Jan. 15, 1946. E. H. BICKLEY 2,392,969

PHOTOELECTRIC TUBE

Filed April 16, 1940 2 Sheets-Sheet 1

Fig. 1.

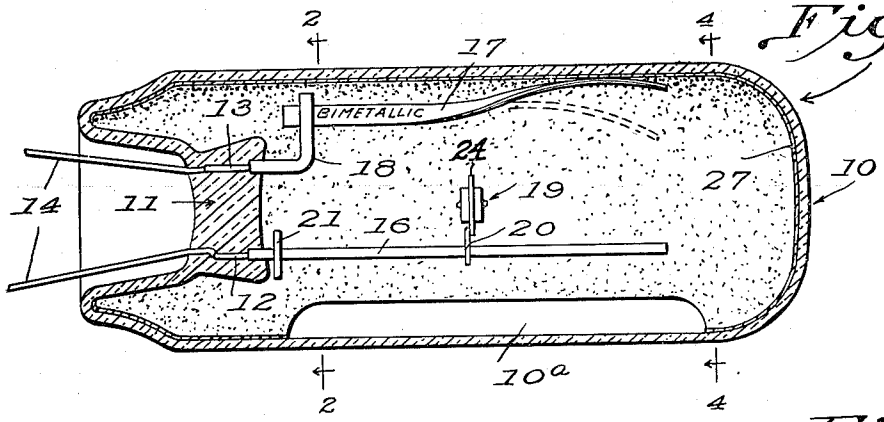


Fig. 4.

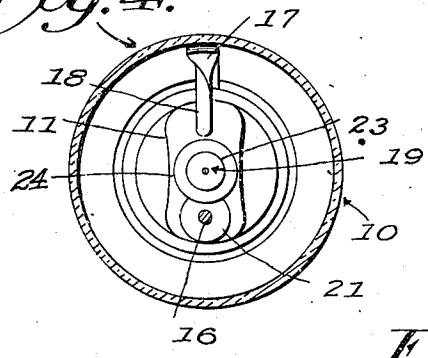


Fig. 2.

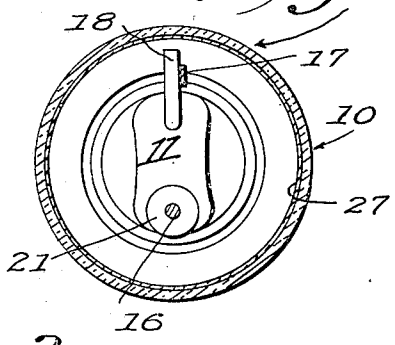


Fig. 3.

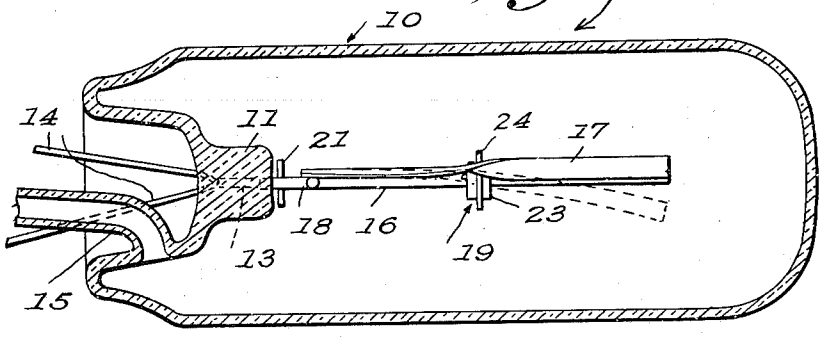
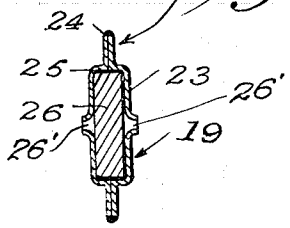


Fig. 5.



Inventor,
EVERETT H. BICKLEY,
By
Attorney,

Jan. 15, 1946. E. H. BICKLEY 2,392,969

PHOTOELECTRIC TUBE

Filed April 16, 1940 2 Sheets-Sheet 2

Fig. 6.

