Jan. 12, 1971 G. F. RITTER, JR., ET AL 3,554,724

METHOD AND APPARATUS FOR BENDING GLASS SHEETS

Filed May 24, 1968

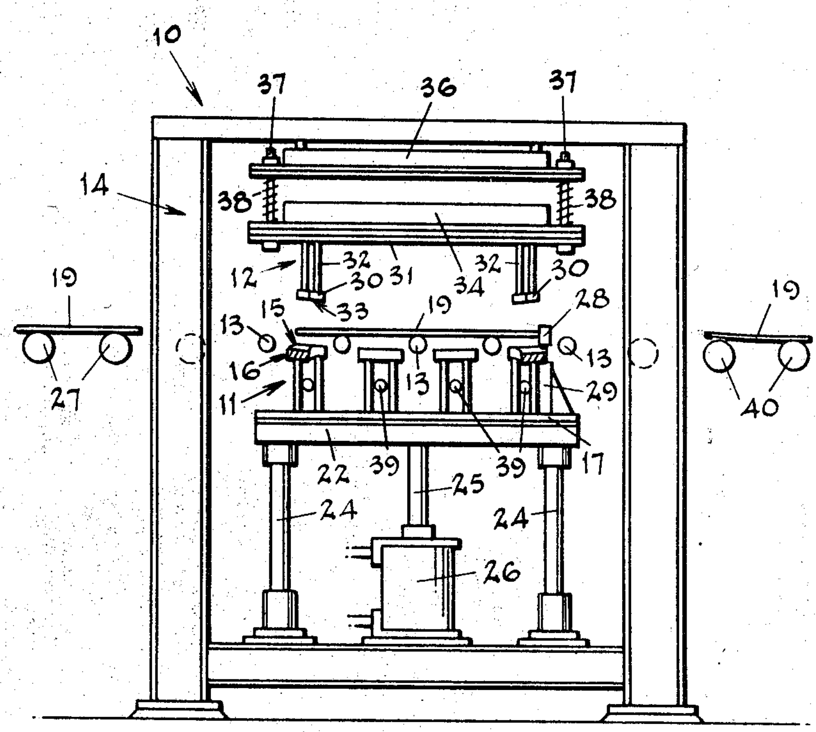

Fig. 1.

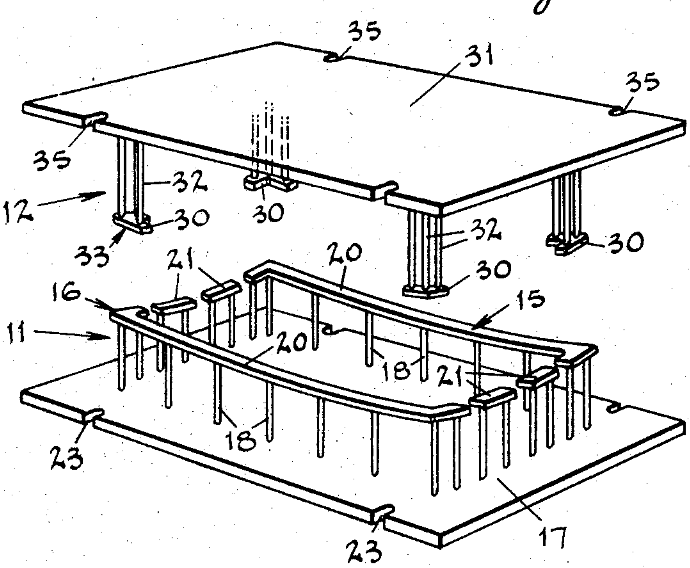

Fig. 2.

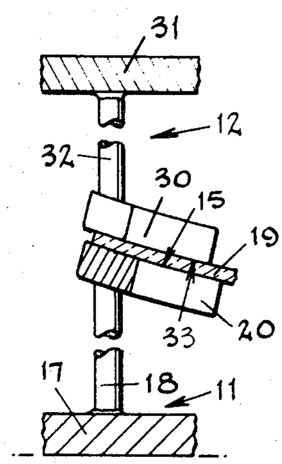

Fig. 3.

INVENTORS

George F. Ritter, Jr. and Frank J. Hymore

BY

Collins & Oberlin

ATTORNEYS

United States Patent Office

3,554,724

Patented Jan. 12, 1971

3,554,724

METHOD AND APPARATUS FOR BENDING GLASS SHEETS

George F. Ritter, Jr., Toledo, and Frank J. Hymore, Oregon, Ohio, assignors to Libbey-Owens-Ford Company, Toledo, Ohio, a corporation of Ohio

Filed May 24, 1968, Ser. No. 731,973
Int. Cl. C03b *23/02*
U.S. Cl. 65—107 12 Claims

ABSTRACT OF THE DISCLOSURE

Method and apparatus for bending glass sheets in which a flat sheet of glass, heated to bending temperature, is supported horizontally above a primary mold member having a shaping surface of the curvature corresponding to the sheet when bent. The mold member is moved upwardly to lift the sheet, whereupon the sheet will settle into contact with the shaping surface of the mold under the influence of forces resulting from the inertia of the sheet and from gravity. A secondary mold member, mounted above the primary mold member, is provided to engage certain spaced portions only on the edges of the sheet which tend to curl upward as inertial forces cause the center of the sheet to sag to insure that these portions will be pressed into conformity with the primary mold member.

The present invention relates to improved apparatus for bending glass sheets.

Curved sheets of glass are widely used as glazing closures for vehicles, such as automobiles or the like. To be acceptable for such application, the curved sheets must be bent to precisely defined curvatures determined by the over-all styling of the vehicle and the manner of mounting the sheet. At the same time, the sheet must meet rather stringent optical requirements, which dictate that the viewing area of the window be free of optical defects which would tend to interfere with clear vision.

In general, the commercial production of curved glass sheets of the above character includes heating the sheets to the softening point of the glass, bending the heated sheets to the desired curvature and thereafter cooling them in a controlled manner to a temperature below the annealing range of the glass.

When produced in large quantities, the sheets are heated, bent and cooled in a substantially continuous process while being moved successively through a heating area, a bending area, and a cooling area. According to one procedure, the sheets are bent into conformity with the shaping surface of a single mold member by a combination of inertial and gravitational forces, which make it possible to bend the sheets rapidly while leaving the viewing area of the sheets completely free from contact with the mold member.

In this method, the sheets are supported horizontally on a concave mold member of outline or ring-type construction which contacts the marginal edge portions only of the sheet, and bending is initiated by accelerating the sheet bodily upwardly, whereupon the sheet will sag into contact with the shaping surface of the mold under the influence of forces resulting from the inertia of the sheet and from gravity. After the mold has moved upwardly a predetermined distance it is halted momentarily while the sheet settles into conformity with the shaping surface of the mold. Such a bending procedure is disclosed in the corresponding application of George F. Ritter, Jr. Ser. No. 573,969, filed Aug. 22, 1966 now Pat. No. 3,476,540.

While this so-called inertia-gravity bending procedure has proved quite successful, there is a practical limitation on the sharpness and complexity of the bends which can be produced thereby. This is particularly true when a relatively sharp curve is to be formed in the end portions of the sheets where there is a tendency for the edge portions and especially the corners to curl upward away from the shaping surface as the inertial forces cause the central area of the sheet to sag, and the subsequent purely gravitational forces are not sufficient to cause them to settle back down again.

In order to overcome the above limitation, the present invention provides a supplemental mold member, engageable with a glass sheet supported on the concave primary mold member, which will insure that the corners, or other areas of the sheet which tend to remain out of contact with the primary mold member, will be bent into conformity with said primary member while, at the same time, retaining all of the advantages of inertia-gravity type bending.

Therefore, the primary object of this invention is to provide improved bending apparatus of the inertia-gravity type on which glass sheets can be bent to relatively sharper and more complex curvatures than heretofore possible.

Another object of the invention is to provide such an apparatus which embodies a supplemental mold member engaging selected areas of the glass sheet in order to insure that they will be bent into conformity with the shaping surface of the primary mold member.

A further object of the invention is to provide apparatus of the above character which includes means for setting the curvature produced in the sheet while the said sheet is still in contact with the primary mold member.

Other objects and advantages of the invention will become more apparent during the course of the following description when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

FIG. 1 is a side elevational view of a bending apparatus constructed in accordance with the invention;

FIG. 2 is a perspective view of the primary and supplemental bending mold members; and

FIG. 3 is a fragmentary sectional view depicting the mold members of FIG. 2 in engagement with a glass sheet.

