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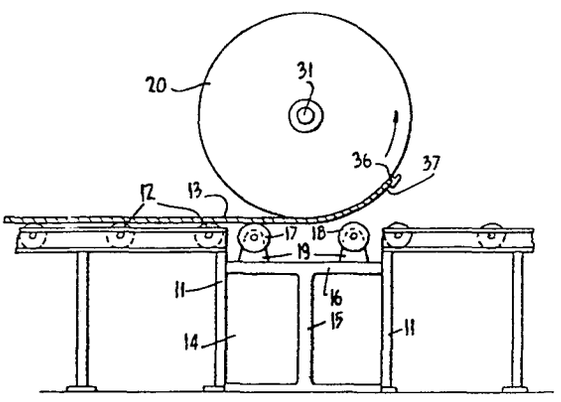
(54) **Method and apparatus for rolling plate.**

(57) Plate is rolled to form a substantially cylindrical article on apparatus comprising a support bed for the plate (13), a rotatable mandrel (20) with a gripper (36) for engaging an edge of the plate (13), and pressure rollers (17, 18) adjacent the mandrel (20) to engage said plate. An edge of the plate (13) is engaged by gripper (36) and the mandrel (20) is rotated to advance the plate (13) past said pressure rollers (17, 18) to curve the plate into a cylinder shape, the mandrel (20) and said pressure rollers (17, 18) are relatively movable to create a force on the advancing plate (13) at least during the final stages of rolling to prevent relative movement of the plate (13) and mandrel (20).

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# METHOD AND APPARATUS FOR ROLLING PLATE

This invention relates to plate rolling and more particularly, but not exclusively to the rolling of steel plate in substantially cylindrical form to produce a pipe.

In U.S. Patent Specification No. 3,879,994, there is proposed a method of plate rolling to form substantially cylindrical pipes simply by bending a plate about a rotatable mandrel. Steel plate is rolled by engaging an edge of the plate under a flange of a gripper rib extending axially on the cylindrical surface of a mandrel. The mandrel is turned to advance and curve the plate. Complete pipes are formed by curving plate about the mandrel through 180° then engaging the opposite edge of the plate with the mandrel and curving the remaining 180°.

One problem that has been experienced in the performance of this method is the maintenance of the plate in a dynamically stable relationship on the rotatable mandrel. Instability does occur during the final stages of curving of the plate through the full 360° unless adequate precautions are taken. This instability is brought about by the moments and forces which are exerted on the plate leading to a tendency for the almost completely circular plate to "spin out" from the mandrel gripper during the final stages of rolling.

The problem has to date been met by the use of frictional devices such as a slipper device similar to that described in the above-mentioned U.S. patent specification or the use of other braking devices imparting

friction to the external plate surface. Although the use of the slipper and other external braking devices have proved workable in practice, they are cumbersome and tend to damage the surface of the workplate.

It has been found that the same results can be achieved in a simple manner according to the invention in a method of rolling a plate to form a cylindrical article which comprises engaging an edge of the plate by gripper means mounted on a cylindrically formed mandrel mounted relative to pressure means adapted to engage said plate, turning the mandrel to advance and curve said plate, reversing the plate to engage its opposite edge to complete the curving process to form a cylinder, said mandrel and said pressure means being relatively movable such that the relationship between said plate and said pressure means can be controlled.

In one aspect of the invention there is provided a method of rolling a plate to form a substantially cylindrical article on apparatus comprising a support bed for the plate, a rotatable mandrel with a gripper means for engaging an edge of the plate, pressure means adjacent said mandrel adapted to engage said plate, including the steps of engaging an edge of the plate by said gripper means, turning the mandrel to advance said plate past said pressure means to curve said plate into a cylinder shape characterized in that said mandrel and said pressure means are relatively movable to create a force on said advancing plate at least during the final stages of rolling to prevent relative movement of the plate and said mandrel.

There is also provided according to the present invention an apparatus for carrying out the method described in the preceding paragraphs comprising a mandrel rotatable above a plate support bed, pressure roller means mounted adjacent said mandrel for contacting and supporting said plate, said mandrel and said pressure roller means being relatively movable during a plate rolling operation at least during the final stages of said operation to apply a force against said plate as it is advanced.

