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Houston

[11] **3,852,131**

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[54] **METHOD OF MANUFACTURING X-RAY IMAGE INTENSIFIER INPUT PHOSPHOR SCREEN**

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[73] Assignee: **General Electric Company,** Schenectady, N.Y.

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[21] Appl. No.: **380,845**

Related U.S. Application Data

[62] Division of Ser. No. 254,100, May 17, 1972, Pat. No. 3,783,299.

[52] **U.S. Cl.**............... **156/3,** 96/36.1, 117/33.5 CP, 156/8, 156/230, 156/280, 156/285, 204/15, 264/219

[51] **Int. Cl.**.......................... **C23f 1/02,** H01j 31/49

[58] **Field of Search**.................. 204/14, 15, 20, 32; 117/33.5 C, 33.5 CP, 69, 124; 96/36.1; 264/219; 156/3, 7, 8, 18, 230, 280, 285; 250/213 R, 483

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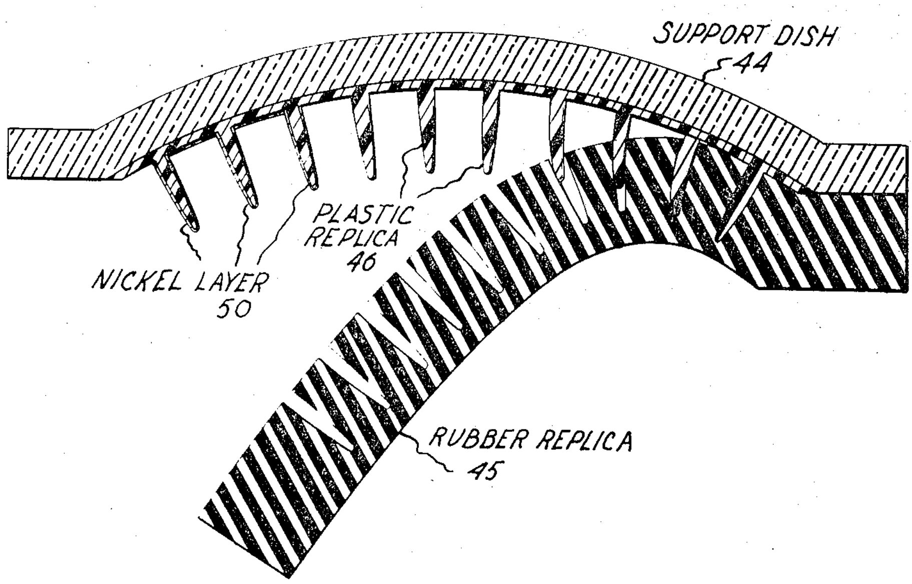
[57] **ABSTRACT**

The surface of a waffle-like metal substrate forms an array of cells for the support for the input phosphor screen of an x-ray image intensifier tube. The hollow projecting walls of the metal surface substantially reduce degradation of image resolution due to lateral scattering of light in the phosphor and thereby permits use of a thicker phosphor screen for higher x-ray absorption and, or higher image resolution. The method of fabricating the phosphor screen includes the intermediate steps of forming rubber and plastic replicas of a metal master of the waffle surface. The plastic replicas are nickel plated to form low cost metal replicas with the plastic being dissolved whereby the projecting walls are hollow.

