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(71) Applicant:
Danieli Wean, a division of Danieli Corporation
Youngstown, OH 44501 (US)

(72) Inventors:
- **Feldbauer, Stephen L.**
  Jackson Center, PA 16133 (US)
- **Scott, Robert**
  Massillon, Ohio 44656 (US)

(74) Representative:
Grünecker, Kinkeldey,
Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(54) Process and apparatus for cleaning metal strip

(57) A process and apparatus for cleaning metal strip without the use of pickling acids, including an uncoiler (1), a leveller (2) capable of removing substantially all dimensional irregularities from the strip, and a cleaner (3), including at least one grinder unit, brushing unit and polishing unit, for removing surface oxide from the strip. Tension is applied to the cleaned strip to enhance material handling and control and to facilitate leveling. The cleaned strip may be treated (5) with acid to remove ground surface material and to condition the strip. Such strip, having a reduced surface roughness of about 5 to 30 microinches, is suitable for many post-processing operations.

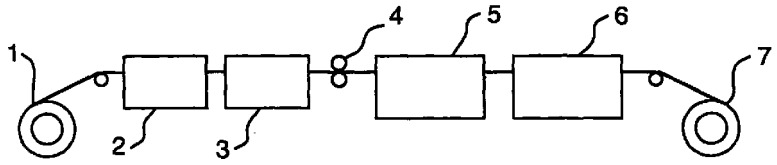

FIG. 1

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Description

BACKGROUND

1. Field of the Invention

[0001] This invention relates to the cleaning of metal strip or plate (hereinafter called "strip"), particularly but not limited to stainless steel strip, whereby adherent oxides are mechanically removed from the surface of the strip to provide a surface finish at least equal to a pickled surface and superior to prior art mechanically cleaned surface without the use of pickling acids.

2. Description of the Prior Art

[0002] Mechanical scale removal, e.g. by cleaning, e.g. by abrasive grinding the surface of metal strip, is known to the art. Useful abrasive compositions and articles are shown and described in U.S. Patent No. 5,273,558. Such prior art processes are effective only on metal strip that is substantially uniformly dimensioned, completely flat and well controlled during the grinding process. It is known, for example as shown and described in U.S.Patent No. 2,759,301, to use staggered or intercalated upper and lower leveler or flattener rolls to straighten or flatten strip before grinding. Such devices, now known within the industry as "flatteners," require the strip to be flexed over the flattening rolls and are useful only to remove coil set from the uncoiled strip by bending the strip, by the flattening rolls, uniformly across the strip width. Accordingly, such flatteners are not applicable to leveling high strength steels or heavy gauge steel strip or plate which cannot be so flexed. Moreover, coiled metal strip as produced in a rolling mill frequently exhibits, in addition to coil set, non-uniform dimensions, out-of flatness and other processing irregularities, such as waves, bubbles, herringbone patterns, and cross-bowing. Waves are produced by elongation of the strip, in the width direction, more than another width direction. If the edges of the strip are elongated more than the center, waves are produced; if the center is elongated more than the edges of the strip, bubbles or center waves or side waves are formed. If the strip goes into the rolling mill at an angle, a diagonal wave, called a herringbone pattern, is produced. Cross-bowing of the strip results from differential cooling of the strip or by too much crown in the strip. Such dimensional irregularities are not amenable to correction by use of flattener apparatus such as that of the latter patent. Consequently, the surface finish produced by such conventional prior art processes are not acceptable for production of fully mechanically cleaned strip of high surface finish, for example strip which is intended for certain post-processing treatments of the cleaned strip surface.