Thus contact is maintained between said plate and said pressure means at least during the final stages of rolling whereby additional lateral forces are generated and applied to said plate thereby preventing lateral movement and rotation of the plate relative to said mandrel. These lateral forces may or may not include frictional forces brought about for example by contact between the internal surface of the plate and said mandrel.

Conveniently the pressure means includes a pair of supporting rollers mounted on either side of centre below the mandrel and are relatively movable to the mandrel or vice versa. It is a simple matter to provide such relative movement such as by adjustable mechanical linkages or hydraulic cylinders thus eliminating additional mechanisms such as slippers or friction brakes engaging the external surface of the plate.

The invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a side elevational view of part of the apparatus in accordance with the invention showing an end view of the mandrel;

Figure 2 is an end elevational view of part of the apparatus showing a side view of the mandrel; and

Figures 3 to 5 are schematic views showing various stages of rolling according to the invention.

Referring firstly to Figures 1 and 2 there is shown therein plate rolling apparatus comprising a horizontal framework 11 embodying supporting rollers 12 or other like means upon which steel or other plate 13 may be advanced horizontally at a convenient height. The framework 11 has a well 14 through which a massive supporting I-beam 15 extends in a direction at right-angles to the direction of advancement of the plate 13 with its flanges horizontal. The upper flange 16 supports two horizontal rollers 17 and 18 the axes of which extend in the longitudinal direction of the I-beam 15 at an appropriate height for the upper surface of the rollers 17 and 18 to be at the same height as the upper surfaces of the rollers 12. Thus flat plate advanced along the rollers 12 also contacts and runs upon the rollers 17 and 18. The lengths of the rollers 17 and 18 are sufficiently great to engage the full width of the plate 13. The rollers 17 and 18 are shown supported by end brackets 19 fixed on the flange 16 and it is to be understood that as many intermediate supporting brackets may be provided along the rollers 17 and 18 as are deemed necessary to prevent significant flexing.

The flange 16 is provided with means for supporting a mandrel 20 with its axis above the web of the I-beam 15 centrally spaced between the rollers 17 and 18 but above them. As shown by Figure 2 the supporting means comprises two hydraulic cylinders 21 and 22. One cylinder 21 is fixed in position with a shaft bearing 23 mounted on the upper end of its piston rod 24. The other cylinder 22 also has a piston rod 25 with a shaft bearing 26 mounted on its end, but instead of being fixed to the flange 16 it is connected by a pivot pin 27 to a bracket 28 fixed on the flange 16. The cylinder 22 is pivotally connected to the piston rod 29 of a further hydraulic cylinder 30 pivoted to the web of the I-beam 15 so that by retraction of the piston rod 29 into the cylinder 30 the cylinder 22 together with its piston rod 25 and bearing 26 can be swung downwardly from the full line position shown in Figure 2 into the position shown in dotted lines in which it is entirely below the path of movement of the plate 13.

With the cylinder 22 in its erect position shown in full lines in Figure 2, its bearing 26 and the bearing 23 provide support for the shaft 31 of the mandrel. Mandrels of different diameters can be used with appropriate raising or lowering of the piston rods 24 and 25. Suitable drive means is provided for the shaft 31 comprising a motor 32 and reduction and reversing gear box 33, both mounted on the I-beam 15 with a double universal drive connection 34 extending from the gear box 33 to the

shaft 31.

The mandrel 20 may be in the form of a cylindrical drum as shown in Figures 1 and 2, in which case for the sake of rigidity it is desirably provided with internal discs or other suitable supporting means, not shown. However, it is not essential for the mandrel to have an enclosing peripheral surface which is a complete cylinder. In addition the power cylinders 21 and 22 are actuatable to move the mandrel up or down during an actual plate bending operation. This will be described in greater detail later.

An important aspect of the mandrel is the provision thereon of a gripper 36 which consists of a continuous rib extending in an axial direction at the peripheral region of the mandrel. The gripper 36 projects radially away from the mandrel for a short distance and has two flanges 37 which extend in the circumferential direction, one at each side. The flanges 37 provide between themselves and the periphery or the partial peripheral surface of the mandrel a recess which is slightly greater in width than the thickness of the plate with which the mandrel is to be used.

