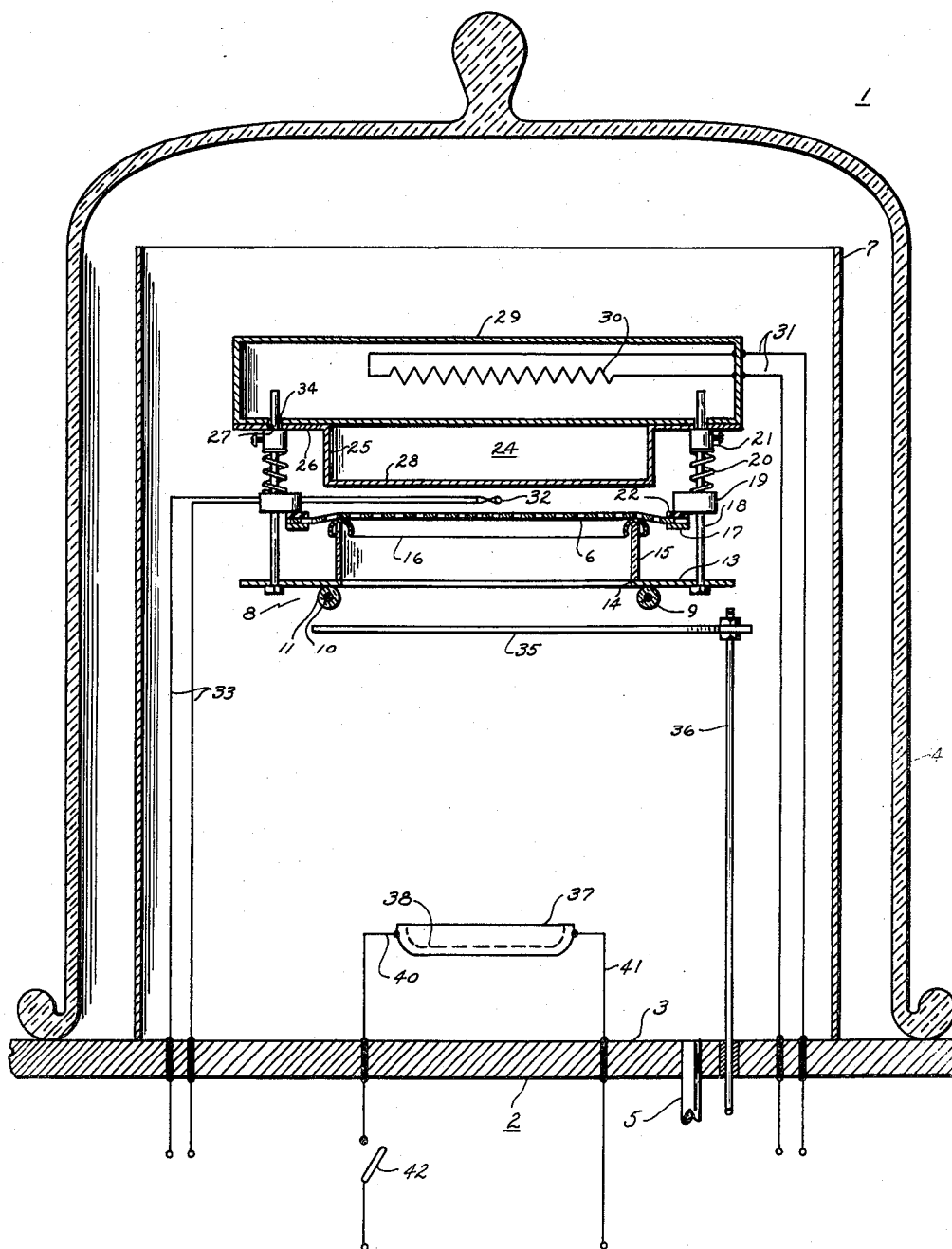


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METHOD OF MAKING STORAGE ELECTRODE
FOR CHARGE STORAGE TUBE
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METHOD OF MAKING STORAGE ELECTRODE FOR CHARGE STORAGE TUBE

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This invention relates generally to charge storage tubes, such as signal-to-image storage tubes and to the storage electrodes therefore, and more particularly to the method of making such storage electrodes.

