Oct. 20, 1931. E. B. CARNS 1,828,489

METHOD AND MACHINE FOR FORMING SHEETS

Filed April 22, 1929 2 Sheets-Sheet 1

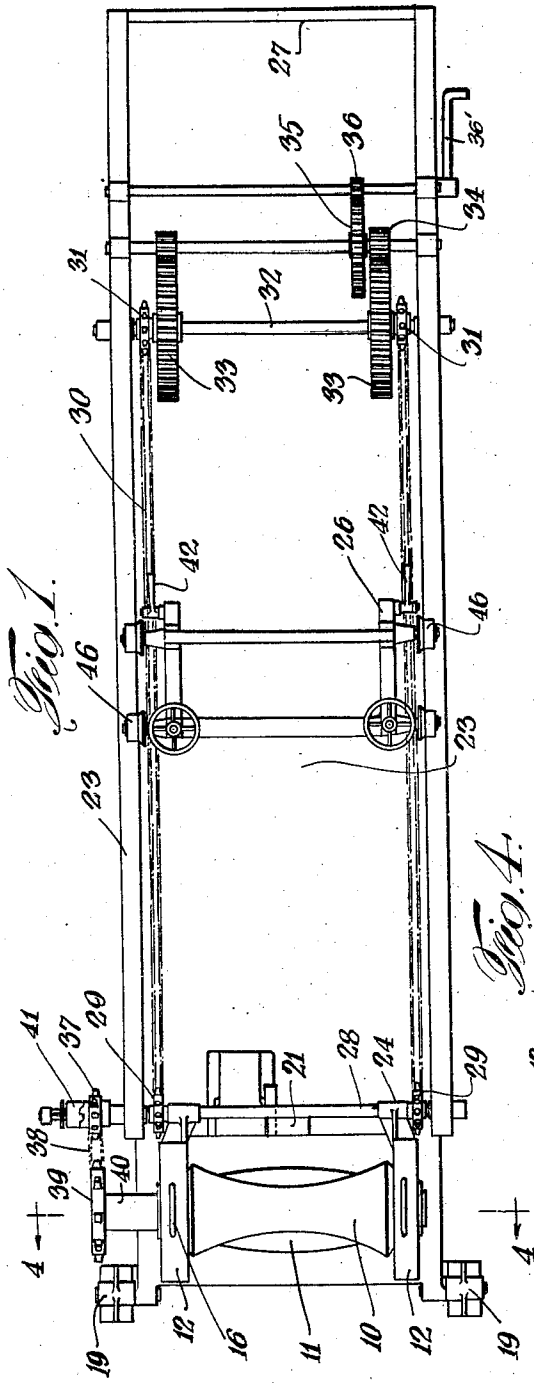


Fig. 1.

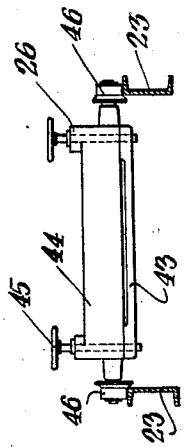


Fig. 3.

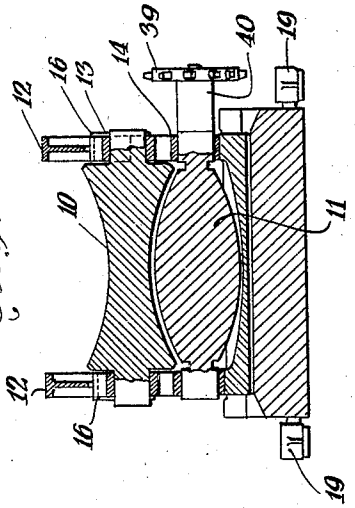


Fig. 4.

