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Langston, Jr. et al.

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[54] **SEALING TECHNIQUE FOR GAS PANEL**

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[52] **U.S. Cl.** **316/20,** 313/220

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

[58] **Field of Search** .... 316/19, 20; 315/169 R; 313/109.5, 182, 220; 29/630 B

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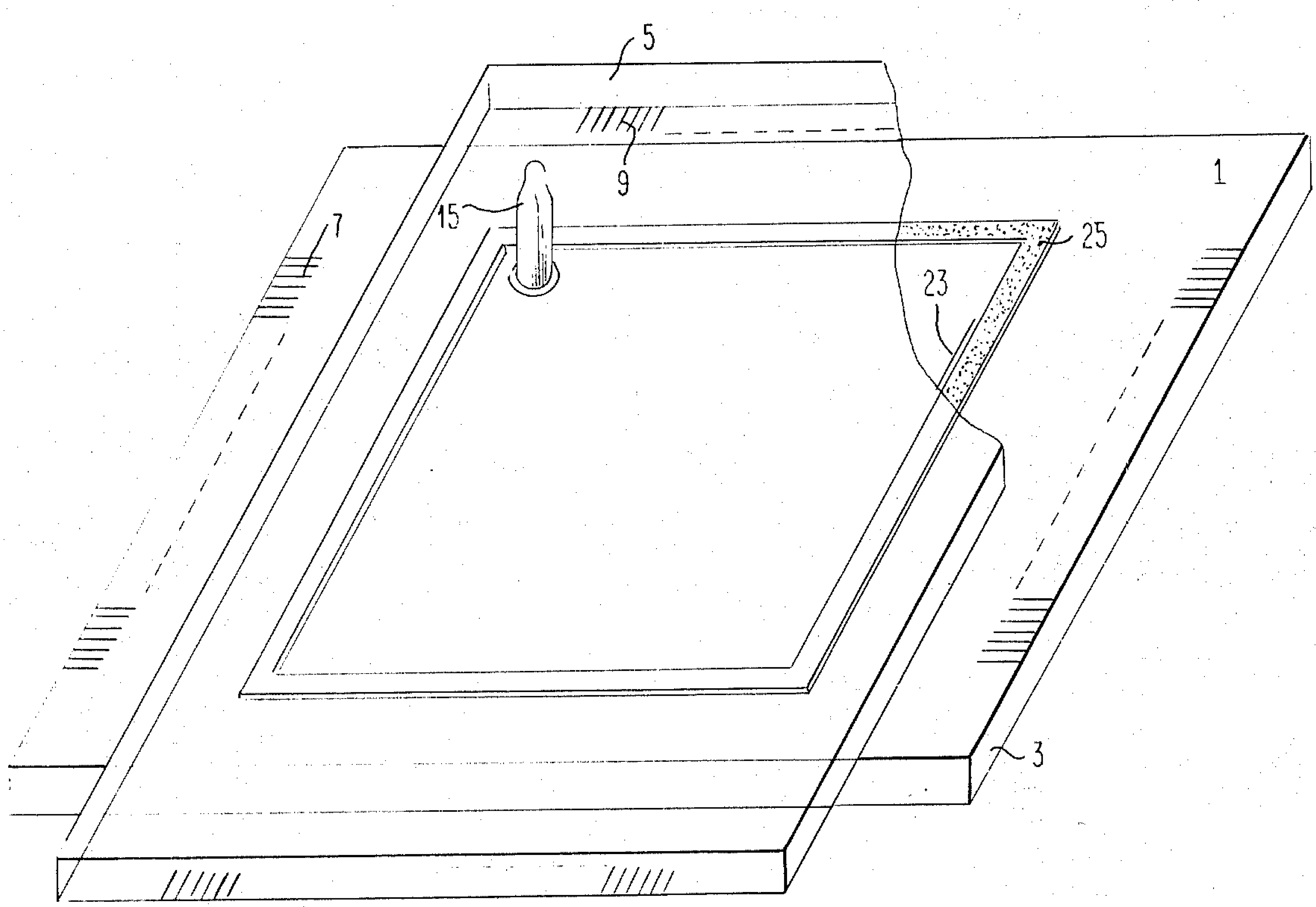
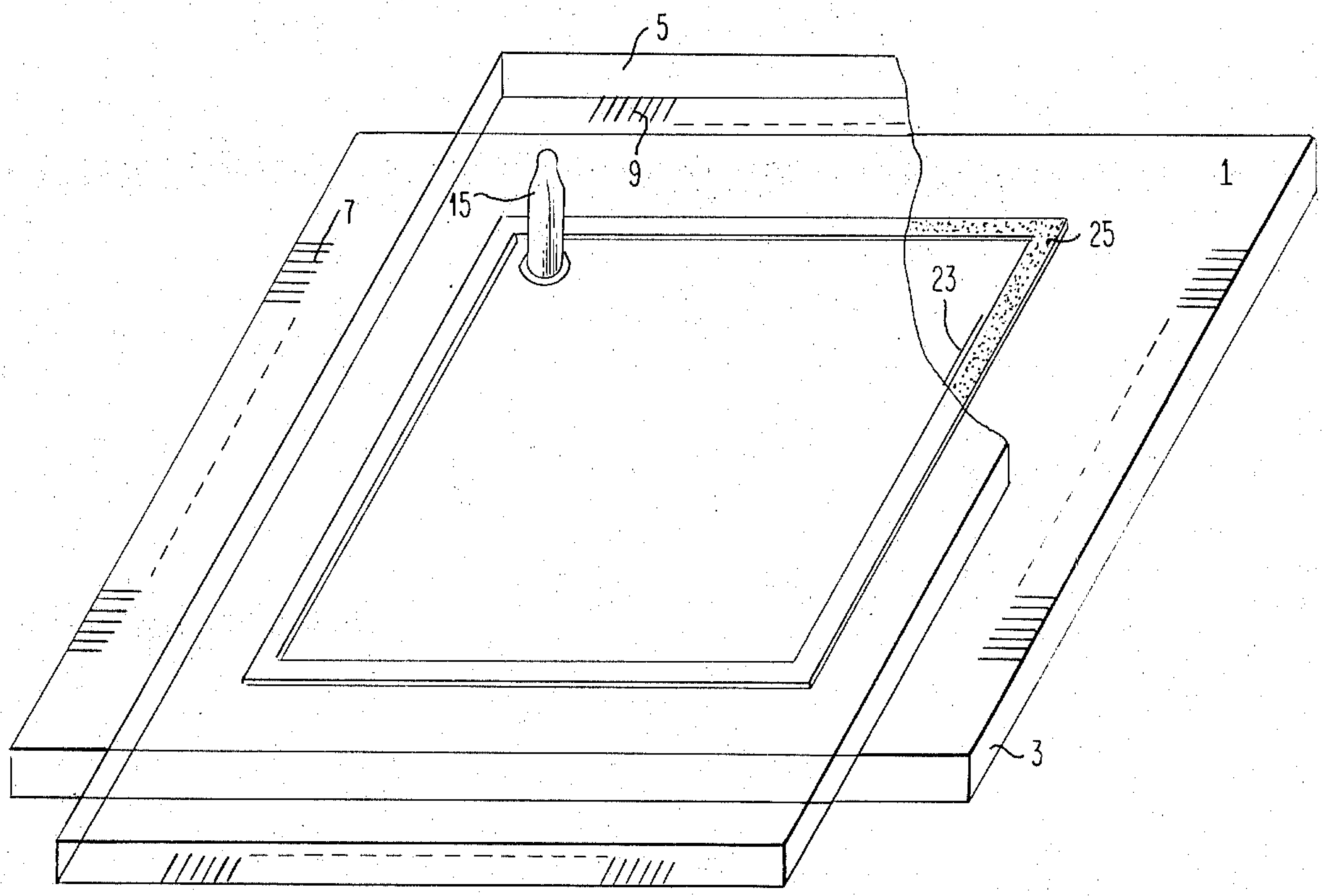
[57] **ABSTRACT**

