

June 8, 1948.

A. F. WAYNE

2,442,943

PLATE FORMING MACHINE

Filed Sept. 2, 1941

4 Sheets-Sheet 1

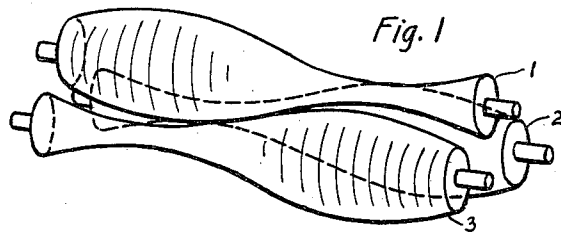


Fig. 1

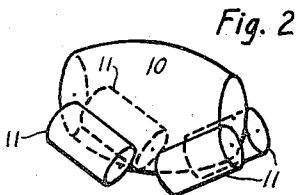


Fig. 2

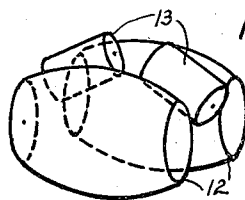


Fig. 3

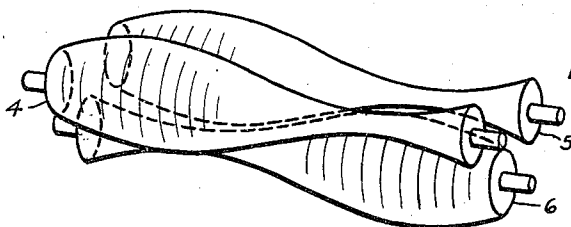


Fig. 4

