July 17, 1956 G. LEVY **2,755,404**

DARK TRACE CATHODE-RAY TUBE AND METHOD OF MANUFACTURE

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Fig. 1.

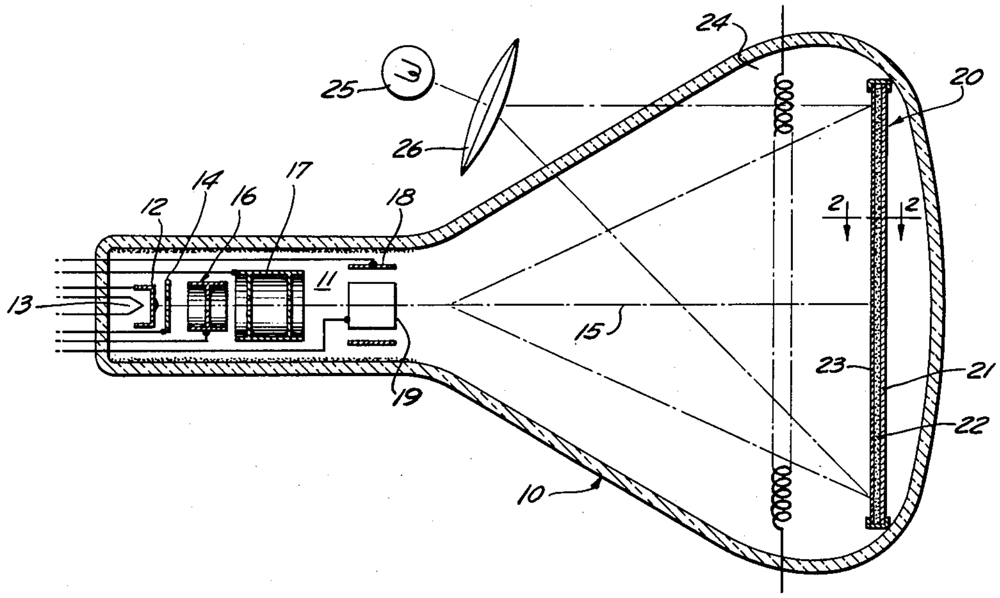


Fig. 2.

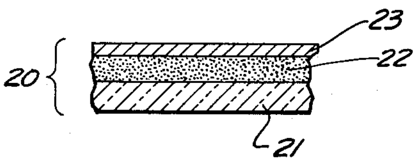
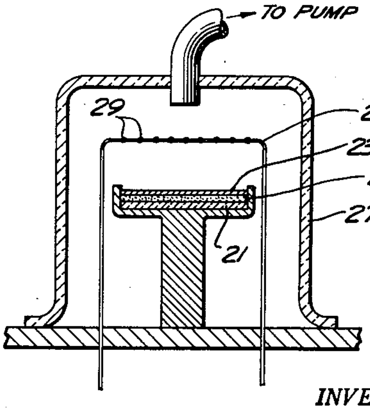


Fig. 3.



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DARK TRACE CATHODE-RAY TUBE AND METHOD OF MANUFACTURE

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15 Claims. (Cl. 313—91)

This invention relates to so-called dark trace tubes employing a cathode-ray responsive screen of scotophor material, and the like.

As is known in the art, the dark trace type of cathode-ray tube comprises an electron gun for developing a deflectable electron beam for scanning a special screen wherein the light-transducing material comprises a scotophor or mixture of scotophors. Such scotophors may consist of any of the alkali metal halides, preferably potassium chloride. One of the limitations on the use of such tubes in certain fields of use is the difficulty or slowness of erasing the dark trace record. It has been known for some time that such dark trace records can be erased by heat, by ultraviolet light, or by the electron bombardment. However, each of these known ways of erasure has certain defects which it is the object of this invention to alleviate.

Accordingly, one of the principal objects of this invention is to provide an improved structure of dark trace or scotophor screen whose dark trace record can be more rapidly erased.

Another object is to provide a novel dark trace screen which produces a high degree of contrast in the dark trace record and which is capable of relatively rapid erasure.

Another principal object is to improve the contrast, while at the same time increasing the useful life and permitting "back lighting" of a scotophor screen, and also simplifying the power supply required for the erasure energy.