7 Claims, 8 Drawing Figures



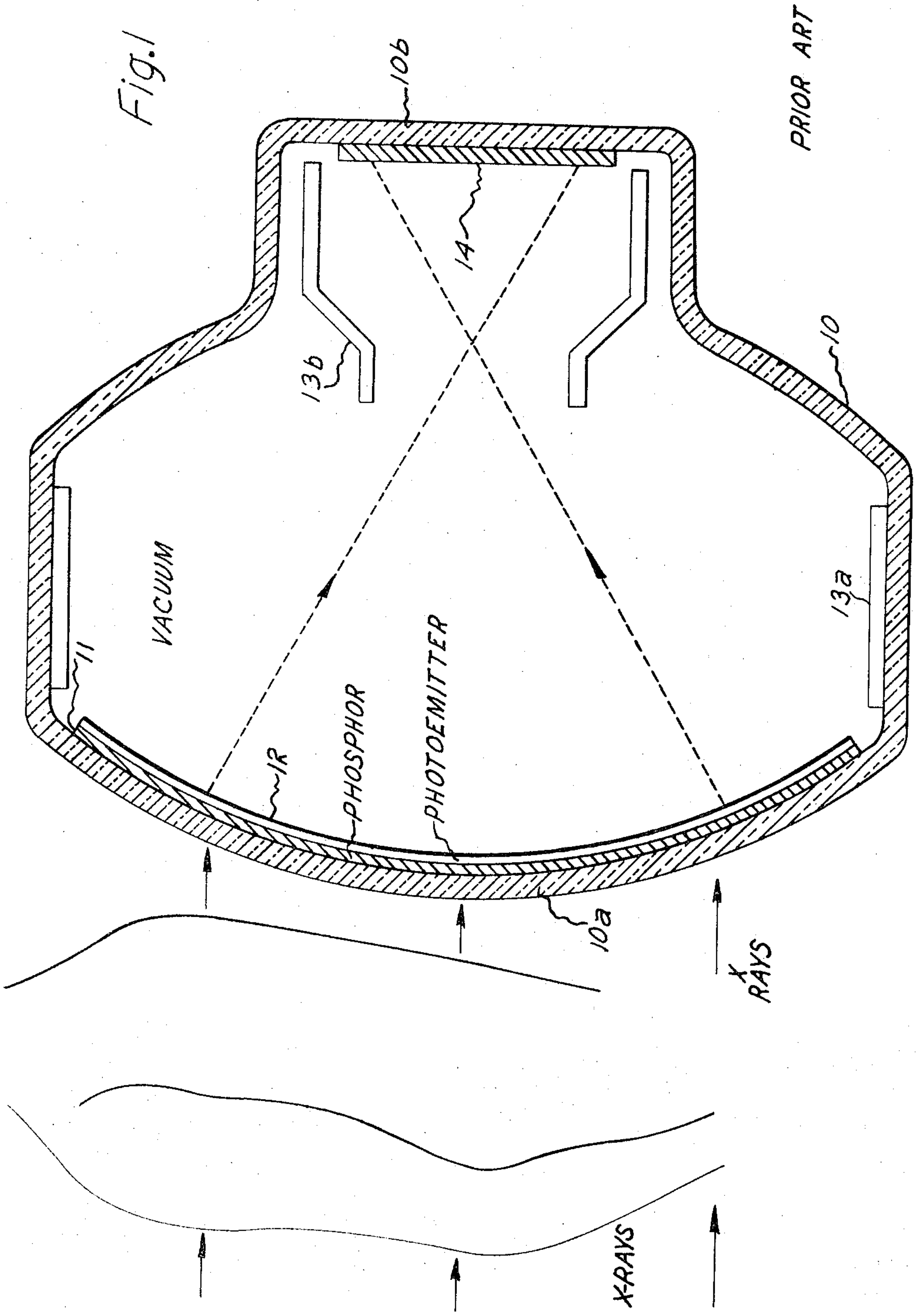


Fig.1
PRIOR ART
10b
14
13b
10
VACUUM
13a
11
12
PHOSPHOR
PHOTOEMITTER
10a
X RAYS
X-RAYS

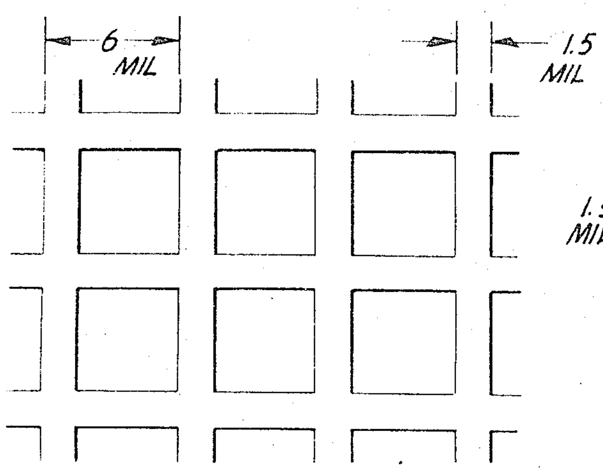


Fig.2a

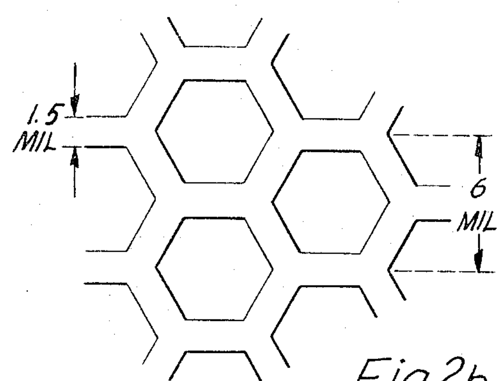


Fig.2b

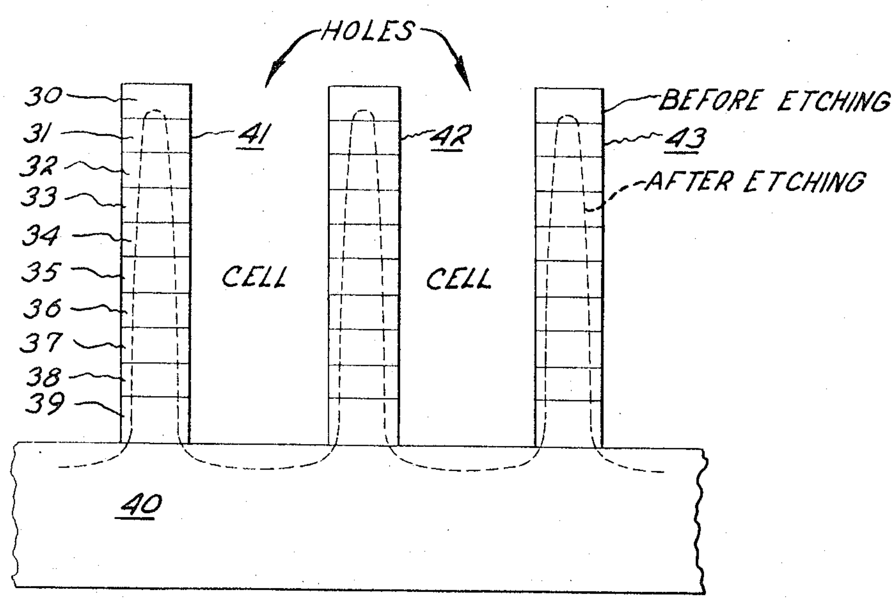


Fig.3

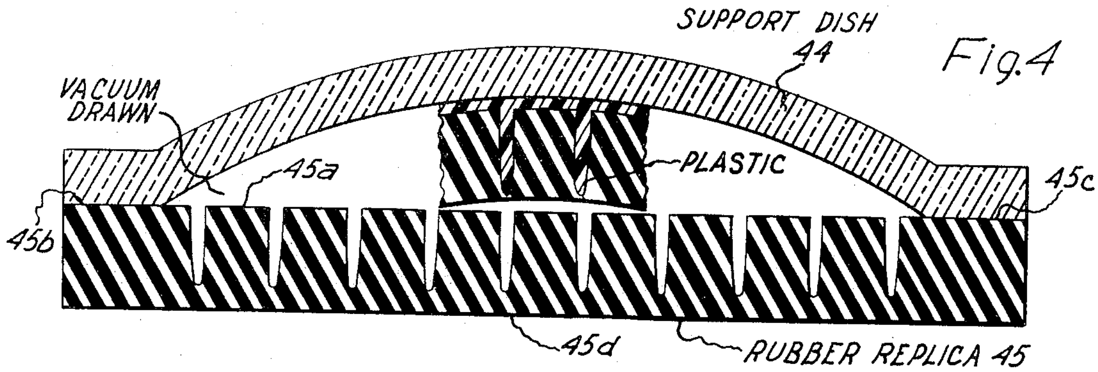

SUPPORT DISH
44
VACUUM
DRAWN
45a
PLASTIC
45c
45b
45d
RUBBER REPLICA 45

Fig.4

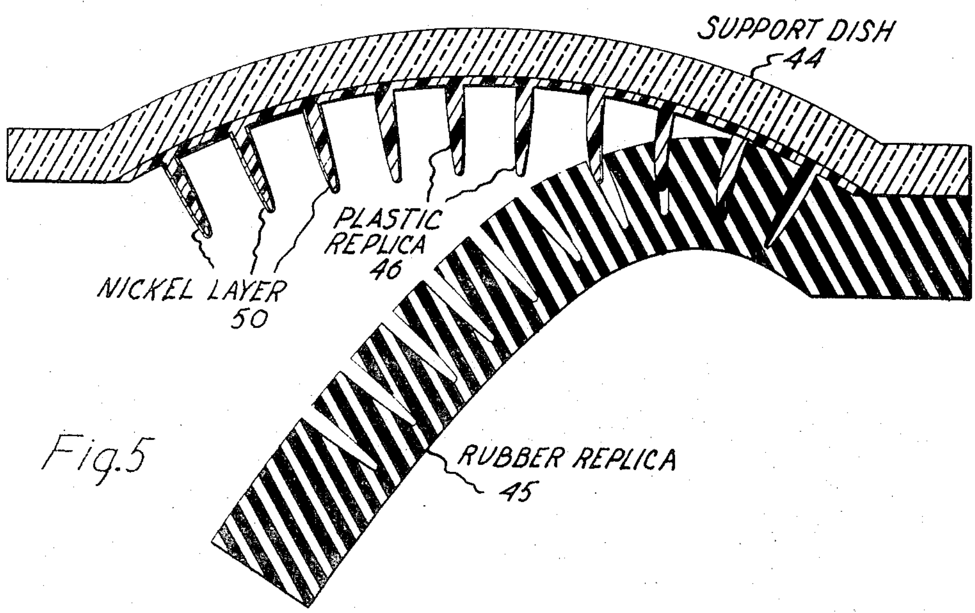

SUPPORT DISH
44
PLASTIC
REPLICA
46
NICKEL LAYER
50
RUBBER REPLICA
45

Fig.5

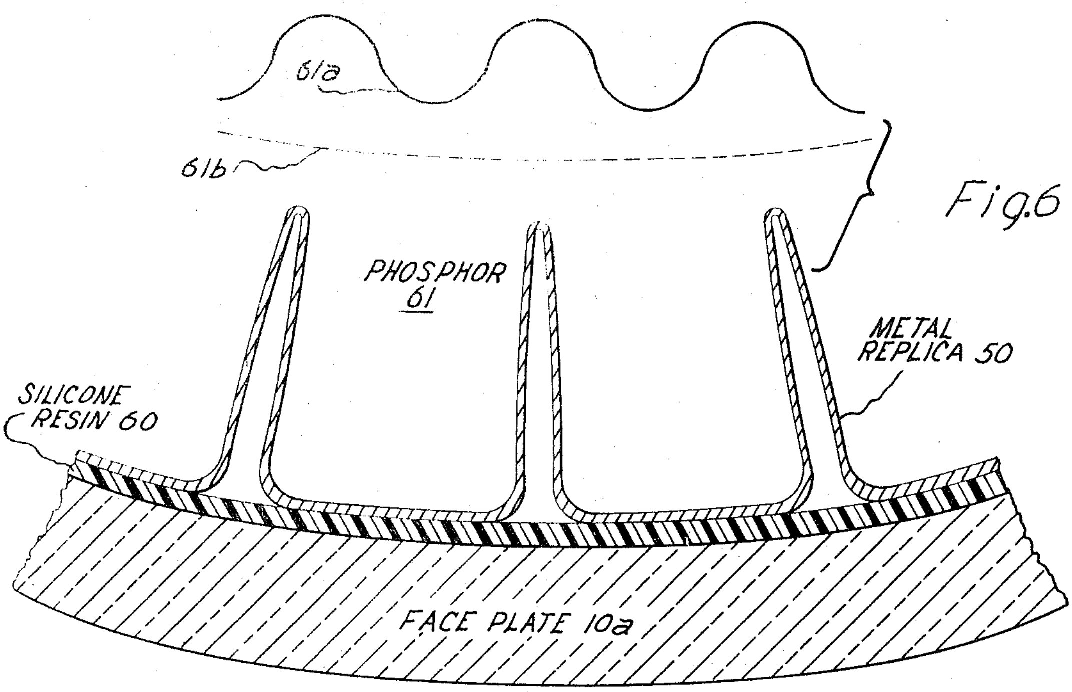

61a
61b
PHOSPHOR
61
METAL
REPLICA 50
SILICONE
RESIN 60
FACE PLATE 10a

Fig.6

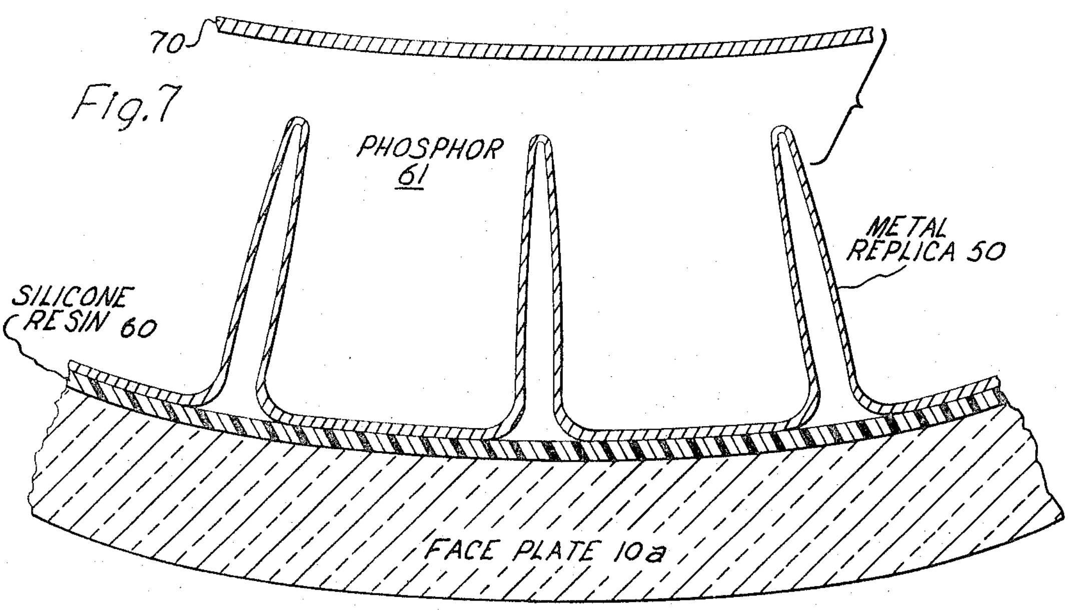

70
PHOSPHOR
61
METAL
REPLICA 50
SILICONE
RESIN 60
FACE PLATE 10a

Fig.7

METHOD OF MANUFACTURING X-RAY IMAGE INTENSIFIER INPUT PHOSPHOR SCREEN

This is a division of application Ser. No. 254,100, filed May 17, 1972, now U.S. Pat. No. 3,783,299.

My invention relates to an x-ray image intensifier tube, and in particular, to the phosphor screen structure at the input end of the tube and method of manufacture thereof.