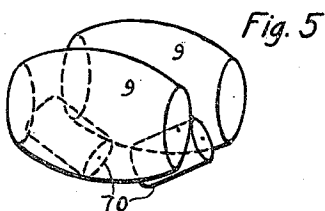


Fig. 5

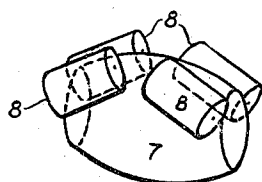


Fig. 6

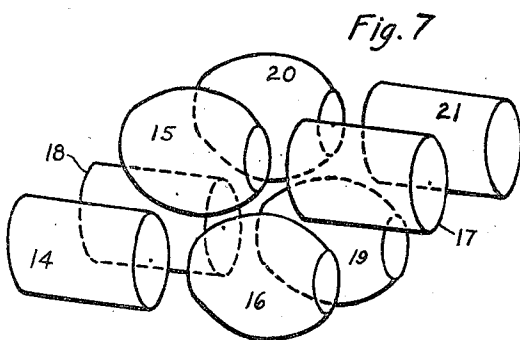


Fig. 7

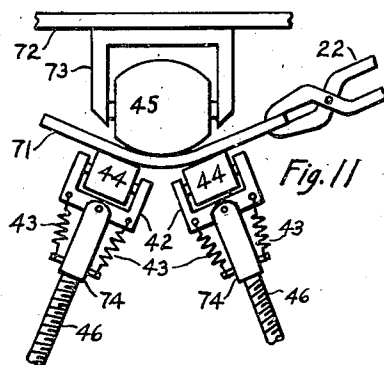


Fig. 11

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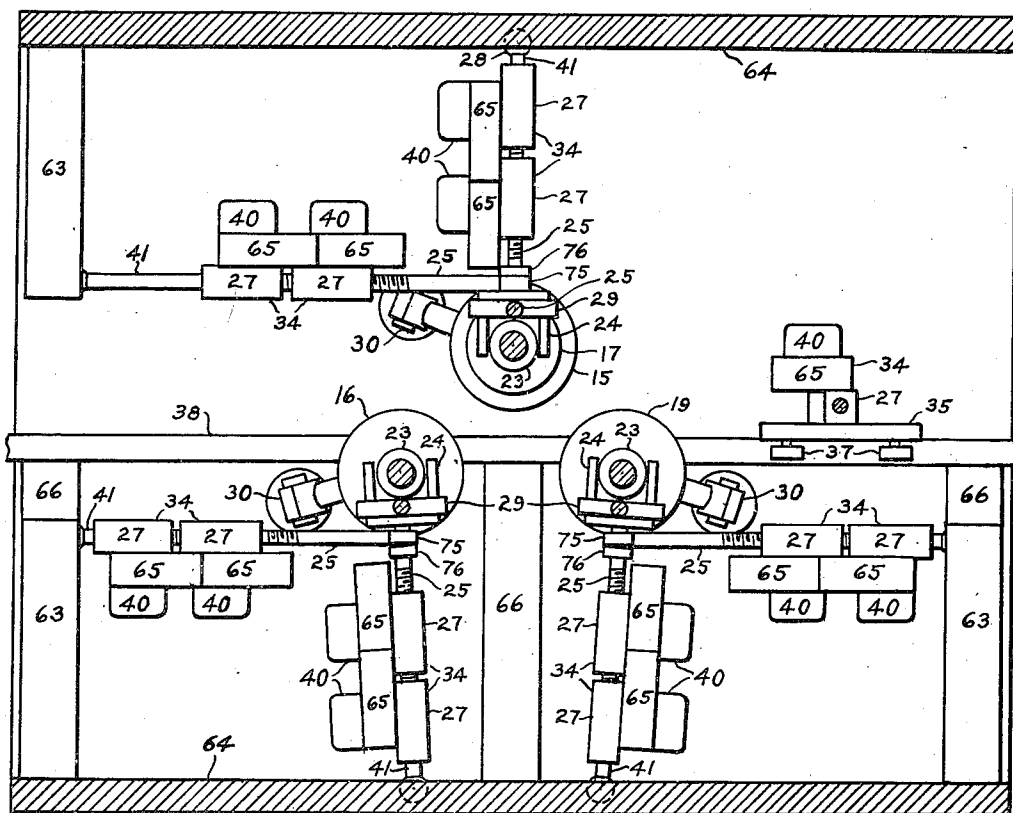