Referring now to the drawings, there is illustrated in FIG. 1 a glass bending apparatus of the type in which sheets are bent by inertial and gravitational forces. The bending apparatus **10** consists essentially of a movable lower primary bending mold member **11**, a substantially stationary upper supplemental mold member **12** and a series of supporting conveyor rolls **13**, all suitably mounted within a rigid framework **14**.

In order to avoid marring of those areas of the glass sheets which will constitute the viewing area of the finished window, the lower mold member **11** is of outline or ring-type construction having a shaping surface **15** which engages only the marginal edge portions of the sheet. The shaping surface **15** is generally concave and is formed on a shaping element **16**, which is supported from a base member **17** by a plurality of supporting bars **18**.

The lower mold member **11** is vertically movable to lift a glass sheet **19** to be bent from the conveyor rolls **13** and to initiate the inertial force required to promote bending. Therefore, in order to provide clearance for the rolls **13**, the shaping element **16** is made up of a plurality of sections including transversely disposed end sections **20**, and spaced longitudinal bar portions or segments **21** between which the conveyor rolls **13** are located.

The base member **17** of the lower mold member **11** is fastened to a carriage **22**, such as by bolts (not shown) received in slots **23** in said base member, and the carriage is supported by telescoping guide members **24** which allow vertical movement only, said vertical movement being provided by the ram **25**, of a pressure cylinder **26**, which bears against the bottom of the carriage.

The glass sheets **19**, which have been heated to the desired softening temperature, are transferred from a furnace (not shown) into the bending apparatus **10** on entry conveyor rolls **27** and are received in position to be bent on the rolls **13**. As each sheet approaches the bending apparatus it actuates a photocell or other detection device, thereby energizing suitable timing mechanisms which initiate and thereafter control the actions of the various components of the bending apparatus.

As each glass sheet **19** arrives in position above the mold member **11** it is halted by engagement of its leading edge with locator stops **28** (one of two shown) which are moved into and out of the path of sheet movement by pressure cylinders **29** mounted on the base member **17**. Upon an appropriate signal from the associated timing device fluid pressure is applied to the lower end of the cylinder **26** causing the ram **25** to rapidly move the mold member **11** upward lifting the sheet from the supporting conveyor rolls **13**. As the sheet **19** is moved bodily upward by the mold, inertia forces acting on the glass cause it to sag. Once the sagging action has started, natural gravitational forces acting thereon are generally sufficient to cause the heat softened sheet to continue bending and assume the concave contour of the shaping surface **15**, by the time, or shortly after the mold member **11** has reached the limit of its upward movement.

In most cases the above-described procedure is adequate to completely form a sheet to the desired curvature, such that the bent sheet can be lowered back onto the conveyor rolls for transfer out of the bending apparatus. In some situations, however, the curvature in certain areas of the sheet, particularly at the corners thereof, may be such that inertia and gravity forces alone are not sufficient to cause the sheet to bend into conformity with the mold shaping surface. In fact, there is a tendency, regardless of the curvature of the sheet, for the corners to curl upward away from the shaping surface as the sudden upward movement of the mold causes the unsupported central area of the sheet to sag. Although the corners will generally sag back down into conformity with the shaping surface this may not always occur, especially when the radius of curvature is relatively small or if compound curves are to be formed.

Therefore, in accordance with the invention, there is provided a supplemental upper mold member **12** which is aligned with the lower mold member **11** and has a shaping element comprising four L-shaped segments **30**, as shown in FIG. 2, which engage only the corners of the sheet. Each of the four segments **30** is suspended from a horizontal base member **31** by depending support rods **32**, each of said segments having a generally convex shaping surface **33** formed on its bottom face which is complementary to the opposed portion of the shaping surface **15** of the lower shaping element **16** as illustrated in FIG. 3.

The upper supplemental mold member **12**, which remains substantially stationary, is attached to a rigid frame member **34** by means of bolts received in slots **35** or in some other suitable manner. The rigid frame member **34** is resiliently suspended from a mounting frame **36** depending from the main framework **14** by bolts **37**. Springs **38** surrounding each bolt **37**, are interposed between the mounting frame **36** and the frame member **34** and limit the amount of force that is applied by the segments **30** when they contact the glass at the upper limit of movement of the lower mold member **11**.