The gripper 36 on mandrel 20 applies a moment to the edge of the plate 13 when the mandrel is rotated in the direction of arrow A, equal to the plastic moment of the plate and a vertical force equal for most of the time to the roller force applied against the plate by rollers 17, 18. Figures 3 to 5 show schematically the various stages of completion of formation of a pipe according to the present invention using the apparatus described

in Figures 1 to 2.

It will be understood that the torque applied to the mandrel, which is constant for practically the full forming cycle, and equal to the plastic moment (MPL) of the plate 13, is in fact applied to the plate edge via the gripper 36. The mandrel 20 acts as guide and there is contact but little pressure between the mandrel 20 and the plate 13. Whilst the plate is in contact with the mandrel there exists all around the plate a bending moment equal to the plastic moment (MPL).

In the closing stages shown in Figures 4 and 5 near the completion of bending, the moment applied at the gripper 36 will cause the plate to escape or spin away from the mandrel in the direction of rotation of the mandrel unless preventative means are employed.

The preventative means are basically those which will apply a horizontal retarding force or component of force to the plate in addition to the roller force Fr which acts vertically until the closing stage.

At the closing stages viz. Figures 4 and 5 MPL (the gripper moment) is opposed by an equal and opposite moment comprising the sum of moments caused by externally applied roller forces $HFr_1$, $HFr_2$ and the internal frictional forces $\mu Fr_1$, $\mu Fr_2$.

The opposing moments are generated by lowering the mandrel by operation of power cylinders 21, 22 in the direction of arrow B or raising the rollers (by means not shown) until both rollers are engaged by the plate thereby creating lateral forces $Fr_1$ and $Fr_2$. The action

of the forces creates a horizontal component of force $HFr_2$ and $HFr_2$, which give rise to these opposing moments. These opposing moments are sufficient to prevent slippage or spinning of the bent plate away from the mandrel.

It has been found that sufficient lateral force can be created to prevent slippage of the curved plate without the imposition of any external frictional component as hitherto used.

CLAIMS

1. A method of rolling a plate to form a substantially cylindrical article on apparatus comprising a support bed for the plate (13), a rotatable mandrel (20) with a gripper means (36) for engaging an edge of the plate, and pressure means (17, 18) adjacent said mandrel (20) for engaging said plate (13), said method comprising engaging an edge of the plate (13) by said gripper means (36), turning the mandrel (20) to advance said plate (13) past said pressure means (17, 18) to curve said plate (13) into a cylinder shape, characterized in that said mandrel (20) and said pressure means (17, 18) are relatively movable to create a force on said advancing plate (13) at least during the final stages of rolling to prevent relative movement of the plate (13) and said mandrel (20).

2. A method as claimed in claim 1 wherein the pressure means includes a pair of rollers (17, 18) mounted on either side of centre below said mandrel (20) and arranged to engage the plate (13) such that upon relative movement between said rollers (17, 18) and said mandrel (20) said rollers (17, 18) apply said force on said advancing plate (13) to prevent relative movement of the plate (13) and said mandrel (20) solely as a result of said applied force.

3. Apparatus for carrying out the method as claimed in claim 1, comprising a mandrel (20) rotatable above a plate support bed, and pressure means (17, 18) mounted adjacent said mandrel (20) for contacting and supporting said plate (13), characterized in that the mandrel (20) and said pressure means (17, 18) are relatively movable during a plate rolling operation at least during the final stages of said operation to apply a force against said plate (13) as it is advanced.

4. Apparatus as claimed in claim 3, wherein the pressure means includes a pair of rollers (17, 18) mounted on either side of centre below the mandrel (20), said mandrel (20) being relatively movable towards the rollers (17, 18).

