Dec. 20, 1955 H. B. LAW 2,727,828

METHOD OF MAKING COLOR-TELEVISION SCREENS

Filed March 18, 1952 2 Sheets-Sheet 1

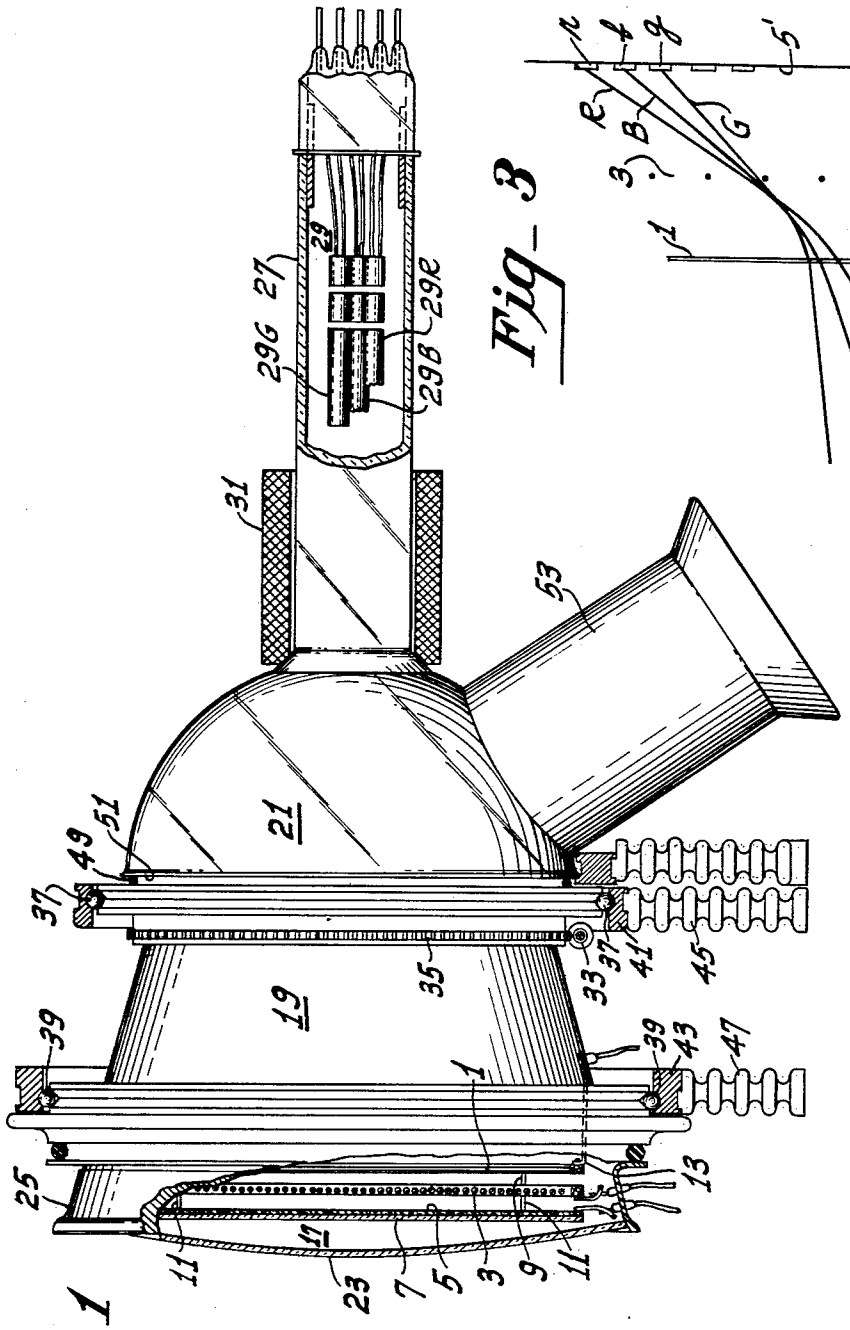


Fig. 1

Fig. 3

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Fig_2

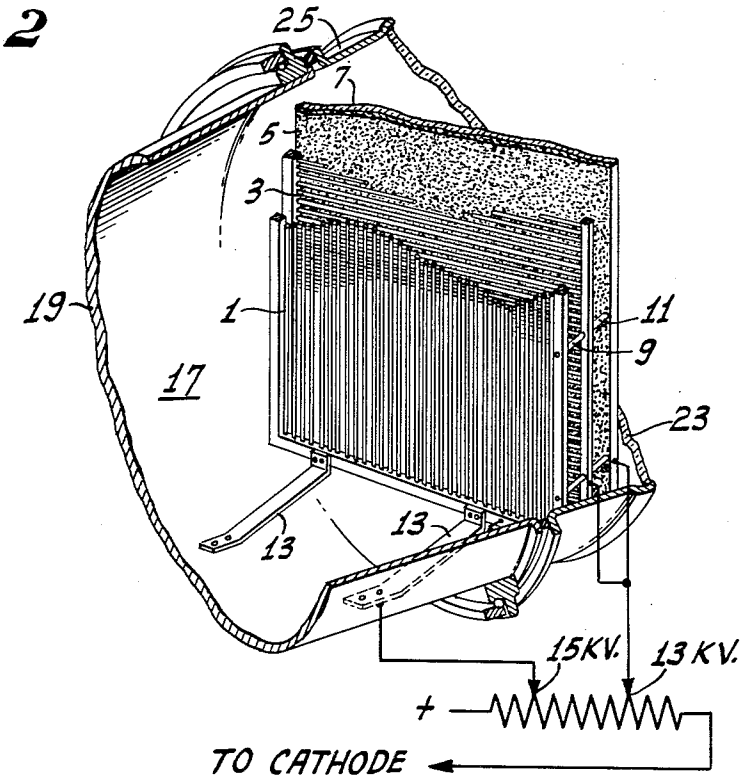


Fig_4

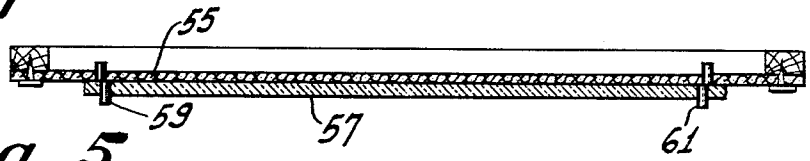


Fig_5

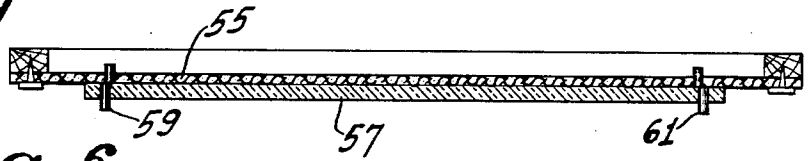
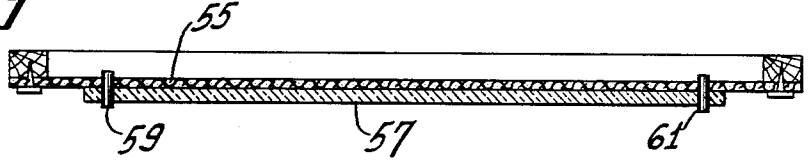


Fig_6



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METHOD OF MAKING COLOR-TELEVISION SCREENS

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Application March 18, 1952, Serial No. 277,133

7 Claims. (Cl. 117—33.5)

This invention relates to color-kinescopes and other cathode-ray tubes of the kind employing a ray-sensitive screen or target of the repetitive or "mosaic" variety, and to improvements in the art of manufacturing such targets and tubes. Considered from one aspect the present invention may be said to comprise an improvement upon the invention described in the copending application of Harold B. Law, Serial No. 158,901, filed April 28, 1950; now U. S. Patent No. 2,625,734, issued January 20, 1953.

