APPARATUS FOR BENDING SHEET MATERIAL

Filed May 26, 1971 3 Sheets-Sheet 1

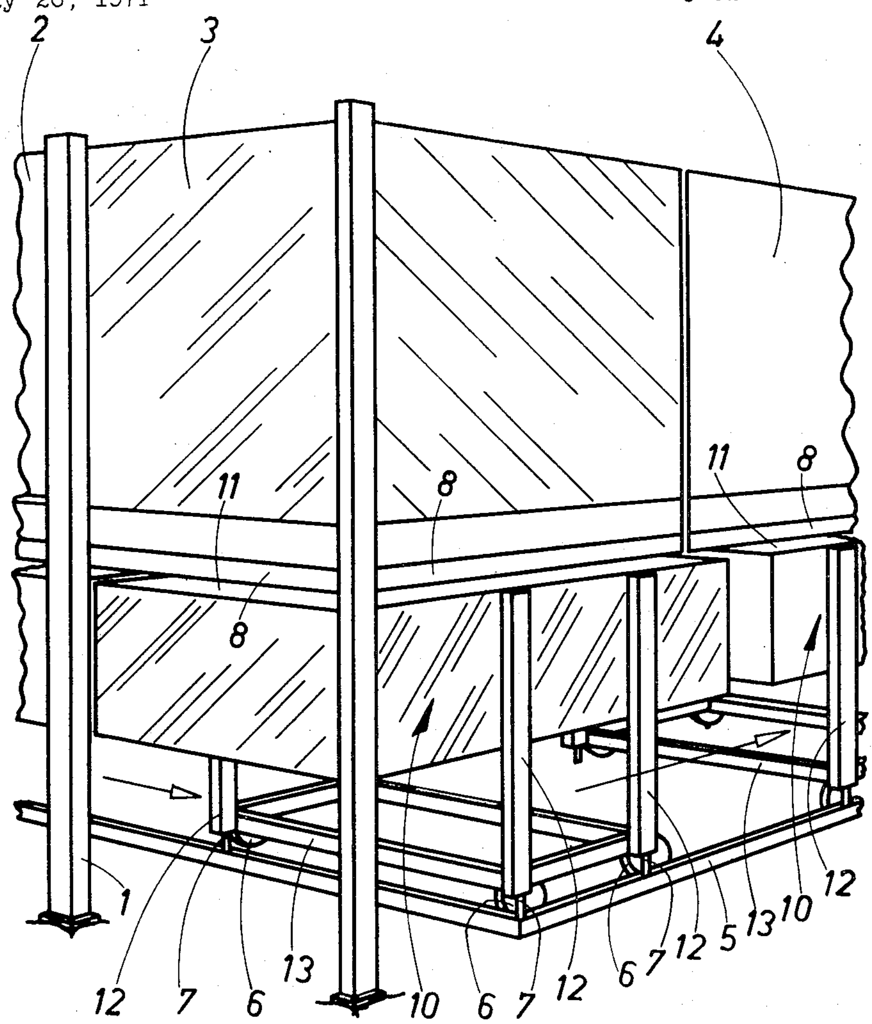

Fig. 1.

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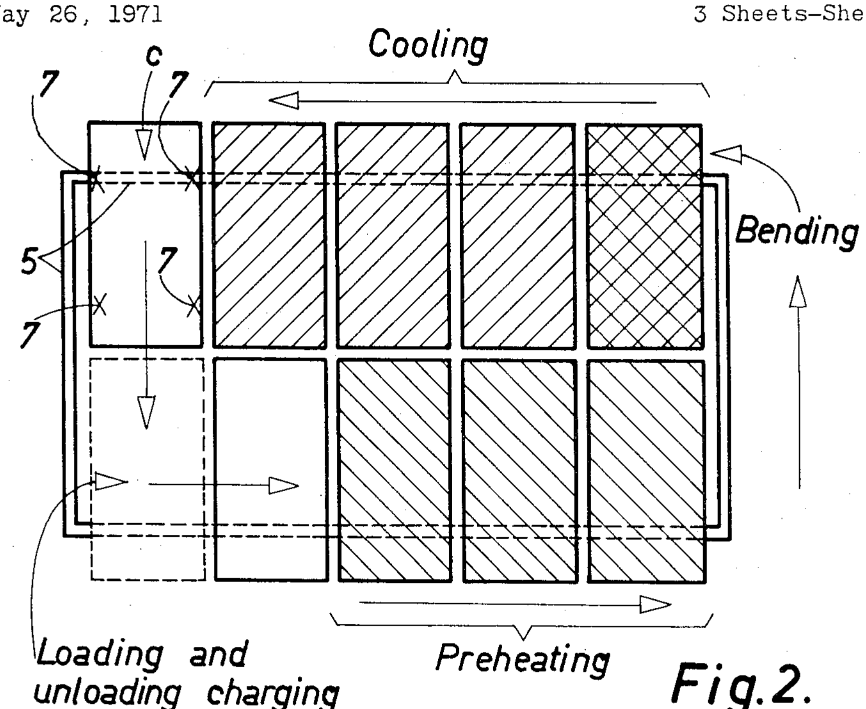

Fig.2.