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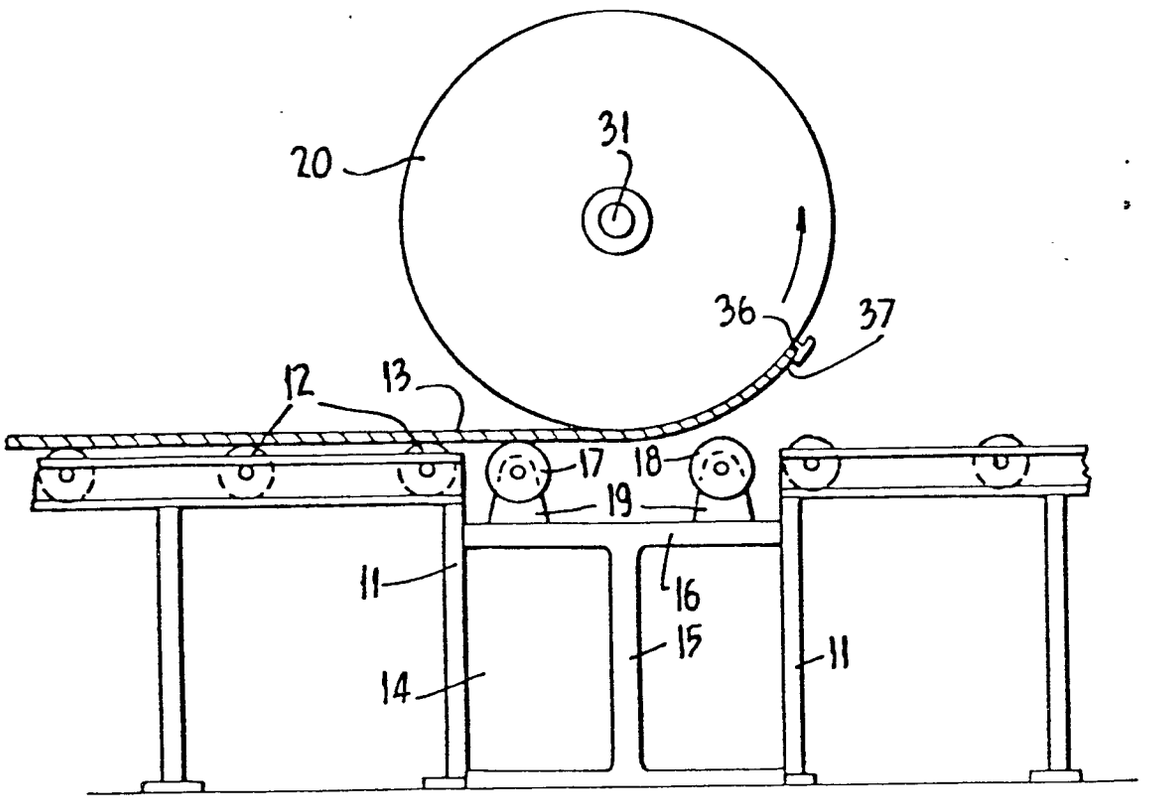
FIG. 1.