The cathode-ray tubes employed in color-television transmitters and receivers usually contain an image-screen made up, effectively, of a multiplicity of similar groups of line-like or dot-like ray-sensitive areas of sub-elemental image dimensions. There are usually three sub-elemental areas in each group; each of said areas being allotted to one of the primary colors (say, red, blue and green, respectively). If the tube is a receiving tube (i. e. a "kinescope") the preferred practice is to cover the target surface of each of said sub-elemental screen areas with a phosphor material of the required color-response characteristic. However, satisfactory results may also be achieved by the use of a continuous coating of a "black and white" phosphor (e. g. "P4") and a multi-color optical filter disposed on or adjacent to the obverse face of the screen. (As to this see, by way of example, Zworykin 1,691,324). Similarly, if the mosaic is designed for use in a color-camera or pickup tube, appropriate color-sensitive filters may be used in conjunction with a continuous photoemissive layer.

The ability of tubes of this general character to handle a color-image without color dilution, loss of contrast, and other image-defects depends, in large measure, upon the achievement of the correct size and proper geometric location of the numerous sub-elemental areas of the mosaic with respect to the path of scan of the electron-beam or beams which serve selectively to energize said screen areas.

In the simplest case, i. e. where the mosaic electrode (or "image-screen") is to be used in a color tube of the so-called "accurate scanning" variety (see Zworykin 2,415,059, and Rudenberg 1,934,821), the principal requirement is that the color emissive areas be distributed uniformly on the target. As set forth on page 452 of the September 1951 edition of "RCA Review": Line or dot screens operated by this method require lines or dots which are of a size less than one-third of the distance between scanning lines (when scanned parallel) or less than one-third of a picture-element size (when scanned transversely). Thus, the dimensions and pattern of distribution of the color-emissive areas on the screen of a tube of the "accurate scanning" variety can readily be calculated, mathematically. The mosaic pattern, thus calculated, may be applied to a suitable foundation surface in any of a number of ways, (e. g. by means of a stencil and spray gun, or by silk-screening or other printing process).

In tubes wherein the image-screen, per se, comprises but one element of a bi-part or multi-part target assembly

the exact distribution of the color-areas on the screen presents a more complex problem than it does in tubes of the above described "accurate-scanning" variety. Thus, if the tube is of the so-called shadow mask variety (wherein an apertured mask casts a Crookes-shadow upon all screen areas other than the ones selected for illumination), the plotting of a truly accurate screen pattern involves a consideration not only of the pattern of the shadows cast by the mask but also of possible imperfections in said pattern resulting from minor inaccuracies in the distribution and contour of the mask apertures.

Several screen-plotting methods have heretofore been devised for overcoming the above mentioned complications in the design of a mosaic screen for use in cathode-ray tubes of the shadow-mask variety. All of these prior-art methods depend for their effectiveness upon the fact that in such tubes the scanning beam or beams follow straight paths in traversing the space between the mask and the screen. (This is so because the mask and the screen are operated at the same potential, hence the space therebetween is a field-free region through which the electrons travel without being subjected to any undesired deflecting force). Accordingly, as described by Dr. Werner Flechsig in French Patent 866,065, the mask itself may be used as a stencil through which the different color-phosphors may be deposited upon a suitable foundation plate. In another method, claimed by H. B. Law (in U. S. Patent No. 2,625,734), the pattern of the mask-apertures is first photographed by exposure to rays projected through the mask from a point disposed a suitable distance from the mask. The photographic pattern is then used to make a stencil which, when mounted upon a silk-screen, is used in laying down the different color-phosphors (in the form of a paste) on a suitable foundation plate.