Fig. 13

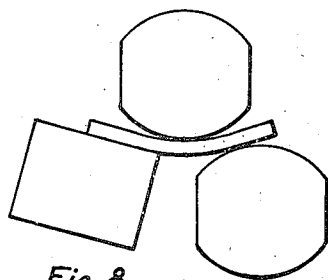


Fig. 8

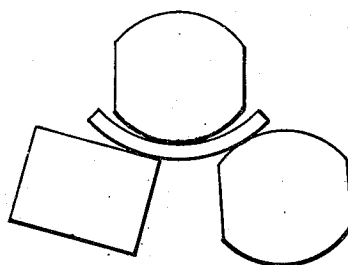


Fig. 9

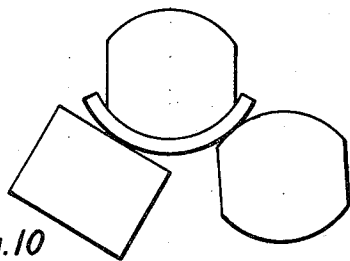


Fig. 10

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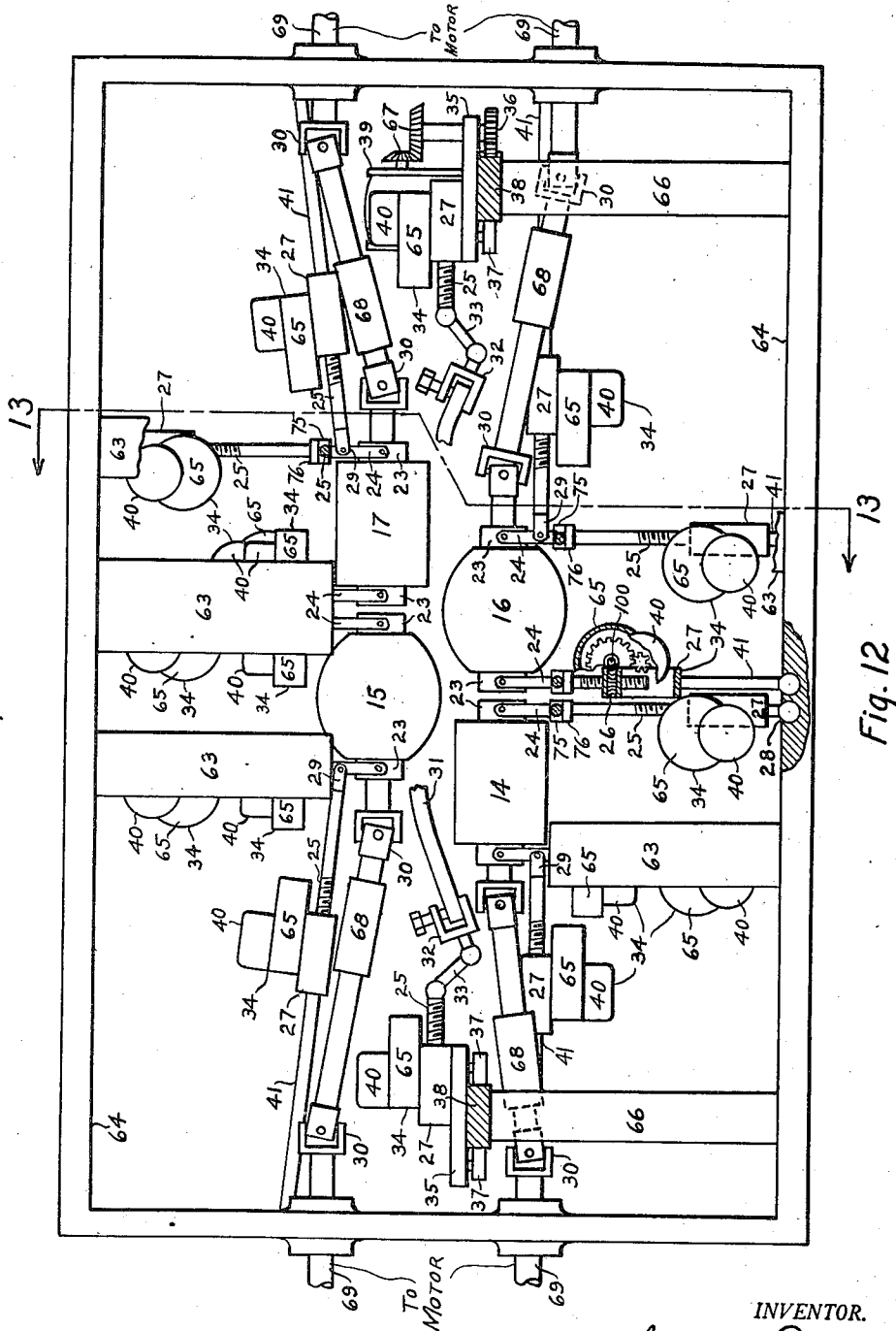