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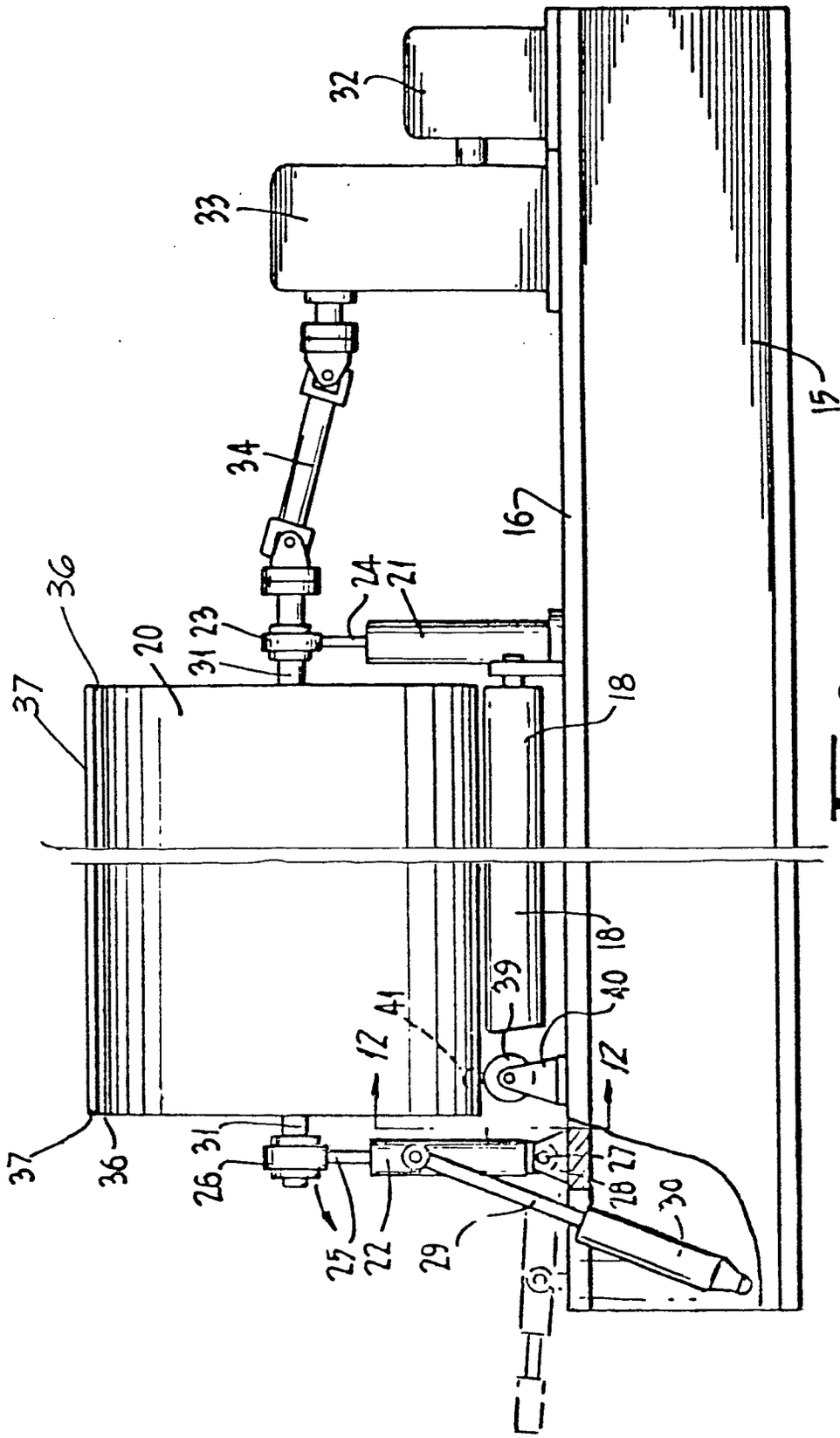


FIG. 2.

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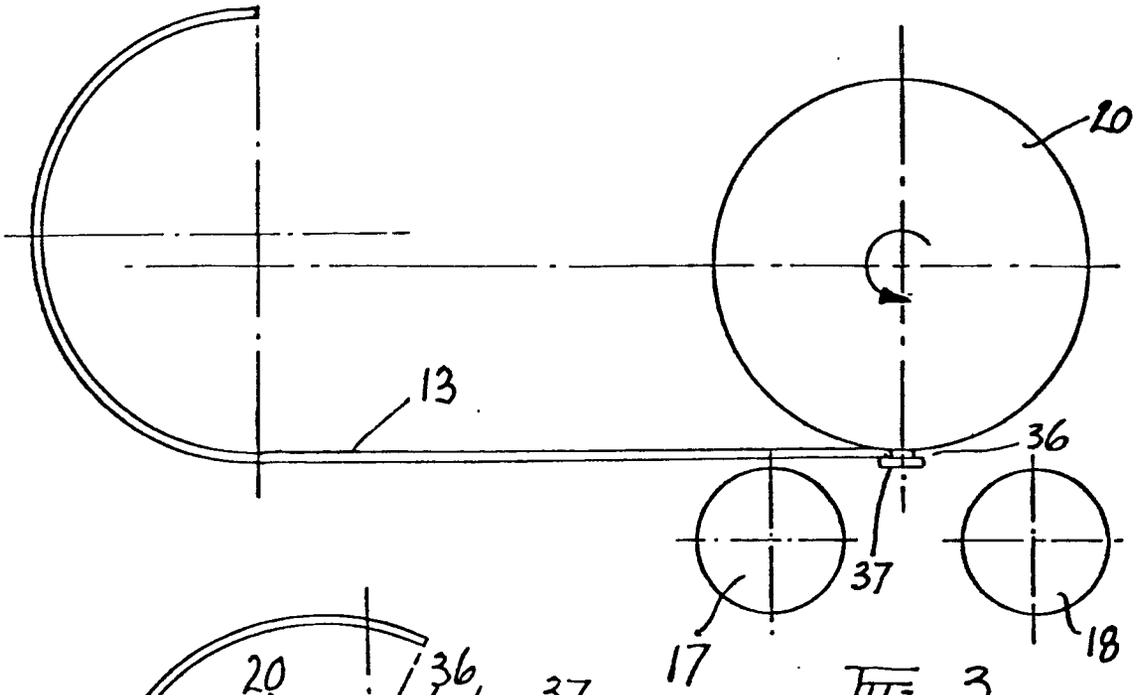


