itself to our requirements can be easily explained.

* *Vice-President, Jenkins Television Corp.*

By D. E. REPLOGLE*

Specially Prepared for TELEVISION NEWS

What is a crater tube? How does it differ from the usual flat-plate neon tube? How much current is required to operate a crater tube? These and other vital questions on the newest television scanner tube are here answered by an eminent authority.

Inefficiency of Flat-Plate Neon Tube

It is obvious that, if we are transmitting square elements at a frame ratio of 5 by 6, only 1/4,320 of the light available on the neon lamp is observable at any instant. In film scanning, and in our later "direct film pick-up", however, the assumption of square elements is incorrect, since our *horizontal resolution* may be from three to five times as great as our *vertical resolution*. Therefore, only 1/17,280 of the actual light on the plate is usable! And even this calculation is based on the assumption that we are covering the whole of the plate with the scanned area.

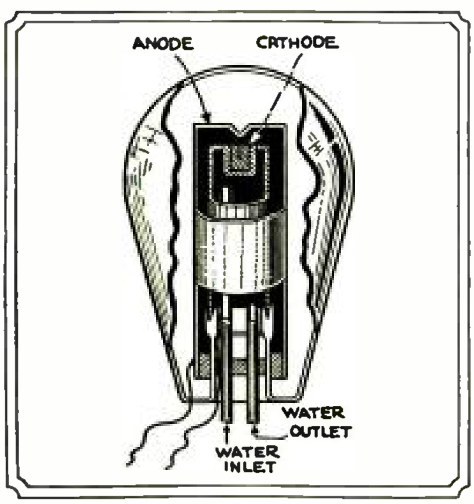
We can readily deduce, from the above situation, that any method which can be devised to utilize the whole glow, of a gaseous source, will result in an enormous increase in illumination of the picture. By its means we could use a projected image thrown on to a translucent screen; we could increase the number of lines per frame for better detail—in short, we would transfer the "bottle neck" of television from the light source, to some other factor in the chain, with a consequent improvement in the resulting pictures. To be more concise, if we could concentrate the light, which we now spread out over the entire surface of the square plate, we could use *all* of it at each hole of the scanner, instead of the very small fraction that now finds its way through the lens.

These facts and their natural deductions have led engineers (who know that in most gaseous types of tube the illumination is, roughly, proportional to the current through the tube) to attempt to develop a tube in which a highly-brilliant, concentrated point of light can be obtained, with a reasonable amount of current, such as from 30 to 150 milliamperes. It was important to preserve the linear increase in illumination with current, that has been developed in the plate type of lamp. The characteristics necessary are that each small increase in current shall provide a constant increase in illumination with faithfulness of modulation; *i.e.*, that the rapidly varying current necessary to television, which may be as high as 40,000 cycles, shall produce no distortion. This last characteristic (*i.e.*, response to high frequencies) has limited our television mostly to gas-discharge devices.

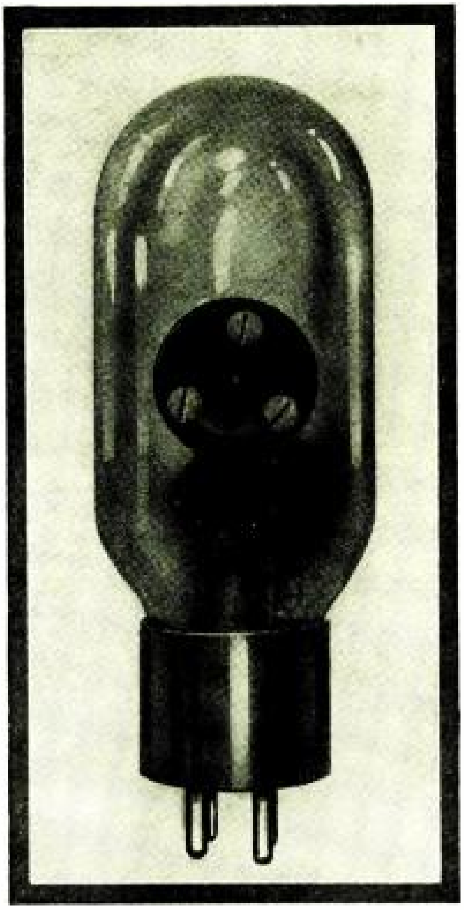
A great number of possibilities for securing a bright projected picture present themselves, the minute we have developed a satisfactory "point source" of light, which can be modulated without distortion. By the use of a scanning disc, we may use each hole of the disc as a "pin-hole" camera; and, by the use of suitable lenses, this brilliant point of light can be projected and caused to scan the picture on the screen. It is also possible to use vibrating mirrors to reflect the image of this source in a scanning cycle. It is also possible to use prismatic discs, such as were first used by C. Francis Jenkins, in his early motion-picture projectors. Resort may also be taken to mirror drums, mirror discs, and mechanisms of various forms to cause the light to be projected in a scanning cycle on a screen, translucent shade or what not.

