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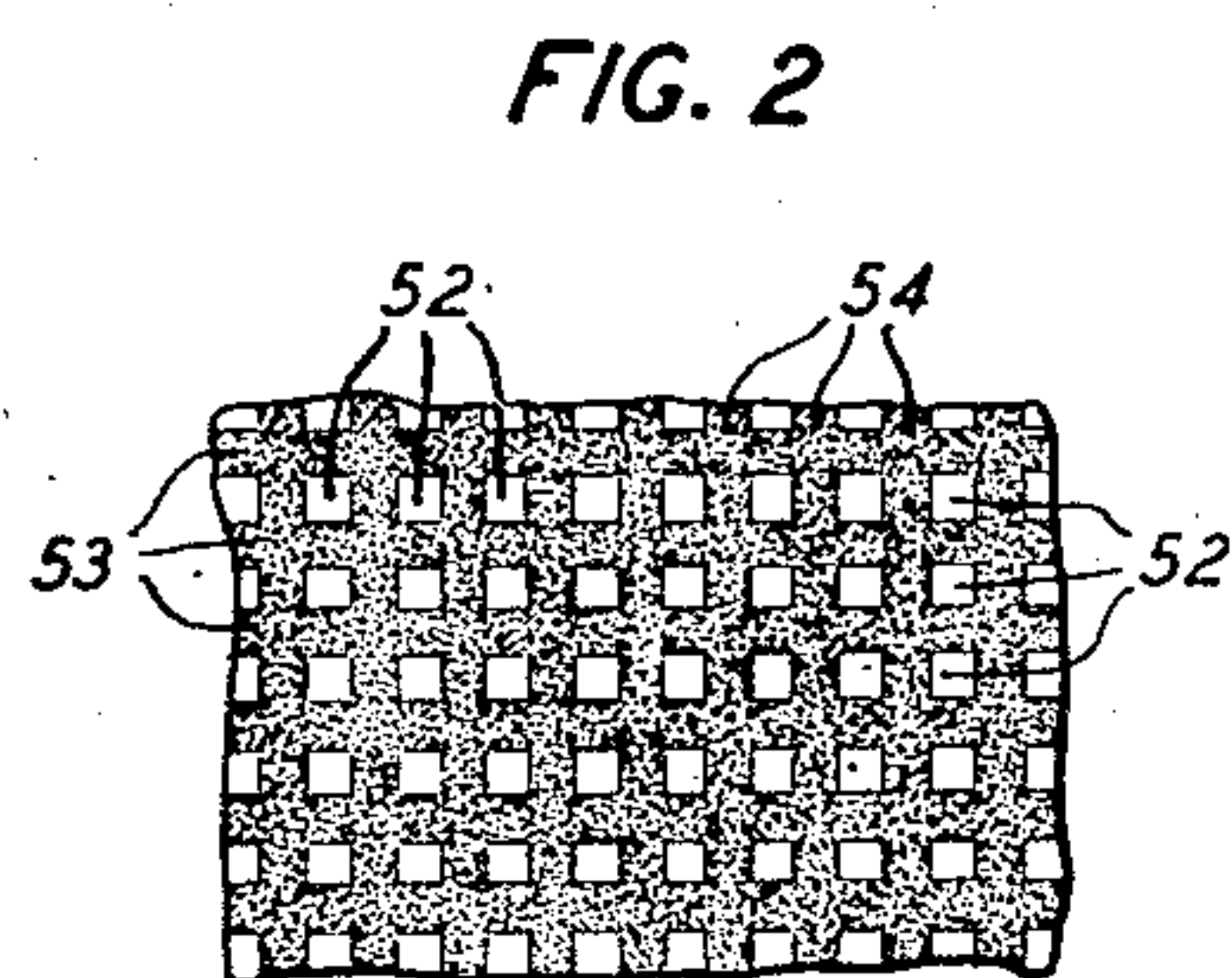