In a method for sealing a gaseous display and/or memory device, an unfused, low-softening point glass rod sealant, arranged in a picture frame pattern, together with high-softening point glass spacing rods are positioned between a pair of aligned flat glass plates, and the resulting assembly is placed in an oven enclosure. The assembly is then heated above the softening point of the glass rod sealant which reflows and fuses the plates to establish a gas-filled envelope. As the sealing material softens, the upper plate settles u;on the spacing rods to thus establish a predetermined and uniform spacing within the envelope.

6 Claims, 5 Drawing Figures




5
9
1
7
15
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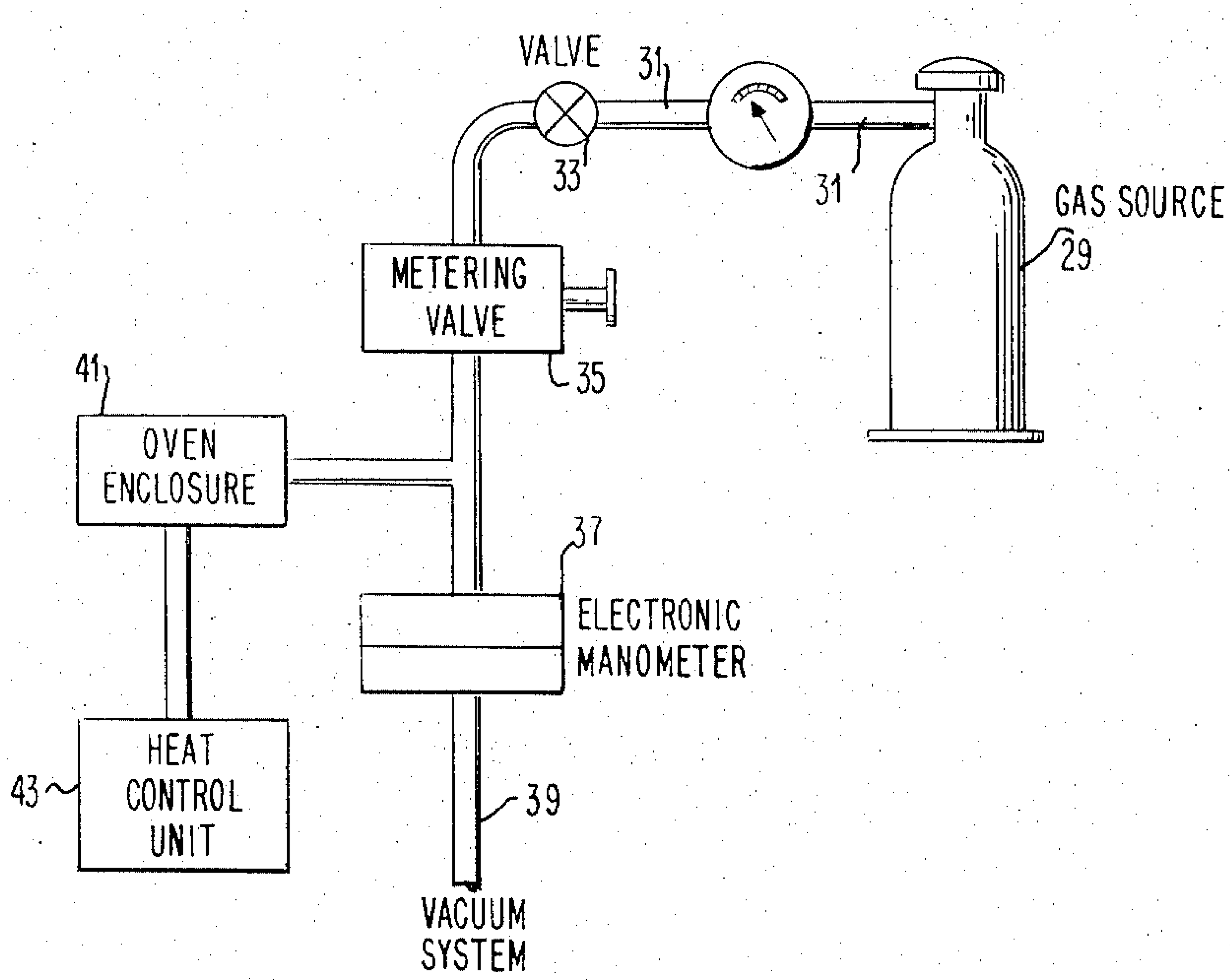
23
3

FIG. 1


VALVE
31
33
31
GAS SOURCE
29
METERING VALVE
35
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OVEN ENCLOSURE
37
ELECTRONIC MANOMETER
43
HEAT CONTROL UNIT
39
VACUUM SYSTEM

