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(54) **DOUBLE GLAZING**

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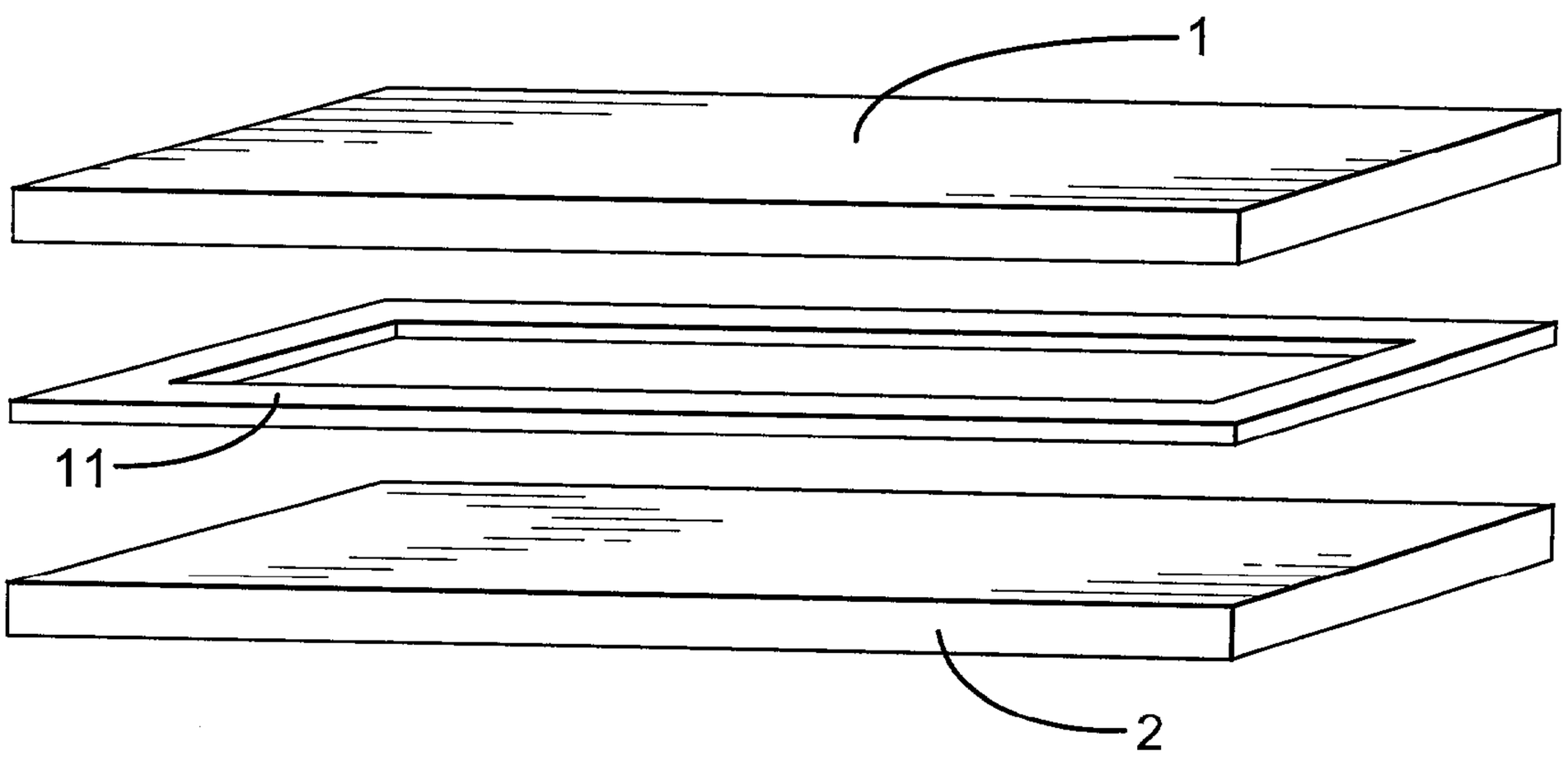
(57) **ABSTRACT**

A double glazing unit has a pair of glass sheets **1, 2,** with a frit seal **3** therebetween, the frit seal being fused to both sheets and extending around the periphery of the unit. The frit seal is fused by irradiation with light **4** from a laser. Typically, the frit is of brown glass, whereby it readily absorbs heat on laser irradiation.



