June 20, 1961 J. D. McGEE 2,989,659

ELECTRON DISCHARGE DEVICES

Filed June 22, 1959

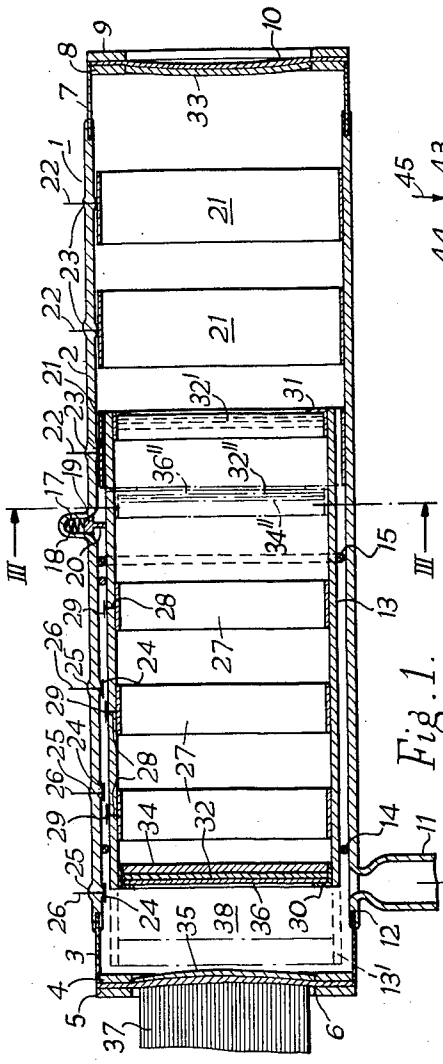

Fig. 1.

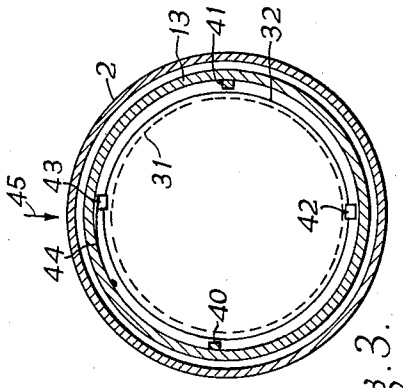

Fig. 3.

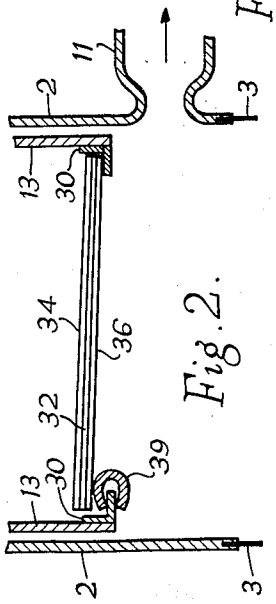

Fig. 2.

INVENTOR

James Dwyer McGee

BY

Stevens, Davis, Miller & Mosher

ATTORNEYS

United States Patent Office 2,989,659 Patented June 20, 1961

2,989,659

ELECTRON DISCHARGE DEVICES

James Dwyer McGee, London, England, assignor to National Research Development Corporation, London, England

Filed June 22, 1959, Ser. No. 821,843
Claims priority, application Great Britain July 2, 1958
12 Claims. (Cl. 313—65)

This invention relates to electron discharge devices and particularly to image intensifier tubes.

According to the present invention, a device for the manufacture of an image intensifier tube of at least two stages has an envelope containing a slide-tube, the slide-tube being adapted to receive a multiple-layer plate in either of two positions, the first position providing a substantially vapour-tight seal at one end of the slide-tube and the second position providing a working location of the multiple-layer plate at the other end of the slide-tube.

