Dec. 12, 1961 G. C. O. LODGE 3,012,477

TRANSLUCENT MATERIALS

Filed May 2, 1957 3 Sheets-Sheet 1

FIG. 1.

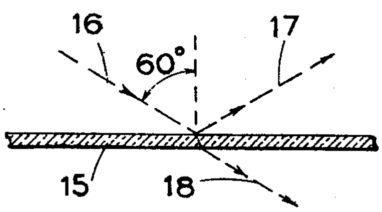


FIG. 2.

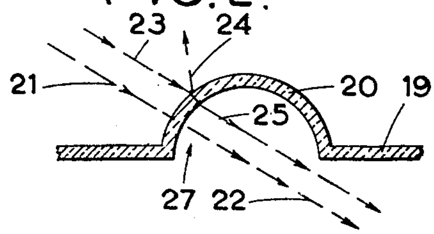


FIG. 6.

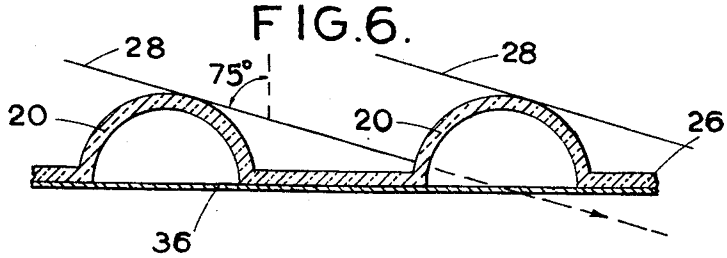


FIG. 7.

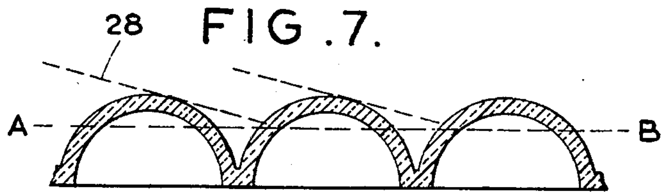
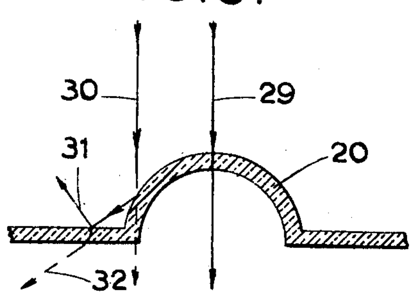


FIG. 8.



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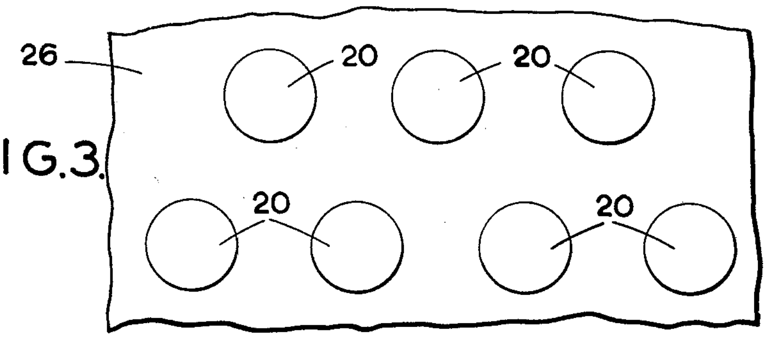

FIG.3.

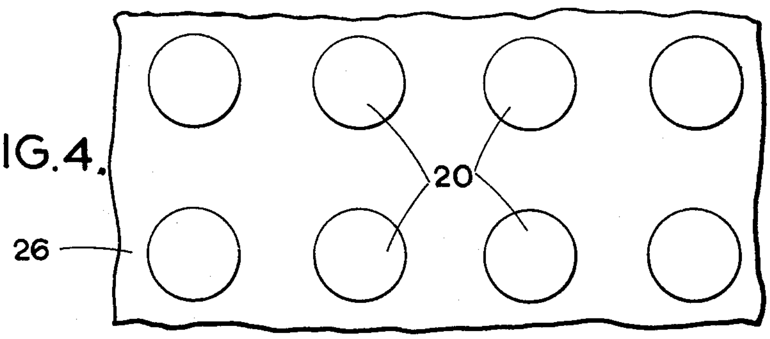

FIG.4.

