July 31, 1956 L. SILVERMAN 2,757,303

DAMP ROD CONSTRUCTION FOR CATHODE-RAY TUBE GRID STRUCTURES

Filed April 19, 1954 2 Sheets-Sheet 1

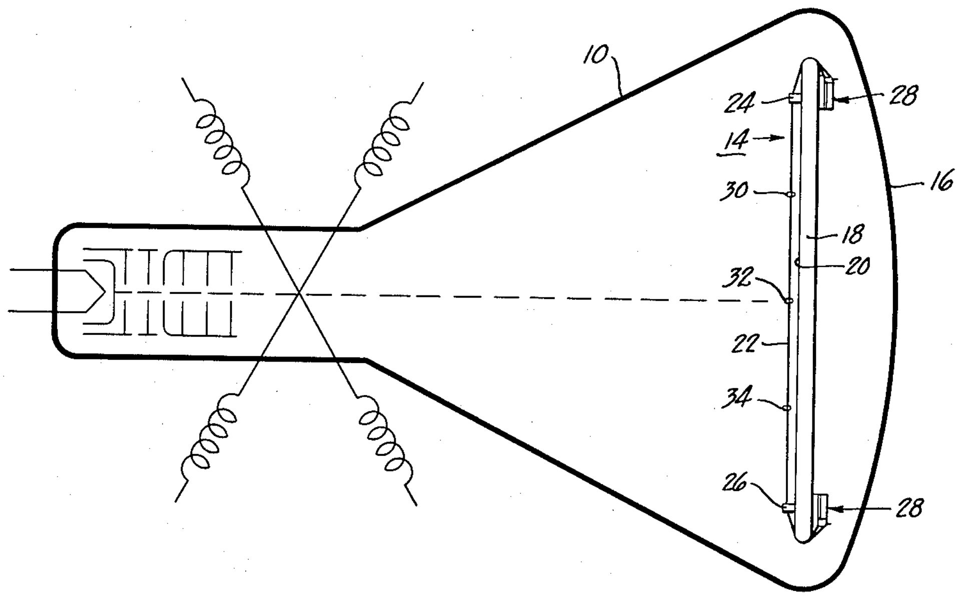

FIG. 1

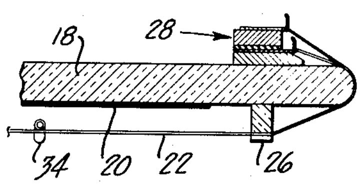

FIG. 2

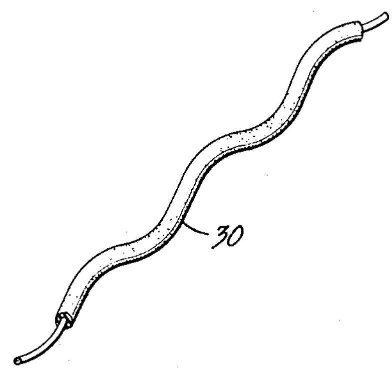

FIG. 6

INVENTOR.
Louis Silverman
BY
Howard J. Murray, Jr.
AGENT

July 31, 1956 L. SILVERMAN 2,757,303

DAMP ROD CONSTRUCTION FOR CATHODE-RAY TUBE GRID STRUCTURES

Filed April 19, 1954 2 Sheets-Sheet 2

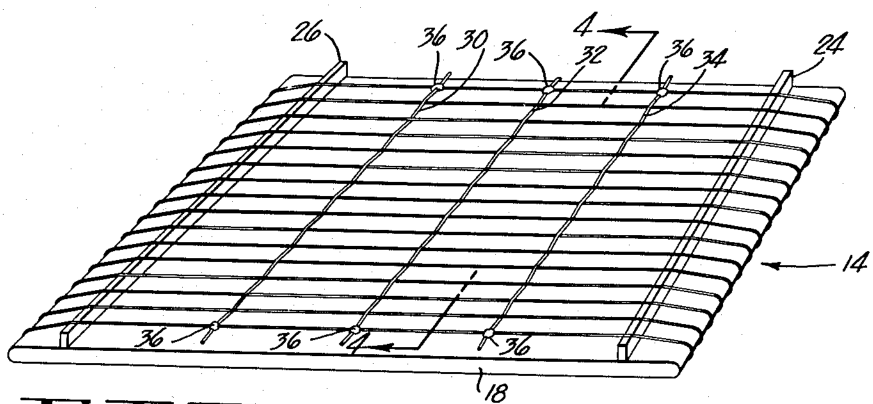

FIG_3_

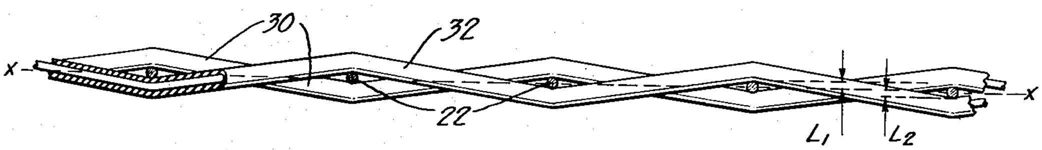

FIG_4_

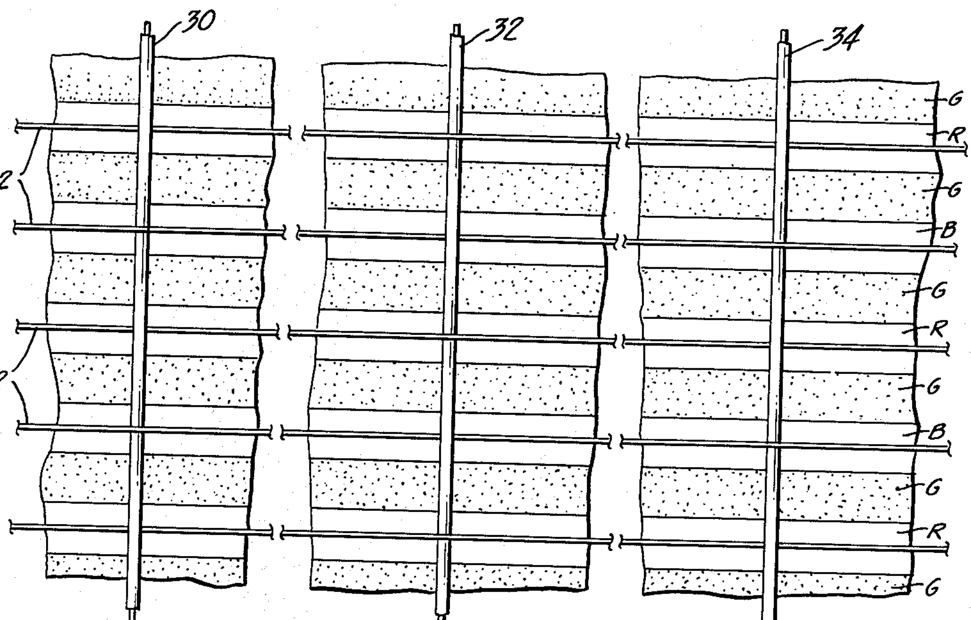

FIG_5_

INVENTOR.
Louis Silverman

BY Howard J. Murray Jr.
AGENT

United States Patent Office 2,757,303
Patented July 31, 1956

2,757,303

DAMP ROD CONSTRUCTION FOR CATHODE-RAY TUBE GRID STRUCTURES

Louis Silverman, San Leandro, Calif., assignor to Chromatic Television Laboratories, Inc., New York, N. Y., a corporation of California

Application April 19, 1954, Serial No. 424,071
10 Claims. (Cl. 313—78)

The present invention relates to cathode-ray tubes of the type adapted to effect the reconstitution of polychrome images. More particularly, the invention relates to cathode-ray tubes having a grid of essentially coplanar wires positioned adjacent to a striped phosphor screen or target electrode.