In particular, a device for the manufacture of an image intensifier tube having two or more stages comprises a first-stage photocathode and a second-stage fluorescent screen in spaced relationship, an envelope having a tubular portion between the said photocathode and the said fluorescent screen, a side-tube having an entry into the envelope at a point nearer to the said photocathode than to the said fluorescent screen, a slide-tube arranged inside the tubular envelope part and adapted to slide from a first position, in which it uncovers the side-tube entry into the envelope, to a second position nearer the said photocathode, in which it covers the side-tube entry and the inner surface of the tubular envelope part at the end thereof near the said photocathode, said device further comprising accelerating electrodes associated with the first stage of the tube and arranged inside the slide-tube, accelerating electrodes associated with the second stage of the tube and arranged between the said fluorescent screen and the end of the slide-tube remote from the said photocathode when the slide-tube occupies its second position, and a multiple-layer plate having a first-stage fluorescent screen and a second-stage photocathode layer at opposite outer faces, said slide-tube being adapted to receive the multiple-layer plate in a first position providing a substantially vapour-tight seal at one end of the slide-tube, in which position the second-stage photocathode layer faces the first-stage photocathode, and in a second position, in which the multiple-layer plate is reversed face to face and is secured in a working location at the other end of the slide-tube, in which location the second-stage photocathode layer faces the second-stage fluorescent screen.

A device according to the present invention may find application in electron discharge devices of various types but the invention was made in connection with, and has particular application to, an image intensifier tube of a particular form designed to overcome certain disadvantages in known image intensifier tubes. The nature of these disadvantages will be more fully explained, in order to explain the background and the particular application of the present invention.

It is commonly required to photograph an intensified visual or other light image produced by an image intensifier tube. If a photographic objective lens is used to focus the image provided by the tube onto a photographic film or plate, a large part of the light energy of the image is lost, owing to the limited acceptance angle of the objective. This loss can be overcome by attaching the photographic film directly onto the output end of the intensifier tube and by making a contact exposure. However, the wall thickness of an evacuated glass envelope is commonly so great that a much degraded

image is produced on the photographic film by reason of the dispersion of rays between the fluorescent screen of the tube and the photographic emulsion of the film.

A similar problem occurs at the input end of an image intensifier tube, in that a light image is commonly focused by a lens system onto a photocathode arranged at the input end of the intensifier tube. Similar light loss occurs, due to the limited angle of acceptance of the lens system. If the aperture of the lens system is increased to provide the maximum light acceptance, the further problem is introduced that the depth of field of the lens system is so small that the light image under examination needs to be confined very nearly to a single plane.

It has now been found that an evacuated envelope can be provided with a thin window comprising a mica sheet of about one thousandth of an inch thickness and of diameter up to some two inches or more. The circumferential margin of the mica window is held by a vacuum-tight seal, and it is found that such a window will withstand the inward pressure of the atmosphere when the envelope is evacuated. This discovery offers the possibility of solving the problems referred to at both the input and the output ends of an intensifier tube. At the output end, a fluorescent layer can be deposited on the inner face of such a mica window and a photographic film can be arranged in close contact with the outer face of the window, for the purpose of taking a photograph of the image formed on the fluorescent layer. In such an arrangement, the loss of definition by reason of the separation of the fluorescent layer and the photograph emulsion by a thousandth of an inch thickness of mica is not objectionable.

At the input end of the tube, a similar mica window is used which is provided with a photocathode layer on its inner surface. This may be provided by first depositing a layer of antimony and subsequently activating the antimony by caesium vapour to form a photocathode layer. Such a photocathode of caesium-activated antimony is well known per se.

The image under examination might be focused onto the photocathode layer by means of a lens system, but it is advantageous to use a different method of transmitting light to the photocathode layer which does not involve the light loss of a lens system mentioned above.

It is known to form a light-image transmitting structure comprising a large number of transparent fibres in axial alignment, the so-called "light-guide." By means of this structure, an image formed in or introduced into one end of the system is conducted to the other end by internal reflection within each fibre of the structure, the relative brightness and spatial relationship of the parts of the image being retained, owing to the regular alignment of the individual fibres. It is convenient to use such a light-guide in conjunction with an image intensifying tube having a mica window at its input end. The light-guide is arranged so that the fibres of the structure terminate at the outer face of the mica window. The degradation of the image in a thousandth of an inch thickness of mica between the ends of the fibres and the photocathode is not objectionable.