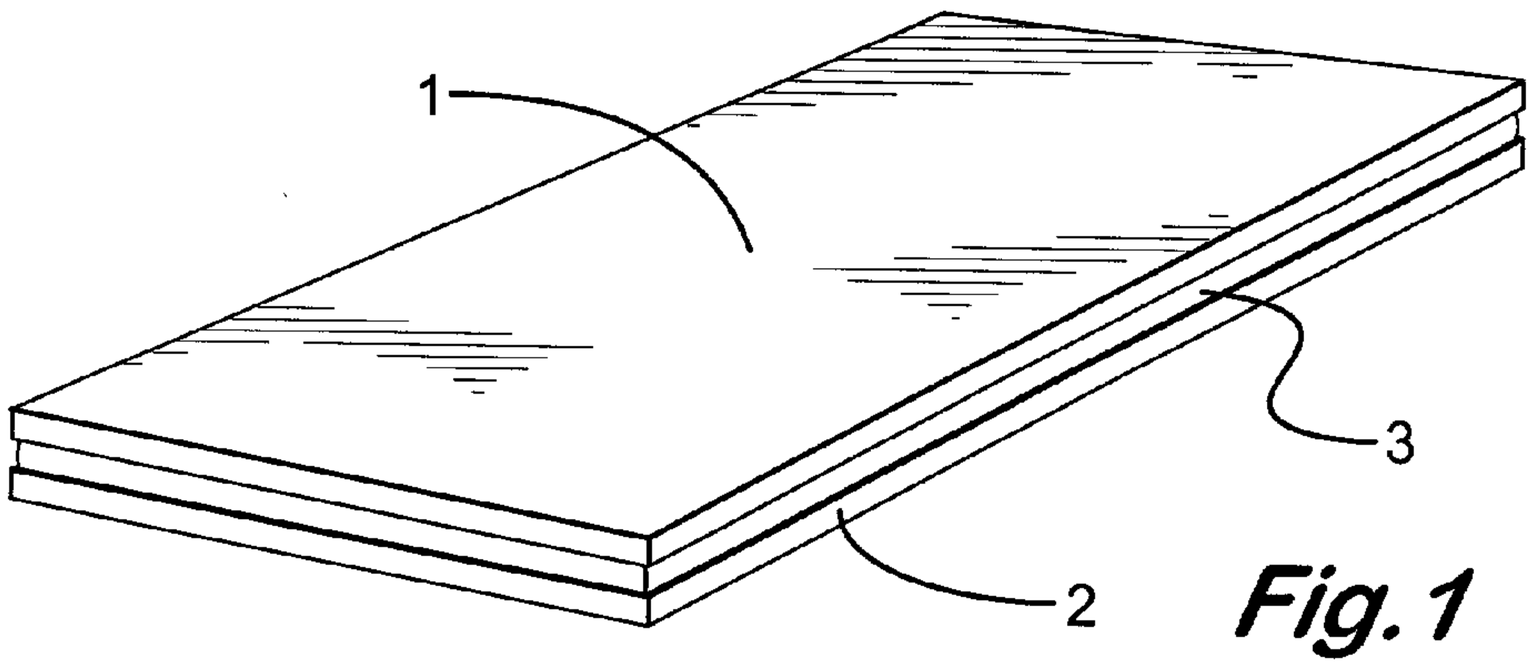


Fig. 1

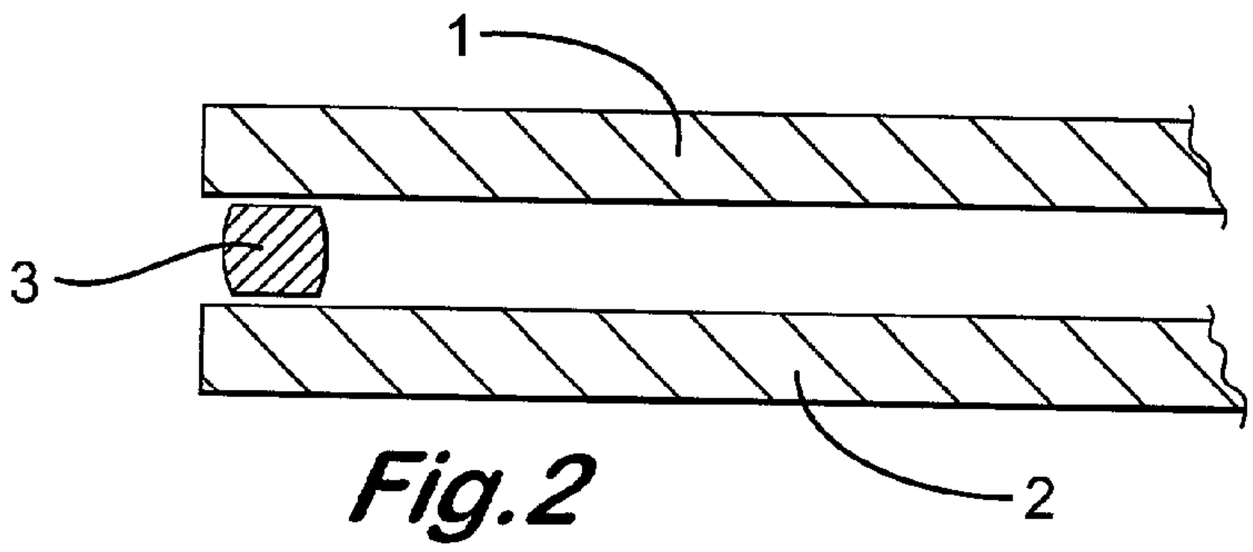