SUMMARY OF THE INVENTION

[0003] The present invention provides a metal strip uncoiling device followed by a device, such as a rolling mill, a tension leveler or a corrective (roller) leveler, capable of flattening the strip, correcting any strip irregularities, such as waves, bubbles, herringbone patterns and cross-bowing, in addition to coil set, and delivering an acceptable shape to the following cleaning step which includes grinding, brushing and polishing of the strip surface. The cleaning step is followed by a device to tension the strip at a level of tension at least sufficient to provide effective material handling and control during cleaning and thereby to aid in achieving or maintaining a flat strip surface during leveling and cleaning.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004]

Fig. 1 is a schematic drawing in side elevation of a processing line in accordance with the invention, showing the leveling, cleaning and tensioning devices;
Fig. 2 is a side elevational sketch of a prior art rolling mill of a type useful in the leveling aspect of the invention;
Fig. 3 is a side elevational sketch of a prior art tension leveler of a type useful in leveling strip in the invention, and
Fig. 4 is a side elevational sketch of a prior art corrective or roller leveler of a type useful in leveling strip in the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0005] Fig. 1 shows an uncoiler 1, a strip leveller 2, a cleaner 3 and a tensioning device 4, as well an optional surface conditioning device 5 and material post-processing apparatus 6, and a strip recoiler 7.

[0006] The essential steps of the invention, levelling and surface cleaning, comprise a process and apparatus capable of removing oxides from metal strip efficiently and in a form possessing an acceptable surface finish for post-processing without acid pickling of the strip. For effective strip cleaning, as hereinafter described, all of the above-mentioned strip irregularities must be removed so that the strip, ready for cleaning, is substantially uniformly dimensioned and completely flat in order to provide a mechanically cleaned surface of high quality, e.g. equal or superior to pickled strip.

[0007] Removal of such dimensional irregularities may be achieved by one or another of several types of prior art levelers, i.e. a rolling mill, a tension leveler or a corrective or roller leveler.

[0008] Fig. 2 shows a prior art rolling mill denoted generally by the numeral 8 having a pair of work rolls 9 and 11 and corresponding upper and lower backup rolls

12 and 13. Guide rolls 14, 16 and 17 aid in guiding a strip 18 through the work rolls of the mill. Such a device reduces the thickness and increases the length of the strip 18 as it passes through the mill, thereby loosening and aiding in the removal of surface oxides.

[0009] Fig. 3 shows a prior art tension leveler, denoted generally by the numeral 19 having a plurality of stands, e.g. 21 and 22 each of which includes vertically movable upper and lower clusters 23 and 24 of tensioning rolls. Passage of the strip 18 through such a leveler device results in elongation of the strip, again loosening and aiding in the removal of adherent surface oxides as well removing strip irregularities and flattening the strip.

[0010] Fig. 4 shows a prior art corrective (roller) leveler generally denoted by the numeral 26 having a plurality of upper and lower leveler rolls 27 and 28, respectively, each of which is backed up by a set of corresponding upper and lower backup rolls 29, 31. By applying different pressures, through the backup rolls, to different pairs of opposed upper and lower leveler rolls, the latter rolls, or either of them, may be bent resiliently in a plurality of desired configurations as necessary to correct specific types of irregularities of the strip as it passes through this type of leveler.

[0011] Any one of these three types of levelers, the mentioned irregularities, including but not limited to coil set, can be removed from the strip to provide a substantially completely level surface. Normally only one of these types of levelers will be used in a particular facility. Selection of the type of leveler to be used depends upon the particular facility and operator experience with one form of leveler or another. In each case, deformation of the strip during leveling also aids in removing scale from the strip surface.

[0012] The cleaning step of the invention comprises three aspects. First, the strip is ground, e.g. with a suitable grinding disc. A suitable article for this purpose is a "DBX" grinding wheel manufactured by Minnesota Mining and Manufacturing Co. and described in the aforesaid U.S. Patent No.5,273,558. Such devices are in the form of articles, such as discs, incorporating a bonded abrasive composition comprising abrasive particles dispersed throughout and bonded to an elastomeric polyurea matrix formed from the polymerization reaction product of a polyfunctional amine and an isocyanate. Secondly, the strip is brushed, e.g. with a suitable brush, for example a 7A medium brush formed of a porous resin matrix and a mineral filler, as produced by Minnesota Mining and Manufacturing Co. A suitable wire brush also may be used. Thirdly, the strip is polished with a suitable abrasive polishing wheel, such as "Scotch-Brite"--a trade-marked product of Minnesota Mining and Manufacturing Co.

