# PATENT SPECIFICATION

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(21) Application No. 36692/76 (22) Filed 3 Sept. 1976
(23) Complete Specification filed 25 Aug. 1977
(44) Complete Specification published 8 May 1980
(51) INT. CL.[3] C03C 27/06
(52) Index at acceptance
C1M 462 WS

(19)

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## (54) LARGE LIQUID CRYSTAL CELLS

(71) We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, of 190 Strand, London, W.C.2., England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to glass envelope manufacture.

The manufacture of certain types of display cells calls for the construction of glass envelopes formed by sealing together two glass sheets with a perimeter seal. For some applications, such as in the construction of liquid crystal display cells, the thickness of the interior space of the envelope is a relatively critical parameter. Up to a certain size of liquid crystal display cell adequate control of this thickness is given solely by control of the thickness of the perimeter seal. It will be apparent however, that if the cell size is to be increased, the flatness of the two sheets will have to be held to correspondingly closer tolerances. At a certain stage these tolerances can only be met by optically working the surfaces of the two sheets. This necessarily involves using relatively thick sheets, and this is undesirable for a number of applications. For instance, in a liquid crystal display cell operated in a reflective mode it is liable to involve separating the reflecting surface from the liquid crystal material by such a distance as to restrict substantially the viewing angle because of the parallax effects between the liquid crystal layer and its image in the reflecting surface. Some of these disadvantages are removed, or at least ameliorated, if at least one of the sheets is relatively thin compared with the thickness of typical optical flats.

According to the present invention there is provided a method of making an envelope in which two glass sheets are secured with a glass perimeter seal to form the envelope, wherein one of the sheets is provided with an array of heat treated glass spacer dots, as hereinafter defined, having a softening point above that of the sheets, which heat treated dots are made of material applied to the sheet which is subsequently fused to produce the heat treated material at a temperature beneath the softening point of the sheets, wherein one of the sheets is provided with an array of glass tie dots, as hereinafter defined, which are of greater thickness than that of the spacer dots and are made of a glass that flows at the softening point of the sheets, wherein one of the sheets is provided with a glass perimeter ribbon of greater thickness than that of the spacer dots and is made of a glass that flows at the softening point of the sheets, wherein the sheets are assembled with the array of dots and the perimeter ribbon facing inwardly, and wherein the assembly is fired to make the perimeter seal at a temperature at which at least one of the sheets softens sufficiently for its inner surface to distort to conform to the contour of the inner surface of the other sheet from which it is held uniformly spaced by the unsoftened spacer dots.

For the purpose of this specification a spacer dot is defined as a mass of material that is used as a spacer that sets a minimum limit to the separation of the two sheets, and a tie dot as a mass of material that is ultimately bonded to both sheets thereby acting as a tie between them inhibiting an increase in their separation.

There are two basic methods of obtaining the desired characteristic of the spacer dots, namely that they be formed at a particular temperature beneath the softening point of the two sheets in such a way as to produce a material having a softening point above that as which the spacer dots were formed. One method relies upon devitrification. The other method involves the use of a mixture of glasses chosen such that at least one constituent part of the mixture will flow at a relatively low temperature, and dissolve another constituent part to form a composition having a higher flow temperature. The first method is thus normally characterised by producing an increase in the number of phases in the material, while the second method normally produces a decrease. The second method is described and explained in greater detail in our Patent Specification No. 1,376,393 to which attention is directed.

It is normally convenient to provide the arrays of dots by screen printing a glass frit paste on the float glass substrate. With this process it is convenient to use the same glass for both the tie dots and the perimeter seal so that they can be printed simultaneously. A particularly close match of thermal expansion co-efficient is not necessary between the substrate and the dots on account of the small size of the latter, but on the other hand, a good match is desirable between the perimeter seal and both the substrate and the sheet so as to avoid introducing the extraneous optical effects of strain.

An alternative method of providing the dots is to dispense the paste from a hollow stylus or set of such styli, using a co-ordinate table to move the substrate between each marking.

In a preferred arrangement the sheets are of different thicknesses, and both arrays of dots and the perimeter track are all deposited on the thicker sheet. This thicker sheet is typically a piece of 3mm thick or thicker glass made by the float process. The thin sheet is typically not more than 1 mm thick so that it can relatively readily be distorted to make its surface contour match that of the thicker sheet. This distortion may be brought about by the action of heat alone, in which case the heat is sufficient for the thin sheet to soften enough to distort under its own weight; in general however, it is preferred to apply both heat and pressure to the thin sheet to distort it.