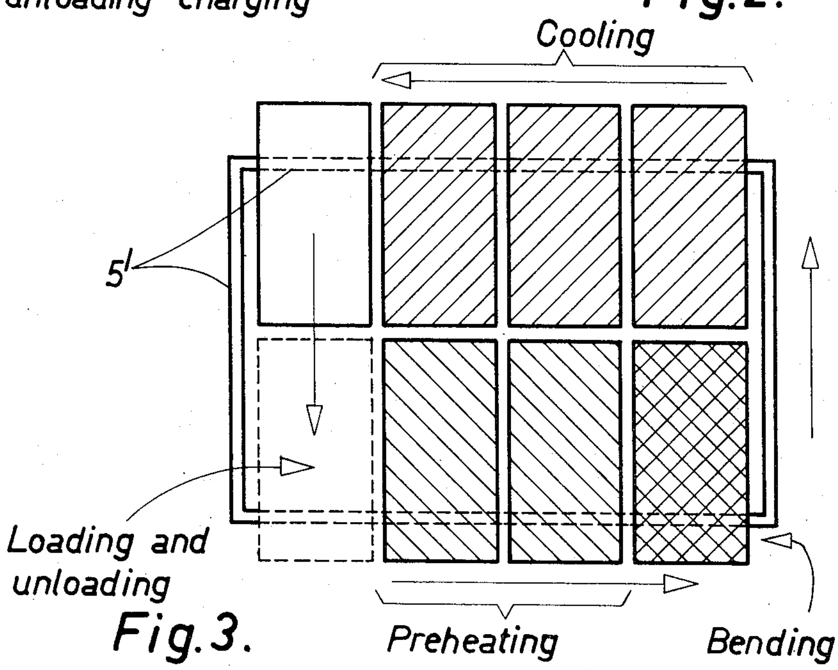

Fig.3.

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APPARATUS FOR BENDING SHEET MATERIAL

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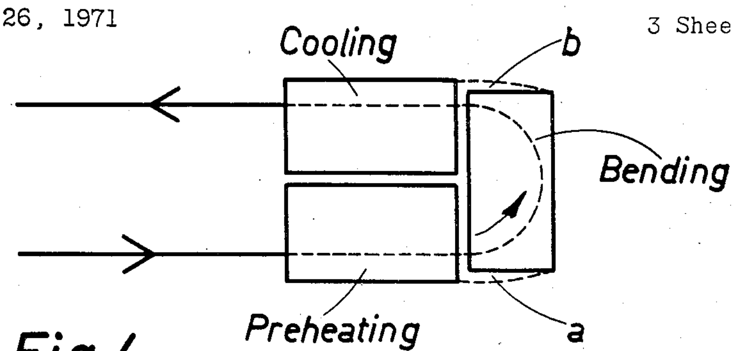

Fig. 4.

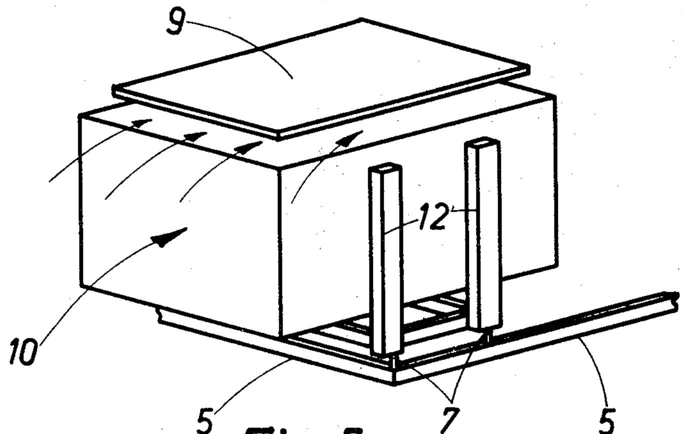

Fig. 5.

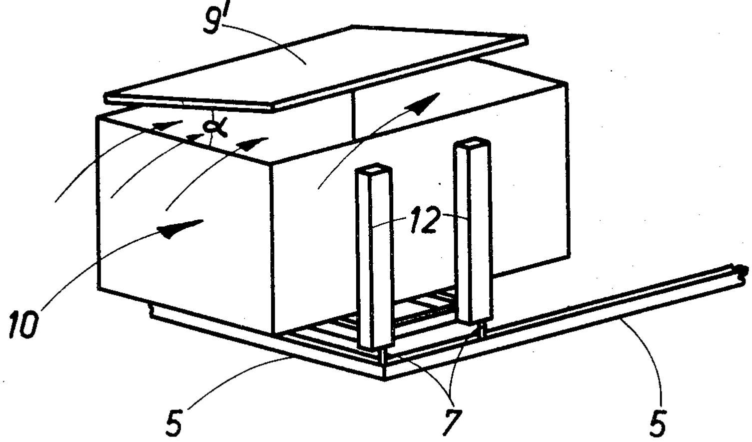

Fig. 6.