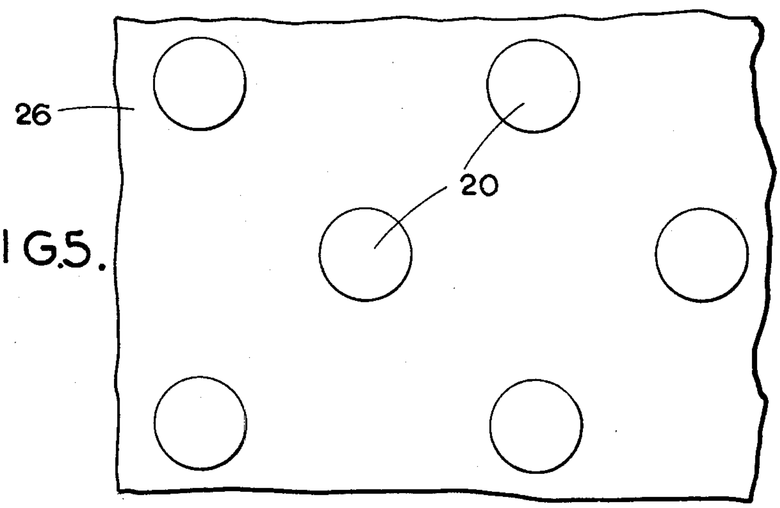

FIG.5.

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FIG. 9.

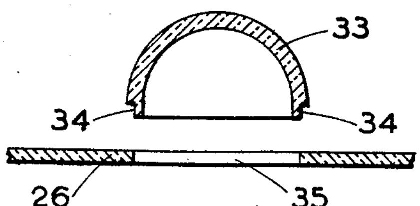


FIG. 10.

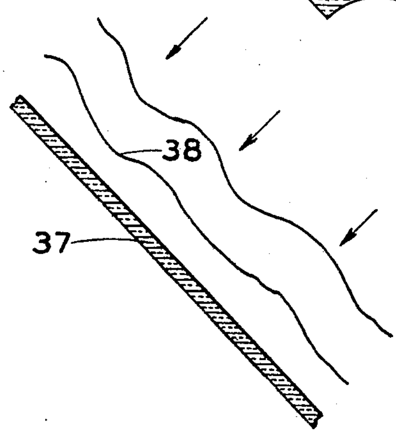


FIG. 11.

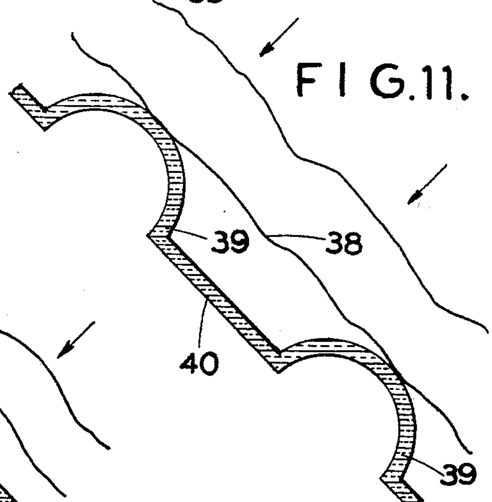


FIG. 12.

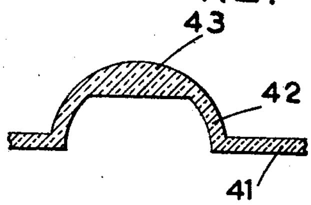
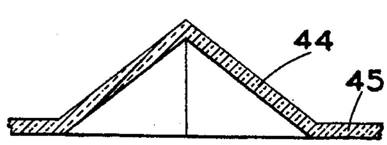


FIG. 13.



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TRANSLUCENT MATERIALS

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Claims priority, application Great Britain May 4, 1956
4 Claims. (Cl. 88—57.5)

This invention relates to translucent materials, especially those in sheet form for use as cloches or for the glazing of greenhouses. Considering greenhouses and similar structures in their simplest form, light which falls on the translucent material of which the structure is mainly composed will, if the angle of incidence is large, penetrate the sheet material only in limited quantity, and large fractions of the light will be reflected externally and the effect of such reflected light will be totally lost so far as the interior of the structure is concerned. In the case of a greenhouse this is a very important factor, because during the early part of the day and in the evening the light is low, i.e. the rays of the sun fall at a high angle of incidence; this effect is more pronounced during the spring and autumn. It is clearly advantageous that the maximum amount of light be transmitted into the greenhouse, and that the minimum be reflected externally, and it is an object of the present invention to provide a material which is not only easily produced but will enable greater quantities of light than heretofore to be transmitted and so trapped in such structures.

According to the invention a translucent sheet material is formed on one surface thereof with convexities spaced apart by a distance at least equal to the width of the convexities and on the other surface with concavities in register with said convexities, the thickness of the material being approximately constant over its whole surface.