However, thus far, the most simple and satisfactory method to be developed is to use a disc which, instead of the usual pinholes in its periphery, has lenses correctly designed and of proper focal length to fit into the desired system. With this "lens-disc" and the latest, most efficient and successful "point-source" of light, it has already been possible to scan with good illumination a received image of ten square feet!

The neon lamp glows because, in the presence of a sufficient potential gradient, the atoms of gas break down and give up one or more electrons, which travel against the potential and cause the current flow. In their migration through the atoms of the gas, they collide with other atoms and cause those to vibrate at light frequencies. This collision is strongest near the plate and causes what we



Sectional view of water-cooled neon crater tube.



Latest type of neon crater tube.

will term a "glow discharge" in the gas.

It has been found that, by increasing the number of molecules in the tube (or, in other words, increasing the gas pressure), this discharge is made to cling closer to the negative electrode; although the potential gradient necessary for "ionization", which the above process is called, must be created.

Another important fact, which enters into the design of the tube, is the point where ionization occurs. The potential drop at that point in the gas, or the resistance to the flow of current, is much less; which tends to concentrate the flow through the gas at the point of least resistance. Still another interesting fact about gas-discharge devices is that, wherever a gas is confined by solid boundaries, such as a crack or crevice in an electrode, ionization will become much more intense; and the light will be much more intense if the discharge can be confined to that part of the electrode.

With these facts in mind, the early experimenters set out to produce a "point-source" of light from a gas-discharge tube. The early work took the form of a small hole bored in the negative electrode of the tube, with an anode surrounding this hole; so that the potential gradient would be even all around the hole. It was possible then to concentrate the flow of current through the electrode, through the gas in the hole, and a very intense light was achieved. This was transformed into heat with the result that, where light was brightest, the heat was greatest; which led to the melting or sputtering of the metallic electrode. This darkened the tube and shortened its useful life considerably.

All this led the experimenters to enlarge the negative electrode for better absorbing the heat, and reradiating it through the walls of the tube.

Figure No. 2 shows this early type of tube. In this will be noted the ring anode which is positive, and the large metallic negative electrode, with its radiating fins to dissipate heat. In the center can be seen the small hole in which the intense glow occurs. If all the voltage gradients are symmetrical in the tube, and the material in the electrodes is homogeneous, the discharge will concentrate itself in the small hole. These factors, however, are difficult to keep constant in production; and other means have been developed to insure the concentration on the discharge at the proper point.

It has been found that oxides of barium, strontium, calcium and the like have the property of emitting electrons, even at comparatively low temperatures. So the next step was to coat the inside of the small hole with a proper mixture of these oxides. This made the concentration of the discharge extremely simple, and permitted the research men to concentrate their efforts on the dissipation of the heat from the enlarged negative electrode (cathode).