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3,764,288
APPARATUS FOR BENDING SHEET MATERIAL
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Int. Cl. C03b 23/02
U.S. Cl. 65—273 16 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for imparting a predetermined permanent curvature to sheet blanks of materials, such as glass, which are softenable by heating, which apparatus presents a preheating zone arranged along a first line, a cooling zone arranged along a second line parallel to the first line, a bending zone arranged adjacent at least one of the preheating and cooling zones, at least one tray provided for holding a sheet blank which is to be given predetermined permanent curvature, and means, including swivel wheels, projecting arms, and a track to engage with the arms, for permitting displacement of the tray in a predetermined direction one of the lines then through the bending zone, and the reverse direction along the other of the lines for exposing a blank held in the tray to successive treatments at the zones.

BACKGROUND OF THE INVENTION

This invention relates to apparatus for imparting a predetermined permanent curvature to, for example, sheet blanks.

The present invention is of special potential importance for the design of a plant for bending vehicle windshield blanks made of glass. The invention will hereafter be described primarily in relation to that particular application.

In order to bend sheets of, for example, glass to a predetermined permanent curvature, they have to be subjected to heating prior to bending and cooling after bending. This is carried out according to a planned schedule. The present practice in mass production plants is to convey the glass blanks through preheating, bending and cooling stations juxtaposed along a production line. The blanks are supported in trays which travel on an endless track. The trays are loaded before entry into the preheating station, or stations, and unloaded on leaving the cooling station, and the unloaded trays continue in movement along their track so that they become recycled for loading with fresh blanks.

The known system has certain disadvantages, one of these being the large floor space taken up by the complete plant, including the various treatment stations and the tray conveying path.

When bending elongated blanks such as vehicle windshield blanks, it is customary to mount the sheets in their trays so that the longitudinal axes of the blanks are normal to the line of motion of the trays. Each blank is initially supported at its ends on a former which determines the final curvature of the blank, and if the blank is orientated in the tray in the specified manner it is less liable to slip out of position on the former, due to forces created by inertia, than if the blank were oriented with

its longitudinal axis parallel with the line of motion of the tray. In the conventional plan, each tray is always oriented in the same way in relation to its line of motion.

SUMMARY OF THE INVENTION

According to the present invention, a plant for use in bending sheet blanks has blank preheating, bending and cooling zones, the preheating and cooling zones being arranged along two abreast parallel lines and the bending zone or zones being arranged in one or both of the lines and/or in a bridging position between them. At least one tray is provided in which a blank can be supported while it is subjected to preheating, bending and cooling at the zones and which can be displaced first in one direction along one of the lines and then in the reversed direction along the other of the lines for exposing a blank held in the tray to successive treatments at the zones.

Preference is given to a plant in which the zones are stations at which the respective treatments are performed while a tray is stationary for the required treatment period.

By adopting a plant layout according to the present invention, a very considerable saving in space—amounting to about one half or more of the space previously required—can be realized.

In the preferred embodiments of the present invention, there are at least two preheating stations and at least two cooling stations, in addition to a bending station, and at least two of the total number of stations are arranged along each of the two parallel lines.

It is considered advantageous for the arrangement of the stations to be such that a preheating station is immediately adjacent a bending station, thereby to reduce loss of heat generated by heaters provided at those stations.

The spacing between the two abreast lines is preferably no greater than is necessitated by the space requirements of the stations in the different lines.

According to a preferred feature of the present invention, the various treatment stations are distributed in such a way that a bending station is located at an end of at least one of the abreast parallel lines. The advantage of this feature is that if it is required to have the bending operation placed under observation, this can very easily be done without the observer having to move from his post to allow movement of the tray(s) into and out of a bending station.

According to one layout of the type which can be adopted in accordance with the present invention, there is a preheating station, or stations, in one of the abreast parallel lines, and the bending and cooling stations are in the other of such lines. The bending station may be arranged directly opposite the last preheating station.

Another possible layout according to the present invention is one in which there is a bending station at the end of one of the abreast parallel lines, the bending station being preceded by one or more preheating stations in that line, and one or more cooling stations in the other of the lines. The first cooling station may be arranged directly opposite the bending station. When a bending operation has been performed, the tray holding the bent sheet has merely to move over a short distance in order to reach the first, or only, cooling station. Preferably, this short distance is not more than twice the width of the tray and most preferably not more than one and a half times such width.