FIG. 5

FIG. 2

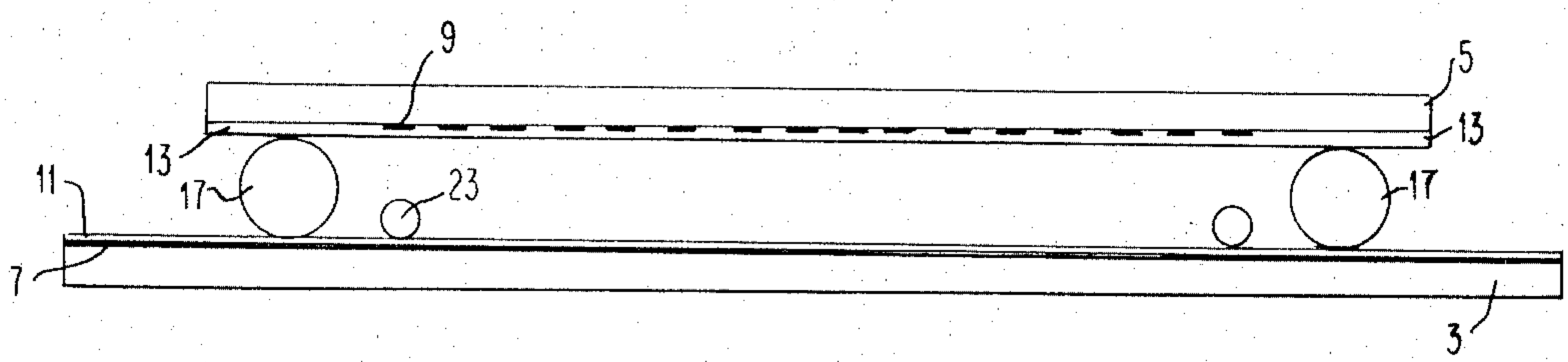


FIG.4

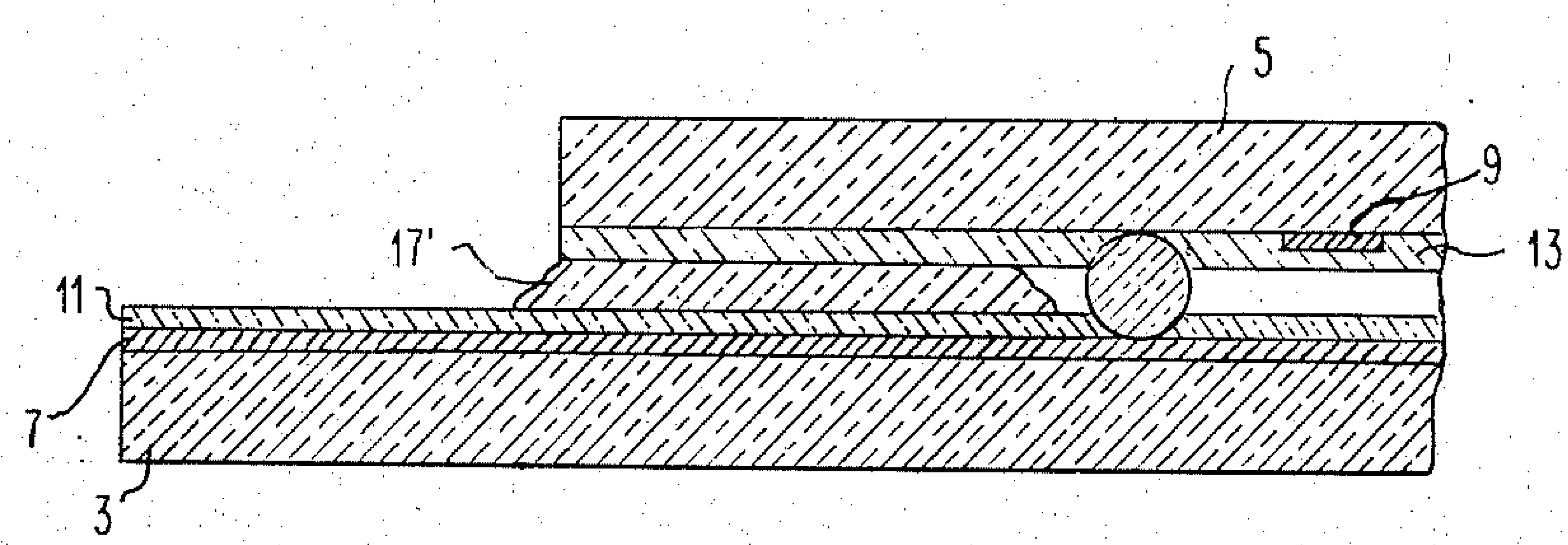
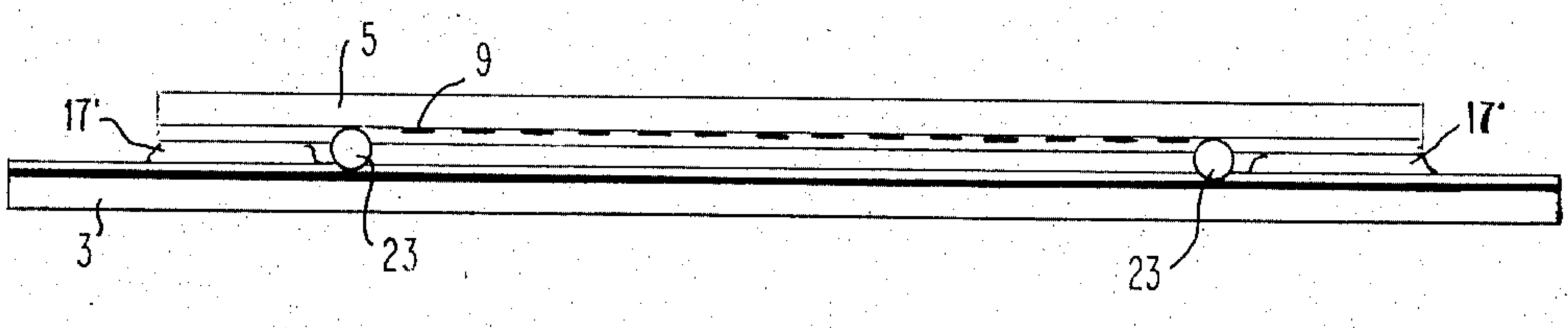


