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C. H. F. MORRIS, JR
METHOD OF PROVIDING INSULATOR WITH MULTIPLICITY
OF CONDUCTING ELEMENTS

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2 Sheets-Sheet 1

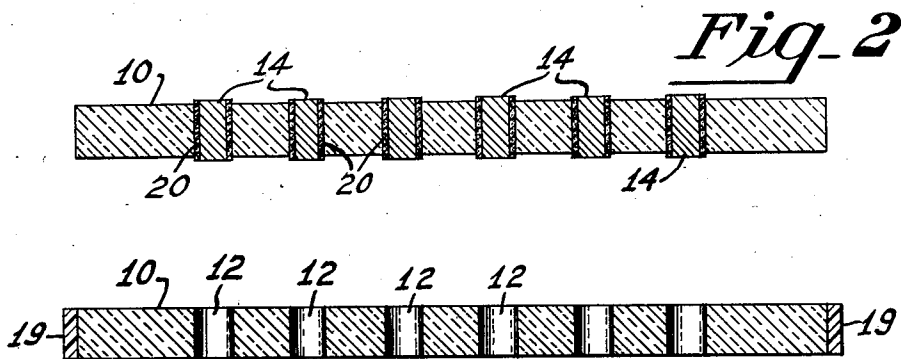
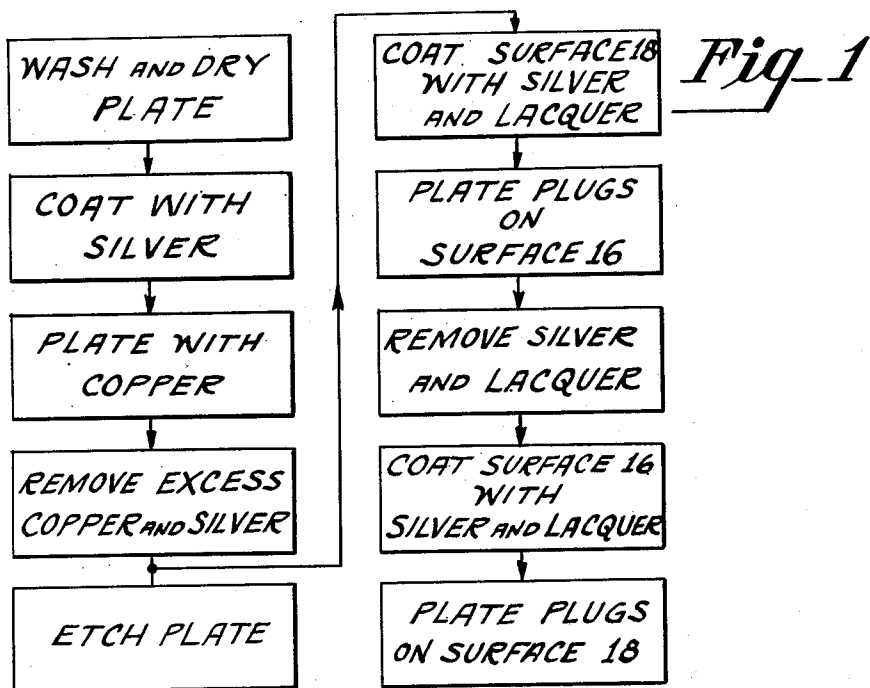


