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DARK TRACE CATHODE-RAY TUBE AND METHOD OF MANUFACTURE

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Fig. 1.

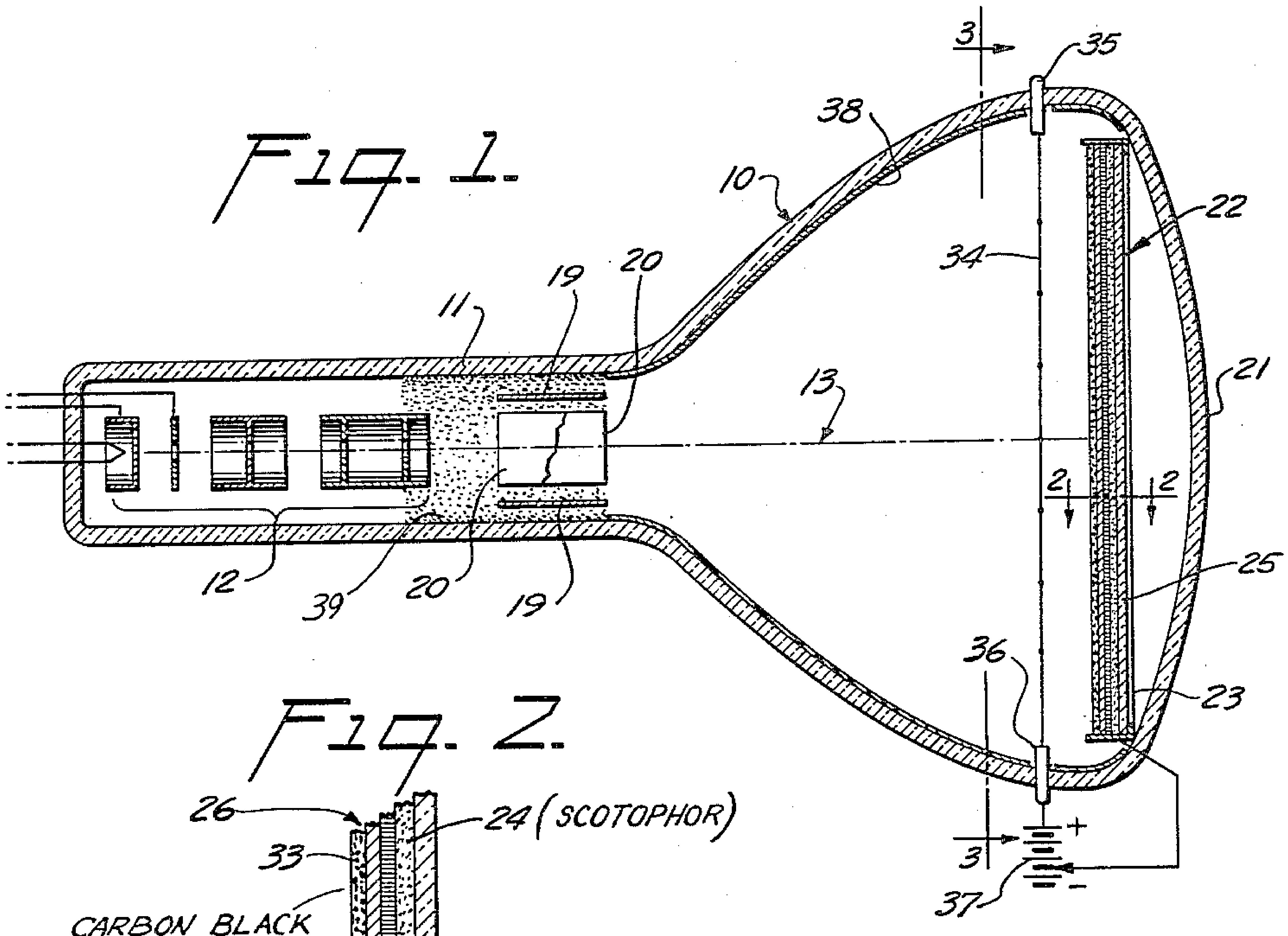


Fig. 2.

