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Wilson

[11] **3,778,126**

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[54] **GAS DISPLAY PANEL WITHOUT EXHAUST TUBE STRUCTURE**

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[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

[22] Filed: **Dec. 30, 1971**

[21] Appl. No.: **214,174**

[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

[56] **References Cited**

UNITED STATES PATENTS

3,499,167	3/1970	Baker et al.	315/169 R
3,340,347	9/1967	Spiegler	29/630 B
3,614,509	10/1971	Willson	315/169 R X
3,559,190	1/1971	Bitzer et al.	315/169 R X
3,602,756	8/1971	Bonnet	313/109.5

Primary Examiner—Charles W. Lanham
Assistant Examiner—J. W. Davie
Attorney—W. N. Barret, Jr. et al.

[57] **ABSTRACT**

Projecting exhaust tube constructions of earlier gas panels are eliminated by the disclosed process. In the present method an unfused low-softening-point glass sealant, arranged in a picture frame pattern, is sandwiched loosely between aligned flat glass plates, and the disjoint assembly is placed in a vacuum oven enclosure. The enclosure is successively evacuated, filled with the requisite gas mixture at predetermined pressure and heated above the softening point of the sealant to establish a sealed gas-filled envelope within the assembly. Previously the plates have been joined initially by heat fused sealant to form an envelope which is thereafter evacuated and filled with gas by connection to a thin glass tubular orifice projecting from one of the plates. Manipulation of this tube for evacuation and gas back-filling of the envelope, which is a difficult operation requiring considerable time, technique and skill, is eliminated by the present method.