Both of the different layouts described above have important advantages over the conventional plants. First, the bending of each blank can be observed from both an end and a side of the tray holding the blank, without the observer having to take up a temporary and possibly dangerous position between successive trays on the tray track. Secondly, the closer spatial relationship of the bending and cooling stations is also of potential advantage in making it much easier to prevent or avoid fouling of the blanks by the deposit on them of contaminating particles present in the air.

Apart from a saving in space—in some cases a saving of as much as ⅔ or ¾ has been realized—the layouts described above afford various other advantages over the known plants. For example, by adopting the layouts according to the present invention, cooling of the preheated blanks between the preheating and bending operations can be prevented, or substantially so, and this means that the blanks can be in a more uniformly heated condition at the start of the bending operation. In addition, it is in certain cases possible to reduce the overall size and/or energy consumption of the equipment used in the preheating of the blanks. In the case of a plant with a succession of preheating stations, each provided with a heat-radiating hood, the number of preheating stations can possibly be reduced from the number previously necessary. By juxtaposing the preheating hood, or the last of such hoods if there is more than one, and the furnace hood at the bending station, thermal losses in this part of the plant can be reduced. In addition, the necessary facilities to enable the operation at the bending station to be observed can be provided at less expense, and the observation duty itself is less fatiguing and can, therefore, be preformed with greater efficiency.

The preheating and bending stations may have separate furnaces, or they may have separate hoods from which heat is radiated, downwardly for heating a blank while they are held beneath the hoods in a tray. Alternatievly, two or more stations may have different portions of a common tunnel-like furnace, or different portions of a common hood. Thus, there may be two tunnel-like furnaces or hoods, respectively, providing the processing stations belonging to one or the other of the two abreast lines of stations.

If hood-type heaters are employed, it is preferable to provide some form of shutter or closure means therefor to enable any given hood to be closed off at the bottom when a tray is not in position at the related station. However, if a plurality of trays which can simultaneously occupy different stations is provided, the provision of such closure means is not so important, or is not necessary—particularly if there are as many trays as there are stations—because in that case the plant can be operated so that at substantially all times the position under any hood is occupied by a stationary tray or by portions of successive trays leaving and entering the station. According to another preferred feature of the present invention, the plant may include means for guiding a tray about a course extending along one of the abreast lines and then back along the other of them. A preferred type of guiding system will be described hereinafter. In the event that one or more tunnel-type furnaces are used having a sole, a vault or roof, and lateral walls, the guide system may be arranged within the furnace or furnaces, or portions or extensions of a tray or trays may extend through slots in a wall or walls of each furnace used for engaging a guide track located externally of the furnace or furnaces. This track may be, for example, beneath the furnace sole(s).

It may sometimes be advantageous to provide tray guide means defining an endless conveying path of which the abreast lines form opposite sides. The length of this endless conveying path, measured parallel with the abreast

lines, may be substantially the same as or only a little greater than the overall distance, parallel with those lines, covered by the preheating, bending and cooling stations. Alternatively, the endless course may extend beyond these processing stations at the end of the system at which a tray enters the preheating station or stations and leaves the cooling station or stations, and further operations on each sheet blank can be performed during travel of a tray along the extended part of the conveying path.

The guiding means, when provided, may alternatively form a discontinuous course for a tray—for example a path of a generally U or horseshoe shape—the preheating, bending and cooling stations being distributed along the parallel portions of the conveying path, and the connecting portion of the path serving to determine the path of a tray from the processing station or from the last processing station of one line to the processing station or the first processing station of the other line.

If guiding means as aforesaid is provided, whether to define an endless conveying path or a generally U-shaped conveying path for a tray, the part of the guide means determining the movement of a tray from one to the other of the parallel first and second lines maybe arranged so that each tray moves parallel with itself in transferring from one to the other of the parallel lines. For example, the guide means may be constructed so that each tray moves parallel with itself or sideways, and in a direction perpendicular to the parallel lines when transferring from one of such lines to the other. Such an arrangement has the advantage that the distance which each tray has to move to transfer from one to the other of the two parallel lines for any given spacing thereof is as short as possible. Alternatively, the guide means may be constructed so that each tray moves only in translation, i.e. without having its orientation changed by any pivotal or rotational movement relative to the parallel lines, along a curved path joining the parallel lines.

It is, of course, not essential for a tray to move parallel with itself during movement between the two parallel lines. The guide means may, as an alternative, be arranged so that each tray follows a curved path joining the two parallel lines without the tray changing its orientation with respect to the line of the tray motion. In this case, each carriage turns through 180° during movement form the ends of one of the two parallel lines to the conveying path starting end of the other of them.

The displacement of a tray during the whole or any part of its travel may be effected either manually or automatically. Automatic displacement may, for example, be achieved by means of known types of driven endless entraining members with which each tray engages, and/or by hydraulic or pneumatic piston and cylinder units, or by any other suitable known means.