The x-ray image intensifier tube is especially useful in the medical field for obtaining brighter x-ray images, particularly the images of body organs which generally are of low contrast. Conventional x-ray image intensifiers employ in the input end thereof a uniform layer of a dense high atomic number phosphor for absorbing the incident x-rays which have traversed through a patient's body. The x-ray photon is absorbed in the phosphor layer and light photons in the order of 1,000 light photons for each x-ray photon are generated in the phosphor layer and emitted in all directions from the point of x-ray photon absorption. A thin photoemitting coating deposited on the surface of the phosphor layer emits photoelectrons in response to light photons incident thereof. The photoelectrons are accelerated and electron-optically focussed onto a second phosphor screen at the output end of the image intensifier resulting in a brighter image than at the input phosphor screen.

The thickness of the phosphor layer in conventional image intensifiers is typically 5 to 12 mils and is a compromise between a thick layer necessary for high x-ray absorption and a thin layer necessary for high image resolution (a 12 mil thick layer yields a resolution of 40 to 50 line pairs per inch), resolution and contrast being deg due to lateral light scattering within the phosphor layer. As a result, the typical 5–12 mil thickness phosphor layer in conventional x-ray image intensifier tubes has a relatively low x-ray absorption in the order of 15 to 40 percent of the incident rays. Obviously, it would be highly desirable to employ a thicker phosphor layer in the input end of the x-ray image intensifier tube to thereby increase the x-ray absorption (and thus the sensitivity) but with less loss in resolution and local contrast than occurs in conventional image intensifiers, or alternatively, use a conventional thickness phosphor layer but with increased resolution.

Therefore, one of the principal objects of my invention is to provide a new and improved x-ray image intensifier tube having an input phosphor screen which simultaneously can achieve both high x-ray absorption and high image resolution, and the method of manufacture thereof.

Another object of my invention is to provide a relatively thick input phosphor screen with means to substantial reduce degradation of resolution and local image contrast due to lateral light scattering in the phosphor and the method of manufacture thereof.