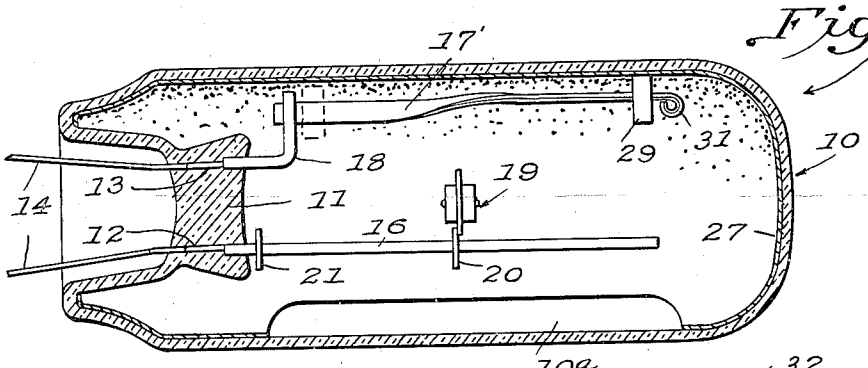


Fig. 9.

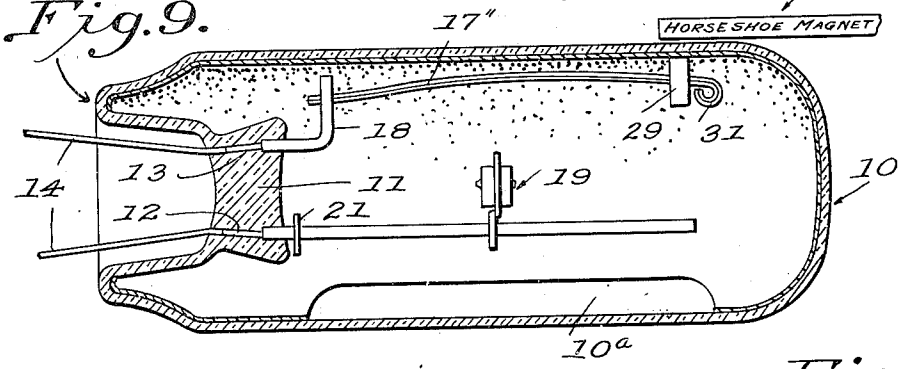


Fig. 10.

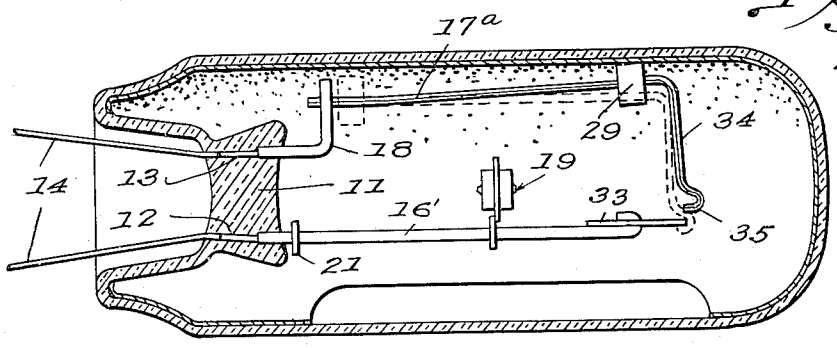


Fig. 7.

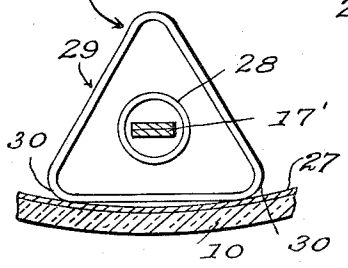
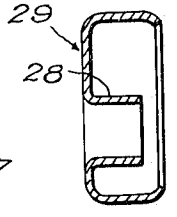


Fig. 8.



Inventor,
EVERETT H. BICKLEY,
By
Attorney.

Patented Jan. 15, 1946

2,392,969

UNITED STATES PATENT OFFICE

2,392,969

PHOTOELECTRIC TUBE

Everett H. Bickley, Bala Cynwyd, Pa.

Application April 16, 1940, Serial No. 329,953

18 Claims. (Cl. 250—165)

The present invention relates to radiation sensitive devices, and more particularly to those known as photoelectric tubes.

Generally, I aim to provide such a device as will be simplified in construction, of more permanent characteristics and longer life, and especially adaptable for relatively inexpensive, safe and uniform manufacture by quantity production methods.

