United States Patent

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[54] **GASEOUS ELECTRIC DISCHARGE TUBE INCLUDING A PLURALITY OF PUNCTURABLE GAS STORAGE CELLS**
4 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **313/177,** 206/0.4; 331/94.5
[51] **Int. Cl.** **H01j 17/26**
[50] **Field of Search** 313/177, 174; 206/0.4, 0.6; 315/108; 331/94.5

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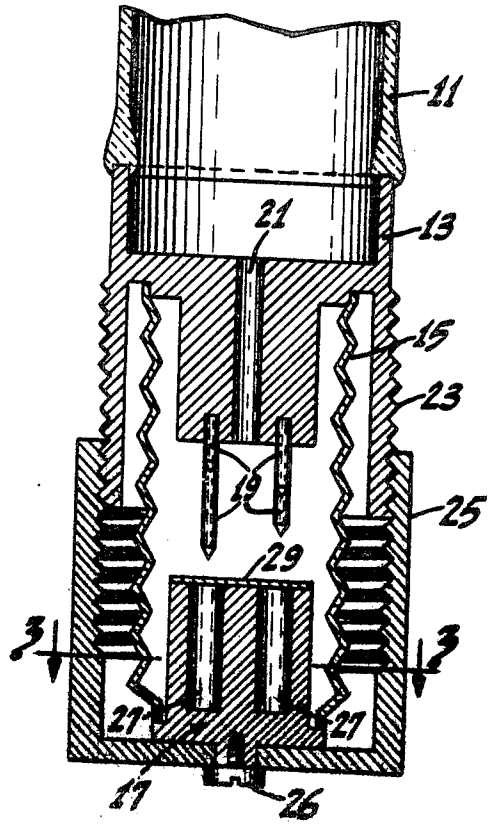
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ABSTRACT: A replenishable gas discharge tube comprises a plurality of closed cells within the tube envelope, each cell containing a quantity of the ionizable gas, and means operable from outside the tube envelope for successively opening the cells to release the gas within the envelope.

In one form of the invention, a plurality of pins are appropriately arranged within the tube envelope, which comprises a gas-tight bellows. The pins are caused to successively puncture the covers of the closed cells by increasing the engagement of two threaded members engaged outside the envelope, which movement is permitted by the bellows.



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Fig. 1.

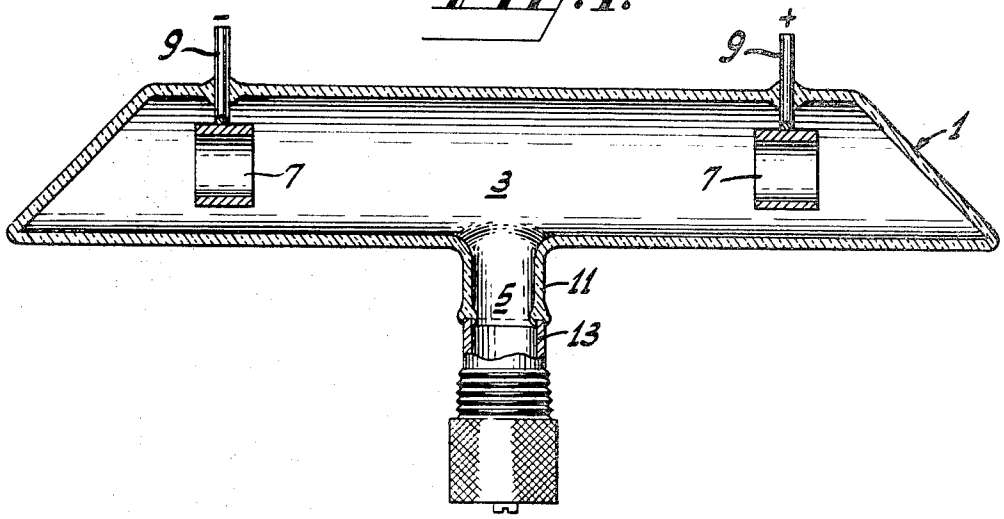


Fig. 2.

