May 27, 1958 **G. HODOWANEC** **2,836,753**

DARK TRACE CATHODE-RAY TUBES AND SCREENS THEREFOR

Filed March 25, 1954

Fig. 1.

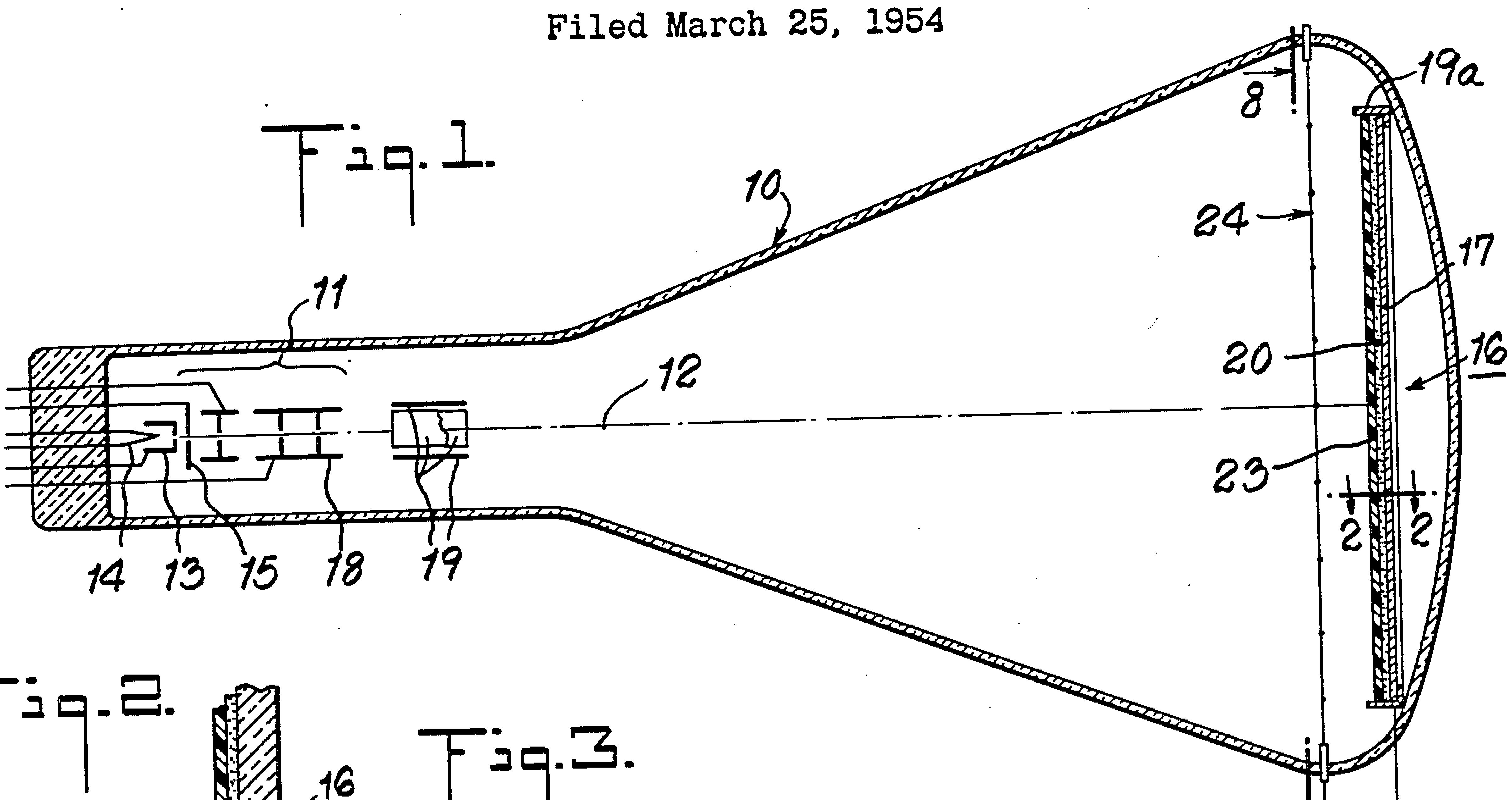


Fig. 2.

