United States Patent [19]

Coleman

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[54] **METHOD OF FABRICATING A PLASMA CHARGE TRANSFER DEVICE**

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[73] Assignee: **The National Cash Register Company**, Dayton, Ohio

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[52] **U.S. Cl.** **316/20**, 313/188

[51] **Int. Cl.** **H01j 9/38**

[58] **Field of Search** ..... 316/17–20; 315/169 R, 169 TV; 313/201, 109.5, 188, 204, 205; 117/5.5, 212, 217

[56] **References Cited**

UNITED STATES PATENTS

3,499,167	3/1970	Baker et al.	315/169
3,262,900	7/1966	Schreiber	117/5.5 X
3,588,571	6/1971	Uemura	313/109.5
3,701,917	10/1972	Kupsky	313/188

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[57] **ABSTRACT**

The method of fabricating a plasma charge transfer device comprising forming electrodes on a pair of substrates and coating certain electrodes with a coating of dielectric material which forms the wall on which a charge is formed during the operation of the device, forming cavity material on the pairs of substrates to hold an ionizable medium to be activated by an electric pulse applied to the electrodes, and positioning and sealing the two pairs of substrates to enclose the cavity, and filling the cavity with the ionizable medium to form a complete plasma charge transfer device.

4 Claims, 5 Drawing Figures

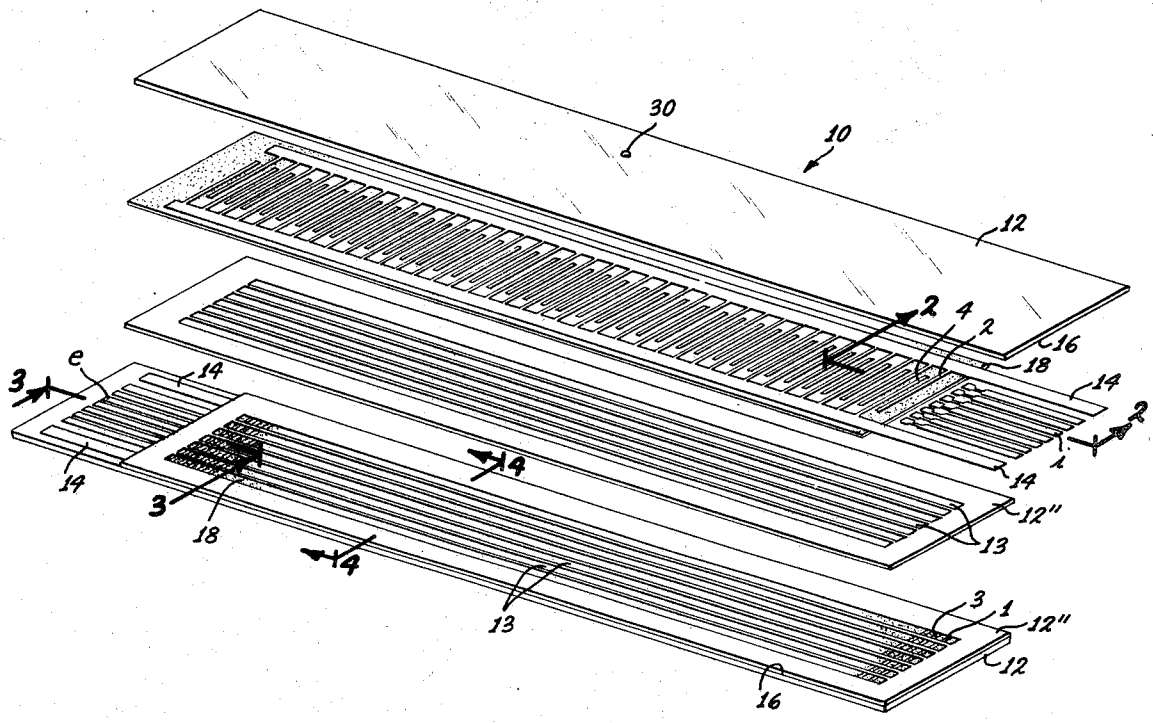


FIG. 1

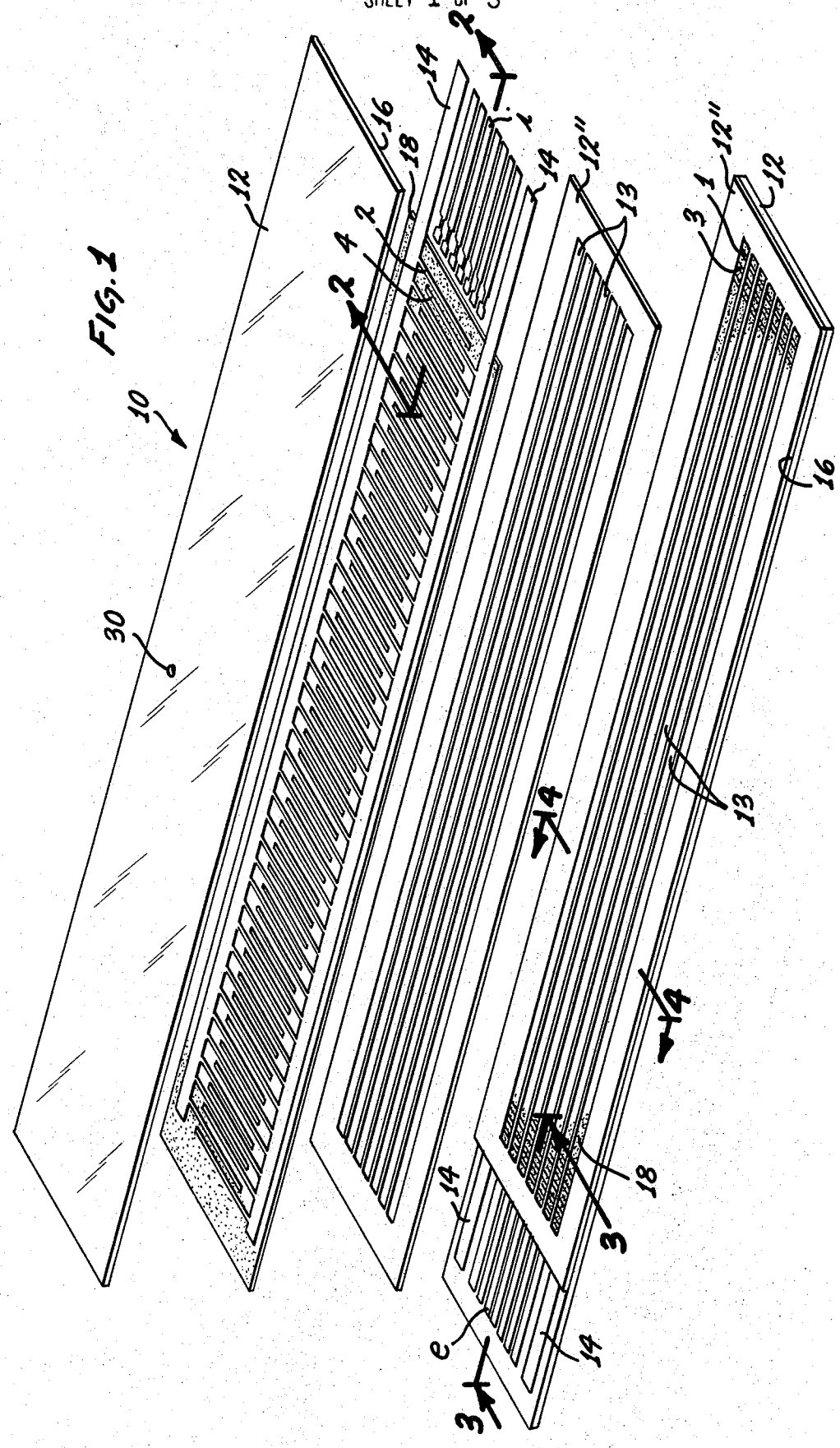


FIG. 2

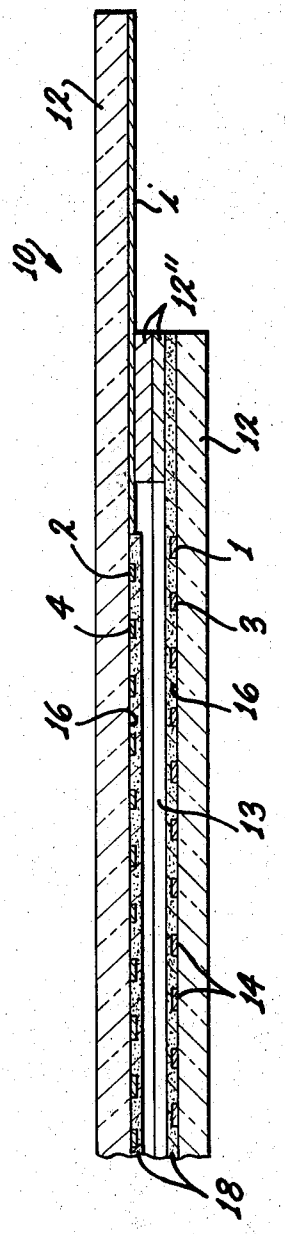


FIG. 3

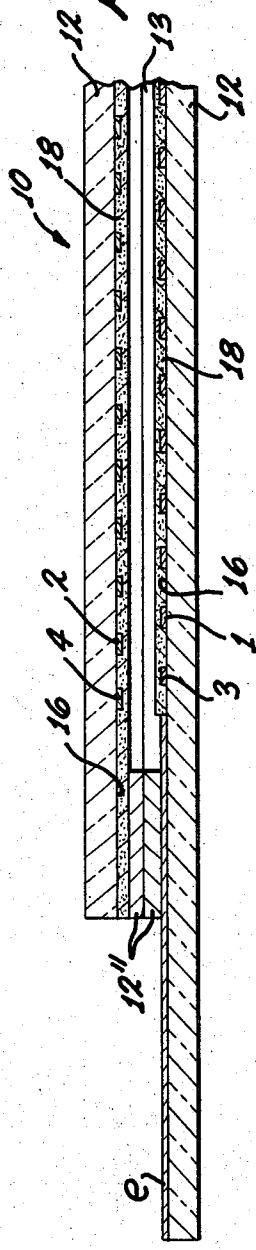


FIG. 4

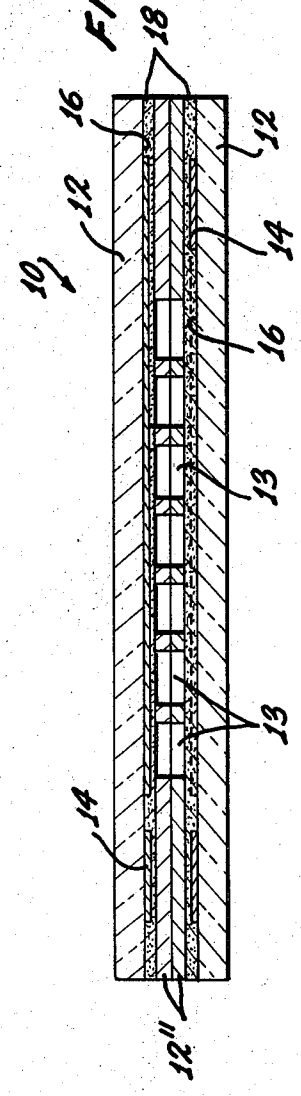
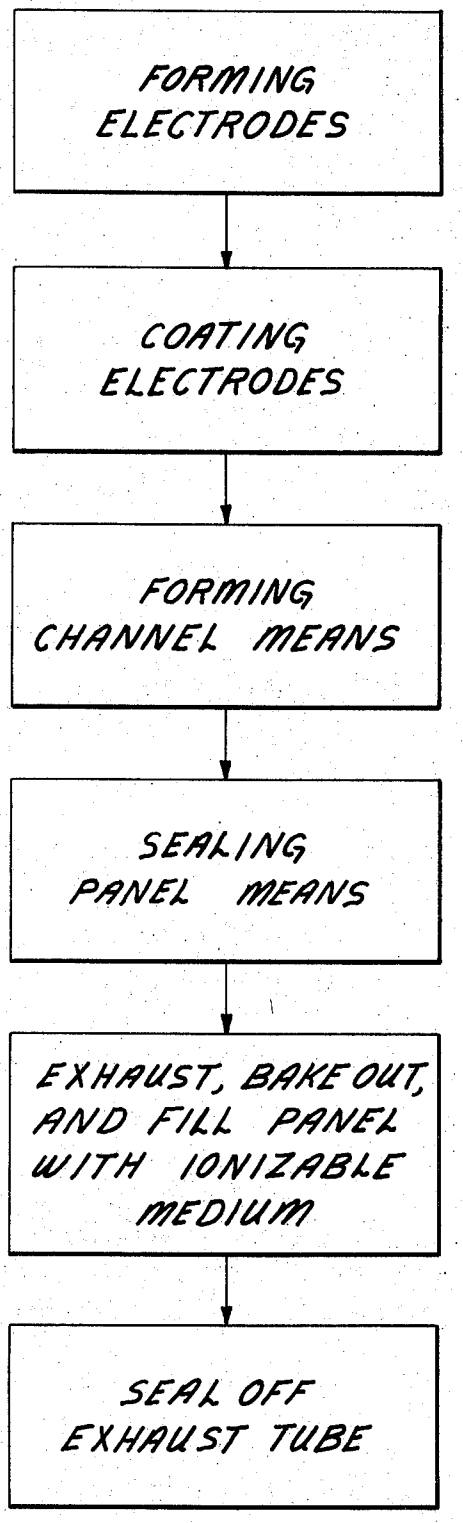


