

[72] Inventor **Josef Moegenbier**
Morton Grove, Ill.
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 [73] Assignee **Zenith Radio Corporation**
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Primary Examiner—Herman Karl Saalbach
Assistant Examiner—Marvin Nussbaum
Attorney—Francis W. Crotty

[54] **IMAGE INTENSIFIER**
3 Claims, 4 Drawing Figs.

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 313/284, 313/286, 313/288, 250/213 R, 316/19,
 29/25.15, 313/65
 [51] Int. Cl. **H01j 19/50,**
 H01j 31/50, H01j 39/04
 [50] Field of Search 313/94-
 — 101, 65—68, 283—288; 250/213

[56] **References Cited**

UNITED STATES PATENTS

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ABSTRACT: The envelope of the image intensifier is principally a glass cylinder closed at one end to support the viewing screen and having a sealing land at the other end with a series of apertures spaced thereabout. This end of the envelope is closed by a glass cap secured to the sealing land by a glass to glass seal. The photocathode has a supporting frame dimensioned to be positioned within the principal envelope section and having threaded mounting bushings in radial alignment with the apertures in the sealing land of the envelope, respectively. Mounting pins inserted through the openings of the envelope thread into these bushings and mechanically secure the photocathode in position. Each pin is sealed to the envelope in a vacuum-tight seal.

In manufacturing the image intensifier three tubulations are affixed to the envelope, being spaced about the viewing screen thereof, and a fixture having three tines is inserted through these tubulations into the envelope and advanced toward the sealing land. The pickup pack is rested on the ends of these tines and the fixture is then withdrawn to draw the pickup pack away from the sealing land where it remains until the cap is sealed to the principal envelope section. Thereafter, the fixture is advanced once more to bring the mounting bushings of the pickup pack into alignment with the apertures on the sealing land for the purpose of receiving the mounting pins.