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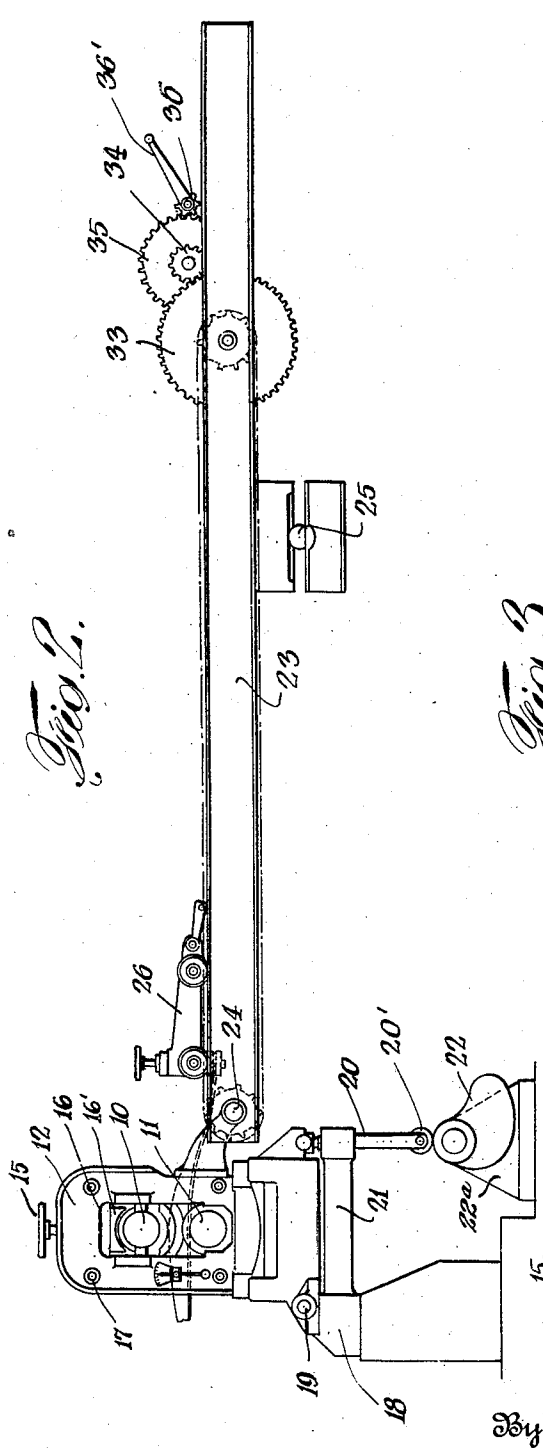


Fig. 2.

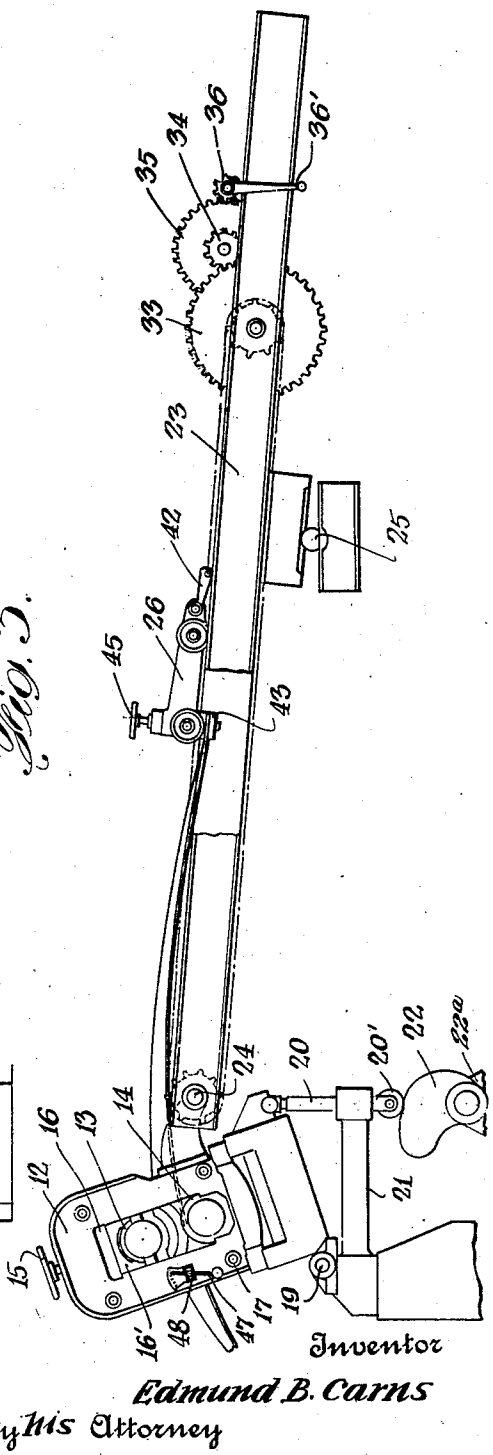


Fig. 3.