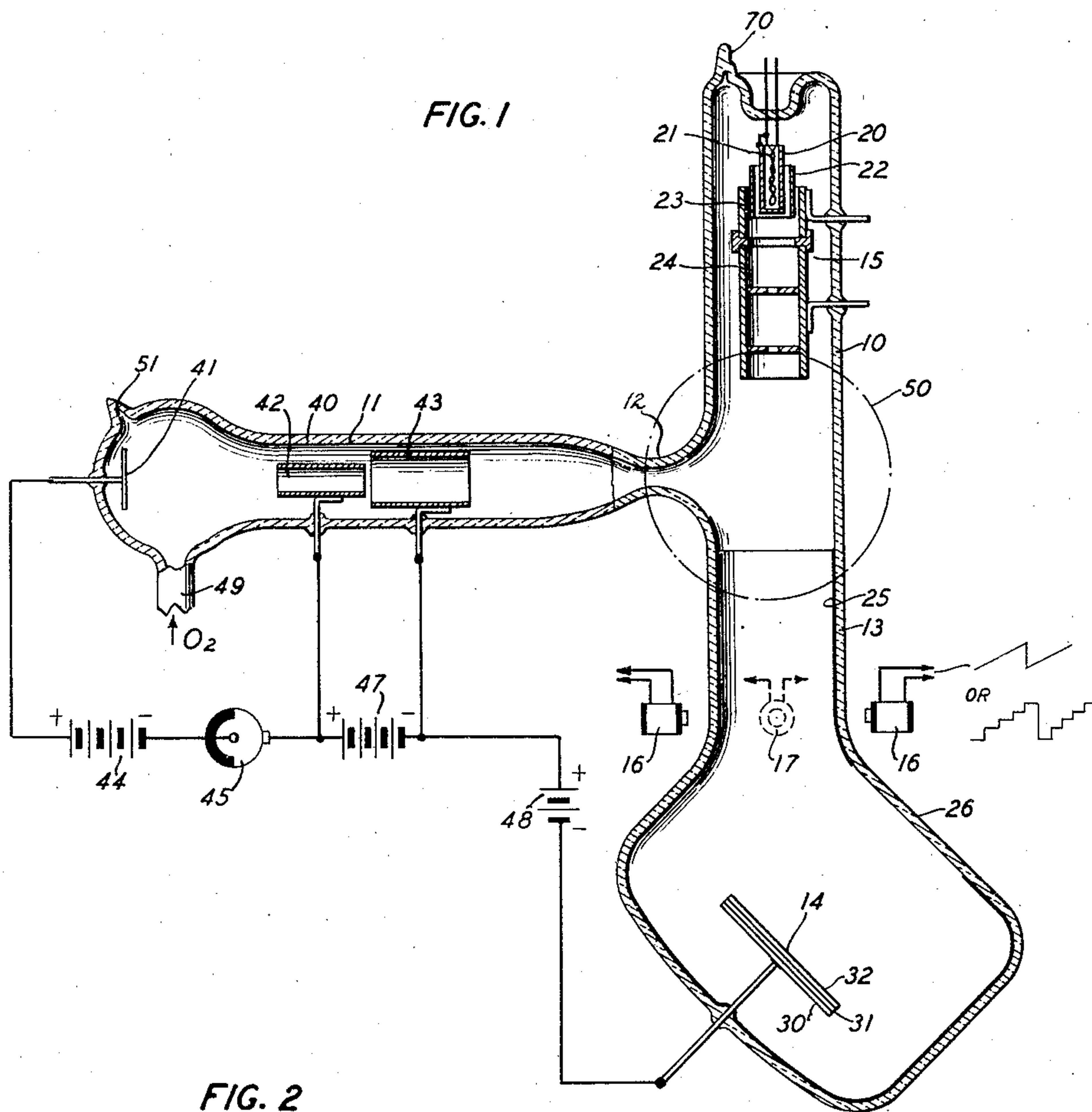
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2,434,931