FIG. 5


FORMING ELECTRODES
COATING ELECTRODES
FORMING CHANNEL MEANS
SEALING PANEL MEANS
EXHAUST, BAKE OUT, AND FILL PANEL WITH IONIZABLE MEDIUM
SEAL OFF EXHAUST TUBE

METHOD OF FABRICATING A PLASMA CHARGE TRANSFER DEVICE

BACKGROUND OF INVENTION

1. Field of Invention

This invention relates to the method of making a plasma charge transfer device in which the plasma phenomenon is used to form a shift register memory and/or display.

In the physical construction of a plasma charge transfer device, an ionizable gas is contained in an enclosure having a plurality of transfer electrodes aligned parallel on opposite inside walls of the enclosure; the transfer electrodes being covered with a dielectric material and offset one another throughout its length. The device is serially addressed by applying electrical pulses to an input electrode which can be either directly (uncoated) or capacitively (coated with a dielectric material) coupled to the gas and forming with the first or nearest of the offset transfer electrodes, the first gaseous cell in the device. By properly applying pulses to the electrodes, this gas will be caused to form gaseous discharges (plasma) which in turn form trapped charges on the dielectric coating on the electrodes, which trapped charges are utilized to transfer the plasma charge serially along channels formed in the enclosure, or held in place at any time by the proper application of alternating potential to any two oppositely adjacent electrode pairs.

This plasma charge transfer phenomenon may be utilized to form either a shift register or a display device and bits of information or dots of light, depending on how the device is to be used, can be fed into the device by the proper application of input signals and when numerous channels are placed side by side a matrix can be formed to as to provide a display.

2. Cross Reference to Other Applications

The foregoing is a brief description of a plasma charge transfer device and its operation as a shift register and a display is more fully described in the U.S. application of William E. Coleman and Clarence W. Kessler filed May 22, 1972, Ser. No. 255,547, which is incorporated by reference herein and made part hereof.

SUMMARY OF THE INVENTION

This invention teaches the method of fabricating a plasma charge transfer device as a panel utilizing the first of a pair of sheet or substrate dielectric material, usually a relatively thin flat, glass plate one-sixteenth to one-eighth inch, upon which are formed electrodes, as by silk screening. Certain of the electrodes are then covered with a dielectric material which forms the walls on which the trapped charges resulting from the discharge of the ionizable medium are formed during the operation of the device. Over the electrodes and coating material still another material is placed as by silk screening to ultimately form an enclosure to contain the ionizable medium.

The foregoing step is repeated and after the two substrates are formed by the foregoing method, the substrates are aligned and sealed face to face with the substrates on the outside. An exhaust port is then formed in one of the substrates to be utilized to exhaust the cavities, i.e., channels, and thereafter an ionizable gas is placed therein, and the device is sealed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded view of the two halves of the plasma charge transfer device showing each of the elements as separate and planar for illustrative purposes;

FIGS. 2, 3, and 4 are cross-sectional views of the plasma charge transfer device in its final form as a panel; and

FIG. 5 is a flow chart showing the steps in the method of fabricating the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Before describing the method of fabrication, a brief description of the device itself is in order. Reference is thus made first to FIGS. 1–4.

The plasma charge transfer device as a panel, indicated in its entirety as **10**, is formed into two halves on substrates **12** of suitable dielectric material such as glass, defining a pluraity of the channels **13** containing ionizable gas, such as neon and nitrogen, at a predetermined pressure. The plurality of electrodes **1–4**, which may be transparent if desired, are located on the wall of the substrate opposite one another in parallel alignment in a laterally offset relationship to subject ionizable gas to an electric field when a suitable potential is applied to any two opposing electrodes.

In FIG. **1**, four conductors **1–4** are located on the inside wall **16** of each of the flat substrates along the outer edge thereof forming continuous conductors with the electrodes **1–4** shown as furcations extending laterally, and in this embodiment, two sheets of dielectric material **18** for coating the electrodes overlay the furcations. For purposes of clarity, the top sheet **12** of dielectric material is shown separately.

In FIG. **3**, and, as shown sandwiched between the two substrates **12**, there are two flat sheets of opaque glass cavity forming material **12''** which together with the substrates and the dielectric coating **18** form seven channels **13** more clearly shown in FIG. **1**. As shown in FIGS. **2** and **3**, the two halves of the device are sandwiched together as a panel facing one another and aligned to form the channels but the two halves are offset lengthwise to another to conveniently expose the ends of the conductors **14**. In addition, this offset also exposes seven input electrodes *i* and the seven erase electrodes *e*.