FIG. 3



SEALING TECHNIQUE FOR GAS PANEL

CROSS-REFERENCE TO RELATED APPLICATIONS

U. S. Pat. application Ser. No. 214,174 for "Gas Display Panel Without Exhaust Tube Structure," by Donald M. Wilson, filed Dec. 30, 1971.

U. S. Pat. application Ser. No. 214,348 for "Gas Panel Fabrication," by P. H. Haberland et al., filed Dec. 30, 1971.

U. S. Pat. application Ser. No. 176,625 for "Dielectric Discharge Insulator for Gaseous Discharge Device," by Peter H. Haberland et al., filed Aug. 31, 1971.

BACKGROUND OF THE INVENTION

A gaseous display and/or memory device comprises an open panel configuration of electrically isolated but not physically isolated cells in which individual cells or sites are selected by energizing associated pairs of orthogonal drive lines disposed on opposite sides of a gas-filled envelope which, when appropriately and selectively energized, cause the gas in the sites between the selected conductors to ionize. In order to provide substantially uniform resolution over the entire display surface, it is essential that the space between opposing walls of the gas envelope be maintained substantially uniform and that the walls of the chamber be sealed to provide a gas-filled container. Initially, such panels were sealed using epoxy which produced outgassing, i.e., impurities in the gas mixture which substantially lowered the life of the panel. One method for eliminating outgassing is bakeout of the panel in an oven, but the epoxy decomposed when subjected to a bakeout temperature of approximately 400°C. In situ fabrication of gas panels utilized solder glass for sealing, but this presented a problem in obtaining a uniform deposition of the solder glass sealant, resulting in an undesirable manual operation in attempting to apply a uniform layer of solder glass to one of the panel plates. Finally, a sealing operation using transfer tape was attempted, but this required an extra bakeout cycle to bakeout the binder and frequently resulted in entrapped bubbles producing a weakened seal.

