

- [54] **ROLL FORMING HEAT-SOFTENED GLASS SHEETS**
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[73] Assignee: **PPG Industries, Inc.**, Pittsburgh, Pa.
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[51] Int. Cl.² **C03B 23/02**
[58] Field of Search **65/101, 104, 106, 245, 65/253, 273, 286**

[56] **References Cited**

UNITED STATES PATENTS

- 3,701,644 10/1972 Frank..... 65/106

Primary Examiner—Arthur D. Kellogg
Attorney, Agent, or Firm—Edward I. Mates; Thomas F. Shanahan

[57] **ABSTRACT**

Minimizing deviations from desired curvature in roll formed sheets of glass and other heat-softenable transparent materials by aligning at least a portion of the conveyor for moving roll formed sheets through a cooling station with a lower set of forming rolls that help shape the sheet at a sheet forming station of roll forming apparatus.

10 Claims, 4 Drawing Figures

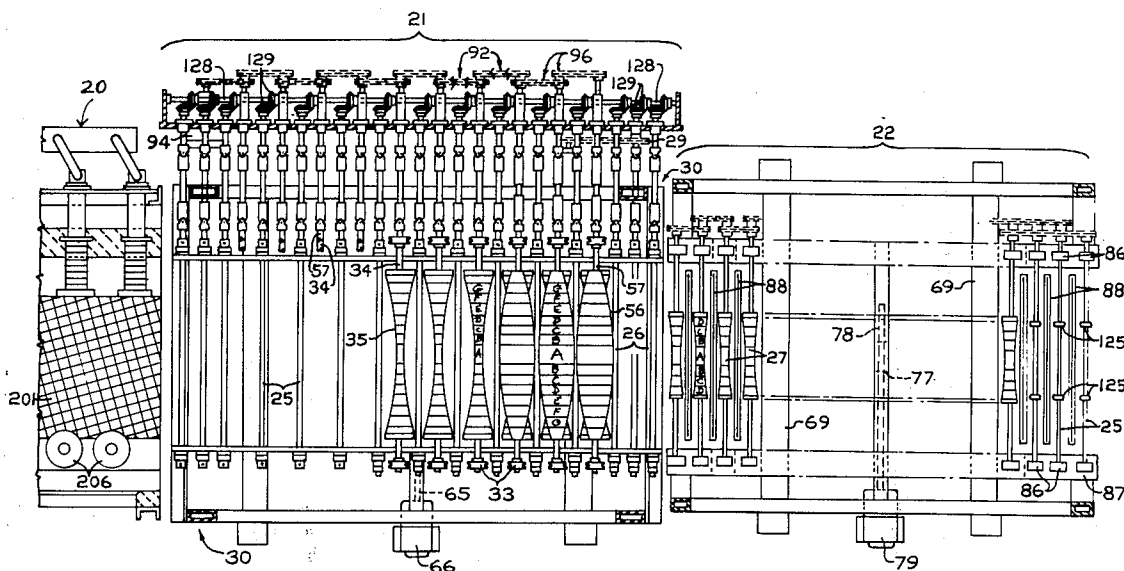
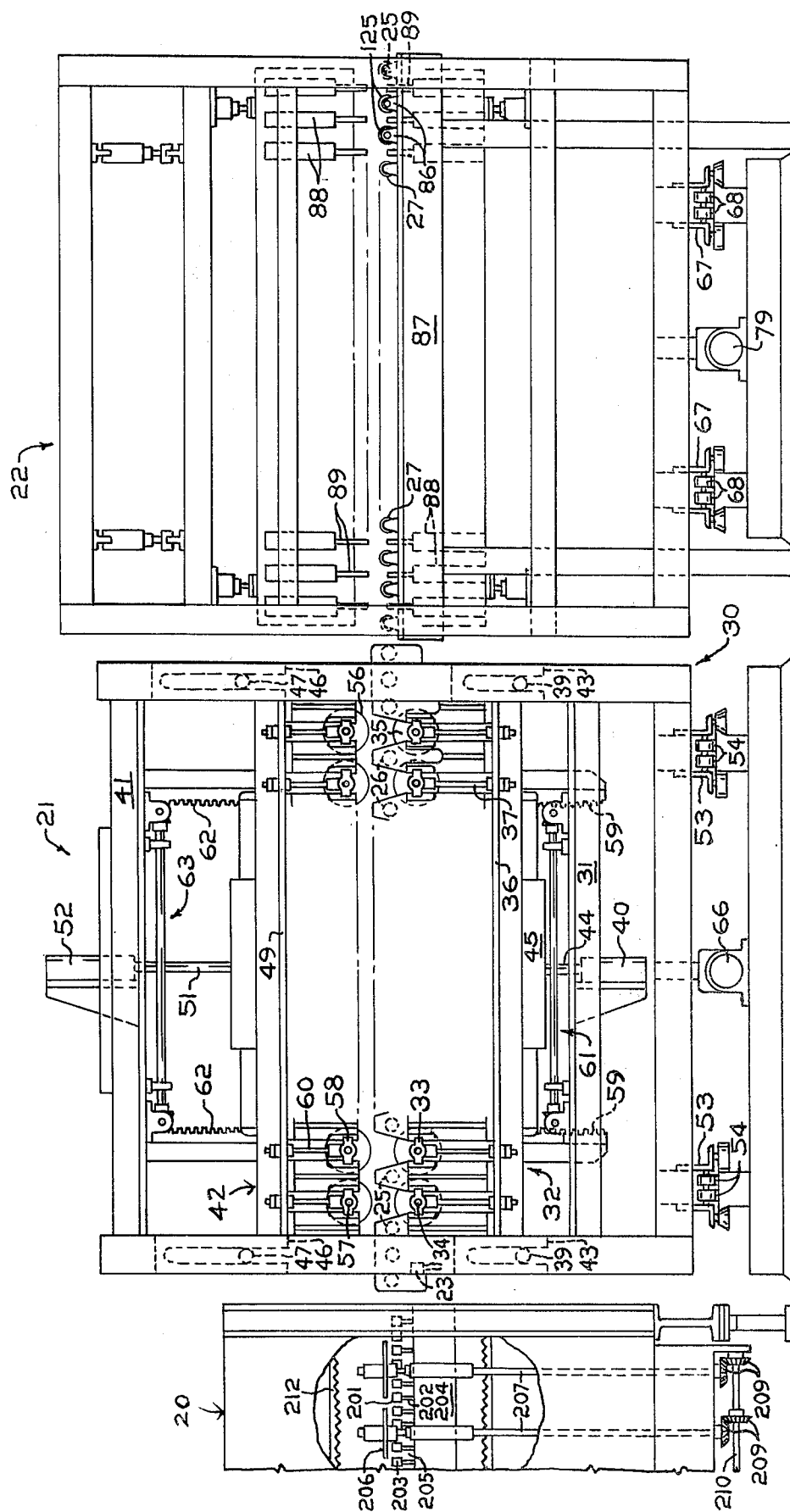


