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ALKALI HALIDE SCREEN AND METHOD OF MANUFACTURE

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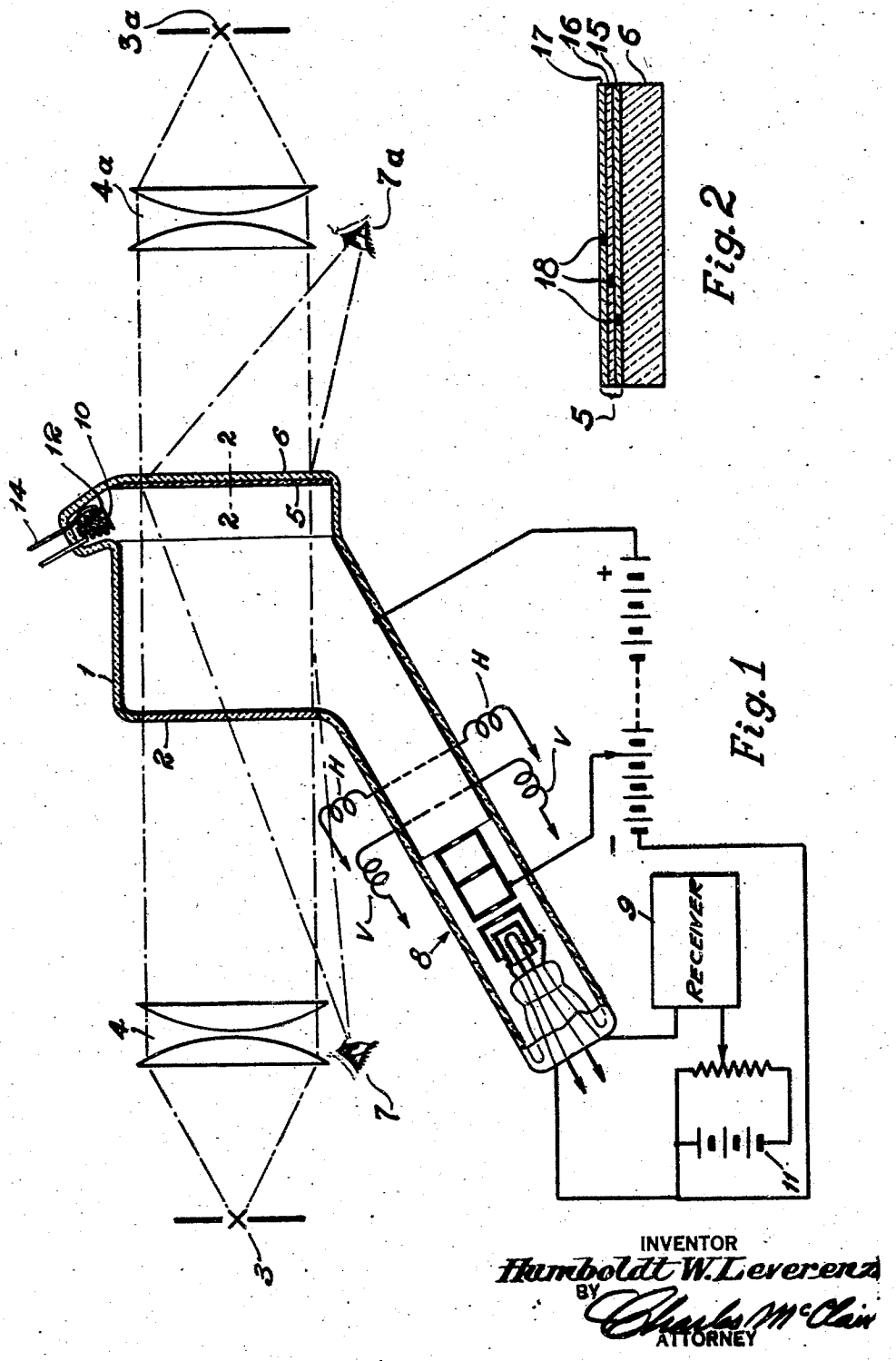


Fig. 1

Fig. 2

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ALKALI HALIDE SCREEN AND METHOD OF MANUFACTURE

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1

My invention relates to cathode ray tubes and their method of manufacture, and particularly to a new and improved method of manufacturing cathode ray tube targets comprising materials which change color under electron bombardment, such as targets incorporating alkali halide crystals.