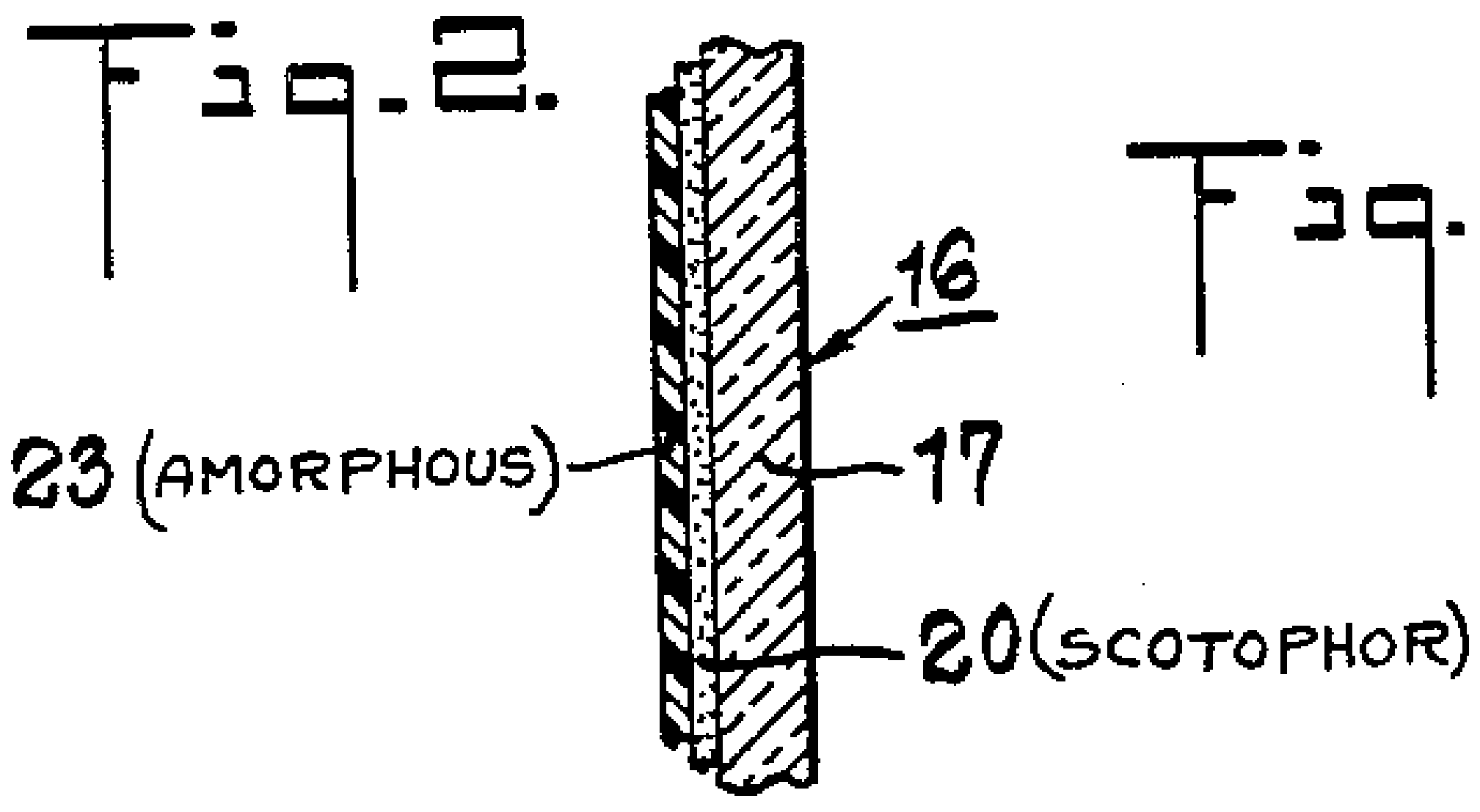


Fig. 3.

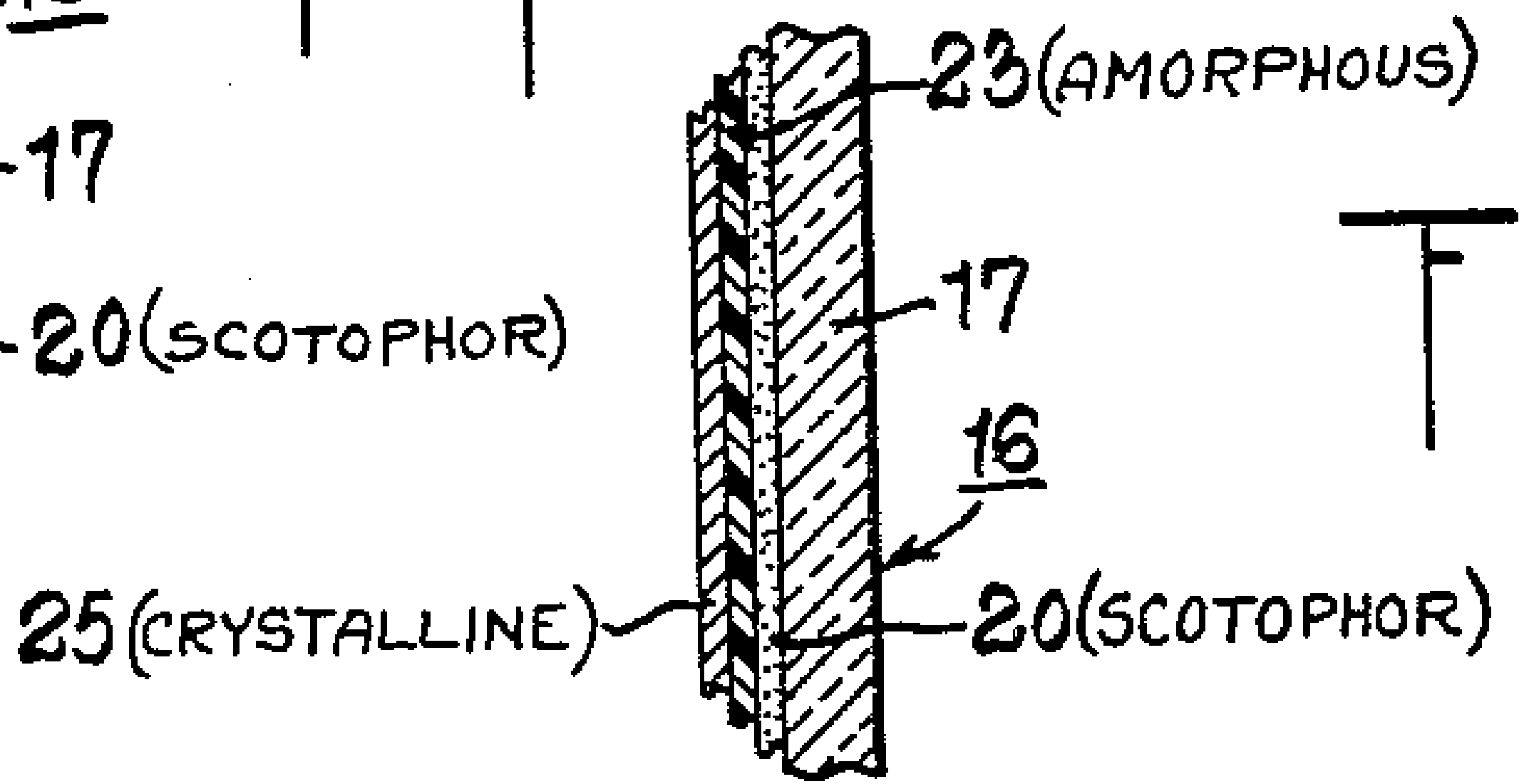


Fig. 4.