FIG. 1



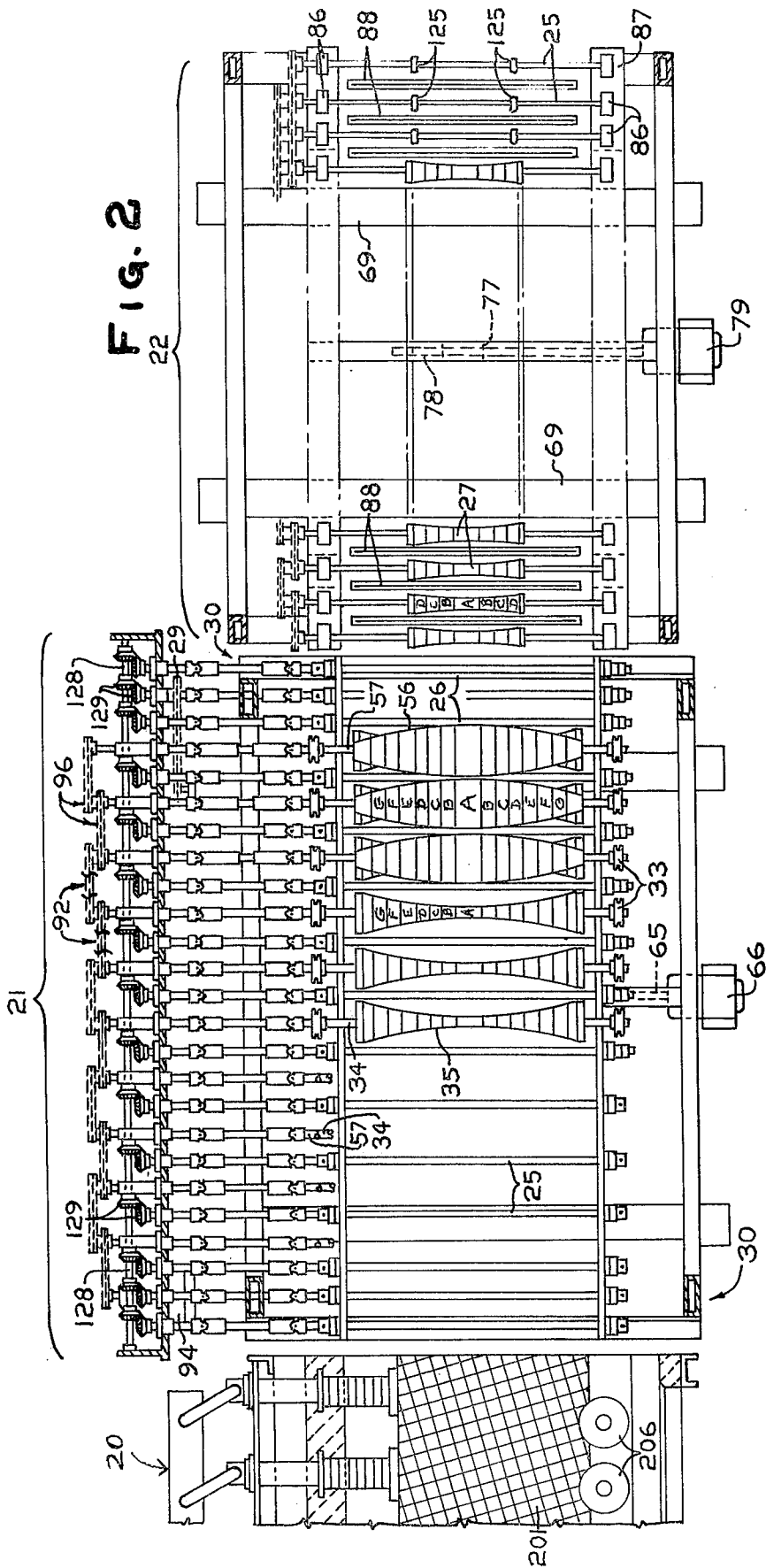


FIG. 3

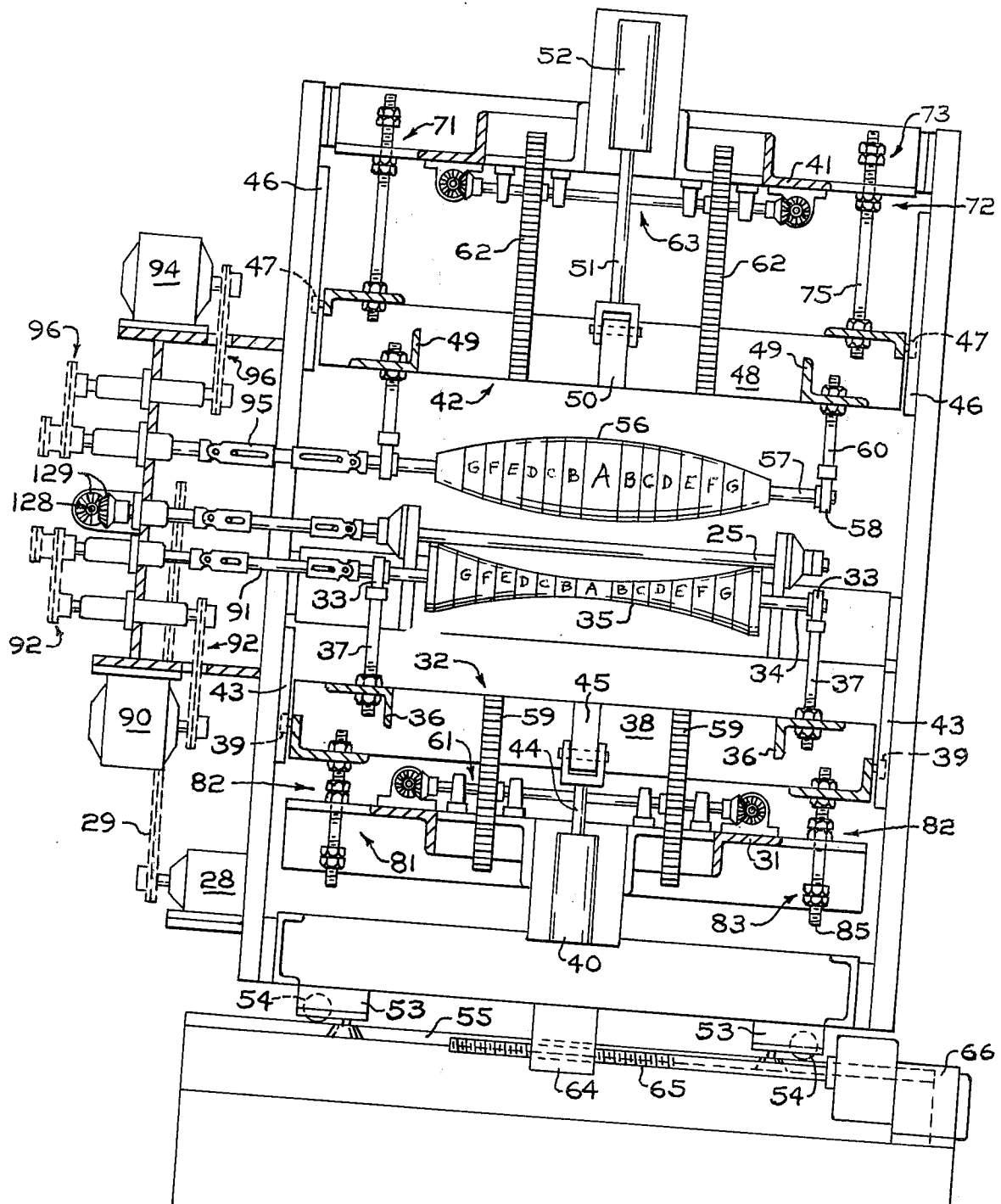
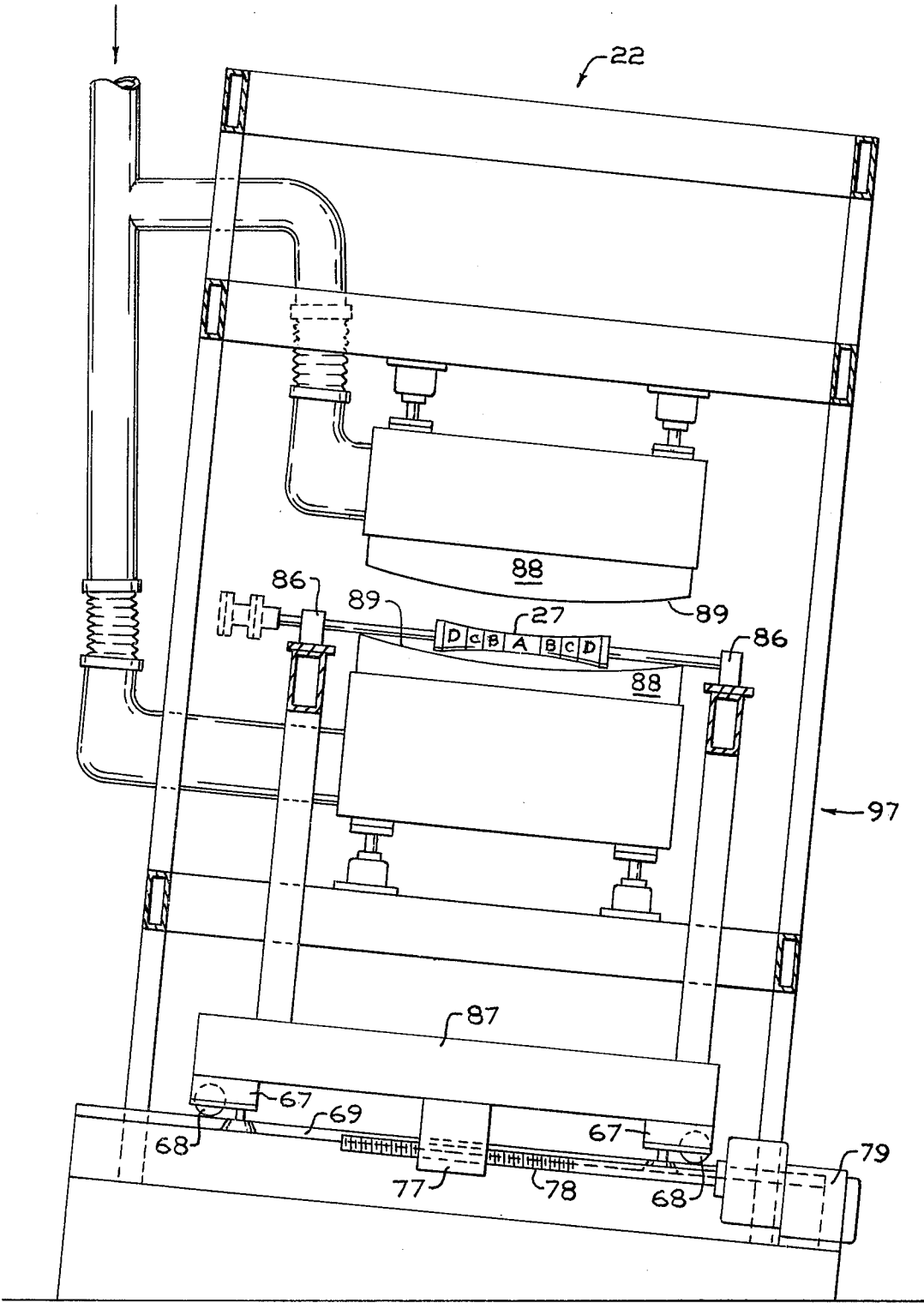


FIG. 4



ROLL FORMING HEAT-SOFTENED GLASS SHEETS

BACKGROUND OF THE INVENTION

In the art of roll forming glass sheets and sheets of other transparent plastic materials, a series of heat-softenable sheets is conveyed along a path through a furnace and thence between a pair of sets of rotating, shaped, forming rolls of complementary curvature that are mounted on an open reinforced frame structure. The position of the frame structure is adjustable in a direction transverse to said path to align said sets of forming rolls with the portion of the path that the sheets traverse when they move through the furnace. The lower set of rotating forming rolls lift each moving sheet in succession above said path and into at least partial engagement with the upper set of rotating forming rolls for sufficient time to have each pair of rolls of complementary shape impress their shape onto a portion of the sheet while other pairs of forming rolls carried by said frame structure are simultaneously doing likewise to other sheets portions. The sets of forming rolls are separated from one another before the formed sheet leaves the sheet forming station.

In U.S. Pat. No. 3,701,644 to Robert G. Frank, the position of the sheet forming station is made adjustable in the direction transverse to the path of sheet movement so that the center line of the forming rolls are aligned with the path taken by the center line of the sheets. This is especially important when the sheets are conveyed on a gas hearth at an angle to the horizontal with their lower edges engaging the peripheries of a series of rotating discs to propel them forward.