SUMMARY OF THE INVENTION

The foregoing problems are resolved and other related objects achieved by arranging high-softening point glass spacing rods and low-softening point glass sealing rods in picture frame configurations between disjoint high-softening point glass plates. In the heat fusion stage, the glass sealing material fuses the plates to form a containing envelope around the gas surrounded by these elements. As the sealing material softens, the upper plate collapses gradually toward and settles upon the spacing rods, the spacing rods having a diameter less than the initial thickness of the unfused sealant, establishing the predetermined spacing of the plates and providing point-to-point contact around the entire sealed surface. The glass sealant material is selected to have viscosity sufficiently low to flow during the heat fusion cycling, and yet high enough so that it will not run off the voids during such cycling. Following the panel sealing, the panel is pumped down and backfilled during a bakeout operation to eliminate outgassing or other impurities, and the tubular orifice projecting from one of the plates and utilized as a vehicle for evacuation and gas filling is tipped off, thereby sealing the gas within the panel. Thus during the fabrication as described above, vacuum and gas are coupled to the envelope while the exterior of the glass plates receives atmospheric pressure.

Accordingly, an object of the present invention is to provide an improved sealing method for a gaseous discharge device.

Another object of the present invention is to provide an improved gas panel assembly utilizing soft glass sealant and hard glass spacing rods.

An associated object of the present invention is to provide an improved process for providng a gas panel seal utilizing a soft glass rod sealant and a hard glass rod spacer wherein the upper plate settles upon the spacing rods during a bakeout operation thus establishing a predetermined and uniform spacing within the envelope.

The foregoing and other objects and features of the present invention may be more fully appreciated and understood by referring to the following detailed description of a specific embodiment thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially schematic perspective view of a gas panel constructed in accordance with the teaching of the instant invention.

FIGS. 2–4 are sectional views of the assembly of FIG. 1 before and after the heat fusion state of the assembly processing.

FIG. 5 is a schematic view of vacuum furnace apparatus utilized in the practice of the present invention to provide evacuation, gas-filling and heat-sealing stages.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and more particularly to FIG. 1 thereof, there is illustrated a gaseous discharge assembly fabricated in accordance with the teaching of the instant invention. The panel assembly **1** consists of lower glass substrate **3** and an upper glass substrate **5** on which transverse passivated metallized conductor arrays **7** and **9**, respectively, are formed. Conductor arrays **7** and **9** may be formed on substrates **3** and **5** by a number of well-known processes such as photoetching, vacuum deposition, stencil screening, etc. While the conductor arrays **7** and **9** may be wires or filaments of copper, gold, silver, aluminum or any other conductive metal or material, formed in situ conductor arrays of transparent, semi-transparent or opaque conductive material are preferred since they are more easily deposited on and adhered to the substrates **3, 5**. In the embodiment constructed in accordance with the teaching of the instant invention, opaque chrome-copper-chrome conductors having a split conductor configuration such as that described in the foregoing application Ser. No. 214,348 are utilized in one of the conductor arrays as the preferred electrode configuration for maximum light output. While not evident in FIG. **1** since they are transparent, each of the conductor arrays **7** and **9** have dielectric layers **11** and **13** (FIG. **3**) formed thereon. The two metallized passivated dielectric coated front and rear glass plates **3** and **5** and exhaust tube **15** are formed into an integral structure by heat union of rod sealant **17** with dielectric plate coatings **11** and **13** of glass substrates **3** and **5**, respectively. The broken-away portion of FIG. **1** indicates an edge spacer rod **23**, one of which would be utilized around each edge in the preferred embodiment shown in FIG. 1. However, the number, spacing and configurations of the spacing rods may vary with various considerations such as the geometry of the panel and are still considered to fall within the scope of the instant invention. The fused seal is indicated in the broken-away section of FIG. 1 as element 25. The dielectric layers 11 and 13 (FIG. 2), formed from sprayed and heated glass frit, cover the conductor arrays indicated schematically as 7 and 9 in FIG. 1 intersecting at illuminable crosspoints of the panel. All glasses used in the fabrication of the subject panel such as the substrate, dielectric layers, orifice, orifice sealant, border sealant, etc., must have compatible thermal coefficients of expansion, albeit differing optical, physical, dielectric and heat-softening properties. The glass substrates 3 and 5 have substantial thickness (e.g. one-fourth inch), the only requirement for such support members being that they be nonconductive and good insulators and substantially transparent for display purposes. Ordinary ¼ inch commerical grade soda-lime-silica glass is utilized in the preferred embodiment. While the panel illustrated in FIG. 1 is representative of a panel after sealing in accordance with the instant invention, reference is made to FIGS. 2–4 for a more complete description of the operation of the sealing process.