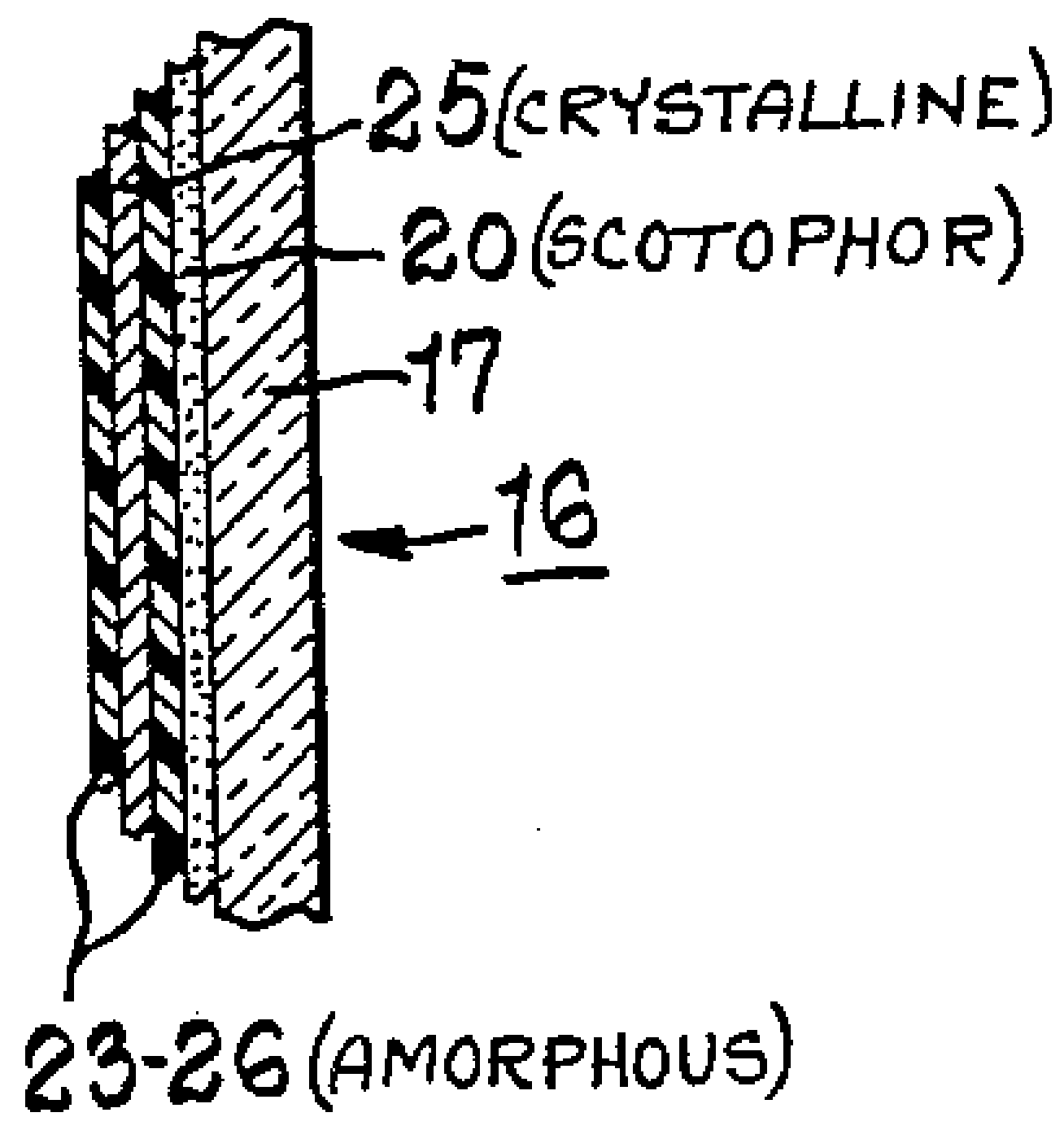


Fig. 5.

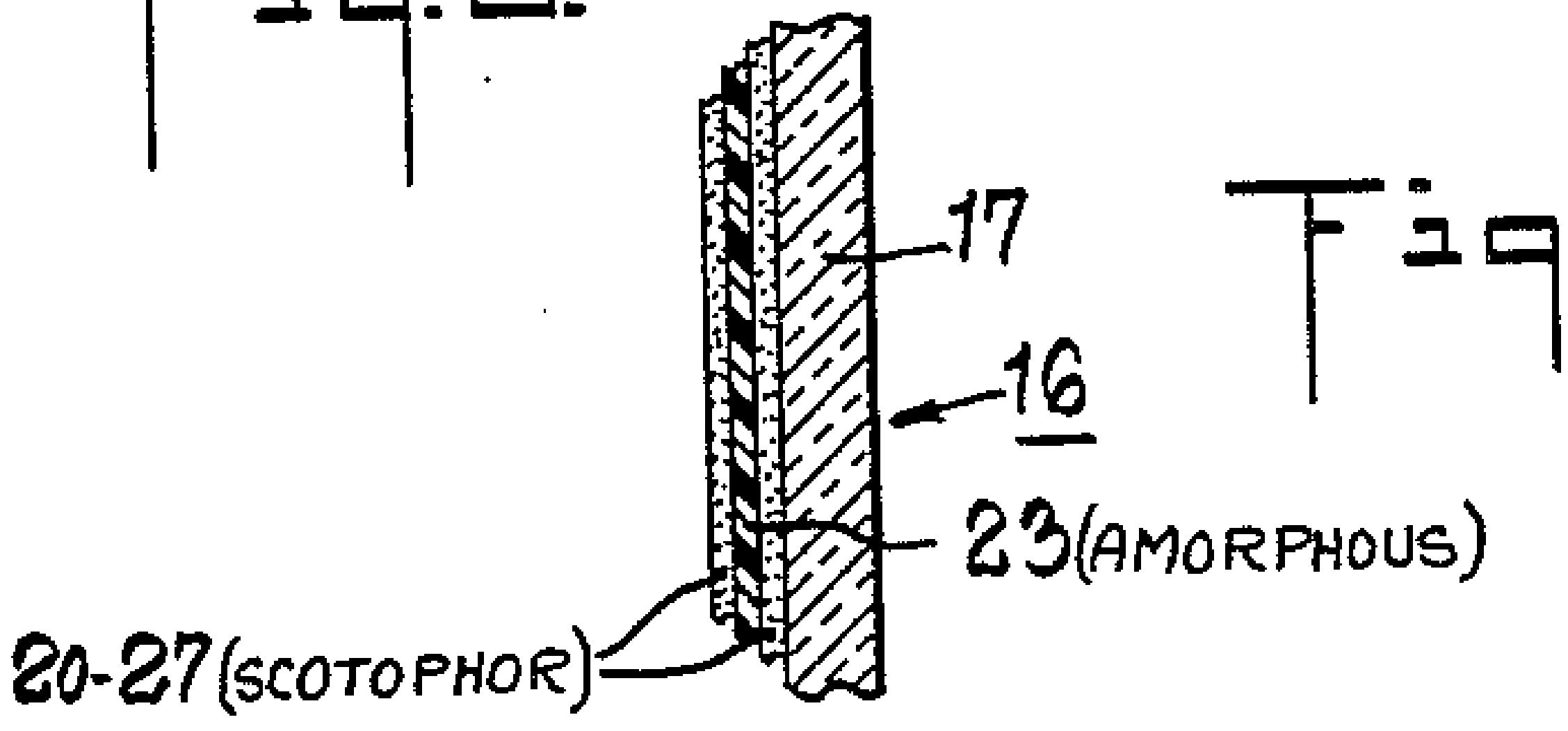


Fig. 6.