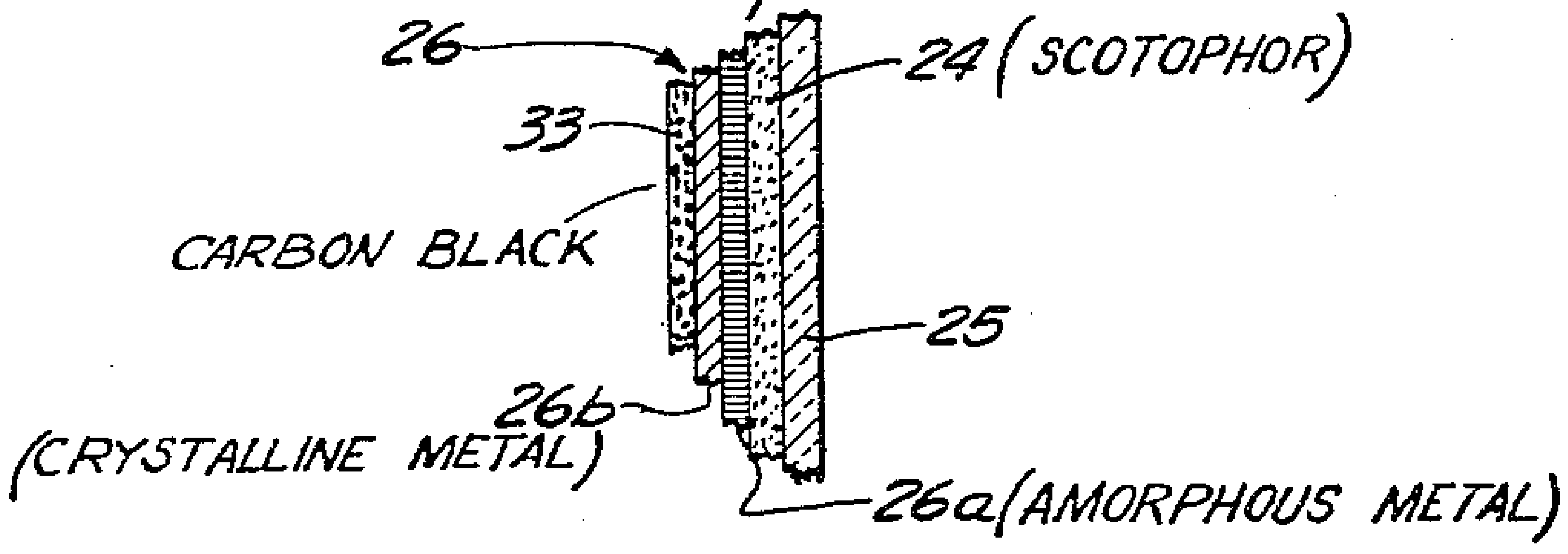