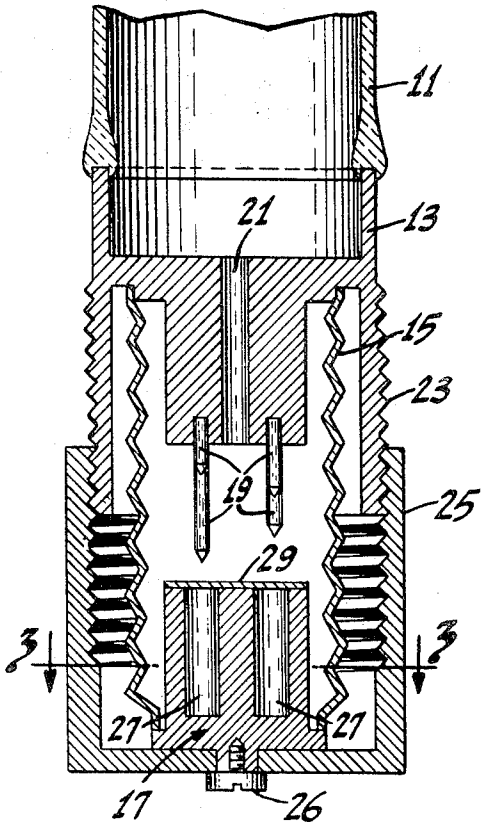
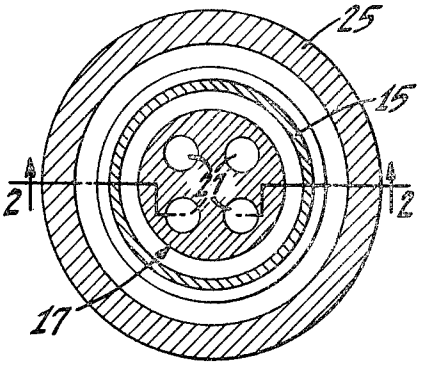


Fig. 3.



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GASEOUS ELECTRIC DISCHARGE TUBE INCLUDING A PLURALITY OF PUNCTURABLE GAS STORAGE CELLS

BACKGROUND OF THE INVENTION

This invention relates to gas discharge tubes and, particularly, to an improved construction for replenishing these devices by internal means operable from outside the tube envelopes.

Under normal operation, gas discharge tubes such as laser and lamp devices are often subjected to processes resulting in gas cleanup within the tubes. For example, sputtering and consequent absorption may reduce the amount of ionizable gas in an operating argon laser tube. Within any such tube, the decrease in gas pressure may be sufficient to prevent further satisfactory operation of the tube. The tube is then discarded or it is replenished with ionizable gas. The tube can be replenished by unsealing it to the atmosphere, refilling it by external means, and then resealing it. However, this procedure is costly and inconvenient.

Gas discharge tubes can also be replenished by internal means. In one type of tube construction, a pressurized container of ionizable gas is permanently appended to the tube through a leak valve which is opened and closed as required. However, the overall size of the device may be prohibitive. Also, leak valves can be costly and troublesome to operate. In another type of tube construction, a frangible ampul containing the ionizable gas is contained within the tube envelope. The ampul is placed in such position that it may readily be shattered as required. For glass envelope discharge tubes, the ampul may be shattered by high frequency induction; for metal envelope tubes, it may be shattered by deformation of the envelope. However, these techniques necessitate auxiliary equipment to shatter the ampul.

SUMMARY OF THE INVENTION

In accordance with the present invention, a gas discharge tube comprises a plurality of closed cells within the tube envelope, each cell containing a quantity of the ionizable gas, and simple means operable from outside the envelope for successively opening the cells to release the gas therewithin. The tube may employ a plurality of pins appropriately arranged within the envelope to successively puncture the covers of the closed cells. The pins and cells may be initially separated by means of two rigid threaded members engaged outside the envelope, which comprises a gastight metal bellows. A relative rotation increasing the engagement of these members moves the cells toward the pins, which movement is permitted by the bellows.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in greater detail in connection with the accompanying sheet of drawings, wherein:

FIG. 1 is a side view, partly in axial section, of a typical gas discharge tube, for example a gas laser tube, having an envelope with a tubular appendage;

FIG. 2 is an enlarged side view, partly in axial section along line 2–2 of FIG. 3, of the appendage in FIG. 1; and

FIG. 3 is a sectional view along line 3–3 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 depicts a typical gas discharge tube, e.g., a gas laser tube, comprising a gastight envelope 1 containing an ionizable gas such as argon. The tube envelope comprises a long hollow body 3, which may be of glass, to which a tubular appendage 5 is joined. The body 3 contains at least two electrodes 7 connected to two terminals 9 extending through the envelope 1 and across which is impressed a voltage for establishing an electrical discharge. The appendage 5 comprises a short tubular section 11, which may be made of glass, to which is sealed the upper part of a cylindrical member 13, which is made of metal. As shown in FIG. 2, the lower part of the member 13 is sealed to one end of a gastight flexible metal bellows 15 the other end of which is sealed to a cell assembly 17. The cylindrical member 13 contains a plurality of puncture pins 19 and a flow-through passageway 21 within the envelope 1. The lower part of member 13 comprises also an externally threaded male extension 23. The threads of extension 23, in turn, engage the mating threads of a female sleeve 25 to which the cell assembly 17 is rotatably attached by means of a screw 26.