In a copending United States patent application of Howard R. Patterson, Serial No. 364,778, filed June 29, 1953, there is disclosed means for enhancing the color fidelity of the image reproduced on such a phosphor screen by inhibiting any tendency the wires of the grid may have to vibrate as a result of the cyclic application of electrical potentials thereto and/or as a result of any shock excitation of either a physical or electrical nature. It is an aim of the present invention to extend the scope of the Patterson concept and to improve the results obtained by a device designed in accordance therewith.

Cathode-ray tubes constructed with a grid of essentially coplanar wires located adjacent to a striped phosphor screen are already known in the art, and may serve to focus the beam electrons into a pattern of thin lines registered with the phosphor strips of the screen. The "PDF" (post-deflection-focusing) type of cathode-ray tube operation has already been set forth and explained by Ernest O. Lawrence in various of his United States patent applications, of which Serial No. 219,213, filed April 4, 1951, (now U. S. Patent No. 2,692,532, granted October 26, 1954), is illustrative.

In order to facilitate an understanding of the principles of the present invention, a brief description of one such form of single-gun "PDF" tube will now be given. This description should be construed as exemplary rather than limiting, since it will be seen that the invention is obviously applicable to tubes constructed along different lines. In general, however, the tube may incorporate a screen, or target electrode, made up of a relatively large number of very narrow component-color phosphor strips laid down in a predetermined sequence and intended to luminesce, when impacted by the cathode-ray beam, in colors such as red, green, blue, green, red, green, and so on. Obviously, when reference is hereinafter made to the color of a phosphor, what is meant is the color of the light emitted therefrom which reaches the eye of an observer. The phosphors are then aluminized or the screen in some other manner provided with an electrically conductive coating.

A grid assembly is located adjacent to such phosphor screen. The grid may be made up of essentially coplanar wires, and so related to the phosphor strips that, in an electron-optical sense, there is a wire aligned with each "blue" strip and similarly a wire aligned with each "red" strip. The "red" wires are connected to a common terminal, while the "blue" wires are similarly joined together electrically.

Between the plane of the grid wire assembly and the conductive coating on the phosphor screen there may be established a relative difference of potential of such magnitude and polarity as to create a series of converging cylindrical lenses for the electrons in the scanning beam. Such converging fields cause the beam electrons to form a fine line pattern on the phosphor screen, this line structure having no necessary direct geometrical relationship to the path covered by the scanning beam in tracing the lines of the raster area.

It will now be appreciated that as the beam electrons travel from the electron gun, they may be focused by the above-described lens structure into a series of lines registered with the phosphor strips. If there is a zero potential difference between the "red" and "blue" terminals of the wire grid, then these lines formed by the beam electrons may be caused to lie within the boundaries of the "green" strips. If the wires associated with the "red" strips are made positive relative to the wires electron-optically related to the "blue" strips, the beam electrons will be deflected, and the thin lines will now lie within the boundaries of the "red" strips. Similarly, the electrons will strike the "blue" strips when the wires associated with such strips are relatively positive with respect to the "red" wires. Different component colors are thus displayed according to the potential difference (if any) existing between the two sections of the grid wire assembly.

Accordingly, color control in a cathode-ray tube having a grid assembly of the above nature (whether used for PDF or not) is brought about by a cyclic change in the potentials applied to selected wires of the grid, with the electrostatic charges on the wires exerting forces the magnitude of which varies as a function of this potential change. If the forces thus exerted vary at a frequency close to the natural resonant frequency of the wires, the latter will vibrate, resulting in an oscillation of the line pattern on the phosphor screen. If the magnitude of this oscillation is sufficiently great, color contamination and/or electrical shorting may occur. Even with relatively little wire vibration the electron beam may be defocused and image reproduction seriously impaired. It is, of course, obvious that wire vibration may also result from electrical shocks received by the grid assembly, or as a result of physical shocks to which the entire cathode-ray tube may be subjected.