Fig. 12

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4 Sheets-Sheet 4

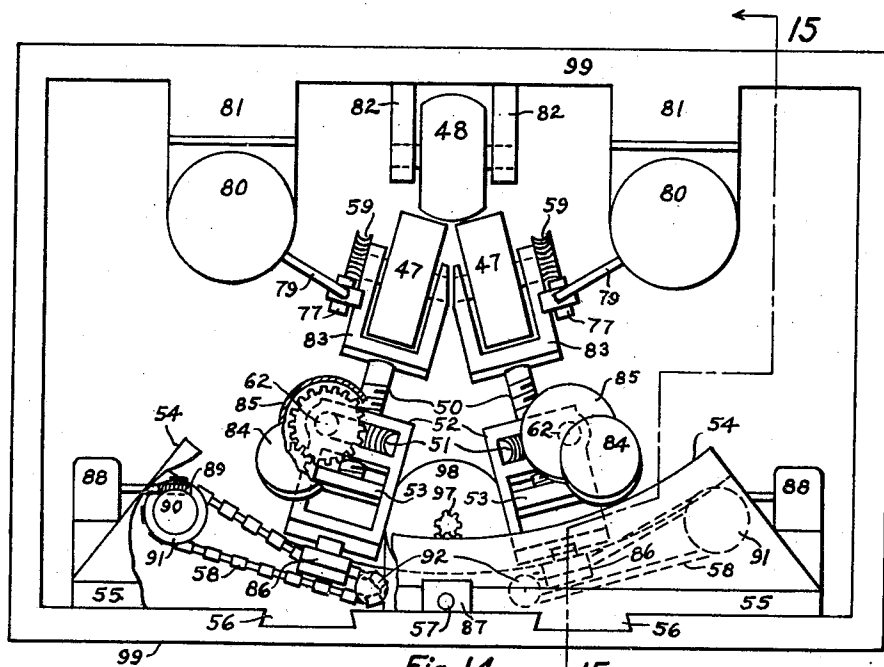


Fig. 14 ← 15

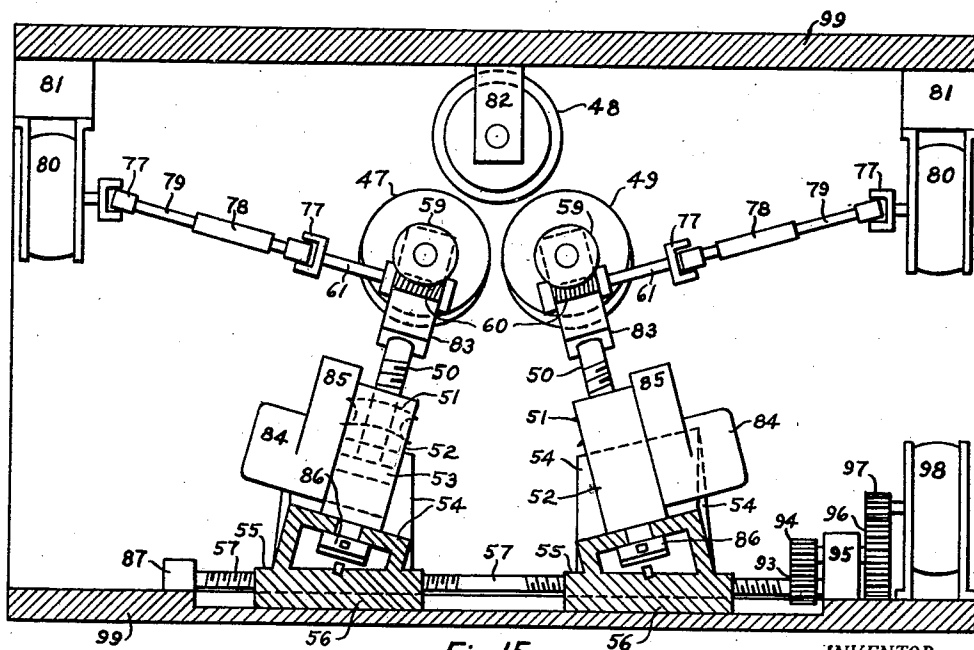


Fig. 15

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PLATE FORMING MACHINE

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8 Claims. (Cl. 153—54)

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This invention relates to methods and means for forming or shaping sheets and plates. More particularly, it relates to methods and means for forming irregular shapes of metal plates, that is, those whose elements are curves, or compound curves. This machine will roll plates no element of which is a straight line. The metal can be rolled hot or cold, depending on the thickness and rigidity of the plate or sheet, and the strength of the machine.

This invention provides a machine for quickly and economically forming plates for ships, automobiles, or airplanes, when compared to the present methods of hand forming, or making extremely expensive dies.

An object of this invention is to provide a machine for rolling plates of irregular and compound curvature from flat stock.

Another object of this invention is to provide a machine for rolling plates of irregular shape, in several stages.

Fig. 1 shows in elementary form a set of 3 rolls.

Fig. 2 shows in elementary form a set of 5 rolls which are equivalent to the left end of Fig. 1.

Fig. 3 shows in elementary form a set of 4 rolls which are equivalent to the right end of Fig. 1.

Fig. 4 shows in elementary form another set of 3 rolls.

Figs. 5 and 6 show in elementary form sets of 4 and 5 rolls which are equivalent respectively to the left and right ends of Fig. 4.

Fig. 7 shows in elementary form a set of 8 rolls.

Figs. 8, 9, and 10 show various steps in the rolling of a plate.