Neither the Flechsig method nor the Law method can be used in plotting the pattern of a mosaic screen for use in a cathode-ray tube of any kind wherein the screen assembly comprises one or more lenticular field electrodes or grills operated at a potential other than that applied to the screen. The reason for this is that the application of different potentials to the viewing screen and grill (or to adjacent grills) creates an electron-optical lens-field which causes the electrons to follow curvilinear paths instead of the straight paths that they would follow in the absence of such a field. The direction and extent of the beam's departure from a straight line depends upon the number (single or compound) and kind (cylindrical or spherical) of lens-fields set up within the screen-assembly. In any event, an electron-beam when subjected to the influence of the different potentials of a lenticular-grill tube will not impinge upon the same elemental area of a mosaic-screen that it would in a cathode-ray tube of the accurate scanning or shadow-mask varieties. Thus, if as taught in Flechsig's French patent, the differently colored elements of a mosaic-screen are disposed in the same location in a lenticular-grill tube as they are in a shadow-mask tube, the result is an unintelligible, or at least badly distorted, color-image.

Accordingly, an object of the present invention is to provide a highly accurate method of and means for plotting the pattern of a mosaic screen for use in cathode-ray tubes, including those of the so-called lenticular-grill variety.

Another and related object of the invention is to provide improved color-television tubes which shall be characterized by the purity and brilliance of their images, by their trouble-free performance and by their adaptability to mass production methods.

The foregoing and other objects are achieved in accordance with the invention by the provision of a novel electronic plotting method wherein electrons are caused to

approach a recording target along the same paths that they approach the image-screen of the particular type of tube to which the invention is applied. As will hereinafter more fully appear, the recording target preferably comprises an insulating foundation plate coated on one side with a photographic emulsion which is sensitive to electron impact and, preferably, insensitive to stray light rays such as those which may emanate from the cathode or cathodes of the plotting apparatus. The emulsion covered surface of said plate is also rendered electrically conductive so that it may be given the same potential, or relative potential, that the image-screen is to assume in the target-assembly of the finished tube. Thus, the electron-beam or beams in the plotting apparatus are caused to follow the same sraight or curved paths that the electron-beam or beams in the finished tube will follow. As a consequence, the pattern with which the plotting beams impinge upon the emulsion covered surface of the recording target is an exact plot of the mosaic pattern required to ensure color purity and optimum performance of the tube for which said mosaic is designed.

The invention is described in greater detail in connection with the accompanying two sheets of drawings wherein:

Fig. 1 is a side-elevational view, partly in section, of a so-called "demountable" cathode-ray tube suitable for use in connection with the screen-plotting method of the invention;

Fig. 2 is a fragmentary view in perspective, taken from the rear of the front section of the tube of Fig. 1, showing one form of lenticular-grill assembly through which electrons approach the recording target in the apparatus of Fig. 1;

Fig. 3 is a partly diagrammatic side elevation of the tri-part target assembly of Fig. 2, showing how the normally straight paths of the three beams are diverted by the lens action of the two grills in said assembly;

Figs. 4, 5 and 6 are sectional views showing a silk screen and a contrivance comprising a pair of eccentric pins for positioning the screen on the glass foundation plate of the target when applying different color-phosphors to said plate.

The invention is herein described as applied to the plotting and manufacture of a line-screen for use in a three-gun tri-color kinescope of the lenticular grill variety described by Edward G. Ramberg in copending application Serial No. 277,182 filed concurrently herewith. However, it will be apparent as the description proceeds that the demountable vacuum tube shown in Figs. 1 and 2 may be used in laying out any of the various dot-like or line-like patterns employed on the plane or curved screens used in color-television and stereoscopic-television image tubes.

In practicing the screen-plotting method of the invention the field electrode or electrodes of the screen assembly, or replicas thereof, are first set up in front of electron-sensitive recording target, such as a photographic plate, in the same relative position that said field electrodes or lens elements are to occupy with respect to the screen of the tube for which they are designed.

