United States Patent [19]

Syster

[11] **3,712,699**

[45] **Jan. 23, 1973**

[54] **CHARGED PARTICLE REMOVAL APPARATUS FOR AN IMAGE DISPLAY DEVICE**

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[22] Filed: **Sept. 1, 1971**

[21] Appl. No.: **177,076**

[52] **U.S. Cl.**.....**316/2,** 316/28

[51] **Int. Cl.**.....**H01j 9/50**

[58] **Field of Search**.....316/17, 18, 19, 1, 2, 3, 21, 316/27, 28, 30, 31

[56] **References Cited**

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[57] **ABSTRACT**

An apparatus for removing charged particles from a conductive element of an image-display device comprises an alternating current high-voltage power supply, means connecting the alternating current high-voltage supply to the element to vary the potential of the element to diminish the electric charge differential between the particles and the element and loosen the particles, and means for injecting a flushing gas into the device and circulating the gas under pressure to suspend the particles in the gas and to exhaust the particles.

6 Claims, 2 Drawing Figures

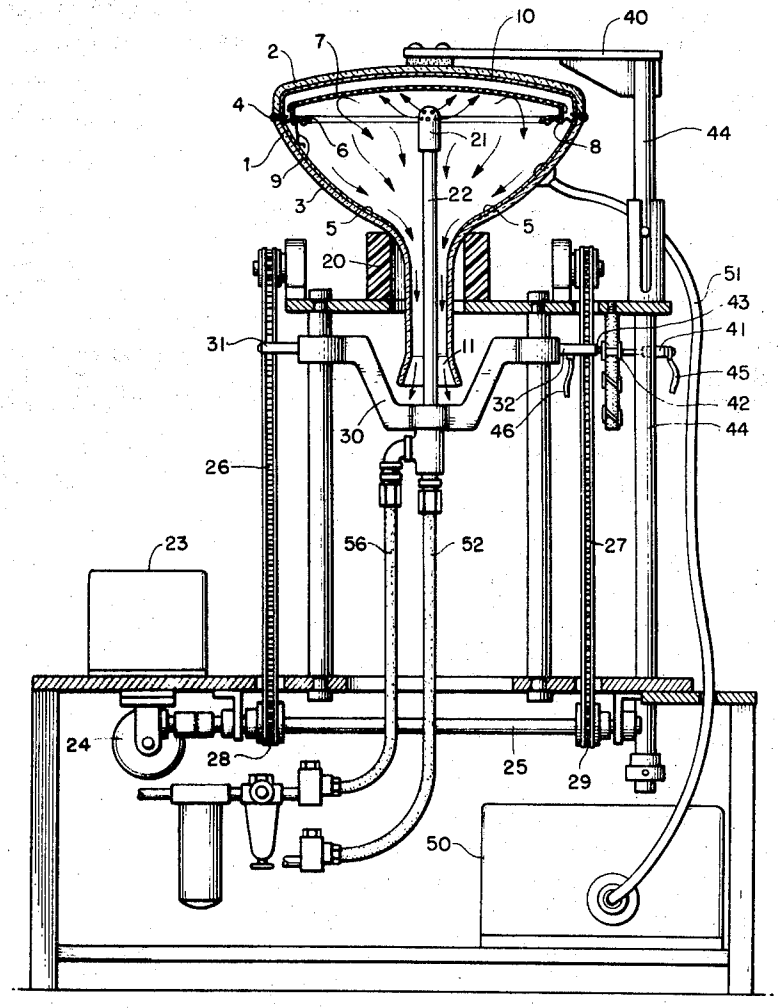


FIG. 2

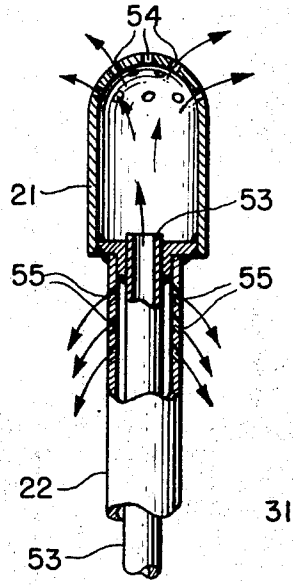

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FIG. 1

10
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CHARGED PARTICLE REMOVAL APPARATUS FOR AN IMAGE DISPLAY DEVICE

BACKGROUND OF THE INVENTION

In the manufacture of an image display device, especially of the type that operates at high-voltage anode potentials, before the device is sealed and evacuated, small nonconductive or semiconductive particles may inadvertently enter the device and be incapsulated therein. During the testing of the device, at partial or full operating potentials, these particles become charged and statically adhere to the conductive elements of the device. These charged particles can cause numerous problems in operation such as arcing, contamination, or deleterious effects in the displayed image, to name just a few.

A good example of such a device which suffers from these defects is the cathode ray tube. Cathode ray tubes generally operate at final anode potentials in the range of 10,000 to 25,000 volts. Extraneous charged particles adhere to the anode or any of the conductive elements electrically connected to the anode. In a color cathode ray tube of the shadow mask type, for example, such particles commonly adhere to the anode, electron shield, and the shadow mask. The charged particles that adhere to the shadow mask cause the electron beam to vary from its desired path causing small shadows in the displayed image. These shadows usually show up as tiny black dots on the screen. As mentioned earlier, the charged particles may also cause arcing within the tube.

In the past, to remove extraneous charged particles, it has been necessary to completely disassemble the cathode ray tube and manually wash those elements that have charged particles statically adhered to them. In doing so, the elements of tube including the panel section and funnel section sealed thereto are exposed to the possibility of damage. Aside from damage, the tube must be completely reassembled in the normal manufacturing process. Of course, such a method of removing the charged particles from the tube is quite costly.

It is therefore an object of the present invention to provide an apparatus for simply and economically removing extraneous charged particles from a conductive element of an image-display device.