When the roll formed sheets leave the sheet forming station, they are sufficiently hot to be distorted upon contact with solid objects that are misaligned with the path taken by the roll formed sheets into the cooling station. The prior art has not taken steps to avoid distortion of roll formed sheets that occurs in the interval between roll forming and the time the roll formed sheet hardens sufficiently to avoid such distortion.

SUMMARY OF THE INVENTION

One aspect of the present invention insures that roll formed sheets are supported by conveyor elements that are shaped similar to and aligned with the forming rolls to conform to the roll formed sheets in the time interval between roll forming and cooling the sheets to a temperature at which they are no longer readily distortable.

According to another aspect of the present invention, the forming rolls at the sheet forming station are adjusted in lateral position so that a line interconnecting the axial centers of the forming rolls is offset from the center line along the sheets to be roll formed pass through a tunnel-type furnace to be heated to sufficient softness to permit their shaping by roll forming. Such misalignment induces the sheets to skew as they pass through the sheet forming station. Even when the sheets must be conveyed while skewed through the sheet forming station to produce a desired shape therein, unless the sheets are supported beyond the sheet forming station on conveying elements properly shaped and aligned with the forming rolls until the shaped sheets cool sufficiently to harden so that the shaped sheets resist deformation on contact with solid objects, the sheets tend to deform from their desired

shape on engaging the conveyor rolls beyond the sheet forming station.