As set forth in the above-referred-to Patterson application, the problem of grid wire vibration has been recognized. Previous solutions are set forth in United States patent applications of James T. Vale, Serial No. 252,664, filed October 23, 1951 (now U. S. Patent 2,721,288, granted October 18, 1955), and Ernest O. Lawrence, Serial No. 342,941, filed March 17, 1953 (now U. S. Patent 2,729,760, granted January 3, 1956). The solutions set forth in these various applications are in general satisfactory for the particular conditions under which they are designed to operate. However, in certain instances care must be taken during tube manufacture to guard against lateral displacement of the grid wires. Furthermore, in the mentioned Lawrence application, the design illustrated and described therein results in a separation of the grid wires into two sets of coplanar conductors lying in separate planes. Consequently, some compensating means is necessary to prevent color fringing due to the difference in raster size of the individual component-color fields.

The improvement illustrated and described by Patterson overcomes the adverse effects of grid wire vibration without, at the same time, rigidly anchoring each grid wire to the damping member, as suggested by Cook, for example in U. S. Patent 2,731,582, granted January 17, 1956, or utilizing elements which separate the grid wires into distinct planes, as proposed by Lawrence. The expedient proposed by Patterson not only permits the cementitious binding material of Cook to be dispensed with, along with the possibility of lateral displacement of the parallel conductors, but also eliminates the unbalanced voltages for the two sets of grid wires frequently required by a structure designed in accordance with Lawrence's teaching.

The particular solution to the problem set forth by Patterson recognizes the desirability of maintaining a coplanar relationship of the grid wires, and takes this into account by employing at least one damping element the configuration of which is specifically chosen so as not to disturb this grid wire relationship. At the same time, not only is wire vibration reduced in magnitude, but, by extending the "interweaving" concept of Lawrence to a degree not attainable in the disclosure referred to, the actual effectiveness of the damping action is greatly enhanced.

This desirable objective is attained by Patterson through the employment of at least one insulating rod of circular cross-section which extends substantially transversely to the grid wires and is interwoven there-between—that is, over one wire, under the next, over the following wire, and so forth. In order to mantain a coplanar relationship of the grid wires, a particular configuration is imparted to each one of these insulating rods, which configuration may be termed "zig-zag" in nature for convenience of description. Expressed differently, a rod which would otherwise be essentially linear is bent at points corresponding in number to the number of grid wires with which the rod is to be interwoven. The direction of bending is the same at alternate points that is, in, out, in, out, etc., so that the result is a rod of undulating form. If the amount by which the rod is bent is chosen so that

$$L_1 L_2 = D$$

L_1=the distance from the inner surface of the damp rod at any selected convolution K to the longitudinal axis of the damp rod,

L_2=the distance from the inner surface of the damp rod at convolutions adjoining convolution K to the longitudinal axis of the damp rod, and,

D=the diameter of the damp rod

then there will be good surface contact between the rod and each of the grid wires with which it is interwoven.

In addition each of the damp rods is "interleaved" not only with the grid wires but also with each adjoining damp rod. The construction accordingly is one in which any selected rod, for example, overlies those particular grid wires which the two adjoining damp rods "go under."

It will thus be appreciated that the particular type of damp rod construction illustrated and described by Patterson is such that, as one portion of the grid wire assembly is subjected to an electrostatic force of a magnitude which would otherwise cause the wires thereof to leave their normal position, these wires must overcome the restraining effect of the damp rod with which they are in contact. However, this same damp rod contacts another portion of the grid wire assembly the wires of which are not subject to a force of this particular value. In fact, the direction in which the force on the last-mentioned grid wire portion is changing may be directly opposed to the direction of changes of the force acting on the first group of wires. The damp rods, by contacting all of the wires, act as an equalizing, or balancing, medium which almost completely cancels out any tendency toward movement the individual wires of the color-control grid structure may possess.

