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APPARATUS, INCLUDING SUCCESSIVE SETS OF BENDING ROLLS FOR FORMING PLATES INTO TUBES

Filed Nov. 16, 1946 2 Sheets-Sheet 1

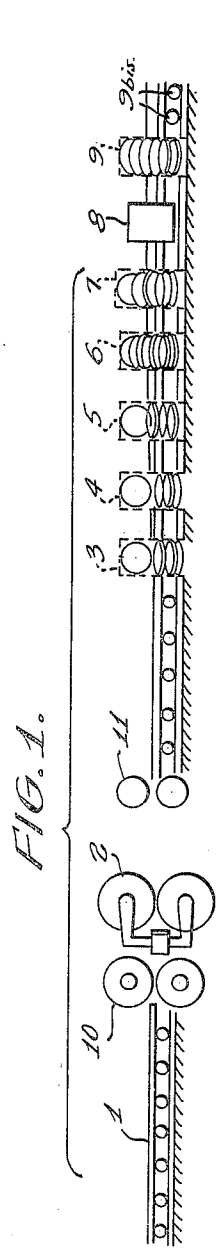


FIG. 1.

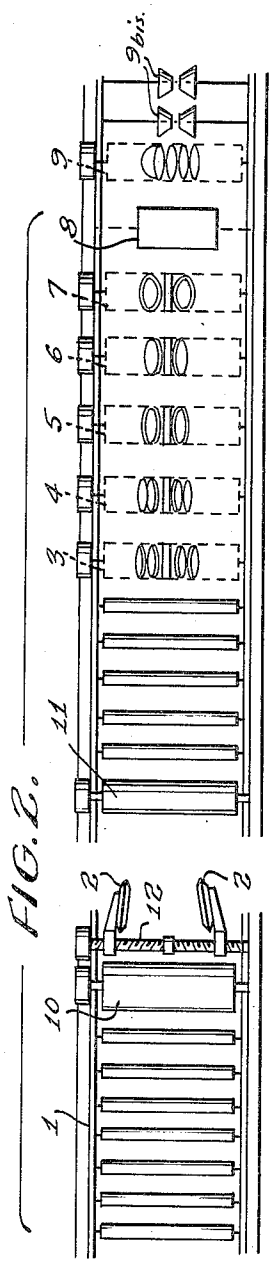


FIG. 2.

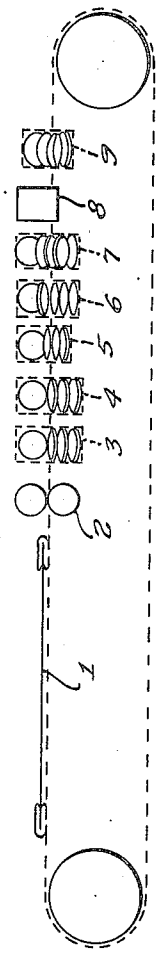


FIG. 3.

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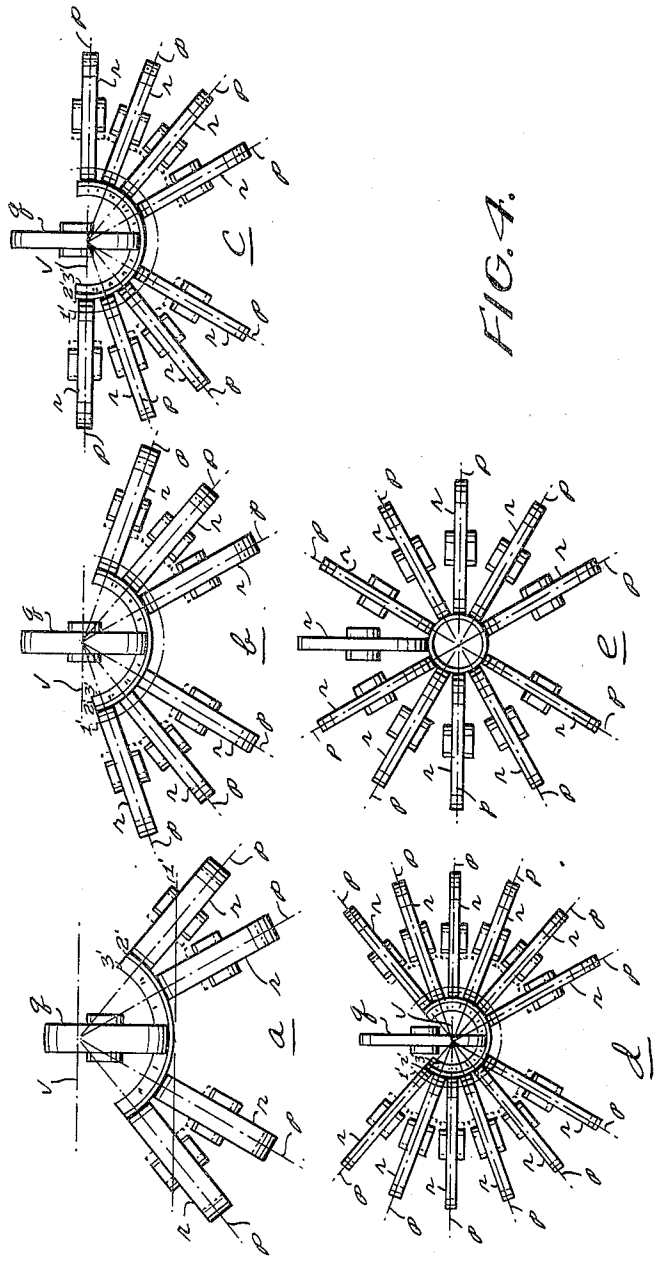