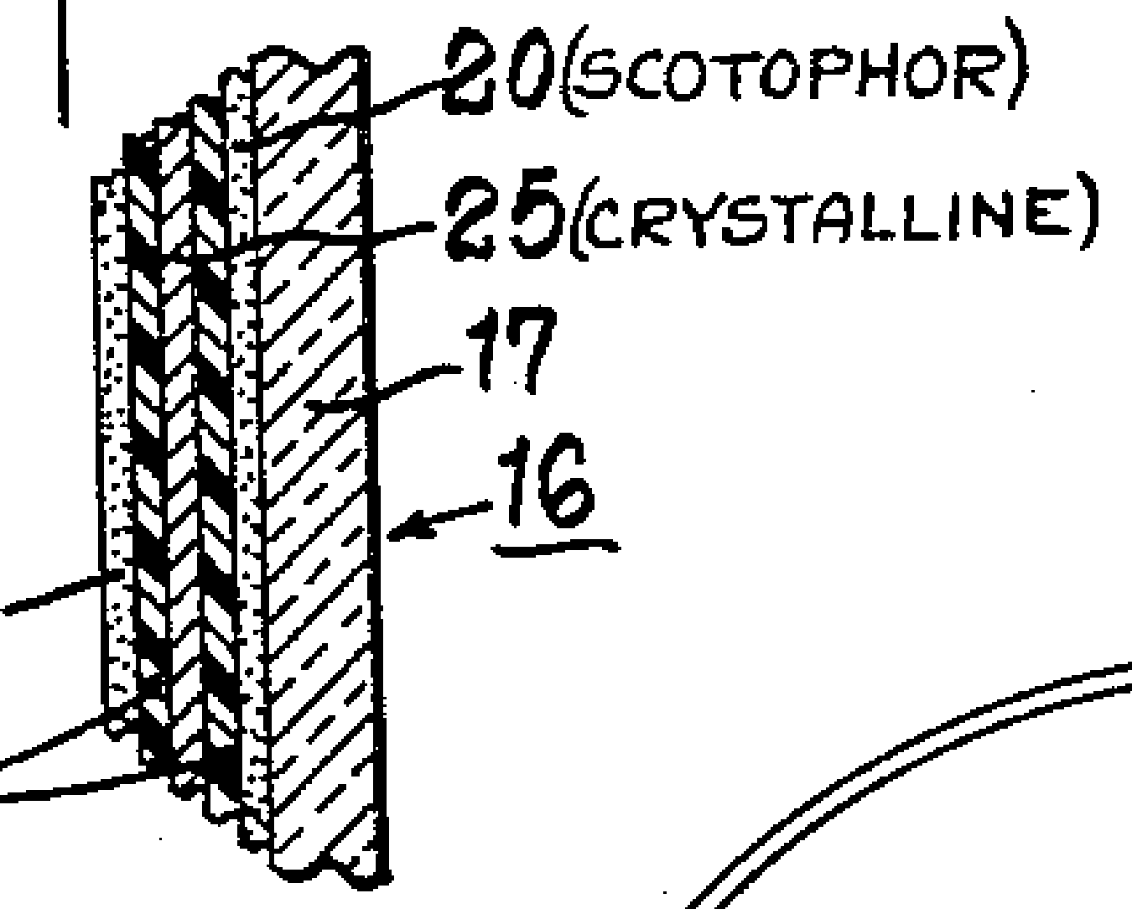


Fig. 7.

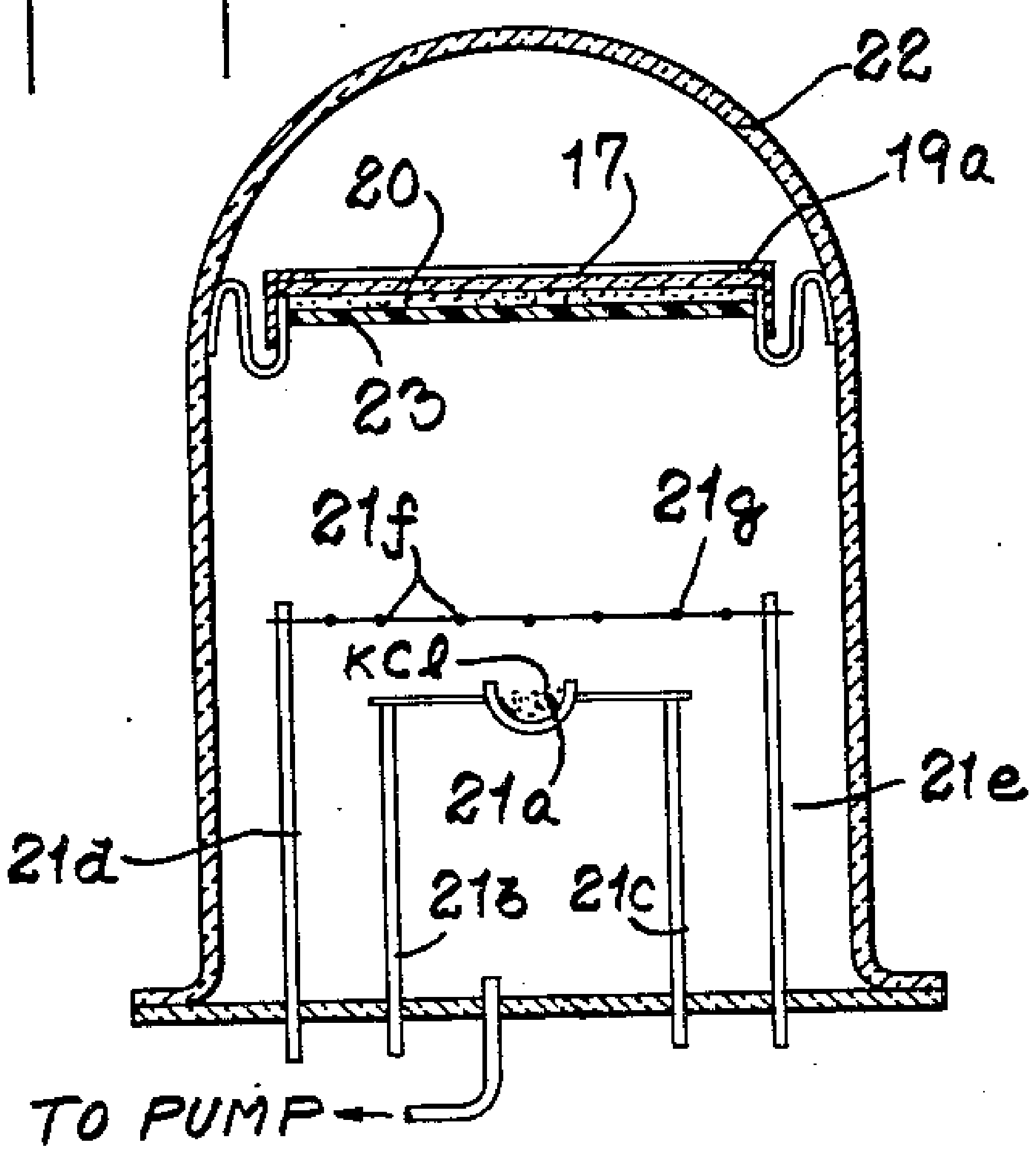
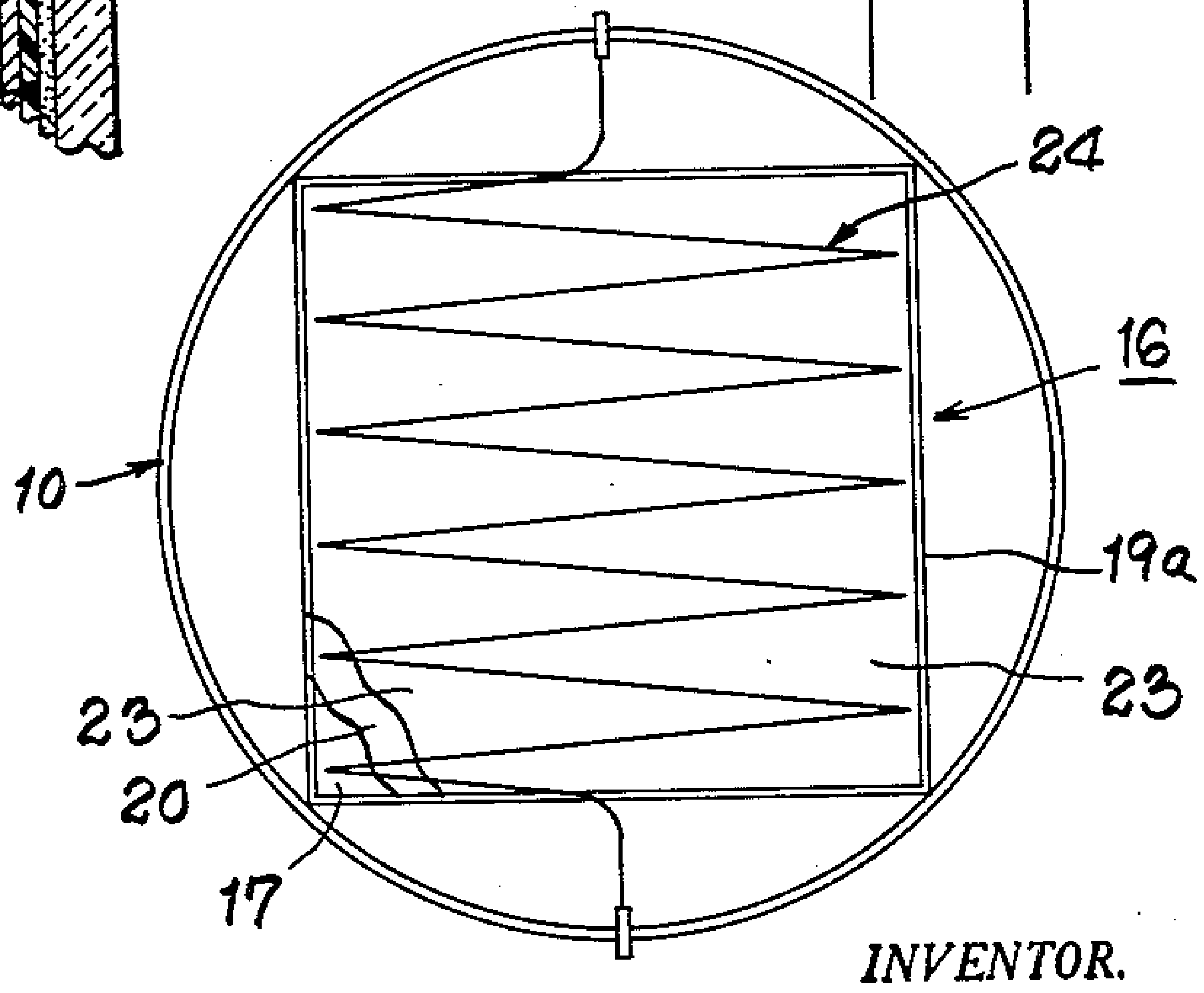