Fig. 2

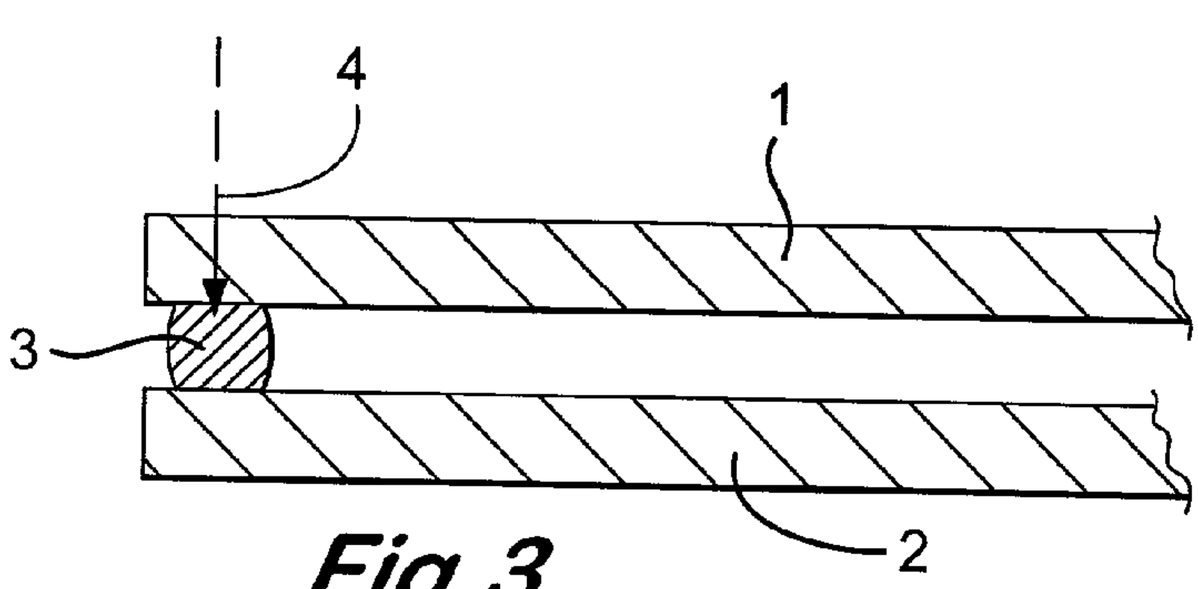


Fig. 3

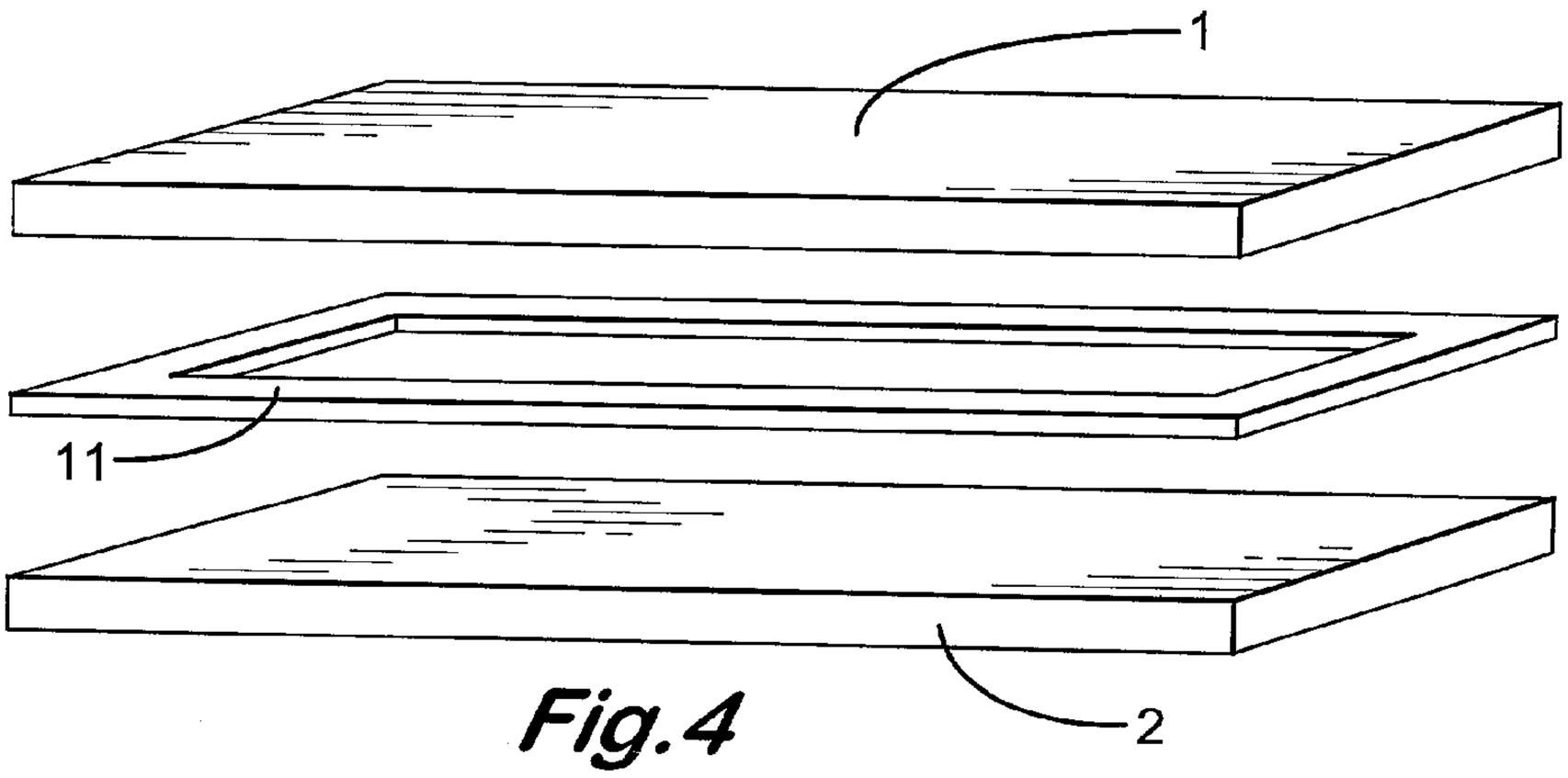


