# United States Patent

[11] 3,572,877


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[33] **Japan**
[31] **43/15580 and 43/59833**


[54] **APPARATUS FOR MANUFACTURING DISCHARGE TUBES**
**7 Claims, 7 Drawing Figs.**


[52] **U.S. Cl.** ..... **316/30,** 316/24
[51] **Int. Cl.** ..... **H01j 7/20**
[50] **Field of Search** ..... 316/30



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**ABSTRACT:** In a method and apparatus for manufacturing a discharge tube wherein an envelope of the discharge tube is connected to an evacuating pipe system to be evacuated and charged with an inert gas and operating substances required through the evacuating pipe system, said system is provided with a closable opening and while the inert gas is being discharged through the opening a capsule carrying the operating substance is inserted into the pipe system through said opening to charge the operating substance into the envelope.

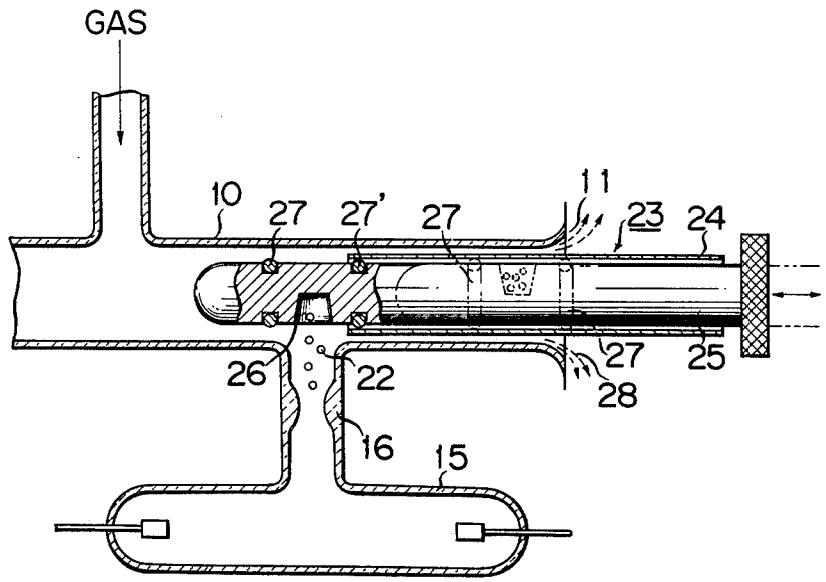



FIG. 1

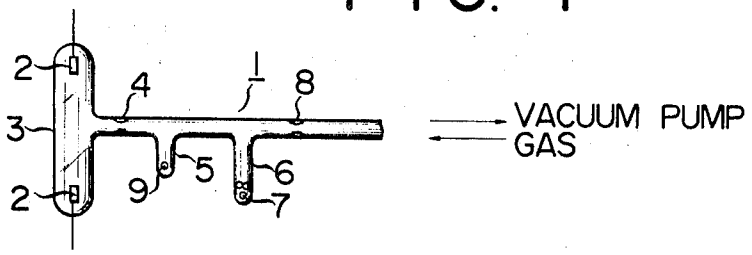



FIG. 2

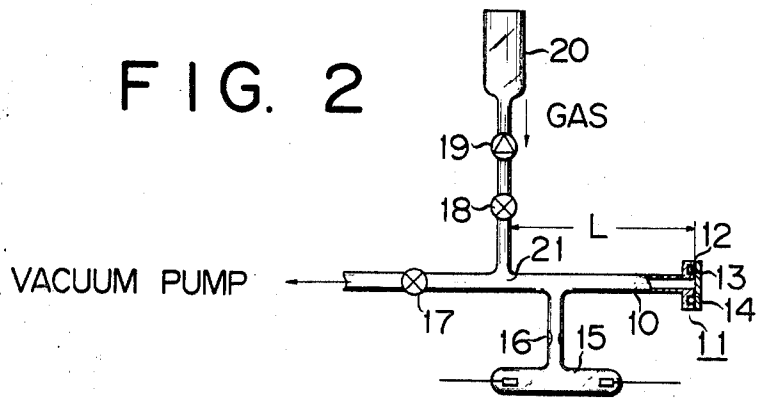
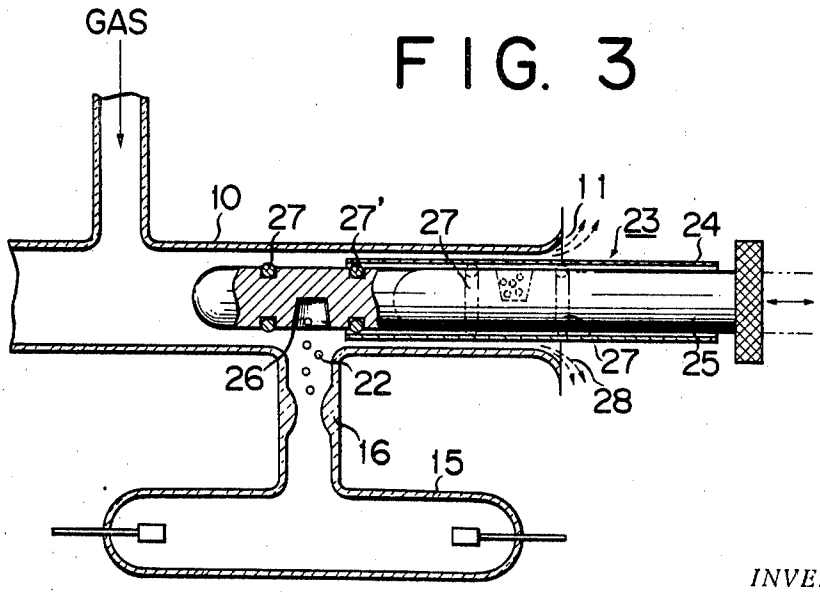



FIG. 3




*INVENTOR.*

*BY*

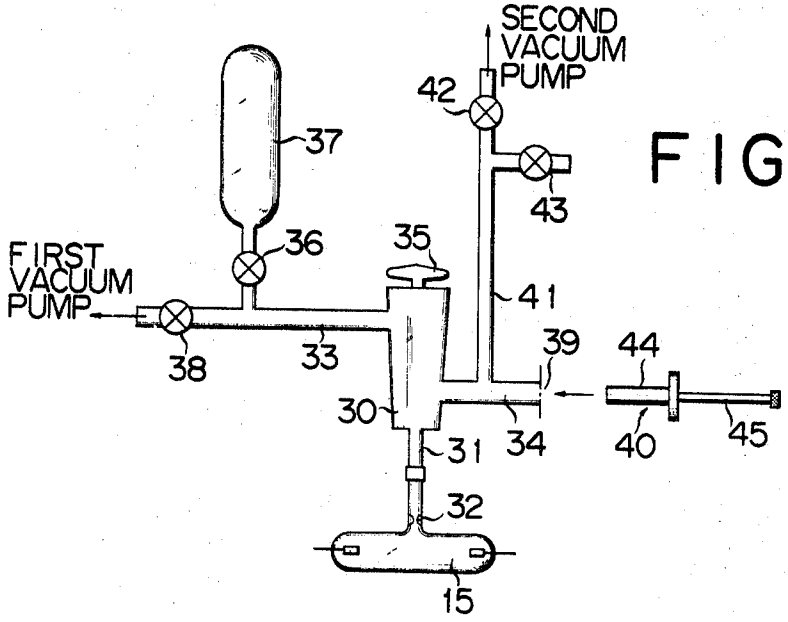

SECOND
VACUUM
PUMP
42
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43
FIRST
VACUUM
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FIG. 4

