Dec. 22, 1970 J. MOEGENBIER 3,549,229

METHOD OF ASSEMBLING AN IMAGE INTENSIFIER

Original Filed Sept. 15, 1967

FIG. 1

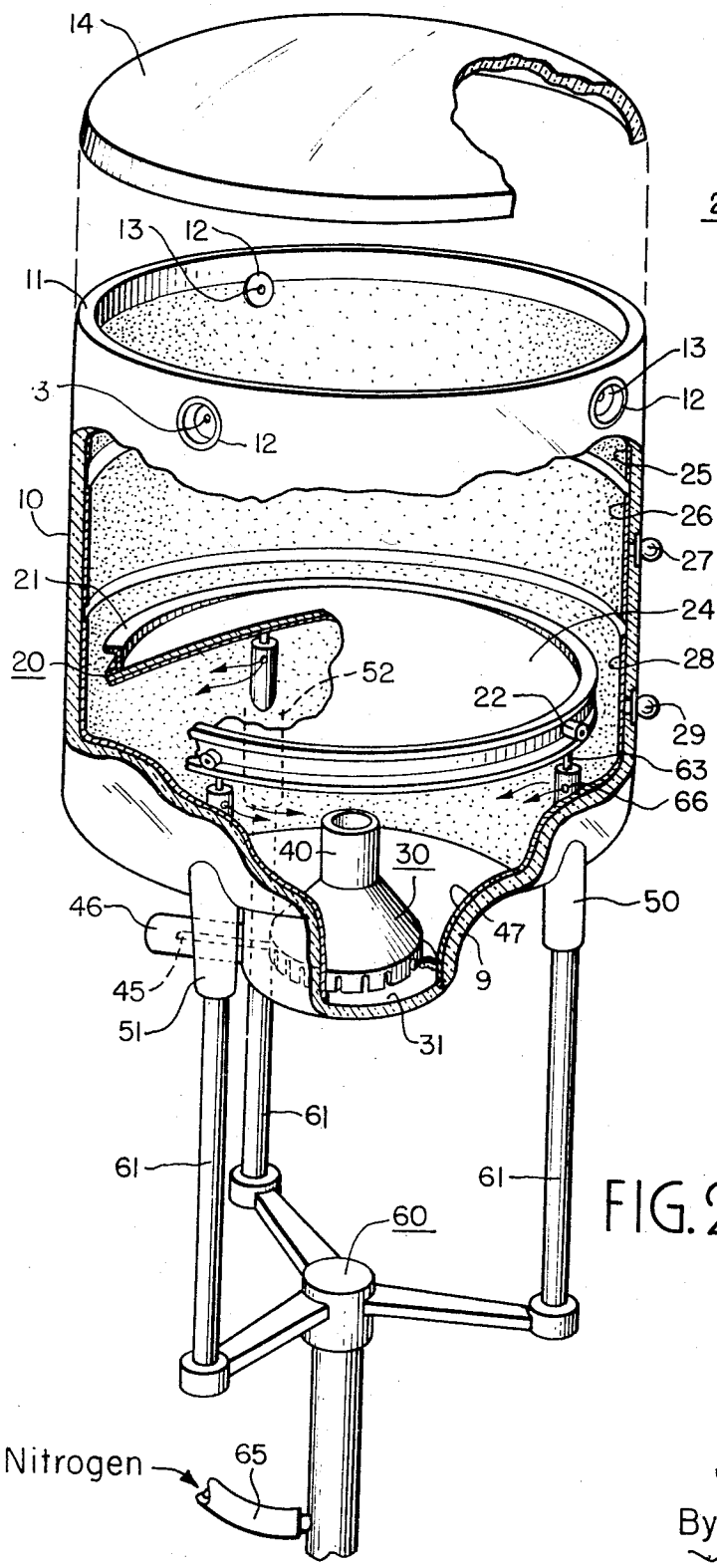


FIG. 3

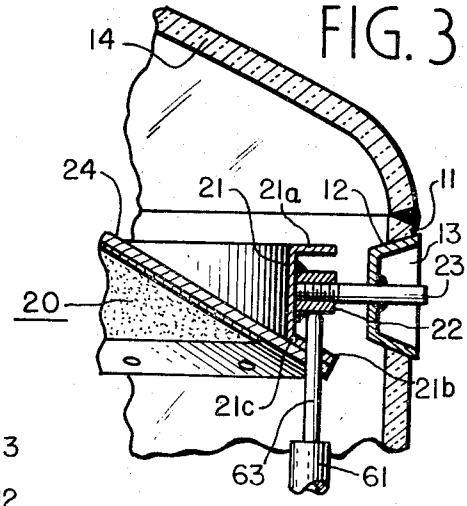


FIG. 4

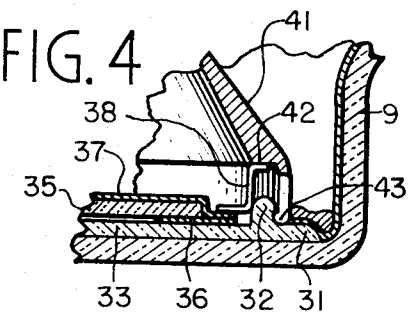
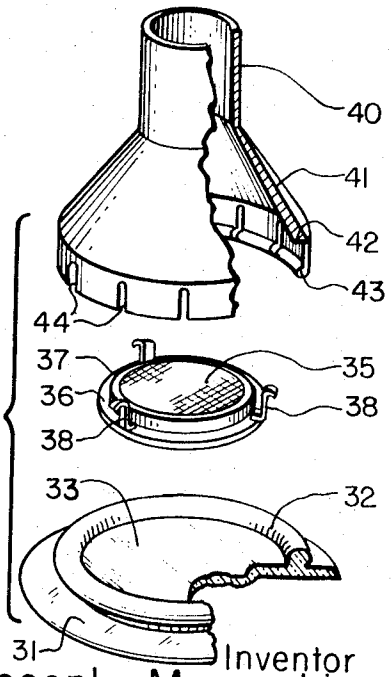


FIG. 2



Inventor
Joseph Moegenbier
By Francis W. Crotty
Attorney

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METHOD OF ASSEMBLING AN IMAGE INTENSIFIER

Josef Moegenbier, Morton Grove, Ill., assignor to Zenith Radio Corporation, Chicago, Ill., a corporation of Delaware

Original application Sept. 15, 1967, Ser. No. 669,470, now Patent No. 3,515,924, dated June 2, 1970. Divided and this application Nov. 13, 1969, Ser. No. 876,424

Int. Cl. H01j 9/38, 17/26

U.S. Cl. 316—21 10 Claims

ABSTRACT OF THE DISCLOSURE

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.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of application Ser. No. 669,470, filed Sept. 15, 1967, 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 on utilizing simply glass envelope pieces.

On 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 provisions 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 **21***a* adjacent sealing land **11** and having on the other side of the rim a canted flange **21***b* which is provided with three apertures **21***c* 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 sulphide 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 antimony-cesium. 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 midway 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 disk of optical flat glass on one surface of which is formed a clamping ring **32**; this ring surrounds and defines the viewing window **33**. Disk **31** is fused to the central portion of envelope section **9**.

The next component of the subassembly is a glass disk **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**. Disk **35** is mounted in a metallic frame comprising an annular ring **36** supporting one face of disk **35** and a similar ring **37** on the opposite face, these rings being suitably welded together firmly to hold disk **35** as indicated in FIG. 4. Three springs **38** are also secured to disk **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 disk **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 disk **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 aluminium. 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 disk **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 disk **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 **21***c* 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 aperture **21***c*, respectively, the fixture 60 is advanced until tine sections **63** pass through apertures **21***c* 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 air flow 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 one 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. In the manufacture of an image intensifier comprised of a multipiece sealed envelope having a plurality of apertures spaced about the sealing end of one of said envelope pieces, having in an envelope section closing the opposite end of said one piece of a multiplicity of apertures spaced closer to the axis of said envelope than said plurality of apertures and further comprised of a component to be secured transversely within said one envelope piece, having maximum dimensions less than the internal dimensions of said one envelope piece and having a like plurality of mounting provisions spaced on the periphery thereof in the same angular orientation as that of said plurality of apertures, a method of assembling which comprises:

inserting said component in said one envelope piece but displaced from said plurality of apertures thereof in the direction of said opposite end;

sealing a second envelope piece to said sealing end of said one envelope piece;

advancing said component toward the seal between said envelope pieces to position said mounting provisions thereof in radial alignment with said plurality of apertures;

inserting mounting pins through said plurality of apertures into coupling engagement with said mounting provisions of said component;

and making a vacuum-tight seal between each of said mounting pins and said one envelope piece.