The assembly 17 comprises a plurality of closed cells 27 equal to the number of pins 19, i.e. four as shown in FIGS. 2 and 3, each cell containing a quantity of the ionizable gas. The cells 27, having been filled prior to the incorporation of assembly 17 within the tube, are closed by a thin metal membrane 29, typically of copper, which may be brazed across the top of assembly 17. The positions of the pins 19 are such that they are axially aligned with respect to the cells 27, and their lengths are such that the initial spacings between the corresponding pins 19 and cells 27 increase progressively.

To increase the amount of ionizable gas, i.e., to increase the gas pressure, which may be decreased due to various processes resulting in gas cleanup within the tube the female sleeve 25 is rotated to increase its engagement with the male extension 23. This rotation, in turn, raises the cell assembly 17 closer to the puncture pins 19, which movement is permitted by the bellows 15. Sleeve 25 is rotated until the membrane 29 is punctured by the longest of the pins 19, thereby releasing the gas contained in the first of the cells 27 within the envelope 1.

If just prior to the puncture of the first of the cells 27, p_1 is the pressure of the gas within the envelope 1, V_1 is the volume of the gas within the envelope 1, p_c is the pressure of the gas within the first cells, and V_c is the volume of the gas within the first cell, then it can be shown that just following the puncture of the first of the cells 27, the pressure of the gas within envelope 1 increases by an amount equal to

$$\frac{V_c}{V_1+V_c}(p_c-p_1)$$

assuming p_c is greater than p_1.

When a further increase in the amount of ionizable gas is desired, sleeve 25 is rotated further until membrane 29 is punctured by the second longest of the pins 19, thereby releasing the gas contained in the second of the cells 27 within the envelope 1. Similarly, the third and then the fourth longest pins 19 are caused to puncture the membrane 29, to release the gas contained in the corresponding cells 27.

The example in FIGS. 2 and 3 shows four closed cells 27 and four corresponding pins 19; however, any plurality of cells and corresponding number of pins may be employed in the manner described above. Also, while the invention is shown in FIG. 1 as being embodied in a gas laser tube, it will be understood that it is not limited to this application.

In an alternative form of the invention (not illustrated) the cell assembly may comprise a plurality of closed gas cells disposed so that the cell covers are coaxial with one another within the envelope of the gas discharge tube. A single pin axially aligned with respect to the cell covers may then be employed to successively puncture the covers in the manner described above.

We claim:

1. A gas discharge tube comprising a gastight envelope containing an ionizable gas and including means for establishing an electric discharge, a plurality of cells closed by thin puncturable membranes and effectively disposed within said envelope, each cell containing a quantity of said gas, and means within said envelope and operable by means from outside said envelope for successively puncturing said membranes to release said gas within said envelope.

2. A gas discharge tube comprising a gastight envelope containing an ionizable gas and including means for establishing an electric discharge, a plurality of cells closed by thin puncturable metal covers and effectively disposed within said en-

velope, each cell containing a quantity of said gas, puncture pin means initially held in proximity to said cell covers within said envelope, and means operable from outside said envelope for adapting said cell covers to be successively punctured by said pin means, thereby releasing said gas within said envelope.

3. A gas discharge tube as set forth in claim 2, wherein said puncture pin means includes a number of puncture pins equal to the number of said cells, said pins being axially aligned with respect to said cells, and wherein the initial spacings between corresponding pins and cell covers increase progressively.

4. A gas discharge tube as set forth in claim 2, wherein said puncture pin means and said cell covers are initially separated by means and said cell covers are initially separated by means of two rigid threaded members engaged outside said envelope, which comprises a gastight bellows, and wherein said cell covers are adapted to be successively punctured by said pin means by increasing the external engagement of said threaded members, thereby decreasing the spacing between said pin means and said cell covers, which movement is permitted by said bellows.