METHOD AND APPARATUS FOR IONIC DISCHARGE COATING

Filed Dec. 1, 1944

2 Sheets-Sheet 1



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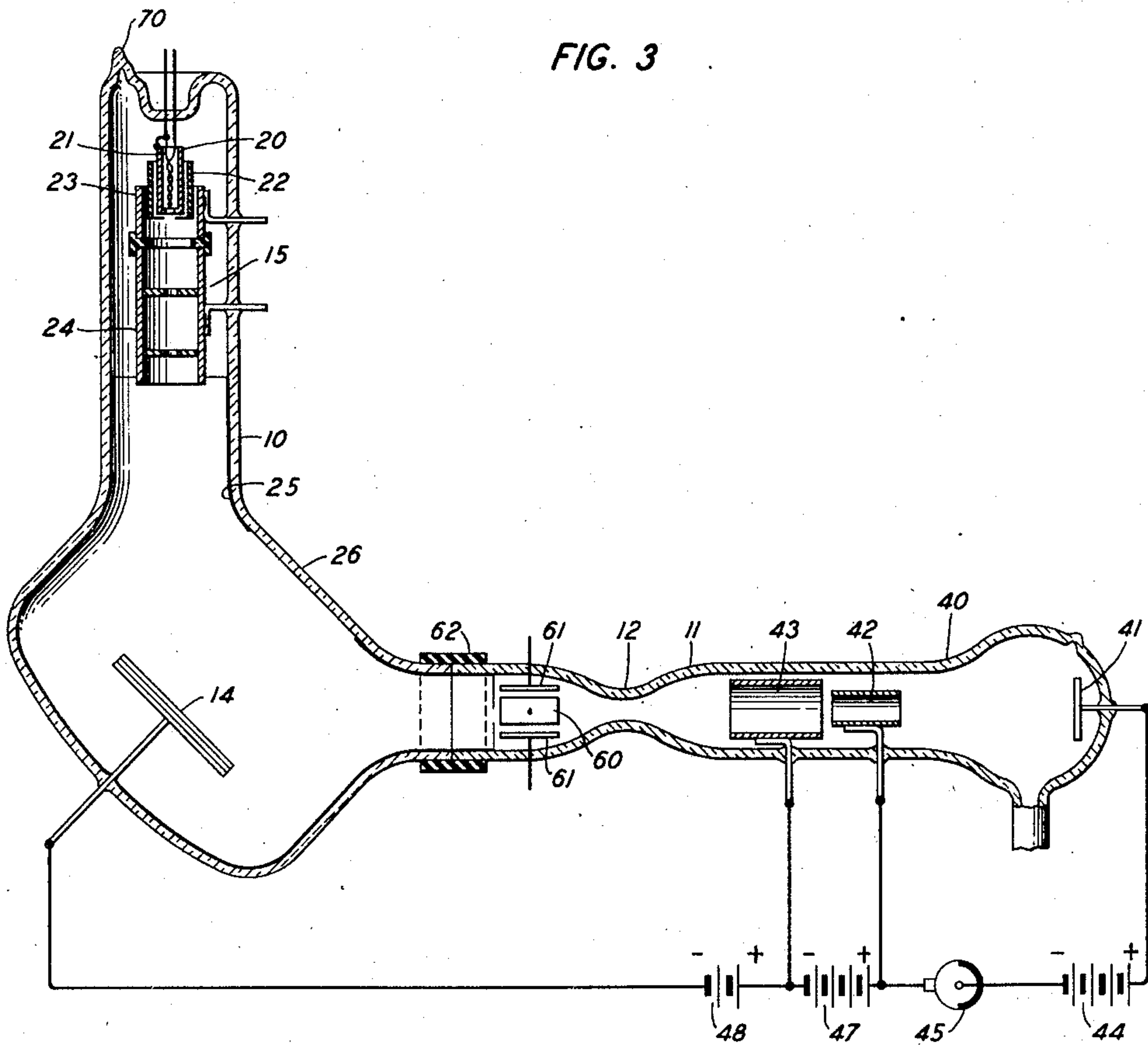
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METHOD AND APPARATUS FOR IONIC DISCHARGE COATING

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2 Sheets-Sheet 2



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2,434,931

METHOD AND APPARATUS FOR IONIC
DISCHARGE COATING

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Application December 1, 1944, Serial No. 566,063

9 Claims. (Cl. 117—33.2)

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This invention relates to method and apparatus for ionic discharge coating and more specifically to methods of and means for generating positive ion beams and for utilizing said beams, for example, in the formation of targets for electron beams in electron camera tubes.