Referring now to FIG. 2, the relative position of the glass plates 3 and 5 with their associated dielectric coated conductor arrays prior to the sealing process is illustrated. While shown exaggerated for ease of understanding, the relative size of sealing rod 17 with respect to the spacing rod 23 is illustrated. In a preferred embodiment constructed in accordance with the instant invention, the soft glass sealant 17 is approximately 40 mils in diameter, while the spacer rod 23 is approximately 7 mils in diameter. However, as noted previously, the configuration of the rods may vary, and other configurations of both sealing and spacing rods such as rectangular rods could be substituted for the circular rods illustrated in the preferred embodiment. When laid out in the general configuration shown in FIG. 2, the component parts of the panel are placed in an oven which is then heated to a temperature sufficient to produce wetting or melting of the low-softening point envelope sealant 17 which, as previously described, comprises in the preferred embodiment a single rod in the form of a picture frame positioned outside the normal display area of the panels. The peripheral spacer rod 23 could comprise a single rod in the same general picture frame configuration or four or more separate spacer rods. The unjoined assembly, when positioned in the desired orientation shown generally in FIG. 2, is placed in an oven enclosure and then heated in accordance with the sequence more fully described hereinafter such that the soft glass sealant 17 softens, flows and fuses with the dielectric metallization coating layers 13 and 11. In practice, the sealing rods are positioned beyond the viewing area of the panel and thus beyond the conductor configurations comprising conductor arrays 7 and 9, although this is not a requirement. When the assembly reaches the wetting temperature in the oven, the upper plate 5 gradually settles against spacers 23, establishing the desired final dimensions of the gas-filled sealed envelope contained between the plates. While the weight of the upper plate 5 is normally adequate, a glass weight providing a pressure of up to 5 lbs. per square inch throughout the sealing area may be added to upper plate 5. Thickness and viscosity of the unfused envelope sealant are selected so that upon softening and flowing the sealant forms a uniform void-free lining around the rectangular parallelepiped gas enclosure space shown within the sealed area bounded by seal 25 in FIG. 1. When the enclosure is returned to room temperature through a controlled cycle, the fused border sealant hardens into a firm totally impervious seal. The resultant seal is shown in FIG. 3, wherein the rod 17 has melted to the point shown as 17′ and the space within the gas envelope is controlled by the spacer rods 23. An enlarged view of the left seal in FIG. 3 is illustrated in FIG. 4, and it will be appreciated that an identical sealing operation and sequence would simultaneously take place along the four edges to be sealed within the panel.

Referring briefly to FIG. 5, the apparatus for providing the pumpdown, bakeout and backfill operation required to fabricate a gas panel is illustrated schematically in FIG. 5. When the panel is sealed in the manner described above, the gas from a gas source 29 is applied through conduit 31 and valve 33 to a metering valve 35 which controls the gas to the desired pressure. Also connected to the metering valve 35 is an electronic manometer 37, which is connected through conduit 39 to a vacuum system. A mechanical pump comprising a portion of the vacuum system creates an initial vacuum below 50 TOR, while a diffusion pump also conventional creates a higher vacuum in the area of 10^{-6} to 10^{-7} TOR. After this pumpdown, a bakeout cycle is provided in oven enclosure 41 to eliminate any remaining impurities within the gas panel, and following the vacuum bakeout the panel is backfilled with gas from the gas source 29. The apparatus of FIG. 1 is considered adequate for an understanding of the present invention. Typical parameters associated with the preferred embodiment of the subject invention are as follows: Glass plates 3 and 5 are conventional soda-lime-silicate glass one-fourth inch in thickness. The glass sealing rods 23 are a hard glass composition described more fully hereinafter which provide a uniform gas spacing of 7 mils. Dielectric layers 11 and 13 may comprise 1 mil thick lead-borosilicate glass sprayed and fired at 600°C. Metallization conductors 7 and 9 are chrome-copper-chrome conductors having chrome layers of 1,000 angstroms and an intermediate copper layers of 10,000–20,000 angstroms which are passivated in a forming gas as described in the aforereferenced application Ser. No. 214,348. The preferred dielectric material has the following composition:

Lead Oxide PbO — 74.46%
Boron Oxide B_2O_3 — 14.95%
Silicon Oxide SiO_2 — 3.24%
Aluminum Oxide Al_2O_3 — 7.35%