Fig. 4

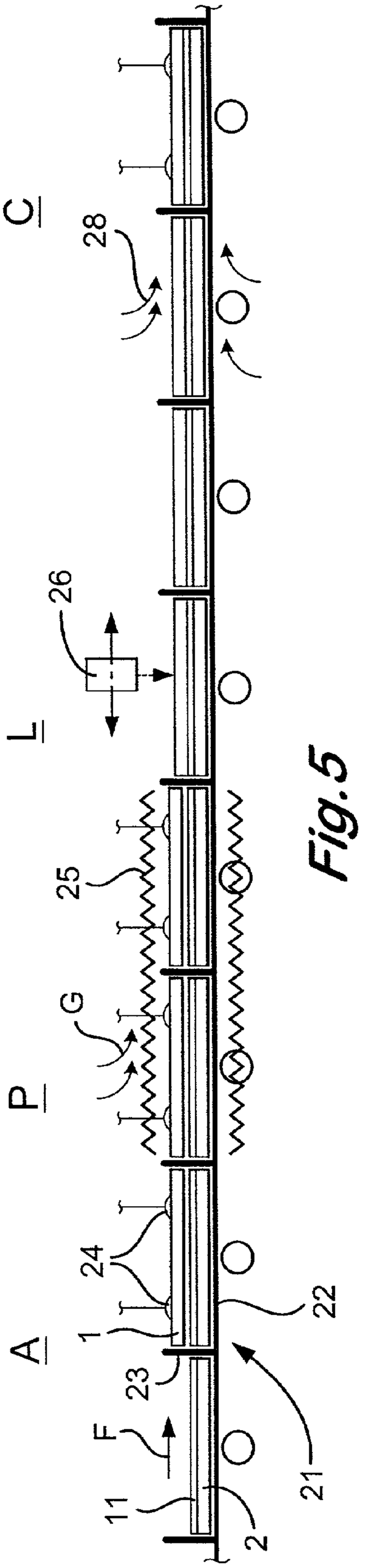


Fig. 5