A further object of my invention is to provide a low cost fabrication process for manufacturing the improved input phosphor screen.

Briefly stated, and in accordance with my invention, I provide an x-ray image intensifier input phosphor screen wherein a phosphor layer is deposited in the cells formed by hollow wall-like projections on the surface of a waffle-like reflective metal substrate. The cells form an array of equal size squares or hexagons and the phosphor layer extends outward slightly beyond the ends of the metal wall projections. The other side of the metallic substrate, which contains indentations corresponding to the opposite side wall projections, is bonded to the x-ray image intensifier tube face plate which may be formed of glass or a low atomic number metal such as aluminum. The outer surface of the phosphor layer, spaced from the metallic substrate, is smooth and substantially parallel to the major surface of the face plate and a thin film of a photoemitter material is deposited thereon. The phosphor layer can be relatively thick and thus obtain increased sensitivity and the metallic cell walls substantially reduce degradation of image resolution and contrast due to lateral scattering of light in the phosphor.

My x-ray image intensifier input phosphor screen is fabricated by the following method. Sheets of metal mesh are formed by photoetching thin metal sheets to produce an array of small holes in the mesh having a square or hexagonal shape. The sheets of metal mesh are superimposed in precise hole alignment and diffusion bonded to a heavy planar metal substrate to thereby obtain a waffle-like surface wherein the wall projections which define an array of cells are each approximately 1.5 to 2 mil wide and the cell width is about 4 to 5 mils. The walls of the cells are then thinned to approximately 0.5 mil width by chemical etching and this metal substrate having a waffle-like surface is used as a master from which silicone rubber replicas are made. Each silicone rubber replica has the wall indentation surface thereof coated with a suitable plastic material and such coated surface is drawn toward a support member having the concave-shape of the x-ray image intensifier face plate. Upon hardening of the plastic, the silicone rubber replica is removed, and the concave-shaped plastic structure has the wall-like projections of the metal master. The plastic replica is treated to be electrically conductive, and is electroplated to form a very thin, high light reflectivity, metal layer on the surface thereof. The plastic material is then dissolved leaving the metallic replica which is transferred to the face plate of the image intensifier tube and bonded to the inner surface thereof. The array of cells formed by the hollow wall projections of the metallic replica are then filled with a phosphor material which extends slightly beyond the ends of the projecting walls and forms a smooth outer surface upon which a thin uniform coating of a photoemitter material is deposited to form the photocathode of the x-ray image intensifier tube.

The features of my invention which I desire to protect herein are pointed out with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawings wherein like parts in each of the several figures are identified by the same reference character, and wherein:

FIG. 1 is an elevation sectional view of a conventional x-ray image intensifier tube;

FIGS. 2*a* and 2*b* are top views of two geometries of an array of cells formed by the waffle-like surface on a metallic substrate utilized in fabricating a master in accordance with my invention;

FIG. 3 is an elevation sectional view of bonded sheets of metal mesh which form the waffle-like surface illustrated in FIGS. 2*a*, 2*b*, but to a larger scale, and also indicates the thinned wals of the cells occurring after a subsequent etching process;

FIG. **4** is an elevation sectional view, to the same scale as FIG. **1,** of a silicone rubber replica of the master illustrated partially in FIG. **3,** and also shows a concave support member onto which the silicone rubber replica is pressed to form a plastic replica;

FIG. **5** is an elevation sectional view of the plastic replica formed on the support member in FIG. **4,** and also shows a thin metal layer plated on a first part of the plastic replica to form a metallic replica, and the silicone rubber replica being peeled from the plastic replica;

FIG. **6** is an elevation sectional view, to a larger scale than FIG. **5,** of the metallic replica formed in FIG. **5** and bonded to the x-ray image intensifier tube face plate, and a phosphor layer deposited on the metallic replica waffle surface; and

FIG. **7** is an elevation sectional view, of the input end structure of my image intensifier tube as shown in FIG. **6** after the phosphor surface has been smoothed and a photoemitter coating deposited thereon.

Referring now in particular to FIG. **1,** there is shown a conventional x-ray image intensifier tube comprised of a glass envelope **10** having an input end (face plate) **10***a* which has a uniform phosphor layer **11** of thickness in the range of 0.005 to 0.012 inch deposited on the inner surface thereof. The phosphor may be zinc cadmium sulfide or cesium iodiode as typical materials onto which a thin film **12** of photoemitter material is deposited of thickness of approximately 100 A. The photoelectrons emitted by the photoemitter coating **12** are focussed by electrode **13***a* maintained at a potential of several hundred volts and are accelerated to approximately 25 kilovolts by means of electrode **13***b* (connected to a suitable D.C. voltage source) at the output end of the image intensifier tube, the electrodes being suitably shaped to provide electron-optical focussing of the accelerated photoelectrons onto a second uniform phosphor screen (layer) **14** deposited on the inner surface of the glass envelope at the output end **10***b* thereof. The image appearing on the second phosphor screen **14** is a brighter version of the image on the first phosphor screen **11** and can be viewed directly by the physician or be subjected to further processing. The paths of two photoelectrons between the photoemitter coating **12** and the second phosphor screen **14** are indicated by dashed line and arrowheads. As stated hereinabove, the thickness of the input phosphor screen **11** in conventional x-ray image intensifier tubes is a compromise between a thick screen for high x-ray absorption and thin screen for high resolution which is determined primarily by lateral scatter in the phosphor.