One well-known type of electron camera tube is called the "iconoscope." In the usual form of this tube, there is provided a mosaic target comprising a metal backing or signal plate, an insulating layer on the signal plate and a discontinuous layer of photosensitized metallic globules or particles on the insulating layer. Radiations from an object are applied to this target and it is scanned with a beam of electrons to produce a signal current in a resistor which is connected to the signal plate. In a well-known method of making mosaic targets, the insulating layer which usually is of mica or glass is coated with a metallic layer of silver and by a heating process the silver is broken up into discontinuous particles which are oxidized and sensitized with caesium to form caesium-oxide-silver globules. In screens made by this process, the particles are of irregular shape and distribution, thus leading to non-uniformity of photosensitivity over the surface of the mosaic. This invention in one of its primary aspects relates to mosaic targets in which this non-uniformity is avoided or greatly reduced.

It is an object of this invention to provide novel methods of and means for making mosaic targets for electrons, the particles of the mosaic being of substantially uniform shape, size and distribution.

In a copending application of the same inventor, Serial No. 484,966, filed April 29, 1943, there is described various methods and means of utilizing beams of positive ions of metallic material in the formation of mosaic targets. The ions may be of a metal which is photosensitive, such as an alkali or alkaline earth metal, or they may be of metal which is not appreciably photosensitive. In this latter instance, the metallic spots formed by the method described in the copending application are photosensitized as in the usual "iconoscope" target technique. In a second copending application of the same inventor, Serial No. 566,062, filed December 1, 1944, a beam of positively charged hydrogen ions is produced by ion-optical means and utilized to scan a metallic oxide or other suitable non-conducting reducible layer to produce ions of metal in a "sea" of insulation. Oxides of aluminum or one of the solid metals from group II in the periodic table

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are suitable for this purpose. The ions of metal are then photosensitized as in the usual "iconoscope" technique.

In accordance with the present invention, an unmodulated oxygen positive ion beam produced by ion-optical means in a side tube is caused to scan a metal layer in crossed spaced lines to produce oxide lines between conducting islands. Aluminum is a suitable metal for the layer. In general, any of the solid metals from group II in the periodic table according to Mendeleeff can be used instead. The aluminum can have its photosensitivity increased by sensitizing it after the oxygen ion treatment with a suitable alkali metal such as caesium. A very uniform pattern is produced by this method.

More specifically, in accordance with an exemplary form of the invention, an oxygen positive ion beam is generated in a side tube connected to the camera tube. This side tube comprises an evacuated container enclosing a first electrode member and one or more additional electrode members. Oxygen is introduced into the side tube and a positive ion discharge is set up within the container which discharge is formed into a beam of ions by placing the additional electrode members at appropriate negative potentials with respect to the first electrode member. This beam of oxygen positive ions is directed into the tube containing the target to be formed and there utilized as described above.

Oxygen gas is present in the space adjacent the target, and tends to slowly oxidize the whole target surface. A metal is chosen which has a normally low rate of oxidation. Such a metal is aluminum or one of the solid metals of group II in the periodic table. The ionic oxygen of the scanning beam, however, has a much greater ability to combine with the metal, and oxidation will be greatly accelerated at the contact of the beam with the surface. The density of normal oxygen near the target is kept low by means of a pump applied to tubulation 70 so as to inhibit the general oxidation over the surface.

In a specific method of operation, the oxygen positive ion beam is caused to scan the target (by electromagnetic or electrostatic means) in parallel lines, the beam being cut off in alternate line scanning periods so that oxide strips separated by metallic strips are produced. Many seconds or even minutes may be necessary to scan the complete target in order to oxidize alternate strips of the target to the required thickness. The beam is then caused to scan alternate strips in a direction 90 degrees from the former direction

so as to produce spaced oxidized lines perpendicular to those produced during the first scanning. After this scanning, conducting islands are left between oxide lines. A very uniform pattern of square metal islands is produced. In an alternative method, the target is formed by repeated scanning, that is, the spaced oxide strips are built up or increased in density on successive scannings until the complete oxide lines are built up. The direction of scanning is then changed as before and the oxide lines at 90 degrees with respect to the first series of lines are built up by successive scannings.

As the photosensitized target loses its sensitivity when exposed to air, the gun system for the electron beam is preferably mounted in the tube before the ionizing process. The gun system for the positive ion beam is mounted in a side tube which is joined to the main tube. Oxygen is admitted into the side tube and the positive ion beam is formed by the electrodes therein and the ion beam is caused to scan the target in the main tube. After the target is oxidized by the ion beam, the connection between the main tube and the side tube is broken, the main tube is sealed off and pumped and the target is subjected to any heat treatments which are necessary.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof in which:

Fig. 1 is a schematic diagram to illustrate a process, in accordance with this invention, of making a target for an electron camera tube by means of an oxidizing ion beam;

Fig. 2 is an enlarged view of a portion of the target for the ion beam; and

Fig. 3 is a modification of the arrangement shown in Fig. 1.