In such a tube, it is found that the mica windows bow inwardly slightly when the envelope is evacuated. This necessitates that the fibres are shaped to the concave configuration of the mica window when it is bowed inwardly. Similarly, at the output window, the photographic film should conform with the concave form of the mica window so that the close contact is maintained with the outer surface of the window. This feature is especially designed for filamentary luminescent nuclear track chambers, in which the filamentary "light guide" fibres are brought into close optical contact with the thin input window.

A further reason for using the above-mentioned arrangement is because it is easier to activate a photocathode which is deposited on the outside wall of a vacuum tube, since it is subject to more direct temperature control. This is particularly important for making tri-alkali photocathodes. The arrangement permits the formation of a tri-alkali cathode on the end window of a vacuum tube.

In such an image intensifier tube as described, in common with other types of electron discharge tubes, there exists the problem of forming antimony coated surfaces, mounted inside the tube envelope, by the admission of caesium vapour into the envelope, without impairing the performance of the tube due to the deposition of caesium on insulating surfaces between tube electrodes which have to be maintained at high potentials in operation. Such contamination of a tube envelope is known markedly to increase the dark current which flows and consequently to reduce the contrast in the intensified image. This particular disadvantage is substantially overcome in a tube according to the present invention, by the following method of manufacture:

It is assumed that a device according to the invention, for manufacturing an image intensifier tube, is in a stage of construction in which a phosphor is deposited on the inner surface of the output mica window and on one face of the multiple layer structure. It is further assumed that the envelope has been completely de-gassed and evacuated and that an antimony layer has been deposited on the inner surface of the input mica window of the tube and on the opposite face of the multiple layer structure. The multiple layer plate is arranged at the input end of the slide-tube and the slide-tube itself is arranged in its first position in which the side-tube entry into the envelope is uncovered. Caesium vapour is introduced through the side-tube into the space at the input end of the tube envelope which is bounded by the input window and the multiple-layer plate. The two antimony layers are formed into photocathode surfaces at the same time, by the action of the caesium vapour. Some caesium vapour is deposited on the interior surface of the envelope between the input window and the input end of the slide-tube. However, the vapour does not penetrate to any objectionable extent between the outer face of the slide-tube and the inner wall of the envelope and such penetration may be substantially inhibited by providing a baffle ring or other such member. Moreover, the marginal peripheral contact of the multiple layer structure with a locating ring at the input end of the slide-tube ensures an effective vapour seal which prevents the entry of caesium vapour into the slide-tube. After the forming operation the envelope is sealed off.

The multiple-layer plate is detached from the input end of the slide-tube, is reversed face to face, is moved to the output end of the slide-tube and there secured in position. In this position, the photocathode layer faces the output window of the tube and the first-stage fluorescent screen is in correct relationship with the first-stage accelerating electrodes mounted in the slide-tube.

The slide-tube is then moved bodily towards the input end of the intensifier tube and, when correctly located, it is retained by any convenient retaining device. In this position of the slide-tube, the first-stage accelerating electrodes are in correct relationship with the first-stage photocathode on the input window of the tube and the second-stage photocathode, provided by the multiple layer plate is in correct relationship with the second-stage accelerating electrodes mounted in the envelope and with the second-stage fluorescent screen on the output window of the tube.

In order that the invention may be readily carried into effect, a practical embodiment of an image intensifier tube of the form described above will now be described in greater detail, by way of example, with reference to the accompanying drawing, of which:

FIG. 1 is a composite diagrammatic view showing a two-stage image intensifier tube in axial section at a stage during the course of manufacture. The input and output windows are shown bowed and the fibre ends of a light-guide are shown in position as for a completed tube.

FIG. 2 is a detail drawing showing an axial section of the device of FIG. 1 during a stage of manufacture; and

FIG. 3 is a detail drawing showing means for retaining the multiple layer screen in its final position.