Fig. 8.



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DARK TRACE CATHODE-RAY TUBES AND SCREENS THEREFOR

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Application March 25, 1954, Serial No. 418,624

8 Claims. (Cl. 313—92)

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.

It is known that such dark trace tube screens, which normally are a diffuse white, darken under electron bombardment. This is due to the creation of an absorption band for light in the visible spectrum. In the case of the ionic alkali-halide crystals, this absorption band is attributed to the trapping of electrons by the electrostatic fields of anion vacancy sites within the crystal. These trapping sites are commonly called F-centers, and the induced absorption band is called F-band. In the particular case of dark trace tubes using potassium chloride as the scotophor, the induced F-band has a peak at a wavelength of approximately 5600 angstroms or the green region of the visible spectrum. When a crystal of potassium chloride containing F-centers is exposed to white light, it appears magenta in color, since the reflected light is now enhanced in red and blue.

The electrons which become trapped at anion vacancy sites to form F-centers are mainly those ejected from the anions of the crystal by electron bombardment. These ejected or internal secondary electrons are free to move within the crystal as conduction electrons. As such they have energies over a range of values generally termed the conduction band of the crystal. At room temperature or lower, there is a high degree of probability that they will be trapped by the electrostatic fields of anion vacancy sites with the formation of F-centers. The anions (chlorine ions in the case of potassium chloride) which have lost an electron will be essentially neutral halogens and are commonly called holes within the crystal. In a scotophor of stoichiometric composition, there will be a hole for every F-center.

Since the F-center is an electron trapped in the electrostatic field of a net positive charge created by the anion vacancy, the energy levels of the various trapping states are determined mainly by the configurational coordinates of the surrounding ions. In the particular case of the potassium chloride scotophor, the F-center has, at normal room temperature, but two prominent metastable trapping states. One is the lowest energy or ground state, and the other is a first excited state which eventually stabilizes just below the conduction band level for the crystal. The electron is raised from the ground state to this first excited state by the absorption of quanta in the F-band. In the excited state, the electron needs to absorb but a small amount of energy (which can be supplied by the surrounding ions) in order to enter the conduction band of the crystal. In the conduction band the electron can either return to a hole or again be trapped as an F-center.

At normal room temperature, where there is but random thermal agitation of the crystal lattice, re-trapping as an F-center is very much more probable than return to a hole. However, if the ions surrounding the F-center are agitated in some way, the probability of return to holes increases tremendously since the F-centers will now tend to be unstable. The decay of F-centers with the return of electrons to holes in the crystal is termed erasure, for then the crystal reverts back to the original uncolored state.