In the present invention, when each tray is moved parallel with respect to itself and normal to the two parallel lines of the conveying path while moving the tray from one of such lines to the other, first one end or side and then another end or side of a tray faces the direction of its motion. In such cases, the blanks are preferably orientated in the trays so that the longitudinal axes of the blanks lie normal to the line of motion of the trays during their movement along the two abreast lines along which the treatment stations are placed. In that event, however, the axes will be parallel with the line of motion of the tray when they move from one of those lines to the other. In order to avoid slipping of the blanks during this latter motion, it is preferably performed with a slow acceleration and deceleration. From this point of view, the second of the two different types of layouts above described may in some cases be preferable to the first one, because the transfer of the blanks from the preheating station or stations to the bending station can be performed more quickly. A slower movement of the blanks from the bending station to the first cooling station is of little or no consequence.

Stops can be provided in each tray for preventing displacement of the blank by inertia or other effects.

According to a further preferred feature of the present invention, the trays are supported on self-orientating castors which engage the floor, and the trays have projecting pins which extend into guide rails, or tracks, secured into or within the floor. It suffices to provide a single guide rail along the periphery of the rectangular path for the trays, and to provide each tray with, for example, four depending arms disposed—as viewed in plan—at the corners of a notional rectangle. During movement of a tray in any one of the four directions in which the tray is moved in the course of one complete "circuit," the tray is guided and constrained to move parallel with itself by engagement of two of its depending arms in one of the, for example, four peripheral rails.

The preheating and bending stations may, as already mentioned, incorporate hood-type heating units.

The cooling station or stations may be merely locations along the conveying path at which each tray dwells for a predetermined period during which cooling of the hot blank takes place as a result of free exposure of the blank to ambient air through the open top of the tray. This is especially suitable for cooling thin sheets. Alternatively, at one or more of the cooling stations there may be some form of hood or cover which restricts or controls radiant heat and/or cooling air flow in and out of the trays. Such a hood or cover may, for example, have a flat or curved plate which closes off, or almost closes off, the top of a tray which is currently at the cooling station in question. Restricted air flow may be permitted by virtue of the plate being raised with respect to the top of the plate, or by virtue of one or more holes being provided in the plate itself. Cooling may take place by natural or forced draft.

According to a further feature which may be adopted in carrying out the present invention, there is at least one cooling station where there is a tray disposed at or movable into a position such that when a tray carrying a bent sheet blank is in position at the cooling station, a cover provides or defines with the tray an opening or openings through which cooling air can flow into the tray. This feature is of importance in its own right to, for example, enable bent sheets of glass to be cooled rapidly without subjecting the glass to a very slow annealing. This is unnecessary in the case of thin sheets, such as sheets less than 2 mm. thick. Therefore, the present invention, according to a second aspect thereof, is any plant for bending sheet blanks and having blank preheating, bending and cooling stations, wherein the cooling station, or at least one of such stations if there is more than one, is equipped with a cover which functions as above described. Such a plant can, of course, also include, if so dtsired, any of the features related to the present invention in its first aspect herein defined. The cover may, for example, be in the form of a flat or curved plate. The operative position of the plate may be a little above the top of a tray when this is at a respective station, or the plate may be in contact with the tray at one side or end and be disposed at an inclination to the horizontal. Alternatively, the plate may have one or more peripheral openings or recesses through which air can enter the tray when the plate is in position on the top of the tray. It is advantageous to be able to regulate the openings to suit different cases, in particular to adjust the level of the cover in relation to the tray in order to regulate the cooling rate. At any given cooling station, the cooling effect can be modified by the action of one or more heaters.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic perspective view of a part of a plant according to the present invention.

FIG. 2 is a schematic top plan layout of the plant of FIG. 1.

FIG. 3 is a schematic top plan layout of another plant according to the present invention.

FIG. 4 is a schematic top plan view of part of yet another plant according to the present invention.

FIG. 5 is a schematic perspective detail of a cooling station according to the present invention.

FIG. 6 is a schematic perspective detail similar to FIG. 5, but showing an alternative embodiment of a cooling station according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2 of the drawings, a main structure **1** is shown supporting a number of hoods containing heating means—for example, suitable, known electrical resistance heaters—and reflectors for reflecting heat downwardly through the openings defined in the bottoms of the hoods. The hoods are located at each of four stations, namely, the three preheating stations and the single bending station labeled as such in FIG. 2. Three of the hoods appear in FIG. 1, that is hoods **2** and **3** which are located at two of the three preheating stations and a hood **4** which is located at a bending station.