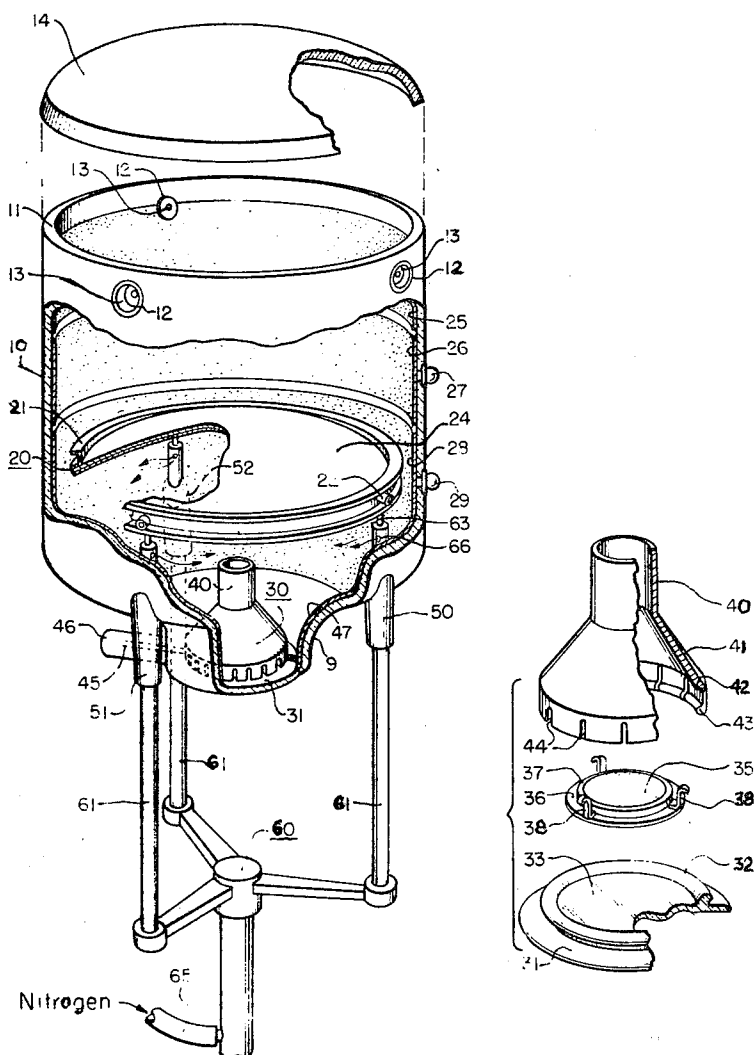


FIG. 1

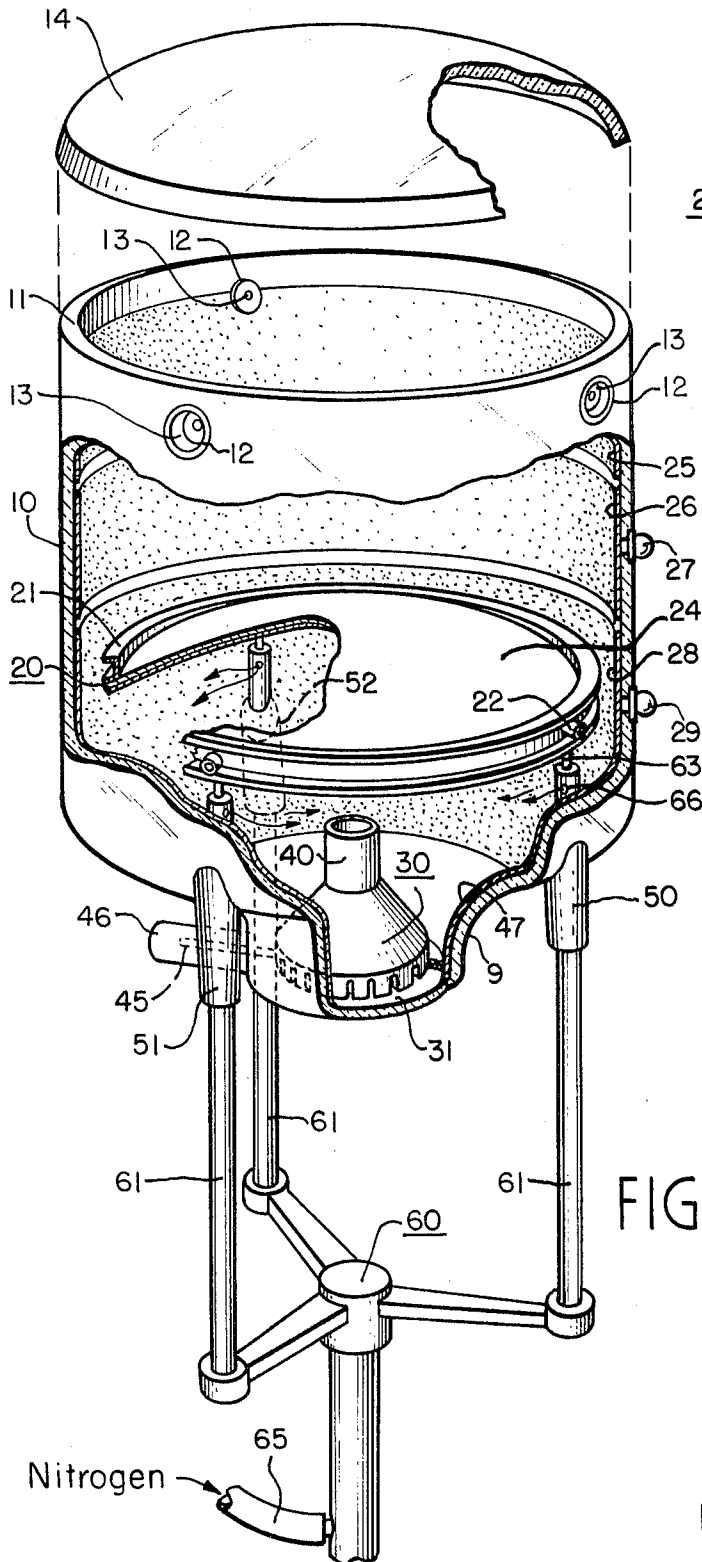


FIG. 3

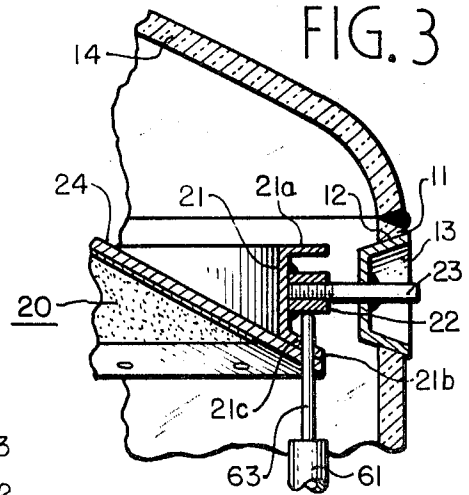


FIG. 4

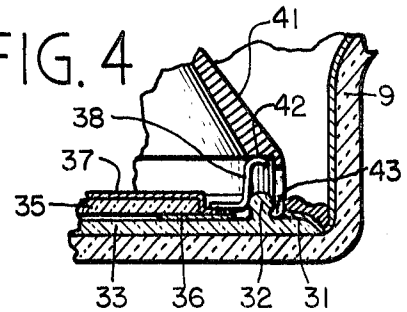
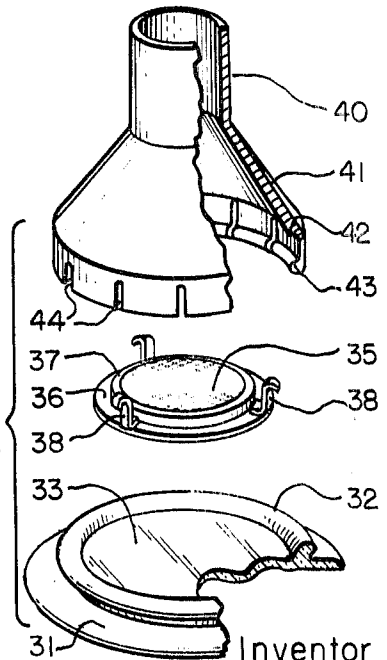


FIG. 2



Inventor
Joseph Moegenbier
By *Francis W. CroTTY*
Attorney

IMAGE INTENSIFIER

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of application Ser. No. 669,470, filed Sept. 21, 1967, now U.S. Pat. No. 3,515,924, and assigned to the same assignee as the present application.

BACKGROUND OF THE INVENTION

Image intensifiers are now quite well known and are used, for example, to obtain X-ray images while subjecting a patient to a minimal radiation dosage. Usually, they comprise an envelope which is transparent to X-radiation in order to admit an X-ray image to a pickup pack. This pack, in response to an incident X-ray image, develops an electron image which is focused and accelerated toward a viewing screen at the opposite closure of the envelope. At that screen, the electron image is converted into a light image. Since the intensifier exhibits high sensitivity to X-radiation, the dosage required to obtain the X-ray picture from a patient is greatly reduced.

As made heretofore, the envelope structure has a principal cylindrical section that terminated in a metallic sealing flange which was dimensioned and configured to match a similar flange provided on the closure cap of the envelope. It was common practice to install the components of the intensifier while the envelope sections were separated, and then to integrate them into a single unit by welding the sealing flanges. Although this has permitted the manufacture of acceptable devices, it has been subject to certain disadvantages. It has been found, for example, that the metal to metal seal of the envelope sections could give rise to leaks which would destroy the required vacuum. It has also been found that the metal flange sections of the envelope present difficult outgassing problems. And, finally, this is a more expensive structure than one utilizing simply glass envelope pieces.