Both aspects of the present invention are brought about by constructing the conveyor in the first portion of the cooling station beyond the sheet forming station so that said first conveyor portion is laterally adjustable in position. This lateral adjustment feature allows the conveyor rolls in the first portion of the cooling station to be adjusted in position for alignment with the lower set of forming rolls in the sheet forming station. Furthermore, the conveyor rolls in the first portion of the cooling station have shapes similar to the shapes of at least the central portions of the lower set of forming rolls to support the major portion of the curved dimension of the shaped sheets before the latter harden sufficiently to resist the aforesaid deformation on contact with a solid object.

The present invention will be understood better in the light of a description of a preferred illustrative embodiment that follows. While the embodiment described herein is especially suitable for roll forming glass sheets and the description that follows relates to apparatus that has been used successfully to produce roll formed glass sheets, it is equally suitable to shape sheets of any heat-softenable material other than glass, particularly transparent materials sometimes used as glass substitutes in windows, such as polycarbonates, acrylics, polyesters and the like. Hence, the term glass as used herein covers the aforesaid glass substitutes.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings which form part of the description of the illustrative embodiment, wherein like reference numbers refer to like structural elements,

FIG. 1 is a side view of a portion of roll forming apparatus illustrating the present invention comprising as adjustable sheet forming station and an adjustable first portion of a sheet cooling station;

FIG. 2 is a plan view of the portion of the roll forming apparatus of FIG. 1;

FIG. 3 is a transverse sectional view of the sheet forming station showing a pair of forming rolls in retracted position; and

FIG. 4 is a view similar to FIG. 3 of the sheet cooling station.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, FIG. 1 discloses a side view of an important part of roll forming apparatus conforming to the present invention. Generally, the apparatus is based on that disclosed in FIG. 21 of U.S. Pat. No. 3,701,644 to Robert G. Frank. The roll forming apparatus comprises a heating furnace 20 of the gas hearth type, a sheet forming station 21 and a sheet cooling or quenching station 22 also depicted in detail in the aforesaid Frank patent. A conveyor system conveys a series of glass sheets through the tunnel 20, the sheet forming station 21 and the sheet cooling or quenching station 22.

A glass sensing device 23 of the type well known in the art, such as an ultraviolet sensing device, is located near the entrance of the sheet forming station 21 to detect the passage of the trailing edge of a glass sheet to actuate operation of the sheet forming station to perform its sheet forming function.

While the illustrative embodiment of the present invention shows a heated furnace of the gas hearth

type, which is based on apparatus depicted in U.S. Pat. No. 3,233,501 to James C. Fredley et al, assigned to PPG Industries, Inc., the gas hearth furnace may also be that disclosed in U.S. Pat. Nos. 3,332,759 and 3,332,760 to Harold E. McMaster et al. Furthermore, the conveyor for the furnace may be of the type containing glass engaging members that move the glass sheets through the hot furnace by edge contact only, or of the roller hearth type such as depicted in U.S. Pat. No. 3,245,772 to James H. Cypher et al, assigned to PPG Industries, Inc., where glass sheets are conveyed in succession over a series of longitudinally spaced conveyor rolls, which are rotated in unison to propel the glass sheets through a heated tunnel-like furnace.

In a gaseous hearth system of the preferred embodiment of the present invention, the furnace 20 is provided with a flat bed formed from a series of modules 201 arranged geometrically like a mosaic in close juxtaposition to each other. Each module has an upper terminus of rectangular configuration. The upper termini lay in a common plane that is obliquely arranged at a small angle (preferably approximately 5°) to the horizontal transversely of the lengthwise dimension of the bed. The latter extends throughout the length of the furnace.

In a gas hearth, the modules 201 are arranged in successive rows crossing the path of travel intended for glass sheets undergoing treatment. Each row of modules is at an oblique angle of about 10° to the path taken by the glass sheets through the length of the furnace 20. Each module has a relatively narrow stem 202 opening up into a module plenum chamber 203 positioned below the gas hearth bed and acting as a support for the bed. Each module extends upward from a plenum chamber 204 and is substantially enclosed and is spaced from adjacent modules by an exhaust zone. The exhaust zones communicate with exhaust passages 205 extending transversely of the common plenum chamber 204 below the surface of the gas hearth bed and above common plenum chamber 204. The bed is adjusted to such a level that the plane of the upper termini of the modules lies parallel to but just below an oblique plane defined by the upper surface of rotatable conveyor rolls 25 of the sheet forming station 21. As an alternative, the gas hearth bed may be composed of a relatively thick apertured wall having hot gas delivery passageways of circular cross-section arranged in a mosaic pattern in an upward direction from a plenum chamber to the upper surface of the wall. Each delivery passageway is surrounded by a series of escape ports of larger circular cross-section as depicted in U.S. Pat. No. 3,455,669 to Harold E. McMaster et al in this gaseous hearth construction.

In the gas hearth furnace, glass sheets are supported by a thin gaseous bed in an oblique plane and are engaged along their lower side edges only by means of a series of rotating driving discs 206 disposed in a series along the lower side edges of the gas hearth bed. The discs rotate in unison to propel a series of glass sheets along the length of the gas hearth bed toward the sheet station 21. The discs 206 are driven in unison by drive shafts 207. The latter in turn are driven through spur gears 209 by a main drive shaft 210. Electrical resistance heaters 212 are provided in the roof of the heating furnace 20 to irradiate heat against the upper surface of each sheet while its lower surface is both heated and supported by the hot gases applied through the modules against said lower surface.

The conveyor rolls 25 of the sheet forming station 21 are disposed to form an upper common tangential plane which is an extension of the oblique plane of support provided by the gas hearth bed formed by the gas applied through the array of modules in the furnace 20. Additional conveyor rolls 26 which are flexible to conform to the shape of shaped sheets are located in the exit end portion of the sheet forming station 21 and have the same outer diameters and roll to roll spacing as rigid conveyor rolls 25. The flexible conveyor rolls 26 are described and claimed in copending U.S. application Ser. No. 466,342, of Robert G. Frank, filed on May 2, 1974 and the description of said rolls in said copending application is incorporated herein by reference. Additional shaped conveyor rolls 27 are longitudinally spaced along the first portion of the cooling station 22, where the roll formed sheets cool to sufficient hardness to resist deformation on further contact with a solid object. Additional rigid conveyor rolls 25 provided with axially adjustable spaced collars 125 convey the cooled sheets through the rest of sheet cooling station 22.

The driving discs 206 and the conveyor rolls 25, 26 and 27 form different sections of the conveyor system. Each conveyor section is driven off a drive motor 28 through a drive chain 29 that interconnects a sprocket on the drive motor shaft with a sprocket on a conveyor roll shaft. A separate longitudinally extending drive shaft 128 is provided with bevel gears 129, one to mesh with a bevel gear for each conveyor roll 25 and 26 to drive each conveyor roll of the conveyor section off the longitudinally extending drive shaft 128 for its respective conveyor section as shown in FIGS. 2 and 3. If desired, certain conveyor rolls of one section may be disconnected by clutches from the motor driving one conveyor section for a driving connection to a motor driving another conveyor section, in a manner well known in the art. Also, the conveyor sections may be further subdivided, or the entire conveyor system may be made as one continuous section off a single drive motor and a single longitudinally extending drive shaft provided with bevel gears, as desired.