The preheating and bending stations may, as already mentioned, incorporate hood-type heating units. These units may, as known per se, have internal radiant heaters or other known heating means and preferably reflectors which direct the heat downwardly into the trays holding the blanks as these move into position beneath the hoods. Particularly at the bending station, there may be electrical resistance or other known heaters which are independently regulatable so that the heat distribution can be locally adjusted to suit the curvature which is to be imparted to the blanks. An embodiment of such heating units is shown in the U.S. Pat. No. 3,166,397, FIG. 1, which describes a windshield bending plant comprising more particularly a bending station **14** provided with radiant heaters as electric coils **63**.

Beneath the main structure **1**, there is a floor track **5** formed by, for example, upwardly opening channel section rails and arranged with respect to the station for defining, for example, a rectangular conveying path. This track **5** serves to guide, for example, a plurality of trays **10**, into each of which a sheet blank to be bent (not shown) is loaded. The number of trays **10** may range from one tray to a number at most inferior of one unity to the number of stations in order to permit the movement of the trays from a station to next station. The manner in which the blanks are supported within the tray is not shown. The manner of support is in accordance with known practice. Briefly described, each blank is supported at its opposed ends on the opposed ends of a former (not shown), the upper surface of which is concavely curved towards the sheet and determines the curvature which will be imparted to the blank in the bending operation.

Stops (not shown) can be provided on each tray for preventing displacement of the blank by the force of inertia or other effects. For example, there may be a few stops for abutting the edges of an elongated blank, such as a vehicle windshield blank, at each of the shorter sides of the blank. If movement of the tray in a direction parallel with the longitudinal dimension of the blank occurs after bending of the blank, then the stops must be brought into effect or made effective at the reduced spacing of the blank ends which is present when bending is complete. The stops can be manipulated into operative position at the appropriate time, either manually or automatically, for example, they may be manipulated by means of a system of levers (not shown). Stops can of course be provided for abutting the longer edges of the blank if so required. For example, such stops can be constituted by the vertical flanges of L-shaped members (not shown) at the periphery of the mold or form (not shown) determining the curvature of the blank. For instance, the German Pat. No. 228,049 describes such a tray 1 comprising a former realized by the curvature of the upper edge 4 of several panels 3 maintained in the tray by the grooves 2 and by the supporting bed 5. In FIG. 2, it may be seen that the blanks are stopped by the upper portion of the walls of the tray. Indeed, the highest part of the panels 3 is smaller than the trays of the tray.

Each tray 10 is supported on uprights 12, frame 13, and, for example, four self-orientating castors or swivel mounted wheels. Three of the wheels of one of the trays are apparent in FIG. 1 and are designated by the reference numeral 6. Each of the trays 10 is also provided on its uprights 12 with four projecting pins 7 (FIG. 1). These pins 7 are arranged to selectively engage with the track 5 and guide each tray 10 about the conveying path defined by track 5. The trays 10 in FIG. 1 move in the direction of the arrows.

The level at which hoods such as 2–4 are supported by the main structure 1 is designed to be such that the trays 10 can just move into position beneath them. Each tray 10 is provided around its top rim 11 with a flexible heat-insulating material 8—for example, asbestos fibers or steel wool—which forms a seal against the bottom rim of the respective hood when a tray 10 is in position at any station at which a hood such as hoods 2–4 is present.

In the layout shown in FIG. 2 of the drawings, there are three preheating stations, one bending station and three cooling stations. In FIG. 2, trays 10 located for a time at the different types of stations are distinguished by different cross-hatchings. The trays 10 move, for example, intermittently through these stations in succession, following a rectangular path determined by track 5.

Preferably, each of the preheating stations is always occupied by a tray 10, or by portions of successive trays 10, so that downward heat losses are minimal.

The circuit of one of the trays 10—that is, the tray designated C in FIG. 2—will be described in more detail. The circuit of the other trays 10 is, of course, the same.

The tray C is advanced in the direction of the arrow in FIG. 2 from its illustrated position to the loading station which appears in the bottom left-hand corner of FIG. 2.

It will be seen that four points on tray C have been marked with a cross in FIG. 2 to indicate the positions of the pins 7. In the illustrated position of tray C, the two pins 7 which are uppermost in FIG. 2 are engaged in the side of the track 5 which also appears uppermost in FIG. 2. The two left-hand pins 7 are shown out of registration with the adjacent end, or vertical in FIG. 2, rail of track 5 in order to clarify the description. In actual fact, when the tray C moves into the position illustrated in FIG. 2, the left-hand pins 7 move into the end rail of the track 5 and this end rail guides the tray in its movement into the loading station. The entry of the lower left-hand pin 7 into that rail is permitted by a notch (not shown) in the inner flange of the rail at the appropriate point. When the tray C is in its illustrated position, the top right-hand pin 7 is opposite a notch (not shown) in the inner flange of the top rail so that that rail does not prevent the movement of the tray towards the loading station. Similar notches (not shown) are also provided at the appropriate points of track 5.