One approach to an all-glass intensifier has been proposed in which the principal envelope section includes the pickup pack which may be installed before the envelope has been completed. The cap or end section to be sealed to the principal envelope piece contains the final viewing screen. Forming an intensifier with this sort of envelope presents difficulties in establishing or completing the electrode system. Usually, the electrodes take the form of conductive coatings deposited on the inner walls of the envelope and such a deposit is apt to be destroyed and a poor glass-to-glass seal made if it has been put in place before the envelope sections are sealed together, at least insofar as concerns a conductive coating in the immediate vicinity of the seal. Accordingly, it has been necessary to try to enter the completed envelope through the exhaust tubulation or similar port and complete the electrode system after having sealed the envelope pieces together. This leads to cumbersome and difficult processing.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a novel image intensifier as well as a novel method of its manufacture.

It is a further object of the invention to provide a novel and simplified method of manufacturing an image intensifier having an all-glass envelope.

It is still another object of the invention to provide an image intensifier that is unique in its overall structure and in particular component parts.

An image intensifier embodying the invention comprises an envelope section having a sealing land at one end and having a plurality of apertures spaced thereabout. Another envelope section, which like the first is preferably formed of glass, is sealed to the land of the first section. The photocathode is disposed transversely of the first envelope section and has a supporting frame with maximum dimensions less than the internal dimensions of the first envelope section. The photocathode frame further has a plurality of mounting provi-

sions arranged in radial alignment with the apertures of the sealing land of the envelope. A plurality of mounting pins individually project through one of the envelope apertures so that one end thereof is received in coupling engagement with the mounting provisions of the photocathode frame while the other end is sealed to the envelope in a vacuum-tight manner.

The anode subassembly of the image intensifier to be disclosed is also unique. It incorporates the anode electrode and phosphor viewing screen in a structural arrangement by which the subassembly is snap-locked to a groove provided on the output window of the image intensifier. This arrangement reduces light feedback from the viewing screen which is highly desirable.

Another desired innovation of the intensifier is the formation of chrome oxide on the inner periphery of the envelope section which intervenes the final focusing electrode and the anode. This is a very high resistance coating with good mechanical properties which obviates the accumulation of charged effects on this portion of the envelope that may otherwise be encountered if this envelope section is permitted to be left bare.

Also, in accordance with the invention, such an image intensifier is assembled by inserting a transverse component, such as its pickup pack, in the open end of the one principal envelope piece but is displaced from the sealing land and the apertures thereof in the direction of the opposite end of the envelope. A second envelope piece is then sealed to the sealing land of the first-mentioned piece. Thereafter, the pickup pack is advanced toward the seal and positioned so that its mounting provisions are in radial alignment with the apertures provided in the sealing land of the envelope. Then, mounting pins are inserted through these apertures into coupling engagement with the mounting provisions of the pickup pack and a vacuum-tight seal is made for each such mounting pin where it exits from the envelope.

One especially attractive utilization of the inventive process takes advantage of the fact that such an image intensifier normally is provided with two tubulations in the end of the envelope that accommodates the viewing screen. Providing a third such tubulation permits the tines of a three-tine fixture to be easily inserted into the principal envelope piece for advancement into coupling engagement with a pickup pack temporarily held near the sealing land of the envelope piece at the start of the sealing process. With the pack thus engaged by the fixture, the fixture may be retracted to displace the pickup pack away from the area where the seal is to take place, protecting it from the adverse influence of the sealing temperature. After the seal has been completed, the fixture may be advanced once again, positioning the pickup pack with its mounting provisions aligned with the apertures provided in the sealing land of the envelope. After mounting pins are inserted to lock the pickup pack in this position, the fixture may be withdrawn and the processing of the tube continued in conventional fashion.

BRIEF DESCRIPTION OF THE DRAWING

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 is a view partially in cross section illustrating one of the assembly steps for the manufacture of an image intensifier;

FIG. 2 is an exploded view showing the details of the anode subassembly;

FIG. 3 is a fragmentary sectional view illustrating another manipulative step in the process of manufacture; and

FIG. 4 is a fragmentary sectional view to show the anode subassembly installed within the image intensifier.

