Oct. 24, 1950 J. B. JOHNSON 2,527,134

METHOD OF PRODUCING FLUORESCENT SCREENS

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FIG. 1

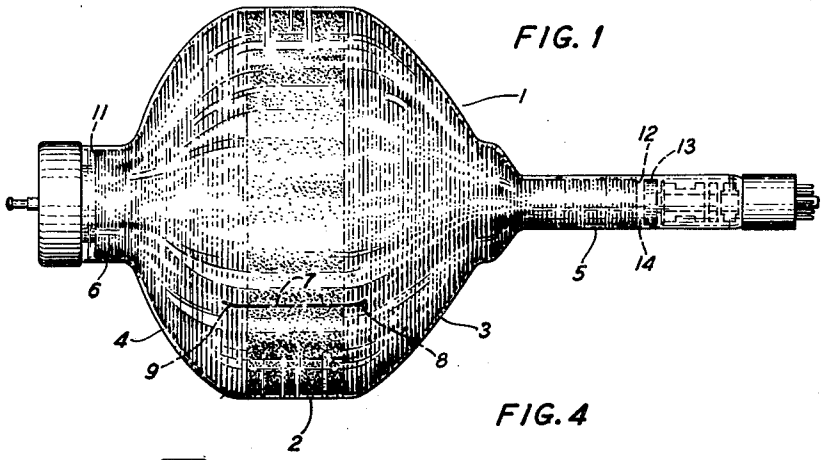


FIG. 3

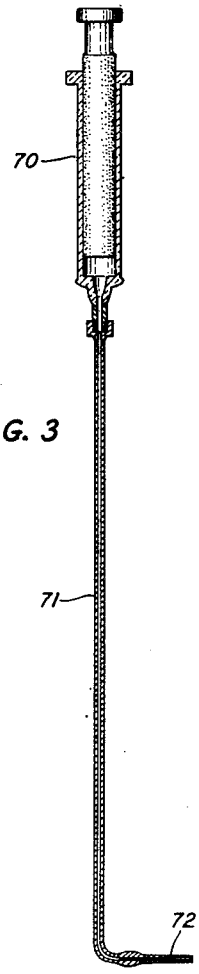
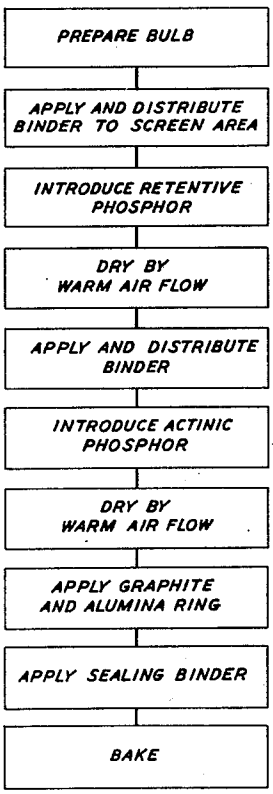