The next step was to make a "water-cooled" electrode, and various types of these tubes have been developed. It was then found possible to put very high current through these tubes, without destroying them, and to secure an extremely intense light. The water-cooled arrangement has, however, proved impractical, and it is

(*Continued on page* 391)

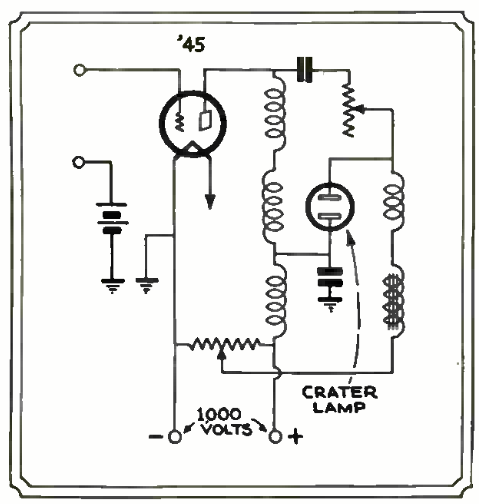


Diagram of connections used with crater tube.

post and make a complete connection to each post. When finished, it will be found in an oblong shape. (See Fig. 3.) Break one of the wires in the primary circuit of the filament transformer about 8 inches from the transformer. Attach this to the A.C. switch.

This attachment is now ready to hook up to the one-tube set.

It might seem that the A.C. current from the output of this apparatus would spoil the incoming picture, it does not in my location. The "B" batteries neutralize this current somewhat.

The Crater Tube

By D. E. REPLOGLE

(*Continued from page* 339)

difficult to secure enough light, from a moderate amount of current, to use these in a simple and inexpensive home radiovisor; so an entirely new principle was developed.

The use of the electric arc has been known for a long time and experimenters have been trying to use this arc for television for several years. Because of its inherent instability, this has been a difficult problem; but the tube research men have come along and utilized the principle of an arc in a gas, to solve their problems in a satisfactory way. An arc is the break-down of a gas medium (somewhat similar to the process used in the earlier neon tubes) but, instead of ionizing a portion of the electrons in the negative electrode, the whole group near the smaller electrodes has been highly ionized, and those give out intense light.

It has been found that, by heating the negative (cathode) electrode—the reverse process to cooling—an arc can be formed, between that electrode and the positive (anode) electrode, and it can be made to present a most intense light-source.

In recent days this new principle has been developed to great length, and now seems to be well on its way to satisfy the condition required for a successful light-source in projecting television images.

There is much of a technical nature involved in the design of these tubes; and it will suffice to say that, among the essential things, are the shape of the electrodes, purity of the gas, method of securing purity, the temperature at which the gas operates in the tubes, etc. All these are important factors which have been tried before production models can be made.

White Light Now Available

Much has been said about the color of the television lamp now in use. A word about the reasons for this color may be of interest.

Neon, which gives a characteristic *orange* glow, was the gas first used for two reasons: the first is that the human eye is more sensitive to the orange color than to white or blue; so that with a given amount of illumination the pictures appeared brighter in that color than in any other. Second, the voltage gradient necessary to ionize neon (though it is not the lowest for any of the gases) is comparatively low.

For a *white* light, nitrogen and argon in proper proportions will give very satisfactory results, with approximately the same voltage applied. Helium gives a bluish white light, but requires considerably more voltage to produce the ionizing condition. Other combinations of gases can be and have been used to produce various colored lights.

It is by use of these various combinations of gases that colored television can be rather simply produced. In this case, three radio or wire channels are necessary: One to transmit the blue color in the image; one to transmit the red; and one to transmit the yellow. At the receiving end, the output from three different colored television lamps is blended to produce the received image. It is even possible to secure satisfactory colored television with two channels; in which case a red and a green lamp are used at the receiving end.

All of the above information will serve to point out very clearly that development work in television, particularly on the receiving end, is very much needed at this time. There are literally hundreds of channels of research work that are opening out before the television researcher.

Large Image Produced by New Scanner

(*Continued from page* 366)

The scanning disc is 12 inches in diameter, containing 60 holes, and is driven horizontally by a small but efficient synchronous motor, insuring constant synchronization with the transmitting station. Vertical framing is accomplished by snapping the motor switch off and on, while a shift device on the neon lamp socket provides for horizontal framing. When attached to the output of a good short wave television receiver, this scanner outfit will give faithful image reproduction. Close adherence to the complete set of blueprints and instructions furnished with the kit, will insure the rapid and easy construction of the televisor. The kit includes a special mirror, visor with focusing adjustments, a rugged frame, the essential motor parts, a synchronizing control and 60 line scanning disc.