DESCRIPTION OF THE PREFERRED EMBODIMENT

It is convenient first to describe the structure of the improved image intensifier and then the process by which it may be manufactured. The envelope is formed of glass and comprises a principal cylindrical section 10 which is closed at one end and has centrally of that end a well portion 9 for accommodating an anode subassembly to be described hereafter. At its opposite end envelope section 10 has a sealing land 11 which accommodates a plurality of apertures 12. Three such apertures have been shown and are spaced 120° apart. As seen most clearly in FIG. 3, a ferrule 13 is inserted in each aperture and is sealed to envelope section 10. Each ferrule has a centrally located aperture or channel through which a mounting pin may be inserted into the envelope. The envelope is completed by a glass cap section 14 which has the same dimension and configuration as sealing land 11 of envelope section 12. They are sealed together in any well-known manner for effecting a glass-to-glass vacuum-tight seal.

Within the envelope there is a transverse component which for the structure under consideration is the usual pickup pack 20, a fragmentary cross-sectional view of which is shown in FIG. 3. The pickup pack has a ring-shaped frame 21, assuming, of course, that the envelope 10 is cylindrical in cross section. The ring is formed of a U-shaped structural element having a horizontal flange 21a adjacent sealing land 11 and having on the other side of the rim a canted flange 21b which is provided with three apertures 21c likewise having an angular separation of 120°. The overall or maximum dimensions of frame 21 are less than the minimum internal dimensions of envelope 10 so that the pickup pack may conveniently be inserted into and supported transversely of envelope 10. To support the pickup pack in position there are a plurality of mounting provisions spaced about frame 21 in radial alignment with the apertures of ferrules 13. As shown, a threaded bushing 22 is in alignment with each ferrule (only one appears in the drawing). The pickup pack is mechanically secured in position by a series of mounting pins 23 which individually are inserted through the apertures of ferrules 13 so that a threaded termination thereof may be accepted by threaded bushing 22. At the opposite end where each pin projects exteriorly of the central portion of ferrule 13, it is heliarc welded to the ferrule to complete a vacuum-tight seal between each ferrule and its mounting pin.

Frame 21 supports a spherical or dish-shaped element 24 serving as the substrate of a photocathode and, of course, it must be transparent to the radiation to which the intensifier is to respond. For many installations, particularly where X-radiation is to be received, this member may be formed of thin aluminum. The photocathode is composed of a first layer of an X-ray sensitive phosphor, such as silver activated zinc sulfide or the like, embodied in a suitable silicone resin and deposited on element 24. Superimposed on the phosphor layer is a barrier layer which may be formed, for example, of aluminum oxide and placed on top of the barrier is a photocathode layer which may be of conventional composition such as antimonycesium. It is necessary to establish the photocathode structure at a desired operating potential which is usually ground and this may be accomplished by utilizing one of pins 23 as a terminal connector.

The remainder of the electrical system of the intensifier includes focusing electrodes, an anode and a phosphor viewing screen. The electrodes are in the form of conductive bands vapor deposited on the inner surface of envelope 10. Three such bands are shown; one designated 25 contacts ferrules 13 and is at the same electrical potential as the cathode. A second band 26 is isolated from the first by an uncoated ring or envelope section therebetween. Its operating potential may be established by connections made to a terminal connector 27 sealed to the envelope and in electrical contact with band 26. The final focus electrode 28 is spaced and insulated from band 26 and has a similar terminal connector 29. It extends to mid-

way of the shoulder portion of envelope 10. Finally, there is an anode subassembly 30 centrally positioned within well 9 of envelope 10.

The components of this subassembly are shown in the exploded view of FIG. 2 and comprise a viewing window 31 which is a circular disc of optical flat glass on one surface of which is formed a clamping ring 32; this ring surrounds and defines the viewing window 33. Disc 31 is fused to the central portion of envelope section 9.