10 Claims, 7 Drawing Figures

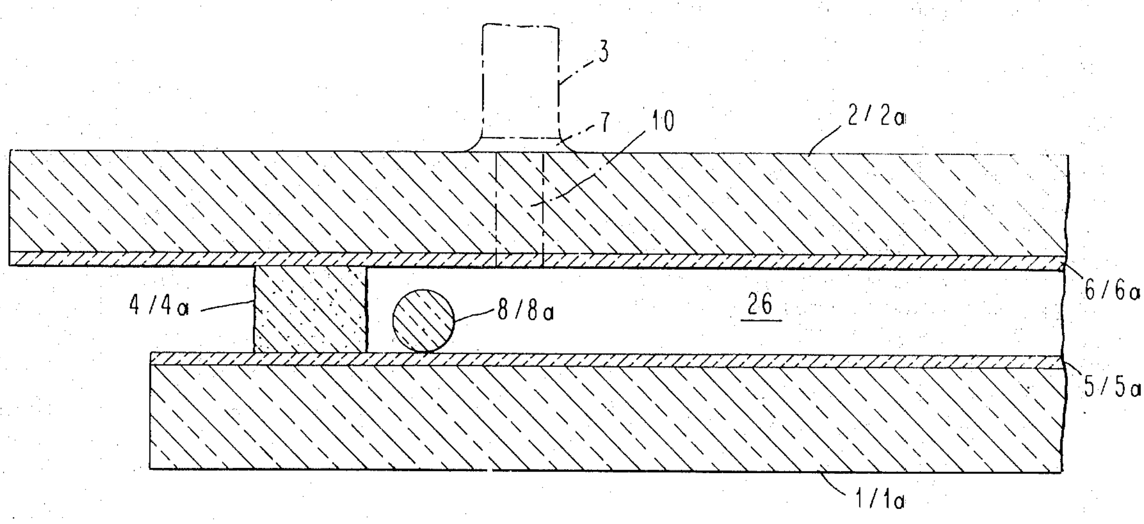


FIG. 1

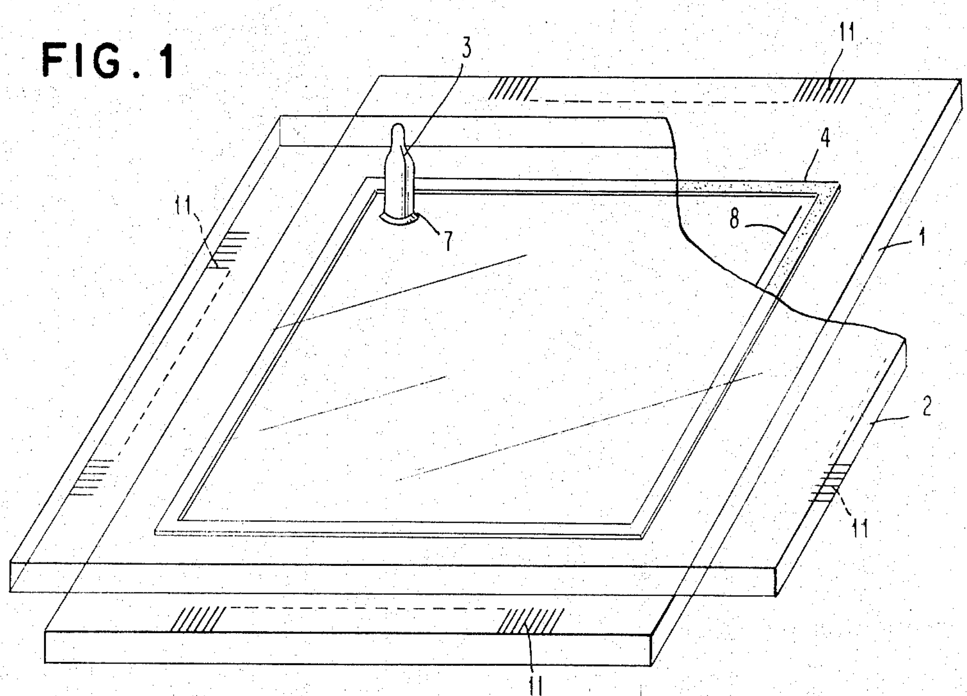


FIG. 2

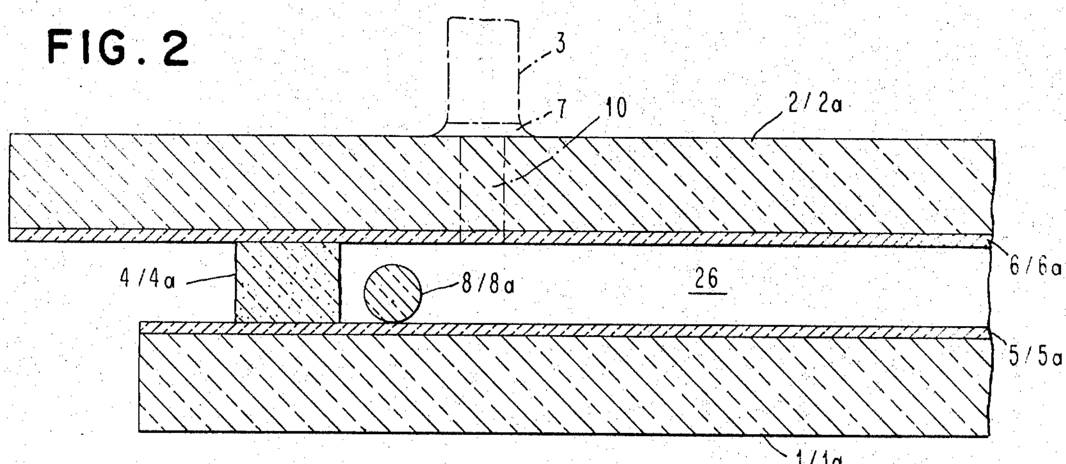


FIG. 3

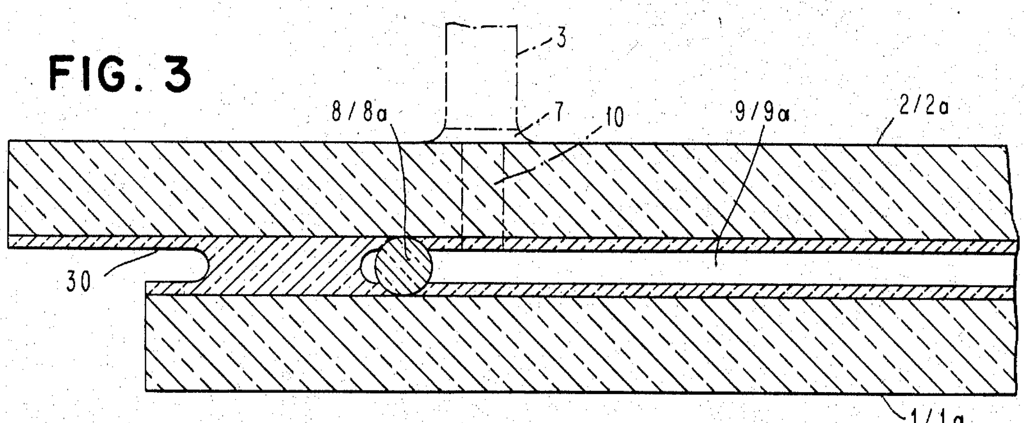


FIG. 4