Fig-3

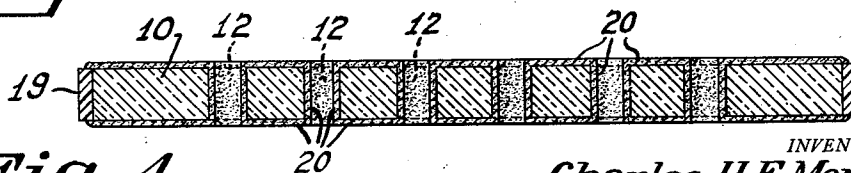


Fig-4

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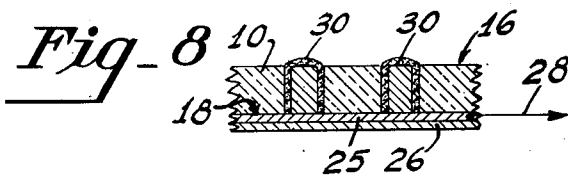
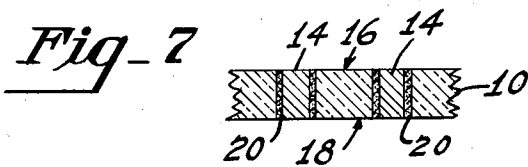
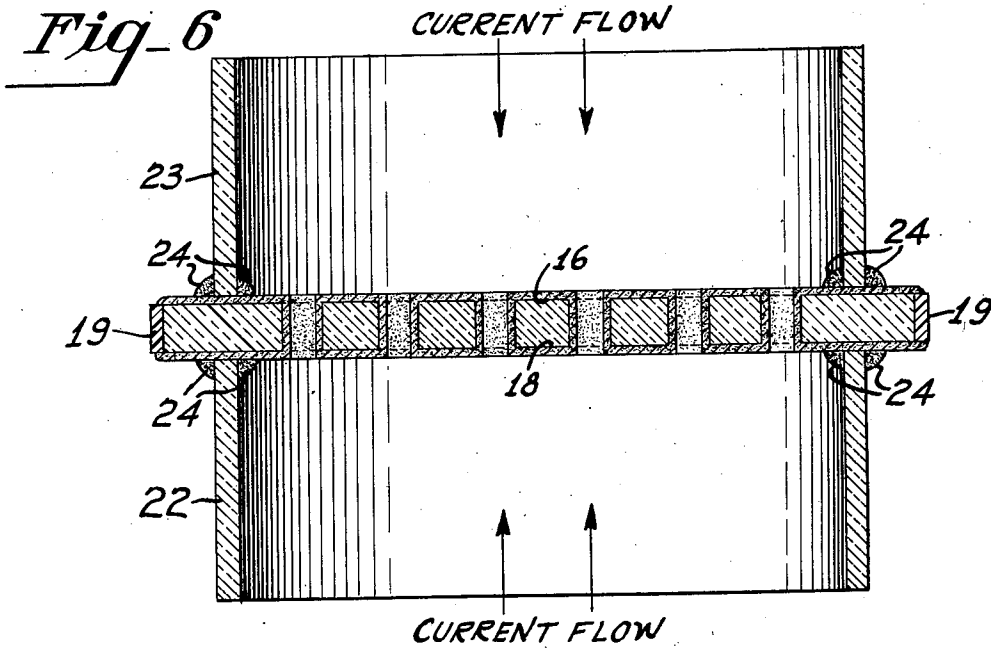
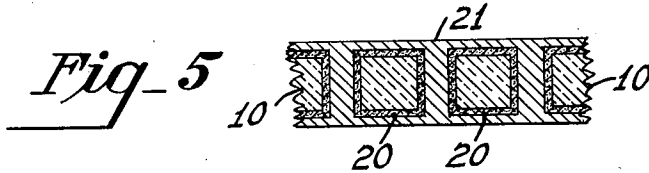
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2 Sheets-Sheet 2



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METHOD OF PROVIDING INSULATOR WITH MULTIPLICITY OF CONDUCTING ELEMENTS

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11 Claims. (Cl. 204—15)

This invention pertains to insulating plates having a plurality of conductive portions and to methods of manufacturing the same.

There are many applications in the sciences, particularly in the field of electronics, wherein it is desirable to maintain two portions of a device at a desired spacing with a plurality of small areas of contact between them. The photoelectric target portion of a television transmitter tube is one example of such a device.

A typical separating element comprises a flat sheet of insulating material, for example glass, plastic or the like having a large number of small regularly spaced openings filled with metal plugs for providing the desired electrical contact. Such a separating device requires that each opening or aperture have a metal plug which is in liquid-tight engagement therewith and which is not easily dislodged therefrom. In addition, it is generally desirable that the plugs extend through the holes and project above the surfaces of the plate on both sides thereof.