Fig. 2 shows a target assembly wherein two field electrodes **1** and **3** are disposed in front of the emulsion covered surface **5** of a photographic plate **7** and the entire assembly mounted within the demountable tube of Fig. 1 in the position required for the plotting operation. Here, as in the Ramberg disclosure, the field electrodes comprise two wire-grills **1** and **3** disposed in spaced apart parallel planes with the wires of one grill extending at right angles to the wires of the other grill. The spacing between the grills **1** and **3** and the spacing between grill **3** and the emulsion covered surface **5** of the plate **7** is established as by insulating pieces **9** and **11** disposed between said parts. The entire assembly is supported on metal legs **13** which serve also to connect the first grill **1**, electrically, to the metal wall of the tube. The

wall thus serves as an accelerating electrode similar to the conductive coating on the inner wall of the main chamber of the Ramberg tube.

The viewing screens used in cathode-ray tubes of the lenticular-grill variety are electrically conductive. It is therefore essential that the photographic plate **7**, or its emulsion covered surface **5**, also be conductive so that it may be maintained at the same relative potential as the screen in the tube for which the screen is designed. Furthermore when, as in the instant case, the recording target comprises an electron-sensitive photographic plate, it should preferably be one which is substantially immune to visible light rays such, for example, as those of the wave-lengths released as an incident to the thermionic emission of electrons from the cathode of the electron gun or guns in the plotting apparatus. Specific formulas for such an electrically conductive, electron-sensitive, light insensitive photographic plate are claimed in the joint application of H. B. Law, N. Rynn and J. Evans in copending application Serial No. 277,132 filed concurrently herewith. One such formula comprises: a gelatin emulsion containing silver halide salts impregnated with a red dye, such as basic fuchsin, and the surface coated with a thin (electron transparent) stratum of graphite which is polished or buffed to lower its electrical resistance.

The plotting apparatus of Fig. 1 comprises an evacuable main chamber **17** having front and rear metal side walls **19** and **21**, respectively. The front section **19** of the main chamber **17** terminates in a window **23** set in a demountable vacuum-tight window frame **25** upon which the target assembly **1, 3, 5, 7**, shown in Fig. 2, is mounted. The rear part **21** of the main chamber **17** terminates in a demountable glass neck portion **27** which is dimensioned to receive an electron gun assembly **29** in the same position, with respect to the target assembly, as in the finished tube.

The gun assembly is preferably a duplicate of the one to be used in the particular type of tube that has been selected for production. In the instant case the gun-assembly comprises a battery of three guns, **29R**, **29B** and **29G** arranged delta-fashion (i. e. in a triangular pattern) about the long central axis of the neck **27** in the manner claimed by Alfred C. Schroeder in copending application Serial No. 730,637 filed February 24, 1947, now U. S. Patent No. 2,595,548, issued May 6, 1952. The details of construction of the electron-gun assembly may be as described by Hannah C. Moodey in copending application Serial No. 295,225 which is based upon application Serial No. 166,416 filed June 6, 1950, now abandoned. As in the Schroeder and Moodey disclosures, a magnetic yoke **31** on the glass neck **27**, in front of the gun assembly, serves to impart a scanning movement to the beam or beams emanating from the gun assembly **29**.

The front portion **19** of the main chamber **17**, and hence the target assembly therein, may be rotated about the axis of the tube, as by means of a pinion **33** and gear **35**, for the purpose of orienting the target assembly with respect to the path of scan of the beam electrons. Such rotary movement is facilitated by ball bearings **37** and **39** which operate in raceways **41** and **43** on the insulating pedestals **45** and **47** upon which the entire assembly is supported. A gasket **49** seated in a flange **51** between the rotatable front and stationary rear sections **19** and **21** of the main chamber permits the entire front section **19, 23, 25** to be rotated without breaking the vacuum. A suitably high vacuum is established within the entire structure by a pumping system (not shown) connected to an exhaust port **53** in the rear or stationary section **21** of the main chamber **17**.

