Jan. 18, 1966 F. J. CARSON ETAL 3,230,067

GLASS SHEET BENDING APPARATUS WITH GUIDE MEANS

Original Filed Sept. 26, 1957 2 Sheets-Sheet 1

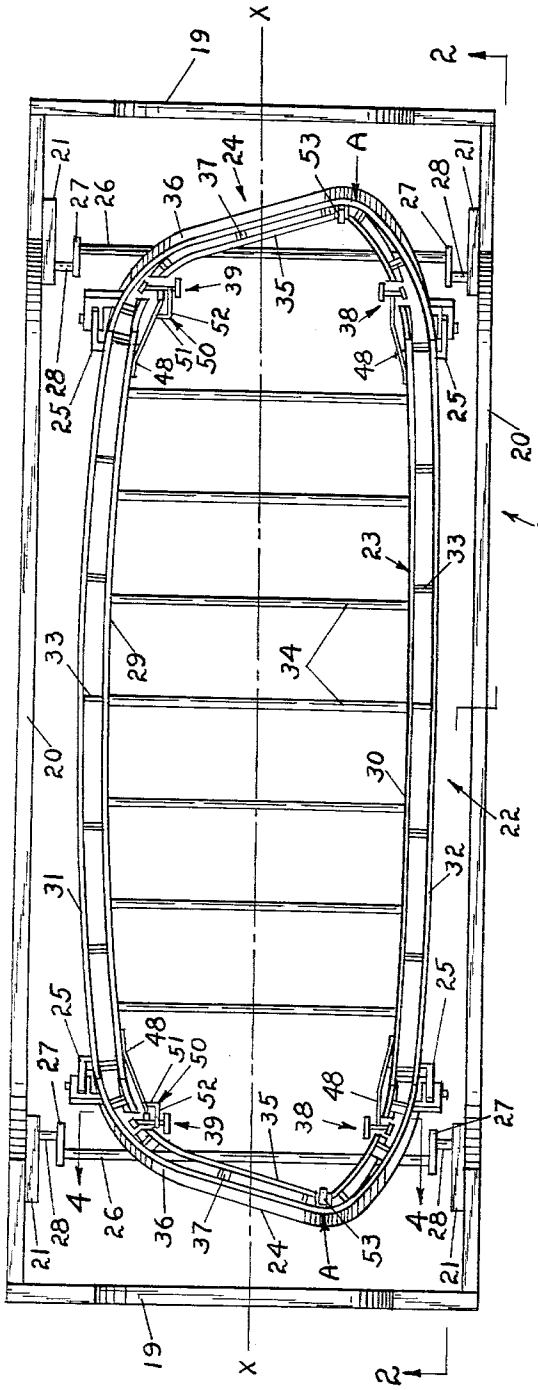


Fig. 1

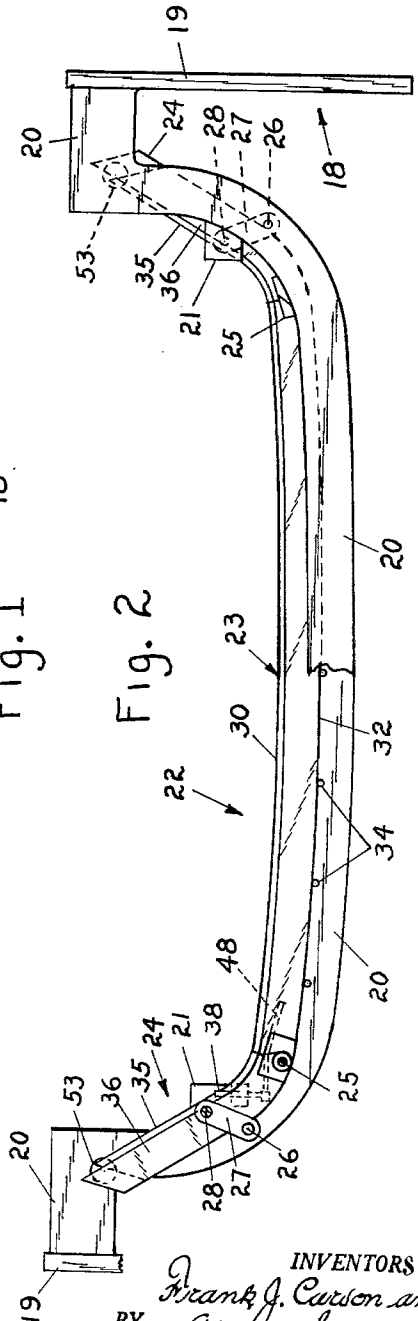


Fig. 2

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GLASS SHEET BENDING APPARATUS WITH GUIDE MEANS

Original Filed Sept. 26, 1957 2 Sheets-Sheet 2

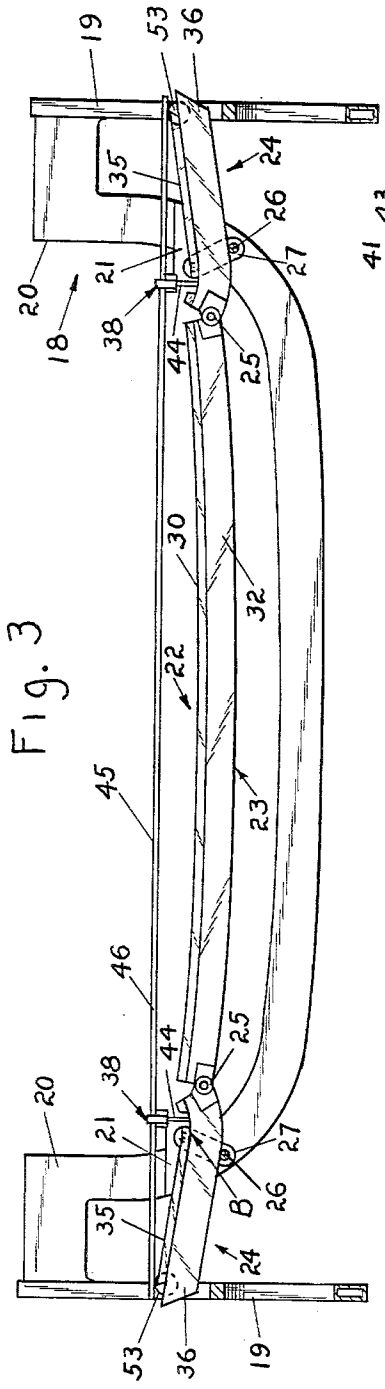


Fig. 3

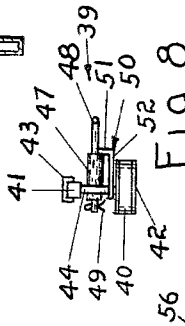


Fig. 8

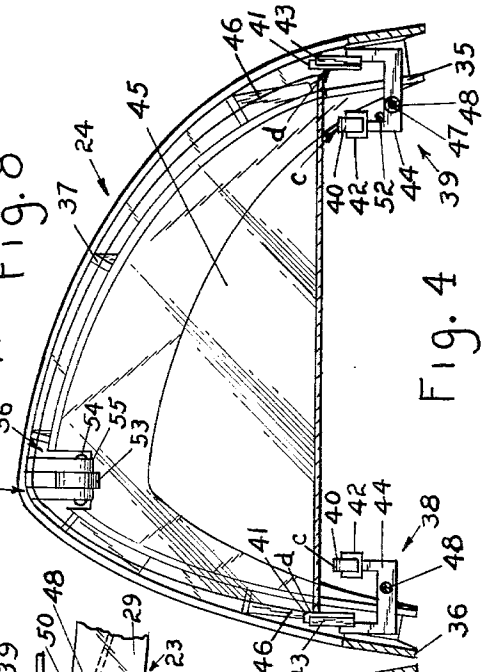


Fig. 4

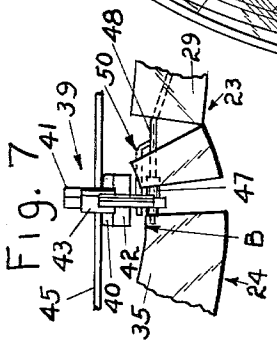


Fig. 7

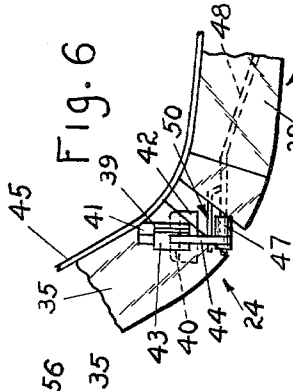


Fig. 6

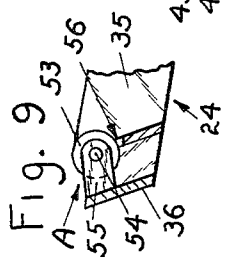


Fig. 9

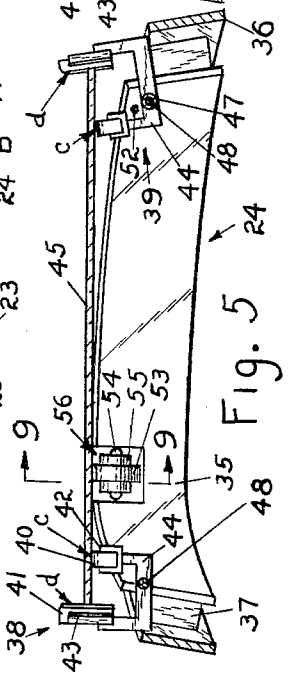


Fig. 5

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GLASS SHEET BENDING APPARATUS WITH GUIDE MEANS

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Continuation of application Ser. No. 686,473, Sept. 26, 1957. This application May 19, 1961, Ser. No. 120,459
4 Claims. (Cl. 65—290)

This application is a continuation of our copending application Serial No. 686,473, filed September 26, 1957, now abandoned.

This invention relates generally to the bending or shaping of sheets of glass to a desired configuration, and more particularly to an improved method and apparatus for bending glass sheets to complex curvatures.