Up to the present time, no completely satisfactory method has been discovered for providing such a plate having metal plugs. One disadvantage of methods attempted heretofore is that all of the openings in the insulating plate could not be filled with metal plugs and, in general, the number filled was less than 50% of the total. Another disadvantage of such methods is that the plugs could not be mounted in substantially permanent, liquid-tight engagement with the openings.

Accordingly, an important object of this invention is to provide a new and improved method of preparing an insulating separating sheet having a plurality of liquid-tight metal plugs therein.

Another object of the invention is to provide an improved method of preparing an insulating plate having a plurality of openings substantially all of which are provided with metal plugs extending therethrough.

Another object of the invention is to provide an improved method of filling a multiplicity of minute openings in a sheet of insulating material with metal plugs.

The method of the invention may be applied to a plate of insulating material, such as glass, having a plurality of openings of a desired size, shape, and spacing extending entirely through the plate. In general, the purposes and objects of the invention are accomplished by first coating the entire insulating sheet or plate, including the walls of the openings, with a layer of a suitable electrically conducting material, such as a metal having the property of adhering well to the surface of the plate. Next, the metal which is selected to form the plugs is plated on the metal coated sheet until the sheet is completely covered and the openings are filled with the second metal. Finally, all of the coated metal adhering to the surfaces of the plate except within the openings is completely removed therefrom and only the metal plugs in the openings remain. If it is desired to have the metal plugs project above the surfaces of the insulating plate, an etching operation may be em-

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ployed to remove the necessary surface portions of the plate.

The invention is described in greater detail by reference to the accompanying drawings wherein:

Fig. 1 is a flow chart of the steps of the method;

Fig. 2 is an elevational sectional view of a device prepared according to the invention;

Fig. 3 is a sectional, elevational view of an insulating plate to be processed according to the invention;

Fig. 4 is a sectional, elevational view of the device of Fig. 2 at an early stage in its preparation;

Fig. 5 is a fragmentary sectional, elevational view of the device of Fig. 2 at another stage in its preparation;

Fig. 6 is a sectional, elevational view of the device of Fig. 4 at the next stage in its treatment;

Fig. 7 is a fragmentary sectional, elevational view of the device of Fig. 5 after the next step in the process; and,

Fig. 8 is a fragmentary sectional, elevational view of the device illustrating an alternative procedure which may be employed for one of the steps of the method.

Similar elements are designated by similar reference numerals throughout the drawings.

A device prepared according to the method of the invention is shown in Figure 2 and comprises a flat, rectangular plate or disk 10 of insulating material such as glass, plastic or the like. The insulating plate or sheet may be of any desired thickness, and, for example may be of the order of one-eighth inch thick. The plate is provided with a plurality of holes or apertures 12 which may be of any size, for example one mil in diameter and may be spaced substantially any distance apart, e. g. one mil. Each hole 12 has a metal plug 14, of copper or the like, held firmly and in liquid-tight engagement therewith. In addition, the plugs 14 extend through the holes at each end and project slightly above the opposite surfaces 16, 18 of the insulating sheet 10. None of the dimensions or materials set forth above is critical and each may be varied as desired.

The preparation of the insulating plate 10 having a plurality of metal plugs 14 therein in accordance with the present invention is preferably accomplished as follows:

Referring first to Figure 3, the insulating plate 10, e. g. of glass, having the desired number and arrangement of holes 12 is thoroughly cleaned by washing with a solution of an alcohol, for example isopropyl alcohol, and a wetting agent, for example Aerosol OS, which is diisopropyl naphthalene sodium sulfonate. Next the plate 10 is rinsed in cool distilled water. The periphery of the plate may be provided with a layer of masking material 19 if desired. Referring now to Figure 4, the next step comprises depositing a coating of silver 20 or other suitable metal over the entire unmasked portion of the glass plate and on the walls of the holes 12 therein.