In order to insure that the glass sheet **19** will retain the desired curvature while it is being transferred from the bending apparatus **10** to another area for additional treatment, such as annealing or tempering, cooling tubes **39** are mounted on the lower mold member **11**, between the shaping element **16** and the base **17**. These tubes, which extend transversely across the full width of the shaping element **16** are provided with upwardly directed orifices so that cooling air may be directed against the bottom surface of the bent sheet as it is being lowered back onto the conveyor rolls **13**. The effect of this cooling is to reduce the temperature of the sheet a sufficient amount to cause it to permanently set in the curved configuration without significantly affecting any further heat treatment which may be performed upon its exit from the bending apparatus.

In a typical operational cycle of the illustrated embodiment, a heat softened glass sheet **19** enters the bending apparatus **10** upon entry conveyor rolls **27** and is deposited on the rolls **13** within the apparatus, whereupon it is stopped by the locator stops **28** when it becomes aligned with the shaping element **16** of the lower mold member **11**. The mold member **11** then moves quickly upward, by virtue of the force applied by the ram **25**, lifting the sheet off the rolls **13**. The combined effffects of inertial and gravitational forces then cause the glass sheet to sag into conformity with the shaping surface **15** of the lower mold member **11**. As the mold member approaches the end of its upward travel the four corner portions of the sheet are engaged by the downwardly directed segments **30** of the supplemental mold member **12**.

While, as pointed out above, the combined forces of inertia and gravity will ordinarily be sufficient to cause the sheet to conform to the shaping surface **15** upon upward movement of the lower mold member, the bending segments **30** of the supplemental mold member will insure that the corner portions of the sheet will always be pressed down into conformity with the corner areas of the lower mold member.

When the mold member **11** reaches the upper limit of its travel, it is stopped momentarily to insure that the sheet has sagged into its bent configuration. Fluid pressure is then applied to the upper end of cylinder **26** causing the mold member **11** to move downward depositing the bent sheet **19** upon the rolls **13**.

During upward movement of the glass sheet **19** the locator stops **28** are moved downward to an out-of-the-way position below the supporting surfaces of the rolls **13**, so that when the bent sheet **19** is deposited on the rolls it is free to be transferred thereby out of the bending apparatus **10** upon exit conveyor rolls **40**. As the bent sheet nears the rolls **13**, cooling air is applied by the tubes **39** to the bottom surface of the sheet **19** to set it to the desired curvature before it is received on the rolls **13**.

Although the illustrated mold is of rectangular configuration, it is contemplated that similar supplemental mold members can be utilized in conjunction with a variety of shapes formed by the inertia-gravity method. It will also be appreciated that the shape and location of the segments **30** will depend upon the exact configuration of the bent sheet desired, and that such segments may be used in locations about the marginal edges other than at corners, when, because of the nature of the bend, there may be a tendency for that portion of the sheet to lift and remain off the shaping surface after the application of the inertial and gravitational forces.

It is to be understood that the form of the invention herewith shown and described is to be taken as an illustrative embodiment only of the same and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention.

We claim:

1. Apparatus for the horizontal bending of glass sheets, the combination of a lower primary mold member having a shaping element with a marginal edge shaping surface of a desired outline and curvature formed thereon, means for supporting a heat softened glass sheet in position above said shaping surface, means for moving said mold member upwardly between a lower and upper limit of travel to lift said sheet bodily from said supporting means thereby creating combined inertial and gravitational forces to initiate the bending of said sheet into conformity with said shaping surface, and a substantially stationary secondary mold member spaced above said primary mold member, said secondary mold member comprising a shaping element having formed thereon a shaping surface aligned with and complemental to a portion only of the marginal edge shaping surface of said primary mold member, said complemental shaping surfaces being engageable with opposite surfaces of a glass sheet supported on said primary mold member when said primary mold member reaches the upper limit of travel.

2. Apparatus for bending glass sheets as defined in claim **1**, in which the shaping element of said secondary mold member comprises at least one bar section aligned with and complemental to a portion only of the marginal edge shaping surface of the primary mold member.

3. Apparatus for bending glass sheets as defined in claim **1**, in which the primary mold member is of ring-type configuration and the secondary mold member is provided with a plurality of spaced shaping surfaces disposed opposite complemental portions of the shaping surface of the primary mold member.

4. Apparatus for bending glass sheets as defined in claim **2**, in which said bar section is substantially L-shaped in plan and is aligned with a corner of the shaping surface of said primary mold member.