2. The method of assembling an image intensifier in accordance with claim 1 in which one tine of a fixture is inserted through each aperture of said closing envelope section into coupling engagement with said component and in which said fixture is moved in the direction of said sealing end to advance said component and position said mounting provisions thereof relative to said plurality of apertures.

3. A method of assembling an image intensifier in accordance with claim 2 in which said component is initially positioned within said one envelope piece in the vicinity of said sealing end and in which said tines of said fixture are brought into coupling engagement with said component while it is in its initial position and in which said fixture is then withdrawn to displace said component from said plurality of apertures in the direction of said closing envelope section prior to the sealing of said envelope sections.

4. A method of assembling an image intensifier in accordance with claim 3 in which said one envelope section is supported in a vertical position with said sealing end thereof facing upward and in which the coupling engagement of the tines of said fixture with said component is effected by gravity.

5. A method of assembling an image intensifier in accordance with claim 4 in which said component has a peripheral rim with a flange portion facing said closing envelope section and having recesses corresponding in number and angular orientation to said apertures of said closing envelope section and into which said tines are inserted to effect a coupling engagement with said component.

6. A method of assembling an image intensifier in accordance with claim 2 in which at least one tine of said fixture is formed of tubing having a port located within said one envelope piece when said fixture is in engagement with said component and in which an inert gas is admitted into said one envelope piece through said tubing to create an inert atmosphere for the sealing of said envelope pieces.

7. A method of assembling an image intensifier in accordance with claim 2 in which a tubulation extends from each of said apertures of said closing end section and in which said tines are inserted through said tubulations.

8. A method of assembling an image intensifier in accordance with claim 1 in which electrodes, individually comprising a conductive coating, are applied to spaced portions of the inner periphery of said one envelope piece in the area thereof between said plurality of apertures and said closing end section prior to the insertion of said component into said one envelope piece.

9. A method of assembling an image intensifier in accordance with claim 8 in which an anode subassembly is affixed to the central portion of said closing envelope section prior to the application of said focusing electrode and in which said component comprises a photocathode the installation of which completes an electrode system for said intensifier.

10. In the manufacture of an image intensifier comprised of a multipiece sealed envelope having a plurality of apertures spaced about the sealing end of one of said envelope pieces, having a plurality of tubulations extending from the opposite end of said one piece but spaced closer to the axis of said envelope than said apertures and further comprised of a photocathode having maximum dimensions less than the internal dimensions of said one envelope piece and having a like plurality of mounting provisions spaced on the periphery thereof in the same angular orientation as that of said apertures, a method of assembling which comprises:

supporting said one envelope piece in position for sealing with another envelope piece;

inserting said photocathode in the sealing end of said one envelope piece with the mounting provisions thereof in the same angular orientation as said apertures;

inserting in each of said tubulations one tine of a supporting fixture and advancing said fixture in the direction of said sealing end into coupling engagement with said photocathode;

withdrawing said fixture to displace said photocathode from said apertures in the direction of said opposite end of said one envelope piece;

sealing said one envelope piece to another envelope piece;

advancing said fixture to position said mounting provisions of said photocathode in radial alignment with said plurality of apertures;

inserting mounting pins through said apertures and into coupling engagement with said mounting provisions of said photocathode;

and making a vacuum-tight seal between each of said mounting pins and said one envelope piece.

References Cited

UNITED STATES PATENTS

2,647,298	8/1953	Pryslar et al.	29—25.15
2,792,273	5/1957	Beggs	316—20
3,026,163	3/1962	Day	316—21
3,366,435	1/1968	Lafferty	316—24
3,465,401	9/1969	Lowery, Jr., et al.	29—25.16

JOHN F. CAMPBELL, Primary Examiner

R. J. CRAIG, Assistant Examiner

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29—25.15, 25.16; 220—2.2; 313—55, 65, 94; 316—20, 24