A prime object is to provide a novel method and means whereby application of the cathodic light sensitive means at a location for engagement by a coacting contactor is assured.

It is also an object to provide the light sensitive means on the interior of the envelope of the tube by vaporization and condensation of a cartridge, and more specifically through the rise of temperature necessary for but prior to the vaporization of the cartridge to temporarily space the contactor therefrom so that the light sensitive means will be deposited on the envelope at the zone of contactor engagement when the vaporization occurs.

Another important object is to provide for establishing conductivity between cathodic light sensitive means and contactor selectively at a plurality of zones or locations, which especially enables expeditious correction of an inoperative, partially impaired or faulty condition attributable to faulty deposition, displacement or wear of the light sensitive means.

I further aim to provide a tube especially having great stability, speed and high response to the radiations in the spectral region commonly called blue and of shorter wave length.

I also aim to provide a novel form and composition of vaporizable cartridge used in the formation of the light sensitive electrode coating within the envelope or tube.

Various additional objects and advantages will become apparent from a consideration of the description following, taken in connection with the accompanying drawings, illustrating operative exemplary embodiments.

In said drawings:

Figure 1 is a central longitudinal sectional view through a photoelectric tube constructed in accordance with the invention;

Figure 2 is a cross sectional view taken on the plane of line 2—2 of Figure 1;

Figure 3 is a central longitudinal sectional view through the photoelectric tube of Figure 1 in the course of manufacture thereof, taken at right angles to Figure 1;

Figure 4 is a cross sectional view taken on the plane of line 4—4 of Figure 1; through the photoelectric tube at the same intermediate stage of manufacture as Figure 3;

Figure 5 is a diagrammatic sectional view through the vaporizable cartridge;

Figure 6 is a longitudinal sectional view taken through a modified form of construction;

Figure 7 is an enlarged detail partly in section, and showing the contact which may be employed;

Figure 8 is a longitudinal sectional view through the said contact;

Figure 9 is a longitudinal sectional view through another modified form of photoelectric tube; and,

Figure 10 is a longitudinal sectional view through a further modified form of photoelectric tube.

Referring specifically to the drawings, and first, to the form of Figures 1 to 5, 10 designates a suitably shaped bulbous evacuated envelope adapted to be mounted on a conventional base, or otherwise, as usual in the art. Said envelope may be of lime glass, fused quartz, or other non-conducting material which is not chemically detrimental to the materials or parts it encloses.

Said envelope has an inturned press 11 at one end thereof containing spaced apart short conductor wires 12 and 13 which are sealed in and by the glass when the latter is blown to provide the press and to the outer ends of which wires 12 and 13, exterior conductor leads 14 are welded. At the time the envelope with the press 11 is blown, an integral glass tube 15 (Figure 3) is attached through which the envelope is later evacuated.

Welded to the inner end of said wire 12 is an electron collecting electrode 16 which is relatively rigid and unbendable by heat. A contactor 17 is thermostatic so as to be bendable by heat to move both inwardly and sidewise away from its normal operative position engaging the inner wall of the envelope, as shown in full lines in Figures 1 and 3, toward electrode 16 to the dotted line positions in the same figures. Usually, contactor 17 is bimetallic and is welded to a connecting conductor 18, which, in turn, is welded to the inner end of the adjacent conductor wire 13. For the electrode 16 and connector 18, I preferably employ a metal having a thermal coefficient of expansion relatively high with respect to that of the material of press 11, so that on cooling, the metal will shrink away from the glass of the press leaving a space between such glass and the electrode 16 and conductor 18.

When the electrode 16 is secured in place, it carries a cartridge 19 welded or otherwise secured

thereto at connection 20, and also carries a small nickel, steel, tantalum or other metallic washer or disk 21 welded to the electrode 16 and normally spaced about $\frac{1}{32}$ of an inch from the press.