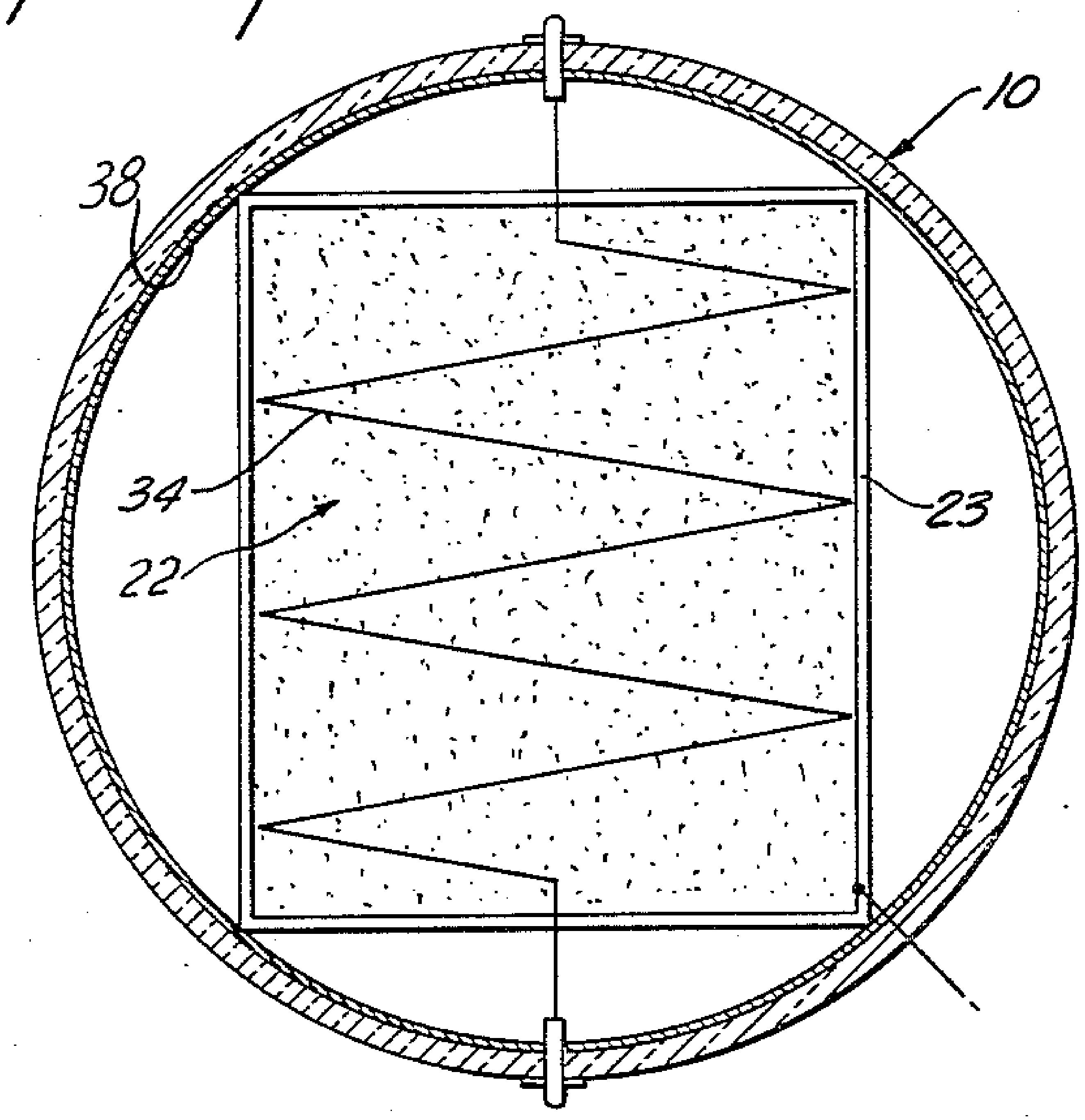