My invention provides a new and improved high resolution x-ray image intensifier input phosphor screen which avoids the compromise between the thick and thin phosphor screen by the use of a waffle-like metallic surface wherein hollow wall projections thereof substantially prevent degradation of resolution and local image contrast due to lateral scattering of light in the phosphor. My invention permits the use of a thicker phosphor screen for achieving higher x-ray absorption without the attendant degradation of resolution and contrast obtained in conventional image intensifiers, or a phosphor screen of conventional thickness but with a significantly higher resolution. The waffle-like metallic surface could be achieved by forming the wall projections which define an array of cells of the waffle pattern, by separate wire elements, however, since it is desired to obtain cells of very small size, in the order of 5 mil width, and have a plurality of such cells of identical size, the fabrication process to be described hereinafter is believed more suitable for providing the consistently equal size cells and projecting walls.

This invention is distinguished in at least the following five respects from a related invention described and claimed in my concurrently filed patent application Ser. No. 380,844 (RD-5100) wherein wall-like projections of a waffle-like substrate are (1) solid, the entire substrate is (2) a relatively thick (3) layer having a completely smooth surface and is made of (4) a silicone resin and granular phosphor mixture, and (5) does not require an additional intermediate step in fabrication to produce a plastic replica on which the final replica is formed.

The fabrication process is initiated by selecting sheets of metal suitable for photoetching such as nickel or stainless steel in the order of 1 or 2 mils thick. This relatively small thickness is chosen since it is easier and more precise to photoetch holes with a depth at least a factor of two smaller than the hole diameter. An identical pattern (array) of holes is etched through each sheet. The etched holes in the metal mesh sheets preferably have a square or hexagonal shape as illustrated in FIGS. **2***a* and **2***b*, respectively, with a center-to-center hole spacing of approximately 6 mils and separation (wall thickness) of approximately 1.5 to 2 mil as indicated on the drawing. The holes are of equal size and equally spaced from each other and form an array of identical rows and columns of holes to maximize the hole area in the mesh. Other shape holes, such as triangular or circular could be used, however, such shaped holes produce less open area in the mesh.

Upon completion of the photoetching step, the sheets of metal mesh are superposed in precise hole alignment to form an assembly of approximately 10 mils height as one example, the sheets of metal mesh **30, 31, 32 - - -** and **39** being stacked on a heavy planar substrate **40** of the same metal as the mesh and subsequently being diffusion bonded thereto. The approximately **10** mil thick stack of metal mesh is diffusion bonded by bolting the mesh assembly between two massive planes of metal, the upper one of which is thinly coated with an oxide such as MgO to prevent sticking, and this assembly is heated to a suitable temperature (e.g., approximately 1,000°C when bonding nickel or stainless steel) in a hydrogen atmosphere or vacuum to accomplish the diffusion bonding. The diffusion bonding results in a "waffle-like" structure having a surface illustrated by the heavy solid line in FIG. **3** wherein the projecting walls **41, 42, 43** from the surface of substrate **40** are rectangular in the section taken vertically through the projecting walls. The space between the surrounding walls and substrate **40** will be hereinafter described as a cell and it is obvious that the diffusion bonding step results in a plurality of identical walls wherein FIG. **2***a* or FIG. **2***b* represent the top view of the cell structure shown in elevation sectional view in FIG. **3.** The walls **41, 42, 43** of the cells are then thinned to approximately 0.5 mil thickness by a chemical etching process to produce the master substrate structure indicated by dashed line in FIG. **3.** The thinned walls are substantially thinner than the corresponding thinned walls described in my aforementioned concurrently filed application Ser. No.

380,844 (RD-5100) since the metal that forms such hollow walls in the final structure is merely light-reflective and does not generate light photons whereas in Ser. No. 380,844 (RD-5100) such walls are solid and the granular phosphor portion thereof is both light-reflective and generates its own light which contributes to the light generated in the adjacent phosphor laser.

The array of cells formed by the waffle-like surface of the metal master structure in FIG. 3 after the chemical etching process could be filled with a phosphor material to form a phosphor screen, however, the process hereinabove described is relatively expensive and in accordance with my invention, I fabricate many inexpensive metal replicas of such original master whereby the cost per x-ray intensifier tube will be small. Also, at some stage in the process it is necessary to sag the planar surface of substrate **40,** that is, to obtain it in a caveshape conforming to the shape of the face plate **10***a* of the image intensifier tube.

In order to replicate the master illustrated in FIG. **3,** an intermediate step of making one or more silicone rubber replicas is utilized. The silicone rubber replica is fabricated by vacuum impregnation wherein the master is covered with a layer of liquid silicone rubber (e.g., General Electric RTV-11) to which a small amount of a suitable curing catalyst has been added. The coated master is then placed in a vacuum chamber for a few minutes in order to pump away all air bubbles and insure that the silicone rubber contacts all the crevices of the master. The rubber is then allowed to cure for an appropriate period, e.g., 24 hours, in order to form an elastic, rubbery solid. The silicone rubber replica is approximately 50 mils thick in order to remain somewhat flexible so that it can be subsequently easily removed by peeling from a plastic replica to be described hereinafter.

