

SPECIFICATION

Method of Manufacturing Electrode Systems for Cathode Ray Tubes and Electrode Systems Thus Manufactured

5 The invention relates to a method of manufacturing an electrode system for a cathode ray tube and to an electrode system manufactured by using this method.

10 The term "electrode system" is to be understood to mean herein a system of electric conductors between which a strong electric field is generated in operating circumstances, for example, in electron gun systems, colour selection electrodes with post-focusing effect for colour display tubes and also printed circuit boards on which conductive tracks extending closely beside each other are provided.

15 In electrode systems, for example, electron gun systems for cathode ray tubes, stringent requirements are imposed upon the high voltage stability of the electrode system. This means that the possibility of the occurrence of an electric flash-over between electrodes situated at a short distance from each other should be minimized in normal operating circumstances of the electrode system. In fact, such flash-overs may damage the electrode system itself but in particular also the electronic circuit connected thereto. The cause of these flash-overs can be generally traced to mechanical imperfections of the electrode system, for example small burrs or loose particles present on the electrodes. It is therefore necessary to remove said burrs and loose particles from the electrodes before ultimately putting the electrode system in operation.

20 According to a conventional method, said burrs and loose particles are removed by applying, in the last or in one of the last phases of the manufacturing process of the electrode system, an electric potential difference between electrodes which are situated at a short distance from each other, said difference exceeding the voltage difference at which said electrodes are operated in normal operating circumstances. If a flash-over occurs, it will usually occur at the area of a burr or loose particle, as a result of which the burr or the loose particle is melted away or burnt away, with which the source of further flash-overs at that area has been removed. This process, sometimes termed "arc out process", usually takes place in a vacuum. During this arcing out however, metal is sputtered and may be deposited on electrically insulating parts of the electrode system. This has for its result that electric conductivity can take place via the surfaces of the insulating parts, which is undesirable. This is a problem in particular in electrode system in which the insulation path along the insulating material between the electrodes is particularly short. Such an electrode system is disclosed, for example, is British Patent Specification 1,496,949. This specification describes a colour display tube of the post-focusing type. In this case the colour selection

65 electrode situated at a short distance before the display screen consists of two substantially flat electrode structures which are kept spaced at a distance of approximately 100 to 200 μm by means of insulators situated between the electrode structures. The two electrode structures are provided with a plurality of apertures which are aligned two by two and through which pass the electron beams generated by an electron gun. The two electrode structures are operated at an electric potential difference of approximately 1000 to 2000 volts so as to exert in the apertures a focusing effect on the electron beams. Arcing out such an electrode system in a vacuum has proved to be an unsuitable method since a small deposit of sputtered metal on the insulators already makes the colour selection electrode unfit for further use. Deposition of sputtered metal forms a problem in particular when a synthetic resin is used as an insulation material. Electric conductivity along the surface of the insulator then results in a local heating of the surface so that decomposition and carbon formation of the synthetic resin occurs. As a result of this the electric conductivity will increase progressively and ultimately a complete shortcircuit is formed between the two electrode structures.

It is the object of the invention to provide a method of arcing out electrode systems in which the deposition of sputtered material on insulating parts of the electrode system is avoided.

70 According to the present invention there is provided a method of manufacturing an electrode system for a cathode ray tube, the electrode system including at least two conductors positioned at a predetermined distance from each other by means of insulating material, wherein burrs and particles on the facing parts of the conductors are removed by an arc out process comprising immersing the electrode system in a dielectric liquid in such a manner that at least the conductors to be arced-out are below the level of the dielectric liquid and applying a sufficiently large potential difference between the conductors to generate an electric flash-over.

75 In the present specification by a dielectric liquid is meant a strongly electrically insulating liquid.

80 When the electrode system is immersed in such a liquid and the desired electric potential difference is then applied between the conductors to be arced out, electric fields are formed having a strength of the same order of magnitude as in a vacuum. When an electric flash-over takes place towards a burr on one of the conductors, sputtering of metal also occurs, but this sputtered material can no longer deposit on the insulating parts of the electrode system as a result of the small path length in the dielectric liquid. The dielectric liquid also serves as a cooling liquid so that local over-heating as a result of the electric flash-overs is prevented.

85 Examples of suitable dielectric liquids are halogenated hydrocarbons, for example, carbon tetrachloride and freons. Other examples of

suitable liquids are inert gases in the liquid phase, preferably liquid nitrogen. Yet other examples of liquids are kerosene, dry-cleaning naphta, and paraffin oil. Generally, those dielectric liquids which can easily be evaporated or rinsed away from the electrode system are suitable.