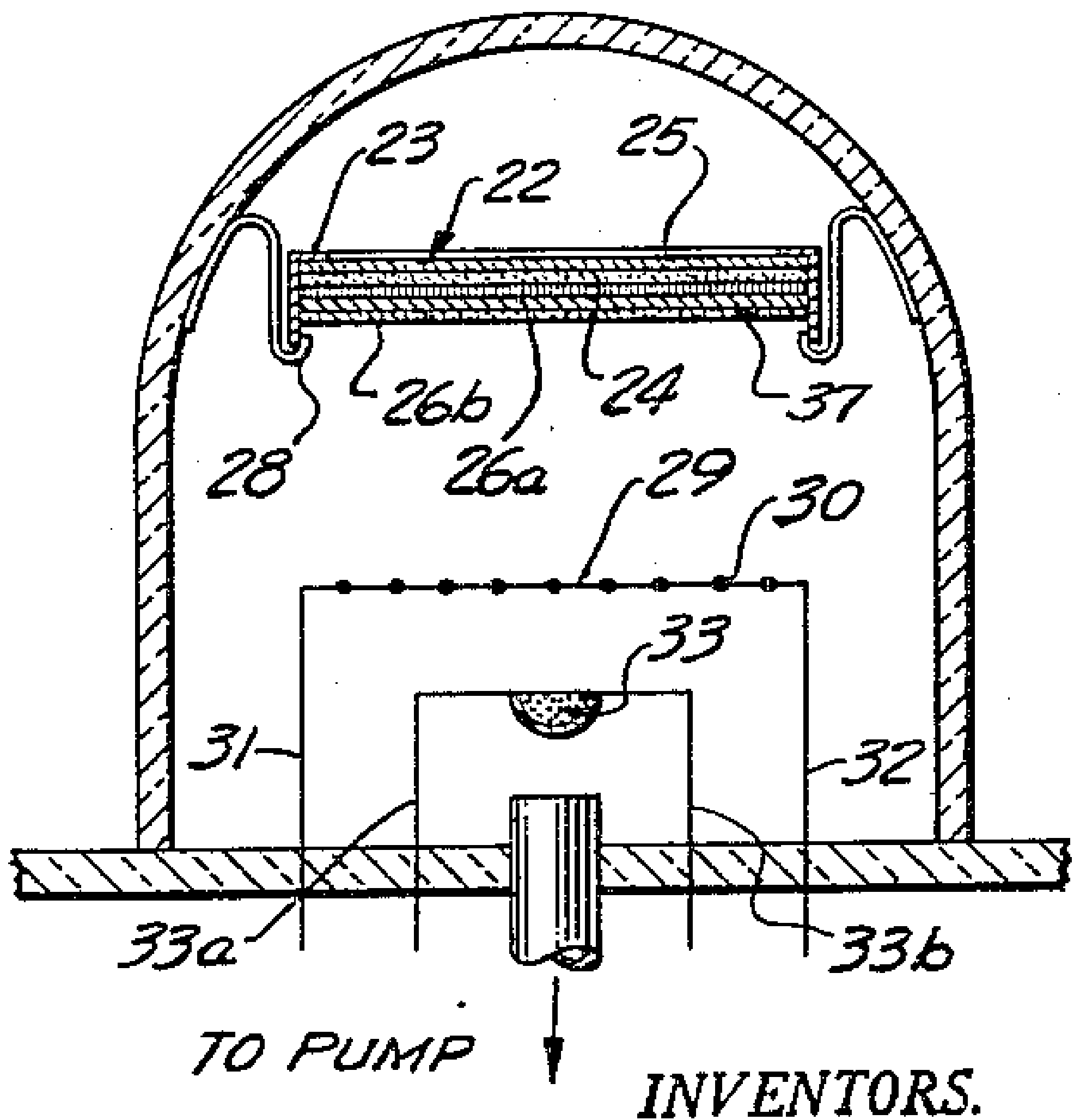