FIG. 4.

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APPARATUS, INCLUDING SUCCESSIVE SETS OF BENDING ROLLS FOR FORMING PLATES INTO TUBES

Ugo Radaelli and Ezio Bertoli, Milan, Italy

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3 Claims. (Cl. 153—32)

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Our present invention relates to machines for producing tubes.

It is known that tube bending machines of conventional type are composed mainly of two or more pairs of cooperating rollers which are shaped so that the plate passing through them takes up the shape of the peripheral faces of the rollers. This process is continued until the plates are bent to a degree that their edges abut against each other or overlap.

Tube bending machines of the above type have considerable disadvantages, the main disadvantages being the following:

1. The bending of the plate along its edges is usually irregular and inaccurate; this is due to the non-uniform thickness of the plate and to differences in the distance between the bending rollers.

2. Sliding of the plate to be bent relative to the bending rollers causes wear on the rollers and is due to the differences in peripheral velocity of the rollers as usual in machines of conventional type.

3. A great inconvenience of machines of conventional type is that it is impossible to produce with such machines tubes having a conical shape.

With a machine of the type proposed by us, the above listed disadvantages are avoided by bending the plates during production of the tube, not by the action of two cooperating rollers which compress the plate over its entire surface, but by the action of internal and external rollers which act and react at points spaced from each other. During the bending process carried out by a machine in accordance with our present invention, the plate assumes an arcuate shape which is due to the elasticity of the plate and does not follow exactly the surface of the bending rollers.

From above it is evident that by using a great plurality of bending rollers acting upon spaced points of the plate to be bent, it is possible to obtain a great variety of differently shaped tubes; actually with a machine of the type proposed by us it is possible, without the necessity of use of differently shaped bending rollers, to obtain a substantially greater variety of shapes and cross sections of tubes than with bending systems used heretofore.

From above it also follows that with an arrangement of the type proposed by us it is possible to produce with one set of bending rollers, and without the need of different exchangeable sets of rollers, simply by the provision of adequate adjusting means, the following types of tubes:

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a. Cylindrical tubes, e. g. tubes with parallel generating lines of whatever cross section, size and wall thickness;

b. Conical tubes, e. g. tubes with generating lines which are converging to a definite point, e. g. vertex; such conical tubes might have any desired apex, angle, shape, size and wall thickness.

The novel features which we consider as characteristic for our invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a side view of a machine in accordance with our present invention equipped with feeding rollers;

Fig. 2 is a top view of the machine shown in Fig. 1;

Fig. 3 is a schematic side view of a bending machine similar to the one shown in Figs. 1 and 2, equipped with a feeding conveyor chain; and

Fig. 4 is a plurality of schematic cross sections through the bending machine shown in Figs. 1 and 2.

Our new machine is composed of a plate feeding device consisting in the embodiment shown in Figs. 1 and 2 of a plurality of feeding rollers, a device for cutting the plate fed by the feeding device 1 in longitudinal direction, a plurality of sets of bending rollers 3, 4, 5, 6 and 7, an automatic welding device 8, a set of straightening rollers 9, and a plurality of tube delivering rollers 9*bis*.