The furnace 20 comprises a tunnel-type passageway which flat glass sheets are conveyed with their lower edges supported by successive rotating driving discs 206. The furnace heating elements 212 and the heat supplied to the glass sheets through the hot gas from the gas hearth as the sheets move through the furnace is adjusted to enable the glass sheets to arrive at the furnace exit at a suitable temperature for shaping by roll forming and tempering.

The sheet forming station 21 of the present invention comprises an open reinforced frame structure 30 comprising a lower platform 31 which supports a vertically movable lower forming roll support housing 32 and an upper platform 41 which supports a vertically movable upper forming roll support housing 42. Both forming roll support housings are oriented in a horizontal plane parallel to the horizontal plane of support provided by the conveyor system. The lower forming roll support housing 32 comprises a pair of sets of vertical brackets 33. Each of the latter is located in spaced relation at 7 inch spacing along a row intersected by one of two spaced vertical planes that extend longitudinally of the conveyor system to receive one of a series of straight lower common shafts 34 near one or the other of its ends. The brackets 33 of each pair of brackets that support one of the lower common shafts 34 are located

in a common vertical plane that extends normal to the first two vertical planes and parallel to the common vertical planes in which other pairs of brackets that support the other straight lower common shafts are located.

The brackets 33 are adjustably positioned in a vertical direction to support the series of common shafts 34 either in alignment with one another either in an oblique line in a plane parallel to the plane of support provided by the upper tangent common to the obliquely extending conveyor rolls 25, 26 and 27 of the conveyor system or in an oblique line in adjustment along a curved line defined by the position of each bracket 33 along each of the two longitudinally extending, spaced, vertical planes or any combination of horizontal, oblique or curved lines as dictated by the nature of the shape to be imparted to the glass sheets being shaped.

Each of the lower common shafts 34 rotatably supports one of a series of lower segmented forming rolls 35. Each segment of the segmented forming rolls 35 is approximately two inches long axially, except for the centermost segments which are approximately four inches long. Each central shaping segment is flanked by an equal number of flanking shaping segments on either side thereof. The segments are depicted by letters A through G, with A being the center segment.

An apertured longitudinally extending horizontal angle member 36 is supported along each side of the lower forming roll support housing 32. Each aperture of each horizontal angle member 36 is vertically aligned below an internally threaded member extending downwardly from a corresponding one of the brackets 33. A series of threaded shafts 37 have their upper ends connected to the brackets 33 and their lower ends extending through a corresponding aperture of one or the other of the horizontal angle members 36. Suitable lock nuts are provided along each shaft 37 above and below a corresponding member 36 to adjust the axial position of the threaded shafts 37 relative to the horizontal angle member 36 so as to fix the position of each bracket 33 relative to the lower roll housing support structure 32. Each horizontal member 36 interconnects a pair of lower end plates 38. A roller 39 is attached to each end of each lower end plate 38.

The vertical position of each bracket 33, as determined by adjustment of its associated threaded shaft 37, controls the position of an end portion of a lower common shaft 34. The adjusted position of each pair of brackets 33 of each lower common shaft 34 establishes the orientation of the segmented forming rolls 35 that are mounted on the shafts 34. Each shaft 34 is straight to facilitate mounting and replacement of the segments of a forming roll of desired configuration thereon. It is thus a simple matter to remove one set of forming rolls conforming to one configuration and replace its segments with another set of forming rolls whose segments conform to another configuration whenever parts of a different configuration are to be produced.

The lower forming roll support housing 32 is rigidly attached to an upwardly extendible rod 44 of a lower piston 40. The latter is supported by the lower platform 31 of the open reinforced frame structure 30. A pair of lower vertical slotted plates 43 is carried by the frame structure 30 for receiving the rollers 39 attached to each end plate 38 of the lower forming roll support housing 32. A structural member 45 is attached to the upper end of the piston rod 44 and interconnects the

end plates 38 which are also interconnected by the lower apertured angle members 36. This provides a rigid structure for the lower forming roll support housing 32 so that the set of lower forming rolls 35 supported by said lower forming roll support housing 32 moves in unison in response to actuation by the piston 40.

The open reinforced frame structure 30 also carries two pairs of upper vertically slotted plates 46 that receive upper guide rollers 47 fixed to the ends of upper end plates 48. The latter interconnect the opposite ends of a pair of upper, apertured, longitudinally extending, horizontal angle members 49 that form part of an upper forming roll support housing 42, and that have a reversed structure of those of the horizontal members 36. The upper end plates 48 are connected to an upper structural member 50, which is fixed to the free lower end of a rod 51 of an upper piston 52, which is extendable in a downward direction. A cylinder for the upper piston is supported on the upper platform 41 forming part of the reinforced frame structure 30.

In vertical planes intermediate the vertical planes occupied by the conveyor rolls 25 and 26 in alignment with the vertical planes occupied by the lower set of segmented forming rolls 35, the upper forming roll support housing 42 supports a set of upper segmented forming rolls 56. Each upper segmented forming roll comprises a plurality of segments A through G mounted on a straight upper common shaft 57. The shape of each segment A through G of each upper forming roll 56 is complementary to the shape of the corresponding segment of its corresponding lower forming roll 35 depicted by a corresponding letter.

The vertical position of each of the upper segmented forming rolls 56 is adjustable in the manner similar to the adjustment provided for the lower segmented forming rolls 35. For example, each upper shaft 57 is received rotatably in one of a series of upper shaft brackets 58, each of which is a reversal of a bracket 33. The lower ends of externally threaded rods 60 are connected to internally threaded upper end portions of brackets 58 and their upper ends extend through apertures in one or the other of the upper, apertured, longitudinally extending, horizontal angle members 49 and are fixed in position to the latter through pairs of adjustment nuts for each threaded rod, one nut being below the angle member 49 and at least one nut mounted above the angle member 49 to determine the vertical position of each upper bracket 58 that determines the vertical position of each end portion of each upper common shaft 57.

As seen in FIG. 2, the segments of the lower segmented forming rolls 35 form a substantially continuous concave contour in the axial direction of the straight common shafts 34. This shape conforms to the shape desired about an axis parallel to the path the glass sheet takes through the sheet forming station 21 for an incremental portion of each glass sheet shaped by roll forming. The segments of the upper segmented forming rolls 56 have generally convex outer configurations that are complementary to the configurations of the lower forming roll segments they oppose.

Hence, if all the upper segmented rolls 56 have their shafts 57 in alignment in an upper oblique plane and the lower segmented rolls 35 have their shafts aligned in a lower parallel plane, when piston 40 is extended upwardly, the segmented rolls 35 are lifted in unison to positions above the oblique plane occupied by the tan-

gent common to the upper portion of the circumferences of the conveyor rolls 25 and 26 in the sheet forming station. Each vertically aligned pair of rotating upper and lower forming rolls engages different increments of a heat-softened glass sheet moving through a sheet forming station when the piston 40 is extended upward a sufficient distance to lift the lower segmented forming rolls 35 into positions of rolling engagement against the undersurface of the glass sheet and force the upper surface of the glass sheet into rolling engagement against the upper set of forming rolls 56. Thus, rotating rolls impose bending forces on different longitudinal increments of the traveling glass sheet simultaneously.

