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METHOD AND APPARATUS FOR MAKING MOSAIC
TARGETS FOR ELECTRON BEAMS
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FIG. 1

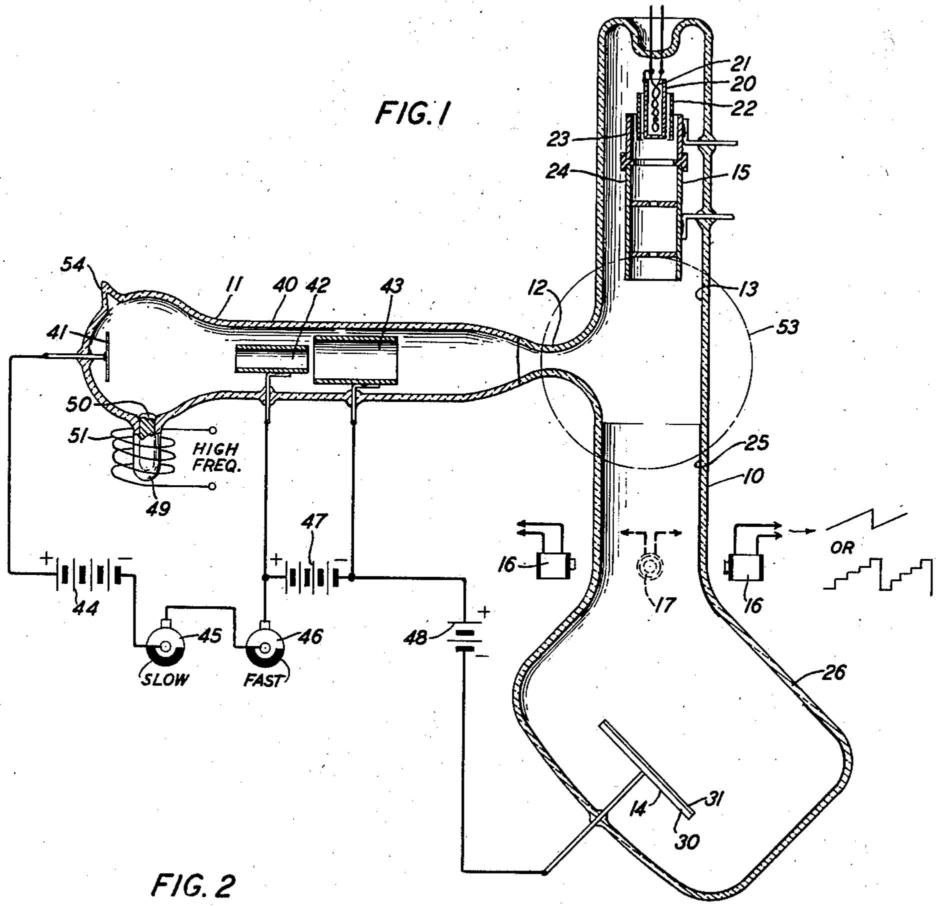

FIG. 2

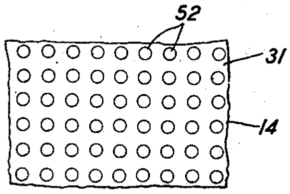

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FIG. 3

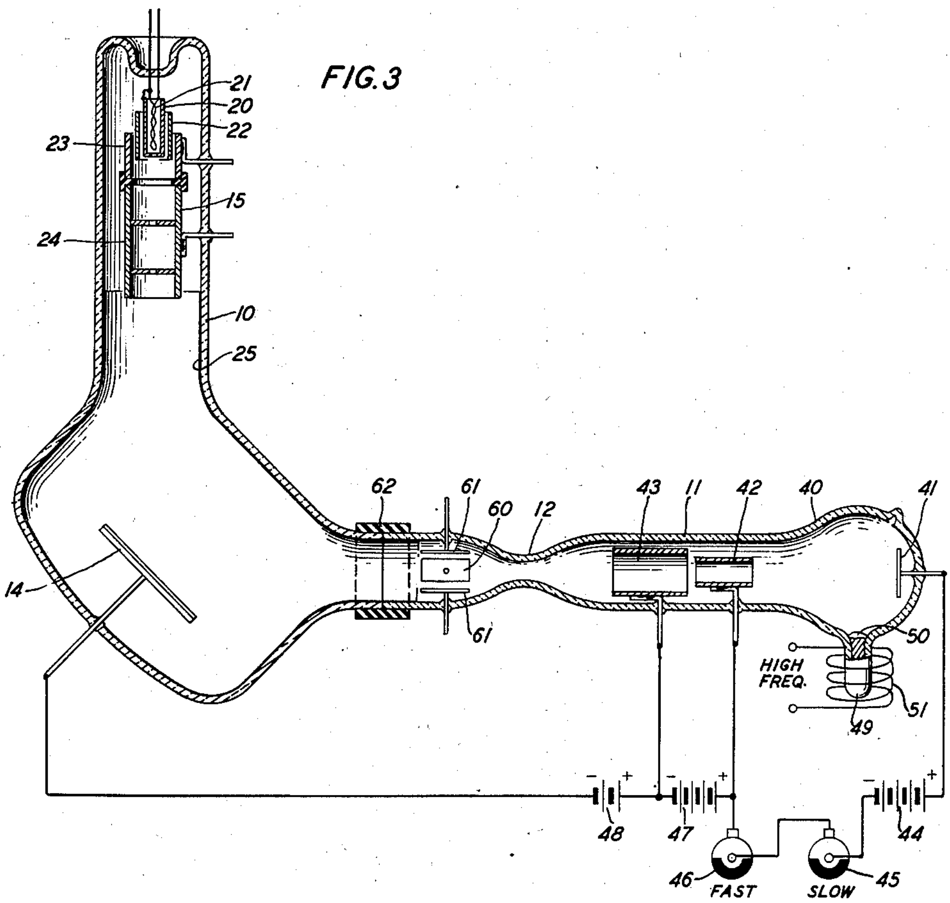
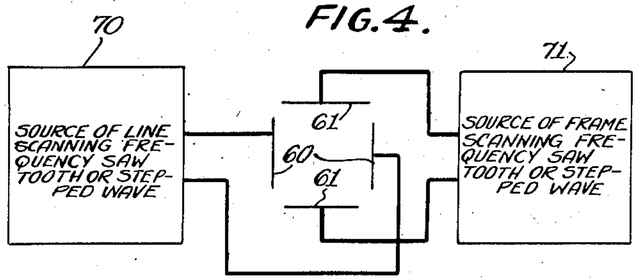


FIG. 4.



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METHOD AND APPARATUS FOR MAKING MOSAIC TARGETS FOR ELECTRON BEAMS

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This invention relates to ionic discharge apparatus 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.

It is an object of this invention to provide novel means for generating and utilizing positive ion beams.

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

The above objects are attained in accordance with the invention by providing apparatus for generating a beam of positive ions which is modulated or otherwise controlled so that it is cut off in alternate time periods. This beam is caused to scan every elemental area of an insulating plate to build up thereon metallic particles. The ions may be of a metal which is photosensitive, such as an alkali or alkaline earth metal, or they may be of a metal which is not appreciably photosensitive. In this latter instance, the metallic spots formed by the method are photosensitized as in the usual iconoscope target technique.

More specifically, in accordance with an exemplary form of the invention, the positive ion beam is generated in a side tube connected to

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the camera tube. This side tube comprises an evacuated container enclosing a first electrode member and one or more additional electrode members. Means are provided for vaporizing a suitable metal within the container, 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 to focus the positive ions into a beam. This beam is directed into the tube containing the target to be formed and there utilized as described above.

In a specific method of operation, the metallic ion beam, which is preferably of one of the alkali or alkaline earth metals, is caused to scan (by electromagnetic or electrostatic means) every elemental area of a desired portion of the insulating blank on which the discontinuous photosensitive elements are to be formed. The beam is varied in intensity during scanning so as to produce a regular pattern. One way of doing this is to cut off the beam in alternate spot scanning periods and also to cut off the beam during alternate line scanning periods so that a regular pattern of dots or squares interspersed with insulating areas is produced. Preferably, the layers of metal are about ten molecules thick. The size of each dot or square is preferably made smaller than a picture element as determined by the size of the electron beam in the electron camera tube although it can be as large as the picture element or even larger. It will take many seconds or even minutes to scan the complete target in order to obtain spots of metal of required thickness.

By an alternative method the target can be formed by repeated scanning, that is, a tiny increment of metal is laid down on each elemental area and this increment is increased by other increments on succeeding scannings until the complete dot structure is built up.