Referring more specifically to the drawings, Fig. 1 shows an arrangement for forming an oxygen positive ion beam and for utilizing this beam to form a mosaic target for electrons, the target being contained in an electron camera tube attached during the process to the tube wherein the ion beam is generated. The main tube 10 containing the target 14 is shown connected to the auxiliary tube 11 by means of a narrow neck 12 which is adapted to be cut and the ends sealed after the mosaic target in the main tube has been formed. The main tube 10 comprises an evacuated container 13 enclosing the target 14 which is to have a mosaic surface formed thereon, an electron gun 15 suitable for generating and focusing a beam of electrons upon the target, and two sets of deflecting elements comprising the magnetic coils 16, 16 and 17, 17. The electron gun comprises, for example, a cathode 20, a cathode heater 21, a control electrode 22, a first anode 23, a second anode 24, and a conducting coating 25 which is preferably placed at the same potential as the second anode 24.

The target 14 is placed in position within the camera tube so that it can be struck by the electron beam generated and focussed by the gun 15 and also opposite an opening 26 in the conducting coating 25 through which radiations from an object are adapted to be applied to the target when the tube is finally completed and operating. During the formation of the mosaic surface on the target 14, however, the electron gun 15 is not operative nor are radiations applied to the target. The target 14 preferably comprises a metallic backing plate 30 and a thin layer of mica

or glass 31 thereon held to the metal backing plate 30 by any suitable means such as by screws or clamps (not shown). The insulating coating 31 has applied thereto a thin layer of a readily oxidizable (by ionic oxygen) metal, such as, for example, aluminum. Other suitable metals are those in group II of the periodic table. The layer 32 is then treated by means of the ion beam generated in the side tube 11 in a manner which will be described more fully below.

The tube 11 which is connected to the tube 13 by means of the neck 12 at a point thereof somewhere between the region of the gun 15 and the deflecting coils 16, 16 and 17, 17 comprises an evacuated container 40 enclosing therein a first electrode 41, a second electrode 42 and a third electrode 43. The electrode 41 is shown as a flat plate while the electrodes 42 and 43 are shown as cylinders, the cylinder 43 being of larger diameter than the cylinder 42. Electrode member 41 is connected to the electrode 42 through a source 44 and a make-and-break contact member 45, the purpose of which will be described below. The positive pole of the source 44 is connected to the electrode member 41 and the negative pole thereof is connected through the member 45 to the electrode member 42. The electrode 43 is placed at a negative potential with respect to the member 42 by means of a source 47 while the backing plate 30 of the target 14 in the tube 13 is placed at a negative potential with respect to the electrode member 43 by means of the source 48. Within a side tube 49, oxygen is produced and applied to the evacuated container 40.

The manner in which the apparatus shown in Fig. 1 operates to produce metallic particles 52 (see Fig. 2) surrounded on all sides by oxide strips 53 and 54 is as follows: The tube 11 is connected to the tube 10 by means of the glass neck 12. If it is desired to photosensitize the target while it is in the camera tube, the target cannot be exposed to the air without losing its photosensitivity. For this reason the electron gun 15 is mounted in the tube 10 and a conducting coating 25 is applied to the portion of the walls in the enclosure by well-known means before the tube 11 is joined to the tube 10. Moreover the target structure comprising the signal plate 30 and the insulating layer 31 and the coating of suitable metal such as aluminum is placed in position before these two tubes are joined together. A yoke holding the magnetic coils 16, 16 and 17, 17 is placed around the tube 10 (in some cases it may be desirable to also perform this step before the tube is connected to the tube 11) and magnetic deflecting current is applied to these coils, which current is preferably of saw-toothed wave form. No potentials are applied to the members of the electron gun 15 as the electron beam does not enter into the process of making the mosaic target coating. A magnetic coil schematically represented by the circle 50 is placed in position so that the beam of oxygen positive ions when formed in the side tube 11 is directed toward the target 14. Before admitting oxygen into the tube 11 all gases are removed from this tube by means of side tube 51, heat being applied during this step if desired. The side tube is sealed off after all occluded gases are removed from both the tube 11 and the tube 10. With the electrode elements 41, 42 and 43 connected as shown in Fig. 1 of the drawing, the element 42 is at a negative potential with respect to the electrode member 41 inasmuch as the top half (as shown in Fig. 1) of the contact member