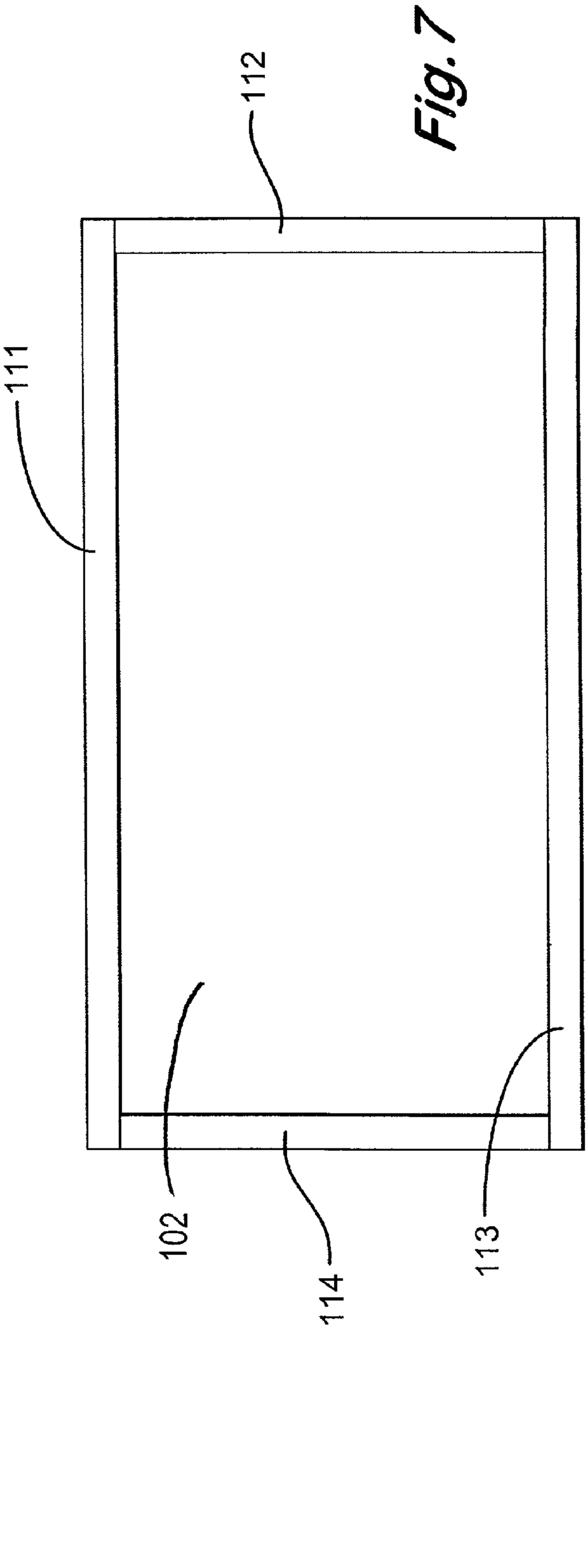


Fig. 7

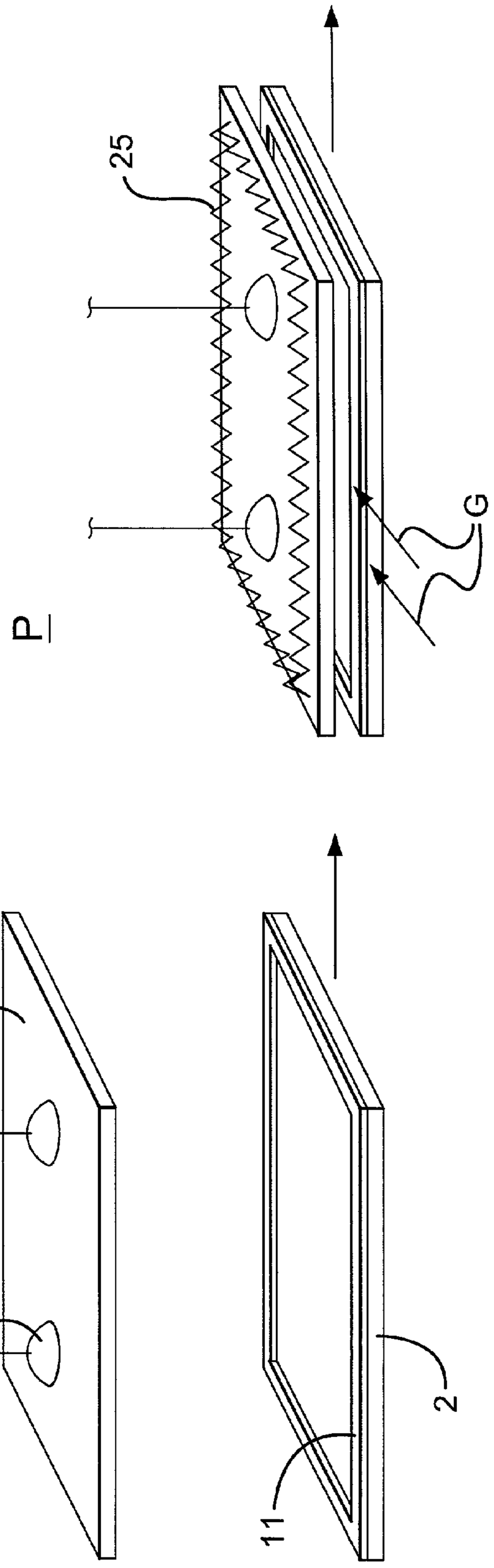


Fig. 6(i)