In the Patterson application, the material of which the damp rods are composed is preferably of a vitreous nature. One substance which has been found to be especially suitable for the purpose of the Patterson case is what is known commercially as "G–12" glass. The damp rods made of any particular substance are homogeneous throughout.

The Patterson concept of "zig-zagging" a ceramic damp rod is satisfactory in every respect insofar as preventing

grid wire vibration is concerned. The only difficulty that has been experienced in practice in the use of such damp rods is that the rods exhibit somewhat of a tendency to break at one or more points during processing and handling of the cathode-ray tube containing the grid wire assembly. Such a broken rod or rods is clearly visible to an observer of the reproduced image. It is not normally possible to increase the diameter of the damp rods appreciably without producing in the image dark lines which stand out rather noticeably. Various types of ceramic materials have been experimented with without discovering one which effectively resists such breakage.

It has been found possible to construct a damp rod of the general type set forth by Patterson and at the same time completely eliminate any possibility of breakage by the expedient of substituting for the all-glass rod of Patterson a rod which has a metallic core. In other words, instead of the all-glass rod, a very fine wire, of some material such as molybdenum or tungsten, is coated with an insulating substance such as Alundum. Alternatively, an insulative substance such as vitreous enamel may be applied as a coating to a wire composed of tungsten, molybdenum, or aluminum. Not only do damp rods of this type have such greater strength than the all-glass rods, but in addition they are somewhat simpler to manufacture since wire can be provided with an Alundum coating by the "drag" method which is well known in the manufacture of filaments for electron receiving tubes.

One object of the present invention, therefore, is to provide an improved form of cathode-ray tube suitable for the reconstitution of polychrome images.

A further object of the invention is to substantially completely overcome, in a polychrome cathode-ray tube having a grid structure of essentially coplanar wires, any tendency toward vibration the wires of the grid structure may possess either when color-changing potentials are cyclically applied thereto or when the grid structure is subjected to shocks of a physical and/or electrical nature.

An additional object of the present invention is to accomplish the above objective while at the same time maintaining the coplanar relationship of the grid wires.

A still further object of the present invention is to provide, in a polychrome cathode-ray tube having a color-control grid structure of essentially coplanar wires, at least one damping element, of non-linear configuration and of non-homogeneous cross-section, interwoven with the wires of the color-control grid.

An additional object of the present invention is to provide a damping element of the above nature the surface of which is formed of insulating material and the core of which is metallic.

Other objects and advantages of the present invention will be apparent from the following description of a preferred form thereof and from the drawings, in which:

Figure 1 is a partly schematic representation of one form of cathode-ray tube in which the present invention may be incorporated;

Figure 2 is an enlarged view of a portion of Figure 1;

Figure 3 is a perspective view of a portion of the wire grid assembly of Figure 1, showing in greater detail the interwoven relationship between the grid wires and the damp rods;

Figure 4 is a sectional view of a portion of Figure 3 along the line **4—4**;

Figure 5 is a plan view of a portion of Figure 3, showing one preferred association of the grid wires and phosphor strips; and

Figure 6 is an enlarged perspective view of one of the damp rods showing the inner construction thereof.

Referring now to Figure 1 of the drawings, there is generally indicated by the reference numeral **10** one type of cathode-ray tube in which the present invention may be incorporated. This tube 10 includes the usual components for developing a beam 12 of electrons and for deflecting this electron beam in substantially mutually perpendicular directions so as to trace a raster on the tube target electrode.