FIG. 3.

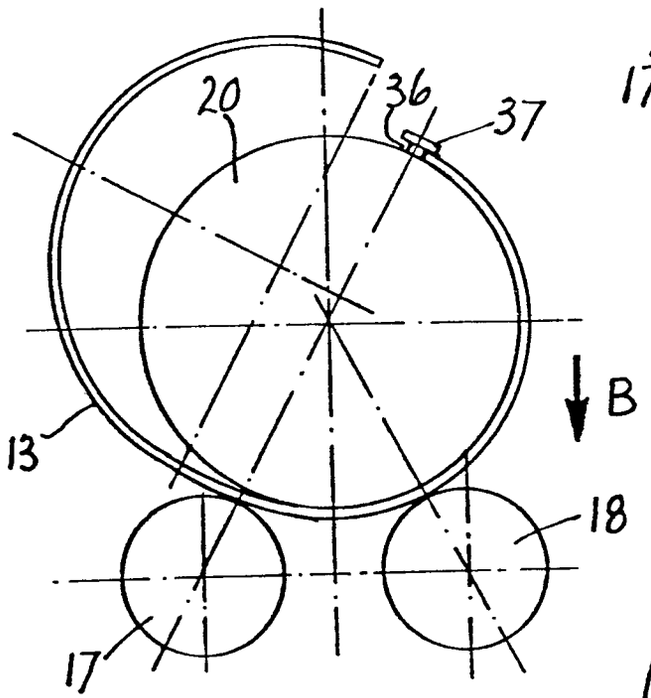


FIG. 4.

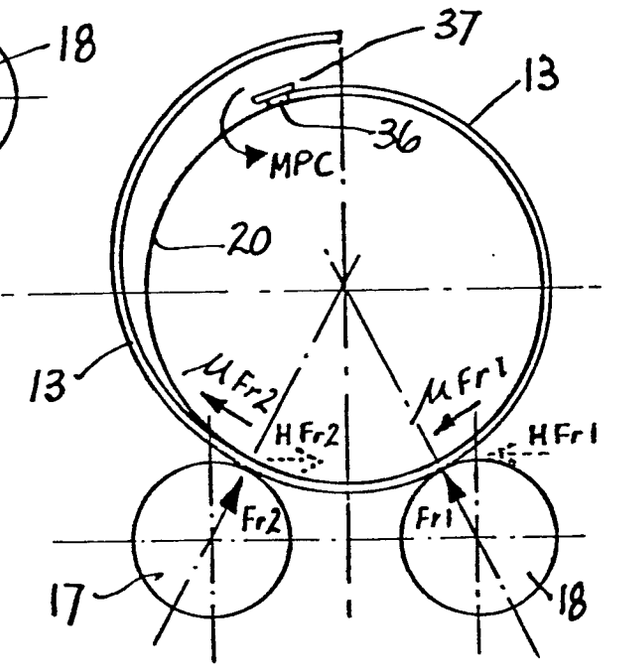


FIG. 5.