It is known that certain salts such as the alkali halides, notably potassium chloride, have the property of coloring, that is, developing color centers under electron bombardment. For example, when such an alkali halide target is scanned by an electron beam, electrons are injected into the crystal or crystals in the scanned area, thereby developing a group of color centers of a density depending upon the instantaneous intensity of the electron beam. This coloration has been used to produce images for television and oscillograph purposes. The recent development of aircraft position and indicating equipment utilizing cathode ray tubes wherein the electron beam of the cathode ray tube is sequentially pulsed to form on the target a trace representing the trajectory of the aircraft necessitates the development of high contrast between the areas of a target indicating the aircraft position and distance with respect to the surrounding areas of the target.

In my copending application, Serial No. 451,871, filed July 22, 1942, I described a cathode ray tube having a target of the alkali halide type wherein the target was formed by evaporation of the alkali halide in high vacuum. Such targets are of variable appearance but sometimes substantially transparent and at other times quite translucent and while they may be made more translucent for the purpose of increasing contrast during operation by subjecting the evaporated and condensed material to water vapor or ammonia, such targets apparently suffer a loss in efficiency. While such a target may be made semi-opaque, that is, translucent instead of transparent in a partial vacuum, such a technique requires a critical control of the absolute pressure between relatively narrow limits. Such critical control is difficult in practice and gives non-uniform results in large production manufacture.

It is an object of my invention to provide a reversible color target of the alkali halide type having high efficiency under electron bombardment. It is another object to provide an improved target and method whereby manufacture of semi-opaque alkali halide targets for use in cathode ray tubes is rendered more reliable and

2

controllable. It is a further object to provide a target having increased contrast and more uniform properties than those disclosed in my said copending application. It is a still further object to provide a more stable and more easily controlled cathode ray target of the alkali halide type and a target which may be manufactured with greater ease and uniformity. These and other objects, features and advantages of my invention will become apparent when considered in view of the following description and the accompanying drawing, wherein:

Figure 1 shows a cathode ray tube having a target structure made in accordance with my invention, and

Figure 2 is a cross-sectional view of the target shown in Figure 1 taken along the line 2—2.

I have shown in Figure 1 one type of a cathode ray tube utilizing a target made in accordance with my invention wherein the effect of the electron beam trace on the target may be viewed either by reflected or transmitted light, and it should be understood that this showing of a tube is merely exemplary, and various other modifications and arrangements may be utilized to an equal advantage as hereinafter explained. Referring to Figure 1, the tube comprises a highly evacuated envelope or bulb 1 of cylindrical shape with a neck or arm section enclosing a conventional electron gun. The cylindrical portion of the bulb 1 is provided at one end with a window 2 if the tube is to be utilized for viewing by transmitted light so that light from a substantially constant light source 3 may be formed into parallel light rays by a lens system 4, projected through the cylindrical portion of the bulb and upon the target 5 which may be adjacent or deposited upon a second window 6 as hereinafter disclosed. The effects of the trace on the target may be viewed preferably from a position as at 7, although a position 7a may be used. Alternatively, the trace may be viewed at 7a utilizing a constant intensity light source 3a developing light projected on the target 5 through the lens system 4a, although for this position of the light source the target is preferably viewed on the side thereof scanned by the electron beam such as from the position 7. Furthermore, conventional Schmidt optical systems may be used to project the light upon a viewing screen for observation purposes. Alkali halide targets have a relatively narrow spectral absorption characteristic so that only a portion of the light from a relatively wide spectral range light source is absorbed by the color centers developed in the

halide target by the scanning operation. Therefore, it is essential that the light source have a spectral emission band falling at least partially, or preferably entirely, within the spectral absorption band of the scanned halide target so that the differences between the light transmission or reflection of excited areas and that of non-excited areas of the target may be distinct.