FIG. 4



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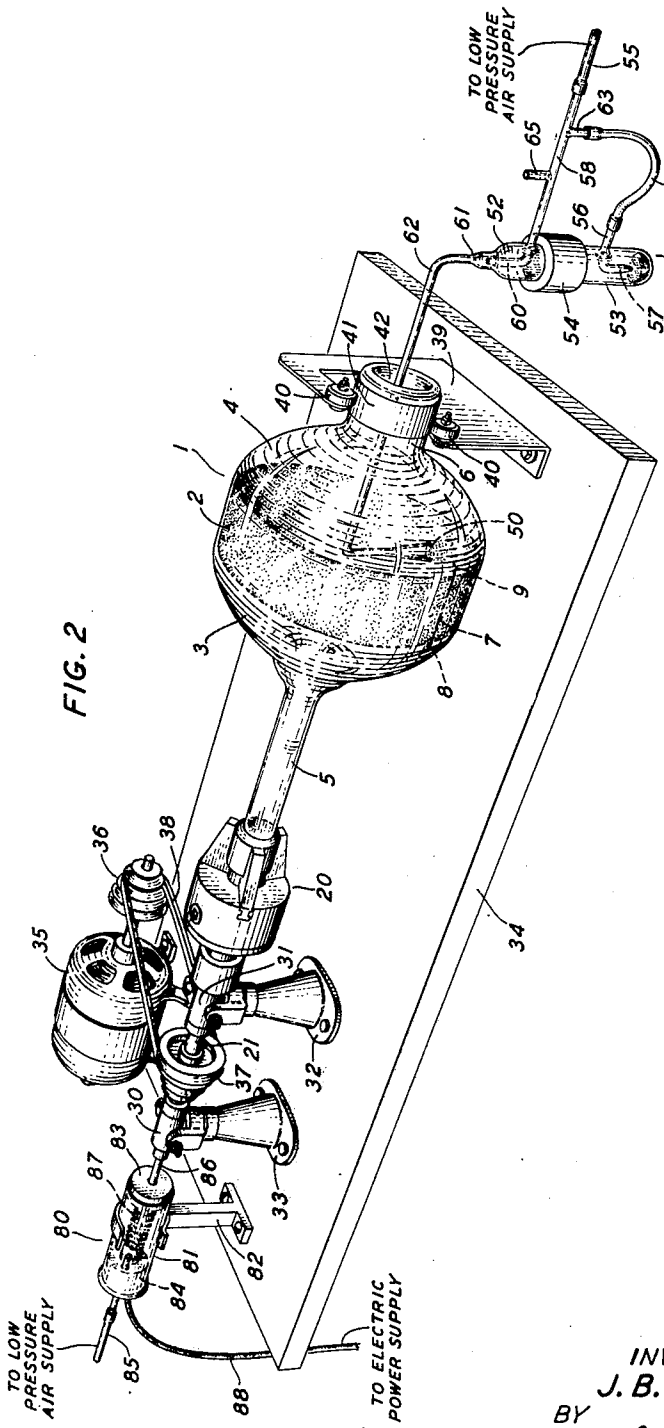

FIG. 2

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METHOD OF PRODUCING FLUORESCENT SCREENS

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4 Claims. (Cl. 117—33.5)

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This invention relates to the manufacture of cathode-ray tubes and more particularly to methods of producing fluorescent screens for such tubes.

One object of this invention is to facilitate the manufacture of a revolving screen type cathode-ray tube for the visual representation of waves, such as disclosed in J. B. Johnson Patent 2,324,089 of July 13, 1943, for Electron Discharge Apparatus.

Another object of this invention is to improve fluorescent coatings for electronic devices and more particularly such coatings of the cascade type and included in revolving screen cathode-ray tubes.

The presently known methods of applying fluorescent materials in the stationary types of cathode-ray tubes cannot be used in the manufacture of revolving screen type cathode-ray tubes because of the shape of these tubes in which the fluorescent material must be applied to the inner surface of a cylindrical side wall portion of the tube.

A feature of the invention relates to a process for producing a fluorescent screen upon the inner wall of a cylindrical portion of a revolving screen type cathode-ray tube in which centrifugal forces of revolution assist in spreading the coatings uniformly over the inner surface of the tube and embedding the fluorescent material in the fluid binder coatings.

Another feature relates to a method of electrically connecting conductive, for example graphite, coatings on the inner surfaces of two spaced, for example end, portions of a cathode-ray tube.

A further feature relates to a coating of refractory material as a ring on the inner surface of a portion of the cathode end of a revolving screen type cathode-ray tube.

The invention and the above noted and other features thereof will be more fully understood from a consideration of the embodiment illustrated in the accompanying drawings in which:

Fig. 1 is an elevational view of a completed revolving screen type cathode-ray tube;

Fig. 2 is a perspective view of a part of a revolving screen type cathode-ray tube and the apparatus utilized in the production of the fluorescent coating therein in accordance with features of this invention.

Fig. 3 is a cross-sectional view of a hypodermic syringe fitted with an extension tube for injecting fluid binder into a revolving screen type cathode-ray tube; and

Fig. 4 is a chart of the steps in the process of

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coating the interior surface of a revolving screen type cathode-ray tube.

Referring now to the drawings, a revolving screen type cathode-ray tube 1 illustrative of one embodiment of this invention, is shown including a cylindrical wall 2 upon which the fluorescent screen is to be formed, dome-shaped ends 3, 4, cathode tubulation 5 and anode stem 6. Tube 1 preferably consists of a glass bulb of generally spherical shape about ten inches in diameter. The screen forms a cylindrical band about two and one-half inches wide upon the inner surface of the cylindrical wall 2 of tube 1. The completed tube is about twenty inches long from the end of the cathode tubulation 5 to the end of the anode stem 6.

The steps in the manufacture of a revolving screen type cathode-ray tube shown in Fig. 4 include preparation of the tube by annealing, washing, drying and applying silver paste to form a line 7 on the inner surface of the tube in a plane that includes the axis of the tube, from a point 8 on dome-shaped end 3 to a point 9 on dome-shaped end 4 followed by baking the tube in a radiant heat oven to dry the silver paste. The baking includes raising the temperature of the tube gradually to about 360° C., holding this temperature constant for about 15 minutes and then permitting the tube to cool to room temperature.

The function of this silver line 7 is to provide an electrical connection between the conductive, for example graphite, coatings that are applied to the inner surface of the dome-shaped end portions of the tube in a subsequent step in the manufacture of the tube.

The succeeding steps in the manufacture of the tube during which the fluid binder, fluorescent material, graphite and alumina coatings are applied to the inner surface thereof take place while the tube is revolved about its axis in a lathe as shown in Fig. 2, in which a three-jawed chuck 20 grips the cathode stem 5 of the tube 1 with the axis of tube 1 coincident with the axis of revolution of chuck 20. Chuck 20 is rigidly attached to a rotatable hollow shaft 21 which is supported by two bearings 30, 31 on stanchions 32, 33 mounted on bench 34. Shaft 21 is rotated by motor 35 which is mounted on bench 34 and which has a pulley 36 that drives pulley 37 on shaft 21 by a belt 38. Bracket 39, also mounted on bench 4, has three rollers 40 equally spaced around the axis of revolution of lathe shaft 21, only two of the rollers being visible in Fig. 2. Rollers 40 support anode stem 6 of tube 1 by con-

tact with cylindrical neck 41 thereof as a three-point bearing while the tube revolves.

While the tube is revolved at about 45 revolutions per minute, about two cubic centimeters of a first fluid binder are injected into tube 1 through the open end 42 of anode stem 6 by means of hypodermic syringe 70 shown in Fig. 3. Syringe 70 has a metal extension tube 71 with its tip end bent normal to the main body thereof and terminating in a hypodermic needle 72. The fluid binder preferably consists of five parts by volume of ethyl silicate, two parts formic acid solution and one part absolute ethyl alcohol. After the fluid binder is injected by means of syringe 70, the extension tube 71 thereof is withdrawn from tube 1. A small brush is then inserted through open end 42 of tube 1 and is used to spread the fluid binder evenly over the inner surface of cylindrical wall 2 of tube 1 while the tube is revolving. The centrifugal action of the revolving tube assists in spreading the fluid binder into a uniform coating on wall 2.

Immediately following the spreading of the fluid binder over the inner wall 2, the nozzle 50 of insufflator 51 is inserted into tube 1 through open end 42 thereof. Insufflator 51 includes a glass upper portion 52 and a glass lower portion 53 which are held together by an air-tight connection composed of rubber sleeve 54. The bottom portion 53 contains about three cubic centimeters of yellow phosphor fluorescent material which was placed therein previously. This fluorescent material preferably is composed of a mixture of about 84 per cent zinc sulphide, 16 per cent cadmium sulphide, activated by copper of an amount in the order of 0.01 per cent or less. Tube 55 is connected to a source of low pressure filtered air. The lower end of nozzle 50 is covered with a fine mesh gauze. Glass tube 56 of insufflator 51 enters lower portion 53 through a sealed opening and end 57 is formed downward normal to the body of tube 56 and is drawn down to form a small opening at the tube end. Glass tube 58 enters the glass upper portion 52 of insufflator 51 through a sealed opening and end 60 thereof is formed upward and drawn down to form a small opening at the tube end at a small distance from the junction 61 of glass tube 62 and upper portion 52 of insufflator 51. Tube 63 opens into tube 58 and is sealed thereto. Tube 61 connects with tube 56 through flexible tube 64. The lower end of tube 65 opens into tube 58 and is sealed thereto. The upper end of tube 65 is open.

When a source of low pressure air is connected to tube 55, air will flow from the upper end of tube 65 which acts as a by-pass and allows only a slight amount of air to escape at the lower end of tube 57 or the upper end of tube 60. When the upper end of tube 65 is closed, as for example, by placing a finger over it, the air pressure causes a considerable increase of air flow through the lower end of tube 57 and the upper end of tube 60. The air flow from the lower end of tube 57 will agitate the fluorescent material in lower portion 53 into a dust cloud within the insufflator body and the air pressure from the upper end of tube 60 will blow the fluorescent material through tube 62 and into the interior of tube 1 through the fine mesh gauze on the end of nozzle 50 causing a cloud of fluorescent material within tube 1. The fluorescent material in the dust cloud gradually settles upon the inner surface of tube 1 to form an evenly spread coating which adheres to the previously applied fluid binder. The centrifugal force of the revolving tube imbeds the particles of the fluorescent material into the wet fluid binder.

The fluid binder is now dried by passing a flow of warm air at about 10° C. above room temperature for about 15 minutes through tube 1. This air is warmed in heater unit 80 shown in Fig. 2 in which a glass cylinder 81 is supported on bench 34 by bracket 82. Cylinder 81 has removable end plugs 83, 84. A tube 85 is inserted through end plug 84 and connects a source of low pressure dry air into cylinder 81. A tube 86 inserted through end plug 63 terminates at one end within cylinder 81 and at its other end within hollow shaft 21. Heater coil 87 is located within heater cylinder 81 and is connected to a source of electric power through cord 88 which passes through end plug 84. The flow of air entering through tube 85 passes through hollow shaft 21 into tube 1 and exhausts at open end 42 thereof.

Following this drying operation, a second fluid binder consisting of about 2.3 cubic centimeters of the same silica solution used as the first fluid binder is injected into tube 1 upon the inner surface of cylindrical wall 2 thereof by means of syringe 70 and is spread evenly over wall 2 by means of syringe 70. The centrifugal action of the revolving tube assists in spreading this fluid binder evenly into a uniform coating on wall 2. Immediately thereafter about 2.3 cubic centimeters of actinic phosphor fluorescent material is injected into the interior of tube 1 by means of insufflator 51 and allowed to settle upon the surface of the coating of the second fluid binder. This fluorescent material preferably is composed of zinc sulphide activated by a mixture of copper and silver of an amount in the order of 0.01 per cent or less. The centrifugal force of the revolving tube imbeds the particles of this fluorescent material into the second fluid binder. The second fluid binder is then dried by blowing warm air at about 10° C. above room temperature through tube 1 by means of heater unit 80 for about 15 minutes. The rotation of tube 1 is then stopped and tube 1 is removed from the lathe. Any loose fluorescent material within tube 1 is removed by slapping the wall of tube 1 with the flat of the hand to shake loose any poorly adhering material and then blowing any loose material off the interior wall with a gentle jet of air.

The amounts of the fluid binders and fluorescent materials depend upon the area of surface to be covered. In the preferred form of tube described herein the area of the fluorescent screen is about 500 square centimeters. Two cubic centimeters of the materials deposited evenly on this area will result in a coverage of about 0.004 cubic centimeter per square centimeter of surface, 2.3 cubic centimeters of material will result in a coverage of about 0.0046 cubic centimeter per square centimeter of surface and 3 cubic centimeters will result in a coverage of about 0.006 cubic centimeter per square centimeter of surface.

Tube 1 is again placed in the lathe and revolved at about 10 revolutions per minute. A flow of air of about two cubic feet per minute about 10° C. above room temperature is now forced into tube 1 through heater unit 80. A coating comprising a colloidal suspension of graphite is evenly applied by brush to the inner surface of dome-shaped ends 3, 4 of tube 1 from the edges of coating of fluorescent material on wall 2, but not covering the fluorescent material, the graphite coating extending from the fluorescent coating over the dome-shaped ends 3, 4 to points 11, 12 of tube 1.

A coating consisting of a mixture of levigated alumina, amyl acetate and a red dye is then applied as a narrow ring 13 on the inner surface of cathode tubulation 5 by means of a brush dipped in the mixture. Ring 13 is apart from the graphite coating, being separated therefrom by an uncoated ring 14 about one-eighth inch wide. A sealing binder composed of about four cubic centimeters of the same silica solution used as the first and second binders is now injected into tube 1 upon the cylindrical wall 2 by means of syringe 70 and spread therewith evenly over cylindrical wall 2 and overlapping about one-quarter inch on the graphite coating on dome-shaped ends 3, 4. The centrifugal force of the revolving tube assists in spreading this fluid binder evenly into a uniform coating. This binder is allowed to dry and then the revolution of tube 1 is stopped and the tube 1 is removed from the lathe chuck 20.

The function of the ring 13 of alumina around the inner surface of the cathode tubulation 5 is to provide a rough surface which will break up any getter material which reaches this part of the tubulation during the subsequent gettering operation in the manufacture of the tube, and, thus, prevent an objectionable electrical connection between the graphite coating and the cathode gun. Without this rough surface, the gettering material may cling to the smooth surface of the glass of the tube and cause an objectionable electrical connection.

The final step in the process of coating the inner surface of tube 1 comprises baking it to drive off any volatile organic matter in the binder coatings and to dry and harden the several coatings. The tube 1 is placed in a ring stand in a radiant heat oven with the axis of the tube 1 vertical with its ends open. The oven temperature is gradually raised so that a temperature of about 500° C. is reached at the end of an hour and this temperature is held constant for about 45 minutes while a circulation of air is forced through the oven and then the oven is permitted to cool. Tube 1 may be withdrawn from the oven when the oven temperature is reduced to about 100° C. Tube 1 is then ready for the further steps in its manufacture including the application of the cathode and anode stem devices.

While this invention has been disclosed with reference to a specific embodiment, it is to be understood that it is to be considered as limited in scope by the appended claims only.

What is claimed is:

1. The method of forming a fluorescent screen upon the inner surface of a cylindrical wall of a transparent hollow glass vessel which comprises continuously revolving said vessel about a horizontal axis coincident with the longitudinal axis of said cylindrical wall at a rate to produce substantial centrifugal forces, introducing a first fluid binder comprising a mixture of ethyl silicate, formic acid and absolute ethyl alcohol into said vessel, brushing said binder evenly over said wall, injecting a cloud of yellow phosphor fluorescent material into said vessel in proximity to said wall, allowing said material to settle on said binder and to be embedded therein by centrifugal force, drying said binder by a flow of warm air at about 10° C. above room temperature for about 15 minutes, introducing a second fluid binder comprising said mixture into said vessel, distributing said second binder evenly over the yellow phosphor fluorescent material on said wall, injecting a cloud of blue actinic phosphor fluorescent material into said vessel in proximity to said wall, allowing said actinic material to settle on the second binder, and finally drying said second fluid binder by a flow of warm air at about 10° C. above room temperature for about 15 minutes.

2. The method of manufacturing a hollow glass vessel having a cylindrical wall portion, two dome-shaped end portions and a cathode tubulation on one of said dome-shaped end portions, which comprises drawing a line with conductive paste between said dome-shaped end portions on the inner surface of the vessel, heating said vessel to dry said paste, continuously revolving said vessel about an axis coincident with the axis of said cylindrical wall portion of said vessel, coating the inner surface of said cylindrical wall portion of said vessel with a fluid binder, injecting a cloud of fluorescent material into said vessel in proximity to said wall, allowing said material to settle on said binder, drying said fluid binder, coating the inner surfaces of both dome-shaped end portions of said vessel with a conductive material overlapping the end portions of the dried conductive paste line, coating the inner surface of said cathode tubulation of said vessel with a ring of refractory material in suspension adjacent to but apart from the conductive coating of the adjacent dome-shaped end portion of said vessel, and finally baking said vessel to dry said coatings.

3. The method of manufacturing a hollow glass vessel having a cylindrical wall portion and two dome-shaped end portions, which comprises drawing a line with silver paste between said dome-shaped end portions on the inner surface of said vessel, drying said silver paste, continuously revolving said vessel about an axis coincident with the axis of said cylindrical wall portion of said vessel, coating the inner surface of said cylindrical wall portion of said vessel with a fluid binder, injecting a cloud of fluorescent material into said vessel in proximity to said wall, allowing said material to settle on said binder, drying said fluid binder, coating the inner surfaces of said dome-shaped end portions of said vessel with a colloidal suspension of graphite covering the end portions of said line of silver paste, and finally baking said vessel to dry the coatings.

4. The method of manufacturing a hollow glass vessel having a cylindrical wall portion, two dome-shaped end portions and a cathode tubulation on one of said dome-shaped end portions, which comprises drawing a line with silver paste between said dome-shaped end portions on the inner surface of said vessel, drying said paste, continuously revolving said vessel about a horizontal axis coincident with the axis of said cylindrical wall portion of said vessel, coating the inner surface of said cylindrical wall portion with a fluid binder comprising ethyl silicate, formic acid and absolute ethyl alcohol, injecting a cloud of yellow fluorescent material into said vessel in proximity to said wall, allowing said material to settle on said binder, drying said binder, coating said yellow fluorescent material with said fluid binder, injecting a cloud of blue actinic fluorescent material into said vessel in proximity to said wall, allowing said blue actinic fluorescent material to settle on said last-mentioned coating of binder, drying said last-mentioned coating, coating the inner surfaces of both dome-shaped end portions of said vessel

with a colloidal suspension of graphite covering the end portions of said line of silver paste, and finally baking said vessel to dry the coatings.

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