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. A pellet of the metallic material is placed in the side tube and heated, for example, by a coil surrounding the tube. The positive ions are focussed into a beam by "accelerating" anodes (at a negative potential with respect to the first electrode or "cathode") and the ion beam is caused to scan the target. After the target is sensitized 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 then 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 ion beam;

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

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

Fig. 4 is a circuit diagram showing the connections of the sources of deflecting waves to the deflecting means of the tube of Fig. 3.

Referring more specifically to the drawings, Fig. 1 shows apparatus for forming a 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 target in the main tube has been formed. The tube 10 comprises an evacuated container 13 enclosing the target 14 which is to have a mosaic surface coated thereon, an electron gun 15 suitable for generating and focussing 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 target 14, however, the electron gun 15 is not operative nor are radiations applied to the target. Target 14 preferably comprises a metal 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 is adapted to have applied thereto a discontinuous regular pattern of metal particles. This is accomplished by means of an ion beam generated in the side tube 11.

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. The electrode member 41 is connected to the electrode 42 through a source 44 and two make-and-break contact members 45 and 46, 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 members 45 and 46 to the electrode member 42. The electrode member 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 a source 48. Within a side tube 49 is placed a metal pellet 50 of any suitable material, such as one of the alkali or alkaline earth metals if it is desired that the target be photosensitive without additional steps, or, if it is desired to photosensitize the target after the metal particles have been formed on the target, another metal, such as magnesium, may be used. The metal pellet 50 can be vaporized by means of the coil 51 placed around the side tube 49 and energized by any suitable source of high frequency current (not shown) or it can be heated by any other suitable means.

The manner in which the apparatus shown in Fig. 1 operates to produce metal particles 52 on the insulating layer 31 of the target 14 is a follows: The tube 11 is connected to the tube 10 by means of the glass neck 12. If the ion beam is of a material which is photosensitive, or if not photosensitive, 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 the conducting coating 25 is applied to a portion of the walls of the enclosure 13 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 is placed in position before the juncture of these two tubes. 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 perform this step also before the tube 10 is connected to the tube 11), and magnetic deflecting current is applied to these coils, which current may be of saw-tooth wave form or stepped wave form as will be described more fully below. 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 in the drawing by the circle 53 is placed in position so that the beam of ions when formed in the side tube 11 is directed toward the target 14. A pellet 50 of any suitable material such as magnesium is placed in the side tube and this tube sealed off. All gases are then removed from the tube by means of the side tube 54, heat being applied during this step if desired. After all occluded gases are removed from both of the tubes the side tube 54 is sealed off. The heat applied should not be sufficient to melt the magnesium pellet 50. High frequency currents are then applied to the coil 51 and the pellet 50 is vaporized. With the electrode elements 41, 42 and 43 connected as shown in 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 each of the contact members 45 and 46 is of conducting material while the bottom half of each is of non-conducting material. A stream of metallic positive ions is thus formed between the members 41 and 42. This stream is focussed into a beam by means of the electrostatic fields between 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 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 represented schematically by the circle 53. The source 48 can be omitted but in many cases it may be desirable to have an additional "accelerating" field between the electrode element 43 and the target 14. If saw-tooth current waves which are of uniform 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 systems. The members 45 and 46 are rotated at such speeds, respectively, that the member 46 makes contact for a period of time necessary to form an elemental particle 52 (see Fig. 2) and breaks contact (cutting off the beam) for a period of time corresponding to a distance between elemental particles 52. The member 45 is rotated at a somewhat slower speed and it acts to cut off the ion beam during alternate line scanning intervals so as to leave a space between lines as shown in Fig. 2. The frequency of rotation of the member 45 is equal to one-half the line scanning frequency of the wave applied to one of the coils 16, 16 or 17, 17 while the frequency of operation of the member 46 is equal to that of the member 45 divided by the number of elemental particles 52 it is desired to make in a line. Each particle 52 may be less than an elemental area as determined by the size of the electron beam from the gun 15 or it may be substantially equal to the size of an elemental area. By means of this method each particle 52 is built up by successive scannings of the ion beam over a surface of the insulating layer 31. At present it is believed that the particles 52 should be of the order of ten molecules thick and it may take many seconds or even several minutes before such a thickness is reached.