In the bending of glass sheets, particularly relatively long sheets, upon a bending mold of the multiple section type wherein one or more mold sections are movable, it is oftentimes desirable to support the glass sheet intermediate the ends thereof prior to the sheet being bent into contact with the mold shaping surface. The multiple section bending molds commonly used for forming symmetrical bends comprise a center section and oppositely disposed movable end sections which move from a spread apart position in the open mold position prior to bending a glass sheet to a closed position during the bending of the sheet. In the open position, the glass sheet is usually supported upon the outermost extremities of the mold and not supported intermediate its ends. However, when the sheet is of abnormal length it is very desirable to support the sheet intermediate its ends so that excessive sheet deflection will not take place. Also the intermediate sheet support tends to stabilize the sheet as it bends into contact with the mold center section and this is also true with respect to sheets of normal length which are also oftentimes bent upon multiple section molds having intermediate supports associated therewith.

Various types of intermediate sheet supports have been used in the past; perhaps the most efficient of these being of the type wherein arms having sheet engaging members carried thereby extend upwardly from the innermost ends of the movable mold end sections and support portions of the glass sheet intermediate the ends thereof which are to be bent into contact with the mold central section. Although intermediate sheet supports of this type have proven to be very effective for certain types of bends, it has been found desirable for other types of bends that the sheet be positively clamped during the action of the mold sections in moving from the open to the closed position. It has also been found desirable that the intermediate sheet supports be carried by the mold central section because the weight of the glass sheet upon the intermediate supports will facilitate the closing action of the mold.

Another problem inherent in the bending of glass sheets is that of scratching the edges of the sheet, especially in the regions of the extreme ends. This scratching occurs because as the mold moves from the open mold position to a closed position the outermost extremities of the mold slide along the outermost marginal surface portions of the underside of the glass sheet as it is bent.

Also, the bending force exerted by the mold upon the ends of the sheet as the mold closes is not consistently normal to the surface of the sheet even if this bending force is normal to the mold end sections. By applying the force at an angle to the surface of the ends of the glass sheet instead of normal thereto, a greater force is required to be exerted by the mold end sections at the surface of the sheet to bend the sheet than would normally be necessary if the bending force were applied normal to the sheet surface throughout the entire bending cycle. By reducing the amount of bending force applied at the surface of the sheet, the possibility of marring the sheet at the point of force application is thereby decreased.