A feature of the invention relates to a dark trace cathode-ray tube having a scotophor screen which is attached to a sheet of light translucent material of extreme thinness, the scotophor being coated with a layer of microcrystalline aluminum of controlled thinness. This aluminum layer is associated with a heat radiation source rich in infra-red radiation so that the aluminum acts as a wavelength converter for the radiation heat energy and thereby more efficiently erases the dark trace record in the scotophor.

A further feature relates to the novel method of preparing scotophor screens for dark trace cathode-ray tubes and the like.

A still further feature relates to the novel organization, arrangement and relative location, and preparation of parts which cooperate to provide an improved dark trace cathode-ray tube having rapid erasure characteristics and high contrast.

In the drawing,

Fig. 1 is a longitudinal plan view of a typical dark trace tube embodying the invention.

Fig. 2 is a greatly magnified view of a section of the dark trace screen of the tube of Fig. 1.

Fig. 3 is a schematic view of one typical apparatus for applying the heat converting coating to the scotophor.

In the drawing, which is merely by way of example, there is shown in schematic form an evacuated bulb **10** of glass having suitably mounted within the neck portion thereof any well-known electron gun **11** for developing an electron beam of high velocity electrons e. g., of the order of 10,000 electron volts. This gun includes for example the heatable electron-emitting cathode **12** with its internal heater element **13**; a centrally apertured metal disc **14**, which may constitute a control grid for controlling the brightness or intensity of the electron beam **15**; a first beam-accelerating and focussing anode **16**; a second and higher voltage anode **17**; and the conventional coordinate beam-deflecting elements which may be the usual electrostatic deflector plates **18**, **19**.

Mounted within the bulb **10** adjacent the flat end thereof is the screen **20**, constituted of an extremely thin sheet of mica or glass **21**, for example .0009 inch to .0014 inch, which carries the coating **22** of scotophor material such as an alkali metal halide, preferably, although not necessarily, a potassium chloride crystal layer. This alkali metal halide layer **22** is covered with a coating **23** of aluminum or similar light-weight metal or critically controlled thinness. Mounted in front of the screen **20** on the side facing the electron gun **11** is a source **24** of radiant heat rich in infra-red for uniformly heating the entire surface of the layer **23** by radiant energy. In accordance with the invention, the source **24** is a fine wire tungsten filament which can be connected to a suitable current supply source (not shown) to heat the filament to a temperature at which it acts as an efficient source of infra-red radiant energy. For example, it is an efficient radiation source of wavelengths shorter than 25×10^{-4} cm. The scotophor layer **22** transmits all wavelengths shorter than 25×10^{-4} cm. Therefore, the scotophor **22** by itself does not absorb sufficient energy in that range to effect rapid erasure of the dark trace record in the scotophor. In order that the erasure filament **24** shall not interfere with the recording, it may be in the form of a very fine wire annular or toroidal winding which is outside the maximum deflection angle of the beam **15**. Or it may be a fine zig-zag filament adjacent the screen **20**.

As is well-known, when the cathode-ray beam is of sufficient intensity, usually expressed kilovolts, e. g., 8 to 14 kv., as the beam scans the scotophor layer **20**, it develops so-called opacity centers or F-centers in accordance with the instantaneous intensity of the beam as modulated by the signal voltages applied to grid **14**. I have found that by using the construction of screen as above described and using an erasure source **24** which is an efficient infra-red radiator, it is possible to erase the previously developed opacity centers in a relatively short time by applying heating current for a corresponding short time to the filament **24** and without subjecting the scotophor screen to electron bombardment for erasure purposes.

In order to effect the proper and rapid erasure, it is necessary to condition the screen so that it will absorb the radiant infra-red energy from source **24**. The KCl material **22** is preferably deposited in a vacuum on the mica sheet **21**. Likewise, the aluminum coating **23** is preferably deposited by vaporization in a vacuum. I have found that this aluminum layer should be of sufficient thinness so as to be transparent to the electrons in the beam **15**, and also of sufficient thinness so that the screen can be viewed from the front of the screen, while the screen is being illuminated from the rear, for example by a conventional light source **25** and a suitable optical system **26**.