Fig. 4.

Fig. 3.





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DARK TRACE CATHODE-RAY TUBE AND METHOD OF MANUFACTURE

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This invention relates to electron tubes of the electron-optical transducer kind, and more especially it relates to tubes of the so-called dark trace variety, especially those employing an alkali-halide crystal screen as the transducer element. Such transducer elements are referred to herein as scotophors.

A principal object of the invention is to provide an improved cathode-ray tube of the scotophor screen kind, having a high degree of optical contrast and capable of rapid record erasure.

The screens of such dark trace tubes become magneta in color when exposed to cathode rays. This is due to the creation of an absorption band for visible light which is attributed to the trapping of electrons by anion vacancy sites within the crystal. These trapping sites are commonly termed F-centers and the absorption band is termed the F-band.

The chlorine ions in the potassium chloride, which represents the preferred form of scotophor material, lose electrons under electron bombardment and become essentially neutral chlorine atoms. These chlorine atoms are generally termed "holes" in the crystal. The ejected electrons are free to move within the crystal, and, at room temperature, there is a high probability that they will be trapped by the electrostatic fields of anion vacancies as F-centers.

At room temperature the F-center has two prominent metastable states. There is the lowest energy or ground state and a first excited state. The excitation of the F-center electron from the ground state to the first excited state by quanta in the visible spectrum gives rise to the absorption band called the F-band. While the F-center is in the excited state, it requires but a small additional amount of energy to be ejected from the trap and thus be free to move within the crystal. This energy can be supplied by the agitation of the ions surrounding the F-centers. When the F-centers are made sufficiently unstable by surrounding ion agitation, then the electrons ejected from F-centers are forced to return to "holes" in the crystal. The crystal now reverts back to its original uncolored state, i. e. erasure takes place.

The primary object of this invention is to provide a dark trace cathode-ray tube using a simple internal erasure mechanism which is not destructive of the alkali-halide screen.

Another object of this invention is to provide a dark trace tube which has an erasure mechanism which is uniform and constant in action.

A still further object is to provide a dark trace cathode-ray tube which has an essentially white screen of long life in conjunction with an erasure mechanism which is reliable, rugged, and which operates with a simple power source.

The above and other objects may be accomplished by practicing this invention which makes use of the infra-red absorption characteristics of potassium chloride and

carbon black in a manner to be hereafter more fully disclosed.

The salient point in this invention is a composite radiation-converting layer applied directly to the alkali-halide of the dark trace tube screen. This composite radiation-converter layer, while absorbing but an inappreciable amount of cathode-rays, appreciably whitens the appearance of the tube screen.

A feature of the invention relates to a scotophor screen which has, as an integral part thereof, a radiation wave-length converter for converting received radiations in the short infra-red range, for example approximately 7000 A.–14,000 A., into long infra-red region, for example 20μ to 100μ, whereby erasure heat energy can be efficiently and rapidly applied directly to the scotophor material without destroying its transducer qualities and without deleteriously affecting its life.

Another feature relates to a scotophor screen having a light-transparent backing for a scotophor, and a multi-layer coating on the scotophor acting as a wave-length converter for incident infra-red radiation, one of the layers of said coating consisting of a light-weight metal such as aluminum, beryllium, magnesium, and a layer of amorphous carbon in the form of soot or carbon black.

Another feature relates to a scotophor screen having a light-transparent backing for a scotophor, and a multi-layer coating on the scotophor acting as a wavelength converter for incident infra-red radiation, one layer of said coating consisting of a light-weight metal transparent to a cathode-ray beam and in crystalline form, and another layer in the form of soot or carbon black also transparent to the cathode-ray beam.

A further feature relates to a dark trace cathode-ray tube having a scotophor screen which carries as an integral part thereof an infra-red wavelength converter including a light-weight metal and carbon black, in conjunction with a fine wire filament metal inside the tube adjacent the screen for irradiating the screen with relatively short wavelength infra-red, e. g. 7000 A.–14,000 A., and with the inside wall of the tube provided with a mirror coating for more efficiently irradiating the said screen with said infra-red.

A still further feature relates to the novel organization, arrangement and relative location and composition of elements which cooperate to form an improved scotophor screen capable of rapid erasure.

Other features and advantages not particularly enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing,

Fig. 1 is a longitudinal sectional view of a dark trace cathode-ray tube, embodying the invention.

Fig. 2 is a magnified cross-sectional view of part of the scotophor screen of Fig. 1, taken along the line 2—2 thereof.

Fig. 3 is a sectional view of Fig. 1, taken along the line 3—3 thereof.

Fig. 4 is a schematic diagram of a typical apparatus for controlling the vacuum deposit of the various screen coatings.