The target electrode of tube 10, for ease of illustration, is disclosed as forming part of a separate unit or assembly 14 mounted in any suitable manner adjacent to the transparent end wall 16 of the tube. Obviously, however, the end wall 16 when suitably configured may itself comprise the target electrode if convenient or desirable. For certain constructional details of the assembly 14, reference is made to above-mentioned Vale U. S. Patent No. 2,721,288, as well as to further applications of Renn Zaphiropoulos, Serial No. 307,435 and Serial No. 307,436, concurrently filed September 2, 1952 now respectively U. S. Patents No. 2,683,833, granted July 13, 1954 and No. 738,436, granted March 13, 1956. However, inasmuch as these constructional details form no part of the present invention, they will be omitted from the description which follows, and it will merely be stated that the assembly 14 (which includes a transparent base plate 18, a phosphor coating 20 thereon, and a grid of essentially parallel color-control conductors 22 adjacent to the phosphor coating 20) is positioned and supported within the tube 10 so that the light produced by impingement of the scanning beam 12 on the phosphor coating 20 may be viewed by an observer through the transparent end wall 16 of the cathode-ray tube.

The base plate 18 may be of glass or other suitable material. The phosphor coating 20 is preferably in the form of a plurality of narrow strips which have the property of fluorescing in different component colors of the image to be reconstituted, these colors, for example, being red, green, and blue. The strips are laid down side-by-side in a predetermined chromatic sequence. As best shown in Figures 3 and 4, the order chosen for illustration is red, green, blue, green, red, green, and so on. This order, however, forms no specific part of the present invention, but is suggested as one sequence which has proven to be satisfactory in practice. The phosphor coating 20 is aluminized or otherwise provided with a thin film of electrically-conductive material on the surface toward the source of the impinging electrons.

The color-control grid adjacent to the target surface 20 is composed of a plurality of linear conductors, such as the parallel wires 22, aligned with the phosphor strips in a manner best shown in Figures 3 and 5. (Only a small section of the striped phosphor surface 29 of the target electrode is illustrated in Figure 3 in order to permit a clear showing of the grid wire relationships.) That is, there is a grid wire associated with each "red" and "blue" phosphor strip, but none with the "green." By cyclically varying the voltage of the "red" wires with respect to the voltage of the "blue" wires, different chromatic aspects of an image are successively presented. In this connection, it must be kept in mind that the drawings of the present application are not to scale, and that the relative dimensions and spacings of the illustrated components are intentionally distorted for ease of presentation. In general, though, each pair of wires may, in an electron-optical sense, be considered subtending strip areas constituting one color cycle.

In a preferred form of tube design, a potential is applied to the conductive coating on the phosphor surface 20 which is relatively positive with respect to the average, of D.-C. potential of the wires 22 of the grid assembly. This gives rise to a plurality of cylindrical electrostatic lenses, which serve to focus the electrons of the scanning beam 12 into a series of fine lines registered with the phosphor strips. However, the present invention is obviously applicable to cases where the wires 22 serve either as a color-changing device alone, as will subsequently appear, or as an electrostatic lens assembly per se.

Although any suitable method may be employed for positioning the wires 22 so that they are adjacent to the phosphor-coated surface 20 of the target electrode, a pair of bars 24 and 26 is shown, each of these bars having on its upper surface a series of equally-spaced grooves for aligning the wires 22 and preventing lateral movement thereof at such points. The wires are respectively held taut (as best shown in Figures 1 and 2) by a plurality of hooks forming part of two retaining assemblies 28 secured to the under surface of the transparent base plate 18 beyond the boundaries of the image raster area. This general type of construction is described and claimed in the Zaphiropoulos U. S. Patent No. 2,683,833, referred to above.

It has been indicated that one of the principal features of the present invention consists in substantially completely overcoming any tendency toward vibration the wires of a color-control grid assembly of the class described may possess by interweaving one of more rigid rod-like members of a non-homogeneous nature between the wires of the color control assembly, while at the same time retaining the coplanar wire relationship. One such arrangement is shown in Figures 1 through 5.

In this construction, three metal-cored insulating rods, 30, 32, and 34 of circular cross-section have been chosen for illustration, although the rod 32 alone will produce results as set forth below. In each case, however, the rods extend substantially transversely to the grid wires 22 and are interwoven therebetween: that is, over one wire, under the next, over the following wire, and so on. Figures 3, 4, and 5 bring out this interwoven relationship most clearly.