The feeding of the plate can be performed either by means of the feeding rollers shown in Figs. 1 and 2, or by means of the conveyor chain shown in Fig. 3.

In the machine shown in Figs. 1 and 2, the plate is guided not only by the feeding device 1, but also in addition thereto by the cooperating pairs of feeding rollers 10 and 11, and by a plurality of other rollers which are only partly shown in the drawings. Of course, the bending rollers 3, 4, 5, 6, and 7, as well as the straightening rollers 9 serve also for guiding and transporting the plate during the bending process.

The plate cutting device mentioned above includes two pairs of cutting discs 2. These discs are mounted on brackets which in turn engage, as clearly shown in Fig. 2, a screw threaded rod member 12 provided with screw portions having an opposite pitch.

In the event it is desirable to produce cylindrical tubes, the two pairs of cutting discs 2 are positioned parallel to each other and are kept during operation of the machine stationary and at a constant distance from each other.

In the event it is desired to produce conical tubes, the two pairs of cutting discs 2 are arranged inclined at an angle which is equal to the desired apex angle of the cone. Furthermore, during production of conical tubes it is necessary to move the cutting discs during operation of the machine towards or away from each other by means of the screw threaded rod member 12 at a uniform speed which is in a predetermined proportion to the transportation of the plate.

As mentioned above, for moving the cutting discs 2, we might use the screw threaded rod member 12; however, it is of course, also possible to obtain the necessary sliding motion of the cutting discs 2 by other types of well-known motion transmitting devices.

After the plate is cut off along its edges to the desired width, the plate is fed by the transporting rollers 11 to the sets of bending rollers 3, 4, 5, 6 and 7. Each of these sets of bending rollers is composed of a plurality of external bending rollers *r* having cylindrical or outwardly curved peripheral faces. These rollers *r* might have either a cylindrical peripheral surface or their peripheral surface might be curved, e. g. have a convex or concave shape. The rollers *r* of each set of bending rollers 3, 4, 5, 6 and 7 are arranged so that their axes of rotation are located in a plane which is normal to the direction of movement of the plate to be bent. Furthermore, these rollers are adjusted so that their peripheral faces contact the curve which the plate should follow during the bending operation.

The middle planes of the bending rollers, indicated in Fig. 4 with *p*, intersect each other in a straight line *v* which coincides with the axis of the bent tube, irrespective of the fact whether this tube has a cylindrical or conical shape.

In order to keep the plate during bending in proper position, we provide in addition to the external bending rollers *r*, the inner supporting rollers *q* which have an outwardly curved or cylindrical peripheral face. The curvature of this peripheral face is preferably such as to conform to the curvature of the plate after bending of the same.

In case the machine is intended for production of cylindrical tubes, the various bending rollers of the various roller sets do not change their position during operation of the machine. This means that during production of cylindrical rollers the axes of rotation of the bending rollers *r* and the supporting rollers *q* remain stationary.

Should the machine produce conical tubes, then the bending rollers have to be arranged so as to be adapted to move during operation of the machine automatically in direction towards or away from the axis *v* of the bent tube. Such movement of the bending rollers is accomplished by sliding of the same along their middle planes *p* towards or away from the axis *v*.

During production of cylindrical tubes, the consecutive sets of bending rollers are adjusted so that the plate is bent by each consecutive set of bending rollers more and more until it assumes a tubular shape. This fact is clearly shown in Fig. 4 where the cross section 4*a* shows the first set of bending rollers, e. g. the bending roller sets 3 only slightly bending the plate. The consecutive sets of bending rollers indicated in Fig. 4 by the letters *b*, *c* and *d* are arranged so as to increase the curvature of the plate until the same forms an entirely closed tube. During such bending the radius of the bent plate is gradually reduced until the two plate edges abut against or overlap each other.

In this position the edges are welded to each other by means of the welding device 8 shown in Figs. 1 to 3. Any desired type of welding device can be used for our purposes. Thus, it is possible to carry out the welding by electric resistance welding methods, by roller welding, arc welding or similar welding means.

After welding, the tube passes between the straightening rollers of the roller set 9 which are disposed as indicated by *e* in Fig. 4, forcing the tube to take up the required final shape. The thus produced tube is delivered by the transporting rollers 9*bis*, wherever required.