The desirable features of positively clamping the sheet and supporting it from the mold central section while applying a bending force normal to the undersurface of the sheet end sections are obtained in accordance with the method and apparatus of the present invention by providing, in combination with a multi-section mold, intermediate sheet supports carried by a central mold section and rollers which are mounted on the mold end sections. The intermediate sheet supports are adapted to clampingly engage the longitudinal edge portions of the glass sheet to be bent as well as support the marginal surface portions of the glass sheet adjacent the points of clamping engagement while the rollers are preferably mounted so as to freely rotate as the mold closes thus maintaining the bending force normal to the sheet surface and preventing scratches by rolling along the undersurface of the glass sheet.

It is therefore, an important object of the present invention to provide an improved method and apparatus for bending glass sheets to complex curvatures.

Another object of the invention is to provide an improved method and apparatus for bending a glass sheet in which longitudinal edges of the sheet are clamped against lateral movement of the sheet during bending.

Another object of the invention is to provide an improved method and apparatus for bending a glass sheet which maintains the sheet surface free from marks and scratches.

Another object of the invention is to provide a multi-sectioned bending mold having improved sheet engaging means carried by a central mold section for supporting and retaining the sheet in a predetermined position.

A further object of the invention is to provide an improved method for bending a glass sheet into conformity with a multi-sectioned mold in which the sheet is simultaneously supported and positively retained in a predetermined position during the bending operation.

A further object of the invention is to provide an improved method of bending a glass sheet in which a bending force is applied to the ends of the sheet and remains normal to the undersurface of the sheet throughout the bending cycle.

A further object of the invention is to provide a bending mold for bending a glass sheet having means associated therewith adapted to positively retain a glass sheet in the bending position relative to the mold by clamping the longitudinal edges of the sheet with a force which is proportional to the weight of the sheet and which automatically releases the sheet when positive retention is no longer required.

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 plan view of a multiple-section type bending mold constructed in accordance with the invention and showing the mold in its closed position;

FIG. 2 is an elevation partly in section taken along the line 2—2 of FIG. 1;

FIG. 3 is a sectional elevation similar to FIG. 2 and showing the mold in the open position with a flat glass sheet mounted thereon;

FIG. 4 is a transverse sectional view taken along the line 4—4 of FIG. 1;

FIG. 5 is a transverse sectional view similar to FIG. 4 showing the mold in its open position;

FIG. 6 is an enlarged fragmentary side elevation of a movable sheet engaging member showing the position thereof when the mold is in the closed position;

FIG. 7 is an enlarged fragmentary side elevation of the movable sheet engaging member showing the position thereof when the mold is in the open position;

FIG. 8 is a fragmentary plan view of a movable sheet engaging member; and

FIG. 9 is a fragmentary section taken along the line 9—9 of FIG. 5 showing a freely rotating sheet supporting roller.

Briefly stated, the present invention provides a novel method and apparatus for bending a glass sheet to complex curvature which includes a multiple-sectioned bending mold having a central section and oppositely disposed movable end sections in combination with improved sheet engaging means carried by the mold central section and adapted to support the glass sheet to be bent as well as to positively prevent the sheet from shifting during the bending cycle by clamping the longitudinal sheet edges whlie the mold is moving from the open to the closed position. The clamping force exerted on the sheet edges is controlled by the weight of the sheet so that it is at a maximum prior to the bending of the sheet and at a minimum or non-existent prior to all portions of the sheet being bent into conformity with the mold shaping surface. By locating the improved sheet engaging means upon the mold central section, the mold end sections rotate with less difficulty and upon contacting the portion of the glass sheet supported and clamped by the sheet engaging means the clamping force is released thus leaving the sheet free to finally conform to all portions of the mold shaping surface.

To insure proper uniform operation of the mold regardless of whether or not the sheet engaging means is used, freely rotating rollers are mounted at the extreme ends of the mold. As the mold closes, the force exerted by the mold end sections upon the glass is always normal to the undersurface of the sheet. Also, any movement of the glass relative to the mold causes the rollers to rotate and roll along the undersurface of the sheet thus preventing scratching.