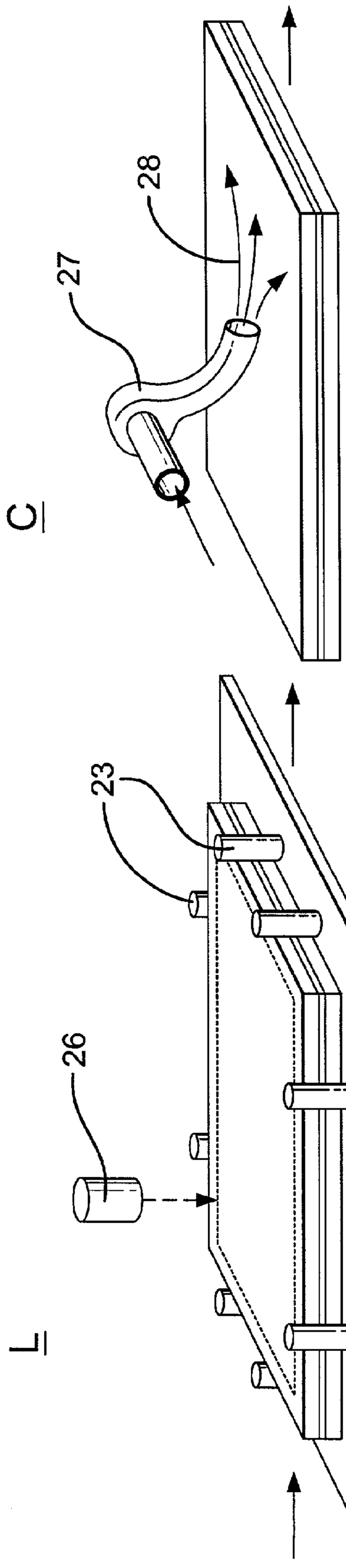


Fig. 6(ii)

DOUBLE GLAZING

[0001] The present invention relates to double glazing.

[0002] This application claims priority from the following U.S. provisional patent applications:

[0003] Application No. 60/224949, dated Aug. 11, 2000 and

[0004] Application No. 60/238269, dated Oct. 5, 2000.

[0005] In a double glazed window, two sheets of glass are arranged parallel to each other with a narrow gap therebetween. A peripheral seal is provided for trapping gas between the panes, to prevent flow of gas degrading the heat transfer, i.e insulation, properties of the assembly, referred to as a doubling glazing unit.

[0006] A problem with present double glazing units is that the seal can leak, allowing the ingress of moisture. This can then condense on the inside of the glass, interfering with the transparency of the unit.

[0007] The object of the present invention is to provide an improved double glazing unit with an improved seal.

[0008] A double glazing unit of the invention comprises two parallel sheets of glass peripherally sealed to each other, the seal being of fused glass frit.

[0009] Glass frit is comminuted glass and a binder. The binder is carried in a solvent, whereby the frit can be tape cast in continuous lengths either for subsequent positioning or in situ or screen printed. On heating, the binder is driven off. The frit can be heated to higher temperature for fusing it to a substrate on which it is carried.

[0010] Our preferred method of fusing the frit is by laser irradiation. However, we anticipate that it will prove possible to fuse the frit by heating the entire unit in an oven to the frit fusing temperature.

[0011] In accordance with a preferred feature, the frit is of colored glass, whereby it absorbs heat on irradiation.

[0012] It should be noted that certain double glazing units have three sheets of glass, in effect forming triple glazing units. The invention is equally as applicable to production of triple glazing units as double glazing units.

[0013] In accordance with another preferred feature of the invention, the frit is chosen to have substantially the same coefficient of thermal expansion—CTE—as that of the glass to be sealed. On the other hand, the softening point of the glass of the frit is preferably markedly less than that of the glass to be sealed, for example 250° C. as against 500° C.

[0014] Further, the degree of preheat of the glass is preferably maintained below the temper firing temperature, whereby the surface compressive stresses induced to strength the glass on tempering are not relieved, at least in the bulk of the glass. Typically, the temper firing temperature is of the order of 500 to 600° C. for a glass with a softening temperature of 750° C.