Certain charge storage tubes, such as signal-to-image storage tubes and various electrical output storage tubes are conventionally provided with a storage electrode assembly; such storage electrode assemblies commonly comprise a fine mesh metal screen coated with a thin layer of dielectric material having secondary emission properties. In the case of conventional signal-to-image charge storage tubes, such a charge storage electrode or screen is disposed between the phosphor display or viewing screen and an electron gun assembly which provides a high velocity "pencil" electron beam which is caused to scan the storage electrode assembly by means of conventional deflection elements. The high velocity electron beam impinging upon the dielectric coating of the storage electrode assembly displaces secondary electrons which are collected by a collector electrode, thus leaving a positive charge on the storage electrode caused by a deficiency in electrons thereon. By modulating the high velocity electron beam in accordance with an incoming signal, the discrete areas of the storage electrode defined by the openings in the mesh of the screen will have different charges thereon thereby forming a pattern or charge image on the storage electrode corresponding to the input signal; this charge image will be retained on the storage screen for a substantial period of time and may be "read-out" at any time during its existence. In accordance with conventional practice, the charge image on the storage electrode of signal-to-image storage tubes is read out by providing a second electron gun assembly which directs a flood beam of low velocity electrons onto the screen; these low velocity electrons pass through the openings in the storage screen in accordance with the elemental charges thereon and thus excite the phosphor viewing screen to provide a visible display of the charge image stored on the storage electrode.

In the past, the storage electrode assembly in conventional charge storage tubes has commonly been made by coating a fine mesh metal screen on one side with a dielectric material having secondary emissive properties, such as silicon monoxide, the coating conventionally being applied by evaporative techniques, as is well known in the art.

It has, however, been felt desirable to employ a dielectric material having a higher value of secondary emission ratio and a higher second cross-over potential than silicon monoxide; the higher value of secondary emission ratio results in a higher writing speed and the higher second cross-over potential results in the ability to operate the tube with a greater writing cathode potential with a resultant improvement in resolution. Studies of dielectric materials have indicated that magnesium fluoride (MgF_2) possesses the desired characteristics. Thin evaporated films of magnesium fluoride have been used for some years as anti-reflecting films on the surface of

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optical lenses. Using conventional techniques as described in the technical literature, for example, "Vacuum Deposition of Thin Films," by Holland, J. Wiley & Sons, Inc. (1956), page 297, evaporated films of magnesium fluoride have been employed as a storage dielectric in both signal-to-image and electrical output storage tubes. However, to the best of the present applicant's knowledge, such use of magnesium fluoride has been restricted to relatively heavy and coarse screens, i.e., on the order of 250 mesh which are stronger than the 1 to 2 micron thick coating of magnesium fluoride. It is, however, generally desirable to employ screens having a considerably finer mesh, i.e., on the order of 500 mesh, with 35% to 45% transmission and to obtain vitreous well-bonded layers of magnesium fluoride on the order of two microns thick on such screens. However, when attempts were made to produce such a vitreous well-bonded layer of magnesium fluoride on 500 mesh copper and nickel screens of 35% to 45% transmission, the screens were found to be badly wrinkled when removed from the evaporating unit. It is therefore desirable to provide an improved method of depositing magnesium fluoride on a very fine mesh metal screen, i.e., on the order of 500 mesh, in which the resulting layers of magnesium fluoride are vitreous and well-bonded and in which the wrinkling of the screen previously encountered is eliminated.