Since thermal agitation of the crystal lattice at room temperature is insufficient for fast erasure, decay of F-centers can be accelerated simply by increasing the lattice agitation by some external means. Erasure devices of the prior art operated mainly by the diffusion of thermal energy (heat) through the crystal in a process of heat conduction. One method of doing this in the prior art was to subject the scotophor to very strong F-band light. The formation of F-centers is accompanied by the generation of a certain amount of lattice vibrations (heat). Under continued exposure to strong F-band light, the crystal temperature eventually rises and therefore decay of F-centers proceeds. However, this is a very slow process involving much power and thus is somewhat impracticable. Another method of the prior art is to excite the crystal lattice by heat conduction from a heated substrate supporting the scotophor, or from a suitable film placed in contact with the scotophor. This has the disadvantage that in many cases the heating element is heated by electronic conduction, i. e., resistance or joule heating. This requires that the conducting element (and thus the scotophor) be rectangular in shape and of uniform resistance for uniform current distribution. Yet another method of the prior art is to irradiate the scotophor with ultra-violet quanta which are strongly absorbed by the surface layers of the crystals of the scotophor. Such absorptions also generate lattice vibration (heat) which then diffuses to within the body of the crystals. Yet another method of the prior art is to bombard the crystal lattice with sufficient electron density so that the crystal temperature rises rapidly through inelastic collisions. Both the ultra-violet method and electron bombardment method of erasures result in irreversible damage to the alkali-halide scotophor. In these methods, some anions are lost as halogen gas, therefore the crystals are no longer of stoichiometric composition. The excess alkali creates additional unwanted and permanent absorption bands.

The primary object of the present invention is to provide an erasure device for use in dark trace cathode-ray tubes using alkali-halides as the scotophor which is relatively fast and uniform in operation, and which is not destructive to the scotophor.

Another object is to provide an erasure device which is suitable for dark trace screens of any practical size or shape.

Still another object is to provide an erasure device which acts uniformly throughout the volume of the scotophor of the screen, and which does not therefore primarily depend upon a general diffusion effect.

A still further object is to provide an erasure device which is simple and which does not require additional equipment or power other than regular commercial electric supply lines.

A feature of the invention relates to a scotophor screen which has, as an integral part thereof, a radiation wavelength converter for converting received radiations in the short infra-red range, for example approximately 7000 A.–14,000 A., into the long infra-red range, 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 thin transparent, low heat capacity backing for a scotophor, and a coating on the scotophor comprising at least two superposed layers, one of which comprises a light-weight element of the group consisting of aluminum, magnesium, beryllium, and carbon in amorphous or randomly oriented particle form, and another layer of which consists of one of said elements in microcrystalline form, the layers acting as a wavelength converter for converting impinging short wavelength infra-red into long wavelength infra-red.

A further feature relates to a scotophor screen comprising a layer of scotophor crystals upon which are deposited in successive overlay a layer of a metal from the group consisting of aluminum, beryllium and magnesium, and a layer of carbon.

A still further feature relates to the novel organization, arrangement, location and composition of parts which cooperate to provide an improved scotophor screen.

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

The above and other objects may be accomplished by practicing this invention which makes use of the long wave infra-red radiant energy absorption characteristic of alkali-halide crystals in a manner hereafter more fully disclosed.

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

Fig. 2 is a magnified sectional view of the screen of Fig. 1.

Figs. 3, 4, 5 and 6 represent respective modifications of the screen of Figs. 1 and 2.

Fig. 7 is a schematic view of one form of apparatus for preparing the screen according to the invention.

Fig. 8 is a sectional view of Fig. 1, taken along the line 8—8 thereof.

The alkali-halide crystals have strong absorption bands in the long wave infra-red region of the electro-magnetic spectrum which are due to volume polarization of the crystal. The anions and cations of the crystal lattice are subject to the electric fields of the incoming electromagnetic waves of long wave infra-red radiation. When the infra-red radiation frequency approaches the natural vibrational frequency of the cation-anion lattice structure, then a resonance effect takes place and the lattice vibrates with maximum amplitude. Much of the incoming radiant energy is therefore converted to lattice vibrations, which, after all, is thermal energy. In the particular case of the screen using potassium chloride as the scotophor, there is appreciable absorption in the region of wavelength 20μ to 100μ with a peak at 63μ for the average screen thickness of 8μ to 10μ. Since the incoming waves have long wavelength compared to the scotophor thickness, the process of polarization is relatively uniform throughout the volume of the screen. This means that all portions of the scotophor gain approximately the same amount of energy in this process. This thermal energy is of itself sufficient to internally ionize the excited F-centers. In addition to this general lattice vibration, the sites of cation and anion vacancies are regions of shifting effective dielectric constant. If the anion vacancy happens to have an electron, i. e., it is an F-center, the effect of an increasing effective dielectric constant is to raise the energy level of the F-center nearer the continuum of the conduction band, thus increasing the probability of ionization of the center. Thus, it is seen that F-centers become very unstable under these conditions.

In the region of the scotophor originally containing F-centers, the electrons from the now unstable F-centers are in the conduction band of the crystal and returning to holes in the crystal. During this time, the crystal is essentially a conductor and the free electrons of the conduction band are subject to excitation by both long wave and short wave infra-red radiation and also by visible spectrum radiation. These "excited" conduction band electrons add to the crystal heat by frequent collisions with the vibrating ions in the lattice structure. In addition, these same free electrons tremendously increase the amount of heat conducted from the long wave infra-red radiator if it is in intimate contact with the scotophor.

Fastest erasure time is achieved only when an adequate amount of F-band quanta is also present, for this radiation places the F-center in the excited state, where the crystal heat developed by polarization is sufficient to destroy F-centers. The additional heat developed by shorter wave radiation absorption and accelerated heat conduction is more than sufficient to destroy or disperse any other more stable centers which may be formed in the process of erasure or coloration.

In the practice of this invention, a relatively strong source of long wave infra-red radiation is secured without large expenditure of power by placing the long wave infra-red radiator in intimate contact with the scotophor of the screen. The long wave infra-red radiator can be a thin film of material which has a high absorption characteristic for radiant energy in the short wave infra-red and long wave infra-red regions of the spectrum. Thus this film can absorb the short wave infra-red energy of a readily available source, for instance a hot tungsten filament. As the temperature of this film rises in this process, it reradiates the absorbed energy at much longer wavelengths.

It has been found that there is a transfer of energy as long wave radiation with maximum efficiency when the radiator reaches a temperature of approximately 80° C. This is in agreement with Planck's radiation law. Therefore the infra-red absorbing film is in effect a converter device, in that it absorbs the short wave infra-red radiation which is readily available but is not absorbed by the scotophor and converts it into radiation of longer wavelength which is absorbed directly by the alkali-halide scotophor.

Suitable materials for this converter-radiator film are quasi-amorphous deposits of the conducting elements of low density. These deposits would abstract but an inappreciable amount of energy from the high velocity electrons of the cathode-ray beam, and yet they would have a good absorption characteristic for the radiant energy concerned. Among such materials suitable for use with alkali-halide scotophors would be beryllium, carbon, magnesium, and aluminum.

Deposition of the above quasi-amorphous films, which are gray to black in appearance, directly on the scotophor of the screen gives a gray appearance to the screen. In addition, these deposits are essentially very poor conductors of electricity and also have poor secondary emission characteristics. Therefore dark trace tube screens coated with such deposits as the erasure device are limited in operation to that anode voltage at which the screen "sticks," i. e., the screen potential no longer increases as the anode voltage is raised.