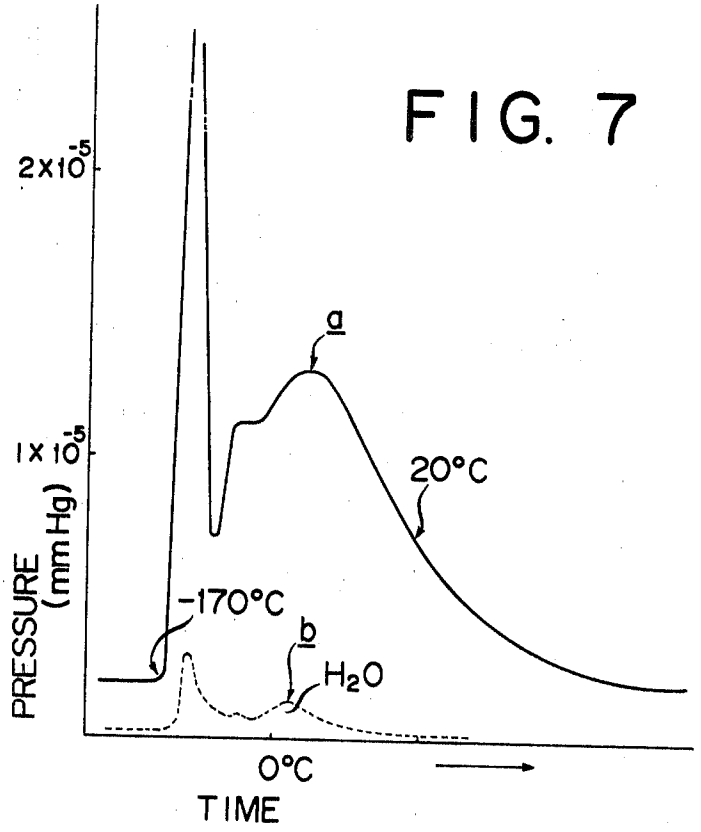

2x10⁻⁵
1x10⁻⁵
PRESSURE (mm Hg)
a
20°C
-170°C
b
H₂O
0°C
TIME

FIG. 7

FIG. 5

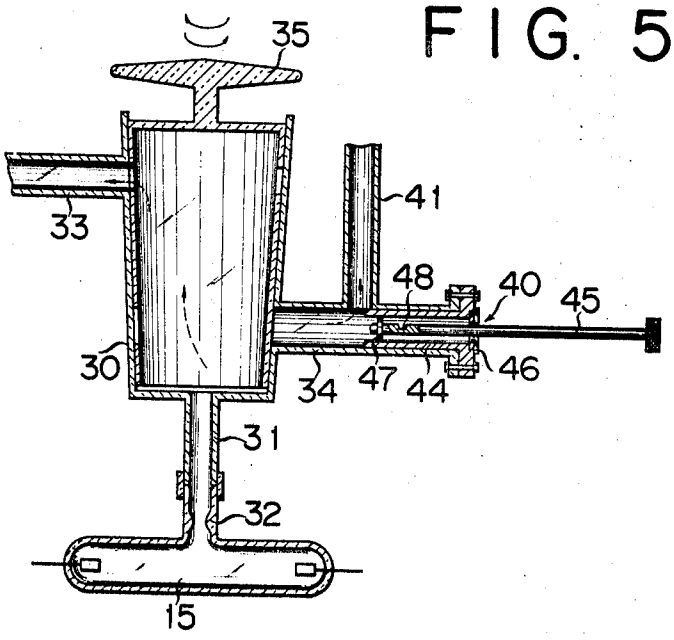
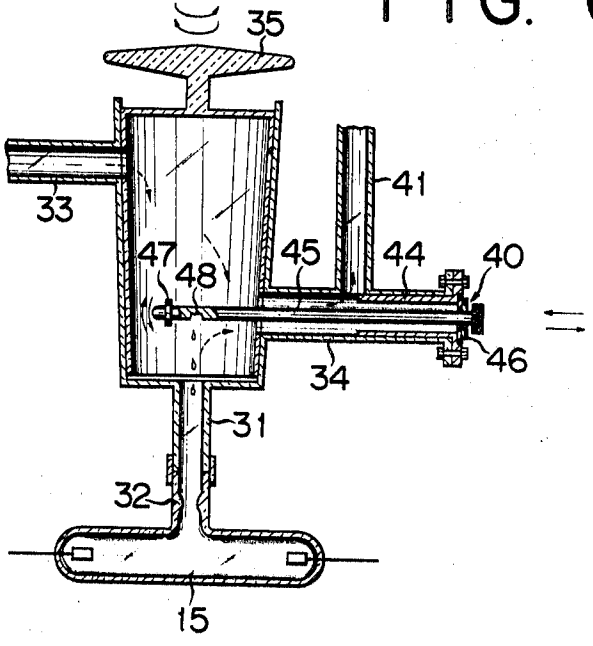

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FIG. 6


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# APPARATUS FOR MANUFACTURING DISCHARGE TUBES

This invention relates to a method and apparatus for manufacturing discharge lamps or tubes containing an inert gas and one or more operating substances sealed therein.