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45 is of conducting material while the bottom half is of non-conducting material. A stream of oxygen positive ions is thus formed between members 41 and 42. This stream is focussed into a beam by means of the electrostatic field between these members and between the members 42 and 43, which are at appropriate negative potentials with respect to the member 41 and thus "accelerate" the positive ions and produce a focussing action on the positive ions in a manner similar to that produced on electrons by cylinders connected at positive potentials with respect to a cathode. This positive ion beam is focussed to a small cross-section at the surface of the target 14, the beam being bent by the constant current applied to the magnetic coil 50. The source 48 can be omitted but in many cases it may be desirable to have an additional "accelerating" field between the electrode elements 43 and the target 14. Saw-toothed current waves of linear slope are applied to the coils 16, 16 and 17, 17. The frequency of these waves can be of the order, respectively, of the line scanning and frame scanning frequencies used in the usual television system. The member 45 is rotated at such a speed that it cuts off the ion beam during alternate line scanning intervals so as to leave a space between horizontal lines 53 as shown in Fig. 2. The frequency of rotation of the member 45 is, for example, equal to one-half the line scanning frequency of the wave applied to one of the coils 16, 16 or 17, 17. Each line 53 may be of a width which is much less than the width of an elemental area as determined by the size of electron beam in the gun 15 or may be substantially equal in width to that of an elemental area and an adjacent insulating area or substantially as wide as an elemental area if the path of the electron beam is carefully controlled so that it goes over lines of sensitized metal islands and skips, by one means or another, the lines of insulation only. By means of this method, each horizontal line 53 is formed by cumulative oxidation of the aluminum in the layer 32. It may take many seconds or even several minutes before a satisfactory thickness of insulation produced by the oxidation of aluminum of the member 32 by the oxygen positive ion beam is reached.

In an alternative way of operating the arrangement shown in Fig. 1, stepped saw-toothed waves of frame scanning frequency are applied to one of the sets of coils 16, 16 and 17, 17, while a saw-toothed wave form of line scanning frequency is applied to the other set of coils. These waves are preferably of such low frequency that one complete scanning of the target is sufficient to build up each oxide line 53 to the desired thickness. Because of the waves being stepped, the ion beam remains on one line until the end thereof and is then almost instantaneously jumped to the next element line 53, leaving a blank space between these two lines as shown in Fig. 2. Such a stepped wave can be produced by a potentiometer having a number of taps with a rotating member connecting each of these taps in turn to the magnetic coils. Another potentiometer comprising a sliding contact on a coil can be used to produce the saw-toothed wave (the upper wave shown at the right of Fig. 1). The two potentiometers can be geared together to maintain the two waves in proper time relation with each other but this may be done electrically as in ordinary television scanning. It will be clear that the frequency of the saw-

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toothed wave applied to one set of coils and the frequency of the stepped wave applied to the other set of coils have the same ratio as the frequencies of the two saw-toothed waves described above. When such current waves are used in the coil, the member 45 can be removed and replaced by a direct connection between the negative pole of the source 44 and the positive pole of the source 47 or allowed to remain stationary in the conducting position.

After the horizontal oxide lines 53 are formed on the metallic layer 32, the direction of scanning is shifted by 90 degrees by any suitable means such as, for example, by applying the line scanning frequency current to the coil formerly producing the frame scanning and the frame scanning frequency current to the coil formerly producing the line frequency scanning. The vertical lines 54 (shown in Fig. 2) are thus produced in the manner corresponding to the horizontal line 53. This leaves metal islands 52 having their surfaces slightly oxidized by the general pressure of oxygen and completely surrounded by oxide lines. These metal islands 52 are thus of rectangular shape and the pattern is very uniform.