In the drawing, which shows by way of example one preferred embodiment, the numeral 10 represents any well-known form of evacuated bulb such as conventionally used in cathode-ray tubes. The said bulb has the usual neck portion 11 in which is mounted any well-known form of electron gun 12 for developing a focused electron beam 13. The tube is also provided with any well-known coordinate beam deflecting means represented schematically by the horizontal and vertical deflection plates 19, 20. The front or face end 21 of the tube is of glass and suitably mounted adjacent that end is the scotophor screen **22** according to the invention. This screen may be supported in an annular or rectangular metal frame **23** which can be fastened in any suitable way against the end wall **21**.

As shown in magnified sectional view in Fig. 2, the screen **22** comprises an alkali-halide crystal material **24**, preferably potassium chloride, which is sprayed, settled, or vaporized in vacuum on a thin mica or glass light-transparent support backing **25**, which is held in frame **23** in any suitable manner. For example, the backing **25** may have a thickness of about 0.001 inch. A thin amorphous or quasi-amorphous coating of a light-weight metal **26**, such as aluminum, beryllium, or magnesium, is then deposited on the scotophor **24**. The depositing of this light-weight metal should be done in a vacuum under controlled conditions. For example, as schematically shown in Fig. 4, the deposition of the scotophor material, such as potassium chloride, on the backing **25** can be effected by placing the frame **23** and the backing **25** in a supporting jig **28** inside the bell jar and the potassium chloride can be vaporized from a suitably heated cup **33**, to form the scotophor deposit. Cup **33** can be heated by current applied to lead-ins **33***a*, **33***b*. Similarly, the light-weight metal coating **26** can be deposited over the scotophor in the evacuated bell jar. For example, there may be mounted within the bell jar a metal filament **29** carrying a series of pellets **30** of the desired light-weight metal. The filament **29** can be connected by means of suitable lead-in members **31**, **32**, to a source of heating current so as to flash or vaporize the pellets **30** on to the scotophor.

In accordance with the invention the vaporization of this light-weight metal is done in successive steps so that the layer **26** is initially deposited as a stratum **26***a* of the light-weight metal in amorphous form, and then the next stratum **26***b* of this vaporized light-weight metal is deposited as a mirror deposit which is highly reflective to visible light rays and is a good metallic conductor. In other words, the stratum **26***b* is crystalline in character, whereas the stratum **26***a* is amorphous. Stratum **26***a* is deposited by vaporizing the light-weight metal against the rough surface of the scotophor **24** in a relatively poor vacuum of say approximately 5×10^{-5} mm. of Hg in pressure while for stratum **26***b*, the evaporation takes place in a vacuum of approximately 10^{-6} mm. of Hg in pressure or better. The evaporation of the aluminum is discontinued when the crystalline deposit is just barely translucent in an intense source of white light. Finally, a thin but black deposit of pure carbon black or soot **33** is deposited on the stratum **26***b*. This soot can be applied by exposing the stratum **26***b* to an atmosphere resulting from the incomplete combustion of a mixture of methane and benzene.

We have found it is important that the amorphous carbon coating referred to hereinabove should be in the form of substantially pure carbon black or soot. This soot can be produced by the incomplete combustion of illuminating gas (namely CH_4) and benzene vapor (C_6H_6). The gas can be bubbled through a wash bottle containing benzene. The soot can be deposited at the screen either by holding the screen in the gas flame or supporting the screen above the flame such as in a bell jar. The soot thus deposited is a heat absorber and transfers its heat energy by conduction to the light-weight metal deposit which reradiates the energy as long wave infra-red radiation. The long wavelength infra-red is readily absorbed by the scotophor material which is, however, diathermic for infra-red radiation of wavelength below 20 microns.

This soot layer **33** has very high absorption for radiation in the visible or inner infra-red spectrum. It has the additional advantage that it requires no special precautions when the screen is finally assembled in the tube **10** and that tube is subjected to the usual processing and exhaust schedules such as are conventionally used in the manufacture of cathode-ray tubes, because carbon black is relatively inactive at the temperatures to which it may be exposed during such processing.