On reaching the loading station, tray C is loaded with a sheet blank (not shown). Tray C is then advanced stepwise through the four succeeding stations in the bottom line of the layout of FIG. 2. A stepwise motion is necessary, because, of course, the motion of tray C is accompanied by motion of the trays 10 ahead of it, and each tray has to dwell for a certain period at each of the treatment stations. The loaded tray C accordingly reaches the three preheating stations one after the other in succession. At those stations, the blank is progressively heated to a temperature somewhat below that at which the blank will bend under its own weight. During movement along the bottom line of stations, tray C is guided by the bottom rail of the track 5, which is engaged by the lower set of pins 7.

The tray C is next moved, parallel with itself, in the direction indicated by the right-hand arrow in FIG. 2 and into the bending station. Tray C is guided in this movement by virtue of engagement of the two right-hand pins 7 with the right-hand end rail (as seen in FIG. 2) of track 5.

At the bending station, the blank is heated to such a temperature that the blank, which is supported only on the ends of its former (not shown), sags under its own weight and takes up the same curvature as the top surface of the former.

The tray C now moves stepwise to the left along the top line of stations until it arrives back at its illustrated position ready to return to the loading station where the bent blank is removed from tray C and replaced by a fresh blank to be bent.

Each of the trays 10 is, of course, always supported on its wheels 6, so that the tray 10 can be displaced quite easily. These wheels 6 are self-orientating according to the direction in which a thrust is exerted against the tray 10.

The movement of trays 10 along the top and bottom lines of the layout of FIG. 2 may be effected by a suitable known pneumatic or hydraulic mechanism (not shown) or by any other suitable, known powered system (not shown). The displacement of each tray 10 from one line into the other may likewise be achieved automatically, but in some cases it may be desirable to perform this movement manually so as to avoid an inertia displacement of a sheet on its former. The need for this caution applies mainly, of course, when moving a tray 10 for the final preheating station into the bending station.

An alternative layout is shown in FIG. 3 of the drawings. In this layout there are two preheating stations and a bending station in the bottom line (as seen in FIG. 3) and three cooling stations in the top line. Trays 10 are guided by a track, designated 5′, which is similar to the track 5, but can be made shorter, as shown when a bending operation has been performed in the layout of FIG. 3, the tray 10 holding the bent sheet has merely to move over a short distance in order to reach the first cooling station. Preferably this short distance is not more than twice the width of a tray 10, and most preferably not more than one and a half times such width.

In the embodiment of the invention represented in FIG. 4 there is a known preheating tunnel-type furnace on one of the two abreast parallel lines of a U-shaped conveying path and a cooling station along the other of such lines. A bending station is arranged at the curved portion of the conveying path, across the ends of the abreast lines. In other words, the bending station is arranged in an end position common to the abreast parallel lines. Guide means is provided for guiding a tray 10 in movement from the preheating furnace to the cooling station along the semicircular portion of the conveying path, which is indicated by the broken line in FIG. 4. In following this portion of the conveying path, a tray 10 becomes turned through 180° so that the same end of the tray 10 leads its motion through the entire plant. A portion of each tray 10 becomes exposed in the region marked *a* during movement from the preheating station to the bending station, and at the region marked *b* during movement from the bending station to the cooling station, unless some form of insulating cover (not shown) is provided at these regions.

The cooling stations in FIGS. 2 to 4 can be merely locations, or zones, at which the trays 10 are freely open to the ambient air. Alternatively, one or more of the cooling stations may be provided with some form of cover member.

Cooling according to the present invention in its second aspect as hereinbefore defined can be carried out at a cooling station or stations equipped with a cover member as shown in FIGS. 5 and 6. The cover, which is designated **9** in FIG. 5 and **9'** in FIG. 6, has a flat plate held in a known manner to supporting structure (not shown) either horizontally (FIG. 5) or at an inclination to the horizontal by some predetermined angle *a* (FIG. 6), in a position such that when a tray **10** moves into position beneath the cover member **9, 9'**, gap or gaps are formed between the tray **10** and the plate **9, 9'** through which gap(s) cooling air can flow into the tray **10** as indicated in FIGS. 5 and 6 by the arrows. That is, the plate is arranged to form a gap or gaps with respect to a tray **10**. The cooling action thus achieved is particularly suitable for rapidly cooling thin bent glass sheets.

EXAMPLE

A number of car windshields were produced by subjecting to bending operation, sheets of a soda lime silica glass (SiO_2 71%, Al_2O_3 2%, Na_2O 12%, CaO 12%, MgO 2%, impurities 1%), of which the length is about 150 c.m., the breadth is about 50 c.m. and having a thickness of 3 c.m.

Each sheet is placed on a bending mould located on a tray and is inserted in the pre-heating zone of the furnace, comprising three pre-heating stations, each of them provided with eighteen electrical coils connected to selecting switches to realize the particular heating pattern to insure correct bending as known in the art.