Some improvement in the above basic radiation-converter layer can be achieved in the case of quasi-amorphous deposits of magnesium and aluminum by placing a very thin conducting but highly translucent layer of the metal over the quasi-amorphous deposit. This enables operation of the screen at any anode potential and also "whitens" the appearance of the screen somewhat. However, erasure time suffers since the thin metallic film reflects a substantial portion of the radiation impinging upon it.

A more suitable arrangement for the erasure device is to make the radiation-converter film in composite form. In this arrangement a thin quasi-amorphous deposit of magnesium or aluminum is placed directly on the scotophor of the dark trace tube screen. This is followed by a thin but highly reflecting (metallic) deposit of the same material. A third thin layer (which can be any of the quasi-amorphous deposits mentioned above) is then deposited. The metallic reflecting layer of magnesium or aluminum serves three purposes. First, it serves to reflect whatever light is transmitted through the scotophor back towards the observer, thus increasing the amount of scattered light in the screen. This "whitens" the appearance of the screen considerably in spite of the very thin quasi-amorphous deposit of metal at the scotophor-metal interface. Second, since it is a conducting layer, it serves to keep the screen at anode potential so that the tube can be operated at any potential desired. Third, it serves as a reflecting layer for the soft X-rays generated by cathode rays in the scotophor. These soft X-rays can contribute to the coloration of the scotophor, i. e., increase screen contrast.

The operation of such a composite radiation-converter device can be described as follows: Short wave infra-red radiation is absorbed by the third quasi-amorphous deposit and the heat generated is transferred to the conducting metallic film by heat conduction. As the temperature of the metallic film rises, long wave infra-red radiation is emitted by the quasi-amorphous deposit of this same metal which faces the scotophor of the screen. This long wave radiation is directly absorbed by the scotophor. If F-centers are present in the scotophor, erasure takes place in a manner described earlier in this disclosure.

In general, the method of dark trace tube erasure stated here is to use easily generated short wave infra-red radiant energy which is not directly absorbed by the alkali-halide scotophors to be converted into long wave infra-red radiant energy which is directly absorbed by the scotophor by means of the composite radiation-converter device described above. The long wave infra-red radiation plus the short wave infra-red and visible spectrum radiation available both from a radiation filament and ambient lighting, rapidly and effectively erase the dark trace of the alkali-halide dark trace cathode-ray tube.

Referring to the drawing, there is shown in Fig. 1, merely by way of example, one typical embodiment of the invention, wherein the numeral **10** indicates any suitable evacuated enclosing bulb or envelope. Mounted within the neck of the bulb is any well-known form of electron gun **11** for developing a sharply focussed electron beam **12**. This gun may comprise the electron-emitting cathode **13** with its internal heater **14**; a centrally perforated metal disc **15** which may constitute the control grid and upon which are impressed the electric signals to be recorded. In the well-known manner, the grid **15** controls the intensity of the electron beam **12** which is arranged to act as a writing or recording beam and scans in a point-by-point fashion, the electro-optical light transducer screen **16**. The beam **12** should preferably be a high intensity beam, for example of 8 kv. to 14 kv. For this purpose the usual beam focusing and accelerating anodes **16** and **18** are provided and the usual coordinate beam deflector elements, such as the deflector plates **19**, are mounted within the bulb. It will be observed that the screen assembly **16** serves as the final anode. Preferably also the neck portion of the bulb is coated with the usual conductive coating which may be connected through the same high direct current potential as that applied to the second anode **18**.

The screen **16**, in accordance with one embodiment of the invention, may comprise a thin glass or mica backing sheet **17**, for example of the order of .0012 inch, which is mounted in any suitable circular or rectangular frame **19***a*, suitably anchored within the bulb **10** adjacent the front end wall. As shown more clearly in the sectional view of Fig. 2, the light transparent backing **17** has on the side facing the gun, a coating **20** of scotophor material which may consist of any of the alkali metal halides, preferably potassium chloride. The thickness of the scotophor material **20** should preferably be correlated with the velocity of the beam **12**. For example, if the beam **12** is a 14 kv. beam, the scotophor material **20** may be deposited with an overall thickness of approximately 8 to 10 microns. Preferably also the scotophor material **20** is deposited in successive depositions. For example, it may be deposited in successive steps with each step depositing a thickness of approximately 2½ microns, and preferably each deposition is allowed to cool before proceeding to the next step. The coating of the glass or mica sheet **17** with the scotophor material should preferably be done before the screen is assembled within the bulb **10** and preferably in a vacuum. For example, as indicated in Fig. 7, the glass or mica sheet **17** can be supported on a suitable frame **21** within a bell jar **22** which is arranged to be evacuated, and when the desired degree of vacuum is reached the potassium chloride material may be deposited in any well-known manner on the glass sheet **17**. For example, a quantity of potassium chloride can be placed in a cup **21***a* which can be heated by applying electric current to the lead-ins **21***b*, **21***c*.

After the deposition of the appropriate thickness of the scotophor material it is coated with a layer **23** of a light weight element in amorphous or quasi-amorphous form, as distinguished from the crystalline or electrically conductive form. In other words, the particles of the metal are deposited in randomly oriented form, as distinguished from a regular crystal formation. This element should be chosen from the group consisting of aluminum, beryllium, magnesium and carbon. This amorphous or quasi-amorphous material should also be deposited in a vacuum, for example as described above in connection with the bell jar method of Fig. 7, and the thickness of the deposited amorphous metal should be limited so that it is transparent to the electron beam **12**. For example with a 14 kv. beam, its thickness may be .25 micron.

I have found that such an amorphous layer of the above elements is capable of acting as a wavelength converter for infra-red radiation, and this characteristic can be taken advantage of for rapidly erasing the record which has been previously produced on the scotophor screen by the writing beam **12**. For this purpose there is employed within the bulb **10** in front of the screen a fine wire tungsten filament **24** which may be supported in zig-zag formation so as to extend across the screen as schematically represented in Fig. 8. This filament, for example, may consist of tungsten wire of approximately 0.008 inch diameter and is sufficiently fine so that it casts negligible electron shadow on the screen **16**. In order to reduce any such shadow effect, the filament **24** can be biased positively with respect to the screen **16**, as indicated schematically in Fig. 1. In any event the filament **24** is designed so that when connected to a commercial 115 volt supply line its temperature can be raised to approximately 2000° K. at which it emits maximum infra-red radiation in the relatively short wavelength region, for example 7000 A.–14,000 A. The coating **23** can be deposited by applying heating current to the lead-ins **21***d*, **21***e*, which can be adjusted to control the vaporization of small aluminum pellets **21***f* on the filament **21***g*.