The electron gun assembly 8 may be of any one of the conventional types either of the magnetic focus or of the electrostatic focus type as shown. The electron beam is developed and accelerated by applying potentials between the electron source of the gun and one or more anodes, the desired electron beam velocity being determined by the thickness of the target 5, and the intensity upon the required density of the dark trace. Furthermore, the electron beam may be modulated in intensity such as by grid control from a receiver 9 and scanned over the target 5 by deflection fields developed in the deflection coils H and V supplied with operating currents of the desired wave form depending upon the type of trace whether of circular, radial or rectangular form. Obviously, other forms of deflection such as electrostatic deflection may be utilized in place of the magnetic deflection coils shown.

In accordance with my invention I form a target of alkali halide material by evaporating and condensing a quantity of such a halide while simultaneously bombarding with corpuscular energy the halide and surface on which it is condensed and bombarding the surface of the deposited halide with electrons either continuously or intermittently during the formation of the halide target. Thus while I will refer to bombardment of the foundation surface, it will be appreciated that this is true only prior to the first formation of a film of the halide and that subsequent to this first formation the halide film or layer is itself bombarded simultaneously with further increase in thickness due to further condensation of the halide thereon. Further in accordance with my invention I deposit the halide with simultaneous corpuscular energy bombardment such as electron bombardment thereof in a relatively high vacuum, that is, a vacuum corresponding at least to 10^{-4} millimeters of mercury.

While I have referred specifically to a target of the alkali halide type, further improvement in contrast and in other operating characteristics may be obtained by incorporating in the halide a small quantity of a polyvalent metal such as thorium chloride or other thorium compound as disclosed and claimed in my said copending application. Furthermore traces of hydroxides with the halide tend to make the condensed halide more opaque whereas traces of cadmium and magnesium increase the transparency. Inasmuch as the benefits recited in my said application as well as the improvements of my present invention may be obtained simultaneously, I will refer in a specific example to a halide incorporating a thorium compound. It will be appreciated, however, that my invention is also applicable to targets consisting of the alkali halides without such polyvalent metals as thorium.

As a source of a preferred target material I weigh 0.462 gram of pure potassium chloride and 0.045 gram of pure octohydrated thorium chloride ($ThCl_4 \cdot 8H_2O$) into a platinum container. I thoroughly mix the two salts in the container and carefully heat the salts to avoid decrepitation. This heating is preferably by radiation from a hot body to a red heat 500° C.–1000° C.) for a sufficient time until the two salts have melted or at least are well sintered together. I utilize the resultant mixture of co-crystallized salts as a source of treated halide to produce the alkali halide screen.

Referring again to Figure 1, the co-crystallized salts are supported as a mass 10 in a small platinum container 12 which is placed within the envelope 1 and suported with its open end facing the foundation such as the end wall 6 on which the halide screen is to be produced. The platinum container is preferably surrounded by an insulated resistance heater coil 14 through which current may be made to flow to heat the platinum container 12. The tube is then evacuated to a residual pressure of at least 10^{-4} mm. Hg. or less and the coil 14 energized, thereby slowly vaporizing the prepared halide mass 10 which is condensed upon the end wall 6 to for the target 5. The end wall 6 may be cooled to aid in the step of condensing the halide thereon. Obviously, other heating means than the resistance heater coil 14 may be utilized such as induction heating or radiant energy incident upon the container 12.

In accordance with my invention and simultaneously with the evaporation of the halide mass 10 I energize the electron gun 8 to develope an electron beam which I scan over the surface of the end wall 6 and over the halide target during its formation by condensation from the halide mass 10 as it is evaporated. During the simultaneous evaporation, condensation and resulting electron bombardment by scanning, I maintain the vacuum within the envelope 1 relatively high, this vacuum corresponding to a pressure at least as low as 10^{-4} mm. Hg.