I have discovered that the wrinkling of such very fine mesh screens was caused primarily by a wide difference in the cooling rates between the metal screen and the magnesium fluoride layers combined with the greater thermal expansion coefficient of the screen, this difference in cooling resulting from the direct conductive coupling of the screen to a heat sink in the form of a metal mounting structure supporting the screen in conventional evaporating apparatus. I have further discovered that vitreous well-bonded layers of magnesium fluoride on the order of two microns thick can be deposited on screens on the order of 500 mesh having a transmission on the order of 35% by so mounting the screen in the evaporating assembly that the screen is thermally isolated from the metallic elements of the assembly so that the screen and the evaporated layer of magnesium fluoride thereon will cool by radiation at an essentially uniform rate. In accordance with my improved method, therefore, the thermally isolated screen is initially preheated to an elevated temperature, such as 250° to 300° C. before beginning evaporation, the magnesium fluoride having previously been melted and outgassed in a vacuum. I have found it necessary to evaporate the magnesium fluoride rapidly, for example at a rate on the order of 1.2 milligrams per second and wrinkling of the resulting screen was found to be eliminated when the evaporated assembly was allowed to cool at its natural rate in a vacuum by radiation only before introducing air to the system.

It is accordingly an object of my invention to provide an improved method of making a storage electrode for charge storage tubes.

Another object of my invention is to provide an improved method of depositing a layer of magnesium fluoride on a thin, very fine mesh metal screen to provide a storage electrode for a charge storage tube.

A further object of my invention is to provide an improved method of depositing a thin layer of magnesium fluoride on a thin, very fine mesh metal screen in which wrinkling of the screen encountered with the employment of published evaporating techniques is eliminated.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction

with the accompanying drawing, wherein the single figure of the drawing schematically illustrates the evaporative apparatus employed in practicing my invention.

Referring now to the drawing, the apparatus for practicing my invention, generally identified as 1, comprises a metal base plate 2 having its upper surface 3 formed so as to provide a vacuum tight seal with bell jar 4. A suitable vacuum line 5 extends through the base plate 2 communicating with the interior of the bell jar 4 and adapted to be connected to a suitable vacuum pump (not shown).

In order to mount the fine mesh metal screen 6 for coating a layer of magnesium fluoride thereon by evaporation, a metal cylinder or shield 7 is provided, preferably formed of aluminum, resting upon the base plate 2. A pair of supporting rods 8 and 9 are provided extending across the shield 7, rods 8 and 9 preferably being formed with an internal metal core 10 and an outer coating 11 of suitable thermal insulating material, preferably glass. Resting on the transverse supporting rods 8 and 9 is a metal ring 13 having a central opening 14 formed therein. Supported in turn by the metal ring 13 is a cylinder 15 formed of suitable thermal insulating material, such as glass, cylinder 15 having its central opening generally coextensive with the central opening 14 in the metal ring 13. Arranged around the upper edge of the glass cylinder 15 is a support ring 16 having a generally cup-shaped cross-section and being formed of any suitable material, such as aluminum.

The very fine mesh metal screen 6 is mounted on an annular metal support ring 17, and it will be seen that the screen 6 is positioned on the support ring 16 generally coaxial therewith.

The very fine mesh metal screen 6 is preferably stretched so as to be taut on the glass cylinder 15 and support ring 16 by means of a plurality of rods 18 (only two being shown, but a circularly spaced plurality such as six being preferably provided), rods 18 being secured to the ring 13 and extending upwardly therefrom. Each of the upwardly extending rods 18 has a screen engaging member 19 slidably mounted thereon, the engaging members 19 being biased downwardly by means of suitable coil springs 20 engaging adjustably fixed stops 21 on the one hand and the screen engaging members 19 on the other hand. In order to prevent heat conduction from the fine mesh metal screen 6 to the screen engaging members 19 and in turn to the metal ring 13 and the aluminum sleeve 7, a mica ring 22 is arranged abutting the outer periphery of screen 6 on its side remote from the metal mounting ring 17 with the screen engaging members 19 in turn engaging the mica ring 22.