The thickness of the aluminum layer **23** is critical in that if it is too thick it will not properly pass the electron beam **15** to the scotophor material **22**; on the other hand, it must be sufficiently thick to enable it to absorb sufficient energy from the infra-red radiator **24** to erase the dark trace record in the scotophor material within the required short period of time.

Furthermore, since the scotophor material is in crystalline form it presents by itself a somewhat uneven surface upon which the aluminum must be evaporated. Advantage is taken of this fact according to the invention to utilize the phenomena of anomalous dispersion at the surface of the aluminum layer to increase the absorption of heat from the infra-red filament source **24**. There is evidence to show that the dielectric constant "E," and the specific conductivity "S" of dielectrics and conductors vary in complicated ways with frequency. Since the scotophor surface **22** is not a smoothly reflecting surface it is possible that with extremely thin aluminum coating, certain minute areas of the scotophor screen may not be covered with aluminum so that the surface of the screen struck by the beam **15** at these minute points will exhibit anomalous dispersion. However, rather than being a disadvantage, this dispersion is an advantage according to the invention. The phenomenon of change of index of refraction with frequency is called dispersion, and where this change is sudden there is anomalous dispersion. In the neighborhood of a region of anomalous dispersion there is energy absorption even where the surface of the material does not absorb the energy elsewhere. Advantage is taken also of this anomalous dispersion phenomenon to decrease the erasure time of the dark trace record. The variation of dielectric constant "E" for a metal such as the aluminum coating **23** with frequency, is analogous to that of a dielectric. Therefore, by making the aluminum layer **23** of the desired critical thinness the absorption of energy in the scotophor results not only from the anomalous dispersion but also the absorption of energy accompanying the electron conductivity through the aluminum layer.

I have found that one practical way for controlling the thinness of the aluminum layer **23** is to deposit the aluminum in successive steps in a vacuum. Thus, the mica sheet **21** with its scotophor coat **22**, can be mounted within the bell jar **27** which can be evacuated by any well-known means. Located within the bell jaw **27**, is a refractory fine wire metal filament such as tantalum filament **28**, to which had been previously attached one or more prefused aluminum pellets **29**. It is thus possible by applying a suitable heating current to the filament **27** in successive steps to evaporate the aluminum **29** in corresponding steps upon the scotophor material **22**. Sufficient time should elapse between each step to allow the micro-crystalline deposit to cool down. In general, the total number of such successive steps can be determined by the physical appearance of the scotophor screen. For example, on the first flashing of the aluminum pellets, the screen does not materially change its normal dark grayish color. After a few successive flashings, the screen assumes a grayish appearance until after a number of steps, for example, five or six, the screen becomes whitened. This is an indication that the desired thickness of aluminum has been applied to the scotophor. This whitening of the screen not only has the desirable feature of indicating the end point of the aluminum evaporation steps but it also increases the contrast in the recorded image when it is being viewed from the front end of the tube.

In one particular tube that was found to be satisfactory, it was possible to erase the image on the scotophor screen completely within 12 seconds by applying 300 watts of energy to the erasure filament **24**. The relation between the electrical wattage applied to erasure filament **24** and the erasure time for the various successive evaporation steps in applying the aluminum to the scotophor screen was as follows:

No. of Steps	Erasure Time	Wattage on Filament 24
1	1.5 min	300
2	1.5 min	300
3	50 sec	413
4	15 sec	300
5	12 sec	275
6	8 sec	368

Since the aluminum layer **23** is of extreme thinness it is not practical to measure it by conventional thickness measurements. Therefore, the above-noted method of depositing it in successive steps and noting the change in appearance from dark gray to white appearance is a practical way of determining the ultimate thickness of the aluminum coating.

Various changes and modifications may be made in the disclosed embodiment without departing from the spirit and scope of the invention.

What is claimed is:

1. A cathode-ray tube comprising in combination, an enclosing evacuated envelope, means to develop a beam of electrons, a screen upon which said beam impinges to make a record, said screen comprising a layer of scotophor material which develops opacity centers when said beam impinges thereon, and means to erase said centers, the last-mentioned means including a layer of aluminum on said scotophor material facing said beam-developing means, and an infra-red radiation generator within said envelope between said beam-developing means and said screen, said generator being especially designed to produce substantial radiation at wavelengths less than 25×10^{-4} cm., said aluminum layer having a thinness which is transparent to said beam but which develops heat by converting said infra-red radiation into wavelengths which are substantially absorbed by said scotophor material.