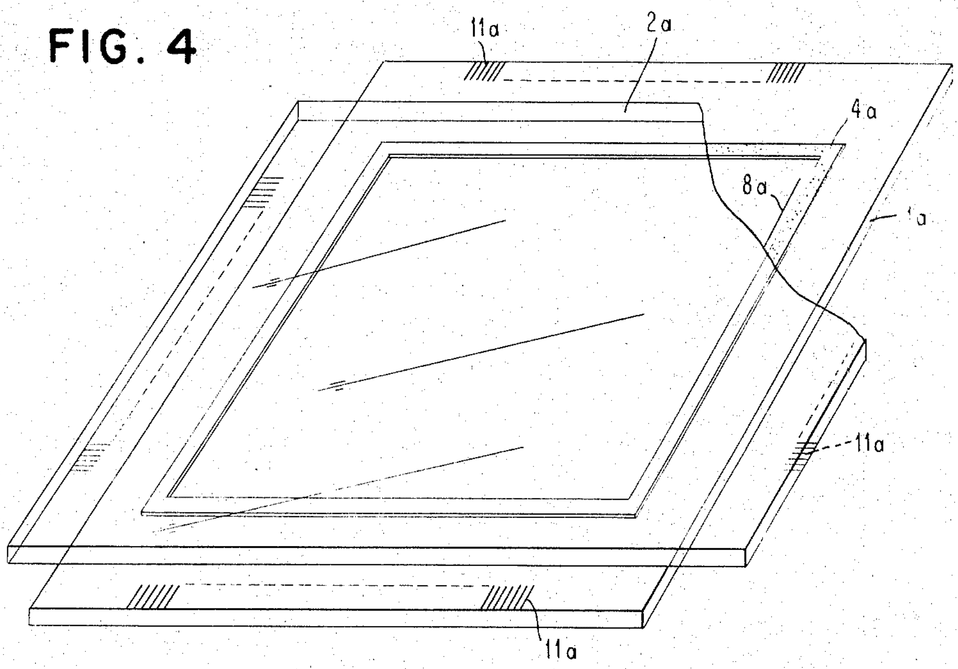

11a
2a
4a
8a
1a
11a
11a

FIG. 5

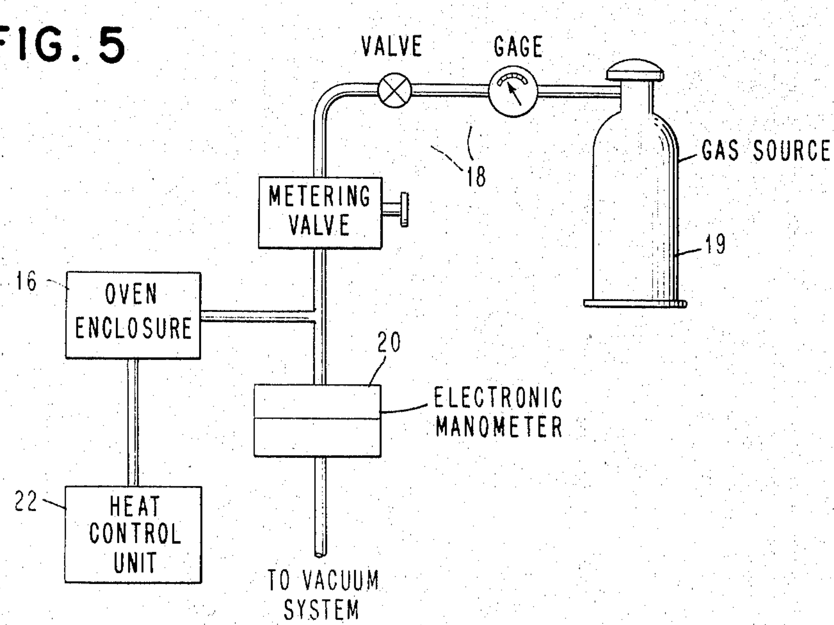

VALVE
GAGE
GAS SOURCE
18
METERING VALVE
19
16
OVEN ENCLOSURE
20
ELECTRONIC MANOMETER
22
HEAT CONTROL UNIT
TO VACUUM SYSTEM