In the manufacture of discharge tubes, for example, discharge lamps containing a mixed vapor of metals, in addition to an inert gas, a small quantity of operating substances such as mercury and metal halides are sealed in the tubes. These metal halides have a property to absorb moisture when exposed to the atmosphere, so that when moisture is inadvertently admitted into discharge lamps of this type during their manufacturing steps the characteristics of the lamps will be greatly impaired. Thus, it is necessary to prevent these metal halides from absorbing moisture or to keep them without exposing to the atmosphere during the manufacturing steps of the lamps.

FIG. 1 shows a typical prior apparatus for manufacturing discharge lamps with due regard to this point. Thus, a glass envelope 3 mounted with electrodes 2 and adapted to form a discharge lamp is connected to one end of an evacuating pipe system 1 made of glass through a chipoff portion 4. Spaced apart branch pipes 5 and 6 are connected to the evacuating pipe system. The other end of evacuating pipe system is connected to a vacuum pump (not shown) and to a source of inert gas to be filled in, for example, a source of argon gas, not shown, through a second chipoff portion 8. Branch pipe 6 contains one of the operating substances to be closed in, for example, a metal iodide 7 while branch pipe 5 contains mercury 9.

In the arrangement shown in FIG. 1 the entire system is evacuated to a high vacuum by the vacuum pump. After admitting argon gas under a desired pressure into the envelope the chipoff portion 8 is sealed off and then the envelope 3 and branch pipes 5 and 6 are separated from the remainder of the system. The separated portions are then suitably slanted to transfer operating substances contained in branch pipes 5 and 6 into the envelope. Thereafter chipoff portion 4 is sealed off and the envelope is separated from the evacuating system, thus completing a discharge lamp.

However, the above described method has following defects. More particularly, (I) As operating substances such as mercury 9 and metal diode 7 are contained in the same vacuum system as the envelope 3 it is impossible to create a high degree of vacuum. Further, as the degree of vacuum that can be attained shoes the state of driving off impurities occluded in the inner wall of the envelope and electrodes where it is not possible to attain the desired high vacuum with the presence of the operating substances in the branch pipes there is no way to confirm that the envelope 3 has been evacuated to the desired extent. (II) Said operating substances tend to cause a loss in quantity due to spattering or decomposition during the baking process, whereby the quality of produce will not be uniform. Further, decomposed products tend to accumulate on cold portions of the evacuating system to rapidly deteriorate the evacuating ability thereof. (III) The moisture that has been contained in the decomposed products or substance 7 tends to deposit on the mercury 9 contained in branch pipe 5, and the deposited mositure is difficult to be completely removed from the system. (IV) Provision of branch pipes for exhaustion of each discharge lamp complicates the process steps as well as the construction of the evacuation system.

It is therefore an object of this invention to provide a new and improved method and apparatus for fabricating high quality discharge tubes by a simple process without accompanying difficulties described hereinabove.

Briefly stated, in accordance with this invention, there is provided a method of manufacturing a discharge tube having an envelope in which an inert gas and a predetermined amount of operating substances are sealed, said method comprising the steps for evacuation of an evacuating pipe system and the envelope connected thereto through a chipoff portion, supplying said inert gas to said envelope and said evacuating pipe system, discharging said inert gas through an opening of said evacuating pipe system, inserting said operating substance into said evacuating pipe system through said opening so as to supply said substance into said envelope while said inert gas is being discharged through said opening, said substance being hermetically sealed against the atmosphere, adjusting the pressure of said gas in said envelope to a predetermined value, and sealing off said chipoff portion to separate said envelope from said evacuating system.



The apparatus for carrying out the method outlined hereinabove comprises an evacuating pipe system in the form of a manifold including a closable opening, a first and a second flow circuits respectively connected to a vacuum pump and to a source of inert gas and a third circuit, one end of said third circuit opening between said second circuit and said closable opening, the other end of said third circuit being connected to an envelope of a discharge tube through a chipoff portion; and means which is inserted into said evacuating pipe system through said closable opening to supply a selected operating substance into the envelope without exposing said substance to the atmosphere.