Referring now to FIG. **4,** a support dish member **44** which has the same concave form as face plate **10***a* of the image intensifier tube is utilized as a form on which to fabricate a plastic replica of the FIG. **3** chemically etched waffle-like metal surface. The support form **44** may be made of virtually any material which is chemically inert to the plastic material and its solvent, glass or stainless steel being two typical materials. A suitable plastic material which readily hardens at room temperature, or at a slightly elevated temperature, such as polymethyl methacrylate (Lucite) or an epoxy resin such as Hysol R8-2038 in the molten state is coated along the wall indented side **45***a* of the rubber replica **45.** The two margins **45***b*, *c* along the wall indented side **45***a* of the rubber replica are suitably retained against corresponding planar margins of the concave support dish **44** and the entire assembly is placed within a chamber wherein a vacuum is drawn between the rubber replica **45** and support dish **44** thereby pressing the rubber replica toward the concave form to produce a plastic replica **46** of the FIG. **3** master waffle-like surface except that the plastic replica is curved into the concave shape of the image intensifier tube face plate **10***a* rather than being planar, as shown in part in FIG. **4.**

Upon hardening of the plastic, the silicone rubber replica **45** is removed therefrom by peeling it from the plastic replica **46** as shown in FIG. **5,** and the rubber replica may be reused to form additional plastic replicas. The plastic replica **46** is made electrically conductive by evaporating an electrically conductive thin metal coating (of silver, gold or copper as three typical examples) onto the plastic surface. Alternatively, the plastic is rendered electrically conductive by mixing the metal or graphite in powder form into the liquid plastic such that the plastic has bulk conductivity. After the plastic replica has been rendered electrically conductive, a very thin layer **50** (of thickness in the range of 0.2 to 0.5 mil) of a suitable metal such as nickel or other metal having relatively high light reflectivity is electroplated onto the plastic surface.

The plastic material is then dissolved in a suitable solvent such as acetone for the Lucite or Hysol dissolver AC-4079 for the Hysol plastic and the remaining metallic replica 50 is carefully transferred to the inner surface of the concave-shaped face plate **10***a* of the x-ray image intensifier tube and positioned thereon. The face plate **10***a* is fabricated of glass or a low atomic number metal such as aluminum.

The metal replica **50** is bonded to the face plate **10***a* by means of a thin coating **60** of silicone resin as one example to form the structure illustrated in FIG. **6** wherein the hollow wall projections of the metal replica extend normal to the surface of face plate **10***a*. The array of cells formed by the metal waffle-like surface are filled with a suitable preferably transparent phosphor material using conventional techniques, the phosphor layer extending beyond the ends of the wall projections of the metal replica **50.** The phosphor **61** can be a conventional granular phosphor (but of large grain size to obtain high light transmission characteristics) such as silver-activated zinc cadmium sulfide without, or in a silicone resin binder, or, more desirably is a transparent phosphor such as evaporated cesium iodiode (CsI) phosphor. Evaporation of the CsI from vertically above the metal replica **50** results in the outer surface of the phosphor layer **61** having the undulating form **61***a* shown in FIG. **6** due to the projecting walls of the metal replica. The uneven surface **61***a* of the phosphor outer surface is mechanically polished in a dry box, since CsI is a relatively soft material, to obtain the smooth surface **61***b* shown in dashed line. If the indulations are not so severe as to upset either the electron-optics or the formation, and or surface resistivity of the photocathode (to be described hereinafter), then it may not be necessary to smooth out such undulations. The phosphor layer is approximately 12 mils thick as one typical example, and obviously can be made thicker if higher x-ray absorption is desired. Large phosphor grain size herein is defined as particle diameter greater than 0.3 mil.

Referring now to FIG. **7,** a thin uniform coating of a suitable photoemitter material **70** is deposited on the smooth surface **61***b* of the phosphor layer **61** during the evacuation of the image intensifier tube to form the photocathode of such image intensifier tube. The photoemitter material may be of the common types known as S-20 (a compound of antimony, cesium, sodium and potassium) or S-11 (a compound of cesium, antimony and oxygen) as two typical examples and is a very thin coating in the order of 100 A. If desired, an isolating layer of transparent alumina, as one example, may be deposited between the phosphor **61** and photoemitter **70** layers in order to isolate the alkali metal of the photoemitter material from the phosphor, however, such isolating layer is not essential to the successful operation of my input phosphor screen.

The light reflectivity of the metal replica surface is generally sufficiently high, but can be increased, if desired, by bright-dipping the metal replica (i.e., immersing the replica for a moment in a solution of nitric acide, sulfuric acide and NaCl or by coating it with MgO smoke obtained by burning magnesium. The reflectivity of the metal replica wall projections is not too critical since the height to diameter ratio of each cell is only slightly greater than unity.

The wall-like projections of the metal replica **50** extend normally through at least 50 percent of the phosphor layer **61** thickness, and as shown in FIGS. **6** and **7**, typically extend through approximately 80 percent of the phosphor layer. The effect of the relatively highly light-reflective wall projection surfaces is to substantially reduce lateral scattering of light in the phosphor and thereby substantially reduce degradation of image resolution and contrast due to such cause. Obviously, the metal master can be made with more sheets of the metal mesh to thereby obtain a metal replica having wall projections of greater height whereby a thicker phosphor layer can be utilized for increased x-ray absorption, and thus increased sensitivity, or, the same thickness phosphor layer can be used and the further extending wall projections further improve the resolution. It should also be noted that the base portion of the metal replica (i.e., the floor portion of each cell which interconnects the hollow wall projections), being fabricated of a light-reflective metal, provides a means for reflecting light photons which are originally emitted toward the face plate **10***a*, back toward the photoemitter layer **70**. Thus, a separate light-reflective coating between the face-plate **10***a* and phosphor layer **61** is not required in my invention, although it is generally utilized in conventional x-ray image intensifiers.