In a preferred form the convexities and concavities are hemispherical, but it will be appreciated that an improvement over known materials, though to a lesser degree, may be effected through other shapes such as prismatic or elliptical projections.

Preferably also the convexities are arranged in rows and are spaced apart, e.g. in the case of hemispherical convexities, at distances of two diameters, centre to centre.

In any given sheet of material, one or more of the convexities may be arranged to be removable, normally being retained in a seating, but detachable therefrom so as to give access to the other side of the sheet so that the interior of the structure may be ventilated.

Alhough it is convenient to have the thickness of the material substantially constant, it may be desired to make the apex of a convexity somewhat thicker than the walls of the convexity, so as to form a lenticular portion at the apex.

The side of the sheet of material on which the concavities are formed may have applied thereto a pressure-sensitive adhesive, so that the material according to the invention may be applied to the outside of an existing structure such as a greenhouse.

In some cases it may be desirable that at least one margin of some or all of the sheets according to the invention is formed with means for engaging with complementary means on another sheet. Such means may take the form of pegs, teeth, or other shapes which will enable one sheet to be readily fastened to another.

Embodiments of the invention will be described with reference to the accompanying drawings, in which:

FIGURE 1 indicates diagrammatically the path of a ray of light falling on a sheet of glass.

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FIGURE 2 indicates diagrammatically the paths of rays falling on material according to the invention,

FIGURES 3, 4 and 5 show, in diagrammatic plan, various alternative dispositions of hemispherical convexities,

FIGURE 6 is a diagrammatic fragmentary sectional elevation of a sheet of material, according to the invention,

FIGURE 7 is a similar view, in contradistinction thereto, of material not according to the invention,

FIGURE 8 is a diagrammatic section illustrating the paths of rays falling at an angle of incidence of 0°.

FIGURE 9 is a fragmentary sectional elevation of a removable convexity,

FIGURES 10 and 11 are diagrammatic representations of shock waves impinging on surfaces,

FIGURE 12 is a fragmentary section of an alternative form of hemispherical convexity, and

FIGURE 13 is a similar view of a pyramidal convexity.

Referring to FIGURE 1, **15** represents a sheet of glass as ordinarily employed for a cloche or a greenhouse. **16** represents a ray of light falling thereon at an angle of incidence of 60°. A substantial proportion of the incident ray is reflected, as indicated at **17**, and is thereby lost, while another fraction, indicated at **18**, is refracted and passes to the interior of the structure. It is clear, therefore, that only the fraction represented by **18** can be usefully employed.

Referring now to FIGURE 2, the sheet material **19** is glass or a plastic such as polythene or polystyrene, and for purposes of comparison is of the same thickness as the glass **15**. It is formed with a hemispherical convexity **20**.

Consider now an incident ray **21**, having an angle of incidence of 60° relatively to the sheet **19**. Since the ray **21** is radial, it impinges on the surface of the convexity at an angle of local incidence of 0°, and substantially all the light (about 98%) passes inside, as indicated at **22**.

Consider next a ray **23** parallel to the ray **21**. This has an angle of local incidence of 20°, and therefore a small fraction (about 5%) indicated at **24**, is reflected outwards, while a larger fraction, indicated at **25**, passes inwards.

It will be seen, therefore, that the convexity of FIGURE 2 will trap considerable quantities of light that would, with the flat sheet of FIGURE 1, be reflected and lost.

Referring also to FIGURE 3, a sheet **26** of material is moulded from polythene, polystyrene or from glass or other suitable material. The degree of translucency will depend on the characteristics required of the finished product. In the case of greenhouses, which are today frequently shattered by supersonic bangs from high-speed aircraft, it may be desirable to employ a relatively resilient material such as polythene, rather than glass.

In the embodiment made from polythene, which may be readily moulded and cheaply produced, the sheet is made of a convenient size, say 2 ft. x 4 ft., although, of course, the size may be related to the type of glazing eventually required. In shape, the sheet is rectangular and of a suitable thickness, say one eighth of an inch, as indicated in FIGURE 2. The sheet **26** is formed with hemispherical convexities **20** on one side, and with corresponding hemispherical concavities (indicated at **27** in FIGURE 2) on the other side, the thickness of the sheet being substantially constant over its entire surface. The diameter of each of the convexities **20** is, say, 1″, and the convexities are arranged in straight rows in staggered formation, each convexity being spaced at a distance of two diameters from its immediate neighbours in its own row and adjacent rows, being similarly spaced.