The invention is now described in conjunction with a preferred embodiment with reference to the accompanying drawings, in which:

FIG. 1 is a schematic representation of a prior apparatus for explaining the prior method of manufacturing discharge tubes;

FIG. 2 is a diagram, partly in section, of the apparatus for carrying out this invention;

FIG. 3 is an enlarged sectional view of a portion of the apparatus shown in FIG. 2;

FIG. 4 is a diagram to show a modified apparatus for carrying out this invention;

FIG. 5 shows an enlarged sectional view of a portion of the apparatus shown in FIG. 4 to show the communication between a first evacuating system and an envelope;

FIG. 6 is a view similar to FIG. 5 but wherein the communication between first and second evacuating systems and the envelope is interrupted; and

FIG. 7 is a diagram to show the effect resulting from discharging an inert gas from the opening of a system according to the invention.

One embodiment of this invention will now be described by referring to FIGS. 2 and 3 of the accompanying drawings. On one end of a manifold 10 is provided a closable opening 11 which may comprise a flange 12, an O-ring 13 fitted in a groove in the flange and a cover plate 14 clamped against the O-ring by means of bolts, not shown. An envelope 15 of glass is connected to a branch pipe of the manifold through a chipoff tube or portion 16. The opposite end of the manifold is connected to a vacuum pump, not shown, through a valve 17. A reservoir 20 of a gas to be filled in the envelope 15 is connected to the portion of the manifold intermediate the valve 17 and chipoff tube 16 through a valve 18 and a flow rate adjusting valve 19. Supply of the operating substances is effected while discharging the gas from the reservoir 20 into the surrounding atmosphere by removing the closure plate 14. It is advantageous to select the distance $L$ between the inlet opening 21 of the gas and the opening 11 such that the gas flows through the manifold in the form of a laminar flow although it is not always essential. Although distance $L$ is determined according to the configuration of the closable opening 11 and the inner diameter of the manifold, such condition for laminar flow can be provided by selecting the distance $L$ to be equal to $5.7 \times 10_1^2\ dRe$, where $d$ denotes the inner diameter of the manifold and $Re$ the Reynolds number.

As a means for supplying an operating substance 22 (including a material to be closed in the envelope) through opening 11, a capsule 23 shown in FIG. 3 may be utilized. Capsule 23 comprises a cylindrical sheath 24 made of stainless steel and the like and a spindle 25 free to slide in the longitudinal direction of the sheath. A depression 26 is formed one end of the spindle to carry the operating substance 22 and on the opposite sides of the depression there are provided circum-

ferential grooves to accommodate O-rings 27 and 27' which contact against the inner wall of the sheath 24 in an airtight fashion to prevent operating substance 22 from coming into direct contact with the atmosphere. As shown in FIG. 3, after being inserted to a suitable position in the manifold against the outflow 28 of inert gas from reservoir 20, the capsule 23 is suitably rotated to drop the substances 22 in the discharge tube.

With the above described apparatus, the discharge tube is manufactured by the following steps. First, as shown in FIG. 2, the opening 11 is closed and the interior of the system is evacuated. In this case the discharge tube and selected portions of the system are suitably heated. After completion of evacuation, valve 18 is opened and valve 19 is adjusted so as to charge the inert gas into the discharge tube under a pressure slightly higher than the atmospheric pressure. Thereafter, the opening 11 is opened to cause the inert gas in the reservoir 20 to flow out into the atmosphere and the flow rate of the gas is kept constant in a suitable range by additional adjustment of valve 19. On the other hand, sufficiently degassed and prepared operating substance 22 is put in depression 26 of capsule 23 in a dry box and is kept in a free-of-moisture state of atmosphere by sliding back the spindle 25 to the position ready for use. Then, as shown in FIG. 3, the capsule is inserted into the manifold against the gas flow through the opening, and after moving spindle 25 from the dotted line position to the solid line position where the depression 26 is to be immediately above the envelope 15 shown in FIG. 3, the spindle is rotated to drop the operating substance into the envelope. Then the capsule is removed from the manifold 10 and the opening 11 is closed again. Thereafter, the envelope is evacuated to the desired pressure and then is taken in completion by sealing the chipoff portion.

Where the expensive gas is to be filled in, a source of cheaper inert gas is provided for the use of insertion of the capsule. In this case, however, the envelope has to be completely evacuated again just after closing operating substance 22 in the envelope 15, before the final charge of the proper gas under a required pressure.