[0013] At least one of these cleaning steps is used and preferably all three are used, and more than one unit of each type of cleaning may be used, depending on the extent and type of initial oxide and the type of final surface which is desired.

[0014] Disposition of the tensioning device 4 following the cleaner enhances material handing and control and hence a level strip.

[0015] Conventional pickling processes typically produce strip with a surface roughness of about 60 microinches. The strip mechanically processed in accordance with the present invention has a surface roughness of about 5 microinches in the direction of the grinding lines, and up to about 30 microinches in a direction transverse to the grinding lines--at least a 100% improvement over the prior art.

[0016] After cleaning by grinding, brushing and polishing, optionally there may be an acid bath and rinse section 5 in the processing line to aid in removal of the ground surface material and to condition the surface to a more preferred condition. Such acid bath and rinse section may be replaced with a rolling device (not shown) to roll the material in order to further enhance the surface of the strip. In many applications, the strip material may only need to be oiled and recoiled after mechanical grinding, brushing and polishing because all these elements rotate in a counterclockwise direction and tend to throw debris back toward the entry of the strip into the cleaner.

[0017] A number of other post-processing steps may be utilized between grinding and recoiling, such as, but not limited to, side trimming, shot-blasting, painting, galvanizing and other coating operations. Moreover, some of such further processing steps could be carried out between the leveling and cleaning steps. For example, the strip may be side-trimmed and/or shot blasted after leveling but before cleaning. Further, it is possible to pass the strip through an acid pickling bath before the strip is cleaned: in this way the speed and quality of an existing pickle line may be increased.

[0018] Practice of the above-described invention provides a means for producing pickled surface finishes with little or no pickling acid requirement, as well as producing far superior surface finishes to those of conventional mechanical cleaning and grinding processes.

Claims

1. A method of removing oxide scale from metal strip, comprising providing an elongated section of wound strip, uncoiling the wound strip, directing the unwound strip into a leveling device capable of removing substantially all strip dimensional irregularities and leveling the strip, and mechanically cleaning the strip surface by a process selected from the group consisting of the steps of grinding, brushing, polishing and combinations thereof, to remove adherent surface oxides.

2. A method according to claim 1, comprising selecting the leveling device from the group consisting of a rolling mill, a tension leveler and a corrective roller

leveler capable of correcting strip irregularities including coil set, waves, bubbles, herringbone pattern and cross-bowing.

3. A method according to claim 2, comprising carrying out the grinding step with use of an abrasive grinding wheel incorporating a bonded abrasive composition comprising abrasive particles dispersed throughout and bonded to an elastomeric polyurea matrix formed from the polymerization reaction product of a polyfunctional amine and an isocyanate.

4. A method according to claim 3, wherein the mechanical cleaning of the strip comprises grinding, brushing and polishing.

5. A method according to claim 1, further comprising applying tension to the strip as it is being leveled and mechanically cleaned.

6. A method according to claim 5, wherein the mechanical cleaning of the strip consists of grinding, brushing and polishing.

7. A method according to claim 1, further comprising passing the cleaned strip through an acid bath and rinse to remove ground surface material and to condition the strip surface.

8. A method according to claim 1, further comprising passing the leveled strip through an acid pickling bath and rinse, and then mechanically cleaning the leveled and pickled strip, thereby further enhancing the speed of the pickling step and the surface quality of the treated strip.

9. A method according to claim 5, further comprising passing the cleaned strip through an acid pickling bath and rinse to remove ground surface material and to condition the strip surface.

10. A method according to claim 1, further comprising post-processing the leveled and cleaned strip, and recoiling the post-processed strip.

11. A method according to claim 5, further comprising post-processing the leveled and cleaned strip, and recoiling the post-processed strip.

