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ELECTRIC DISCHARGE DEVICE

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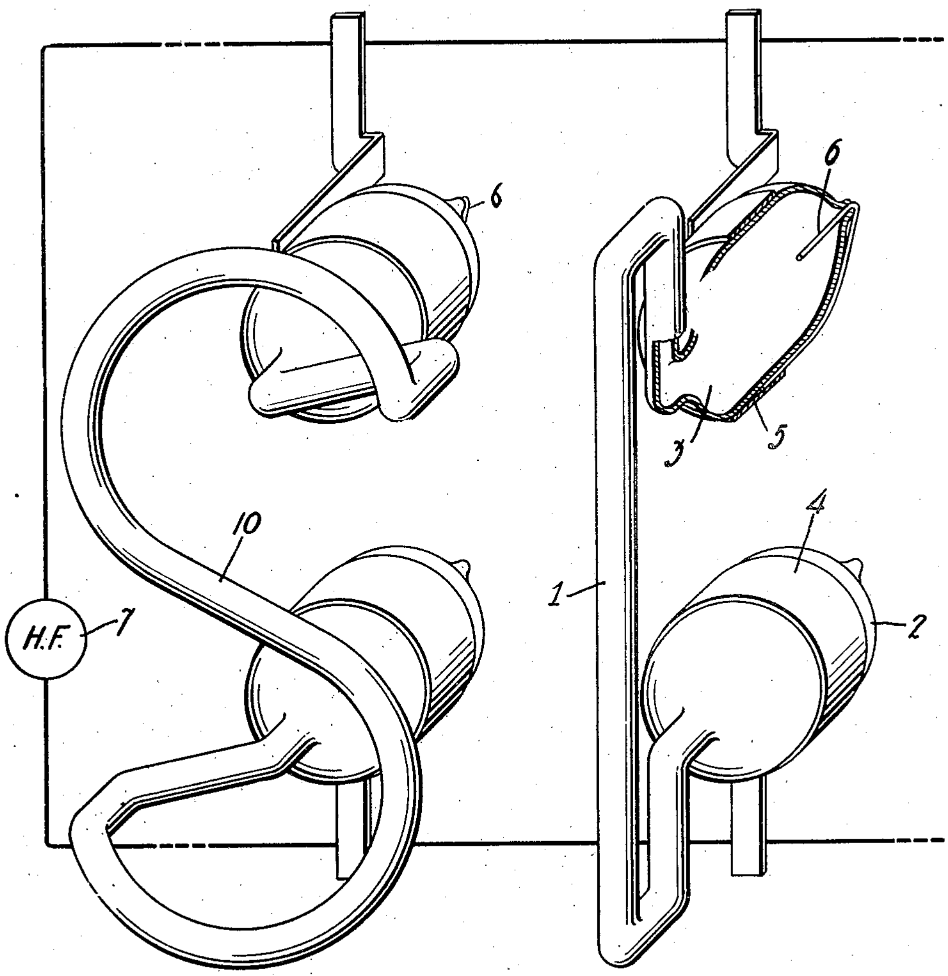

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UNITED STATES PATENT OFFICE

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ELECTRIC DISCHARGE DEVICE

Application filed November 9, 1926. Serial No. 147,298.

This invention relates to new and useful improvements in electric discharge devices and in their methods of manufacture and operation, and its particular object is the provision of a neon or other rare gas-filled luminous sign which has a long life, and may be economically operated in parallel with one or more other tubes.

It is well known that in electric discharge devices such as neon sign tubes or lamps, electrodes provided within the glass vessel must be carefully designed as to size, material and shape, and then skillfully treated to remove, as far as practicable, all occluded gases. The size is important because the current density must be kept below a certain maximum value for a given tube in order to reduce to the minimum objectional sputtering; and yet the larger the size the more difficult it is to remove occluded gases. A material must be selected which will sputter a minimum amount and yet can be commercially employed, and the shape must be such that no concentrated points of high current density can occur. Tubes with internal electrodes, even when carefully treated for removal of impurities, give trouble owing to continued sputtering of electrodes and to the high temperature of the tube, which causes expansion and contraction resulting eventually in minute cracks.