Above described method is advantageous in the following points. During evacuation, since my operating substance is not contained in the evacuating system it is easy to evacuate the envelope to a sufficiently high degree of vacuum (for example, to a pressure of $2 \times 10_1^{-9}$ torrs which is required to provide necessary characteristics for discharge lamps containing a vapor of mixed halogens). More particularly, as the moisture contained in the operating substance is not introduced in the tube during evacuation thereof, deleterious effect of the moisture can be avoided. Since the operating substance to be closed does not decompose and lose its quantity in the evacuating system, nonuniformity in the quality of finished lamps due to loss of the substance and difficulty in evacuation caused by the decomposed products can be precluded. Since the inert gas flows outwardly through opening 11 at the time of introducing the operating substance, there is no fear that impurities in the atmosphere may enter into the discharge tube. By utilizing a capsule as shown in FIG. 3 to introduce the operating substance, even an extraordinary hygroscopic substance can be readily closed without being affected by moistures in the atmosphere. Since it is not necessary to provide many branch pipes, the construction of the evacuating system is simple and economic.

A modified embodiment of this invention is illustrated in FIGS. 4 to 6. As shown, an envelope 15 of a discharge lamp is connected to a branch pipe 31 projecting downwardly from the bottom of a cutoff cock 30 of glass, through an evacuating pipe 32. First and second evacuating systems 33 and 34 are connected to the sidewall of the cutoff cock. These component parts are combined such that rotation of a plug 33 of the cutoff cock selectively establishes communication between the first evacuating system 33 and envelope 15 and communication among the three members 33, 34 and 15. the first evacuating system 33 comprises a main pipe directly connected to cock 30 and a branch pipe connected to an intermediate point of the main pipe, said branch pipe being connected to a bomb 37 containing an inert gas through a flow rate adjusting valve 36. The main pipe is also connected to a first vacuum pump (not shown) through a flow quantity control valve 38. One end 39 of the second evacuating system is opened to fix a capsule 40 to be described later.

The evacuating system 34 includes bifurcated branch pipe 41 which is connected to a second vacuum pump (not shown) and to a flow gas recovering device (not shown) respectively through adjusting valves 42 and 43. It is preferable to use a following device as said capsule or an additive closing device 40. The capsule comprises an open ended cylindrical sheath of stainless steel and provided with an radially extending flange at one end, and a spindle 45 of stainless steel and adapted to be coaxially inserted into the sheath through said one end. The interior of the sheath 44 is sealed in the airtight fashion by means of a fluorinated rubber packing 46 mounted on one end thereof and a fluorinated rubber ring 47 mounted near the outer end of spindle 45. The spindle can be moved axially or rotated about its axis by manipulating a knob secured to the outer end thereof extending beyond sheath 44. A depression 48 for accommodating the additive or the operating substance is formed on one side of spindle 44 near the movable packing ring 47. The operation of this modification is as follows.

First, cock 35 is operated to the position shown in FIG. 5 to intercommunicate the first evacuating system 33 with envelope 15 through the cock. While maintaining closed valve 36 for the inert gas bomb 37, valve 38 is opened to evacuate envelope 15 through the first evacuating system 33. As above described, envelope 15 and other desired portions are heated. On the other hand, an accurately weighed operating substances, for example, a mixture of a metal halide and mercury is deposited in depression 48 of spindle 45 of the capsule in a dry box. Then the capsule 40 is inserted into the second evacuating system 34 through opening 39 with its movable packing ring 47 firmly engaged with the inner wall of sheath 44 to seal the interior of sheath 44 from the atmosphere. After insertion, the capsule is secured by an O-ring (not shown) in an airtight fashion of the flange surrounding the opening and the spindle is pushed into the system 34. Then flow gas recovering valve 43 is closed while valve 42 for the second evacuating pump is opened to evacuate the interior of the second evacuating system and of sheath 44 of the capsule 40. After completion of the evacuation step, valve 38 for the first vacuum pump is closed and valve 36 associated with the inert gas bomb 37 is adjusted to introduce the insert gas into the first evacuating system 33 and envelope 15 under higher pressure than the atmospheric pressure.