Summarizing the gas panel fabrication process utilized in the instant invention, the plates, plate sealant, spacer tubes and tube sealants are prepared, the upper plate having a hole for tube coupling and the interior surfaces of the plates metallized, i.e., having the metallic conductors deposited, etched and passivated and the lead-borosilicate powdered glass frit which comprises the dielectric layer sprayed and reflown over the conductors. The component parts are then assembled in an unjoined state as shown in FIG. 2 and placed in the oven used only for temperature cycling to heat-fuse the components into an integral assembly. When the panel has been sealed in the above described manner, the space confined by the joint assembly is evacuated and baked out to establish fusion of the tube sealant to the tube and outer surface of the rear plates and fusion of the soft rod sealant between the plates to dielectric coating of the plates. Details of the specific duration and temperature of the heating cycle are described in the aforereferenced copending application Ser. No. 214,348. This and the other steps of the process are performed with the exterior of assembly at atmospheric pressure. The gas discharge device is checked for leaks and then coupled to the gas source as shown in FIG. **5** where the confined space in the panel is filled with gas. The tube will then be tipped off or sealed, and the terminal connection processing completed. The terminal connection processing comprises removing the dielectric and passivation coatings from the plate metallization at appropriate edge termination sites while the tests provided are the conventional tests applied to gas filled envelopes and familiar to those skilled in the art. With respect to specific parameters of the preferred embodiment, the dielectric layers **11** and **13** are 1 mil thick lead-borosilicate glass sprayed and fired at 600°C, the metallization composition chrome-copper-chrome having upper and lower layers of chrome 1,000 angstroms in thickness and an intermediate layer of copper 10,000 angstroms thick. Passivation is provided in forming gas with water vapor. In addition, the surfaces of dielectrics **11** and **13** in contact with the gas may be formed from a refractory material having a high secondary coefficient of emission as described in the aforenoted copending application Ser. No. 176,625.

While the invention has been shown and described with reference to a preferred embodiment thereof, it will be understood that various omissions, substitutions and changes in form and detail of the invention as described herein may be made by those skilled in the art without departing from the spirit and scope of the invention. It is the intention therefore to be limited only by the scope of the following claims.

What is claimed is:

1. A process for constructing a gaseous discharge display/storage device comprising

assembling discrete parts, including transparent flat members with pre-processed printed circuit metallization and dielectric coating, a tubulation for exhausting and backfilling said gaseous discharge display storage device, spacer rods and heat fusible sealing material,

said heat fusible sealing material being in the form of a sealing rod, the cross-sectional area of said sealing rod being substantially larger than the corresponding area of said spacer rods, and

heating said assembly of discrete parts to a temperature above the softening point of said sealing material but below the softening temperature of said remaining components to effect fusion of said sealing material and said transparent flat members into an impermeable envelope confining a predetermined volume of gas whereby the space between the walls of said envelope is controlled by the vertical dimension of said spacer rods.

2. The process according to claim **1** wherein said heat fusible sealing material is of a greater viscosity than said spacer material to permit control of the spacing between said transparent glass members by said spacing means during the heating of said assembly of discrete parts after the softening temperature of said sealing material is reached.

3. The process according to claim **1** including the further step of evacuating and backfilling said envelope through said tubulation with a predetermined volume of a gas at a pressure suitable for display usage.

4. A process for constructing a gas discharge display/storage device comprising the steps of

arranging components, including transparent nonconductive plates with pre-processed printed circuit metallization and dielectric coating, a tubulation member, transparent spacer means and heat fusible sealing material in unfused condition, the cross-sectional area of said sealing means being substantially greater than that of said transparent spacer means,

placing said arranged components into an oven enclosure adapted for selective coupling to sources of vacuum, gas and heat,

cycling said oven to a temperaturee above the softening point of said heat fusible sealing material but below the softening point of said other components to effect reflow and fusion of said sealing material and said transparent flat members into an impermeable envelope confining a predetermined volume of said gas,

evacuating said envelope and backfilling through said tubulation member with a predetermined volume of gas at a pressure suitable for display purposes, and

sealing the tube used for evacuating and backfilling of said display device.

5. A process according to claim **4** wherein said transparent spacer means and said sealing material are in the form of rods, the cross-sectional area of said spacer means controlling the distance between said flat plates during the reflow of said sealing material.

6. A process according to claim **5** including the further step of weighting the upper plate to facilitate the settling of said upper plate on said spacing rods.

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