[0015] In accordance with another aspect of the invention, there is provided:

[0016] a method of producing a double glazing unit comprising two parallel sheets of glass peripherally sealed to each other, consisting in the steps of:

[0017] applying the frit to one of the sheets of glass,

[0018] positioning the other sheet of glass over the first sheet on the frit and

[0019] locally heating the frit to fusing temperature by traversing it with laser irradiation, whereby the two sheets of glass become peripherally sealed together

[0020] Preferably, the sheets are preheated to close to the frit fusing temperature, whereby the energy supplied by the laser is only that required to raise the temperature of the frit locally to its fusing temperature from the preheat temperature.

[0021] Again, preferably the degree of preheat of the glass is maintained below the temper firing temperature of the glass, whereby the surface compressive stresses induced to strength the glass on tempering are not relieved, at least in the hulk of the glass.

[0022] Subsequent to irradiation, the sealed unit is cooled in a controlled manner.

[0023] Normally, the laser irradiation will be carried out in a dry, inert atmosphere whereby such an atmosphere is enclosed within the double glazing unit.

[0024] The frit can be preliminarily tape cast and positioned on the glass in continuous lengths. Alternatively, it can be positioned by tape casting direct onto the first sheet of glass. Again, the frit can be positioned by screen printing onto the first sheet of glass.

[0025] Normally, the frit is preliminarily heated to drive off its binder, prior to positioning of the other sheet of glass on it.

[0026] According to a third aspect of the invention, there is provided a double glazing sealing machine comprising:

[0027] a frit application station for applying frit peripherally to a glass sheet to form one side of a double glazing unit;

[0028] an assembly station for assembling the double glazing unit from the two glass sheets on top of each other with the frit between them;

[0029] a preheating station for preheating the assembled pairs of sheets;

[0030] a laser irradiation station for fusing the frit to seal the sheets to each other; and

[0031] a cooling station for cooling the sealed units to room temperature.

[0032] To help understanding of the present invention, a specific embodiment thereof will now be described by way of example and with reference to the accompanying drawings, in which:

[0033] **FIG. 1** is a perspective view of a double glazing unit of the invention;

[0034] **FIG. 2** is a scrap cross-sectional view of an edge portion of the unit of **FIG. 1**;

[0035] **FIG. 3** is a similar scrap view of the frit in the edge portion being irradiated;

[0036] **FIG. 4** is an exploded view of the double glazing unit of **FIG. 1**;

[0037] **FIG. 5** is a diagrammatic view of a line for producing the double glazing units of **FIG. 1**;

[0038] **FIG. 6**(*i.*) is a diagrammatic view of an assembly station and a preheating station of a sealing machine for producing **FIG. 1** units;

[0039] **FIG. 6**(*ii.*) is a diagrammatic view of laser irradiation station and a cooling station of the sealing machine; and

[0040] **FIG. 7** is a plane view of an alternative frit arrangement.

[0041] The double glazing unit of **FIGS. 1 and 2** has a pair of glass sheets **1**, **2**, with a frit seal **3** therebetween, the frit seal being fused to both sheets and extending around the periphery of the unit.

[0042] As shown in **FIG. 3**, the frit seal is fused by irradiation with light **4** from a laser. Typically, the frit is of brown glass, whereby it readily absorbs heat on laser irradiation. The precise color adapting the frit to absorb maximum light energy is dependent on the wave length of the laser light.

[0043] Two frits which have been used satisfactorily are Nos. 75-10052-25 and 75-10052-26 from Emca-Remex/Ferro. These are dark brown and dark green in color. The laser used for fusing these frits was an Optopower CW diode Laser with fiber delivery and having a power of 60 watts at 830 nm wavelength. Whilst we have satisfactorily fused these frits with this laser, we expect other frits and lasers to be suitable.

[0044] Referring to **FIG. 4**, the frit seal is formed of a rectangle **11** of tape cast frit material. Tape casting is a process well known in the electronics component industry, whereby a slurry of frit material is continuously cast onto a substrate. During casting, the binder is mobile due to the presence of the solvent, whereby the comminuted glass can be positioned on the substrate which normally moves continuously away from an orifice whence the frit material is extruded. It passes beneath a so called "doctor blade", which is accurately spaced from the substrate, whereby the frit is formed to an controlled, even thickness. When the solvent has evaporated, the frit has coherence for handling. In particular it can be cut into lengths for use. It can also be cast on a disposable laminate from which it can be peeled for use. In this configuration, it can be stamped to shape for use. Prior to fusing, as by laser irradiation, the frit is referred to as "green". Tape casting of frit and its handling in green form is believed to be within the capabilities of the skilled reader of this specification and will not be described further.