In FIG. 1, a device for the manufacture of a two-stage image intensifier tube has an envelope, indicated generally at **1**, comprising a cylindrical part **2**. In the completed tube, the input end is the left-hand end as seen in the drawing and the output end is the right-hand end. At the input end of the envelope part **2**, there is sealed a cylindrical metal end-piece **3** terminating in an annular frame. This frame has an inner part **4** and an outer part **5**, between which parts is sealed, in a vacuum-tight manner, a mica window **6**, of thickness one thousandth of an inch and of diameter about two inches. At the output end of the cylindrical part **2** is similarly sealed a metal end-piece **7** terminating in an annular frame having an inner part **8** and an outer part **9**. Between these parts is sealed, in a vacuum-tight manner, a mica window **10**, of thickness one thousandth of an inch and of diameter about two inches.

At the input end of the cylindrical envelope part **2**, spaced a short distance from the seal with the end-piece **3**, is a side-tube **11**, the reduced end of which enters the envelope **1** at **12**.

Arranged inside the cylindrical envelope part **2** is a cylindrical slide-tube **13**, which is slidably located inside the envelope part **2** by rings **14** and **15**. The slide-tube **13** is adapted to slide between the position in which it is shown in full lines in the drawing and the position shown in broken lines at **13'**, where the input end of the slide-tube abuts against the frame **4** at the input end of the tube.

The cylindrical envelope part **2** is provided with a sealed side-tube **17** containing a compression spring **18** and a withdrawable locking-pin **19**. When the slide-tube is in the position shown at **13**, the locking pin **19** is withdrawn into the tube **17**, but when the slide-tube is moved to the position **13'**, the locking-pin is urged forwardly by the compression spring **18**, so that a reduced part **20** of the pin locates in a detent near the output end of the slide-tube **13** to retain it in the position **13'**.

Between the side-tube **17** and the output end of the envelope part **2**, are arranged a number of accelerating electrodes **21**, three such electrodes being shown in the drawing, each of which has a lead-out connection **22** passing through a seal **23**.

Arranged in the cylindrical envelope part **2**, on the input side of the side-tube **17**, are a number of contact springs of which three are shown at **24** each having a lead-out connection **25** passing through a seal **26**.

In the slide-tube **13** are arranged a number of accelerating electrodes, associated with the first stage of the tube, of which three electrodes are shown at **27**, each having a connection **28** to a spring contact **29** arranged on the outer face of the slide tube **13**. When the slide-tube is in the position shown at **13'** the spring contacts **24** and the spring contacts **29** register with each other, so that each of the accelerating electrodes **27** has a conducting connection to the outside of the envelope at **25**.

At the input end of the slide-tube **13** is provided a retaining and sealing flange **30** and at the output end of the slide tube **13** is arranged a similar flange **31**. A multiple-layer screen, indicated generally at **32** and comprising phosphor and photocathode layers on a mica supporting plate, is adapted to be located in a vapour-tight manner against the flange **30**. It can alternatively be reversed face to face and located against the flange **31**, where it occupies the position shown at **32'** in the drawing. Then,

when the slide-tube 13 is moved to occupy position 13', the multiple-layer screen occupies the position shown at 32".

The inner face of the mica window 10 is provided with a phosphor layer 33 and the face of the multi-layer screen 32 facing the window 33 when the multi-layer screen occupies the position 32 is provided with a phosphor layer 34. The inside of the mica window 6 is provided with a layer 35 of antimony backed by an aluminium film and the layer 36 of the multi-layer screen 32, facing the window 6 when the screen occupies the position 32, is also of antimony backed by an aluminium film.

A light-guide comprising a large number of light conducting fibres 37 is shown having its output end in contact with the mica window 6.

In the manufacture of the tube, at a stage after the evacuation of the envelope and after the deposition of the antimony layers upon the aluminium backing films, the multiple-layer screen is arranged as shown at 32 with the slide-tube in the position shown at 13. In this position, the entry 12 of the side-tube 11 into the envelope 1 is uncovered. Caesium vapour is admitted through the side-tube 11 into the space between the antimony layers 35, 36 which space is indicated generally at 38 in the drawing. The caesium vapour forms the antimony layer into a photocathode surface, in known manner, and some of the caesium vapour is deposited as a thin caesium layer on the cylindrical surface of the envelope bounding the space 38. However, the multiple-layer screen 32 makes a substantially vapour-tight seal with the flange 30, so that substantially no caesium vapour can enter the slide-tube 13. The caesium vapour also does not permeate to any appreciable extent along the space between the slide-tube 13 and the cylindrical envelope part 2.