In both single gun and multiple-gun tri-color kinescopes of the subject variety the particular color area that is illuminated at any given instant is a function of the particular angle or direction at which the beam electrons approach the screen. Where, as in the instant case, three

guns are employed, the beam from the gun 29R approaches the target from the direction required to strike the areas on the target surface 5 which are to be allotted to the red phosphor and the other two guns 29B and 29G are so positioned that their beams approach said surface 5 at the particular angles required to strike the blue and green areas respectively.

As previously set forth, in tubes of the lenticular grill variety the lens action of the field electrodes or grills causes the beam electrons to depart from the straight paths which they travel in approaching the first grill 1. This is illustrated in Fig. 3, wherein, as a result of the relative voltage distribution illustrated in Fig. 2 a lens field is set up adjacent to the field electrodes 1 and 3 which diverts the red (R), blue (B) and green (G) electron beams from the straight angular paths which they follow in traversing the space between the beam source and the first field electrode 1, into the bent or curvilinear paths, which terminate respectively on the red (*r*) blue (*b*) and green (*g*) phosphor lines on the line screen 5'. Since light rays would pass straight through the apertures in the grills 1 and 3 and impinge upon areas other than the ones (*r*, *b* and *g*) upon which the focused electron beams (R, B and G) impinge, it will be apparent why the method of the earlier filed Law disclosure and the method of French Patent 866,065 cannot be used in laying out the pattern of a screen for use in a cathode-ray tube of the lenticular grill variety.

In plotting the distribution of the color areas to be applied to the screen of the kinescope it is not necessary to expose the photographic plate 7 to the action of all three of the guns 29R, 29B, 29G. Excellent results have been achieved by employing a stencil made by exposing a single electron-sensitive plate to the scanning action of a single gun. In this case, using a 9" x 12" (108 square inches) plate of the above specified formula, the exposure time, to a beam of 200 microamperes from a single gun (in this case the "blue" gun, 29B), was approximately forty (40) seconds. The plate was developed in a Kodalith developer in a period of two minutes. When fixed and dried the plate was contact printed on a standard Kodalith film for examination and retouching, when required. The film was then contact printed to restore the polarity of the pattern, as required in making a silk-screen stencil. The stencil was made in the usual way, i. e. by using the last mentioned print as a negative to expose the silk-screen gelatin.

In using a stencil made from such a single exposure the different color-phosphors were laid down on the surface of the screen by shifting the position of the stencil with respect to said surface prior to applying the second and third phosphors. This is illustrated in Figs. 4, 5 and 6 wherein 55 represents a silk screen which will be understood to incorporate a stencil having a pattern of apertures corresponding to the pattern photographically recorded on the plate 7 by the beam from a single one of the three electron-guns 29 in the plotting apparatus of Fig. 1. Here the silk screen 55 and the glass foundation plate 57, to which the different color phosphors are to be applied, are provided with paired holes through which eccentric pins 59 and 61 extend. Before applying the phosphor of the first color, the silk-screen 55 is swung, say, to the left on the pins 59 and 61, as shown in Fig. 4. With the silk-screen 55 thus positioned on the glass plate 57 a color-phosphor in the form of a paste is forced through the porous areas of the silk screen, as with a roller or squeegee, not shown. Thereafter, as shown in Fig. 5, the silk screen 55 is swung 180° to the right, on the pins 59 and 61 and the second group of color-phosphor lines are applied to the glass plate 57 through the silk-screen, as before. Before applying the third group of color-phosphor lines, the silk-screen is swung 90°, in either direction, from its previous position on the plate 57, as shown in Fig. 6. The silk screen should, of course, be thoroughly cleansed before using it in laying down the different color-phosphors.

Where the ultimate in accuracy is required, three photographic plates may be employed, exposed one at a time, each to the action of a different gun. The three silk-screens made from the three separately exposed photographic plates may be used, with appropriate centering means, in laying down the separate color-phosphors in any desired sequence on the foundation plate 57.

After all three of the color-phosphors have been laid down on the foundation plate 57 it is baked to remove the binder in the phosphor paste (or ink). Thereafter, the target surface of the screen may be metalized in the usual way to render it conductive and highly light reflecting. It is then mounted in place in the target assembly prior to inserting the assembly in the envelope of the cathode-ray tube in which it is to be used.