I have found that the above-described simultaneous steps regulate and control the degree of crystallinity and micro-crystalline structure of the target and that the degree of translucency may be controlled and a semi-opaque or translucent target formed without recourse to subjecting the target to water vapor or ammonia. The electron velocity of the electrons impinging on the end wall and subsequently on the target during formation may be varied over wide limits such as a velocity corresponding to 500 to 50,000 volts accelerating potential applied to the final anode of the electron gun 8. Furthermore, the current density of the electron bombardment may likewise vary over wide limits such as from 0.001 to 1000 micro-amperes per square millimeter ($mm.^2$) of target area. For low current density bombardment such as 1 micro-ampere per $mm.^2$, the deposited halide tends to be more translucent while for higher density such as 40 micro-amperes per $mm.^2$, a more opaque deposition is formed. Consequently, the degree of translucency may be very effectively controlled by following my method. The velocity and density of the electron bombardment may be varied depending upon the total weight of the alkali halide material per unit of target area, the rate of deposition of the halide and the materials comprising the halide. I have found, however, that the electron velocity and current density may be increased during the halide evaporation and condensation in accordance with increasing thickness of the halide target. The rate of deposition of the halide may be 5 milligrams per square centimeter deposited in a period of from 1 to 15 minutes.

I have referred to corpuscular bombardment of the halide during deposition and referred specifically to electron bombardment. By corpuscular

bombardment I mean any bombardment by energy particles such as electrons, ions, alpha particles or beta rays.

Further in accordance with my invention I intermittently bombard the halide target with electrons during formation thereof to provide stratified layers of alternate transparent and translucent halide target material. In addition, I have found that such intermittent bombardment may be utilized to provide hot and cold cycles of deposition so that the crystalline characteristics of alternate layers may be varied depending not only upon the electron bombardment velocity and intensity but also upon the temperature of the foundation or previously condensed layers.

Referring to Figure 2 which shows the halide target 5 and end wall 6 in cross-section, it will be noted that the target in accordance with this teaching of my invention may be made of stratified layers of halide crystallized during condensation under different conditions. For example, for a target to be viewed by reflected light such as from the light source 3a the first layer or stratum 15 in contact with the foundation 6 is of crystalline halide of semi-opaque character deposited by condensation from the vapor stage during simultaneous relatively high density electron bombardment. The adjacent layer or stratum 16 is subsequently deposited with or without simultaneous low density bombardment by electrons. Additional stratified layers such as the layer 17 alternately of transparent and semi-opaque halide may be deposited in a similar manner, the stratum on the side from which the target is to be viewed preferably being of semi-opaque character.

Further in accordance with my invention I form pattern structures such as translucent areas or lines on a transparent target or transparent areas or lines on a semi-opaque target to serve as identifying indicia. Thus during the vaporization of the halide from source 10 I vary the characteristics of certain areas over which condensation occurs by applying predetermined scanning currents to the deflection coils or voltages to the deflection plates to scan only selected areas of the target. For example, horizontal and vertical axes may be produced by sequentially energizing the horizontal and vertical deflection coils so as to alternately scan a vertical and horizontal line-like area over the target with a relatively high intensity electron beam. Similarly, radial axes may be provided by energizing the deflection coils or plates, as the case may be, with quadrature currents or voltages of varying amplitude from a phase splitting deflection supply to form the radial lines, ellipses or circles desired. The selective bombardment of the halide may be termed a masking of certain areas of the target during its formation and although not as convenient, the desired characteristics of the halide may be obtained by use of a removable mask which shields certain areas of the target from bombardment by the electrons without shielding the condensation of the halide. The mask may be hinged and pulled out of registering position by gravitational, centrifugal or electromagnetic force. In the latter case it would be made of iron. In the other cases it can be made of anything having suitable mass. A suitable wire catch can be sealed in the glass to hold the mask in retracted position. Since low current bombardment increases the transparency and high current bombardment increases the opacity of the halide, one layer may be made exceedingly transparent whereas an adjacent layer or indicia thereon may be made more translucent.