In order to counteract the former it has been suggested to provide means for increasing from time to time the rare gas content of the tube, but owing to their expensiveness and unreliability, such arrangements have not found great favor. The manufacture of this type of sign or illuminating device under commercial conditions where continual technical supervision is not always practical is quite troublesome, because procedure in one direction to avoid one kind of difficulty if carried too far brings in another difficulty and ordinary labor is not easily trained to carry on processes so precise.

In order to avoid expensive treatment of the electrodes and to guard against the ever present danger of excessive sputtering and occlusion of neon or other noble gas, it has been suggested to provide such electrodes on the outside of discharge tubes. However, in the operation of such devices new defects arise. Water vapor and gases in the glass wall of the vessel become liberated, the pressure increases, whereby the relative neon or other rare gas content of the tube is reduced to a point where the color of the discharge changes or the tube ceases to operate. When the pressure rises or the percentage of impurities increases to the point where the color changes or the resistance increases sufficiently to stop the discharge, there being no metal in the tube to sputter, it is impossible to do anything to bring it back to operating condition.

An important advantage of external electrodes resides in the possibility of operating two or more independent tubes in parallel from the secondary of a transformer irrespective (within practical limits) of the lengths of such tubes. An advertising sign may be made up of separate and interchangeable letters and the latter operated in parallel from a common source of current supply without the necessity of providing separate transformers or condensers for the individual letters. With internal electrodes, a short tube, e. g., one representing the lettter "I", would tend to short-circuit a long tube, e. g., "S", if the two were connected in parallel to the secondary of a transformer.

However, for the above mentioned reasons, the art generally adhered to the use of inside electrodes which, if of proper size or supplemented by auxiliary electrodes, could be relied upon to eliminate the impurities and operate for awhile (2–4 thousand hours). This necessitated the forming of entire words or groups of letters of a single tube and the obvious advantages of an interchangeable letter sign could not be availed of.

In accordance with the present invention an electric discharge device is so constructed that the advantages of external electrodes are obtained without any of the attendant disadvantages. Tubes constructed in accordance with the present invention can be operated in parallel on the secondary of a transformer for very long periods of time without the necessity of repairs or other attend-

ance to maintain intact the original gaseous content thereof.

I have found that neon tubes provided with two external electrodes and a single cooperating internal electrode retain their luminosity and their original color for very long periods of time. In this connection it should be noted that discharge tubes made in accordance with the present invention have been successfully operated for seven thousand hours, when the test was abandoned solely because no further proof as to life was thought necessary. The probable reason for this seems to be that in normal use the gases, water vapor, etc., which may be driven out of the walls of the vessel are forced by the discharge to combine with the particles of metal sputtered from the internal electrode which may be a fine copper wire. Current indicating instruments inserted in the branch circuits of a mature tube (one that has operated two thousand hours) show that the current at 60 cycles divides so that less current flows through the condenser electrode (external) than through the internal electrode. The proportional current flow is affected by the relative dimensions of the external and internal electrodes and also by the frequency of applied current. During the life of the tube most of the current flows continuously through the internal electrode. Prior to curing, maximum current flows through the external and minimum current through the internal electrode. In a cured tube, maximum current flows through the internal and minimum current through the external electrode. Furthermore, the currents flowing through these electrodes seem to be displaced in phase. At a frequency of 60 cycles the displacement was found to be of 180°. The phase of the current flowing through the external electrode lead the impressed E. M. F. A tube constructed in accordance with the description to follow may be heated with a gas flame so that gases are driven out of the glass walls until the neon color is changed to a thin yellow or pink, in fact the glass may be heated hot enough to bend it, and the tube will appear spoiled, yet in from ten minutes to an hour of normal operation, the original color will be entirely restored. I have even found that a leak, if not too bad, may be counteracted by this arrangement. The question immediately arises as to why the tube does not "go hard" as the ordinary type of internal electrode tube does. The answer may be that while impurities such as oxygen, hydrogen, etc., unite chemically with the molecules, atoms or ionized particles knocked loose from the internal electrode, the noble or inert gases, helium, neon, argon, krypton and xenon, are only entangled mechanically and carried over to the wall of the glass envelope. In normal operation the current that flows through the external electrode to and from the metallic or conducting coating which is formed on the inside wall of the vessel in the initial curing of the tube, very possibly causes breaking down of the metallic part of this coating which has entangled the neon and consequently liberates the neon as fast as the sputtering of the internal (wire) electrode entangles it. Whether this is the correct theory or not, the external electrode functions to aid the gas regulation in some manner, because if it is omitted the tube will "go hard" in a short time. The fact that the current through the external electrode is displaced in phase may be important.