In an alternative way of operating the arrangement shown in Fig. 1, stepped saw-tooth waves of line and frame scanning frequencies are applied to the coils 16, 16 and 17, 17. These waves are preferably of such low frequencies that one complete scanning of the target is sufficient to build up each particle 52 to the desired thickness. By means of the stepped wave the ion beam is held stationary over an elemental area and remains on that elemental area until it builds up the desired thickness on the target and then the beam is almost instantaneously jumped to the next elemental area leaving the space between the elemental areas blank, 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. The potentiometers (one for the line and one for the frame scanning) can be geared together to maintain the two waves in proper time relation with each other or this may be done electrically as in ordinary television scanning. It will be clear that the frequency of the wave applied to one set of coils 16, 16 and that applied to the other set of coils 17, 17 have the same ratio as the two sawtooth waves described above. When such current waves are used in the coils 16, 16 and 17, 17 the members 45 and 46 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.

After the metal particles 52 are formed on the insulating layer 31, the neck 12 is broken and the tube 10 baked out and evacuated so that all of the elements in the tube are thoroughly degassed. The tube is allowed to cool to room temperature and oxygen is then admitted. The magnesium layer is then wholly or partially oxidized by any suitable means such as, for example, a high frequency discharge. At the conclusion of the oxidation process, excess gas is removed by evacuation and a known amount of caesium is admitted into the bulb by flashing a "caesium pill." The pill is flashed in a side tube or in the bulb so that caesium vapor passes into the bulb to photosensitize the 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 10 is then baked at a temperature of about 200 to 225° C. for varying periods of time to remove all gases. 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 "Iconoscopes and Kinescopes in Television."

If instead of the pill 50 being made of magnesium, it is made of one of the alkali metals, such as caesium, sodium, potassium, lithium or rubidium or one of the alkaline earth metals, such as barium, strontium, or calcium, the oxidizing and photosensitizing steps can be omitted as the metal itself is photosensitive.

The tube 11, as mentioned above, can be used over and over again for the preparation of targets and 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 tubes.

Fig. 3 shows apparatus of somewhat different form from that shown in Fig. 1 for utilizing the 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 ion beam to scan the mosaic target 14. Any suitable sources 70 and 71 connected, respectively, to these pairs of deflecting plates may be used to produce saw-toothed or stepped wave deflecting signals. The manner in which these sources are connected to the plates 60, 60 and 61, 61 is shown in Fig. 4 The magnetic bending field 53 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 are common to the structure shown in Figs. 1 and 3 has been given the same reference character in each figure. The 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 tiny particles 52 are formed on the insulating layer 31, the neck 12 is broken and tube 10 is sealed up, evacuated, and allowed to cool. The magnesium layer is then wholly or partially oxidized by any suitable method and 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 53 or an electrostatic equivalent thereof not being required.

When a metal is used which is to be subsequently oxidized and then photosensitized (such a metal, for example, is magnesium), 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 at 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 coated with the metallic pattern, air can be admitted, the connection 62 broken and the opening sealed up. This alternative method reduces the handling of the target after the first deposit. The tube 10 is then degassed, oxidized and sensitized in any known manner.

While the invention in its primary aspects relates to a process of or 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; 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.

What is claimed is:

1. The combination with a container, of means for producing a vapor of metallic material therein, spaced electrodes within said container between which said vapor is present, a source of potential having its terminals connected to said electrodes respectively whereby positive ions move to one of said electrodes and electrons move to the other of said electrodes, said electrode toward which said positive ions move having an aperture through which some of them pass, and a target for receiving said positive ions, said target comprising an element of insulating material upon which said positive ions impinge backed by a conducting element electrically connected to said apertured electrode.

2. The combination with a container, of means for producing a vapor of metallic material therein, spaced electrodes within said container between which said vapor is present, a source of potential having its terminals connected to said electrodes respectively whereby positive ions move to one of said electrodes and electrons move to the other of said electrodes, said electrode toward which said positive ions move having an aperture through which some of them pass, a target for receiving said positive ions, said target comprising an element of insulating material upon which said positive ions impinge backed by a conducting element electrically connected to said apertured electrode, and means for causing said beam to scan said target, whereby said coating is laid down in a progressive manner.