Fig. 11 shows a simplified form of device for plate rolling.

Fig. 12 shows a front elevation of a plate rolling machine.

Fig. 13 is a section on line 13—13 of Fig. 12.

Fig. 14 is a front elevation of another form of plate rolling machine.

Fig. 15 is a section on line 15—15 of Fig. 14.

This invention can be understood best by considering first rolls of compound shape, and then the arrangements which are used to approximate the compound rolls.

In Fig. 1 the elementary rolls 1, 2, and 3 shown will roll a sheet with its longitudinal elements concave upwards. The rolls are shown with their axes separated more than ordinarily, to show the shape of the rolls. The shafts fit into bearings which have supporting and adjusting means, such as a bearing block, slides, and screw adjustments to preserve the rolls in the same positions longitudinally and adjust the transverse dis-

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tances between the axes of the rolls, keeping said axes parallel, to accommodate material of different thicknesses and to bend the metal to different degrees of longitudinal curvature, which depends on the setting of the rolls. The transverse curvature is determined by the shape of the rolls. The bearings and their supporting and adjusting means are not shown, being well understood in the art. Rolls similar to this are shown in U. S. Patents No. 125,691 to Price and No. 1,041,471 to Hoag and Thomas. The transverse elements will be concave upwards at the left side, and convex upwards at the right side. To roll sheets of different transverse sections then requires a set of rolls of different shapes for each shape of sheet. This method cannot produce sheets having different transverse sections along the same sheet.

Fig. 2 shows how 5 rolls, a curved roll 10 in the center and top position, and two approximately parallel pairs of cylindrical rolls 11, one pair bearing on each end of 10, may be substituted for a set of rolls having the shapes shown for the left ends of the rolls in Fig. 1. The top roll 10 has a radius of curvature as small as required to produce the sheet of the greatest transverse curvature desired. The sheet will be bent both longitudinally and transversely with the curvature concave upwards. Such a sheet is produced by starting with the 4 bottom rolls 11 together and passing the sheet back and forth, moving the bottom rolls out a little at each pass until they reach the outside of the top roll, as shown in Figs. 10 or 11, and then by shifting the sheet laterally at each pass, until the entire plate has attained the desired shape. If a curvature less than that of roll 10 be desired, rolls 11 are adjusted accordingly, as shown in Figs. 8 and 9. Fig. 8 shows the start of the rolling, with only the center part of the plate curved, and Fig. 9 shows the finish, with the plate all curved. If greater curvature be desired, the plate can be curved as in Fig. 9, and the rolls then adjusted to produce the greater curvature. Fig. 10 shows this completed. If desired, and if the flexibility of the material and the strength of the machine and driving power permit, the final curvature can be produced at once from the straight plate, instead of going through intermediate stages. The longitudinal curvature can be produced initially, or in as many stages as desired, and in combination with the transverse bending steps as desired. In this case, as also in Figs. 3, 5, and 6, the supports for the rolls take a form to be presently disclosed.

Fig. 3 shows how 4 rolls, a pair of curved and approximately parallel rolls 12 in the outside and

bottom positions, and a pair of cylindrical center or inside rolls 13, one bearing on one end of each of rolls 12, the other roll 13 bearing on the other ends of rolls 12, may be substituted for a set of rolls having the shapes shown for the right ends of the rolls in Fig. 1. Again, the maximum transverse curvature which can be rolled into a sheet is determined by the curvature of the curved rolls 12. The sheet will be bent longitudinally concave upwards and transversely convex upwards. The sheet is manipulated for as many passes as desired or necessary, as before, and rolls 13 moved toward each other or away from each other, and the angles of their axes with the axes of the cylinders 12 varied, as desired. The adjustments may be performed manually, and the plate manipulated with a pair of tongs. In this type of work the correct shaping of the plate depends to a great degree on the skill of the operator.