During the arcing out of the electrode system it may occur that as a result of an electric flash-over small solid particles are loosened from the insulation material or the electrode material. These particles are mainly taken along in the liquid flows which are formed as a result of the injection of charge carriers in the liquid in the proximity of the electrode system (electrohydrodynamic effect). The removal of these particles from the proximity of the electrode system can be promoted by causing the dielectric liquid to be circulated by a pump through a circuit including a filter. A further possibility is to remove the particles from the proximity of the electrode system *via* electrostatic forces by means of an auxiliary electrode placed in the dielectric liquid.

The present invention will now be described by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows diagrammatically an arrangement for carrying out the method in accordance with the invention,

Figure 2 shows an example of an electrode system for a cathode ray tube manufactured by using the invention,

Figure 3a shows another example of an electrode system manufactured by using the invention,

Figure 3b shows a detail of the electrode system shown in Figure 3a, and

Figure 4 shows a structure of electric conductors provided on an insulating plate.

In Figure 1, an electrode system consisting of a first electrode structure 3, a second electrode structure 4, and a number of insulators 5 arranged between the electrode structures and adhering thereto, is situated in a container 2 filled with a dielectric liquid 1, for example carbon tetrachloride. The electrode structures 3 and 4 are connected to a high voltage generator 8 *via* conductors 6 and 7 and a series-arranged impedance R. If desired, a capacitor C may be incorporated in the circuit parallel to the electrode system, with which the quantity of energy available in an electric flash-over can be controlled at will. The potential difference between the electrode structures 3 and 4 necessary for arcing out the electrode system depends on the potential difference which, in normal operating circumstances, is between the electrode structures 3 and 4. For example, a potential difference of approximately 3000 volts is sufficient for arcing out when the normal operating voltage of the electrode system is approximately 2000 volts. For the arc out process, there is used a voltage generator 8 which provides voltage pulses or an alternating voltage so as to improve the voltage stability of the electrode system in both directions. If a burr is

present on at least one of the facing surfaces of the electrode structures 3 and 4 or if a particle of solid has adhered thereto, an electric flash-over will occur at that area. As already said, a capacitor C may be incorporated in the circuit, if desired, which discharges during the flash-over and the electric energy which is released usually is sufficient to melt away the burr or the particle of solid. The comparatively high impedance R of, for example, 5 MOhm prevents the formation of an arc discharge between the electrode structures 3 and 4 so as not to damage the electrode system itself. As a result of the small free path length in the liquid, the metal sputtered during the flash-over cannot deposit on the insulators 5. By an electrohydrodynamic effect, a circulation of the liquid 1 is formed in the proximity of the electrode structures 3 and 4, and any solid particles detached during the electric flash-over of the electrode system are taken along. If desired, the particles can be removed from the liquid 1 by circulating the liquid by pumping *via* a duct 9 in which a filter 10 and a pump 11 are incorporated.

It is alternatively possible to remove said particles electrostatically from the surroundings of the electrode system. For this purpose, at least one auxiliary electrode 12 is provided and maintained at such a potential that an electrostatic field extending outside the electrode system is generated. The particles, if any, detached during a flash-over are "sucked away" from the surroundings of the electrode system by electrostatic forces. Of course, in this case also, the pumping circuit 9 may be used to remove the particles from the liquid.

Figure 2 shows an electrode system as this is applied usually in a colour television display tube and which has been manufactured by using the method in accordance with the invention. The electrode system comprises three electron guns 13, 14 and 15. Each gun has a first electrode 21, a second electrode 22, a third electrode 23 and a fourth electrode 24. These electrodes are positioned with respect to each other by means of metal strips 17 which are sealed in glass assembly rods 18. In such an electron gun system, the electrodes 23 in operating conditions are at a potential of substantially 5 kV and the electrodes 24 are at a potential of substantially 25 kV. In order to minimize the possibility of the occurrence of an electric flash-over between the electrodes 23 and 24, the electron gun system has been arced out in a manner as described with reference to Figure 1. Of course, a voltage generator should be used which provides considerably larger voltage pulses than the voltage difference which is between the electrodes 23 and 24 under operating conditions. Voltage differences of from 30 to 50 kV are sufficient for arcing out such an electrode system. The desired voltage difference can be obtained by means of voltage pulses which may be superimposed on a direction voltage level.