A cylindrical heat condenser 24 is provided formed of suitable metal, such as aluminum, the heat condenser 24 having a depressed cylindrical portion 25 and an annular rim portion 26 having openings 27 formed therein with rods 18 extending therethrough; heat condenser 24 is thus supported by means of its annular flange 26 engaging stops 21 on the rods 18. It will be seen that the bottom plate 28 of the heat condenser 24 is closely spaced from the upper surface of the very fine mesh metal screen 6. A heater chamber 29 again formed of suitable metal such as aluminum, is in turn positioned above the heat condenser 24 with the rods 18 extending through openings 34 formed therein as shown. A suitable heating coil 30 formed for example of Nichrome wire is in turn positioned within the heating chamber 29 having its leads 31 extending through a wall of the heater chamber 29 by means of suitable feed-through insulators and in turn extending through the base plate 2 again by means of suitable feed-through insulators as shown. A suitable thermocouple 32 is disposed in the space between the bottom plate 28 of the heat condenser 24 and the upper surface of the fine mesh metal screen 6 with its leads 33 likewise extending through the base plate 2 by means of suitable feed-through insulators.

A shutter member 35, formed of suitable material such as aluminum, is positioned a short distance below the metal ring 13 and is secured to a rod 36 extending through the base plate member 2 as shown; rod 36 may thus be externally manipulated in order to move shutter 35 so as to shield the screen 6 from the evaporating boat 37 when desired and at other times to expose the screen 6 to the evaporating boat 37. The evaporating boat 37 which is formed of suitable material, such as tantalum, is disposed within the aluminum shield 7 in a spaced apart relationship from the fine mesh metal screen, as shown; the case of a nickel screen 6 having a 500 mesh with 35% transmissivity and a diameter of four inches, the satisfactory two (2) micron thick layers of magnesium fluoride were deposited by the use of a tantalum evaporating boat 37 having a recess 38 therein two and one-half (2½) inches long disposed nine and three-quarters (9¾) inches below the lower surface of the screen 6. Boat 37 is heated, thereby to evaporate the magnesium fluoride deposited in the recess 38, by means of passing current therethrough and thus leads 40 and 41 are connected respectively to its ends and passed through base plate 2 by means of suitable feed-through insulators. While for purposes of clarity, the supporting rods 8 and 9 are shown as extending transversely with respect to the axis of evaporating boat 37, in actual practice, I prefer to dispose the boat 37 in parallel relationship with the supporting rods 8 and 9.

It will now be seen that an appreciably more uniform cooling rate is provided for the coated metal screen by mounting the screen 6 over the glass cylinder 15 and further insulating the screen from its connection points with the engaging members 19 by means of the mica washer 22. It will thus be seen that the mounted screen is thermally isolated, permitting the screen with its magnesium coating to cool by radiation only, so that the temperature of the metal screen and its magnesium fluoride coating stay approximately the same at all times and reduce simultaneously at approximately the same rate, thus eliminating excessive stresses due to the different thermal expansion characteristics of the screen and the magnesium fluoride coating. It will be readily apparent that if the screen were directly mounted upon a metal supporting ring, i.e., in high heat conductive relationship, the metal screen would cool faster by conduction than its magnesium fluoride coating and this, combined with the inherently larger thermal expansion coefficient, results in the setting up of high stresses resulting in turn in the fine wrinkling pattern previously observed.

In practicing my improved method, I have found that better coatings are obtained by employing a nickel screen rather than one of copper with the screen having a transmission of about 35% or less. In accordance with my improved method, when a new evaporating boat 37 is employed, the boat is first placed in its electrodes (not shown) and prior to mounting of the screen 6 to be coated, the bell jar 4 is positioned over the boat 37 and its interior evacuated to provide as high a vacuum as possible, i.e., 1×10^{-5} mm. of mercury. The switch 42 is then closed connecting leads 40 and 41 across a suitable source of power (not shown) and the boat 37 is thus heated by passing current therethrough, this initial heating being to a point above the normal evaporating temperature employed, i.e., with a voltage applied on the leads 40 and 41 above 4.44 volts, providing a current flow above 275 amps. Following brief application of this current in order to heat the boat to beyond its normal evaporating temperature, the switch 42 is opened and the boat allowed to cool for approximately one-half (½) hour following which the vacuum is released and air admitted to the interior of the bell jar 4. This initial step is employed in order to clean and outgas a new evaporating boat.