Fig. 4 shows rolls 4, 5, and 6 which will roll a sheet similar to those of Fig. 1, but in the opposite sense. The transverse elements will be concave upwards at the left side, and convex upwards at the right side, as before, but this time the longitudinal elements will be convex upwards. Fig. 5 shows how 4 rolls, a pair of curved and approximately parallel rolls 9 occupying the outside and top positions, and a pair of cylindrical center or inside rolls 10, one bearing on one end of each of rolls 9, and the other roll 10 bearing on the other ends of rolls 9, can be arranged to perform functions similar to the left end of Fig. 4. The sheet will be bent longitudinally convex upwards and transversely concave upwards.

Fig. 6 shows how 5 rolls, a curved roll 7 in the center and bottom position, and two approximately parallel pairs of cylindrical rolls 8, one pair bearing on each end of 7, can be arranged to perform functions similar to the right end of Fig. 4. The sheet will be bent longitudinally convex upwards and transversely convex upwards. It will be noted that Figs. 3 and 5, and also Figs. 2 and 6 have the same rolls in similar relations except that they are inverted. The provision of the inverted rolls is not essential, but it obviates having to turn the work over at times. Suppose a sheet were to require Fig. 2 to work on one end and Fig. 6 to work on the other. It could be transferred from one set of rolls to the other without turning, but if only Fig. 2 were available, it would have to be turned over.

In Fig. 7 rolls 14, 15, 16 and 19 can be combined as rolls 10 and 11 in Fig. 2, all the rolls in Fig. 7 being adjustable in position and angle, as explained hereinafter. Rolls 15, 16, 19, and 17 can be combined as rolls 12 and 13 in Fig. 3. Rolls 15, 20, 18, and 19 can be combined as rolls 9 and 10 in Fig. 5. Rolls 15, 20, 17, 21, and 19 can be combined as rolls 7 and 8 in Fig. 6. Thus a set of 8 rolls as in Fig. 7 can perform the same types of bending as Figs. 1 and 4, that is, without turning the work over. If the work is allowed to be turned over, 6 rolls, 14, 15, 16, 17, 18, and 19, can be combined to perform all the functions of Fig. 1, though not all simultaneously, as the plate must be rolled element by element; first the transverse elements which are concave upwards, then the rolls are rearranged, and the transverse elements which are concave downwards are rolled. The equivalence of Figs. 2 and 6, and Figs. 3 and 5 shows that such an arrangement of 6 rolls as just described will roll plates of all possible curvatures. If a plate cannot be rolled with

the desired curves on the upper side, it can be rolled with them on the bottom side, and then merely has to be turned over when finished to present the desired curves. Such a machine is simpler than one having all 8 rolls, and is illustrated in detail in Figs. 12 and 13.

However, to provide a machine of even greater flexibility, two additional rolls, 20 and 21, may be provided.

Figs. 12 and 13 are front elevation and end section, respectively, of a stand of 6 rolls. The rolls are mounted in thrust bearings 23, which are held in yokes 24 which in turn are restrained in two directions in the case of the center bearings, and in three directions in the case of the outside bearings, by length adjusting units 34. Each length adjusting unit 34 comprises a frame 27 housing internally threaded worm gear 26, worm 100, screw 25, and supporting motor 40 and gear case 65 which houses reduction spur gears which operate to convey the torque of motor 40 to the worm. Each unit 34 is supported at one end from main frame 64 by rod 41, the latter having ball joint 28 at the end, 28 being retained by frame 64, except in the case of horizontal rods 41, when 28 is retained by posts 63, and the other end of 34, comprising screw 25, being supported by screw 25 from yoke 24 or 29, or eye 75, as the case may be. The outside yokes 24 are also supported by yokes 29, the other yokes 24 are also supported by eyes 75 which are held in place by collars 76. Universal joints 30, splined sleeves 68, and drive shafts 69 convey the driving torque from 6 main driving motors (not shown) to the rolls. There is sufficient clearance between the horizontal and vertical screws 25 where they join to permit adjusting these parts to the necessary angles.