Figure 3a shows an electrode system which is constructed from two flat electrode structures.

Such an electrode system is suitable for use as a colour selection electrode in a colour television display tube of the post-focusing type. The electrode system comprises a first electrode structure consisting of a set of mutually parallel metal conductors 37 and a second electrode structure consisting of a set of mutually parallel conductors 36 crossing the conductors 37 at right angles. The crossing conductors are kept spaced apart at a distance of approximately 150 μm by means of insulators 35, while apertures 39 are present between the conductors 36 and 37. For illustration Figure 3b shows diagrammatically the operation of such an electrode system in a colour television display tube. Shown is a display screen 38 on which three phosphor strips associated with an aperture 39 are provided and are denoted by R(red), G(green) and B(blue).

As regards the colour selection, the electrode system shown operates analogously to the shadow mask known from colour television display tubes, that is to say that three electron beams pass through the apertures 39 at a small angle with each other (the so-called colour selection angle) and consequently each impinge only on phosphor strips of one colour. Figure 3b shows only one electron beam namely that one which impinges on the green phosphor strip G. The electron beam is focused in the aperture 39 in such manner that the electron spot denoted by 30 is formed on the display screen 38 and not the electron spot 29 denoted in broken lines. In order to produce said focusing, the electrodes 36 are operated at a lower electric potential than the electrodes 37. For example, at a potential of the display screen 38 of 25 kV, the potential of the conductors 36 is approximately 24.5 kV and that of the conductors 37 is approximately 25.5 kV. For a good focusing of the electron beams in the apertures 39 a large voltage stability of the electrode system is required. Due to the short insulation path (150 μm) between the electrodes 36 and 37, the arc out process for such an electrode system in a manner as described with reference to Figure 1 presents great advantages as compared with arc out processes in a vacuum. For the arcing out of this electrode system voltage pulses of approximately 3 kV are amply sufficient. The required time for the arcing out may differ for different electrode systems but generally is approximately one minute.

Figure 4 relates to a part of an electric circuit in which electrically conductive tracks 51 are provided on an electrically insulating plate 50 (printed circuit board). In this case also, electric flash-overs may occur between the conductors 51 when a large potential difference exists between them in operating conditions. The method in accordance with the present invention may be applied advantageously in the above-described manner by immersing the plate 50 in a dielectric liquid and applying a potential

difference between the conductors 51 so as to arc out the conductors 51.

65 Claims

1. A method of manufacturing an electrode system for a cathode ray tube, the electrode system including at least two conductors positioned at a predetermined distance from each other by means of insulation material, wherein burrs and particles on the facing parts of the conductors are removed by an arc out process comprising immersing the electrode system in a dielectric liquid in such a manner that at least the conductors to be arced-out are below the level of the dielectric liquid and applying a sufficiently large potential difference between the conductors to generate an electric flash-over.
2. A method as claimed in Claim 1, wherein the dielectric liquid is a halogenated hydrocarbon.
3. A method as claimed in Claim 1, wherein the dielectric liquid is an inert gas which is in the liquid phase.
4. A method as claimed in Claim 3, wherein the dielectric liquid is liquid nitrogen.
5. A method as claimed in any one of Claims 1 to 4, wherein the dielectric liquid is circulated by pumping the liquid through a circuit including a filter.
6. A method as claimed in any one of Claims 1 to 5, further comprising placing at least one auxiliary electrode in the dielectric liquid in the proximity of the electrode system, which auxiliary electrode is brought to an electric potential such that an electrostatic field extending beyond the electrode system is obtained.
7. A method of manufacturing an electrode system for a cathode ray tube, substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.
8. An electrode system for a cathode ray tube, manufactured by using the method as claimed in any of the Claims 1 to 7.
9. An electrode system as claimed in Claim 8, wherein the electrode system consists of an electron gun system for generating at least one electron beam in a cathode-ray tube.
10. An electrode system as claimed in Claim 8, wherein the electrode system consists of at least two flat or substantially flat electrode structures which are kept spaced at a defined distance by means of insulators.
11. An electrode system as claimed in Claim 8, wherein the electrode system consists of a structure of electric conductors arranged on an insulating plate.
12. An electrode system as claimed in Claim 8, substantially as hereinbefore described with reference to Figure 2, Figures 3a and 3b, and Figure 4 of the accompanying drawings.
13. Apparatus for carrying out the method as claimed in Claim 1, substantially as hereinbefore described with reference to and as shown in Figure 1 of the accompanying drawings.