With reference now to the drawings and particularly FIGS. 1 to 3, the numeral **18** designates in its entirety a mold supporting frame. This frame comprises a pair of spaced upwardly extending end members **19** which are connected to one another at their uppermost ends by a pair of concavely curved U shaped mold supports **20**. To support the mold, which will be later described in detail, a pair of brackets **21** are rigidly secured to the inside vertical face of each of the supports **20** approximately midway in elevation and each bracket projects toward the transverse center line of the supporting frame.

The mold proper is generally indicated by the numeral **22** and comprises a plurality of cooperatively connected mold shaping rail sections including a center section **23** and two oppositely disposed aligned U shaped end sections **24**. The center section **23** is movably connected to each of the oppositely disposed end sections **24** by means of the commonly used hinges **25** so that, in the closed mold position of FIG. 2, there is formed a continuous shaping surface of the desired contour for the bent glass sheet.

To support the mold for movement from the open position of FIG. 3 to the closed position of FIG. 2, a transversely extending support rod **26** is rigidly secured to each of the mold end sections and has its opposite ends rotatably supported by a link **27** which, in turn, is pivoted about a pin **28** which is fixedly mounted in a bracket **21**. The support rods **26** are so positioned that the mold will close due to the weight of the center section unless a force is applied to the outermost portions "A" of the oppositely disposed end sections **24**.

The center section **23** of the mold includes a pair of concavely curved shaping rails **29** and **30** which rise from the center in an arc that terminates at the pivot point of each hinge **25**. Mating support rails **31** and **32** are joined to the shaping rails **29** and **30** by separator blocks **33**. The top surface of each of the support rails (FIG. 2) substantially parallels the top surface of each of the shaping rails, but the top surface of each support rail is substantially below the corresponding surface of the respective shaping rail. Tie rods **34** span the space between the shaping rails **29** and **30** and are secured to the underside thereof thus rigidly maintaining the relative position of the two rails.

Each end section **24** comprises a U shaped shaping rail **35** and a mating support rail **36**. The shaping rail **35** is carried by the mating support rail **36**, and the top surface of each rail substantially parallels the top surface of the other. However, the top surface of the shaping rail **35** is above the top surface of the support rail **36**. Also, the shaping rail **35** and the support rail **36** are joined by blocks **37** spanning the space therebetween. Both the shaping rails **35** and the support rails **36** are secured to and carried by the transversely extending support rods **26**, and the support rails **36** are movably connected to the support rails **31** and **32** by means of the hinges **25**.

The novel sheet engaging means of the invention comprises both fixed and movable U shaped members generally indicated by the numerals **38** and **39** mounted in pairs along each side of the center section **23** and spaced outwardly and adjacent the ends of each of the shaping rails **29** and **30**. The fixed members **38** and the movable members **39** extend outwardly of the ends of the mold center section and engage portions of the glass sheet which are also engaged by the mold end sections **24**.

As shown in FIG. 4, each member **38** and **39** comprises a support block **40** and a locator block **41** of suitable refractory material which will not fuse with the glass at the bending temperature. Both blocks are respectively mounted in holders **42** and **43** which position the sheet engaging surfaces *c* and *d* respectively of the blocks **40** and **41** at substantially right angles to each other. These holders **42** and **43** are fastened to uprights of a modified U-shaped bracket **44**. In the sheet supporting position of FIGS. 3 and 5, the bearing surface *c* of the support block is disposed in a substantially horizontal plane and engages a portion of the undersurface of a glass sheet **45** located inwardly of the shaping rail **35** while the retaining surface *d* of the locator block **41** is disposed in a substantially vertical plane and clampingly engages an adjacent portion of the longitudinal edge **46** of the sheet **45** located outwardly of the shaping rail **35**. As seen in FIGS. 6 and 7, the continuity of the end shaping rails **35** has been interrupted by slots to permit the shaping rails to move past the members **38** and **39**.

It was previously brought out that the retaining or clamping force exerted by the novel sheet engaging means of the present invention is proportional to the weight of the sheet and that the clamping force is released prior to the sheet settling into complete conformity with the mold shaping surface. To carry out this function, each of the movable members **39** is mounted over the mold end sections, in the open mold position, for limited free rotational movement in a substantially vertical plane about an axis substantially parallel to the longitudinal mold axis *x*—*x* as well as the longitudinal edge **46** of the glass sheet **45**.