It is a more specific object of the invention to provide an apparatus for removing charged particles from a conductive element of an image-display device which negates the necessity of completely disassembling the device.

It is also an object of the invention to provide an improved method for removing charged particles from a conductive element of an image-display device.

SUMMARY OF THE INVENTION

The invention provides an apparatus for removing charged particles from a conductive element of an image-display device which comprises an alternating current high-voltage power supply, means connecting the alternating current high-voltage supply to the element to vary the potential of the element to diminish the electric charge differential between the particles and the element and loosen the particles, and means for injecting a flushing gas into the device and circulating the gas under pressure to suspend the particles in the gas and to exhaust the gas with particles suspended therein.

The invention also provides a method of removing charged particles from a conductive element of an image-display device comprising the steps of applying a varying electrical potential to the element to vary the potential of the conductive element to diminish the electric charge differential between the particles and the element and loosen the particles, circulating a flushing gas within the device to suspend the particles in the flushing gas, and exhausting the flushing gas and the particles suspended therein.

DESCRIPTION OF THE DRAWINGS

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 is a side view, partially in cross-section and partially cut away, of an apparatus embodying the present invention;

FIG. 2 is an exploded view partially in cross-section and partially cut away to show in better detail the spray nozzle shown in FIG. 1.

The apparatus shown in FIG. 1 which embodies the present invention is suitable for treating a cathode-ray tube image-display device in accordance with the present invention. The particular device being treated as shown in FIG. 1 is a color cathode-ray tube of the shadow mask type. Cathode-ray tube **1** has a glass envelope comprising a faceplate panel section **2** and a funnel section **3** sealed thereto at seal line **4**. Funnel section **3** has a conductive coating on its inner surface constituting the final anode **5** of the cathode ray tube. Disposed within the faceplate panel section **2** is mask frame **6** which supports shadow mask **7** and electron shield **8**, all three being electrically connected together and also electrically connected to anode **5** by contact spring **9**. As explained earlier, these conductive elements are most susceptible to having charged particles adhere to their surfaces. Until the present invention, to remove extraneous charged particles from these elements, it has been necessary to break open the cathode-ray tube by breaking the envelope seal at seal line **4**. During this process, the faceplate panel section **2** and funnel section **3** are exposed to the possibility of damage. Also, the conductive elements must be removed and thoroughly washed. Because of excessive handling, it may become necessary for phosphor screen **10**, the result of a tedious manufacturing process well known in the art, to be thoroughly washed off and redeposited at substantial additional expense. Thus, the prior art method of eliminating extrameous charged particles from the elements of such a device requires essentially complete remanufacturing of the tube.