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UNITED STATES PATENT OFFICE

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METHOD AND MACHINE FOR FORMING SHEETS

Application filed April 22, 1929. Serial No. 357,036.

My invention relates to improvements in the art of shaping sheets with compound curves, that is, sheets which are curved in both longitudinal and transverse dimensions, the arcs of both curves intersecting in all points.

My invention includes the method of shaping and also the means for shaping such sheets.

An object of my invention is to produce such sheets having compound curvature and to produce them in a rapid and economical manner. Another object is to produce sheets which are not distorted to such an extent that their strength is decreased but which are exceedingly stiff and rigid, thus giving the sheets advantageous structural qualities. A further object is to produce sheets which are under inherent tension.

Heretofore sheets have been shaped by pressing in moulds or dies or by passing through rolls while at the same time bending the sheet. In using these methods it has been exceedingly difficult to produce a sheet which has compound curvature and which has the properties of great rigidity and strength which my method brings out in the sheet. Further the sheets produced by former methods have been unevenly strained and are often weakened by distortion of the metal beyond its elastic limit.

In my invention I obtain a transverse curvature of a metal sheet by means of concave and convex rollers which are recessed one in the other. The longitudinal curvature of the metal sheet is obtained at the same time and at the same point at which the transverse curvature is given to the sheet. This is done by forcing these rollers to pull against the metal sheet as it is being pulled through the rollers. This motion of the rollers in giving the sheet the longitudinal curve is a peculiar one and it can be easily understood by the description given later concerning the operation of my apparatus. In my method the vectors of the stress diagram would not be in the same horizontal plane and would not merely have opposite directions as would be the case if the rolls were holding back the sheet and the direction of pull was in the center line of the pull, but rather as nearly as can be represented the vectors would be in different planes and might have opposite directions. The vectors representing the action of the rollers on the sheet would have an upward and backward direction and the vectors representing the action of the pulling mechanism would have a downward and forward direction. In this manner, owing to the difference in circumferential distances taken at the edges of the transversely curved sheet and at the center line, the metal along the center line of the sheet is stretched a greater amount than the metal along the edges of the sheet which results in a curvature along the longitudinal dimension of the sheet. The result is that when the sheet is taken from the rolls it is found to be very rigid and stiff with all of the elements in tension and having both longitudinal and transverse curves, the arcs of which intersect at all points.

In my copending application Serial No. 174,454 I have also described a method for making sheets with compound curvature. However, in that application the method used is one in which all of the factors in rolling the sheet are constant inasmuch as the rolls were moved on a rack fixed in position. My present application is distinguishable from application Serial No. 174,454, filed March 11, 1927, in that the factor which imparts to the sheet the longitudinal curvature is a variable factor, for by increasing the force with which the transverse bending rollers bear against the metal sheet being pulled through them, the stretching of the metal is increased along the center line of the sheet and in gradually diminishing amounts outwards towards the edge. In this way it can be seen that definite pressure on a metal sheet will give definite curvature to the sheet granting, of course, that the elasticity of the metal sheet is constant. It can thus be seen that a variety of compound curvature sheets may be made by only changing the pressure with which the rolls bear and hold back against the sheet when it is fastened through them, whereas on my copending application No. 174,454 it is necessary in order to change

the longitudinal curvature to change the curve of the rack which directs the rollers.

My invention is of especial importance in the manufacture of sheets in an economical and rapid fashion for use in the manufacture of aircraft, but it is obvious, of course, that the invention can be applied to making sheets for any purpose where a compound curved sheet is desirable, such as boat construction. From the following description and drawings I have disclosed a simple method for carrying out my invention. Reference is to be had to the accompanying drawings forming a part of the specification in which like reference characters denote like parts and in which

Figure 1 is a plan view of my apparatus;

Figure 2 is a side elevation of the same;

Figure 3 is a side elevation showing the movement of certain parts;

Figure 4 is a cross-section taken at 4—4 of Figure 1; and

Figure 5 is a detail of the carriage and its connections.