After the photo-cathode forming operation, the residual caesium vapour in the envelope is partly absorbed by suitable caesium absorbers, not shown in the drawings and partly diffuses out into the pumping system through the side-tube 11, which formed the exhaust tube, and the side-tube 11 is then sealed off. The multiple-layer screen is then removed from the flange 30, reversed face to face and replaced on the flange 31, where it occupies the position 32'.

The slide-tube 13 is then moved to the position 13', where it is located by the locking-pin 20. The multiple-layer screen then occupies the position 32".

It will be appreciated that in this position of the slide-tube 13, the side-tube entry 12 is covered and also that portion of the envelope 1 upon which a caesium deposit was formed, except the photocathode 35, is also covered. The accelerating electrodes 27 are brought into the correct working relationship with the photocathode layer 35 and the phosphor screen, now occupying the position 34", is in the correct working relationship with the electrodes 27. The second-stage photocathode, now occupying the position 36", is in correct relationship with the accelerating electrodes 21 associated with the second stage of the tube and with the phosphor screen 33 on the output window 10.

FIG. 2 shows a stage of manufacture before the envelope is evacuated and degassed. In the figure, only a part of the envelope 2 is shown and only the end of the slide tube 13 near the envelope end piece 3. The envelope is arranged with its axis vertical with the input end of the tube downwards. In this position of the envelope 2, with the slide tube 13 in its first position, the side tube 11 is uncovered. During the construction of the device, a horseshoe-shaped chock 39 of magnetic material was clipped over the sealing flange 30. In the position of the envelope 2 shown in FIG. 2, the multiple-layer plate 32 rests on the chock 39 and, in this raised position, provides a clearance between the surface of the multiple-layer plate 32 and the sealing flange 30.

In this way, the whole of the envelope 2 can be evacuated by way of the single side tube 11 used as an exhaust tube. After this operation, the chock 39 is drawn off the flange 30 by an external magnet and is shaken or otherwise withdrawn from the inside of the envelope 2 by way of the side tube 11.

Returning the envelope then to the vertical position, the multiple-layer plate 32 then lies flat on the flange 30 forming a substantially vapour-tight seal therewith.

FIG. 3 shows the means used, in this embodiment, for securing the multiple layer plate 32 in its second position in the slide tube 13. FIG. 3 shows a cross section of the device approximately in the plane III—III of FIG. 1 with the multiple layer plate 32 in its second position and with the envelope 2 arranged vertically with its output end downwards.

The securing means comprise fixed guide lugs 40, 41 arranged diametrically opposite each other, a fixed catch 42 having an undercut portion to receive the edge of the multiple layer plate and a spring-loaded catch comprising a clip 43 and leaf spring 44 arranged opposite the fixed catch 42.

Initially, the multiple-layer plate 32 is moved so that its edge enters the clip 43. The sides are then located in position by the fixed lugs 40, 41. At this stage the edge of the multiple-layer plate 32 opposite the clip 43 lies on top of the catch 42. By giving the envelope 2 a sharp displacement in the direction of the arrow 45, the inertia of the plate 32 forces back the spring-loaded catch 43, 44 so that the plate 32 drops onto the flange 31. The spring 44 restores the position of the catch 43, 44 and engages the opposite edge of the plate 32 in the undercut part of the catch 42.

What I claim is:

1. An image intensifier tube having an input end, an output end and at least two image intensifying stages, comprising a closed tubular envelope, a plate member carrying a phosphor layer of a first intensifier tube stage and a photocathode layer of the next following stage and an open-ended support tube supporting electrodes for said first image intensifier tube stage, mounted inside the tubular envelope substantially coaxially therewith, said support tube having locating means for locating the plate member in a position at each end thereof, a first said position closing the end of the support tube nearer the input end of the image intensifier tube with a substantially vapour-tight seal and the second position locating the said phosphor layer in operative relationship to the said electrodes.