5. Apparatus for bending glass sheets as defined in claim **1**, including means for directing a cooling medium against the bottom surface of the sheet after bending and while the sheet is still supported on said primary shaping surface.

6. Apparatus for bending glass sheets as defined in claim **3**, including cooling tubes disposed below the shaping surface of said primary mold member, said tubes having orifices formed therein operable to direct streams of cooling gas against the bottom surface of said sheet after it is bent in conformity with said shaping surface and while the sheet is still supported by said primary shaping surface.

7. In apparatus for bending each of a plurality of heat softened glass sheets moving successively along a predetermined substantially horizontal path, a lower primary mold member having an upwardly facing marginal edge shaping surface, an upper secondary mold member, and a conveyor having a horizontal run extending along said path between said upper and lower mold members for receiving a sheet to be bent and for positioning it between said mold members, said primary mold member being vertically movable between a lower and upper limit of travel to bodily lift said sheet from said conveyor causing the application of inertial and gravitational forces to said sheet to initiate bending of the same into conformity with the shaping surface on said primary mold member, and said upper secondary mold member comprising a bar vertically spaced from a section of the marginal edge shaping surface of the primary mold member and having a shaping surface aligned therewith and complemental thereto, said shaping surface on said secondary mold member being engageable with the upper surface of said glass sheet when the lower surface thereof is in contact with said upwardly facing shaping surface at the upper limit of travel of said primary mold member.

8. Apparatus for bending glass sheets as defined in claim **7**, in which said bar is substantially L-shaped in plan corresponding to a corner portion of said upwardly facing shaping surface.

9. Apparatus for bending glass sheets, comprising a horizontal lower primary mold member having a shaping element with an upwardly facing shaping surface of outline configuration formed thereon, means for supporting a heat softened glass sheet in bending position above said shaping surface, means for moving said mold member bodily upward between a lower and upper limit of travel to lift said sheet and initiate bending of the same under the influence of inertial and gravitational forces, and a substantially stationary upper, secondary mold member spaced above said primary mold member and having a shaping element with a shaping surface formed thereon, said secondary shaping surface being aligned with and complementary to a portion only of said upwardly facing shaping surface and engageable with a marginal portion of the upper surface of said sheet when said primary mold member is at the upper limit of its travel.

10. Apparatus for bending glass sheets as defined in claim **9**, in which the primary mold member is of ring-type configuration and in which the secondary mold member comprises a plurality of spaced shaping elements having shaping surfaces disposed opposite complemental portions of the shaping surface of said primary mold member.

11. Apparatus for bending glass sheets comprising a lower primary molding member having a shaping surface of a desired outline and configuration formed thereon, means for supporting a heat softened glass sheet in a plane above and in bending relation to said shaping surface, means for moving said molding member upwardly to lift said sheet bodily from said supporting means and create combined inertial and gravitational forces to initiate the bending of said sheet into conformity with said shaping surface, and a supplemental molding member located above said plane and having formed thereon a shaping surface aligned with and complemental to a portion only of the shaping surface of said primary molding member, said complemental shaping surfaces being engageable with opposite surfaces of a glass sheet supported on said primary molding member after said initial bending to insure said sheet being finally bent into conformity with the shaping surface of said primary molding member.

12. In a method of bending glass sheets, the steps of heating a sheet to the softening point of the glass, supporting the heated sheet in a substantially horizontal plane and in bending relation to a primary contoured outline shaping surface disposed below said plane and shaped to the curvature desired in the sheet when bent and to a supplemental shaping surface disposed above said plane and in alignment with and complemental to a portion only of said primary shaping surface, moving said primary shaping surface upwardly through said plane to lift said sheet bodily from said plane and create an inertial force which when combined with the force of gravity initiates the bending of said sheet into conformity with said primary shaping surface, and thereafter engaging a marginal portion of the upper surface of said sheet with said supplemental shaping surface to urge said sheet into contact with said primary shaping surface and insure said sheet being finally bent into conformity therewith.

References Cited

UNITED STATES PATENTS

3,459,526 8/1969 Stickel et al. -------- 65—268
3,476,540 12/1969 Ritter et al. ---------- 65—107

S. LEON BASHORE, Primary Examiner

S. R. FRIEDMAN, Assistant Examiner

U.S. Cl. X.R.

65—287