It should be understood that the thickness of the various coatings **24**, **26** and **33** should be controlled and limited so that their combined thickness is transparent to the electron beam **13**. For example, if the beam **13** is a high velocity beam of the order of 8 to 14 kilovolts, the thickness of the scotophor **24** may be 8 to 10 microns; the thickness of the double strata layer **26** can be 0.3 to 0.5 micron; and the thickness of the carbon black **33** can be 0.5 to 2.0 microns.

We have found that when such a screen is subjected to the oscillating cathode-ray beam **13**, there is produced in the scotophor **24** a record of the signal modulations which occur in the beam **13**, and it is possible to erase this record comparatively rapidly by subjecting the screen **22** to infra-red radiation in the relatively short wavelength range, for example 7000 A.–14,000 A. However, as a result of the composite character of the coatings **26** and **33**, they act as a frequency converter for this relatively short wavelength infra-red and convert it into relatively long wavelength infra-red, for example in the range of 20μ to 100μ.

In order to effect this rapid erasure, therefore, it is necessary to provide within the tube **10** an efficient and stable source of the short wavelength infra-red and this source should be such that it does not deleteriously affect the scotophor material permanently. For this purpose, there is mounted adjacent the screen **22**, for example at a distance of 2 to 4 inches therefrom, a fine wire tungsten filament **34** which is supported in any suitable manner and connected to respective lead-in members **35**, **36**, for connection to a supply of electric current which may be the conventional commercial 115 volt supply line. For example, the filament **34** may consist of a tungsten wire of approximately 0.008 inch diameter which, when connected to a 115 volt supply line, rises very rapidly to a temperature at which it becomes an efficient source of infra-red radiation, for example in the range from 7000 A.–14,000 A., corresponding to a filament temperature of approximately 2100° K. In other words, the filament converts the filament heating current mainly into radiated energy in the short wavelength infra-red range. Preferably, the filament **34** is zig-zag in shape so as to substantially uniformly irradiate the screen **22** over its entire surface and because of the fineness of the filament it casts negligible electron shadow on the screen as the beam **13** is scanning the screen. If desired, this liability to shadow may be even further reduced by biasing the screen negatively with respect to the filament **34** by a suitable adjustable source schematically represented by the battery **37**. It will be understood that by a suitable switch (not shown) the current is applied to filament **34** only when the beam **13** is blanked off during the erasure period. The beam can be blanked off by applying a cut-off bias to the control grid of the electron gun in known manner.

In order further to increase the efficient infra-red radiation to the screen, the entire bowl or bulb portion of the tube **10** can be coated on its inner surface with a layer **38** in the form of a mirror-like coating of aluminum. This coating **38** also serves to keep the bowl or bulb portion of the tube relatively cool during the erasure cycle. Preferably the coating **38** extends into contact with the metal frame **23**. The neck portion of the bulb **10** can be provided with the usual non-reflecting or colloidal graphite coating **39**.

The operation of the erasure cycle can be described as follows. The visible and short wavelength infra-red radiation from the tungsten filament **34** is directly absorbed by the soot layer **33** on the screen. The soot thereupon heats the metallic layer **26** which in turn acts as an infra-red converter and radiates long wavelength infra-red with relatively high efficiency from the quasi amorphous stratum **26a** which is in direct contact with the scotophor 24. The scotophor 24, therefore, directly absorbs this long wavelength infra-red radiation in the process of volume polarization of its crystals. Sufficient energy is thus absorbed by the scotophor to effect erasure of the F-centers in the crystal. There is additional absorption of energy from the radiation source and by heat conduction during the interval that the electrons are mobile in the conduction band of the crystal. During this interval, the scotophor crystal has metallic characteristics, while normally it is a good insulator. One of the advantages of constituting the metallic layer **26** of a double strata coating is that the amorphous stratum **26a** is a relatively poor heat conductor while the crystalline stratum **26b** is a good heat conductor and thus more efficiently converts the heat adsorbed by the carbon black layer **33** into the desired infra-red radiation for erasing the record on the scotophor 24.