From the foregoing description it will now be apparent that the present invention provides a highly accurate method of and means for recording the pattern of impact of electrons upon a target, and one which lends itself readily for use in plotting the patterns of color-television and stereoscopic-television screens of various "mosaic" varieties.

What is claimed is:

1. Method of recording the pattern traced by a moving beam of electrons upon the target of a cathode-ray tube; said method comprising: thermionically generating a beam of electrons with incident generation of light, in an evacuated envelope, mounting an electron-sensitive photographic surface in said envelope in the same relative position as the target of said cathode-ray tube, and shielding said electron-sensitive photographic surface from light-rays of the visible range emitted as an incident to the thermionic generation of said beam of electrons while causing said thermionically generated beam of electrons to trace a pattern on said electron-sensitive photographic surface corresponding to the pattern traced upon said target by the beam in said cathode-ray tube.

2. In the art of manufacturing cathode-ray tubes of the kind containing a screen-unit comprising at least one foraminous electrode having a multiplicity of systematically arranged apertures therein through which beam-electrons pass along different angularly related paths in their transit to sub-elemental areas of respectively different response characteristics on the mosaic surface of a nearby screen electrode, the method of plotting the desired relative location on said mosaic surface of all sub-elemetal screen areas of a particular response characteristic; said method comprising: mounting an electrode containing the same pattern of apertures as said foraminous electrode and an electron-sensitive photographic surface in an evacuable envelope in the same relative position that said foraminous electrode and said mosaic-surface are to occupy in said cathode-ray tube, evacuating said envelope, establishing adjacent to said apertured electrode an electric field corresponding to the field normally present adjacent to said foraminous electrode in said cathode-ray tube, thermionically generating a beam of electrons with incident generation of light, within said evacuated envelope and projecting said beam upon said apertured electrode and said electric field along the same angular paths that the electrons are to follow in their transit to said particular sub-elemental areas in said cathode-ray tube, and photographically recording, as the desired plot, the pattern of impact of said electrons upon said electron-sensitive photographic surface while shielding said plate from light rays emitted as an incident to the thermionic generation of said electrons.

3. In the art of manufacturing cathode-ray tubes of the kind containing a screen-unit comprising at least one foraminous electrode having a multiplicity of systematically arranged apertures therein through which beam-electrons pass along different angularly related paths in their transit to sub-elemental areas of respectively differ-

ent response characteristics on the mosaic surface of a nearby screen-electrode, the method of plotting the desired relative location on said mosaic surface of all sub-elemental screen areas of a particular response characteristic; said method comprising: mounting an electrode containing the same pattern of apertures as said foraminous electrode and an electron-sensitive photographic surface in an evacuable envelope in the same relative position that said foraminous electrode and said mosaic-surface are to occupy in said cathode-ray tube, evacuating said envelope, establishing adjacent to said apertured electrode an electric field corresponding to the field normally present adjacent to the foraminous-electrode in said cathode-ray tube, projecting a beam of electrons upon said apertured electrode and upon said electron-lens field along the same angular paths that the electrons are to follow in their transit to said particular sub-elemental areas in said cathode-ray tube, and photographically recording upon said electron-sensitive photographic surface, as the desired plot, the pattern of impact of said electrons upon said surface subsequent to their passage through said apertured electrode and said electron-lens field.

4. Method of plotting the desired relative location of the individual areas that are to comprise the mosaic target-surface of a cathode-ray tube of the type wherein the cathode-rays pass through a systematic pattern of apertures in a lenticular field electrode and subsequently traverse curvilinear paths in their transit to selected ones of said individual areas; said method comprising: mounting said lenticular field-electrode and an electron-sensitive photographic surface in an evacuable envelope in the same relative position that said field electrode and said mosaic target-surface are to occupy in said cathode-ray tube, evacuating said envelope; establishing within said evacuated envelope an electron-lens field of a direction adapted to pass electrons to said photographic surface along curvilinear paths corresponding to the ones to be traversed by said cathode-rays, generating an electron-beam within said evacuated envelope and projecting said beam upon said photographic surface through said lenticular-field electrode and thence through said electric field, and photographically recording upon said electron-sensitive photographic surface, as the desired plot, the pattern of impact of said electrons upon said surface.