During the pre-heating stage, the temperature of each sheet has been increased, in twelve minutes, up to about 590° C. and said sheet is inserted, at this temperature, in the bending zone comprising a bending station provided also with electrical coils, in which the temperature of the glass sheet is increased up to 610–620° C.

At this temperature, the viscosity of the glass is such that the sheet is bent by gravity and takes the form of the mold. This bending operation lasts four minutes which is the time during which each tray remains in each station. The bended windshield is then sent through three cooling stations to a discharging station.

The time of a whole treatment is comprised between twenty or twenty five minues according to the width of the sheet.

It will be understood that the above descripion of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. Apparatus for imparting, to sheet blanks, a predetermined permanent curved configuration, the maximum curvature of which is relative to a given axis of curvature;

tray means including a former for holding such a blank and having a curved upper surface which defines the permanent curved configuration to be imparted to the blank;

means defining a preheating zone arranged along a first line;

means defining a cooling zone located along a second line parallel, and adjacent, to said first line;

means defining a single bending zone arranged adjacent at least one of said preheating and cooling zones for imparting to each blank, in a single operation, such permanent curved configuration;

heating means in said bending zone for heating a blank in said bending zone to a temperature at which the viscosity of the blank is sufficiently low to permit it to conform to the shape of said upper surface of said former;

said zones being arranged so that a free space exists along at least two adjacent sides of the bending zone, one of which sides is transverse to the given axis of curvature when a sheet blank is in said bending zone;

said bending zone including means along said one side thereof for permitting observation of a sheet blank therein from a location in said free space along said one side of said bending zone;

means for supporting, and permitting displacement of, said tray means, in a predetermined direction along one of the lines, then between the lines, and finally in the reverse direction along the other of the lines for exposing a blank held in said tray means to successive treatments at said zones.

2. Apparatus as defined in claim **1**, wherein each said preheating and cooling zone is constituted by at least two stations arranged along its respective line.

3. Apparatus as defined in claim **2**, wherein there are a plurality of said tray means.

4. Apparatus as defined in claim **3**, wherein said means for permitting displacement of said tray means comprises guide means arranged with respect to said stations for defining a conveying path, and means mounted on said tray means and cooperating with said guide means for guiding said tray means along said conveying path.

5. Apparatus as defined in claim **4**, wherein at least one of said cooling stations is equipped with a cover member.

6. Apparatus as defined in claim **5**, wherein said cover member is a flat plate mounted horizontally and arranged to form a gap with respect to said tray means.

7. Apparatus as defined in claim **5**, wherein said cover member is a flat plate mounted at an inclination to the horizontal and arranged to form a gap with respect to said tray means.

8. Apparatus as defined in claim **5**, wherein at least one of said preheating stations has a hood defining an opening adjacent said conveying path.

9. Apparatus as defined in claim **8**, wherein said guide means is a track, and said means arranged to cooperate with said guide means is a plurality of pins mounted on said tray means and arranged to selectively engage with said track.

10. Apparatus as defined in claim **9**, wherein said means for movement of said tray means is swivel mounted wheels.

11. Apparatus as defined in claim **4**, wherein there are three preheating stations arranged along said first line and three cooling stations arranged along said second line, and wherein said bending zone comprises a single bending station arranged along, and at one end of, said second line, said tray means being displaced first along said first line, then between said first and second lines, and then along said second line and said conveying path being rectangular such that said tray means undergo only translational movement while being so dislaced.

12. Apparatus as defined in claim **4**, wherein there are two preheating stations and said bending zone comprises a single bending station arranged along, and at one end of, said first line, and wherein there are three cooling stations arranged along said second line, said tray means is displaced first along said first line, then between said first and second lines, and then along said second line, and said conveying path is rectangular such that said tray means undergo only translational movement while being so displaced.

13. Apparatus as defined in claim **4**, wherein said preheating zone is constituted by a preheating tunnel-type furnace, said cooling zone is constituted by a cooling station, and said bending zone is constituted by a bending station arranged transversely to said furnace and said cooling station at one end of the lines, said conveying path being U-shaped and extending through said furnace, said bending station, and said cooling station in sequence.

14. Apparatus as defined in claim **1** wherein the distance between said first and second lines is no greater than twice the width of each of said tray means, measured transverse to said lines.

15. Apparatus as defined in claim **1** wherein the distance between said first and second lines is no greater than one and a half times the width of each of said tray means, measured transverse to said lines.

16. Apparatus as defined in claim 1 wherein said bending zone comprises a single bending station arranged entirely along, and at one end of, one of said lines, and said means for permitting displacement of said tray means causes said tray means to be displaced first along said first line, then between said first and second lines, and then along said second line, along a rectangular conveying path such that said tray means undergo only transitional movement while being so displaced.

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