The next component of the subassembly is a glass disc 35 which bears on one surface a fluorescent coating to respond to impinging electrons and develop a light image to be viewed through window 33. Disc 35 is mounted in a metallic frame comprising an annular ring 36 supporting one face of disc 35 and a similar ring 37 on the opposite face, these rings being suitably welded together firmly to hold disc 35 as indicated in FIG. 4. Three springs 38 are also secured to disc 36, 37 and are spaced approximately 120° from one another. The various components of phosphor screen 35 and its mount are dimensioned to be received within the enlarged end of an anode electrode having a small diameter cylindrical section 40 which faces pickup pack 20 and a conical section 41, the large end of which receives fluorescent screen 35 with its mount. It is preferred to cut away the final portion of conical section 41 for a depth corresponding essentially to the height of screen 35 and its mount. Where this is done, an angular rim 42 is presented against which springs 38 may bear to urge section 35 forwardly against viewing window 33 when the subassembly is installed. To facilitate the installation the cutaway final portion of the anode terminates in a ring 43 and has a series of longitudinally extending slots 44 which permit this section to be resilient. The inner diameter of ring 43 is slightly less than the maximum diameter of ring 32 constructed on disc 31. To install the subassembly, fluorescent screen 35 with its mount is positioned within anode 40 and the anode is then positioned concentrically over ring 32 and advanced forward. The flexibility of the terminal portion of the anode permits ring 43 to slide over and lock beneath ring 32 of disc 31, installing subassembly 30 as shown in FIGS. 1 and 4. An anode terminal connector 45 connects with conical section 41 and is available to connect with a power supply through a tubulation 46. The supporting frame of screen 35 is of conductive material so that the anode potential extends to the screen. The surface of well 9 extending from the outer periphery of anode subassembly 30 to the shoulder of the envelope is covered with a deposit of conductive metal such as chrome or aluminum. Between this conductive coating and electrode 28, there is a coating 47 of high resistance material such as chrome oxide. This coating extends between both conductive coatings and establishes a desired potential gradient therebetween but, more importantly, precludes the establishing of electrostatic charges on the shoulder of the envelope.

Finally, the image intensifier when completed has a pair of tubulations 50 and 51. These are attached to the closure portion of envelope section 10 and are spaced closer to the axis of the envelope than apertures 12 of sealing land 11. One, of course, is supplied for purposes of exhausting the envelope and it is sealed when the exhaust step has been completed. The other permits the attachment of an appendage or ion pump that is frequently employed with image intensifiers to preserve the vacuum condition throughout its operation. This ion pump which constitutes no part of the present invention has not been shown.

In the operation of the described image intensifier, operating potentials from a suitable and conventional power supply (not shown) are applied to focusing electrode terminals 27 and 29 as well as to anode lead-in 45 while the photocathode is established at ground potential. An image of X-radiation is focused through cap 14 of the envelope onto pickup pack 20. It is converted into a light image at the phosphor layer of the photocathode which excites the photocathode layer giving rise to an electron image. That image is accelerated in the direction of the anode and focused through anode cylinder 40

upon fluorescent screen 35. The screen, in response to the electron image, produces another and intensified light image which is viewed through window 33. The operation of the image intensifier is, in all respects, conventional.

In the manufacture of the described structure, the glass disc 31 with its formed ring 32 is sealed centrally of well 9 of the envelope. Thereafter, a deposit of chromium is made on the shoulder of the envelope and is baked for approximately one-half hour at approximately 425° to be converted into chrome oxide. This coating is the high resistance layer 47 of FIG. 1 and is most resistant to scratching. It is also resistant to acids that may be used in washing or processing the envelope. After chrome oxide layer 47 has been formed, it is covered or masked as are the other portions of envelope section 10 that are to be left free of a conductive deposit. Chromium or aluminum is now deposited by evaporation on the exposed portions of envelope 10 which provides bands 25, 26, 28 as well as the conductive coating that is to extend from shoulder 9 to anode subassembly 30. Having formed these conductive deposits, the anode subassembly 30 is installed in position by forcing a coupling engagement of ring 43 of anode section 41 with ring 32 of disc 31. Thereafter anode lead 45 is inserted through tubing 46 and is attached.