2. An image intensifier tube having an input end, an output end and at least two image intensifying stages, comprising a closed tubular envelope, a plate member carrying a phosphor layer of a first intensifier tube stage and a photocathode layer of the next following stage and an open-ended support tube supporting electrodes for said first image intensifier tube stage, mounted inside the tubular envelope substantially coaxially therewith and for movement longitudinally therein, said support tube having locating means for locating the plate member in a position at each end thereof, a first said position closing the end of the support tube nearer the input end of the image intensifier tube with a substantially vapour-tight seal and the second position locating the said phosphor layer in operative relationship to the said electrodes, said support tube being movable to a first position and to a second position, nearer to the said input end than said first position, in which the second position of the support tube, with the plate member in its said second position, the photocathode layer thereof is located in operative position in the said next-following stage of the image intensifier tube.

3. An image intensifier tube having an input end, an output end and at least two image intensifying stages, comprising a tubular envelope closed at the ends thereof and having a side-tube with an entry near the input end thereof, a plate member carrying a phosphor layer of a first intensifier tube stage and a photocathode layer of the next following stage and an open-ended support tube supporting electrodes for said first image intensifier tube stage, mounted inside the tubular envelope substantially

coaxially therewith and for movement longitudinally therein, said support tube having locating means for locating the plate member in a position at each end thereof, a first said position closing the end of the support tube nearer the input end of the image intensifier tube with a substantially vapour-tight seal and the second position locating the said phosphor layer in operative relationship to the said electrodes, said support tube being movable to a first position, in which the said side-tube entry is uncovered and opens into a chamber bounded at one end by the input end of the image intensifier tube and at the other end by the plate member, in its said first position, and to a second position in which, when the plate member occupies its second position, the photocathode layer of the plate member is located in operative position in the said next following stage of the intensifier tube.

4. An image intensifier tube structure for a tube having at least two image intensifying stages, comprising a tubular envelope closed at the ends thereof, a plate member carrying a phosphor layer of a first intensifier tube stage and a layer capable of being activated by an activating vapour to form a photocathode layer of the next following stage, an open-ended support tube supporting electrodes for said first image intensifier tube stage, mounted inside the tubular envelope substantially coaxially therewith, and a side tube with an entry into the envelope near one end of the support tube, said support tube having locating means for locating the plate member in a position at each end thereof, the one position closing the end of the support tube nearer the side tube entry with a substantially vapour-tight seal and the other position locating the said phosphor layer in operative relationship to the said electrodes.

5. An image intensifier tube structure for a tube having at least two image intensifying stages, comprising a tubular envelope with closed ends, a plate member carrying a phosphor layer of a first intensifier tube stage and a layer capable of being activated by an activating vapour to form a photocathode layer of the next following stage, an open-ended support tube supporting electrodes for said first image intensifier tube stage, mounted inside the tubular envelope substantially coaxially therewith, and a side tube with an entry into the envelope near one closed end thereof, said support tube having locating means for locating the plate member in a position at each end thereof, the one position closing the end of the support tube nearer the side tube entry with a substantially vapour-tight seal and the other position locating the said phosphor layer in operative relationship to the said electrodes, the said support tube being movable to a first position, in which the said side tube entry is uncovered, and to a second position in which, when the plate member occupies its second position and when the said layer thereof is activated to form a photocathode layer, said photocathode layer is located in operative position in the said next following stage of the intensifier tube.

6. An image intensifier tube having an input end, an output end and two image intensifying stages, comprising a closed tubular envelope, a plate member carrying a phosphor layer of the first intensifier tube stage and a photocathode layer of the second stage and an open-ended support tube supporting electrodes for first image intensifier tube stage, mounted inside the tubular envelope substantially coaxially therewith, said support tube being mounted inside the tubular envelope for longitudinal movement between a first position and a second position, said envelope supporting electrodes for the second intensifier stage positioned between the output end of the image intensifier tube and the end of the support tube nearer thereto, said support tube having locating means for locating the plate member in a position at each end thereof, a first said position closing the end of the support tube nearer the input end of the image intensifier with a substantially vapour-tight seal and the second position locating the said phosphor layer in operative relationship to the said electrodes for said first image intensifier tube stage, the first said position of the support tube being further from the input end than said second position and said second position, together with said second position of said plate member in said support tube locating the said photocathode layer in operative relationship to the said electrodes for said second image intensifier tube stage.