Then, after closing valve 42 for the second vacuum pump, plug 35 of cutoff cock 30 is rotated to connect the second evacuating system 34 to envelope 15 and first evacuating system 33. Valve 43 for the flow gas recovering device is opened to cause the inert gas to flow through the second evacuating system 34. Then spindle 45 of capsule 40 is manipulated to insert its inner end into cutoff cock 30 and when depression 48 is brought to a position just above branch pipe 31 of cutoff cock 30 the spindle 45 is rotated 180° to drop the additive contained in depression 48 into the envelope 15 as shown in FIG. 6. Thereafter spindle 45 is retracted into the second evacuating system, plug 35 is rotated in the opposite direction to disconnect the second evacuating system 34 from cock 30, valve 36 of inert gas bomb 37 associated with the first evacuating system 33 is closed and valve 38 of the first vacuum pump is opened to remove the inert gas which has been admitted. Again, valve 38 of the first vacuum pump is closed and valve 36 is adjusted to introduce the inert gas into envelope 15 under a predetermined pressure, and the chipoff portion of exhaust pipe 32 is sealed off to separate the envelope or a completed discharge lamp from the cock.

In this manner while evacuating the envelope by means of the first evacuating system, the additive is weighed and deposited in the capsule in the dry box filled with a dried inert

gas and the charged capsule is inserted into the second evacuating system. Immediately thereafter the second evacuating system is brought into operation. Thus the additive is at once subjected to vacuum, thus eliminating the effect of the atmosphere tending to deteriorate it. Once mounted, the capsule is sealed against the atmosphere so that introduction of the moisture and other impurities from the atmosphere can be positively precluded. Thus contamination by the atmosphere and introduction of moisture into the discharge tube can be prevented. Yet the evacuation process of the discharge tube, loading of the additive in the capsule and insertion thereof into the second evacuating system are effected simultaneously in parallel so that the interval of time required to fabricate the tube can be greatly reduced. Since this also reduces the flow time of the inert gas it is possible to save the same. By recovering the inert gas its consumption is reduced. Further, the inert gas may be used to admit substances to be sealed in the evacuating system.

Each one of the first and second evacuating systems may comprise a plurality of evacuating circuits. Thus for example, the second evacuating system may comprise a plurality of evacuating circuits radially extending from the cutoff cock, one of said circuits being used for admitting mercury and the other, for example, a halide the first evacuating system may also comprise a plurality of evacuating circuits for admitting different gases.

Thus, this invention provides a method and apparatus for manufacturing discharge tubes which can evacuate discharge tubes to sufficiently high vacuum, can admit additive substances free from moisture into the tubes without being affected by the atmosphere, can correctly control the quantity of the additive, whereby to provide discharge tubes of uniform qualities in relatively short time. Moreover, consumption of the inert gas is small.

There will now be described the manner in which an evacuating system is not contaminated by atmosphere when an inert gas is discharged into the atmosphere from said system according to the method of the present invention.

The envelope was evacuated through the evacuating system with an ordinary trap cooled by liquid nitrogen interposed between the inlet opening 21 and branching portion of the manifold. The inert gas was discharged through the evacuating system into the atmosphere. After said system was again evacuated, the trap was rewarmed therefrom. FIG. 7 is a diagram showing the gas pressure within the trap as measured by a vacuum gauge when the temperature of the trap was slowly raised. In FIG. 7, the gas pressure mmHg within the trap as measured by a vacuum gauge is represented by the ordinate and varied times (minute) at the inner wall of the trap by the abscissa. The results of the aforesaid determination are denoted by a curve *b*.

On the other hand, the gas from the lamp envelope which is not yet completely degassed was measured in the same manner as described above, excepting that the inert gas was not discharged. The results seemed to be harmless are indicated by a curve *a*. The initial and second peaks on the curves indicate an inert gas such as Ar or Ne. Such gases having lower condensation temperature than that of $H_2O$, are considered to be not harmful to lamp qualities. The curve *b* shows that though there still remain some amounts of $H_2O$ after evacuation, such amounts will have substantially no harmful effect on the method of the present invention.

We claim:

1. Apparatus for manufacturing a discharge tube having an envelope in which an inert gas and an operating substance are sealed, comprising an evacuating pipe system in the form of a manifold including a closable opening; and means which is inserted into said evacuating pipe system through said opening to supply an operating substance into said envelope without exposing said substance to the atmosphere, said manifold further including a first and a second flow circuits respectively connected to a vacuum pump and to a source of said inert gas and a third circuit, one end of said third circuit connected to said evacuating pipe system between said second circuit and said closable opening, the other end of said third circuit being connected to said envelope through a chipoff portion.