This spacing is of considerable importance. If the convexities were too closely spaced, each convexity would shield its neighbours to some extent from the impinging light, but if the convexities are spaced as described above, very little shielding will take place.

This is clearly shown in FIGURE 6. Convexities **20**, spaced at two diameters from centre to centre, have rays **28** falling on them at an angle of incidence of 75°. It will thus be seen that rays having angles of incidence up to 75° (the greatest angle normally encountered) can impinge on the convexities, the full surface of which can be utilised. If the convexities were too close together, as is shown in FIGURE 7, the rays **28** would impinge only on the upper parts of the convexities. In consequence, their angles of local incidence would be large, and a considerable fraction would be reflected and lost. Indeed, the lower parts of the convexities, for example those parts below the line AB, would be largely ineffective, and the benefits of the invention would be lost.

Incident light falling normally, that is, at an angle of incidence of 0°, will penetrate the material with relatively little loss, there being only a small fraction of the light reflected externally.

This is illustrated in FIGURE 8. A ray **29** falling normally and radially will pass in with a loss of only 2%. A ray **30**, also falling normally, but nearer the margin of the convexity, will be partly reflected, as indicated at **31**, but mainly refracted, as indicated at **32**. This, incidentally, shows that a desirable diffusion is effected within the greenhouse.

When, however, the light falls on the sheet at an angle of incidence of about 45° or more, much of it will fall on the hemispherical convexities at smaller angles of incidence in such a way as to pass through the convexity (see FIGURE 6), the local angle of incidence remaining at or near 90°, whereas, had the sheet been a continuous flat sheet, the angle of incidence would have been say 50° or 60° or even more, and most of the light would have been lost.

It will therefore be appreciated that when the angle of incidence is very small, the sheet material behaves in substantially the same form as would a normal sheet of glass in a greenhouse, i.e. the majority of the light falling upon it is transmitted to the interior of the greenhouse, but when the angle of incidence becomes larger, and in particular when it exceeds about 45°, the majority of the light falling upon it passes through a sheet according to the invention, instead of being reflected externally and therefore being wasted as would occur with oridinary sheets of glass.

Thus, sheets according to the invention enable a greater amount of the light falling onto a greenhouse to be transmitted thereinto to serve a useful purpose. Further, the transmitted light is more diffused.

FIGURE 4 illustrates an alternative embodiment in which the convexities are arranged in rows in rectilinear fashion, while FIGURE 5 shows a more widely spaced arrangement in staggered formation.

The ventilation of a single cloche differs from that required for a large greenhouse, but it can be arranged to any extent required by simple means such as the provision of one or more removable convexities in one or more of the sheets making up a structure. In its simplest form, the ventilating means could consist of a sheet having an aperture in place of a convexity, the margin of the aperture being formed as a seating to accommodate a convexity separately moulded so as to be capable of location in the aperture during normal use.

A removable convexity is shown in FIGURE 9. The convexity **33** is rebated as at **34** and is arranged to seat removably in an aperture **35** in the sheet **26**. Ventilation would then be promoted merely by removing the convexity **33** from its seating. It could, however, be achieved by other means such as hinged flaps within the area of the sheets.

In the case of making up cloches, which may be of a variety of shapes, there may be provided pegs, grooves, apertures, or a variety of other interlocking means to ensure the location of the margin of one sheet against the margin of another sheet, in any desired manner. It will be clear that the provision of such means will not interfere with the formation of the convexities over the main area of the sheet.

Convexities may be of differing sizes in the same sheet if desired, and may be arranged in patterns instead of in rows.

It is within the scope of the invention to provide a sheet of material which may be affixed to the glass of an existing greenhouse. For this purpose, as shown in FIGURE 6, a sheet **26** having convexities **20** may have on the under side thereof a layer **36** of adhesive, preferably a pressure-sensitive adhesive whereby the sheet is merely pressed into position.

It is though that the superior resistance of the material to supersonic bangs is due not only to the resilience of, e.g. polythene, but also to the shock-breaking and absorbent effect of the convexities on the impinging air, and to the increased structural resistance imparted by the convexities.

FIGURES 10 and 11 illustrate this. In FIGURE 10 a flat sheet of glass **37** is subjected to a shock wave indicated at **38**. The impact of the air is believed to be simultaneous over the whole area of the sheet, so inducing vibrations in the glass sufficient to break it.

In FIGURE 11, the wave **38** first hits the convexities **39**, and by the time it reaches the sheet **40** it has become disturbed, and so no longer has an unbroken front which can produce the impact previously experienced.