In order more clearly to explain the nature of the present invention, I have schematically illustrated one embodiment in the drawing.

1 is a tubular glass vessel representing the letter "S" and having bulging ends 2 and 3 provided with the usual tips. 4 and 5 are the external electrodes in the form of tinfoil wrappers around the bulging ends and 6 is a fine copper (or other sputterable material) wire projecting through the tip of the end 3 within the vessel. The outside end of the wire 6 is bent back after curing and maintained in contact with the external electrode 5. The external electrodes must be spaced from the tips and particularly from the tip through which the electrode 6 passes. The vessel is exhausted through the tip of the bulging end 2. The tube is filled with neon and is operated from a high frequency current source 7 which is bridged across the electrodes 4 and 5. For the curing of the tube any well known getter may be used to accelerate the process and high frequency source 7 is connected between the electrode 4 and the copper wire 6 until the water vapor or gases have been eliminated, which is indicated by a deep orange color in the case of neon, by the sputtering of the wire 6. During this curing process a dark film or coating is formed on the inside of the wall of the vessel opposite the wire 6. This coating is conductive, showing that some copper, magnesium or whatever metal is used for electrode 6, has been detached from this electrode and driven away from it by the action of the applied electric stress. The metal in this peculiar ionized or unstable state probably combines chemically with any gases or vapors in the tube that have an uncompleted ring of electrons in the outer shell and the resultant particle which finally impinges against the wall of the vessel may be, for example, copper oxide, although many particles of the metal alone reach the surface of the glass wall.

The noble gases, such as neon, etc., which are believed to have 8 electrons in the outer shell, and thus are not readily susceptible to chemical union, may be to some extent entangled or occluded by the flying particles,

but the combination is perhaps not permanent and are probably broken up if again subjected to electric stress.

In the construction of such tubes care must be exercised in establishing sufficiently high neon pressures. In large tubes, pressure may be of the order of two mm. mercury, but in small tubes, the pressure must often be carried as high as four mm. mercury.

The tube 1 may be formed into any desired shape such as letters, numerals or figures, and will operate in parallel as indicated at 10. The tube 10 represents the letter "S" and is provided with two external and an internal electrode like tube 1. As clearly shown in the drawing, the individual letters may be readily connected in circuit by pushing the electrodes into socket openings where they may be suitably held by means of spring contacts or the like. The construction of such sockets is more fully described in my copending application Serial No. 139,223, filed October 2, 1926.

I have found that best results are obtained by having external electrodes of a large area. Instead of the copper wire 6, other material may also be used for the internal electrode and the high frequency source may be replaced by a low frequency current generator. Other variations and adaptations of the invention will be apparent to those skilled in the art.

What I claim is:

1. In combination, a glass tube having tipped bulging ends and filled with neon gas, a separate sheet of conducting material wrapped around each of said bulging ends respectively but spaced from the tips, a thin copper wire projecting through the tip within a single one of said bulging ends, the outwardly projecting end of the wire being bent back and contacting with the surrounding conducting wrapper and a source of current bridged across the conducting wrappers.

2. The method of making and operating gas filled luminous signs which comprises providing an external and an internal electrode, bridging a source of current across said electrodes until the sign is "cured", then connecting said internal electrode with a second external electrode, and bridging a current source across said external electrodes.

3. The method of making and operating neon filled luminous signs which comprises providing an external and an internal electrode, bridging a source of high frequency current across said electrodes until the sign is "cured", then connecting said internal electrode with a second external electrode, and bridging current source across said external electrodes.

4. An electric discharge device comprising, in combination, a hermetically sealed vessel, and two relatively spaced electrical discharge means providing for electrical connection to said container, one of said discharge means consisting of electrically connected and substantially concentrically arranged internal and external electrodes and the other of said discharge means consisting solely of an external electrode.

In testimony whereof, I have signed my name to this specification, this 8th day of November 1926.

WILLIAM F. HENDRY.