5. In the art of manufacturing a cathode-ray tube of the kind containing a screen-unit comprising at least one lenticular field-electrode having a multiplicity of systematically arranged apertures therein through which beam-electrons pass along different angularly related paths in their transit to sub-elemental areas of respectively different response characteristics on the mosaic surface of a nearby screen-electrode, the method of plotting the desired relative location on said mosaic surface of all sub-elemental screen area of a particular response characteristic, said method comprising: mounting an electrode containing the same pattern of apertures as said lenticular field-electrode and an electron-sensitive photographic surface in an evacuable envelope in the same relative position that said lenticular field-electrode and said screen-electrode are to occupy in said cathode-ray tube, evacuating said envelope, establishing in the space between said apertured electrode and said photographic surface an electron-lens field corresponding to the field normally present between said field-electrode and said screen electrode in said cathode-ray tube, projecting a beam of electrons upon said apertured electrode along the particular angular paths that the cathode-rays are to follow in their transit to said lenticular field electrode in said cathode-ray tube whereby the electrons that pass through the apertures in said apertured electrode are subjected to said electron-lens field and are photographically recorded, as the desired plot, upon areas of said photographic surface corresponding to the desired location of said particular sub-elemental screen-areas in said cathode-ray tube.

6. In the art of manufacturing color-kinescopes of the kind containing a screen-unit comprising at least one foraminous electrode having a multiplicity of systematically arranged apertures therein through which beam-electrons pass along different angularly related paths in their transit to sub-elemental areas of respectively different color-response characteristics on the mosaic surface of a nearby color-screen; the method of plotting the desired relative location on said mosaic surface of all sub-elemental screen areas of a particular color-response characteristic; said method comprising: mounting said foraminous electrode and an electron-sensitive photographic surface in an evacuable envelope in the same relative position that said foraminous electrode and said color-screen are to occupy in said color-kinescope, evacuating said envelope, establishing in the space between said foraminous electrode and said photographic surface an electric field of a direction adapted to pass a beam of electrons through said foraminous electrode to said photographic surface along the particular angular paths that the beam is to follow in its transit to said particular sub-elemental color-areas on the mosaic surface of the color-screen of said color-kinescope, projecting a beam of electrons upon said foraminous electrode and thence through said electric leld to said photographic surface, and photographically recording upon said surface, as the desired plot, the pattern of impact of said electrons upon said surface.

7. Method of manufacturing a color-kinescope of the kind containing a screen-unit comprising at least one foraminous electrode having a multiplicity of systematically arranged apertures through which beam-electrons pass along different angularly related paths in their transit to sub-elemental areas of respectively different color-response characteristics on the mosaic surface of a nearby color-screen; said method comprising: mounting an electrode containing the same pattern of apertures as said foraminous electrode and an electron-sensitive photographic surface in an evacuable envelope in the same relative position that said foraminous electrode and said color-screen are to occupy in said color-kinescope, evacuating said envelope, establishing in the space between said apertured electrode and said photographic surface an electric field of a direction adapted to pass a beam of electrons through said apertured electrode to said photographic surface along the particular paths that the beam is to follow in its transit to sub-elemental areas of a particular one of said color-response characteristics on the mosaic surface of the color-screen of said color-kinescope, projecting a beam of electrons upon said apertured electrode and thence through said electric field to said photographic surface whereby photographically to record the pattern of impact of said electrons upon said surface, and then applying a color-phosphor of said particular color-response characteristic to a screen-plate in the pattern disclosed by said photographic recording.

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