As stated hereinabove, the silicone rubber replica **45** is changed from its original planar shape (on the non-indented major surface **45***d* thereof) into the desired concave shape conforming to the face plate surface. Alternatively, the final electroplated metal replica **50** is relatively flexible due to its thinness and corrugated (hollow wall projections) form and therefore all of the replication (including the electroplated metal replica) can be accomplished using planar geometry and the final metal replica can then be sagged into the desired concave shape while bonding such replica to the face plate thereby simplifying the process of fabricating the plastic replica.

From the foregoing description, it is apparent that my invention attains the objectives set forth and makes available a new and improved x-ray image intensifier tube which has an input phosphor screen that simultaneously achieves both high x-ray absorption (and thus high sensitivity) and high image resolution as well as providing a method of manufacturing such input phosphor screen. The method of manufacturing the input phosphor screen is a low cost fabrication process due to the use of a silicone rubber replica which permits fabrication of many inexpensive metal replicas of the original master. The light-reflective surfaces of the hollow projecting walls of the metal replica prevent degradation of image resolution and contrast due to lateral scattering of light in the phosphor layer and thereby avoid phosphor layer thickness compromise in conventional x-ray image intensifier tubes between high x-ray absorption and high image resolution. It will be apparent to those skilled in the art that the waffle-like surface on the metal replica which constitutes the essence of my invention may take other forms than that specifically illustrated and described above. Also, the support for the input phosphor screen, herein described as the face plate, may be slightly spaced from the input window of the tube glass envelope. Thus, it is to be understood that changes may be made in the particular embodiment of my invention as described which are within the full intended scope of the invention as defined by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A method for manufacturing an improved x-ray image intensifier input phosphor screen comprising the steps of

forming an electrically conductive plastic replica having wall-like projections forming a waffle-like surface on a first major side thereof and a smooth surface on a second major side,

forming a thin, relatively high reflectivity metal layer on the waffle-like surface of the plastic replica,

dissolving the plastic material thereby leaving a thin metal replica having wall-like projections forming a waffle-like surface on a first major side thereof and the second major side having indentations corresponding to the wall-like projections on the first side,

transferring the metal replica to the face plate of an x-ray image intensifier tube, and positioning the metal replica on the inner surface of the face plate,

firmly attaching the metal replica to the face plate,

depositing a phosphor layer on the waffle-like surface of the metal replica to a thickness wherein the phosphor layer extends slightly beyond the ends of the wall-like projections,

smoothing the outer surface of the phosphor layer to obtain a surface substantially parallel to the inner surface of the face plate, and

depositing a thin uniform coating of a photoemitter material on the outer surface of the phosphor layer.

2. The method set forth in claim **1** wherein the step of forming the thin metal layer on the plastic replica consists of electroplating the plastic replica with nickel to a thickness in the range of 0.0002 to 0.0005 inch.

3. The method set forth in claim **1** wherein

the step of firmly attaching the metal replica to the face plate consists of applying a thin coating of silicone resin to the second major side of the metal replica and pressing the coated surface against the concave-shaped inner surface of the face plate of the x-ray image intensifier tube to cause bonding therebetween.

4. The method set forth in claim **1** wherein the step of forming the electrically conductive plastic replica comprises the steps of

photetching a predetermined number of thin metal sheets to produce an array of small holes therein forming a mesh,

superimposing the sheets of metal mesh in precise hole alignment upon a heavy planar substrate,

diffusion bonding the sheets of metal mesh to the planar substrate to obtain an array of rectangular shaped wall-like projections in vertical section through the solid portions of the sheets of metal mesh, chemically etching the bonded metal mesh-substrate assembly to obtain a waffle-like surface having thin wall projections which define an array of cells of the same shape as the photoetched holes and thereby form a metal master,

forming at least one silicone rubber replica from the metal master,

coating the wall indentation surface of the rubber replica with a plastic material,

drawing the plastic-coated surface of the rubber replica to a support member,

hardening the plastic material,

removing the rubber replica from the hardened plastic structure which forms a plastic replica of the metal master, and

treating the plastic material to render it electrically conductive.

5. The method set forth in claim **4** wherein

the step of drawing the plastic coated surface of the rubber replica to a support member consists of drawing the rubber replica to a support member having the concave shape of the face plate of the x-ray image intensifier tube whereby the hardened plastic replica conforms to the concave shape of the face plate.

6. The method set forth in claim **4** wherein

the step of drawing the plastic coated surface of the rubber replica to a support member consists of drawing the rubber replica to a planar support member, and

sagging the metal replica into the concave shape of the face plate of the X-ray image intensifier tube upon transferring the metal replica to the face plate whereby the replication process is accomplished with simpliied planar geometry.

7. The method set forth in claim **4** wherein

the step of photoetching thin metal sheets consists of photoetching sheets of the metal each being of thickness in the order of 1 to 2 mils to thereby precisely photoetch holes with a depth at least a factor of two smaller than the hole diameter to obtain the array of small holes of equal size and equal shape having a center-to-center spacing of approximately 6 mils and separation of approximately 1.5 to 2 mils from which the array of rectangular shaped wall-like projections is formed, and

the step of chemically etching the bonded metal mesh-substrate assembly results in the wall projections being thinned to approxiately 0.5 mil thickness.

* * * * *