2. The apparatus for manufacturing a discharge tube according to claim 1 wherein said evacuating pipe system has an auxiliary pipe system which is connected to a second vacuum pump and provided with an opening adapted to receive said means for supplying said substance and means is provided to selectively control the communication between said third circuit and said first and second circuits and the communication between said first, second and third circuits and said auxiliary evacuating pipe system.

3. The apparatus for manufacturing a discharge tube according to claim 1 wherein said means for supplying said operating substance to said envelope comprises an open ended cylindrical sheath, a spindle axially movable in said sheath and rotatable about the axis of said spindle, one end of said spindle projecting outwardly through one end of said sheath, a depression provided on the periphery of said spindle near the other end thereof to accommodate the substance and packings provided around the periphery of said spindle on the opposite sides of said depression to seal said substance against atmosphere.

4. Apparatus for manufacturing a discharge tube having an envelope in which an inert gas and operating substance are sealed, comprising an evacuating pipe system in the form of a manifold including a closable opening; and means which is inserted into said evacuating pipe system through said opening to supply an operating substance into said envelope without exposing said substance to the atmosphere, said manifold further including a first and a second flow circuits respectively connected to a vacuum pump and to a source of said inert gas and a third circuit, one end of said third circuit being connected to said evacuating pipe system between said second circuit and said closable opening, the other end of said third circuit being connected to said envelope through a chipoff portion; said evacuating pipe system having an auxiliary pipe system which is connected to a second vacuum pump and provided with an opening adapted to receive said means for supplying said substance; and means is provided to selectively control the communication between said third circuit and said first and second circuits and the communication between said first, second and third circuits and said auxiliary evacuating pipe system.

5. Apparatus for manufacturing discharge tube having an envelope in which an inert gas and an operating substance are sealed, comprising an evacuating pipe system in the form of a manifold including a closable opening; and means which is inserted into said evacuating pipe system through said opening to supply an operating substance into said envelope without exposing said substance to the atmosphere, said manifold further including a first and a second flow circuits respectively connected to a vacuum pump and to a source of said inert gas and a third circuit, one end of said third circuit connected to said evacuating pipe system between said second circuit and said closable opening, the other end of said third circuit being connected to said envelope through a chipoff portion; said means for supplying said operating substance to said envelope comprises an open ended cylindrical sheath, a spindle axially movable in said sheath and rotatable about the axis of said spindle, one end of said spindle projecting outwardly through one end of said sheath, a depression provided on the periphery of said spindle near the other end thereof to accommodate the substance and packings provided around the periphery of said spindle on the opposite sides of said depression to seal said substance against atmosphere.

6. Apparatus for manufacturing a discharge tube having an envelope in which an inert gas and an operating substance are sealed, comprising, in combination: an evacuating pipe system including a closable opening; means which is inserted into said pipe system through said closable opening to supply an operating substance into said envelope without exposing said substance to the atmosphere; said means including an outer

member and an inner member which is translatable and rotatable relative to said outer member; a first flow circuit connected to a vacuum pump; a second flow circuit connected to a source of inert gas; and a third flow circuit having one end thereof connected to said evacuating pipe system between said second flow circuit and said closable opening, the other end of said third flow circuit being connected to said envelope through a chipoff portion.

7. Apparatus for manufacturing discharge tubes having an envelope in which an inner gas and an operating substance are sealed, comprising, in combination: an evacuating pipe system; a chipoff portion connecting said evacuating pipe system to said envelope; first means for evacuating said evacuating pipe system and said envelope connected to said evacuating pipe system through said chipoff portion; second means for supplying said inert gas to said envelope through said evacuating pipe system; third means for discharging said inert gas through an opening of said evacuating pipe system; fourth means for inserting said operating substance into said evacuating pipe system through said opening to transfer said substance into said envelope while said inert gas is being discharged through said opening; said operating substance being hermetically sealed against the atmosphere; fifth means for adjusting the pressure of said gas in said envelope to a predetermined value; and sixth means for sealing off said chipoff portion to separate said envelope from said evacuating pipe system.