My device consists of the concave roller 10 and the convex roller 11 which are positioned so that they are recessed one in the other. These rollers are held in place by the frames 12 and the bearings 13 and 14 placed in them. The pressure with which the upper roll 10 bears against a sheet passing between the rolls may be adjusted by the screws 15 which control the pressure on the springs 16, which bear against the journal bearings 16′. The frames are held rigid by means of the braces 17. The rolls and frames are supported on one side by the base 18 and on the other side by the rod 20. The frames 12 are pivotally connected with the base 18 by means of the shaft and journals 19. The rod 20 is held in position, but allowed an upward and downward movement by the guide and brace 21. Movement of the rod 20 is caused by the cam 22 which is held in position by the journal bearing 22*a*. This cam may be driven by any external force or may be connected to the same gear train which operates the rollers. The longitudinal frame or track 23 is connected by the journal and shaft 24 to the frames 12. This is a pivot connection and, as can be seen from Figures 2 and 3, the frame 23 rests on the roller bearing 25 which allows easy rocking movement. The carriage 26 operates on the track 23. 27 is a bracing element at the ends of the longitudinal frame. 28 designates a shaft which may also act as a part of the connection at 24 between the frames 12 and the track 23. Fixed to this shaft are the sprockets 29 which carry the chain 30 which is connected with the sprockets 31. The sprockets 31 are connected with the shaft 32 and are driven by means of the gear train 33, 34, 35 and 36. 36 is the driving gear and may be driven by any of the usual methods. Shaft 28 carries also the sprocket 37 which is connected by means of a chain 38 to the sprocket 39 which is on the shaft 40 of the lower roller 11. The gear ratio between the sprockets 37 and 39 may be adjusted so that the lower roller 11 will be driven at any desired speed. This speed may be either the same as or greater or less than the speed at which the sheet is pulled between the rollers. A clutch 41 operates to throw the sprocket 37 out of operation, thus eliminating the drive on the roller 11. This clutch may also be designed in such a manner that the sprocket 37 and thus the roller 11 may be given a greater speed than that ordinarily imparted to it by the shaft 28.

The carriage 26 is connected to the chains 30 by the links 42. The clamp by which the metal sheet is held by the carriage consists of a lower portion 43 and an upper section 44, Figure 5. These sections may be opened or clamped together by means of screws 45. The carriage is supported on the track by the wheels 46 and adapted to travel along the track when the chains 30 are moved.

More particularly describing the operation of my device, a sheet of metal to be formed to compound curvature is passed through the rolls 10 and 11 and attached to the carriage 26 as shown in Figure 2. It is advisable to make a small flange on each of the longitudinal edges of the metal by bending down the metal. It had been found that a better product is obtained in this way inasmuch as the flange edges which are little effected in passing through the rolls act as drawbars on the sheet. The gear train at 33, 34 and 35 is actuated by means of the driving gear 36. This movement is imparted to the chains 30 which in turn are connected to the carriage 26 and cause a movement of the carriage along the track 23 away from the rolls 10 and 11. At the same time that the carriage moves along the track the rollers are gradually raised pivoting about the point 19 as shown in Figure 3. This upward movement of the rollers is caused by the rotation of the cam 22 which operates on the rod 20 connected to the roller frames. The velocity of the upward movement of the rolls is dependent upon the curve of the cam and may not be constant. The velocity of the carriage remaining constant, the distortion of position of the molecules of the metal sheet is dependent upon the force with which the rolls bear against the sheet in their upward arc movement. The velocity of the carriage remaining constant this force would be dependent upon the velocity of the upward movement of the rolls 10 and 11 and frames 12. It can be seen, therefore, that the curvature imparted to the sheet is dependent upon the curvature of the cam. The cam 22 may be designed, therefore, to cause the desired curve to be imparted to the metal sheet.

It is possible to have a cam which causes

such movement of the rolls as to give a spherical shape to the metal or one which will give a parabolic curve to the sheet. It is also possible, of course, to have a cam which will impart one type of curve to the first part of the sheet and another type of curve to the latter part of the sheet, the two curves merging together. The cam 22 may be driven by the gear train 33 to 36 or it may be driven by a separate means. The cam may be arranged so that others with different curves may be easily substituted thus enabling the apparatus to form a variety of compound curved sheets.