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Such an electrode system is suitable for use as a colour selection electrode in a colour television display tube of the post-focusing type. The electrode system comprises a first electrode structure consisting of a set of mutually parallel metal conductors 37 and a second electrode structure consisting of a set of mutually parallel conductors 36 crossing the conductors 37 at right angles. The crossing conductors are kept spaced apart at a distance of approximately $150\text{ }\mu\text{m}$ by means of insulators 35, while apertures 39 are present between the conductors 36 and 37. For illustration Figure 3b shows diagrammatically the operation of such an electrode system in a colour television display tube. Shown is a display screen 38 on which three phosphor strips associated with an aperture 39 are provided and are denoted by R(red), G(green) and B(blue).

As regards the colour selection, the electrode system shown operates analogously to the shadow mask known from colour television display tubes, that is to say that three electron beams pass through the apertures 39 at a small angle with each other (the so-called colour selection angle) and consequently each impinge only on phosphor strips of one colour. Figure 3b shows only one electron beam namely that one which impinges on the green phosphor strip G. The electron beam is focused in the aperture 39 in such manner that the electron spot denoted by 30 is formed on the display screen 38 and not the electron spot 29 denoted in broken lines. In order to produce said focusing, the electrodes 36 are operated at a lower electric potential than the electrodes 37. For example, at a potential of the display screen 38 of 25 kV, the potential of the conductors 36 is approximately 24.5 kV and that of the conductors 37 is approximately 25.5 kV. For a good focusing of the electron beams in the apertures 39 a large voltage stability of the electrode system is required. Due to the short insulation path ($150\text{ }\mu\text{m}$) between the electrodes 36 and 37, the arc out process for such an electrode system in a manner as described with reference to Figure 1 presents great advantages as compared with arc out processes in a vacuum. For the arcing out of this electrode system voltage pulses of approximately 3 kV are amply sufficient. The required time for the arcing out may differ for different electrode systems but generally is approximately one minute.

Figure 4 relates to a part of an electric circuit in which electrically conductive tracks 51 are provided on an electrically insulating plate 50 (printed circuit board). In this case also, electric flash-overs may occur between the conductors 51 when a large potential difference exists between them in operating conditions. The method in accordance with the present invention may be applied advantageously in the above-described manner by immersing the plate 50 in a dielectric liquid and applying a potential

difference between the conductors 51 so as to arc out the conductors 51.

65 Claims

1. A method of manufacturing an electrode system for a cathode ray tube, the electrode system including at least two conductors positioned at a predetermined distance from each other by means of insulation material, wherein burrs and particles on the facing parts of the conductors are removed by an arc out process comprising immersing the electrode system in a dielectric liquid in such a manner that at least the conductors to be arced-out are below the level of the dielectric liquid and applying a sufficiently large potential difference between the conductors to generate an electric flash-over.
2. A method as claimed in Claim 1, wherein the dielectric liquid is a halogenated hydrocarbon.
3. A method as claimed in Claim 1, wherein the dielectric liquid is an inert gas which is in the liquid phase.
4. A method as claimed in Claim 3, wherein the dielectric liquid is liquid nitrogen.
5. A method as claimed in any one of Claims 1 to 4, wherein the dielectric liquid is circulated by pumping the liquid through a circuit including a filter.
6. A method as claimed in any one of Claims 1 to 5, further comprising placing at least one auxiliary electrode in the dielectric liquid in the proximity of the electrode system, which auxiliary electrode is brought to an electric potential such that an electrostatic field extending beyond the electrode system is obtained.
7. A method of manufacturing an electrode system for a cathode ray tube, substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.
8. An electrode system for a cathode ray tube, manufactured by using the method as claimed in any of the Claims 1 to 7.
9. An electrode system as claimed in Claim 8, wherein the electrode system consists of an electron gun system for generating at least one electron beam in a cathode-ray tube.
10. An electrode system as claimed in Claim 8, wherein the electrode system consists of at least two flat or substantially flat electrode structures which are kept spaced at a defined distance by means of insulators.
11. An electrode system as claimed in Claim 8, wherein the electrode system consists of a structure of electric conductors arranged on an insulating plate.
12. An electrode system as claimed in Claim 8, substantially as hereinbefore described with reference to Figure 2, Figures 3a and 3b, and Figure 4 of the accompanying drawings.
13. Apparatus for carrying out the method as claimed in Claim 1, substantially as hereinbefore described with reference to and as shown in Figure 1 of the accompanying drawings.