One of the key factors to be taken into account when choosing suitable glasses is the firing temperature. In general raising the firing temperature is liable to increase the risk of the conducting tracks becoming degraded particularly in the region under the perimeter seal. On the other hand, if the firing temperature is lowered the thin sheet will not be so soft at the firing temperature, and therefore more pressure has to be applied to the assembly to get the surface contour of the thin sheet to conform to that of the thick sheet, less of the resulting stress is likely to be relieved, and hence there is an increased risk of the completed assembly having undesirable strain patterns across the display surface.

If the perimeter seal material and the dots are both deposited as paste made from glass frit, it is generally convenient to drive off the binder and sinter the frit of both together. If the particular choice of glasses permit, it may be advantageous combine this with the firing treatment required for heat treating the spacer dots.

There follows a description of the construction of a liquid crystal display cell embodying the invention in a preferred form. The description refers to the drawings accompanying the Provisional Specification, in which:—

Fig. 1 depicts in schematic form a transverse section through the component parts of the cell assembled, ready for firing to make the perimeter seal, and

Fig. 2 depicts the assembly after this firing.

The particular cell whose construction is now to be described is required to have its front and back sheets spaced apart by 12 ± 3 microns, and typically its display area measures more than 10 cm square. For panels of smaller area, it has been found that cells can be constructed to satisfy this tolerance requirement using typically 1 to 1.5mm thick glass, which rely solely upon the perimeter seal to provide the required spacing.

The surfaces 1 and 2 respectively of a sheet 3 of 3mm thick float glass and a sheet 4 of thinner glass, typically 0.5 to 1.0mm thick, both made of soda lime glass, are provided with transparent indium-tin oxide electrodes (not shown). These electrodes are applied in conventional manner, and their configuration is to suit the particular display requirements of the completed cell. The surface 1 of the float glass is then provided with an array of dots of a paste which is either dispensed from a hollow stylus (not shown), or is applied by screen printing. The paste is formed of a glass frit made into a paste with a suitable vehicle, typically using terpineol as a solvent and ethyl cellulose as the binder. The glass frit is made of a glass that readily devitrifies at a temperature beneath the softening point of the two glass sheets to produce a material that has a higher temperature softening point than the two sheets. Examples of such glasses include Owens Illinois glasses designated CV 870 and CV 97, and an Electro Science Laboratories glass designated ESL 4010. The paste dots are fired to drive off the printing vehicle and the resulting glass dots 5 are fused and sintered to cause them to devitrify. Then, after the sheet has been cooled, a second array of paste dots is applied to the surface together with a ribbon of paste extending round the perimeter of the surface. This paste is like the first mentioned paste, but is based upon a different composition of glass frit. The thickness of the paste dots and paste ribbon is slightly greater than that of the paste dots deposited to form the array 5 so that, when they too have been fired to drive off the printing vehicle and fuse the frit, they produce an array of glass dots 6 and a glass perimeter ribbon 7 that stand slightly proud of the array of glass dots 5. The composition of frit used for making the second array of dots and the perimeter ribbon 7 is one which flows at a temperature beneath the softening point of the sheets 3 and 4 and which does not readily devitrify. Examples of suitable glasses include glasses made by Corning Glass Works under their designations CORNING (Registered Trade Mark) 7555 and CORNING 1417, and an Electro Science Laboratories, glass designated ESL 4017 CMG.

The sheet 3, complete with its array of dots 5 and 6 and its perimeter ribbon 7, is placed face up underneath the thin sheet 4 which has its surface 2 face down. At this stage the dots 5 are stood off a short distance from the surface 1 by the slightly greater thickness of the dots 6 and the ribbon 7. Sheet 3 is supported on a flat horizontal surface (not shown), while sheet 4 is loaded with a flat weight (not shown), made for instance of polished stainless steel or other suitable good conductor of heat. Next the assembly is heated in a furnace (not shown) to cause the dots 6 and the ribbon 7 to flow and wet the surface 2 of sheet 4. The ribbon 7 forms the perimeter seal, while the dots 6 spreads slightly to allow the sheet 4 to sink under the pressure provided by the weight towards the sheet 3 till arrested by the dots 5 which have remained unsoftened. The heating of the assembly is just sufficient to soften the thin sheet 4 to the extent that it distorts slightly under the loading of the weight so that the surface 1 is brought into conformity with the surface contour of surface 1 of sheet 3. This occurs at a temperature in the region of 580°C. Finally, after the assembly has been cooled, it is filled with a liquid crystal material either through a gap left in the perimeter seal or through an aperture on sheet 3. The filling orifice is then plugged for instance with a pellet of indium which is then sealed in position with epoxy resin.