During production of conical tubes, all rollers of the various bending and straightening roller sets are moved towards or away from each other during the transportation of the plate to be bent. The direction of movement of the rollers depends upon the shape of the conical tube to be produced; if the wider end of the conical tube is produced first, then the rollers have to move during operation of the machine towards each other; on the other hand if the narrower end of the conical tube is produced first, then the bending rollers have to move away from each other during operation of the machine.

In Fig. 4 we have indicated the various steps during production of a conical tube. The roller of the first set of bending rollers 3 are at the beginning of the welding in such a position as to bend the first portion of the plate along the curve 3'. During operation of the machine the bending rollers *r* are moving away from each other in radial direction along the central planes *p* so as to bend the next portion of the plate along the curve 2' and the final portion along curve 1. Similarly, the other sets of bending rollers shown in Figs. 4*b*, 4*c* and 4*d* are adjusted so as to start bending of the tube along the curve 3' and to bend the consecutive portions of the tube along the curve 2' and the final portion along curve 1'. As clearly shown in Fig. 4, the radius of the curve decreases in the consecutive bending devices so that the final tube has a conical shape.

It should be noted that only some of the sets of bending rollers are provided with internal supporting rollers *q*. This is due to the fact that the advanced sets of bending rollers bend the plate to such a degree that no supporting roller can enter the same. It is evident that during production of a conical tube not only the bending rollers of the roller sets 3 to 7 have to move in a radial direction away from each other, but that also the welding means 8 and the straightening rollers 9 have to slide in radial direction away from the axis *v* of the tube.

The moment production of a conical tube is finished, the bending rollers quickly return into their initial position so as to be adapted to start bending of the next tube. This means that during bending of a conical tube the bending rollers travel from an initial position in which they bend the plate along curve 3' to a final position in which they bend the plate along curve 1'; therefore, at the end of the bending process the bending rollers have to return quickly from the bending position

indicated by reference numeral 1' into the bending position indicated by reference numeral 3'.

The rollers are moved as explained above during production of a conical tube away from and towards each other by means of well-known type, e. g. mechanical transmission means or electric, hydraulic, or pneumatic driving systems.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of bending machines, differing from the types described above.

While we have illustrated and described the invention as embodied in machines for producing tubes, we do not intend to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of our invention.

What we claim as new and desire to secure by Letters Patent is:

1. In a machine for producing tubes from plates, in combination a plurality of consecutive sets of bending rollers, each of said sets of bending rollers comprising a plurality of outer bending rollers arranged with their axes of rotation in a plane being normal to the direction of transportation of the plate during bending and with their central planes intersecting in one common straight line and the distance of the rollers of consecutive sets from said common straight line being varied along their central planes so that a gradually increasing bending effect is exerted on the plate, and at least one inner supporting roller adapted to support the plate during bending of the same by said outer bending rollers.

2. In a machine for producing tubes from plates, in combination a plurality of consecutive primary sets of bending rollers, each of said sets of bending rollers comprising a plurality of outer bending rollers arranged with their axes of rotation in a plane being normal to the direction of transportation of the plate during bending and with their central planes intersecting in one common straight line and the distance of the rollers of consecutive sets from said common straight line being varied along their central planes so that a gradually increasing bending effect is exerted on the plate, and at least one inner supporting roller adapted to support the plate during bending of the same by said outer bending rollers; and at least one secondary set of bending rollers comprising a plurality of outer bending rollers arranged along a closed curve with their axes of rotation in a plane being normal to the direction of transportation of the plate to be bent and with their central planes intersecting in one common straight line.

3. In a machine for producing tubes from plates, in combination, an initial and a final set of bending rollers, said initial and final set of bending rollers comprising a plurality of outer bending rollers arranged with their axes of rotation in a plane being normal to the direction of transportation of the plate during bending and with their central plane intersecting in one common straight line, and the distance of the rollers of consecutive sets from said common straight line being varied along their central planes so that a gradually increasing bending effect is exerted on the plate, and at least one inner supporting roller adapted to support the plate during bending of the same by said outer bending rollers, and said machine including a plurality of intermediate sets of bending rollers, each of said intermediate sets of bending rollers comprising at least one bending roller arranged with its axis of rotation in a plane being normal to the direction of transportation of the plate during bending; and at least one inner supporting roller adapted to support the plate during bending of the same by said latter outer bending roller..

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