Said cartridge 19 generally corresponds to and functions like that disclosed in my copending application, Serial No. 282,972, filed July 16, 1939. Cartridge 19, as best shown in Figure 5, consists of a casing having similar disk-like halves 23 marginally welded together at 24. Said halves have reversed depressed portions or pockets 25 enclosing and intimately fitting a chemical pellet 26 and provided with central outlet ports 26', said pellet 26 being of materials intimately mixed and compressed and serving to center the halves 23 during the marginal welding thereof together at 24. The pellet 26 is preferably composed of 1.26 parts of dehydrated potassium chromate and 1.00 part of a fine metallic powder prepared from barium and aluminum alloy combined in the proportion of 1 part barium to 1 part aluminum, all parts mentioned and to be mentioned being by weight. If desired, from approximately 0.15 part to approximately 0.25 part, by weight, of finely powdered magnesium may be added. Where the pellet is too soft, aluminum powder can be used as a binder. I may substitute as the fine metallic powder, with 1.26 parts of highly compressed potassium chromate, 1 part of powdered magnesium and aluminum, combined in the proportion of 1 part magnesium to 1 part of aluminum. The proportions may be varied since pellets have been produced having 5 parts of potassium bichromate or potassium chromate down to ½ part of either potassium bichromate or potassium chromate to 1 part of the fine metallic powder. The potassium chromate is preferred over potassium bichromate because less gas is evolved and the pellets can be made smaller, since a large quantity of the potassium bichromate has to be used in proportion to the metallic powder to obtain the same yield of potassium.

The envelope 10 is usually transparent and provided at any desired location with a window 10*a* for the reception of the desired radiations by the tube.

The parts are all assembled as described before the envelope 10 is evacuated and before vaporization of the pellet 26 in cartridge 19, the tube at such stage being as shown in Figures 3 and 4. The gases and vapors are evacuated from the envelope 10 in any known manner through the tube 15, following which the tube is thoroughly baked at high temperature and the metal parts are heated by electro-induction or other means until all absorbed and adsorbed gases and vapors are driven off. Thereafter, the cartridge 19 is subjected to additional heating of a higher degree, sufficient to decompose the pellet and release the vapors therefrom through ports 26' which vapors condense on and adhere to the inner surface of the envelope which is relatively cool to form the light sensitive cathode film 27. After additional evacuation to a high point, the tube 15 is sealed off with a torch. Before sealing off, a small amount of inert gas such as argon may be introduced or hydrogen sensitization may be used according to known methods. Electrode 16 constitutes an anode coacting with the cathode 27, and they are insulated from each other by the glass of the envelope at the press.

Attention is particularly called to the fact that upon subjecting the device to heat, the contactor 17 will be heated and will move inwardly and sidewise from the full line position shown in Figure 1 to the dotted line position in the same figure, thereby exposing that portion or zone of the inner surface of the envelope 10 which it normally engages, and, hence, during vaporization, the vapor from the cartridge will enter such zone and deposit and condense thereat, the contactor 17 upon cooling automatically moving to its original or normal position and engaging the film 27 at such zone. It is also to be noted that when the cartridge 19 is heated, the disk 21 also becomes heated, and during the vaporization of the pellet 26, the disk 21 prevents condensation of conductive material thereunder. In a vacuum, vapors move in straight lines from their source until condensed. They are reflected from any heated object and for that reason the contactor 17 is moved sidewise and away so that no "shadow" will be formed on the envelope where it normally rests when at room temperature. Should the vapor condense on the press and short circuit the elements 16 and 18, when the tube is in use, induced radio frequency eddy currents may be used to heat the washer 21, thus driving away the condensation and eliminating leakage.

Various changes may be resorted to provided they fall within the spirit and scope of the invention. For instance, I may use the modified form of Figure 6. This form corresponds to that just described, except as follows: The contactor 17' corresponds to that at 17 and like the former, is thermostatic, being of one kind of metal or bimetallic, as preferred. Surrounding the contactor 17' at the neck or collar 28 (Figures 7 and 8) is a metallic contact 29. This contact 29 may be of any suitable shape and, for instance, capable of being manufactured by stamping. As shown, it is triangular in form.

As the photoelectric tube of Figure 6 is manufactured, the distal end portion of the contactor 17' is in engagement with the electrode 27, as in Figure 1, and the contact 29 is out of engagement with such electrode 27, being in a retracted position, shown by dotted lines in Figure 6.