As pointed out hereinabove, the efficient and rapid erasure of the record in the scotophor screen is obtained by the conversion of this relatively short wavelength infra-red incident radiation to much longer wavelength infra-red radiation, for example, in the region 20μ to 100μ, and this conversion takes place in the layer **23**, which is in direct and overall uniform surface contact with the scotophor. In other words, the layer **23** of amorphous light-weight material, which is transparent to the cathode-ray beam **12**, acts directly as a wavelength converter for the incident short wavelength infra-red radiation and it becomes itself a radiator of long wavelength infred-red radiation which is in direct and complete surface contact with the scotophor **20**.

Fig. 3 shows a modification of Fig. 2, wherein the screen consisting of the thin mica or glass backing **17**, the scotophor **20**, and amorphous light-weight element **23**, is provided with an additional coating **25** of one of the above-mentioned light-weight elements, of sufficient thinness to be transparent to the electron beam **12** but which is deposited in a crystalline form so as to be highly reflecting on the side facing the scotophor **20**. This layer **25**, for example, may have a thickness of approximately 700 A.–900 A. Furthermore, being in the crystalline state, as distinguished from the amorphous state, it is a good electric conductor.

Fig. 4 shows a still further modification wherein the elements **17**, **20**, **23** and **25**, may be the same as those of Fig. 3, and in addition another layer **26** of the above-noted light-weight material in amorphous form, is applied to the coating **23**. Here again the layer **26** is of sufficient thinness to be transparent to the electron beam **12**, and it acts as a wavelength converter in the same way that the layer **23** acts as a converter. One of the advantages of the embodiments of Fig. 3 and Fig. 4, is that the intervening micro-crystalline layer **25** is a good electrical conductor, whereas the amorphous layers **23** and **26** are relatively poor electrical conductors and the tendency of the screen to "stick" at a given potential is avoided. This sticking as is well known arises by the secondary electron emission when the screen is struck by the beam **12**. If the material is a poor conductor, it tends to assume an equilibrium or sticking potential.

Fig. 5 shows a further modification of Figs. 1 and 2, wherein the screen consists of the thin light-transparent backing **17** with the scotophor coating **20** and with a single amorphous coating **23** similar to coating **23** of Fig. 2. In this embodiment however, an additional coating **27** of the scotophor material is applied over the amorphous light-weight coating **23**.

In the embodiments of Figs. 2 and 5, where the screen has only the amorphous light-weight element coating in contact with the scotophor, the "writing voltage" for the tube is restricted to a value below the "sticking" potential of the screen. Furthermore, when the scotophor is coated only with the amorphous light-weight conductor material **23**, the screen may assume a grayish or blackish appearance, and the amorphous metal coating may become oxidized during the production and processing of the tube **10** after the screen has been assembled therein. The embodiment of Fig. 4, wherein an additional highly reflecting microcrystalline coating **25** of the light-weight material is used over the amorphous light-weight material, the screen becomes whitish in appearance.

Fig. 6 shows a modification of Fig. 4, wherein an additional layer or coating **28** of the scotophor is deposited over the second layer **26** of the amorphous light-weight material. This final layer **28** of the scotophor film protects the underlying metal against oxidation, and also increases the contrast when the tube is viewed with back lighting. In all the preceding embodiments, where reference is made to a light-weight amorphous coating or film, it is understood that this film may consist of aluminum, beryllium, magnesium, or carbon.

Various changes and modifications may be made in the disclosed embodiments without departing from the spirit and scope of the invention. In all of the foregoing embodiments, in order to prevent damage to the screen, a suitable switching arrangement well-known in the art may be provided for blanking off the beam **12** during the period that the erasure filament **24** is being lighted.

What is claimed is:

1. Cathode-ray tube apparatus 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 scotophor material which develops opacity centers when said beam impinges thereon, and means to erase said centers, the last-mentioned means including a heatable filament within said envelope for emitting a substantial amount of short wavelength infra-red radiation on to said screen, and means forming part of said screen to convert said incident short wavelength infra-red radiation into long wavelength infra-red radiation and including a layer of amorphous particles of an element chosen from the group consisting of aluminum, beryllium, magnesium and carbon in direct surface contact with said scotophor, said layer being of a thinness which is substantially transparent to said electron beam.

2. Cathode-ray tube apparatus 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 including a 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 amorphous particles of an element selected from the group consisting of aluminum, beryllium, magnesium and carbon, and in direct heat exchange relation with the scotophor, and an overlayer of crystalline particles of said selected element, said layer and overlayer being substantially transparent to said beam.

3. Cathode-ray tube apparatus 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 including a 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 scotophor material, a coating of amorphous particles of an element from the group consisting of aluminum, beryllium, magnesium and carbon, in direct contact with said layer of scotophor, a second coating of crystalline particles of said selected element on the first coating, and a third coating of amorphous particles of said selected element on the second coating, said coatings being substantially transparent to said beam.

4. Cathode-ray tube apparatus, 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 including a scotophor material which develops opacity centers when said beam impinges thereon, and means to erase said centers including a coating of amorphous particles of an element selected from the group consisting of aluminum, beryllium, magnesium, and carbon in direct contact with said scotophor, and a second layer of scotophor material on said coating, said coating being substantially transparent to said electron beam.

5. Cathode-ray tube apparatus, 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 including a scotophor material which develops opacity centers when said beam impinges thereon, and means to erase said centers, including a first coating of amorphous particles of an element selected in amorphous form from the group consisting of aluminum, beryllium, magnesium and carbon, a second coating of crystalline particles of said selected element in crystalline form, a third coating of amorphous particles of said selected element, and a fourth coating which is a scotophor, all said coatings being transparent to the cathode-ray beam.

6. A cathode-ray tube comprising an evacuated envelope containing an alkali-halide crystal screen which develops opacity centers in response to an incident cathode-ray beam, an electron gun for developing said beam and facing said screen, a fine wire filament supported between said gun and screen and having lead-ins for connection to a current supply for heating said filament to a temperature at which it emits a substantial quantity of infra-red in the range 7000 A.–14,000 A., means to oscillate said beam to trace a record on said screen, and means to erase said record, the last-mentioned means including a multi-layer and beam transparent coat

on said screen on the side facing said gun for converting said infra-red to infra-red in a longer wavelength range, said multi-layer coat including at least two layers of an element transparent to said beam and chosen from the group consisting of aluminum, beryllium, magnesium and carbon, one layer being of amorphous particles and another of crystalline particles.

7. A cathode-ray tube according to claim 6, in which the said amorphous particle metal layer is in direct contact with the alkali-halide crystals of said screen.

8. A cathode-ray tube according to claim 6, in which the screen is constituted of potassium chloride crystals and said multi-layers are constituted of aluminum.

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