As shown in FIGS. 4 and 8, each of the U shaped brackets **44** of the movable members **39** is provided with a rigidly secured bearing **47** extending transversely therethrough and having its axis located inwardly of the center of gravity of the bracket and substantially parallel to both the bearing surface *c* and retaining surface *d* thereof. The U shaped bracket **44** is rotatably mounted for move-

ment in a substantially vertical plane upon a Z shaped support rod 48 having its innermost end rigidly secured to the inside edge of the center section shaping rail 29, and the support rod 48 is provided at its outermost end with a cotter key 49 which limits outward sliding movement of the bracket 44. The U shaped bracket 44 of the fixed member 38 is rigidly secured to its support rod 48; thus no bearing, or cotter key is required for this retainer.

Since the bearing 47 is located inwardly of the center of gravity of the movable member 39 and is freely rotatable upon the support rod 48, the block has a tendency to rotate outwardly. To limit this outwardly rotational movement and locate the block in the sheet releasing position of FIG. 4, an L shaped stop rod 50 is provided and has its innermost leg 51 rigidly secured to the support rod 48 immediately inwardly of the bearing 47, thus limiting inward movement thereof, and its outermost leg 52 spaced from the support rod 48 a distance so that the retaining surface *d* of the locator block 41 is maintained substantially vertical and in sheet receiving position by engagement of the inner bracket surface with the rod 50. As will be later more fully described, the supporting of a glass sheet upon the bearing surface of the support block 40 of the movable member 39 causes the bracket 44 to rotate toward the longitudinal mold axis *x*—*x* about the rod 48 thus bringing the retaining surface of the locator block 41 into clamping engagement with a longitudinal sheet edge. This, in turn, forces the opposed longitudinal sheet edge into contact with the locator block retaining surface *d* of the fixed member 38.

Since the members 38 and 39 are disposed opposite one another on both sides of the mold, opposed locator blocks 41 engage the glass sheet and thus provide opposed clamping forces which are substantially equal and directly proportional to the weight of the sheet since the sheet weight provides the rotational force to the movable member 39 which is necessary to bring the locator blocks 41 into engagement with the longitudinal sheet edges 46.

The freely rotating cylindrical shaped rollers 53 which are used in conjunction with the mold 22 and which may be optionally used in connection with the members 38 and 39 in the preferred form of the invention to permit the end portions of the glass sheet 45 to move relative to the mold end sections 24 while the center portions of the glass sheet are securely clamped are shown in FIGS. 1 to 5 and 9. To enable the glass sheet 45 to move over the rollers 53 as the mold 22 closes, each roller 53 is mounted upon a shaft 54 for free rotation at the apex "A" of each end section 24 on a pair of spaced brackets 55 which are fastened to the inside surface of the support rail 36. In order that the roller 53 may engage only the extreme outermost marginal surface portions of the glass sheet 45 during bending and be tangent to these surface portions at the completion of the bending cycle a portion of the end shaping rail 35 has been removed to form a notch 56 to receive the roller 53 therein.

Inasmuch as the axis of rotation of the end sections 24 is perpendicular to the longitudinal mold axis *x*—*x*, the glass sheet 45 moves relative to the end sections 24 along a path which is perpendicular to the axis of rotation of the end sections 24. To permit the rollers 53 to rotate in the direction of sheet movement, they are mounted in the brackets 55 to rotate about an axis which is substantially parallel to the axis of rotation of the end sections 24 and perpendicular to the longitudinal mold axis *x*—*x*.

The proper position of the roller 53 with respect to the shaping rail 35 and the notch 56 therein is quite critical and is most clearly shown in FIG. 9. Optimum results are achieved when the outer periphery of the roller 53 is tangent to the plane of that portion of the upper surface of the shaping rail 35 which is immediately adjacent the notch 56. If the periphery of the roller 53 is located substantially below this plane, the glass sheet 45 will contact the outermost ends of the shaping rail 35 before the bend is completed and the glass sheet 45 will become scratched as it moves along the shaping rail 35 during the final stages of the bending cycle. If the periphery of the roller 53 extends substantially above the plane of the shaping surface the glass sheet 45 will be prevented from completely conforming to the contour of the shaping rail 35, especially in the regions immediately adjacent the notch 56.