As the shock wave first impinges on the small areas of the tops of the domes, pressure is transmitted through the walls of the domes, and the sheet **40** is prepared gradually to receive the impact and to yield thereto. Turbulence and counterwaves occur, with opposite and various directions of force, and much of the energy of the shock wave is thus dissipated.

In the specification, it has been stated that the thickness of the material is approximately constant over its whole surface. There will, of course, be minor variations by reason of the provision of convexities, for example, at the junction of a convexity with the sheet there may be quite an appreciable extra thickness but it is intended in general that the thickness of a hemispherical convexity is, measured radially, approximately the same as the thickness of the sheet, and that similar considerations should apply for other shapes of convexity.

It is, however, possible to vary the thickness of the convexity, as illustrated in FIGURE 12, for example, to achieve certain effects. Thus in FIGURE 12 the sheet **41** has a hemispherical convexity **42** formed with a thickened apex **43** constituting a lens. Thus, a sheet of material can be designed to effect concentration of light falling over a predetermined range of angles of incidence.

There may be other forms of convexities. For example, FIGURE 13 illustrates a pyramidal convexity in a sheet **45**. Other shapes may be ellipsoids, trapezoids or round-topped cones.

When the material is to be used for cloches, it may be moulded in curved or angled formation if desired. Thus, there may be a semi-cylindrical sheet arranged to be located on the top edges of two flat sheets which are maintained in parallel and almost vertical relation, or two flat sheets may be moulded in one at an angle of, say, 45°. Such an angled sheet would form a complete cloche. Alternatively, the Dutch barn type of cloche may be moulded in a single sheet. Alternatively again, where a flexible material such a polythene is employed, the sheet may be moulded with a weak band of reduced thickness, enabling the sheet to be hinged. This not only allows it to be bent to any desired angle and maintained at that angle in a framework, e.g. of wire, but allows one side of a cloche to be fixed and the other side to be hingeable for purposes of ventilation.

When moulding material for cloches, it is convenient to allow a flat plain border of suitable size, say, one inch wide, around the edge of each sheet free from convexities, so as to enable the sheet to be gripped or joined to neighbouring sheets.

Frames for cloches may be either of bent wire or of light channel or T section metal or plastic, and it is convenient with materials of such light weight as constitutes the cloche to provide anchoring means such as serpentine pegs which may be driven into the ground.

It is possible to make structures, or even sheets of material according to the invention, out of two different materials having different properties. Thus, a cloche may be made with a top formed of one material, and the sides and ends formed of another material, the materials being chosen for their resistance to ultraviolet light. The top may be chosen to be of a material more resistant to ultra-violet light than the sides. During the day, when there is plenty of ultraviolet light falling at low angles of incidence, quite sufficient for normal purposes may be obtained through the top, even though it is somewhat resistant to the ultra-violet light. The sides are arranged to be of a material less resistant to the ultra-violet light, and during the day they admit as much as can be accepted. During the night, when the ground is radiating, the top of the cloche, being somewhat resistant to ultra-violet light, prevents its escape. Since the angle of incidence of rays radiated from the ground upon the sides of the cloche is very high, considerable internal reflection from the sides within the cloche will take place and therefore there will be less loss and more complete protection from frost.

It will be appreciated of course that under all circumstances the escape of light or heat energy from the under side of a sheet of material according to the invention will be considerably less than in the case of orthodox materials such as glass, since considerable diffusion and reflection of the heat will take place.

I claim:

1. A greenhouse glazing comprising a sheet of imperforate translucent material having a monoplanar body formed on only one side thereof with a plurality of concavo-convex bosses, each of said bosses being spaced from adjacent bosses by a distance at least equal to the width of one of said bosses, and the thickness of the material being approximately constant over the surface both of said body and of said bosses.

2. A greenhouse glazing comprising a sheet of imperforate translucent material as in claim 1, said bosses being hemispherical.

3. A greenhouse glazing comprising a sheet of imperforate translucent material having a monoplanar body formed on one side thereof with a plurality of hemispherical concavo-convex bosses arranged in rows and spaced apart at distances of two diameters, center to center.

4. A greenhouse glazing comprising a sheet of imperforate translucent material having a monoplanar body formed on one side thereof with a plurality of hemispherical concavo-convex bosses, each of said bosses being spaced from adjacent bosses by a distance at least equal to the width of one of said bosses, the thickness of the material being approximately constant over the surface of said body and over the margins of said bosses, and the thickness of the central portions of said bosses being slightly greater than said constant thickness, whereby lenticular portions transmitting light rays are provided at the centers of and integral with said bosses.

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