Plate 31 is held in clamps 32, connected to screws 25 by double swivel joints 33. Screws 25 are part of length adjusting units such as are used to support the rolls, but in this case are fastened to carriages 35. The swivels and length adjusting units are to insure that clamps 32 will be at the correct position and angle for the edges of plate 31. The carriages 35 may be as long as the plate, or shorter than it. Carriage 35 rides on rack rail 38, guided by roller 37 and pinion 36, and driven by the latter, which in turn is driven by motor 39 through appropriate bevel gearing 67. One or both carriages 35 may be motor driven. In the machine illustrated, only the one on the right is provided with a driving motor. Rails 38 are supported by posts 66. The lateral guide screws 25 may be attached farther away from the rolls if necessary to provide greater clearances for the work. Using a larger diameter for the rolls also provides greater clearances.

For thin sheets of simple shape a simple arrangement such as shown in Fig. 11 can be used. Top roll 45 is mounted on fixed bearings supported by arms 73 and frame 72. Bottom rolls 44 are mounted in yokes 42, which are pivoted to the tops of screws 46 by yokes 74. Yokes 42 are held in a centered position by springs 43 except when deflected by the work 71. Screws 46 are moved toward or away from each other and raised or lowered by suitable means. The rolls are positioned until the work is bent as desired. The work is guided by tongs 22, which may move freely with the work, or be held back to cause the latter to slide circularly through the rolls and thus produce additional curvature. The equivalent of such operation is produced in Figs. 12 and 13 by clamping the work on only one side

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and by leaving the motor open and the carriage freely rolling, by locking the motor mechanically or electrically, or by driving the motor so that the carriage progresses at a lesser rate than the work. If the carriage is locked it can be omitted, and clamp 32 attached to a fixed swivel by a rod of suitable radius. A plurality of clamps distributed along the work may be employed, all connected by links to the same fixed swivel.

Fig. 14 is a front elevation, and Fig. 15 an end section of a form having larger rolls, greater clearances for the work, and stronger construction. Roll 48 is mounted in a fixed yoke 82. Rolls 47 and 49 are mounted in yokes 83 mounted on screws 50 guided by and fastened to crossheads 53 sliding in frames 52. Screws 50 are adjusted by internally threaded worm wheels 51. Motors 84 are mounted on frames 52 as are also gear housings 85, and drive worm wheels 51 through reduction spur gears and worms 62. Frames 52 slide on curved rails 54, being retained thereto by T heads 86. Rails 54 may be made straight, and have their angle with the horizontal made adjustable, but this form is not shown. Rails 54 are mounted on base plates 55 which slide on dovetails 56 in main frame 99 and are adjusted by screw 57, which is supported by bearings 87 and 95 and is driven by motor 98 through gears 93, 94, 96, and 97. The positions of frames 52 on rails 54 is controlled by cables or chains 58, which are supported on wheels 92 and 91, the latter being attached to worm gears 90, which are driven by motors 88 through worms 89. Rolls 47 and 49 are driven by worms 60, and worm wheels 59, through shafts 61, universal joints 77, splined sleeves 78, shafts 79, and motors 80, which are supported by hangers 81.

Machines such as shown in Figs. 12 and 14 cannot be controlled by one operator. In Fig. 12, for instance, there are 39 separate controls, requiring 3 or 4 operators. Fig. 14 has 13 controls. For this reason it may be advisable to provide automatic controls, such as those of the card or plate pattern type, where the number of identical pieces to be made is enough to justify it.

Any of the methods described above not only form a plate to an irregular cross section without the necessity of hand forming, or having a set of rolls or dies for each shape desired, but also form plates in which the cross sections vary along the length of the plate. The plates may be cut to size before rolling, or may be rolled first from stock slightly larger than necessary, and then have their edges trimmed off.

I claim:

1. A plate forming machine comprising, in combination, a convex roll, a frame, means to rotatably mount said roll in said frame, four auxiliary cylindrical rolls rotatably mounted on the same side of said first roll, said auxiliary rolls being arranged in pairs, the rolls of each pair being approximately parallel to each other, and each pair approximately parallel to the axis of said first roll as projected onto a first plane approximately equidistant from the four auxiliary rolls, and the rolls of each pair being at an angle with the axis of said first roll as projected onto a second plane perpendicular to the first plane, one pair being adapted to coact with one end of said first roll, the other pair being adapted to coact with the other end of said first roll, adjustable supporting means to independently support each end of each auxiliary roll, said adjustable supporting means being adapted to vary the distance between and the degree of parallelism between

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the auxiliary rolls of each pair, and being also adapted to vary the distance and angle between the axis of each auxiliary roll and the axis of said first roll, and means to drive said first and auxiliary rolls.