The envelope is now supported in a vertical lathe, assuming the position represented in FIG. 1. At this time, the envelope has both tubulations 50, 51 and it also has a third tubulation 52, the three being angularly spaced by 120° and being in alignment with although closer to the axis than apertures 12 of envelope 10. More specifically, a plane including the tube axis also includes one of apertures 12 and one of tubulations 50—52 which is one convenient geometrical arrangement to facilitate attaining the necessary radial alignment of bushings 22 with ferrules 13 even though the screen pack is brought to its final position after the intensifier envelope shall have been completed. At this point, a fixture 60 having three tines 61 is positioned so that its tines enter tubulations 50—52, respectively. The fixture is advanced toward well 9 of the envelope and the lengths of the tines are such that with the fixture thus advanced, the apertures 21c provided in frame 21 of pickup pack 20 may receive reduced diameter portions 63 of the tines as illustrated in FIG. 3. If bushings 22 are in alignment with apertures 21c, respectively, the fixture 60 is advanced until tine sections 63 pass through apertures 21c and abut against bushings 22 which serve as stops. This completes a coupling engagement of fixture 60 with the pickup frame and as the fixture is now withdrawn or moved axially away from envelope 10, pickup pack 20 is displaced away from sealing land 11 in the direction of anode subassembly 30. With pickup pack 20 in the position indicated in FIG. 1, cap 14 is sealed to land 11 of envelope section 10 and during this sealing process nitrogen or other inert gas is admitted from a supply 65 through the components of fixture 60 which are formed of tubing or channeled components to establish a suitable distribution from supply 65 to lines 61. Each tine has an exhaust port 66 that is located within envelope section 10 at this time and the flushing with the nitrogen or argon produces an airflow directed away from pickup pack 20. This not only cools the plate, as desired to protect it from heat damage during the sealing of the envelope pieces, but also flushes the pickup pack and tends to prevent contaminants from coming to rest on the pickup pack.

After cap 14 has been sealed and the structure permitted to cool, the nitrogen supply is cut off and fixture 60 is advanced

once again to elevate pickup pack 20 and position mounting bushings 22 in radial alignment with the apertures of ferrules 13. Mounting pins 23 are then installed, one end threaded into bushing 22 and the other heliarc welded to ferrule 13. Of course, if pins 23 have excessive length, it is appropriate to cut the ends that would otherwise project beyond ferrules 13. With pickup pack 20 secured in position, fixture 60 is withdrawn completely and one of the tubulations 50—52 is sealed off, leaving the other two to accommodate the exhaust and the ion pump.

At this juncture, the processing of the tube insofar as assembling the structure is concerned will have been completed except for the establishment of the photocathode layer of pickup section 20 which, as installed initially, is only equipped with its phosphor and barrier layers. The photocathode layer is put down by evaporation or other well-known techniques in a process that is thoroughly understood in the art and need not be described herein. Thereafter, the appendage pump is affixed to the tubulation 50 or 51 and the intensifier is evacuated and sealed off; again by process steps well known to the art.

The described structure has very distinct advantages over predecessor devices, both as to ease of manufacture and reduction in cost. It is a more suitable structure from the standpoint of mass production and has a minimum of metallic components integrated into the envelope. The arrangement of phosphor screen 35 within anode section 41 prevents light feedback from the viewing screen pickup pack 20 which is highly desirable.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. An image intensifier comprising:

an envelope which is closed at both ends and has a viewing window at one end;

a clamping element disposed about the periphery of and attached to said window and having a bead which is spaced from said window in the direction of the opposite end of said envelope;

an anode having a cylindrical section at one end and a flared conical section at the other end, said conical section having a resilient termination carrying an inwardly disposed bead dimensioned to releasably engage said bead of said clamping element to attach said anode in position within said envelope;

and a phosphor-coated screen positioned within said termination of said conical section of said anode in juxtaposition to said viewing window.

2. An image intensifier in accordance with claim 1 in which said resilient termination of said anode has an annular recess adjacent said inwardly disposed bead and in which said screen has a frame with resilient fingers for engaging a wall of said recess to bias said screen against said window.

3. An image intensifier in accordance with claim 1 in which said conical section of said anode is a light shield which minimizes light feedback from said screen toward said other end of said envelope.