Should engagement or contact between the electrode 27 and contactor 17' be faulty at the time of manufacture or become faulty in use from wear or for various reasons, effective contact may be reestablished by disposing the photoelectric tube of Figure 6 in an inverted position whereby the contact 29 is uppermost, thereupon subjecting the photoelectric tube to a jolt which causes the contact 29 to slide from the dotted line position of Figure 6 to the full line position of the same figure. Attention is called to the fact that the contact 29 is so proportioned that a part thereof wedges between electrode 27 and the contactor 17' so that the latter is under tension when the contact 29 is in the position of Figure 6 and, hence, effective engagement of the latter with the electrode 27 is maintained. Also note that, as best shown in Figure 7, the contact 29 at a plurality of spaced locations 30, is in engagement with electrode 27 to insure effective engagement. This contact 29 is held in the full line position of Figure 6 by the frictional tension of contactor 17', in addition to cohesion between the contact 29 and electrode 27.

The distal end of the contactor 17' may be curled or otherwise enlarged at 31 to prevent disengagement of the contact 29 therefrom.

Since the contact 29 engages electrode 27 at spaced locations, which are on opposite sides of and out of the zone of engagement of contactor 17' with electrode 27, the photoelectric tube may

be manufactured with the contactor 17' without thermostatic properties because after deposition of the electrode 27, the contact 29 could be jolted from the dotted line position of Figure 6 to the full line position thereof, and retained in place through the frictional tension of the contactor 17' and engaged at the two locations 30 with electrode 27.

The form of Figure 9 corresponds to that of Figure 6, with the exception of the contactor shown at 17'', which corresponds to those shown at 17 and 17'. This contactor 17'' may be made of one kind of metal or bimetallic, as preferred, but usually has a metal wire of a single kind of metal and normally of arcuate shape, as shown. The contact 29 is also employed, being mounted on the contactor 17'' to function in the same manner as in Figure 6.

The contact 29 is of a metal which may be attracted by a horseshoe magnet and, hence, by moving the magnet along the outside of the envelope, the contact 29 may be moved from the dotted line position in Figure 6 to the full line position shown in Figures 6 and 9, the horseshoe magnet being fragmentarily suggested in the latter figure.

In Figure 10, a mica, metallic or other extension 33 is attached to an electrode 16' corresponding to that at 16, and a contactor 17*a* is employed in lieu of those at 17, 17' and 17''. This contactor 17*a* is resilient, being a wire, of a single kind of metal or bimetallic, as preferred. This contactor 17*a* has an angular extension 34 provided with a hook at 35 adapted for detachable engagement with the distal end of extension 33, as shown in dotted lines in Figure 10, whereby the contactor 17*a* throughout is spaced from the electrode 27. The contactor 17*a* is in such dotted line position when assembled in the photoelectric tube and the latter is evacuated and the cartridge 19 vaporized. Following deposit of electrode 27 through such vaporization, the photoelectric tube may be inverted, causing the contact 29 to slide into the solid position shown and then the tube is jarred or jolted to effect the disengagement from hook 35 through extension 33, so that the resilience of contactor 17*a* or the contact 29 will engage the electrode 27.

Attention is called to the fact that the terms "contactor" and "contactor means" as used in the claims are of a breadth to include not only an element like 17, 17', 17'' or 17*a*, but also an element 17, 17', 17'' or 17*a*, or any equivalent, plus the element or contact 29, or any equivalent, as a part thereof.

I claim as my invention:

1. A photoelectric tube having an envelope, contactable light-sensitive means therein, an electrode to coact with said means, a contactor means, said electrode and contactor means being mounted and sealed within said envelope, said contactor means being normally in engagement with said light-sensitive means and movable by inertia into and out of engagement with said light-sensitive means.

2. A photoelectric tube comprising an envelope having an electrode and a contactor therein, a photo-electric surface within said envelope normally engaged by said contactor, vaporizable means within the envelope to provide a light-sensitive deposit on said surface to coact with said electrode, said contactor being movable by heat of a degree insufficient to vaporize said means to expose said surface before vaporizing said means to enable deposition at the zone of engagement of the electrode with the said surface.

3. A photoelectric tube having an envelope, a light-sensitive electrode means therein, an electrode to coact with said electrode means, a contactor engageable with said electrode means, and a contact carried by the contactor and movable along the same to engage said electrode means.

4. A photoelectric tube according to claim 3 wherein said contact is sized and proportioned to wedge at a part thereof between the electrode means and said contactor to tension the latter to maintain the contact in the wedged position.

5. A photoelectric tube having an envelope, a photo-electric cathode therein, an electrode therein coacting with said cathode, a conducting support within the envelope, and a conductive contact variable as to position relative to the support and cathode held against said cathode by said support.