If silver is the metal selected for the coating, the conventional Brashear process may be employed. This process employs a silvering solution comprising a mixture of a reducing agent such as hydrazine sulfate solution and a silver nitrate solution. The glass plate to be silvered is immersed in a quantity of the aforementioned silvering solution for a time of the order of two to three minutes to produce a satisfactory coating of silver. Alternatively, the reducing solution and the silver solution may be sprayed simultaneously onto the plate 10.

Next, referring to Figure 5, another metal 21, e. g. copper, is plated over the entire glass plate and in the holes 12 which are filled thereby. The deposition of copper may be accomplished by an electro-plating process. According to such a process the silvered sheet 10 is placed in an electro-plating bath of a suitable solution contain-

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ing ions of the metal to be plated, in this case copper. Since both surfaces of the sheet 10 are to be plated, a bar of the pure plating metal, copper, is provided in the bath on each side of the sheet. A suitable source of electric power is connected to the copper bars which serve as anodes and to the silvered sheet which constitutes the cathode in the plating process. As current flows through the solution, particles of copper plate on the silvered glass sheet 10 and in the silver-coated holes 12. It is desirable to control the flow of current so that a comparatively fine-grained copper plate is formed.

Ordinarily, in such an electro-plating procedure, copper deposits to a greater extent at the periphery of the body being plated where the current density tends to be the greatest. Such uneven distribution of copper is not critical in this method, but if it is desired to prevent it, two hollow, cylindrical insulating shields 22, 23 (Figure 6) are provided in contact with the glass plate on opposite sides thereof. The shields are of a diameter sufficient to enclose the portions of the sheet 10 to be plated and are held in contact with the plate by an insulating medium 24 such as wax or the like. The shields are thus disposed in the path of the plating current which is thereby rendered more uniform. The distribution of the plated metal is also thereby rendered more uniform.

After the holes or apertures 12 are filled with copper and the entire plate is covered with copper, it is removed from the plating bath and rinsed in cool water. Referring to Figure 7, a grinding or lapping operation is next employed to remove all of the copper and silver from the surfaces 16 and 18 of the plate 10 whereby the metal plugs 14 remain in the holes or apertures 12. The plate is then washed in alcohol or other suitable solvent such as trichlorethylene.

Finally, in order to have copper plugs 14 project above the surfaces 16 and 18 of the glass plate 10, the plate is placed in a dilute solution of an etchant such as hydrofluoric acid. The etching operation is allowed to proceed until the desired amount of glass is etched away and the metal plugs project above the surfaces of the plate to the desired extent, as shown in Figure 2. Finally the etched plate is rinsed thoroughly in cold distilled water to remove the excess etchant.

An alternative method of treating the device to raise the metal plugs above the surfaces of the insulating sheet is particularly suitable for sheets made of plastic material. This alternative method is employed after the above-described method has reached the stage represented by Figure 7, that is, where the sheet has been cleaned of metal except for the openings which are filled with the copper plugs 14. According to the alternative method and referring to Figure 8, one surface e. g. 18 of the sheet 10 is provided with a coating of silver 25 which is then covered with a layer 26 of inert material such as lacquer. An electrode 28 is connected to the silver coating and the assembly is immersed in a copper plating bath such as that described above. The plating operation deposits additional copper 30 on the copper plugs on the free surface 16 of the sheet 10. The plating is continued until the plugs are raised to the desired level above the surface of the sheet. The silver and lacquer layers 25 and 26, respectively, are then removed from the sheet and the plating operation is repeated on the surface 18.

Some of the advantages of the method of the invention are as follows: all of the holes in the insulating plate are provided with a metal plug regardless of the number, size, or spacing of the holes; the plugs are substantially uniform, homogeneous and form liquid-tight bonds with the holes; and each of the steps of the method is comparatively simple to carry out.

What is claimed is:

1. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of a first

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metal, depositing a layer of a second metal on said first metal and filling said openings with said second metal, removing said layers of said first and second metals from the surfaces of said insulating plate and leaving said metals in said openings, and raising the level of the metal in said openings above the surfaces of said insulating plate.

2. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of a first metal, depositing a layer of a second metal on said first metal and filling said openings with said second metal, removing said layers of said first and second metals from the surfaces of said insulating plate and leaving said metals in said openings, and removing portions of said insulating plate whereby the metal in said openings extends above the surfaces of said plate.

3. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of a first metal, depositing a layer of a second metal on said first metal and filling said openings with said second metal, removing said layers of said first and second metals from the surfaces of said insulating plate and leaving said metals in said openings, and plating more of said second metal on the metal in said openings to raise the level thereof above the surfaces of said plate.

4. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of silver, depositing a layer of a second metal on said silver and filling said openings with said second metal, removing said layers of silver and said second metal from said insulating plate and leaving said silver and said second metal in said openings, and raising the level of the metal in said openings above the surfaces of said plate.

5. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of silver, depositing a layer of copper on said silver and filling said openings with said copper, removing said silver and copper from said insulating plate and leaving said silver and copper only in said openings, and raising the level of the copper in said openings above the surfaces of said insulating plate.

6. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of silver, electroplating a layer of copper on said silver and filling said openings with said copper, removing said silver and copper from said insulating plate and leaving said silver and copper only in said openings, and raising the level of the copper in said openings above the surfaces of said insulating plate.

7. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of silver, positioning hollow cylindrical insulating shields adjacent the opposite surfaces of said plate to achieve uniform deposition of another metal to be electroplated, electroplating a layer of copper on said silver and filling said openings with said copper, removing said silver and copper from said insulating plate and leaving said silver and copper only in said openings, and raising the level of the copper in said openings above the surfaces of said insulating plate.

8. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said

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plate and the walls of said openings with a layer of silver, positioning hollow cylindrical insulating shields adjacent the opposite surfaces of said plate to achieve uniform deposition of another metal on said silver and filling said opening a layer of copper on said silver and filling said openings with said copper, removing said silver and copper from said insulating plate and leaving said silver and copper only in said openings, and removing portions of said insulating plate whereby the metal in said openings extends above the surfaces of said plate.

9. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of silver, positioning hollow cylindrical insulating shields adjacent the opposite surfaces of said plate to achieve uniform deposition of another metal to be electroplated, electroplating a layer of copper on said silver and filling said openings with said copper, removing said silver and copper from said insulating plate and leaving said silver and copper only in said openings, and plating more of said second metal on the metal in said openings to raise the level thereof above the surfaces of said plate.

10. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of a first metal which forms a bond with said plate, positioning hollow insulating shields adjacent the opposite surfaces of said plate to achieve uniform deposition of another metal to be deposited thereon, depositing a layer of a second metal on said layer of said first metal and filling said openings with said second metal, removing said layers of said first and second metals from said insulating plate and leaving said first and second metals only in said openings, and applying a conductive lamina to one surface of said plate, coating said lamina with a layer of insulating material, depositing an additional quantity of said second metal on the metals in the openings on the free surface of said insulating plate, removing said con-

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ductive lamina and said layer of insulating material from said one surface, applying another conductive lamina and another layer of insulating material on said free surface, and depositing an additional quantity of said second metal on the metals in the openings on said one surface, and finally removing said other lamina and said other layer of insulating material.

11. The method of providing an insulating plate having a plurality of openings with metal plugs within said openings comprising the steps of coating the surfaces of said plate and the walls of said openings with a layer of silver, positioning hollow cylindrical insulating shields adjacent the opposite surfaces of said plate to achieve uniform deposition of another metal to be electroplated, electroplating a layer of copper on said silver and filling said openings with said copper, removing said silver and copper from said insulating plate and leaving said silver and copper only in said openings, applying a layer of silver to one surface of said plate, coating said layer of silver with a layer of insulating material, plating copper on the metals in the openings on the free surface of said insulating plate, removing said layers of silver and insulating material from said one surface, applying another layer of silver and another layer of insulating material on said free surface, plating copper on the metals in the openings on said one surface, and removing said other layers of silver and insulating material.

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