Following initial cleaning and outgassing of the evapo-

rating boat 37, the recess 38 therein is filled level with granular magnesium fluoride, the bell jar 4 is again placed over the boat 37 and the interior of the bell jar is then again evacuated to provide the maximum obtainable vacuum. The switch 42 is then again closed and the boat temperature is brought up slowly in order to melt the magnesium fluoride therein; a maximum voltage of 3.24 volts with a current flow of 200 amps. is found to be satisfactory for this purpose. The switch 42 is then again opened and the boat 37 allowed to cool for one-half (½) hour following which the vacuum is released.

The boat 37 is then refilled level with granular magnesium fluoride and the screen 6 to be coated is assembled as shown in the drawing. Bell jar 4 is then again placed over the assembly as shown in the drawing, shutter 35 is positioned to isolate screen 6 from boat 37, and the interior is again evacuated to obtain the maximum possible vacuum, i.e., somewhat less than 1×10^{-5} mm. of mercury. The added magnesium fluoride is then melted by the application of approximately the same voltage and current and following this melting, the switch 42 is again opened and the boat 37 allowed to cool for one-half (½) hour.

With the vacuum within the bell jar 4 remaining at the maximum obtainable amount, i.e., somewhat less than 1×10^{-5} mm. of mercury, the first outgassing of the magnesium fluoride is initiated. In the case of a four inch (4") diameter, 500 mesh nickel screen having a 35% transmissivity, the following outgassing procedure was followed:

- Five minutes at .6 volt (65 amps.)
- Five minutes at 1.2 volts (120 amps.)
- Ten minutes at 1.8 volts (145 amps.)
- Ten minutes at 2.4 volts (165 amps.)
- One minute at 3.0 volts (200 amps.)
- One minute at 3.6 volts (230 amps.)
- One-half (½) minute at 4.2 volts (260 amps.)
- Ten seconds at 4.44 volts (275 amps.)

The above progressive increase in the boat temperature thereby to outgas the magnesium fluoride is accomplished with a shutter 35 manipulated by means of rod 36 so that the screen 6 is shielded from the boat 37.

Following the above described progressive increase in boat temperature, switch 42 is opened and the apparatus and the system allowed to cool for one-half (½) hour while vacuum is maintained. The heater 30 is then turned on and the temperature of the screen 6, as sensed by the thermocouple 32 connected to suitable temperature measuring apparatus, such as a thermocouple bridge (not shown) is brought up to 250° C. As soon as this temperature is reached, the heater 30 is turned off and the assembly again allowed to cool for one-half (½) hour while the vacuum is maintained. When the vacuum, which will decrease to some extent when the heater 30 is turned on, has been brought down to its maximum obtainable value, a second outgassing cycle is initiated, following the same procedure as the first outgassing cycle. Following the second progressive increase in boat temperature, the assembly is again cooled for one-half (½) hour and when the desired vacuum is again obtained, the heater 30 is again turned on and a temperature of 250° C. obtained at the screen 6 with vacuum still being maintained until a vacuum on the order of 5 to 8×10^{-6} mm. of mercury is obtained. At this point, switch 42 is closed to heat the boat 37 and in the case of the particular tantalum boat employed, a voltage of 4.44 applied to leads 40 and 41 and a current flow of 275 amps. were employed. With this current flow and a vacuum no greater than about 1×10^{-5} mm. of mercury, shutter 35 was opened thereby to expose the surface of the screen 6 to be coated and the magnesium fluoride contained in the recess 38 and boat 37 was then evaporated for fifty-five seconds, which was found to provide the requisite deposit of approximately two (2) microns

thickness (a total deposit of approximately 55 milligrams on the four inch (4") diameter, 35% transmissivity, 500 mesh nickel screen). After the fifty-five second evaporation, the boat 37 and the heater 30 are immediately turned off and the entire assembly allowed to cool down below about 60° C., sensed by the thermocouple 32, with the vacuum being maintained. The vacuum is then released and the bell jar 4 removed thereby to remove the coated screen 6 from the apparatus.