In accordance with the present invention, instead of reopening the envelope at the face plate seal, the electric gun structure located within neck portion **11** of the cathode ray tube is removed as in conventional regunning practices used in picture tube rebuilding operations. This in no way affects the screen portion of

the faceplate panel and greatly reduces any possibility of costly damage to the tube.

After the electron gun structure has been removed from the neck of the cathode ray tube, and a new neck splice has been added in accordance with the usual regunning procedure, the tube is placed into the apparatus as shown in FIG. 1.

The apparatus has a support ring 20 which supports the cathode ray tube 1 with its neck portion 11 pointing downwardly. An air nozzle 21, secured to an air pipe 22, is introduced into the cathode-ray tube envelope by raising a yoke 30. A motor 23 rotates a gear reducer 24 which then rotates a drive shaft 25. Chains 26 and 27 engage drive shaft sprockets 28 and 29 respectively to raise yoke 30 which is secured to chains 26 and 27 by mounting pins 31 and 32.

A more detailed view of the spray nozzle 21 is shown in FIG. 2. Spray nozzle 21 is affixed to pipe 22, an outer pipe, which has a center pipe 53 within it. The gas, which is forced through the spray nozzle openings 54, is supplied through the center pipe 53. Pipe 22 also has nozzle openings 55 which project in a downward direction.

The extent to which nozzle 21 extends into cathode ray tube 1 is determined by a caliper configuration comprising caliper arm 40, pin 41, and contact pads 42 and 43. Pin 41 travels up and down with vertical member 44 and when arm 40 contacts the faceplate of the cathode-ray tube, pin 40 comes to rest on a pad 42 determined by the particular tube size. Wires 46 and 45, contacting pins 32 and 41 respectively, are connected to a relay (not shown) which controls motor 23, so that when yoke 30 is raised to the proper position, pin 32 contacts the pad 43 connected to pin 41 through its contacted pad 42, and this completes an electrical circuit to actuate the relay and turn off motor 23. This prevents nozzle 21 from traveling too far within the tube and damaging either the shadow mask or the faceplate panel. It is preferred that nozzle 21 be about even with frit seal line 4 as shown in FIG. 1.

An alternating current high-voltage power supply 50 is connected to the final anode 5 of cathode-ray tube 1 by lead 51. Power supply 50 may be of any type capable of supplying a high-voltage alternating electrical potential, such as a Tesla supply well known in the art. The alternating current high-voltage power supply 50 varies the potential of the conductive tube elements connected to the final anode to diminish the electric charge differential between the conductive elements and any extraneous charged particles adhering to such elements, and this loosens the particles. To assure that all such particles are loosened, the power supply should be capable of producing a peak voltage at least as great as the maximum potential applied to the elements during the manufacture of the tube.

After spray nozzle 21 is raised into the tube in the manner previously described, the alternating current high voltage is applied. While the particles are being loosened by the application of the alternating high voltage, spray nozzle 21 injects a flushing gas through a pipe 52 into the device, and the flushing gas is circulated under pressure. This suspends the particles in the gas, and the force of the gas exhausts the suspended particles out of the device. Compressed air at 80 pounds per square inch has been found effective to flush and remove the loosened particles, although neither the composition of the flushing gas nor its source pressure is particularly critical.

After approximately three minutes, the particles have been loosened by the alternating high voltage, suspended in the flushing gas, and exhausted out of the tube. The application of the high voltage to the elements is then terminated. Also, the gas supply to pipe 52 is turned off and the spray nozzle is pulled down out of the tube.

After the circulated gas with its suspended particles has been exhausted, a few particles may still remain in the device. These remaining particles usually come to rest in areas where the circulated gas is unable to reach them or, due to the contour of the device, has a decreased velocity.