After the oxide lines 53 and 54 are formed, leaving the metal islands 52, the neck 12 is sealed off and the tube 10 baked out and evacuated so that all of the elements of the tube are thoroughly degassed. The tube is then allowed to cool to room temperature. A known amount of caesium is then admitted into the bulb by flashing a "caesium pill." The pill is flashed in a side tube or in the tube 11 so that caesium vapor passes into or is present in the tube to photosensitize the surface oxidized metallic particles 52. A description of a suitable process of photosensitizing with a "caesium pill" and the composition of such a pill may be found in British Patent 381,606, to George R. Stilwell and Charles H. Prescott, Jr., complete accepted October 10, 1932. The tube is then sealed off.

The operation of the mosaic screen in the cathode ray tube 10 is similar to that of the well-known iconoscope tube described in an article entitled "The iconoscope," by V. K. Zworykin in the January 1934 Proceedings of the Institute of Radio Engineers, pages 16 to 32, inclusive, and an article by the same author in the July 1936 "RCA Review," page 60, entitled "Iconoscope and kinescopes in television."

The tube 11, as mentioned above, can be used over and over again for the preparation of targets in storage type tubes, it being merely necessary to connect it to each tube in turn, go through the process described above, and then break the connection between the two.

Fig. 3 shows apparatus of somewhat different form from that shown in Fig. 1 for utilizing an oxygen positive ion beam to form a mosaic target for electrons. In the arrangement shown in Fig. 3, deflecting plates 60, 60 and 61, 61 are used to replace the magnetic coils 16, 16 and 17, 17 of Fig. 1 which are used to cause the oxygen positive ion beam to scan the mosaic target 14. The magnetic bending field 50 is not required in the arrangement of Fig. 3 due to the fact that the tube 11 is joined to the tube 10 at such an angle that the axis of the ion beam in its undeflected position strikes the center of the target 14. Each of the elements of the apparatus which is common to the structures shown in Figs. 1 and 3 has been given the same reference character in both figures. The oxygen positive ion beam is formed

in the tube 11 in the manner described above in connection with Fig. 1 and the photosensitive mosaic is formed on the target 14 as described above with the exception that the scanning is caused by means of voltage waves applied to the deflecting plates 60, 60 and 61, 61 instead of current waves passed through the magnetic coils 16, 16 and 17, 17. After the formation of the oxide surfaces 53 and 54, thus leaving metallic particles 52 as metal islands, the neck 12 is sealed off and tube 10 evacuated and allowed to cool. The metal particles 52 are then photosensitized as in the process described above. The deflecting plates 60, 60 and 61, 61 are left within the tube 10. The process performed by the apparatus of Fig. 3 in some respects is preferable to that of Fig. 1 inasmuch as it is somewhat difficult to bend an ion beam by electromagnetic means due to the large mass of the ion as compared with that of the electron whereas electrostatic deflection may be obtained with field strengths of the order of those commonly used to deflect an electron beam. Another advantage is simplification, the magnetic bending field 50 or an electrostatic equivalent thereof not being required.

As the metal used as the material of the layer 32 has to be subsequently photosensitized, the mosaic pattern can be applied in a separate tube or receptacle and then exposed to the air before being inserted in the cathode ray transmitter tube. The transmitter tube in this modified arrangement has means for admitting the sensitizing metallic vapor but has no positive ion gun associated with it in any stage of the process. In this arrangement, the target is preferably placed at right angles to the beam.

Alternatively, a tube such as tube 11 of Fig. 3 can be connected to the tube 10 by means of a rubber hose or similar connection 62. After the target has been formed with its pattern of crossed-lines 53 and 54, leaving many metallic islands 52, air can be admitted, the connection 62 broken and the opening sealed up. In this alternative arrangement, handling of the target after the formation of the pattern thereon is reduced. The tube 10 is then degassed and sensitized in any known manner.

While the invention in its primary aspects relates to processes of and means for forming a mosaic target for use with an electron beam, it will be appreciated that the invention in its broader aspects is not limited to producing targets as the coating may be provided for some other purpose for which coatings are used. It will be understood also that various modifications can be made in the specific embodiments described above without departing from the principles upon which the invention is based. For example, while scanning by the ion beam of every other line of the target has been disclosed it is obvious that the main criterion is that a strip of unscanned target is left between repeated line scanings thereof. Such a strip can be as wide as the ion beam or greater than or less than this width. Preferably the strip should be as small as possible to provide as large an "active" area as possible.