Inasmuch as the plasma discharge device is more fully described in the copending application of William E. Coleman and Clarence W. Kessler supra, no further explanation is deemed necessary herein.

As explained in the foregoing, for sake of clarity of disclosure, FIG. **1** shows the electrodes and dielectric coating material and channel or cavity forming material as separate sheets whereas, in fact, they are formed by the following method forming the present invention which will now be described in detail.

The substrate **12** is a flat sheet of glass preferably about one-eighth of an inch thick, and preferably a soda lime glass on which the electrode pattern is silk screened onto the substrate. The material forming the electrodes **1–4** and conductors **14** in the practicable embodiment is a Silver Paste, Number 590, and sold by the Electro Science Company of Philadelphia, Pa. This is fired in a furnace and, being a paste of glass mixed with silver, when fired it becomes essentially glass but

remains conductive since silver is dispersed within the glass. The firing also binds the glass to the substrate.

In lieu of the foregoing, in the event it is desired to make the electrodes transparent, a tin oxide would be coated on the substrate, then a resist material of the electrode pattern would be placed on the tin oxide and the electrodes would then be etched in the conventional etching manner.

In the next step, a glass paste is screened over certain of the electrodes to coat the same with coating **18** except the input electrode *i* and erase electrode e which will be DC coupled to the gas when the device is finally assembled. The reason for leaving input electrode *i* uncoated is more fully explained in the Coleman and Kessler application supra. One such material for this coating **18** is essentially 75 percent lead oxide glass; the remaining ingredients being boron oxide and aluminum oxide sold under the commercial name of Vitta 1001 by the Vitta Corporation of Wilton, Conn.

This coating material **18** is then fired to form a glass coating.

The next step is to silk screen the cavity material **12''** with a crystallizing glass paste, such as 1014 also sold by Vitta Corporation, which when fired will turn opaque as compared to the vitreous glass paste **18** which covers the electrodes and which is essentially clear when fired. It has been found that the crystallizing material will hold its shape better and therefor form the cavities better.

The foregoing steps in the method are repeated since this essentially makes only one-half the device.

Thereafter, in one of the halves, an aperture **30** is formed in a substrate and opening into the cavity to be utilized as an exhaust outlet once the two halves are formed. The two halves are then faced front to front so that the electrodes **1–4** are staggered and the channels, the input and erase electrodes i and e are appropriately aligned.

At this point, still another type glass paste is placed around the periphery of the cavity and finally a glass paste is placed on the edges of the substrate to seal the two halves.

After the finished substrates are thus sandwiched together, it is again fired so that these last two applied glass pastes form a glass and seals the two halves together. The material used to seal the two edges together is sold by Corning Glass Company of Corning, N.Y., under the number 7575.

Once the two plates are sealed together, a suitable exhaust tube is placed over the aperture **30** and sealed as before to the plate and the device is placed in a vacuum and checked for leaks. If there is no leak, it is placed in a baking oven to about 400° under a vacuum, so as to remove all water vapors and impurities and thereafter it is filled with ionizable medium and the exhaust tube is sealed off.

From the foregoing it can be seen that there is disclosed a method of fabricating a commercially practical version of a plasma charge transfer device.

What is claimed is:

1. A method of fabricating a plasma charge transfer device comprising the steps of:

a. forming electrodes on a pair of dielectric substrate meansby silk screening said electrodes on said substrate means and firing to form a permanent bond therewith;

b. forming a dielectric coating over said electrodes by silk screening said dielectric coating on said electrodes and firing to form a permanent bond therewith;

c. forming a portion of a plurality of channel means with a channel defining material on the dielectric coating on said electrodes by silk screening said channel defining material on the dielectric coating on said electrodes and firing to form a permanent bond therewith;

d. positioning and sealing the pair of dielectric substrate means to form a plurality of channel means; and

e. filling said plurality of channel means with an ionizable medium.

2. The method claimed in claim **1** wherein said plurality of channel means are first evacuated and then filled with an ionizable medium.

3. The method claimed in claim **1** wherein said pair of dielectric substrate means are positioned and sealed such that the electrodes on one dielectric substrate are staggered in position with respect to the electrodes on the other substrate.

4. The method claimed in claim **1** wherein said pair of dielectric substrate means are positioned and sealed such that said formed electrodes are parallel to each other.

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