The particular configuration imparted to each of the damp rods 30, 32, and 34 may be, for convenience of description, termed "zig-zag" in nature. In other words, an essentially linear rod is bent at points corresponding in number to the number of grid wires with which the rod is to be interwoven, with the direction of bending being the same at alternate points. The rod configuration which results is undulating in character, with the amount of bending being just sufficient so that good contact is maintained between the zig-zagged damp rod and the grid wires with which it is interwoven, while at the same time avoiding any displacement of the latter from their normal coplanar position.

Adjacent damp rods contact different sections of the same grid wire. This is particularly brought out in Figure 5, which shows the rod 32, for example, overlying those particular grid wires which the rods 30 and 34 "go under." Also, in Figure 4, the side view of rods 30 and 32 brings out that the former (which lies in back of the rod 32) contacts each grid wire at a point which is diametrically opposed to the point at which each grid wire is contacted by the rod 32. The rod 34, although shown in Figure 4, would occupy a position relatively similar to that of the rod 30.

The electrostatic forces developed on the wires of the grid assembly, which would otherwise cause the individual conductors to undergo vibration, have their influence materially diminished by the presence of the damp rods. This is because each damp rod has a definite restraining effect upon each wire in a physical sense. Moreover, the direction in which the force on one grid wire section is changing may be directly opposed to the direction of changes of the force acting on another group of wires. The damp rods, by contacting all of the wires, act as an equalizing or neutralizing medium, which tends to almost completely cancel out any tendency toward movement the individual wires of the color-control grid structure may possess.

In the particular structure described by Patterson, the all-ceramic damp rods are preferably of a diameter between .003" and .005", or in other words between 3 and 5 mils. This size has been found to be especially suitable in actual tube constructions. Glass rods of such small diameter obviously have relatively little strength, and consequently, as stated above, the problem of breakage of the damp rods has been a serious one.

A damp rod formed in accordance with the teaching of the present invention is illustrated in Figure 6. This damp rod comprises a wire of, say, between one and two mils diameter (preferably composed of some such material as molybdenum or tungsten) which is provided with a very thin coating of an electrically-insulating substance such as Alundum. As previously stated, vitreous enamel may also be applied as a coating to wire composed of tungsten, molybdenum or aluminum. Although the particular process by which the metal wire is coated forms no part of the present invention, it might be stated that a satisfactory coating may be applied by standard commercial processes such as are well known in the manufacture of filaments for electron receiving tubes. The wire is first zig-zagged, and then the insulating coating applied so that the coated wire has a final diameter in the neighborhood of the three to five mil limit set forth by Patterson. However, because of its metallic core, such a damp rod exhibits very much greater resistance to breakage than does the all-ceramic damp rod previously employed.

Although the invention has been described in connection with a single-gun cathode-ray tube in which the damp rods are employed to minimize grid wire vibration caused by cyclic variation in the color switching potentials, it should be understood that damp rods such as described herein are of great advantage in either single-gun or multiple-gun cathode-ray tubes in order to reduce the amplitude of any vibratory action induced by sudden changes in potential difference between the grid wire assembly as a whole and the conductive coating of the phosphor screen. This may take place, for example, when there is an arcing or "flash-over" between the wire grid and phosphor screen, causing the grid wires to be suddenly released from the position to which they had been drawn by the attraction of the positively-charged screen. The damp rods of the present disclosure are especially effective in preventing this vibratory action from reaching an amplitude where it might cause color contamination in the reproduced image, or, in severe cases, actual fusion of the grid wires of a single-gun tube when the displacement is so great that adjacent wires are brought into contact with one another.