FIG. 6

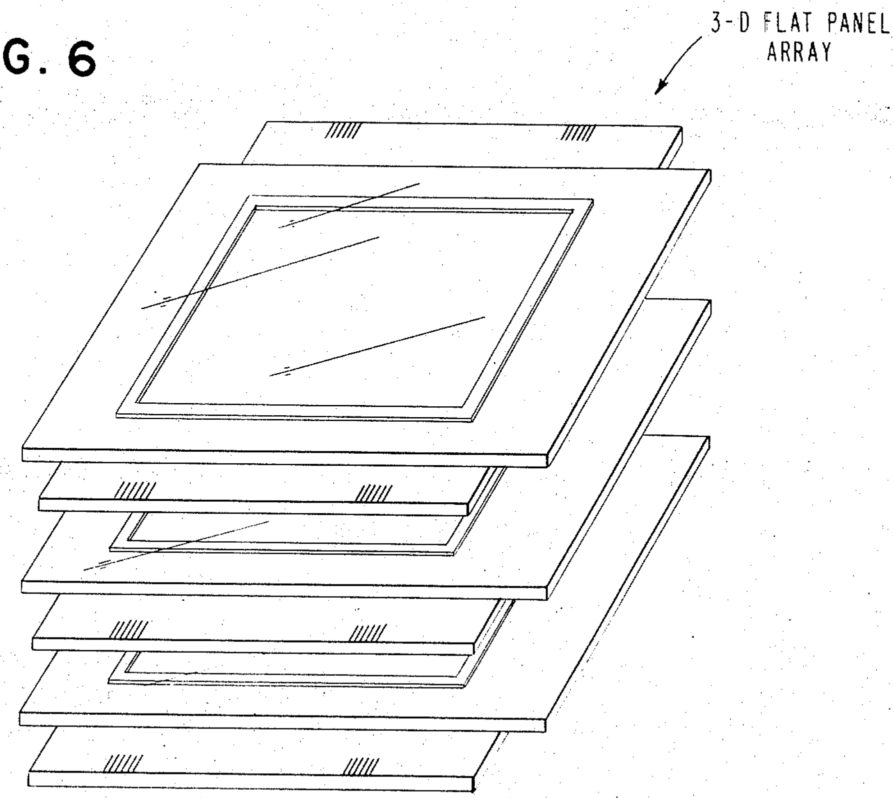
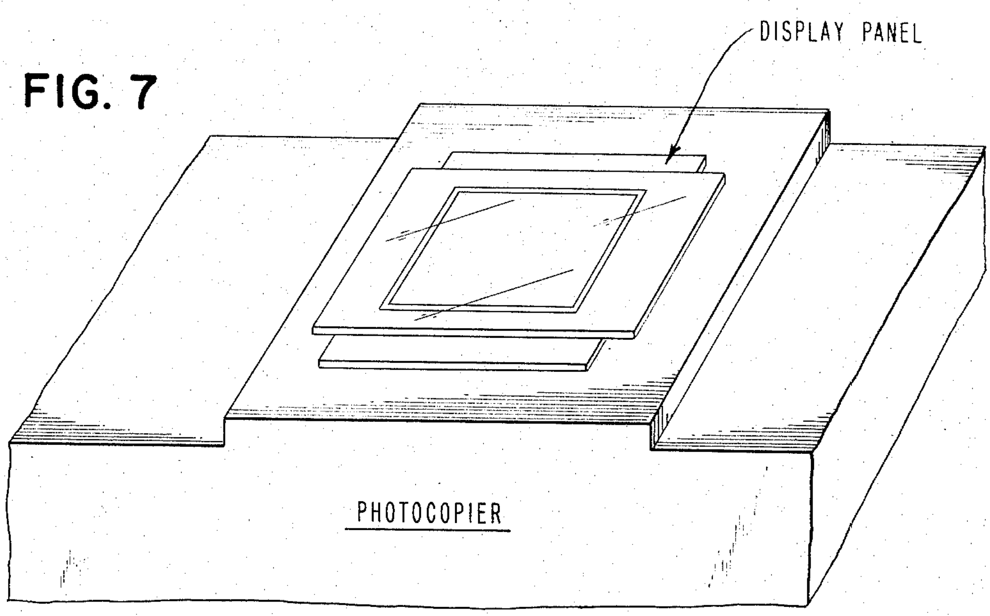


FIG. 7



GAS DISPLAY PANEL WITHOUT EXHAUST TUBE STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

U. S. Pat. application Ser. No. 214,298 for "Sealing Technique For Gas Panel," by Perry R. Langston, Jr. et al., 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. 198,953 for "Protection of Terminal Metallurgy During Working and Reworking of Gas Discharge Display Devices" filed No. 15, 1971 by N. M. Poley et al.

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

U. S. Pat. application, Ser. No. 829,692, for "Pilot Light Gas Cells For Gas Panels" filed June 2, 1969 by P. Soltan, now U.S. Pat. No. 3,609,658 issued Sept. 28, 1971.

BACKGROUND OF THE INVENTION

Earlier gas panels have included a special tube structure communicating with and used for evacuating and gas-filling a confined envelope formed in an early stage of assembly processing. This tube has been considered a weak link in the assembly process and the resulting panel structure since it is a relatively thin and fragile glass part projecting from an exterior surface of the panel structure. Its coupling to and disconnection from sources of vacuum and gas has required special skills and sealing tenchiques. The coupling operation therefore is quite time consuming and expensive.

Accordingly an object of the present invention is to provide a simpler gas panel assembly process and product structure characterized by elimination of formation and handling of special exhaust connections to the envelope contained in the structure.

An associated object is to provide improved gas panel display stuctures of uniformly flat construction which can be stacked adjacently in layers to form three-dimensional displays.

A further object is to provide a gas panel display structure having uniformly flush surfaces without projections; whereby one surface of the structure may be conveniently arranged for viewing as a display while the opposite surface may be positioned in contact with photocopying equipment for contact printing of hard copy of displayed images.

Another object is to reduce significantly the time and cost of fabricating a gas panel display structure.

Another object is to reduce the possibility of gas panel failure by eliminating tubular exhaust/gas filling couplings and associated seals which inherently tend to be thermally and mechanically mismatched in relation to other elements of a panel assembly.

The foregoing and other related objectives are achieved by arranging high softening point glass spacing rods and low softening point glass sealing material in picture frame pattern between disjoint high softening point glass plates within a vacuum oven enclosure. The oven is adapted for selective coupling of vacuum, gas and heat into its enclosure. The disjoint assembly is thereby successively scrubbed by vacuum, immersed in the gas which forms the light emitting medium of the display panel, and heat-fused while immersed in the gas. In the heat fusion stage the blass sealing material fuses with the plates to form a containing envelope around the gas surrounded by these elements. As the sealing material softens the upper plate collapses gradually towards and settles upon the spacing rods (diameter less than initial thickness of the unfused sealant); establishing the desired predetermined spacing of the envelope. The sealing material is selected to have viscosity sufficiently low to flow during heat fusion cycling and yet high enough so that it will not run off and leave voids during such cycling.

Since the foregoing evacuating, gas-filling and heating functions are all performed within the oven enclosure there is never a differential in the pressure exerted upon the glass parts of the panel assembly. In the earlier exhaust tube processing vacuum and gas were coupled to the envelope while the exterior of the glass plates received atmospheric pressure. Consequently the thickness (and weight) of present glass substrata may be considerably reduced (e.g. from one-fourth inch to one-eighth inch) for more economical usage, more efficient light transmission and generally easier bulk shipment and handling.

Accordingly, additional objects of the present invention are to provide for improved display panel fabrication processing under conditions of reduced pressure stress whereby glass parts forming the bulk of the panel structure may be made with reduced thickness; such being desirable for both economy, and general effectiveness of light transmission and handling.

It is worth noting also that with equalized pressures throughout the in situ filling/sealing stages of the present process the glass plates do not need central support. Previously an additional spacing rod was used to provide central support for large area glass parts during evacuation of the enclosure since the parts by themselves could not sustain the external atmospheric pressure without bending. With the present arrangement the center spacer is unnecessary and it is therefore eliminated.

Therefore another object of the invention is to reduce or eliminate central support elements of gas panel structures which although useful only during assembly processing are incorporated in the assembly and may interfere with panel operation or viewing.

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 and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 4 provide contrasting partially schematic perspective views of gas panel assemblies formed respectively by earlier and present methods (FIG. 4 serves to indicate the elimination of the exhaust tube and the relatively reduced thickness of the glass plates forming the gas enclosure);

FIGS. 2 and 3 provide sectional views of the assembly of either FIG. 1 or FIG. 4 respectively before and after the heat fusion stage of assembly processing;

FIG. 5 is a schematic view of vacuum furnace apparatus utilized in the practice of the present invention to provide equalized pressure handling of the assembly throughout the in situ evacuation, gas-filling and heat sealing stages of the present process;

FIGS. **6** and **7** indicate additional uses which can be made of the flush rear surfaces of gas panels formed by the present method.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

FIGS. **1** and **4** show earlier and present gas panel assemblies. The respective fabrication/assembly processes are compared as follows:

Prior Method	Present Method
. Prepare components (Note 1)	. Prepare (Note **1***a*)
. Assemble in unjoined state (Note (2) place in oven used only for temperature cycling;	. Assemble in unjoined state; place in air-tight vacuum-oven enclosure (Note **2a**)
. Join (heat fuse) into integral assembly (Note 3)	. Evacuate, gas fill, heat fuse, restore ambient; all in situ in oven chamber, no handling of assembly required (Note 3a)
. Evacuate space confined by joined assembly through tube (Note 3)	
. Bake-out confined space (Note 3)	
. Tip-off tube (Note 3)	
. Leak test (Note 3)	
. Couple tube to gas source (Note 3)	
. Fill confined space of assembly with gas (Note 3)	
. Tip-off tube (Note 3)	
. Complete terminal connection processing (Note 4)	. Complete terminal connection processing per prior method

Notes:

1. Prepare plates, plate sealant, spacers, tube, tube sealant. Plate preparation:
   cut to size and clean soda-lime-silica window glass (e.g. 1/4 inch thick) into front and rear substrates; make hole in rear (top) plate for tube coupling; metallize "interior" surfaces of plates (deposit layer of metal, etch, passivate by heat treatment in forming gas, test); insulate (spary lead-borosilicate powdered glass frit over passivated metallization and fuse by heating); inspect.

1*a*. Same as **1** but omit preparation of tube, tube sealant and tube coupling hole in rear plate; also use thinner plates (e.g. one-eighth inch instead of one-fourth inch).

2. Lay down unfused plate sealant "picture frame strips" on "interior" surface of front plate (preshaped lead-borosilicate glass rod or powdered glass frit in viscous binder; preparation available in strip form on plastic release tape); spacer rods on surface of same plate near and within sealant border; place other (rear) plate, with "interior" face down, on top of border sealant orthogonally aligning metallization on the two plates; place tube sealant and tube over rear plate opening.

2*a*. Assembly same as 2 but omit placement of tube sealant and tube. Oven equipped for selective coupling of vacuum, gas plasma and heat to enclosure.

3. Heat in oven at atmospheric pressure to above softening point of sealants (plate and tube) and dielectric covering of plate metallization (softening point of latter approx. 400° C). Heating cycle: room temperature (approx. 25° C) to approx. 500° C at rate of 1°–3° C per minute — establishes fusion of tube sealant to tube and outer surface of rear plate and fusion of envelope sealant between plates to dielectric coatings of plates — and back to room temperature at 1°–3° C per minute. Softening point of glass composition of plates, spacers and tube is well in excess of 500° C. This and other steps of process are performed with exterior of assembly at atmospheric pressure.

3*a*. Vacuum oven enclosure successively exhausted at room temperature, filled with Ne-A gas mixture at specific pressure (700 torr), heated (at temperature cycle of note 3 above) to establish envelope sealant fusion and, upon cooling to room temperature, restored to ambient pressure. Exhaust cycle: pressure reduced from atmospheric pressure (approx. 750 torr) to about 10 torr in about 5 minutes, and from 10 torr to between 10^{-3} and 10^{-6} torr in about another hour. Alternate process sequence: a) evacuate enclosure; b) heat enclosure to temperature T(°C) below softening point (400° C) of envelope sealant and dielectric plate coatings; c) supply gas plasma to oven enclosure at elevated pressure $T/25 \times 700$ torr; d) continue oven temperature cycle, per note 3, from T to 500° C and back to room temperature; e) restore oven enclosure to atmospheric pressure.

4. Remove dielectric and passivation coatings from plate metallization at appropriate (edge) termination sites; test; make connections; test; etc.

Referring to FIGS. **1–3** in the prior method the metallized-passivated-dielectric coated front and rear glass plates **1**, **2** and exhaust tube **3** are formed into an integral structure by heat union of envelope sealant **4** with dielectric plate coatings **5**, **6** and heat union of tube sealant **7** with tube **3** and plate **2**. For large area panels edge spacer rods such as **8** may be supplemented by a not shown central spacer rod providing central support for the glass plates during subsequent evacuation and gas filling of envelope space **9** (FIG. **3**) through tube **3** and hole **10** in plate **2** (FIG. **3**) with the parts subject externally to atmospheric pressure. The fused dielectric layers **5**, **6**, formed from sprayed and heated glass frit cover the patterned metallization (indicated schematically at **11** in FIG. **1**) intersecting at illuminatable cross points of the panel. Layers **5**, **6** have specific dielectric properties requisite to support of gas plasma discharge in envelope space **9**. All glasses (substrate, dielectric layers, tube, tube sealant, border sealant) must have compatible thermal coefficients of expansion, albeit differing optical, physical, dielectric, and heat softening properties. The expense and effort involved in the exhaust and back filling operation are considerable. The projecting exhaust tube structure **3** is also a relatively weak element in comparison to the main body of the panel formed by glass parts **1**, **2**.

Tube **3** also restricts contact between the exterior surface of plate **2** and other media; for instance other panels as suggested in FIG. **6** or hard copy photocopying equipment as suggested in FIG. **7**.

Glass plates **1**, **2** must have substantial thickness (e.g. one-fourth inch) and may require potentially obstructive central support rods in order to be able to withstand the differential pressures existing when envelope space **9** is evacuated while atmospheric pressure exists externally.

Gas panels processed in accordance with the present invention have the form exemplified in FIGS. **4**, **2** and **3**. In this process metallized-passivated-insulated glass plates **1***a*, **2***a* entirely free of projecting exhaust tubes or other obstructions, are assembled as in the previous method about low softening point envelope sealant **4a** (e.g. powdered lead borosilicate glass in viscous binder peeled from plastic release tape or lead borosilicate glass rod pre-formed into "picture frame" outline). Peripheral spacer rods such as **8a** having higher softening temperature than the envelope sealant establish ultimate separation spacing of the fused glass parts.

The unjoined assembly is positioned in the desired orientation (FIG. **2**) within vacuum oven enclosure **16** (FIG. **5**), associated with gas supply apparatus **18, 19,** vacuum coupling apparatus **20** and heating unit **22.** Such ovens, without the gas supply fittings, are sold under commercial designation High Temperature Vacuum Oven, Model 1408, by T-M Vacuum Products Co.

The unfused envelope sealant **4***a* permits unimpeded evacuation of the extended envelope space **26** bounded by the unjoined plates when enclosure **16** is evacuated and unimpeded permeation of gas into the same space when oven enclosure **16** is filled with gas. When enclosure **16** is thereafter heated in accordance with note **3***a* above envelope sealant **4***a* softens, flows and fuses with the dielectric metallization coating layers **5***a*, **6***a* of the plates as suggested at **30** (FIG. **3**), while the upper plate sinks down against spacers **8***a* establishing the desired final dimensions of the gas-filled/sealed envelope **9***a* contained between the plates. 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 parellepiped gas enclosure space **9***a*.

When enclosure **16** (FIG. **5**) is restored to room temperature the fused border sealant hardens into a firm totally impervious seal. At this time the plasma gas within the enclosure **16** and therefore within confined space **9***a* is under pressure just slightly less than atmospheric (about 700 torr).

Further details of component preparation, assembly handling and terminal connection processing ancillary to but not directly relevant to the present process are found in the references listed above under Cross-Reference to Related Applications.

Typical parameters of the present process are:

Glass plate (**1***a*, **2***a*) dimensions:

4 × 2 ⅛ × ⅛inches (compared to 4 × 2 ⅛ × ¼ inches previously) Envelope sealant 4*a*:

glass frit (Corning 7570) or Glass Rod (PbO–62 percent, ZnO–15 percent, B_2O_3–20 percent, Bi_2O_3–3 percent) the frit in viscous binder (amyl acetate nitrocellulose) applied to glass plate in thickness 10 mil where final envelope height is 4.5 mil

Dielectric/metallization layers **5***a*, **6***a*:

1 mil thick lead borosilicate glass sprayed and fired 600° C Composition:

a. metallization: Cr 1,000A, Cu 10,000A, Cr 1,000A

b. passivation: 525° C in forming gas 5°–8° C per minute up and down

c. insulation: PbO–73.5 percent, Si^0–13.6 percent, B_2O_3–12.7 percent, Al_2O_3–0.2 percent

We have shown and described above the fundamental novel features of our invention as applied to a preferred embodiment. 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 true 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 gas discharge display device devoid of gas-filling ducts or tubulations, comprising:

assembling discrete parts — including a pair of transparent dielectric support plates bearing dielectric coated conductive circuits in a spaced apart unfused configuration with uniform spacing between the unfused plates established by a heat fusible sealing material of generally uniform thickness arranged in an enclosure shape of predetermined form in an unfused condition, said sealing material having a pedetermined softening temperature substantially lower than the softening temperatures of said plates — to form an enclosed space which is relatively permeable to gas flow at a boundary between said sealing material and said plates;

providing spacer elements within said enclosed space having thickness dimensions establishing a predetermined limiting dimension within said space less than the thickness of said unfused sealing material; said elements having softening temperature substantially higher than that of the sealing material;

filling said enclosed space, with an ionizable gas suited for display usage, by exposing said assembled parts to an atmosphere of said gas at predetermined pressure; and

heating said assembled parts with said enclosed space filled with and retaining said gas, over a temperature range exceeding the softening point of the sealing material but below the softening points of said support plates and spacer elements, to cause selective softening of said sealing material with resulting fusion of said sealing material, dielectric circuit coatings and plates into a sealed unit impermeably confining a predetermined volume of said gas between said circuits in an envelope space of predetermined uniform height dimension established by said spacer elements.

2. A process according to claim **1** wherein said step of filling said space is accomplished by successively evacuating a volume of space containing said unfused assembled parts and filling said containing volume of space with said gas at said predetermined pressure while maintaining said volume at a temperature below the softening temperature of said sealing material.

3. A process for constructing ductless gas discharge display devices comprising in succession:

arranging transparent flat glass plates, bearing orthogonally oriented printed circuit conductors encapsulated in transparent dielectric films, in substantially parallel spaced apart orientation with initial spacing determined by an enclosed strip of heat fusible envelope sealing material in unfused condition and ultimate spacing determined by glass spacer elements thinner than said sealing material; said material and dielectric films having softening temperatures lower than softening temperatures of said plates and spacer elements;

locating said arranged parts in the interior of a vacuum oven equipped for selective evacuation, gas filling and heating;

evacuating said oven interior while maintaining a temperature therein below the softening temperatures of said sealing material and dielectric films;

filling said oven interior with a gas subject to ionization display usage at predetermined pressure while maintaining temperature in said interior below said sealing material and dielectric film softening temperatures; and

varying the temperature in said oven interior over a range encompassing the said sealing material and film softening temperatures but substantially below the softening temperature of the glass plates and spacer elements to effect selective softening of said sealing material and films and fusion of said sealing material to said plates forming an integral unit impermeably confining an ionization space of predetermined uniform height dimensions determined by said spacer elements, said ionization space filled exclusively with a predetermined volume of said gas at a predetermined pressure.

4. Process of claim **3** wherein said sealing material is arranged initially in a uniformly thick picture frame strip pattern with initial thickness exceeding the desired height dimensions of said ionization space.

5. A process for constructing gas discharge display devices devoid of specialized gas-filling structural projections or tubulations comprising:

arranging components — including transparent flat dielectric support members having predetermined softening temperature and bearing integral printed circuit metallization patterns encapsulated in transparent dielectric film coatings of predetermined thickness, said coatings having predetermined softening temperature, and transparent dielectric spacer rods having predetermined softening temperature assembled in a spaced configuration established by a closed strip of heat fusible sealing material forming a permeable enclosure of a space between said members; said strip having predetermined generally uniform thickness greater than the diameter of the spacer rods and having predetermined softening temperature less than the softening temperatures of said members, film coatings and spacer rods — within a vacuum oven enclosure; said spacer rods being located and dimensioned to establish a predetermined limiting spacing between the encapsulated metallization patterns on said plates upon subsequent softening of said sealing material;

evacuating said oven enclosure with said arranged components located therein and with the temperature thereof maintained below the softening temperature of said sealing material;

filling said oven enclosure with a predetermined gas suited for display usage; with said gas at predetermined pressure specifically related to the pressure required for display operation and with said enclosure maintained at temperature below the softening point of said sealing material;

uniformly heating said gas-filled oven enclosure, with said gas confined therein, to a selected temperature above the softening points of said sealing material and film coatings but below the softening points of said members, film coatings and spacer rods thus effecting selective softening of said sealing material and fusion of said sealing material to said flat members forming an impermeable gas-filled envelope between said members of predetermined uniform height dimension determined by the thickness of said spacing rods, said envelope sealably confining a predetermined fractional volume of the gas in said oven enclosure at a predetermined elevated pressure; and

restoring said oven enclosure to ambient temperature and atmosphere and pressure conditions.

6. Process according to claim **5** wherein said oven enclosure is maintained at the temperature of the ambient environment surrounding the enclosure during said evacuating and gas filling step.

7. Process according to claim **5** wherein said oven enclosure is pre-heated to a temperature above the temperature of the surrounding ambient and below the softening points of said material prior to said gas filling step, whereby said gas may be introduced at a reduced pressure.

8. A process according to claim **5** wherein a plurality of panels are aggregately assembled in stacked formation to form a three-dimensional display.

9. A process according to claim **6** wherein the evacuating step comprises reducing pressure within said oven enclosure from atmospheric ambient to approximately 10 Torr in approximately 5 minutes and from 10 Torr to between 10^{-3} and 10^{-6} Torr in approximately 60 minutes; and wherein the heating step comprises raising the oven temperature at a rate of between 1° and 3° C per minute to a point sufficient to establish selective softening and complete fusion of the sealing material and the restoring step comprises first cooling the oven enclosure at said rate of 1°–3° C per minute and then restoring ambient atmosphere and pressure to the oven enclosure.

10. A process according to claim **7** wherein the evacuating step comprises reducing the pressure in said oven enclosure from atmospheric ambient to approximately 10 Torr in approximately 5 minutes and from 10 Torr to between 10^{-3} and 10^{-6} Torr in approximately 60 minutes; and said pre-heating step is executed between said evacuating and filling steps by adding heat to produce a temperature rise of between 1°–3° C per minute; and wherein said heating step comprises adding more heat sufficient to increase the temperature at 1°–3° C per minute to a value above the selective softening point of the sealing material before initiating ambient cooling and re-pressurization.

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