Referring again to Figure 2, various indicia may be formed as shown at 18 by vaporizing and condensing the halide simultaneously with electron bombardment over only a portion of the target surface. For example, transparent indicia may be provided by scanning the high intensity electron beam, such as over a television raster form, and interrupting the beam where the indicia are desired. For example, lines, circles or other areas may be left transparent by cutting off or decreasing the electron beam with a signal applied to the receiver 9 developed in synchronism with the scanning currents applied to the coils H and V shown in Figure 1. Alternatively, the areas of the target serving as indicia may be opaque rather than transparent, although the reverse is preferred, by interrupting the beam over the major portion of the scanned area and thereby bombarding only the area on which the semi-opaque indicia are desired. Such indicia may be produced by energizing the receiver 9 with television signals derived by scanning a tube of the iconoscope type generating signals in synchronism with the scanning of the tube of Figure 1 which are representative of an optical image corresponding to the desired indicia. Furthermore, the indicia may be formed in one or more of the multiple layers. When viewing the target 5 by reflected light, the indicia should be in the target layer exposed to the viewing side. Consequently when viewing by reflected light two different sets of indicia may be used, one in each exposed layer, each indicia being effective by reflected light from its own side.

In certain of the appended claims I will describe the target as a halide rendered semi-opaque over selected areas by corpusular or electron bombardment in lieu of a specific recitation of the crystal structure produced by such bombardment inasmuch as the exact character of the crystal forms of the bombarded alkali halide is unknown.

While I have described my invention with particular reference to potassium chloride as a representative alkali halide, it will be appreciated that other materials such as magnesium oxide or other materials which color upon corpuscular bombardment may be used to substantially equal advantage, that the type of target made in accordance with my invention may be utilized in any type of tube either in oscillograph or television application, and that other modifications of my invention will at once suggest themselves to those skilled in the art and, therefore, I do not wish to be limited in practicing my invention except as set forth in the appended claims.

I claim:

1. The method of manufacturing a cathode ray tube having an envelope and a target foundation comprising evacuating said envelope to a pressure corresponding at least to 10^{-4} mm. Hg, bombarding said foundation with cathode rays, vaporizing an alkali metal halide within said evacuated envelope and condensing said alkali halide on said foundation during the cathode ray bombardment thereof.

2. The method of manufacturing a cathode ray tube having an envelope enclosing a target foundation, an electron source, and a quantity of an alkali metal halide, comprising evacuating said envelope to a residual pressure no greater than 10^{-4} mm. Hg, energizing said source to develop electrons, bombarding said foundation with

said electrons, vaporizing a portion of said quantity of alkali metal halide and condensing the vaporized alkali metal halide on said foundation during said bombardment whereby the condensed halide is subjected to bombardment during condensation thereof.

3. The method claimed in claim 2 including the step of intermittently interrupting the bombardment of said condensed halide during the condensation thereof.

4. The method of manufacturing a cathode ray tube having an envelope enclosing a target foundation, an electron gun and a quantity of alkali metal halide comprising the steps of evacuating said envelope, developing an electron beam from said gun, bombarding selected areas of said foundation, vaporizing a portion of said alkali metal halide, and condensing the vaporized halide on said foundation during bombardment of said selected areas thereof.

5. The method claimed in claim 4 including the step of intermittently interrupting the bombardment of said first-mentioned selected areas during the condensation of said halide.

6. A target for cathode ray use comprising a uniform coating of material which assumes a reversible color under corpuscular bombardment, one portion of said coating being more opaque than the remainder of said coating.

7. A target for cathode ray tubes comprising a coating of alkali metal halide of predetermined

transparency, said, coating having adjoining indicia of alkali metal halide material of a transparency different from said predetermined transparency.

8. A target adapted to be scanned by an electron beam comprising a coating of extended area of alkali metal halide material, the crystal form of said alkali metal halide being different over selected areas than that of surrounding areas, one of said crystal forms being more transparent than the other form of said alkali metal halide.

9. A target for cathode ray use comprising a coating of alkali metal halide crystals and indicia portions integrally formed with said coating, the indicia portions having a transparency differing from that of the remainder of said coating.

10. A target for cathode ray use comprising a multi-layer coating of alkali metal halide crystals, the transparency of one of said layers being greater than the transparency of another of said layers.

11. A target for cathode ray tubes comprising a foundation, a multi-layer coating of alkali metal halide crystals on said foundation, the layer of said coating adjacent said foundation having a transparency which is less than the transparency of the layer next adjacent said first-mentioned layer.

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