The composition of the roll segments is very important to insure proper operation of the roll forming apparatus with minimum glass breakage or glass marking. The material must have a low thermal conductivity to minimize thermal shock on the hot glass when the latter engages the relatively cold shaping rolls. The rolls must have a low coefficient of thermal expansion over a wide range of temperatures of approximately 600°F. from room temperature to an elevated temperature that the forming rolls attain on periodically contacting hot glass. They must be of a composition that does not react chemically with glass, that is durable over said wide temperature range, and is readily shaped or machined to complex contours. To meet the aforesaid requirements, the segments of the forming rolls 35 and 56 are composed of an asbestos cement of aluminosilica composition sold by Johns Manville under the trademark of TRANSITE.

In order to assure proper alignment between the upper roll support housing 42 and the lower roll support housing 32 when there is relative movement between the housings 32 and 42 or between each housing and the frame structure 30, each housing is provided with an alignment mechanism. The alignment mechanism for the lower roll housing 32 comprises four lower racks 59 extending downward from housing 32 to mesh with certain gears of a lower rectangular array 61 of lower horizontal connecting rods and gears connected to lower platform 31 forming part of the frame structure 30. A similar arrangement of upper racks 62 extends upward from the upper roll support housing 42 to mesh with certain gears of an upper rectangular array 63 of rods and gears affixed to upper platform 41 forming part of the frame structure 30 to align the upper roll housing 42.

The lower forming roll support housing 32 is provided with lower stop members 81 and the upper forming roll support housing 42 is provided with upper stop members 71. Each of the lower stop members 81 comprises a lower limit adjustment means 82 and an upper limit adjustment means 83 in the form of lock nuts adjustably mounted on one of a plurality of lower threaded shafts 85. Each of the latter is rigidly secured at its upper end to the lower forming roll support housing 32 and extends through an aperture in the lower platform 31 of the open reinforced frame structure 30 with lower limit adjustment means 82 disposed above the lower platform 31 and the upper limit adjustment means 83 disposed below the lower platform 31.

Each of the upper stop members 71 comprises an upper limit adjustment means 72 and a lower limit adjustment means 73 in the form of lock nuts adjustably mounted on one of a plurality of upper threaded shafts 75. The latter is rigidly secured at its lower end to

the upper forming roll support housing 42 and extends through an aperture in the upper platform 41 of the open reinforced frame structure 39 with upper limit adjustment means 72 disposed below the upper platform 41 and the lower limit adjustment means 73 disposed above the upper platform 41.

The lower limit adjustment means 73 of the upper forming roll support housing 42 and the upper limit adjustment means 83 of the lower forming roll support housing 32 are adjusted according to the thickness of glass sheets undergoing roll forming so that the minimum spacing between corresponding shaping rolls in the direction of the glass sheet thickness exceeds the glass sheet thickness by a predetermined amount based on the tolerance permitted by the customer. This is usually between 0.01 inch and 0.05 inch, preferably 0.02 inch to .04 inch.

FIG. 3 shows the roll forming apparatus in the position it occupies when the rotating forming rolls 35 and 56 are retracted from one another when a flat glass sheet is entering the sheet forming station 21. While it is possible to operate the roll forming apparatus so that only the lower set of segmented forming rolls 35 are moved vertically toward and away from the corresponding upper set of segmented forming rolls 56 to shape the glass sheets, greater flexibility is provided when both the upper forming rolls 56 and the lower forming rolls 35 are provided with vertical movement. However, it is necessary that the lower forming rolls 35 retract in the flat glass receiving position to a position below the oblique plane occupied by the common tangent to the upper surfaces of all of the conveyor rolls 25 and 26 in the sheet forming station 21, as depicted in FIG. 3, and that the lower forming rolls 35 occupy an upper position wherein the entire upper surfaces of the forming rolls 35 is above the common plane of the conveyor rolls 25 and 26.

The cooling station 22 may be of any type of glass tempering or heat-strengthening apparatus that is well known in the art. One type of cooling station that may be used is disclosed in U.S. Pat. No. 3,245,772 to James H. Cypher and Charles R. Davidson, Jr. Preferably, it comprises upper and lower nozzle boxes 88, each having a set of longitudinally spaced, elongated slot nozzle openings 89 extending transversely of the path defined by the conveyor system and alternating with shaped conveyor rolls 27 and thin conveyor rolls 25 provided with collars 125. The slot openings through which cool pressurized air is applied to cool the moving sheets are preferably about 3/16 inch to 1/4 inch wide and about 4 inches apart in each set and the nozzle openings of one set are about 5 inches from the nozzle openings of the other set, and aligned in vertical planes in spaces between adjacent conveyor rolls.

Rolls 27 are segmented like the forming rolls and have an outer diameter of 3 inches or less at their axial ends and decrease in diameter toward their central portion along curves similar to the shape of the roll formed sheets. Rolls 25 have an outer diameter of 1 inch and the two collars 125 are axially adjustable along rolls 25 to provide three axially spaced supports along curves similar to the shape of the shaped conveyor rolls 27.

If desired, exit doors of the type well known in the art may be included to intermittently close the exit slot openings of the furnace 20 and a similar door at the entrance of the cooling station 22 may intermittently close the opening to the cooling station 22. This mini-

mizes the exposure of the sheet forming station 21 to the hot atmosphere of the furnace 20 at one end and to the cold blasts of the cooling station 22 at the other end.

In order to minimize marking of the glass surface due to rubbing by portions of the forming rolls whose peripheral velocity differs sufficiently from the speed of the glass sheet moving through the roll forming apparatus to cause observable rubbing marks, only selected segments of each segmented forming rolls 35 have been keyed to the lower shafts 34 to rotate therewith and the remaining segments of the lower forming rolls have been made freely rotatable relative to the lower shafts. Likewise, only selected segments of the upper segmented forming rolls 56 have been keyed to the upper shafts 57, while the remaining segments have been made freely rotatably thereon. In addition, low friction devices have been disposed between adjacent segments to minimize friction between adjacent segments. A recent invention has eliminated scuff marks when they occurred in the shaped sheets by independently adjusting the peripheral speed of the upper driven segments and/or that of the lower driven segments keyed to the respective shafts 57 and 34.

According to a preferred embodiment of the present invention, the lower shafts 34 are connected to a lower shaft drive motor 90 through lower flexible coupling means 91 and a lower shaft drive system 92, while the upper shafts 57 are connected to an upper shaft drive motor 94 through upper flexible coupling means 95 and an upper shaft drive system 96. Both drive motors 90 and 94 are of the variable speed type.

The lower shaft drive motor 90 operates independently of the upper shaft drive motor 94 to rotate the lower shafts 34 in unison at any selected rotational speed that may be the same or different from the rotational speed of the upper shafts 57.

Whenever, in the course of mass production operation, scuff marks begin to appear on the shaped sheets, the operator merely adjusts at least one of the motors 90 or 94 to change the rotational speed of its driven shafts 34 or 57. If the change in rotational speed is made in the wrong direction, the scuff marks become worse. If the change is proper in direction, the scuff marks become more faint and even disappear altogether.