As an alternative to using a glass which readily devitrifies, the frit from which the spacer dots 5 are made may be made of a glass mixture as defined in Claim 1 of Patent Specification No. 1 376 393 previously referred to. An advantage of using this type of glass mixture is that with an intimate mixture of fine powders of heat treatment required to raise the temperature of its fixed points can be much faster than that for achieving a corresponding effect with a devitrifying glass. This is because devitrification is inevitably a relatively slow process in order for it to be possible—for the particular glass composition concerned to be capable of being prepared in a vitreous form in the first instance.

In the above described method it will be appreciated that the uniformity of spacing between the two sheets of the completed cell is primarily limited by the flatness of the float glass sheet 3 and that of the weight loading sheet 2. In certain circumstances some improvement in uniformity of spacing may be achievable by removing this limitation by using a non-rigid weight to load sheet 2. For instance the sheet can be loaded with fine sand placed in a flexible foil container.

It may be preferably to choose for the spacer dots a glass that has a lower integrated thermal expansion co-efficient than that of the tie dots and the perimeter seal so that, upon cooling down to room temperature after firing, the tie dots pull the thinner sheet firmly against the spacer dots.

WHAT WE CLAIM IS:

1. A method of making an envelope in which two glass sheets are secured with a glass perimeter seal to form the envelope, wherein one of the sheets is provided with an array of heat treated glass spacer dots, as hereinbefore defined, having a softening point above that of the sheets, which heat treated dots are made of material applied to the sheets which is subsequently fused to produce the heat treated material at a temperature beneath the softening point of the sheets, wherein one of the sheets is provided with an array of glass tie dots, as hereinbefore defined, which are of greater thickness than that of the spacer dots and are made of glass that flows at the softening point of the sheets, wherein one of the sheets is provided with a glass perimeter ribbon of greater thickness than that of the spacer dots and is made of a glass that flows at the softening point of the sheets, wherein the sheets are assembled with the array of dots and the perimeter ribbon facing inwardly, and wherein the assembly is fired to make the perimeter seal at a temperature at which at least one of the sheets softens sufficiently for its inner surface to distort to conform to the contour of the inner surface of the other sheet from which it is held uniformly spaced by the unsoftened spacer dots.

2. A method as claimed in claim 1 wherein the spacer dots, the tie dots and the perimeter seal are all applied to one sheet.

3. A method as claimed in claim 1 wherein one of the sheets is thinner than

the other.

4. A method as claimed in claim 3 wherein the thinner sheet is not more than 1mm thick and the thicker sheet is 3 mm thick or greater.

5. A method as claimed in claim 3 or 4 wherein the spacer dots, the tie dots and the perimeter seal are all applied to the thicker sheet.

6. A method as claimed in claim 3, 4 or 5 wherein the thicker sheet is made of float glass.

7. A method as claimed in any preceding claim wherein tie dots and the perimeter seal are made of the same glass.

8. A method as claimed in any preceding claim wherein the perimeter seal is made of a glass having an expansion co-efficient matched with that of the two sheets.

9. A method as claimed in any preceding claim wherein the integrated thermal expansion co-efficient between room temperature and the firing temperature of the spacer dots is less than that of the tie dots.

10. A method as claimed in any preceding claim wherein the heat treated glass dots are made by a devitrification including heat treatment process.

11. A method as claimed in any of claims 1 to 9 wherein the heat treated glass spacer dots are made from a glass mixture as claimed in claim 1 of British Patent Specification No. 1 376 393.

12. A method as claimed in any preceding claim wherein said distortion is brought about by the action of heat alone.

13. A method as claimed in any claim of claims 1 to 11 wherein both heat and pressure are applied to the envelope to effect said distribution.

14. A method as claimed in any preceding claim wherein said spacer dots are applied by screen printing.

15. A method as claimed in any claims 1 to 13 wherein said spacer dots are applied with a hollow stylus or set of such styli.

16. A method as claimed in any preceding claim wherein the tie dots are applied by screen printing.

17. A method as claimed in any claim of claims 1 to 15 wherein the tie dots are applied with a hollow stylus or with a set of such styli.

18. A method of making an envelope substantially as hereinbefore described with reference to the drawings accompanying the provisional specification.

19. An envelope made by the method claimed on any preceding claim.

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Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1980. Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1566558 PROVISIONAL SPECIFICATION

1 SHEET

*This drawing is a reproduction of the Original on a reduced scale*

FIG. 1.

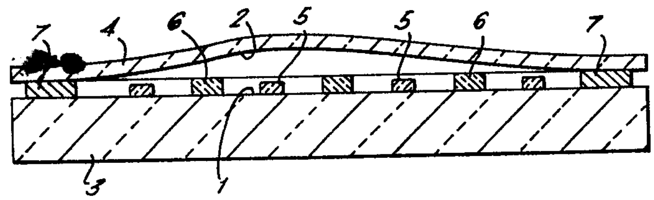


FIG. 2