[0045] As shown in FIGS. **5**, **6**(*i.*) & **6**(*ii.*), the stamped rectangles **11** of green, tape cast frit is placed on the lower sheets of glass **2** carried by a conveyor **21** moving in the direction F. The conveyor has a number of frames **22** with upstanding fingers **23** for locating upper and lower sheets. Upper sheets **1** are lowered onto the frit and lower sheets **2** at an assembly station A, by means of suckers **24**.

[0046] At the next, preheat station P, the sheets and the frit are radiantly heated by ohmic heaters **25** to close to the frit fusing temperature. At this stage, one of the upper sheets are still held slightly clear of the frit by the suckers **24**, to allow volatile material from the frit binder to be dissipated and for inert gas G to be introduced between the sheets. The sheets are not heated bodily above the temper firing temperature of the glass, to avoid loss of the strengthening of the glass.

[0047] At the laser station L, shown in **FIG. 6**(*ii*) a laser **26** is traversed around the frit, to fuse it together and to the two glass sheets, thereby sealing the unit. The laser locally raises the frit temperature above its melting point, but the average temperature of the unit remains below it.

[0048] The sealed unit is passed on to a cooling station C, where a fan **27** blows cool air **28** onto the unit at a controlled rate so that the unit is evenly cooled to avoid build up of thermal stresses in the unit and raising of the temperature of the body of the glass above its temper firing temperature.

[0049] The invention is not intended to be restricted to the details of the above described embodiment. In place of use of a stamped rectangle of green tape, as shown in **FIG. 7**, individual lengths **111**, **112**, **113**, **114** of tape cast frit can be assembled onto the lower sheet **102** prior to addition of the upper sheet. Particular attention should be paid to abutment of individual lengths at the corners, so that on fusing, the corners as well as the sides are gas tight.

[0050] Again, the frit can be screen printed to either or both sheets, the latter being preferable to enhance the separation of the sheets by the fused frit.

[0051] More than one laser may be used at once to enhance the speed of fusing. The second laser may operate from below. This is particularly appropriate where three sheets are being united with two frit seals, the one on top of the middle sheet being irradiated from above and the one below from below.

1. A double glazing unit comprising two parallel sheets of glass peripherally sealed to each other, the seal being of fused glass frit.

2. A double glazing unit according to claim 1, wherein the frit is of colored glass, whereby it absorbs heat on irradiation for sealing.

3. A double glazing unit according to claim 1, wherein the unit comprises three or more parallel sheets of glass peripherally sealed to each other by fused glass frit.

4. A double glazing unit according to claim 1, wherein the frit has substantially the same coefficient of thermal expansion as that of the glass to be sealed.

5. A double glazing unit according to claim 1, wherein the glass of the frit has a softening point less than that of the glass to be sealed.

6. A method of producing a double glazing unit comprising two parallel sheets of glass peripherally sealed to each other, consisting in the steps of:

applying the frit to one of the sheets of glass,

positioning the other sheet of glass over the first sheet on the frit and locally heating the frit to fusing temperature by traversing it with laser irradiation, whereby the two sheets of glass become peripherally sealed together.

7. A method according to claim 6, wherein the sheets are preheated to close to the frit fusing temperature, whereby the energy supplied by the laser is only that required to raise the temperature of the frit locally to its fusing temperature from the preheat temperature.

8. A method according to claim 6, wherein the degree of preheat of the glass is maintained below the temper firing temperature of the glass, whereby the surface compressive stresses induced to strengthen the glass on tempering are not relieved, at least in the bulk of the glass.

9. A method according to claim 6, wherein the sealed unit is cooled in a controlled manner.

10. A method according to claim 6, wherein the laser irradiation is carried out in a dry, inert atmosphere, whereby such an atmosphere is enclosed within the double glazing unit.

11. A method according to claim 6, wherein the frit is preliminarily tape cast and positioned on the glass in continuous lengths.

12. A method according to claim 6, wherein the frit is positioned by tape casting direct onto the first sheet of glass.

13. A method according to claim 6, wherein the frit is positioned by screen printing onto the first sheet of glass.

14. A method according to claim 10, wherein the frit is preliminarily heated to drive off its binder, prior to positioning of the other sheet of glass on it.

15. A double glazing sealing machine comprising:

a frit application station for applying frit peripherally to a glass sheet to form one side of a double glazing unit;

an assembly station for assembling the double glazing unit from the two glass sheets on top of each other with the frit between them;

a preheating station for preheating the assembled pairs of sheets;

a laser irradiation station for fusing the frit to seal the sheets to each other; and

a cooling station for cooling the sealed units to room temperature.

* * * * *