7. An image intensifier tube as claimed in claim 2 in which the said electrodes for the said first stage of the tube are connected to conductive contacts on the outer surface of the support tube and, when the support tube is in its second position, the said conductive contacts conductively engage corresponding contacts mounted on the inner surface of the envelope and having lead-out connections through the envelope.

8. A structure as claimed in claim 6, in which the support tube is movably held in the envelope by rings located between the support tube and the envelope.

9. A structure as claimed in claim 6, in which the envelope carries a catch for retaining the support tube in the second position thereof.

10. An image intensifier tube having at least two stages, comprising a first-stage photocathode and a second-stage fluorescent screen in spaced relationship, an envelope having a tubular portion between the said photocathode and the said fluorescent screen, a side-tube having an entry into the envelope at a point nearer to the said photocathode than to the said fluorescent screen, a support tube, supporting electrodes for said first stage arranged inside the tubular envelope part and adapted to slide from a first position, in which it uncovers the side-tube entry into the envelope, to a second position nearer the said photocathode, in which it covers the side-tube entry and the inner surface of the tubular envelope part at the end thereof near the said photocathode, said image intensifier tube further comprising accelerating electrodes associated with the second stage of the tube and arranged between the said fluorescent screen and the end of the support tube remote from the said photocathode when the support tube occupies its second position, and a plate member having a first-stage fluorescent screen and a second-stage photocathode layer at opposite outer faces, said support tube being adapted to receive the plate member in a first position providing a substantially vapour-tight seal at one end of the support tube, in which position the second-stage photocathode layer faces the first-stage photocathode, and in a second position, in which the plate member is reversed face to face and is secured in a working location at the other end of the support tube, in which location the second-stage photocathode layer faces the second-stage fluorescent screen.

11. An image intensifier tube as claimed in claim 10, in which, when the support tube is in its first position and the plate member is in its first position, a substantially vapour-tight chamber is formed extending between the fluorescent screen end of the envelope and the plate member and in which, when the support tube is in its second position and the plate member is in its second position, the accelerating electrodes arranged in the support tube and the fluorescent screen of the plate member are located at the required working position in relation to the first-stage photocathode and the photocathode of the plate member is located at the required working position in relation to the accelerating electrodes arranged in the envelope and the second-stage fluorescent screen.

12. A method of manufacturing an image intensifier tube having at least two stages, comprising constructing a tube envelope having a metallic layer capable of being activated by an activating vapour to form a first-stage photocathode and a second-stage fluorescent screen in spaced relationship, an envelope having a tubular portion between the photocathode layer and the said fluorescent screen, a side-tube having an entry into the envelope at a point nearer to the photocathode layer than to the said fluorescent screen, a support tube, supporting accelerating electrodes associated with the first stage of the tube,

arranged inside the tubular envelope part and adapted to slide from a first position, in which it uncovers the side-tube entry into the envelope, to a second position nearer the said photocathode layer, in which it covers the side-tube entry and the inner surface of the tubular envelope part at the end thereof near the photocathode layer, said structure further comprising accelerating electrodes associated with the second stage of the tube arranged between the said fluorescent screen and the end of the support tube remote from the photocathode layer, when the support tube occupies its second position, and a plate member having a first-stage fluorescent screen and a metallic layer capable of being activated by an activating vapour to form a second-stage photocathode at opposite outer faces, said support tube being adapted to receive the plate member in a first position providing a substantially vapour-tight seal at one end of the support tube, in which position the

second-stage metallic layer faces the first-stage metallic layer, and in a second position, in which the plate member is reversed face to face and is secured in a working location at the other end of the support tube in which location the second-stage photocathode layer faces the second-stage fluorescent screen, the method further comprising arranging the support tube in its first position in the envelope and arranging the plate member in the first position in the support tube, introducing through the side-tube into the chamber comprising the envelope part between the two metallic layers an activating vapour to form the said metallic layers into said first-stage and second-stage photocathodes, sealing off the side-tube, moving the support tube to its second position and moving the plate member to its second position.

No references cited.