3. The combination with a container, of means for producing a vapor of metallic material therein, spaced electrodes within said container between which said vapor is present, a source of potential having its terminals connected to said electrodes respectively whereby positive ions move to one of said electrodes and electrons move to the other of said electrodes, said electrode toward which said positive ions move having an aperture through which some of them pass, a target for receiving said positive ions, said target comprising an element of insulating material upon which said positive ions impinge backed by a conducting element electrically connected to said apertured electrode, and means for causing said beam to impinge on discrete elemental areas of said target in succession to cause said coating to be laid down in the form of discrete portions forming a regular pattern.

4. The method of making a mosaic target for an electron beam which comprises vaporizing a metal in an evacuated container, ionizing the vapor formed thereby in an electric field produced between two electrodes in the container, electrostatically 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 an insulating surface to lay down a two-dimensional metallic pattern thereon, and photosensitizing the metallic portions of said pattern.

5. The method of making a mosaic target for an electron beam which comprises vaporizing a metal in an evaporated container, ionizing the vapor formed thereby in an electric field produced between two electrodes in the container, electrostatically 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 an insulating surface to lay down a uniform two-dimensional metallic pattern thereon, oxidizing the metallic portions of said pattern, and photosensitizing said oxidized metallic portions.

6. The method of making a mosaic target for an electron beam which comprises vaporizing a metal in an evaporated container, ionizing the vapor formed thereby in an electric field produced between two electrodes in the container, electrostatically 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 an insulating surface at the same time that the beam is being periodically cut off at such a rate with respect to the scanning speed that there is laid down on said surface a two-dimensional uniform pattern of metallic particles separated by insulating spaces.

7. The method of making a mosaic target for an electron beam which comprises vaporizing a metal in an electric field in a highly evacuated container to produce ions focussing and accelerating the positive ones of said ions to form a beam of positive ions which is highly concen-

trated and of relatively small cross-sectional area, and scanning a target surface with said beam while periodically cutting off the beam at such a rate with respect to the scanning speed that the metal is deposited in a regular two-dimensional pattern of small isolated portions.

8. The method of making a mosaic target for an electron beam which comprises vaporizing a metal in an electric field in a highly evacuated container to produce ions, focussing and accelerating the positive ones of said ions to form a beam of positive ions which is highly concentrated and of relatively small cross-sectional area, scanning a target surface with said beam while periodically cutting off the beam at such a rate with respect to the scanning speed that the metal is deposited in a regular two-dimensional pattern of small isolated portions, oxidizing the metallic portions of said pattern, and photosensitizing said oxidized metallic portions.

9. In combination, means for forming a beam of positive ions, a target member of insulating material for said beam, means for causing said beam to scan said target member, means for causing said beam to impinge on said target member intermittently during said scanning, a metallic element on the opposite side of said target member, and means for giving said metallic element a potential which causes said beam to be accelerated toward said target.

10. In combination, means for forming a beam of positive ions, a target member, means for causing said beam to scan said target member, and means for cutting off said beam periodically many times within the period of time required for the scanning of one line of said target.

11. In combination, means for forming a beam of positive ions, a target member, means for causing said beam to scan said target member, and means for cutting off said beam periodically many times within the period of time required for the scanning of one line of said target and also periodically for complete line intervals.

12. In a gas tight container, means including two apertured electrode members for forming a beam of positive ions which is highly concentrated and of relatively small cross-sectional area, a target member in the path of said beam, means for causing said beam to scan said target member, and means for applying to said scanning means saw-tooth deflecting waves.

13. In a gas tight container, means including two apertured electrode members for forming a beam of positive ions which is highly concentrated and of relatively small cross-sectional area, a target member in the path of said beam, means for causing said beam to scan said target member, and means for applying to said scanning means deflecting signals having stepped wave forms.

14. In a gas tight container, means including two apertured electrode members for forming a beam of positive ions which is highly concentrated and of relatively small cross-sectional area, a target member in the path of said beam, means for causing said beam to scan said target member, said scanning means comprising two sets of deflecting elements which cooperate to cause the scanning of a two-dimensional pattern on said target, and means for applying to each of said sets of deflecting elements deflecting signals having stepped wave forms.

15. In a gas tight container, means including two apertured electrode members for forming a beam of positive ions which is highly concentrated and of relatively small cross-sectional area, a target member in the path of said beam, and means for causing said beam to impinge on said target intermittently during said scanning.

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