The carriage 26 moves along the track 23 until it reaches the shaft 32 or until a sheet has been pulled through the rollers. The clamping screws 45 are then loosened and the sheet removed. The rollers are then lowered and the carriage returned to position near the rolls and the apparatus is ready for another operation.

A desired amount of pressure may be given to the sheet by adjustment of the screws 15 bearing on the roll 10. It is also possible to bring in several other different factors into the rolling of the sheet such as maintaining the peripheral speed of the rolls at a slightly slower speed than that of the carriage 26. The usual procedure, however, is to allow the rolls to turn merely by the friction of the sheet being pulled between them.

The angle of tilt of the rolls may be judged by indicator 47 which pivots at point 48 on the scale. I have shown the gear train 33, 34 and 35 as operated by the gear 36 which is driven by the crank 36′. This, however, has only been done to disclose on what shaft the driving force is applied and any conventional method of driving gears may be used. I have also shown the cam 22 as operating against the roller 20′ attached to the rod 20. The shaft of the cam is held in the journal bearing 22′. This is, of course, only a conventional arrangement and has been disclosed in this manner for the sake of simplicity.

There are many variations which may be made in this apparatus, without departing from the essence of the invention. For instance the rolls and frame may be given a downward movement by means of a cam arrangement. This may be done with the rolls in the relation in which they are shown in the drawings; that is, with the lower roll convex or the position of the rolls may be inverted. For this reason I do not wish to be limited by the specification and drawings but only by the appended claims and the prior art.

What I claim is:

1. The method of forming compound curved sheets comprising pulling a sheet through means for imparting a transverse curvature to said sheet and simultaneously causing said means to bear against said sheet by changing the direction of pull.

2. The method of forming compound curved sheets comprising pulling a sheet through means for imparting a transverse curvature to said sheet and simultaneously moving said means in a direction across the direction of pull.

3. The method of forming compound curved sheets comprising pulling a sheet through rolls for imparting a transverse curvature to said sheet and simultaneously causing said rolls to bear against said sheet by changing the direction of pull.

4. The method of forming compound curved sheets comprising pulling a sheet through recessed rolls and simultaneously moving the rolls in a direction transverse to the direction of pull.

5. The method of forming compound curved sheets comprising pulling a sheet through concave and convex recessed rollers, and simultaneously moving the rollers bodily in an upward direction.

6. An apparatus for bending sheets comprising a transverse bending means, a sheet pulling means, and means for moving bodily the transverse bending means.

7. An apparatus for bending sheets comprising recessed concave and convex rollers, a sheet pulling means, and means for moving bodily said rollers while maintaining their position with respect to each other.

8. An apparatus for bending sheets comprising recessed concave and convex rollers, a frame holding said rollers, a sheet pulling means, and means for moving said frame.

9. An apparatus for bending sheets comprising recessed concave and convex rollers, a frame holding said rollers, a track pivotally connected to said frame, a sheet pulling means adapted to ride on said track, and means for moving said frame.

10. An apparatus for bending sheets comprising recessed concave and convex rollers, a frame holding said rollers, a track pivotally connected to said frame, a sheet pulling means adapted to ride on said track, and a cam bearing on said frame adapted to move the same.

11. An apparatus for bending sheets comprising recessed concave and convex rollers, a frame holding said rollers, a base pivotally connected to said frame, a track pivotally connected to said frame, a sheet pulling means riding on said track, and a means for pivoting said frame.

12. An apparatus for bending sheets comprising recessed concave and convex rollers, a frame holding said rollers, a base pivotally connected to said frame, a track pivotally connected to said frame, a sheet pulling means riding on said track, and a cam bearing against said frame.

13. An apparatus for bending sheets comprising recessed concave and convex rollers, a frame holding said rollers, a base pivotally connected to said frame, a track pivotally

connected to said frame, a carriage riding on said track, and means for pivoting said frame.

14. An apparatus for bending sheets comprising recessed concave and convex rollers, a frame holding said rollers, a base pivotally connected to said frame, a carriage riding on said frame, said carriage having a gripping means, and means for pivoting said frame.

In testimony whereof, I have signed my name to this specification this 18th day of April, 1929.

EDMUND B. CARNS.