Inasmuch as the plane of the undersurface of the glass sheet 45 is angularly disposed to the plane of the shaping surface of the outermost ends of the shaping rails 35 when the mold is in the open position as shown in FIG. 3 the sheet 45 is supported by the rollers 53 which due to their being supported by the upwardly moving end sections 24, apply a bending force normal to this sheet undersurface throughout the bending cycle until the sheet 45 conforms to the contour defined by the shaping rails 35. When the completely bent sheet 45 is entirely supported by the shaping surface of the mold 22 in the closed position as shown in FIG. 2 the rollers 53 are tangent to the undersurface of the sheet 45 and no force is transmitted by the rollers 53 from the mold end sections 24 to the sheet 45. As the mold moves from the open position of FIG. 3 to the closed position of FIG. 2 the undersurface of the sheet 45 stays in contact with and moves along the outer edges of the rotating rollers 53 until the last increment of bending is accomplished, thus the possibility of the undersurface of the sheet 45 sliding along the shaping rail 35 is removed.

In accordance with the method of the invention and prior to actual bending of the sheet, the mold is moved to the open position of FIG. 3 by rotating the mold end sections 24 about the rods 26 which elevates the central section 23 and lowers the outermost ends A of the end sections. In this position, the members 38 and 39 are disposed above the mold end sections 24 and immediately above the portions "B" of the end section rails 35 and the supporting surface *c* of each of the blocks 40 is located in a common substantially horizontal plane which also contains the topmost portion of the rollers 53. Due to the off-set mass of the U shaped movable members 39, the inner surface of the U shaped brackets are located in engagement with the stop rods 50 and in the sheet receiving position.

The glass sheet 45 is then placed upon the U shaped members 38 and 39 as shown in FIGS. 3 and 5 and the sheet is thus supported in a given plane above the mold 22 by the bearing surfaces *c* of the blocks 40 upon which rest marginal surface portions of the sheet 45 as well as the rollers 53 mounted at the outermost ends of the mold end sections 24. The lateral position of the glass sheet relative to the mold 22 is determined by the fixed location of the retaining surfaces *d* of the locator blocks 41 and, as previously set forth, the weight of the sheet causes the locator block 41 of the movable members 39 to be rotated into clamping engagement with the longitudinal sheet edges 46 with the magnitude of the clamping force being proportional to the weight of the sheet. Also, because of the cylindrical shape of the rollers 53 the upward force exerted by the mold end sections 24 is normal to the undersurface of the glass sheet 45.

With the glass sheet 45 thus supported and retained, the mold 24 is passed into and through a suitable bending furnace (not shown) wherein the glass sheet 45 is progressively heated until it reaches bending temperature and begins to sag toward the mold shaping surface. At this time, the mold end sections 24 begin to rotate upwardly and inwardly about the transverse support rods 26, and the glass sheet 45 is initially bent between its points of contact with the rollers 53 mounted at the outermost ends of the mold end sections 24 and the points of clamping engagement and support adjacent the fixed and movable members 38 and 39. As the mold 22 continues its closing movement, the rollers 53 roll along the undersurface of the glass sheet 45 maintaining the bending force constantly normal to the sheet, and the portion "B" of the end section shaping surface gradually approaches the bear-

ing surfaces *c* of the support blocks **40**. Immediately prior to the mold moving to the full closed position the last increment of mold closing action rotates the shaping surface portion "B" into and above the plane defined by the bearing surfaces *c* of the support blocks **40** thus lifting the glass **45** free of contact with the members **38** and **39**. At this time, the movable members **39** rotate to their open position and no longer clamp the sheet edges **46**.