2. A cathode-ray tube according to claim 1, in which said scotophor material by itself transmits without substantial absorption infra-red wavelengths shorter than 25×10^{-4} cm., and said aluminum layer converts incident infra-red wavelengths of 25×10^{-4} cm. into longer wavelength infra-red.

3. A cathode-ray tube according to claim 1, in which said scotopher material by itself has very little absorption for infra-red below 25×10^{-4} cm., and said aluminum layer has a thinness which is transparent to red light in the visible range.

4. A cathode-ray tube comprising in combination, an evacuated enclosing envelope, an electron gun for developing a focussed electron beam, a light-transducing screen comprising a thin backing sheet which is light transparent to visible light, a coating of scotophor material on said sheet facing said gun, a layer of aluminum on said scotophor facing said gun, an infra-red radiator mounted between said screen and gun, said aluminum having a thinness which is transparent to said beam and to visible light and which forms a heat generator in contact with said scotophor in response to incident infra-red radiation from said radiator.

5. A cathode-ray tube comprising in combination, an evacuated enclosing envelope, an electron gun for developing a focussed electron beam, a light-transducing screen comprising a thin backing sheet transparent to visible light, a coating of scotophor material on said sheet, said scotophor being normally dark in appearance, a layer of aluminum on said scotophor having a thinness which is transparent to visible light but which is of sufficient thickness to impart a substantial whitish appearance to said screen, and a heatable infra-red radiation generating filament mounted between said screen and said gun.

6. A cathode-ray tube according to claim 5, in which said scotophor by itself passes an infra-red radiation of all wavelengths shorter than 25×10^{-4} cm., and said filament is provided with lead-ins for connection to an electric power supply to raise the filament to a temperature at which it is an efficient radiator of infra-red wavelengths shorter than 25×10^{-4} cm., said aluminum converting said short wavelength infra-red radiation into infra-red radiation of longer wavelength in a range which is substantially absorbed by said scotophor.

7. A cathode-ray tube according to claim 6, in which said filament is a tungsten filament mounted adjacent said

screen without materially masking the screen against scanning by the electron beam.

8. A cathode-ray tube according to claim 6, in which said backing sheet has a thickness of the order of 0.001 inch.

9. A cathode-ray tube according to claim 6, in which said scotophor and aluminum layer have an anomalous light dispersion surface on the aluminum coated side, and said aluminum has a critical thinness correlated with the electron velocity of the beam to effect heating of said scotophor in part by anomalous dispersion by the infra-red radiation at the surface of the aluminum coating.

10. The method of making a scotophor screen which comprises depositing scotophor material on a thin heat-insulating but visible-light transmitting backing said material having an anomalous dispersion surface, applying successive coats of vaporized aluminum to said scotophor until the visual appearance of the screen changes from dark gray to substantially white, and limiting the thickness of said coats to maintain it transparent to a cathode-ray beam while maintaining an anomalous dispersion at said surface.

11. The method according to claim 10, in which the scotophor and said aluminum coats are applied to said backing in a vacuum.

12. A scotophor screen for dark-trace tubes and the like comprising a thin visible-light transparent backing, a coating of scotophor material on said backing which is substantially transparent to infra-red radiation of wavelengths lower than 25×10^{-4} cm., and a coating of aluminum on said scotophor of critical thinness for converting incident infra-red radiation of wavelengths shorter than 25×10^{-4} cm. into an infra-red radiation of longer wavelength which is substantially absorbed by said scotophor material.

13. A scotophor screen according to claim 12, in which said scotophor material by itself has an anomalous dispersion surface and imparts a dark appearance to said screen, and said aluminum has a critical thinness which is transparent to an electron beam but of sufficient thickness to impart a whitish appearance to said screen while maintaining said anomalous dispersion surface.

14. A scotophor dark-trace screen according to claim 13, in which said aluminum comprises successive layers but has an overall critical thinness whereby the scotophor particles impart an infra-red anomalous dispersion characteristic thereto.

15. A scotophor dark-trace screen according to claim 12, in which said aluminum has a thinness which is substantially transparent to visible light.

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