Another feature of the prior art that is desirable for incorporation in the illustrative embodiment of the present is a moving glass locator device of the type covered by U.S. Pat. No. 3,701,643 of Robert G. Frank, the disclosure of which is incorporated herein by reference. The moving glass locator device is located at the exit portion of the furnace 20 and comprises a pair of carriages, each mounted for reciprocating movement in unison along parallel paths exterior to one of the other side of the exit portion of the furnace between an upstream position and a downstream position, a pair of glass sheet engaging members carried by each of said carriages in longitudinally spaced relation to one another and in laterally inward spaced relation to one or the other of said parallel paths, means to move each of said glass engaging members laterally inward from a retracted position to a glass edge engaging position in a direction transverse to said parallel paths, means to move said carriages in unison in the direction of glass travel at a pre-established conveyor speed as the glass engaging members move inward in unison to said glass engaging position, means to retract

said glass engaging members to said retracted position after they have engaged the opposite side edges of the moving glass sheet to orient and align the latter properly, and means to return said carriages in unison to said upstream position. This patented device avoids improper sheet shaping in the sheet forming station due to misalignment or misorientation of the sheets entering the sheet forming station.

The open reinforced frame structure 30 is provided with carriages 53 whose wheels 54 are adapted to roll along the upper surfaces of inclined planes 55 oriented at a 5° angle to the horizontal in a transverse direction at the sheet shaping station 21. The upper surfaces of the inclined planes 55 are located in the same plane so that the sheet forming station 21 is disposed horizontally in the direction of glass sheet movement through the roll forming apparatus.

An internally threaded bracket 64 is supported at the bottom portion of the open reinforced frame structure 30. An externally threaded drive shaft 65 engages the threads of the internally threaded bracket 64. A reversible drive shaft motor 66 rotates the externally threaded drive shaft 65 either clockwise or counterclockwise to move the internally threaded bracket 64 in a direction transverse to the path of movement defined by conveyor rolls 25, 26 and 27. The open reinforced frame structure 30 fixed to the internally threaded bracket 64 moves with the latter when motor 66 is energized. Hence, the drive shaft motor 66 is capable of moving the sets of the segmented forming rolls 35 and 56 in unison with the open reinforced frame structure 30 to adjust the center line of the forming rolls relative to the center line of the arriving sheets.

At the sheet cooling station 22, the shaped conveyor rolls 27 are rotatably supported by brackets 86. The latter, in turn are supported by a support structure 87. The support structure 87 is movable in position relative to a fixed nozzle box support structure 97 along a plane parallel to the oblique plane along which the open reinforced frame structure 30 is capable of transverse position adjustment. To accomplish this, the support structure 87 is also provided with carriages 67 having wheels 68 movable along the surfaces of inclined planes 69 at the sheet cooling station 22. Support structure 87 is provided with an internally threaded bracket 77 at its lower portion. The latter receives an externally threaded drive shaft 78 which rotates axially in response to actuation by a reversible drive shaft motor 79 to position the internally threaded bracket 77 into a position where the center line common to the shaped conveyor rolls 27 is aligned with the center line common to the lower set of forming rolls 35 in the sheet shaping station 21.

When the center lines common to the sets of forming rolls 35 and 56 are aligned with the center line of glass sheets leaving the furnace 20, each glass sheet in turn is formed to a shape conforming to those of the forming rolls. However, since the roll formed sheets do not cool to below a deformation temperature at which they are deformable on contact with a solid member, it is extremely important that the shaped conveyor rolls 27 (or at least the shaped conveyor rolls in the portion of the sheet cooling station 22 where the roll formed sheets remain above said deformation temperature) be aligned with the forming rolls. Otherwise, the shape imparted by the rotating forming rolls 35 and 56 in the sheet shaping station 21 is deformed somewhat when the roll formed sheet is transferred to shaped conveyor

rolls 27 that are misaligned with the forming rolls. Once the sheet cools to below the deformation temperature, some conveyor roll misalignment does not have the effect of distorting the shaped sheet. Hence, any type of conveyor rolls may be used in the portion of the sheet cooling station where the sheets are below their deformation temperature.

The lateral adjustability of the position of the open reinforced frame structure 30 to align the longitudinal center line or the roll forming station 21 with the center line of the glass sheets leaving the furnace 20 is described in U.S. Pat. No. 3,701,644 to Robert G. Frank. Since the filing of the aforesaid patent, a roll forming technique has been developed that takes advantage of misaligning the center line common to the forming rolls of the sheet forming station 21 with respect to the center line of the glass sheets entering the sheet forming station 21. Misaligning the forming rolls causes the glass sheet to skew somewhat when it is lifted by the misaligned lower forming rolls 35 before the sheet is engaged by both sets of forming rolls. Thus, the sheet is bent about an axis angularly disposed to the longitudinal center line of the unformed sheet. The greater the misalignment of center lines, the more is the sheet skewed prior to its roll forming. However, the nature of the roll forming operation is such that each successive glass sheet is shaped in a manner substantially identical to every other sheet in the series provided the amount of the aforesaid misalignment is not changed during the processing of a series of sheets.

The adjustability of the open reinforced frame structure 30 transverse to the sheet movement path is also important to insure that sheets of non-rectangular outline having a straight longitudinal side edge are bent along a desired axis of bending to cylindrical shapes. The longitudinal center line of the non-rectangular sheet, if aligned with the longitudinal center line common to the lower set of forming rolls 35, tends to develop a skew in the sheet forming station 21 because the longer longitudinal side edge of the sheet to be roll formed is driven by frictional rolling engagement with more forming rolls to one side of the common longitudinal center line of the lower forming rolls 35 than the number of forming rolls that engage the shorter longitudinal side edge of said sheet by frictional engagement to the other side of said common longitudinal center line when the lower forming rolls lift the sheet off the conveyor rolls 25 at the sheet shaping station. In such a case, the open reinforced frame structure 30 is adjusted in position transversely of the sheet movement path to offset the common longitudinal center line of the forming rolls 35 and 56 from the longitudinal center line of the sheet as the latter enters the sheet forming station 21 a sufficient distance to compensate for the skew that would be imparted to the sheet if the common center line of the forming rolls 35 were aligned exactly with the longitudinal center line of the sheet. Since no two outline patterns are alike, it takes a little adjustment of the transverse position of the open reinforced frame structure 30 to obtain the optimum position for a given pattern. Usually, the optimum position is one where the common center line of the forming rolls is closer to the longer longitudinal side edge of the sheet than to its shorter longitudinal side edge.

Once the optimum position is determined for a given pattern, it is used over and over again whenever that pattern is again produced. Indicia marks (not shown) may be made on the floor to indicate the transverse

positions of structures 30 and 87 so that the positions may be repeated whenever desired.

A strange phenomenon exists when a pattern that is the mirror image of another pattern (that is, a curved sidelight for the left side of a vehicle that has the same shape but a mirror image of the outline of the corresponding sidelight for the right side of the vehicle) is processed. One would expect that the mirror image pattern would require a misalignment in the opposite transverse direction of the common center line of the forming rolls of an equal distance from exact alignment with the longitudinal center line of the sheet entering the sheet forming station as that required for the original pattern. Such is not necessarily the case, probably due at least in part to the oblique plane along which the sheets travel along the path of travel defined by the conveyor system. However, once the optimum transverse position of the open reinforced frame structure 30 is determined for any given pattern, the roll forming apparatus operates at that position whenever that pattern is again in production. A record is kept of the proper transverse position of the open reinforced frame structure 30 and that of structure 87 for each pattern so that there is no need for repeating the adjustment procedure whenever additional production of a particular pattern is required after the apparatus has been used to produce roll formed sheets of other patterns.