In accordance with this additional aspect of the invention, in order to remove these few remaining particles, the inner wall of the envelope is swept out with a gaseous medium after the circulated flushing gas with its suspended particles has been exhausted. This may be practiced, for example, in the environment of the preferred embodiment as represented in the figures, by supplying a gaseous medium (which may also be compressed air at 80 pounds per square inch) through pipes 56 and 22, as shown in FIG. 1. The gaseous medium is sprayed out of openings 55, aimed in a downward direction, while the nozzle is lowered out of the tube, sweeping out through the neck 11 any particles that may have come to rest at the bottom of the tube envelope and not exhausted from the tube. Although this is necessary for only an insignificant number of particles, it does assure that all particles are removed from the tube.

It has been found that superior results are achieved if the flushing gas injected into the tube through spray openings 54 during the application of the alternating high voltage is ionized air. The ionized air, at the time it comes into contact with a charged particle which has been loosened from an element, discharges the particle, decreasing the possibility that the charged particle will statically adhere to some other element in the tube.

It is also preferred that center pipe 53 be electrically grounded. By doing so, the effectiveness of the ionized air is increased. Also, this creates an electrostatic stress field between spray nozzle 21 and the conductive elements adding additional force to loosen the particles, and creates corona within the tube, further ionizing the air.

Once the charged particles have been removed from the tube and the nozzle 21 has been lowered out of the tube, the tube is taken off of ring 20 and sent to the appropriate manufacturing work station where a new gun is put into the tube neck 11, completing the regunning process, and the tube is then ready for normal operating use.

The invention provides a simple, convenient and inexpensive method and apparatus for removing charged particles from the conductive elements of an image display device, and more particularly a cathode-ray tube of the shadow mask type. Effective purging of extraneous particles is achieved without breaking the frit seal between the glass faceplate panel section and the funnel section of the tube envelope, by a process which is little more complicated or time consuming than an or-

dinary regunning procedure as employed in picture tube rebuilding operations.

While particular embodiments of the invention have been shown and described, modifications may be made, and it is intended in the appended claims to cover all such modifications as may fall within the true spirit and scope of the invention.

I claim:

1. An apparatus for removing charged particles from a conductive element of an image-display device, which apparatus comprises:

an alternating current high-voltage power supply;

means connecting said alternating current high-voltage supply to said element to vary the potential of said element and to diminish the electric charge differential between said particles and said element and loosen said particles;

and means for injecting a flushing gas into said device and circulating said gas under pressure to suspend said particles in said gas and to exhaust said particles.

2. A method of removing charged particles from a conductive element of an image-display device, which method comprises:

applying a varying electrical potential to said element to vary the potential of said conductive element to diminish the electric charge differential between said particles and said element and loosen said particles;

circulating a flushing gas within said device to suspend said particles in said flushing gas;

and exhausting said flushing gas with its suspended particles.

3. An apparatus for removing charged particles from the final anode and all other elements electrically connected thereto of a cathode-ray tube of the type having a glass envelope comprising a faceplate panel section and a funnel section sealed thereto, said funnel section having a conductive coating on its inner surface constituting said final anode and a narrow extension to form the neck of said tube, which apparatus comprises:

an alternating current high voltage power supply;

means connecting said alternating current high voltage supply to said final anode of said tube to vary the potential of said final anode and all said elements electrically connected thereto to diminish the electric charge differential between said particles and said anode and elements and loosen said particles;

and means for injecting a flushing gas into said envelope and circulating said gas under pressure to suspend said particles and to exhaust said particles through said tube neck.

4. A method of removing charged particles from the final anode and all other elements electrically connected thereto of a cathode-ray tube of the type having a glass envelope comprising a faceplate panel section and a funnel section sealed thereto, said funnel section having a conductive coating on its inner surface constituting said final anode and a narrow extension to form the neck of said tube, which method leaves said seal intact and comprises the steps of:

applying a varying electrical potential to said final anode and said elements electrically connected thereto, to diminish the electric charge differential between said particles and said anode and elements and loosen said particles;

circulating a flushing gas within said tube to suspend said particles in said flushing gas;

and exhausting said flushing gas through said neck.

5. A method in accordance with claim 2 where said flushing gas circulated within said device is ionized air.

6. A method in accordance with claim 2 which comprises the additional step of sweeping said device with a gaseous medium after said circulated flushing gas with its suspended particles has been exhausted.

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