In instances when the evaporating boat 37 is between one-quarter (¼) and one-half (½) full, from a previous evaporation, the initial outgassing of the evaporating boat and melting of the granular magnesium fluoride described above can be eliminated with the procedure being initiated by refilling the boat 37 level full with magnesium fluoride and placing the assembly of the screen 6 thereover.

The above described procedure has been successfully used to deposit vitreous, well-bonded layers of magnesium fluoride on the order of two (2) microns thick upon 500 mesh nickel screens having a transmissivity of 35%. If a still thicker layer of magnesium fluoride is required, the same techniques may be employed, however, it has here been found necessary to decrease the mesh transmission, or to employ a screen of smaller mesh.

By the employment of my improved method, it is now possible to eliminate the wrinkles previously encountered in attempts to deposit thin coatings of magnesium fluoride on 400 to 500 mesh screens with conventional evaporation techniques as described in the available technical literature. It will be seen that fundamentally my invention resides in initially heating the screen to an elevated temperature, i.e., on the order of 250° to 300° C. before evaporating, employing a thoroughly degassed evaporating source, evaporating at a very high rate, and finally cooling the resulting assembly at a uniform rate so that the metal screen does not cool appreciably faster than the magnesium fluoride thereon. As previously pointed out, without this controlled cooling step to insure that no mechanical strains are set up in the screen assembly, the forces set up due to the different thermal expansion coefficients of the metal screen and the magnesium fluoride coating and their respectively different cooling rates would cause the fine mesh metal screen to buckle and wrinkle.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention.

What is claimed is:

1. The method of making a storage electrode for a storage tube comprising the steps of: mounting a fine mesh metal screen in a container by thermally insulated means and maintaining said screen taut; evacuating said container; heating said screen to an elevated temperature; rapidly evaporating a thin layer of magnesium fluoride onto said screen; cooling said screen with said magnesium fluoride layer thereon and with said container still evacuated so that said screen cools at substantially the same rate as said magnesium fluoride layer; and admitting air to said container and removing said screen therefrom.

2. The method of making a storage electrode for a storage tube comprising the steps of: mounting a fine mesh metal screen in a container in thermally isolated relationship and maintaining said screen taut; evacuating said container to a high vacuum; heating said screen to an elevated temperature; rapidly evaporating a thin layer of magnesium fluoride onto said screen; cooling said screen with said layer of magnesium fluoride thereon in said vacuum by radiation only so that said screen cools at substantially the same rate as said magnesium fluoride layer; and releasing said vacuum and removing said screen from said container.

3. The method of making a storage electrode for a

storage tube comprising the steps of: mounting a fine mesh metal screen in a container in thermally isolated relationship by a thermally insulated connection and maintaining said screen taut; positioning an evaporating boat in said container spaced from said screen; depositing granulated magnesium fluoride in said boat; evacuating said container to a high vacuum; heating said boat to melt said magnesium fluoride in said vacuum while shielding said screen from said boat thereby to outgas said magnesium fluoride; heating said screen to an elevated temperature; exposing said screen and heating said boat to a temperature rapidly to evaporate a thin layer of said magnesium fluoride onto said screen terminating said screen and boat heating; allowing said screen with said layer of magnesium fluoride thereon to cool at its natural rate in said vacuum by radiation only so that said screen cools at substantially the same rate as said magnesium fluoride layer; and releasing said vacuum and removing said screen from said container.

4. The method of making a storage electrode for a storage tube comprising the steps of: positioning a fine mesh metal screen over a cylinder formed of low thermal conductivity material; maintaining said screen taut by thermally insulated connections at spaced points around the periphery thereof; positioning an evaporating means for evaporation therefrom onto one side of said screen; depositing magnesium fluoride in said evaporating means; positioning an evacuable container over said screen, cylinder and evaporating means and evacuating the same to a high vacuum; heating said evaporating means while maintaining said vacuum thereby to melt said magnesium fluoride and to outgas the same; heating said screen to an elevated temperature; heating said evaporating means rapidly to evaporate a thin layer of said magnesium fluoride onto said screen; terminating heating of said screen and evaporating means; allowing said screen with said magnesium fluoride layer thereon to cool at its natural rate in said vacuum by radiation only so that said screen cools at substantially the same rate as said magnesium fluoride layer; and releasing said vacuum and removing said screen from said container.