6. A photoelectric tube having an envelope, a light-sensitive cathode therein, electrode means and a contactor extending into the envelope, said contactor being tensioned to normally engage said cathode, and a separable connection between the contactor and electrode means to hold the contactor out of contact with the envelope at the zone of normal engagement, said connection being separable through jolting of the envelope.

7. A material to be vaporized within an envelope of a photoelectric tube to provide a cathode, the material comprising by weight, 1.26 parts of potassium chromate and 1.00 part of a fine metallic powder of a barium and aluminum alloy combined in the proportion of 1 part barium and 1 part aluminum.

8. A material to be vaporized within an envelope of a photoelectric tube to provide a cathode, the material comprising by weight, ½ to 5 parts of either of the group of potassium chromate or potassium bichromate, and 1 part of fine metallic powder of barium and aluminum mixed together.

9. A material to be vaporized within an envelope of a photoelectric tube to provide a cathode, the material comprising by weight, 1.26 parts of potassium chromate and 1.00 part of a fine metallic powder of a barium and aluminum alloy and combined in the proportion of 1 part barium and 1 part aluminum and from approximately 0.15 to 0.25 part of magnesium.

10. A material to be vaporized within an envelope of a photoelectric tube to provide a cathode, the material comprising by weight, 1.26 parts of potassium chromate and 1.00 part of a fine metallic powder of a barium and aluminum alloy combined in the proportion of 1 part barium and 1 part aluminum and aluminum powder as a binder.

11. A photoelectric tube having an envelope with a photo-sensitive cathode coating therein, an anode adjacent thereto, a movable contactor means, said anode and contactor means being mounted within said envelope, said contactor means being normally in engagement with said coating and movable into engagement with said coating at a plurality of zones of the latter.

12. A photoelectric tube having an envelope, a cathode therein, a conducting support within the envelope, a contact positioned by the support in engagement with the cathode, said contact being movable relative to the support through jolting of the latter to different points of engagement with the cathode.

13. A material to be vaporized within the en-

velope of a photoelectric tube to provide a cathode, the material comprising by weight, ½ to 5 parts of either of the group of potassium chromate or potassium bichromate, and 1 part of fine metallic powder of magnesium and aluminum mixed together.

14. The process of manufacturing a photoelectric tube having an envelope enclosing an anode, there being lead-in means for a photo-sensitive electrode comprising a bimetallic contactor, said process comprising heating said contactor to displace the contacting portion thereof from said envelope, and coating the inner surface of said envelope with a photo-sensitive material to form a photo-sensitive cathode including the area normally engaged by said contactor.

15. The process of manufacturing a photoelectric tube having an envelope enclosing an anode, there being lead-in means for a photo-sensitive electrode comprising a bimetallic contactor, said process comprising heating said contactor to displace the contacting portion thereof from said envelope, and coating the inner surface of said envelope through subjection of the photo-sensitive material to heat of a temperature higher than during the aforesaid heating to form a photo-sensitive cathode including the area normally engaged by said contactor.

16. The process of manufacturing a photoelectric tube having an envelope enclosing an anode, there being lead-in means for a photo-sensitive electrode comprising a bimetallic contactor and a contact movably mounted thereon, said process comprising heating said contactor to displace the contacting portion thereof from said envelope, and coating the inner surface of said envelope with a photo-sensitive material to form a photo-sensitive cathode including the area normally engaged by said contactor, and positioning said contact by inertia.

17. The process of manufacturing a photoelectric tube having an envelope enclosing an anode, there being lead-in means for a photo-sensitive electrode comprising a bimetallic contactor and a contact movably mounted thereon, said process comprising heating said contactor to displace the contacting portion thereof from said envelope, and coating the inner surface of said envelope with a photo-sensitive material to form a photo-sensitive cathode including the area normally engaged by said contactor, and magnetically moving said contact on the contactor to position the contact relatively to the photo-sensitive cathode.

18. A capsule for vaporization to provide a cathode vapor comprising initially separate disks having opposed depressions, a vaporizable compressed pellet within and of a size filling and intimately fitting the depressions to cause registry of the disks in manufacturing the capsule, the walls of the depressions having discharge ports, and means marginally securing the disks together against rupture during discharge through the said ports.

EVERETT H. BICKLEY.