Various changes and modifications can be made in the disclosed embodiment without departing from the spirit and scope of the invention. By the expression carbon black, as used herein, is meant powdered carbon as distinguished from pelletized or crystalline carbon. Such carbon blacks are referred to in the trade by various names, such as channel blacks, furnace blacks, lamp blacks, acetylene blacks, soot, flame blacks, and the like, as distinguished from crystalline carbon or graphite.

What is claimed is:

1. Cathode-ray tube apparatus of the dark trace scotophor kind comprising in combination, an enclosing envelope, means to develop a beam of electrons, a screen upon which said beam impinges to make a record, said screen including a scotophor material which develops opacity centers when said beam impinges thereon, and means to erase said centers, the last mentioned means comprising a source of infra-red radiation, a layer of carbon black on said screen facing said beam developing means, and a layer of metal from the group consisting of aluminum, beryllium and magnesium, sandwiched between said carbon black and said scotophor, said layers of carbon black and metal having a total thickness which is transparent to said beam.

2. Cathode-ray tube apparatus according to claim 1, in which said metal layer is composed at least in part of a stratum in amorphous form.

3. Cathode-ray tube apparatus according to claim 1, in which said metal layer is composed of two strata, one of which is amorphous and the other crystalline.

4. Cathode-ray tube apparatus of the dark trace scotophor kind comprising in combination, an enclosing envelope, an electron gun to develop a beam of electrons, a screen upon which said beam impinges to make a record, said screen comprising a scotophor which develops opacity centers when said beam impinges thereon, a source of infra-red radiation within said envelope between the gun and screen, and an infra-red wavelength converter forming an integral unit with said screen, said converter comprising a layer of carbon black facing the gun and a layer of amorphous aluminum between the carbon black and the scotophor.

5. Cathode-ray tube apparatus according to claim 4 in which said infra-red source is a fine wire refractory filament having lead-ins for supplying it with heating current to raise it to a temperature at which it efficiently radiates infra-red in the region between 7,000 A–14,000 A.

6. A screen for dark trace cathode-ray tubes, comprising a transparent thin backing support, a coating of scotophor material on said support, and means to convert incident short wavelength infra-red radiation into long wavelength infra-red radiation for record erasure, said means comprising a layer of amorphous carbon, and a layer of a metal from the group consisting of aluminum, beryllium and magnesium the last-mentioned layer being located between the scotophor and the first-mentioned layer.

7. A screen for dark trace cathode-ray tubes, comprising a transparent thin backing support, a coating of scotophor material on said support, a coating of metal from the group consisting of aluminum, beryllium and magnesium, on said scotophor, and a layer of soot on said coating for the purpose described.

8. A screen for dark trace cathode-ray tubes, comprising a transparent thin backing support, a coating of scotophor material on said support, a stratum of amorphous aluminum in direct contact with said scotophor, a stratum of crystalline aluminum in direct contact with the amorphous stratum, and a stratum of carbon black on said crystalline aluminum stratum, said strata having a total thickness which is transparent to an incident cathode-ray beam while converting incident short wavelength infra-red radiation into long wavelength infra-red radiation.

9. The method of making a scotophor screen for a dark trace cathode-ray tube and the like, which comprises depositing a scotophor on a light transparent backing, applying to said scotophor a coat of an element from the group consisting of aluminum, magnesium and beryllium, then applying a coating of carbon black to said element and limiting said element and carbon black to a thickness which is transparent to an incident cathode-ray beam while of sufficient thickness to act in conjunction with said element as a wavelength converter to convert incident short wavelength infra-red radiation to longer wavelength infra-red radiation.

10. The method according to claim 9 in which said element is applied in a vacuum to form it with two successive strata, one of which is amorphous and the other crystalline.

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