5. The method of claim 4 in which said screen is a nickel screen of approximately 500 mesh and 35% transmissivity and said heating of evaporating means is contained until said magnesium fluoride layer is approximately two (2) microns thick.

6. The method of claim 4 in which said screen is heated to a temperature in the range of 250° C. to 300° C. and said evaporating means is heated to evaporate said magnesium fluoride at a rate of approximately 1.2 milligrams per second.

7. The method of making a storage electrode for a storage tube comprising the steps of: positioning a nickel screen of approximately 500 mesh and 35% transmissivity over a glass cylinder; maintaining said screen taut by mica connections at spaced points around the periphery thereof; positioning an evaporating boat for evaporation therefrom onto one side of said screen; depositing granulated magnesium fluoride in said boat; positioning an evacuable container over said screen, cylinder and boat and evacuating the same to a high vacuum; heating said boat to an elevated temperature while shielding said screen therefrom and maintaining said vacuum thereby to melt and outgas said magnesium fluoride; terminating said boat heating and allowing the same to cool while continuing said evacuation; heating said screen to a temperature in the range of 250° C. to 300° C. while continuing said evacuation; exposing said screen to said boat and heat-

ing said boat to evaporate a layer of magnesium fluoride approximately 2 microns thick onto said screen at a rate of approximately 1.2 milligrams per second; terminating said boat and screen heating; allowing said screen with said magnesium fluoride layer thereon to cool at its natural rate in said vacuum by radiation only to below about 60° C. so that said screen cools at substantially the same rate as said magnesium fluoride layer; and releasing said vacuum and removing said screen from said container.

8. The method of making a storage electrode for a storage tube comprising the steps of: providing an evaporating boat; positioning an evacuable container over said boat and evacuating the same to a high vacuum; heating said boat to a temperature beyond that employed for evaporation; cooling said boat; releasing said vacuum; filling said boat with granular magnesium fluoride; evacuating said container; heating said boat to melt said magnesium fluoride; cooling said boat; releasing said vacuum; refilling said boat with magnesium fluoride; positioning a nickel screen of approximately 500 mesh and 35% transmissivity over a glass cylinder and spaced from said boat; maintaining said screen taut by mica connections at spaced intervals around the periphery thereof; evacuating said container; heating said boat while shielding said screen therefrom to melt said magnesium fluoride; cooling said boat while maintaining said vacuum; heating said boat to progressively higher temperatures thereby to outgas said magnesium fluoride; cooling said boat; heating said screen to a temperature in the range of 250° C. to 300° C.; terminating said screen heating while continuing said evacuation; repeating said outgassing and screen heating steps; exposing said screen to said boat; heating said boat to evaporate a layer of magnesium fluoride approximately 2 microns thick onto said screen at a rate of approximately 1.2 milligrams per second; terminating said boat and screen heating; allowing said screen with said magnesium fluoride layer thereon to cool at its natural rate in said vacuum by radiation only to below about 60° C. so that said screen cools at substantially the same rate as said magnesium fluoride layer; and releasing said vacuum and removing said screen from said container.

9. The method of making a storage electrode for a storage tube comprising the steps of: mounting a fine mesh metal screen in a container in thermally isolated relationship thereto; maintaining said screen taut; evacuating said container; heating said screen to an elevated temperature; rapidly evaporating a thin layer of magnesium fluoride onto said screen; and cooling said screen and said magnesium fluoride layer with said container still evacuated so that said screen cools at substantially the same rate as said magnesium fluoride layer.

10. The method of making a storage electrode for a storage tube comprising the steps of: mounting a fine mesh metal screen in a container in thermally isolated relationship thereto; maintaining said screen taut; evacuating said container; heating said screen to an elevated temperature; evaporating a thin layer of magnesium fluoride onto said screen; and cooling said screen and said magnesium fluoride layer at substantially the same rates.

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