Having thus described the invention, what is claimed is:

1. A vibration-inhibiting element for a cathode-ray tube designed for the reconstitution of polychrome images and having a grid structure of essentially coplanar wires lying between the cathode-ray beam developing means of said tube and the target electrode scanned thereby and substantially adjacent to the target, said vibration-inhibiting element comprising a non-linear rod having a metallic core surrounded by a substance having the properties of an electrical insulator, extending substantially transversely to the parallel wires of said grid structure and interwoven therebetween in such a manner as to retain a coplanar wire relationship.

2. A vibration-inhibiting element according to claim 1, in which the metal comprising said core is tungsten.

3. A vibration-inhibiting element according to claim 1, in which the metal comprising said core is molybdenum.

4. A vibration-inhibiting element according to claim 1, in which the metal comprising said core is aluminum.

5. A vibration-inhibiting element according to claim 1, in which the electrical insulating substance surrounding said metallic core is Alundum.

6. A vibration-inhibiting element according to claim 1, in which the electrical insulating substance surrounding said metallic core is in the nature of a vitreous enamel.

7. A vibration-inhibiting assembly for a cathode-ray tube designed for the reconstitution of polychrome images, said tube having a planar-surfaced target electrode and a grid structure of essentially coplanar wires lying adjacent to the planar surface of said target electrode, said vibration-inhibiting assembly including a plurality of rod-like members of zig-zag configuration, each extending substantially transversely to the wires of said grid structure and interwoven therebetween the zig-zag configuration of each of the said rod-like members being such that the interweaving of each said member with the wires of said grid structure results in the former contacting each of the said grid wires and at the same time substantially retains the said coplanar grid wire relationship, each said rod-like member having a surface portion which possesses insulating properties and a core portion which is composed of metallic material, thereby causing each said rod-like member to exhibit a relatively high resistance to breakage under any stress to which it may be subjected.

8. A zig-zag damp rod for inhibiting vibration of the linear conductors of a grid structure forming part of a cathode-ray tube designed for the production of polychrome images, said linear conductors lying adjacent to the target electrode of said cathode-ray tube, said damp rod being essentially of a linear nature but being bent in-and-out at points substantially corresponding in number to the number of linear conductors making up said grid structure, the direction of bending of said damp rod being the same at alternate points, so that the said bent rod is substantially symmetrical about its longitudinal axis, said damp rod having a surface area composed of material which acts as an electrical insulator and a metallic core.

9. In a cathode-ray tube designed for the production of polychrome images, the combination of a color-control grid structure of parallel wires arranged in coplanar relation in a plane adjacent to the target electrode of said cathode-ray tube, and at least one rod-like element having a metal core and a coating of insulating material, said one rod-like element being respectively bent in-and-out at equally-spaced points corresponding in number essentially to the number of parallel wires making up said grid structure, said rod-like element being interwoven with the said parallel wires without disturbing the coplanar relationship of the latter, whereby the tendency of said wires to vibrate when color-control potentials are applied to said grid structure will be strongly inhibited, and whereby the tendency of said rod-like element to break as a result of physical shocks applied thereto will be strongly resisted by the metallic material making up said core.

10. A vibration-inhibiting element for a cathode-ray tube designed for the reconstitution of polychrome images and having a grid structure of parallel coplanar wires lying between the cathode-ray beam developing means of said tube and the target electrode scanned thereby and substantially adjacent to the target, said vibration-inhibiting element comprising a non-linear rod extending substantially transversely to the parallel wires of said grid structure and interwoven therebetween to contact said wires but in such a manner as to retain the coplanar wire relationship, said non-linear rod being formed of metal having a coating of insulating material on at least that portion of its surface which is in contact with the parallel wires of said grid structure.

References Cited in the file of this patent

UNITED STATES PATENTS

1,572,726	Kelly	Feb. 9, 1926
1,930,563	Pante	Oct. 17, 1933
2,072,638	Jobst	Mar. 2, 1937
2,416,056	Kallman	Feb. 18, 1947
2,446,791	Schroeder	Aug. 10, 1948
2,461,515	Bronwell	Feb. 15, 1949
2,568,448	Hansen	Sept. 18, 1951