What is claimed is:

1. The combination with a container, of means for introducing oxygen therein, spaced electrodes within said container between which said oxygen is present, a source of potential having its terminals connected to said electrodes respectively whereby oxygen positive ions move to one of said electrodes and electrons move to the other of

said electrodes, an aperture in said electrode toward which said positive ions move and through which some of them pass, and a target for receiving said oxygen positive ions, said target comprising an element of metallic material upon which said positive ions impinge to oxidize the portions of said target struck thereby.

2. The combination with a container, of means for introducing oxygen therein, spaced electrodes within said container between which said oxygen is present, a source of potential having its terminals connected to said electrodes respectively whereby oxygen positive ions move to one of said electrodes and electrons move to the other of said electrodes, an aperture in said electrode toward which said positive ions move and through which some of them pass, and a target for receiving said oxygen positive ions, said target comprising elements of insulating material having a coating of an oxidizable metal facing said beam and a backing of a conducting material electrically connected to said apertured electrode.

3. The combination with a container, of means for introducing oxygen therein, spaced electrodes within said container between which said oxygen is present, a source of potential having its terminals connected to said electrodes respectively whereby oxygen positive ions move to one of said electrodes and electrons move to the other of said electrodes, an aperture in said electrode toward which said positive ions move and through which some of them pass, a target for receiving said oxygen positive ions, said target comprising elements of insulating material having a coating of an oxidizable metal facing said beam and a backing of a conducting material electrically connected to said apertured electrode, and means for causing said beam to scan said target whereby portions of the metallic layer facing said beam are oxidized in a progressive manner.

4. The combination with a container, of means for introducing oxygen therein, spaced electrodes within said container between which said oxygen is present, a source of potential having its terminals connected to said electrodes respectively whereby oxygen positive ions move to one of said electrodes and electrons move to the other of said electrodes, an aperture in said electrode toward which said positive ions move and through which some of them pass, a target for receiving said oxygen positive ions, said target comprising elements of insulating material having a coating of an oxidizable metal facing said beam and a backing of a conducting material electrically connected to said apertured electrode, and means for causing said beam to scan spaced lines of said target and then to scan spaced lines of said target in a direction at 90 degrees with respect to the first scanning.

5. The method of metallic coating which comprises ionizing oxygen in an electric field formed between two electrodes in an evacuated container, focussing the positive ions formed by said ionization into a beam which is highly concentrated and of relatively small cross-sectional area, and causing said beam to scan a two-dimensional portion of a metallic target surface comprising a metal from the group consisting of the solid metals of group II in the periodic table and aluminum.

6. The method of metallic coating which comprises ionizing oxygen in an electric field formed between two electrodes in an evacuated container, focussing the positive ions formed by said ionization into a beam which is highly concentrated and of relatively small cross-sectional area, and caus-

ing said beam to scan in a manner to produce a uniform oxide pattern thereon a two-dimensional portion of a metallic target surface comprising a metal from the group consisting of the solid metals of group II in the periodic table and aluminum.

7. The method of metallic coating which comprises ionizing oxygen in an electric field formed between two electrodes in an evacuated container, focussing the positive ions formed by said ionization into a beam which is highly concentrated and of relatively small cross-sectional area, causing said beam to scan in a manner to produce a uniform oxide pattern thereon a two-dimensional portion of a metallic target surface comprising a metal from the group consisting of the solid metals of group II in the periodic table and aluminum, and photosensitizing the metallic portions of said pattern.

8. The method of metallic coating which comprises ionizing oxygen in an electric field formed between two electrodes in an evacuated container, focussing the positive ions formed by said ionization into a beam which is highly concentrated and of relatively small cross-sectional area, and causing said beam to scan a two-dimensional portion of a metallic target surface in spaced crossed lines to produce a pattern of metallic islands be-

tween oxide lines, the metal being from the group of the solid metals of group II of the periodic table and aluminum.

9. The method of making a mosaic target for an electron beam which comprises ionizing oxygen in an electric field formed between two electrodes in an evacuated container, focussing the positive ions formed by said ionization into a beam which is highly concentrated and of relatively small cross-sectional area, causing said beam to scan a two-dimensional portion of a metallic target surface in spaced crossed lines to produce a pattern of metallic islands between oxide lines, the metal being from the group consisting of the solid metals of group II of the periodic table and aluminum, and photosensitizing the metallic islands.

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