2. Apparatus in accordance with claim 1 further characterized in that means are provided to guide and restrain laterally the plate being formed, and to move said plate longitudinally.

3. A machine for forming compound curved plates comprising, in combination, a convex roll, a frame, means to rotatably mount said roll in said frame, four auxiliary cylindrical rolls mounted on the same side of said first roll, said auxiliary rolls being arranged in pairs, the rolls of each pair being approximately parallel to each other, and each pair approximately parallel to the axis of said first roll as projected onto a first plane approximately equidistant from the four auxiliary rolls, and the rolls of each pair being at an angle with the axis of said first roll as projected onto a second plane perpendicular to the first plane, one pair being adapted to coact with one end of said first roll, the other pair being adapted to coact with the other end of said first roll, adjustable supporting means to independently support each end of each auxiliary roll, said adjustable supporting means being adapted to vary the distance between and the degree of parallelism between the auxiliary rolls of each pair, and being also adjustable in such manner that each auxiliary roll may be made tangent to the first roll at any point between its center and the end toward which the auxiliary roll is mounted, whereby the plate being formed may be bent laterally to any degree up to that curvature which fits said first roll, and whereby said plate may be bent longitudinally to a degree determined chiefly by the distance between said auxiliary rolls of each pair, and means to drive said convex and auxiliary rolls.

4. Apparatus in accordance with claim 3 further characterized in that means are provided to guide and restrain laterally the plate being formed, and to move said plate longitudinally.

5. A plate forming machine comprising, in combination, two convex rolls, said rolls being adjacent and having their axes approximately parallel, a frame, means to rotatably mount said rolls in said frame, two auxiliary cylindrical rolls rotatably mounted on the same side of said first two rolls in the same space between said first two rolls, said auxiliary rolls being approximately in line and approximately parallel to the axes of said first two rolls as projected onto the plane of the axes of the said first two rolls, and at an angle to the axes of said first two rolls as projected on a second plane perpendicular to the first plane, one auxiliary roll being adapted to coact with one end of each of said first two rolls, the other auxiliary roll being adapted to coact with the other ends of said first two rolls, adjustable supporting means to independently support each end of each auxiliary roll, said adjustable supporting means being adapted to vary the distance between each auxiliary roll and said first plane and also adapted to vary the angle between the axis of each auxiliary roll and said first plane, and means to drive all four rolls.

6. Apparatus in accordance with claim 5, further characterized in that means are provided to guide and restrain laterally the plate being formed, and to move said plate longitudinally.

7. A machine for forming compound curved plates comprising, in combination, two convex

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rolls, said rolls being adjacent and having their axes approximately parallel, a frame, means to rotatably mount said rolls in said frame, two auxiliary cylindrical rolls rotatably mounted on the same side of said first two rolls in the same space between said first two rolls, said auxiliary rolls being approximately in line and approximately parallel to the axes of said first two rolls as projected onto the plane of the axes of said first two rolls, and at an angle to the axes of said first two rolls as projected on a second plane perpendicular to the first plane, one auxiliary roll being adapted to coact with one end of each of said first two rolls, the other auxiliary roll being adapted to coact with the other ends of said first two rolls, adjustable supporting means to independently support each end of each auxiliary roll, said adjustable supporting means being adapted to vary the distance between each auxiliary roll and said first plane, and being also adjustable in such manner that each auxiliary roll may be made tangent to the first two rolls at any point between their center and the end toward which the auxiliary roll is mounted, whereby the plate being formed may be bent laterally to any degree up to that curvature which fits said first two rolls, and whereby said plate may be bent longitudinally to a degree chiefly determined by the distance between said auxiliary rolls and said first plane, and means to drive said convex and auxiliary rolls.

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8. Apparatus in accordance with claim 7 further characterized in that means are provided to guide and restrain laterally the plate being formed, and to move said plate longitudinally.

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