Depending upon the exact type of bend to the formed, the clamping force exerted by the sheet engaging means may be progressively decreased prior to the sheet being released by varying the location of the support points of the respective mold end sections upon the transversely extending support rods **26**. When the transverse rods **26** are located as shown in FIG. 3, the center of the glass sheet **45** through proper furnace heat control will contact the rails **29** and **30** substantially simultaneously with or immediately after the portions "B" of the mold end section shaping surface **35** being rotated into the plane of sheet support as defined by the bearing surface *c* of the support blocks **40** and thus the clamping force will remain substantially constant during the closing action of the mold.

In some instances it is desirable that the clamping force be progressively decreased immediately prior to all portions of the glass sheet contacting the mold. This may be accomplished by locating the transverse rods **26** inwardly of their positions as shown in FIG. 3. This will cause the center of the sheet **45** to sag into contact with the rails **29** and **30** prior to the portions "B" of the mold end section shaping rails passing through the sheet support plane defined by the bearing surfaces *c* of the support blocks **40**. During further closing action of the mold **22**, the areas of contact with the rails **29** and **30** are progressively increased, and, in turn, the rails support a greater proportion of the weight of the sheet. This correspondingly leaves a lesser amount of weight to be supported by the fixed and movable members **38** and **39**, which, in turn, further decrease the clamping force applied to the longitudinal edge portions **46** of the sheet. Immediately preceding the mold closing, at which time the major portion of the glass sheet **45** corresponds to the mold center section shaping rails **29** and **30** and is supported on the center section rails **29** and **30**, the clamping force is at a minimum. The final mold closing action again displaces the portions "B" of the end section shaping rails **35** above the plane of the bearing surface of the support block **40** thus completely freeing the glass sheet **45** which then is not influenced by external forces and is able to properly and finally conform to all portions of the mold sections.

Regardless of whether or not the clamping force remains constant, the basic features of the method of the invention remain the same and comprise initially supporting the sheet in a given plane while supporting the undersurface thereof intermediate the ends and clampingly engaging the opposed longitudinal sheet edges. After the sheet is softened by heat the central portion of the sheet is lowered while the opposite ends thereof are rotated upwardly by a force which is constantly normal to the undersurface of the sheet until the supported and clamped sheet portions are completely released by the upward movement of the mold end sections after which the sheet settles into final conformity with the mold.

It is to be understood that the forms of the invention disclosed herein are to be taken as the preferred embodiments thereof and that various changes may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

We claim:

1. In apparatus for blending flat glass sheets, a bending mold having a plurality of mold sections disposed end to end along the longitudinal axis of the mold and including oppositely disposed movable end sections and an intermediate section pivotally joined together at their adjacent ends, a plurality of substantially U-shaped support elements mounted on opposite sides of said intermediate section and each having upwardly directed leg portions disposed in a vertical plane extending perpendicular to said longitudinal axis, means pivotally mounting each of said support elements disposed at one side of said intermediate section on said intermediate section to turn in said plane about a second axis parallel to said longitudinal axis, a support surface provided at the upper end of one of said legs to engage the underside of a glass sheet disposed on said mold, a substantially vertical locating surface formed on the other of said legs to engage the longitudinal edge of the sheet, said support elements at said one side of the intermediate section being urged to rotate about said second axis in response to the weight of said sheet resting on said support surface to move said locating surface inwardly to exert an inwardly directed force against the edge of said sheet, and a lifting means mounted on the outer ends of said movable end sections and operable to exert a single lifting force against the outer ends of the sheets acting at all times along a line extending normal to the sheet.

2. In apparatus for bending flat glass sheets as defined in claim **1**, in which said lifting means comprises a roller journaled adjacent the outer end of each of said movable end sections to rotate about an axis perpendicular to said longitudinal axis and operable to support the end of the sheet in rolling contact therewith throughout the movement of the end section.

3. In apparatus for bending flat glass sheets as defined in claim **2**, in which the support surface provided at the upper end of one of said legs to engage the underside of the glass sheet consists of a roller journaled in said leg to rotate about an axis substantially parallel with the axis about which said lifting rollers at the outer ends of the movable end sections rotate.

4. In apparatus for bending flat glass sheets as defined in claim **1**, in which the U-shaped support elements at said one side of said intermediate section are biased such that said elements will swing in a direction to move the locating surfaces outwardly from the edges of the sheet upon removal of the weight of the sheet from said support surfaces.

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