12. A method according to claim 9, further comprising post-processing the leveled, pickled and cleaned strip.

13. An apparatus for cleaning metal strip by mechanically removing oxides from the strip surface, comprising an uncoiler on which the strip may be wound, a strip leveling device capable of removing substantially all strip dimensional irregularities, a cleaner device for cleaning the surface of the strip to remove surface oxides therefrom and capable of grinding, brushing and polishing the strip, and means for recoiling the strip.

14. Apparatus according to claim 13, wherein the leveling device comprises a rolling mill adapted to reduce the strip thickness, to elongate the strip and to reduce strip dimensional irregularities, including coil set, waves, bubbles, herringbone pattern and cross-bowing of the strip, and aiding in removing oxides from the strip surface.

15. Apparatus according to claim 13, wherein the leveling device comprises a tension leveler for applying tension to the strip of a magnitude sufficient to elongate the strip and capable of correcting dimensional irregularities in the strip, including coil set, waves, bubbles, herringbone pattern, and cross-bowing, and to aid in removing oxides from the strip surface.

16. Apparatus according to claim 13, wherein the leveling device comprises a corrective roller leveler comprising at least one pair of leveling rolls having a length extending substantially across a width of the strip, and a plurality of backup rolls spaced apart along the length of the leveler rolls and adapted to be moved toward and away from the leveler rolls whereby the leveler rolls may be bent resiliently into a configuration adapted to correct dimensional irregularities in the strip, including coil set, waves, bubbles, herringbone pattern, and cross-bowing.

17. Apparatus according to 14, wherein the cleaner device is selected from the group consisting of a grinder, an oxide removing brush, a polisher and combinations thereof.

18. Apparatus according to claim 15, wherein the cleaner device is selected from the group consisting of a grinder, an oxide removing brush, a polisher and combinations thereof.

19. Apparatus according to claim 16, wherein the cleaner device is selected from the group consisting of grinder, an oxide removing brush, a polisher and combinations thereof.

20. Apparatus according to claim 17, wherein the grinder comprises an abrasive grinding wheel incorporating a bonded abrasive composition comprising abrasive particles dispersed throughout and bonded to an elastomeric polyurea matrix formed from the polymerization reaction product of a polyfunctional amine and an isocyanate.

21. Apparatus according to claim 20, wherein the cleaner device comprises, in addition to the grinder, an oxide removing brush and a polisher.

22. Apparatus according to claim 18, wherein the grinder comprises an abrasive grinding wheel incorporating a bonded abrasive composition comprising abrasive particles dispersed throughout and bonded to an elastomeric polyurea matrix formed from the polymerization reaction product of a polyfunctional amine and an isocyanate.

23. Apparatus according to claim 22, wherein the cleaner device comprises, in addition to the grinder, an oxide removing brush and a polisher.

24. Apparatus according to claim 19, wherein the grinder comprises an abrasive grinding wheel incorporating a bonded abrasive composition comprising abrasive particles dispersed throughout and bonded to an elastomeric polyurea matrix formed from the polymerization reaction product of a polyfunctional amine and an isocyanate.

25. Apparatus according to claim 24, wherein the cleaner device comprises, in addition to the grinder, an oxide removing brush and a polisher.

26. An apparatus according to claim 13, further comprising a tensioning device disposed after the cleaner device.

27. An apparatus according to claim 25, further comprising a tensioning device disposed after the polisher for applying tension to the strip during grinding, brushing and polishing.

28. An apparatus according to claim 13, further comprising an acid bath and rinse apparatus disposed after the cleaner device to remove ground surface material and condition the strip.

29. An apparatus according to claim 13, further comprising a post-treatment device following the cleaner device for further treatment of the strip.

30. An apparatus according to claim 29, wherein the post-treatment device is selected from the group consisting of a device to side trim, shot-blast, paint, galvanize, and otherwise to coat the cleaned strip.

31. A metal strip made by the method of claim 1 having a maximum surface roughness in a direction of grinding lines of about 5 microinches and a maximum surface roughness in a direction across grinding lines of about 30 microinches.

32. A metal strip made by the method of claim 2 having a maximum surface roughness in a direction of grinding lines of about 5 microinches and a maximum surface roughness in a direction transverse to the direction of grinding lines of about 30 microinches.

33. A metal strip made by the method of claim 3 wherein the cleaned strip has a maximum surface roughness in a direction of grinding lines of about 5 microinches and a maximum surface roughness in a direction transverse to the direction of grinding lines of about 30 microinches.

34. A metal strip made by the method of claim 3, wherein the mechanical cleaning step comprises, in addition to grinding, oxide-removing brushing, and polishing.

35. A metal strip made by the method of claim 34 wherein the cleaned strip has a maximum surface roughness in a direction of grinding lines of about 5 microinches and a maximum surface roughness in a direction transverse to the direction of grinding lines of about 30 microinches.

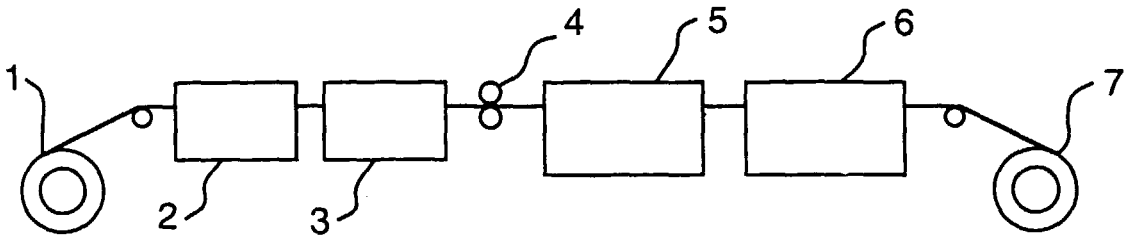

FIG. 1

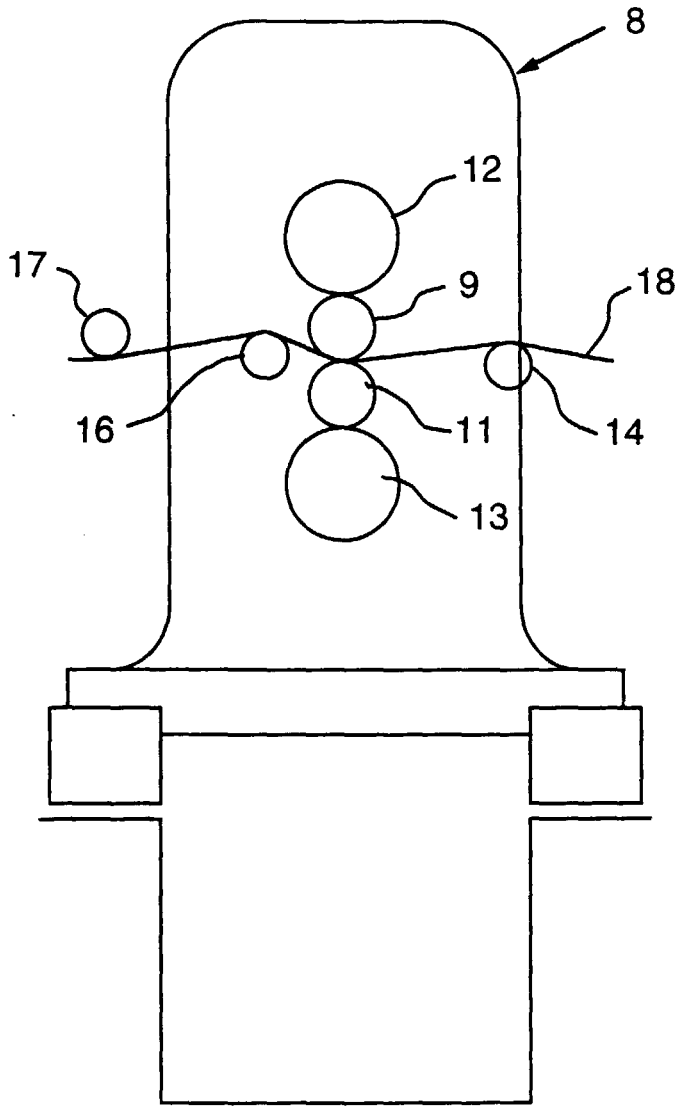

FIG. 2 Prior Art

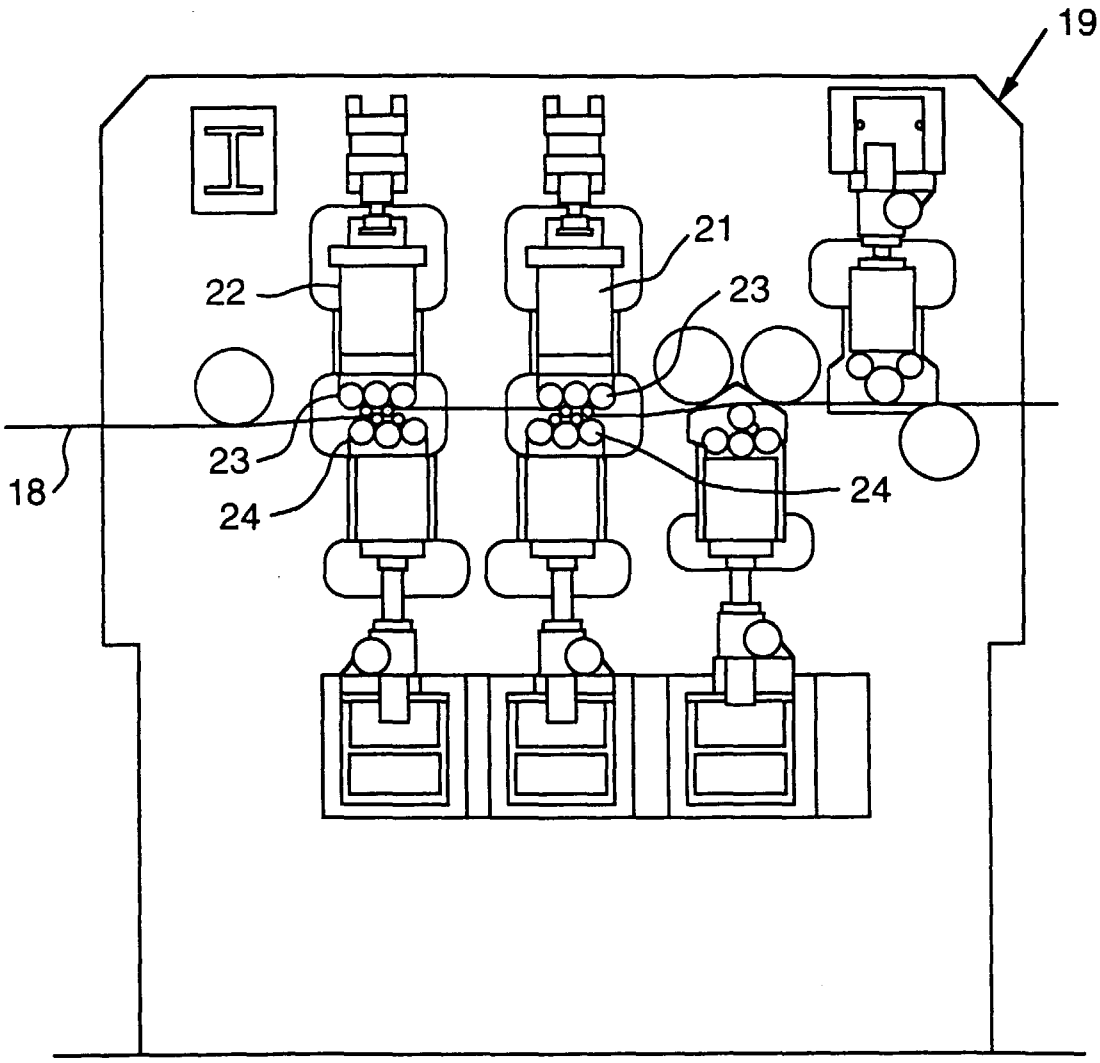

FIG. 3 Prior Art

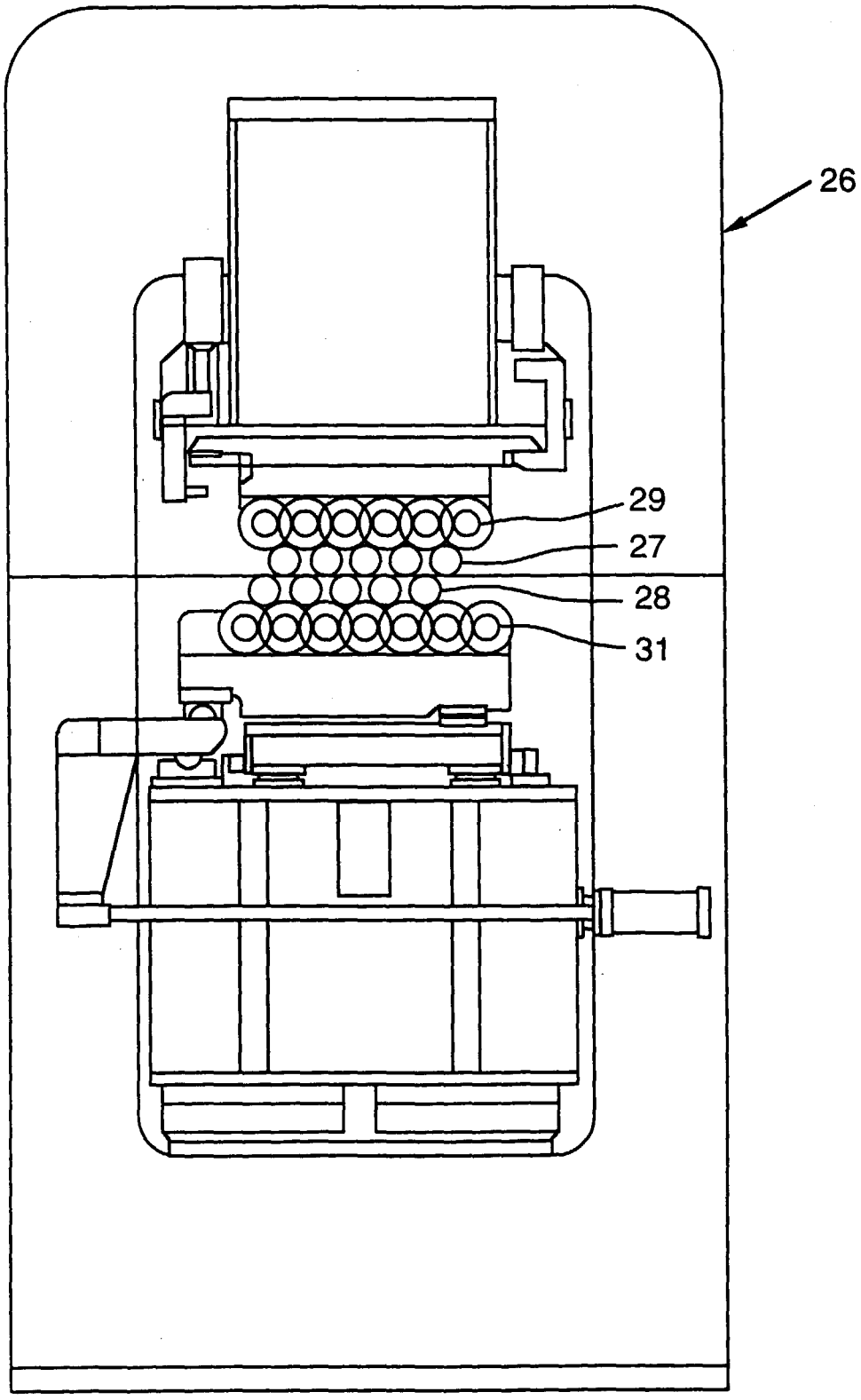

FIG. 4 Prior Art