While a single motor may be used to adjust the lateral position of both the forming rolls 35 and 56 and the shaped conveyor rolls 27 simultaneously, separate drive shaft motors 66 and 79 are used for the sheet forming station 21 and the sheet cooling station 22 to utilize relatively small motors rather than a single large motor. Two small motors are much less costly than a single large motor, both as to initial purchase cost and as to cost of operation.

The shaped conveyor rolls 27 in the portion of the sheet cooling station 22 where the sheets are above their deformation temperatures are preferably positioned transversely of the conveyor path with their common center lines aligned with the center line common to the forming rolls in the sheet forming station 21 regardless of whether the center line common to the forming rolls are aligned or misaligned with the center line occupied by the sheet on entering the sheet forming station 21. Hence, the provision of the present invention of means to adjust the transverse position of the conveyor rolls in the portion of the sheet forming station where the sheets are above their deformation temperature makes it possible to align the center line common to the shaped conveyor rolls in the sheet cooling station with the center line of the forming rolls in the sheet forming station regardless of whether the forming rolls are in a transverse position suitable to induce skew or reduce skew along the center lines of the sheets as the latter enter the sheet forming station.

The form of the invention shown and described in this disclosure represents an illustrative preferred embodiment and modification thereof. It is understood that various changes may be made without departing from the gist of the invention as defined in the claimed subject matter which follows.

I claim:

1. An apparatus for forming shaped sheets of heat deformable materials comprising a conveyor means for conveying sheets along a normal path of movement defined by a longitudinally extending center line sequentially through a furnace for heating the sheets to a

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deformable state, a sheet forming station and a sheet cooling station, said furnace and said stations being in end to end relationship, said sheet forming station comprising opposed sets of forming rolls of complementary curvature for imparting a curvature to said deformable sheets aligned along a longitudinally extending common center line, said conveyor having shaped conveyor rolls in at least the initial portion of said sheet cooling station aligned along a longitudinally extending common center line, means for adjusting the transverse position of the center line common to said forming rolls relative to the center line of the normal path of movement of the conveyor, and means for adjusting the transverse position of the center line common to the shaped conveyor rolls in said initial portion of said cooling station where the sheet is at an elevated temperature such that it is subject to distortion upon contact with a solid surface whereby the rolls in the sheet forming and cooling stations may be offset laterally with respect to the normal path of movement of the sheets in an amount sufficient to modify the curvature of portions of the sheets disposed outwardly of the center line of the longitudinally extending path of movement of the sheets.

2. In the method of shaping sheets of heat-softenable material by roll forming wherein a series of heat softened sheets is conveyed along a predetermined path in a forming station having a longitudinally extending center line and each sheet of said series in turn is moved continuously between a pair of sets of forming rolls rotating about axes transverse to said path, each set comprising a series of rotating forming rolls spaced longitudinally along said path and being aligned along a longitudinally extending center line common to said sets of forming rolls, and adapted to engage one or the other major surfaces of said sheet and each roll in one of said sets corresponding to a roll of complementary curvature in the other of said sets, and providing said sets with relative motion toward one another while said sheet is moving therebetween to engage said moving sheet in sandwiching position between said sets of rotating forming rolls for sufficient time to impart the shape of said rolls onto said sheets, and cooling each roll formed sheet until it is cooled to below a temperature at which it is subject to deformation on contact with a solid object while conveyed on rolls in a cooling station, said rolls having shapes similar to the shape of said forming rolls and positioned with their common center line normally in alignment with the common center line of said forming rolls,

the improvement comprising offsetting the rolls in the forming station or the shaped conveyor rolls in the cooling station laterally with respect to the center line of the predetermined path of movement of the sheets in an amount sufficient to modify the curvature of portions of the sheets disposed outwardly of the center line of the longitudinally extending path of movement of the sheets.

3. Apparatus as in claim 1, wherein said sheet forming station comprises upper and lower sets of forming rolls having said complementary curvature and a movable open reinforced frame structure supporting said

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sets of forming rolls, and said sheet cooling station comprises a series of shaped conveyor rolls having shapes similar to those of said lower forming rolls and a movable structure for supporting said shaped conveyor rolls, said means for adjusting the position of said sheet forming station transverse to said path comprises a first reversible drive motor operatively connected to said open reinforced frame structure and said means for adjusting the position of said shaped conveyor rolls transverse to said path comprises a second reversible drive motor operatively connected to said laterally movable structure for supporting said shaped conveyor rolls.

4. In the method according to claim 2, wherein said roll formed sheet is cooled to below a temperature at which it is subject to deformation on contact with a solid object while conveyed on rolls having shapes similar to the shape of said forming rolls and positioned with their common center line in alignment with the common center line of said forming rolls.

5. In the method according to claim 2, wherein sheets of non-rectangular outline are shaped to cylindrical configurations about an axis parallel to said predetermined path,

the improvement wherein said forming rolls are positioned with their common center line offset from the longitudinal center line of said sheet during the performance of said roll forming method.

6. The improvement as in claim 5, wherein said roll formed sheet is cooled to below a temperature at which it is subject to deformation on contact with a solid object while conveyed on rolls having shapes similar to the shape of said forming rolls and positioned with their common center line in alignment with the common center line of said forming rolls.

7. The improvement as in claim 5, wherein said sheets of non-rectangular outline have a longer longitudinal side edge and a shorter longitudinal side edge, wherein the common center line of said forming rolls is offset closer to the longer longitudinal side edge than the shorter longitudinal side edge of said sheets during the performance of said roll forming method.

8. The improvement as in claim 2, wherein said sheets are composed of glass.

9. The improvement as in claim 2, wherein sheets of rectangular outline are shaped to curvatures about an axis skewed relative to the longitudinal center line of said sheets, wherein said sets of forming rolls are positioned so that their common center line is offset transversely of said predetermined path with respect to the longitudinal center line of each said sheet in said series sufficient to develop a skew of the desired angle in said sheet relative to said common center line during the performance of said roll forming method.

10. The improvement as in claim 9, wherein said roll formed sheet is cooled to below a temperature at which it is subject to deformation on contact with a solid object while conveyed on rolls having shapes similar to the shape of said forming rolls and positioned with their common center line in alignment with the common center line of said forming rolls.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,929,441
DATED : December 30, 1975
INVENTOR(S) : Robert G. Frank

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 56, insert --which-- after "along".

Column 2, line 22, "expecially" should be --especially--.

Column 3, line 61, insert --forming-- before "station".

Column 4, line 43, insert --through-- after "passageway".

Column 7, line 11, insert --the-- after "Thus,".

Column 8, line 3, "39" should be --30--.

Column 9, line 49, insert --invention-- after "present".

Column 9, line 57, "of" (first occurrence) should be --or--.

Column 11, line 10, "or" should be --of--.

Signed and Sealed this
eleventh Day of May 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks