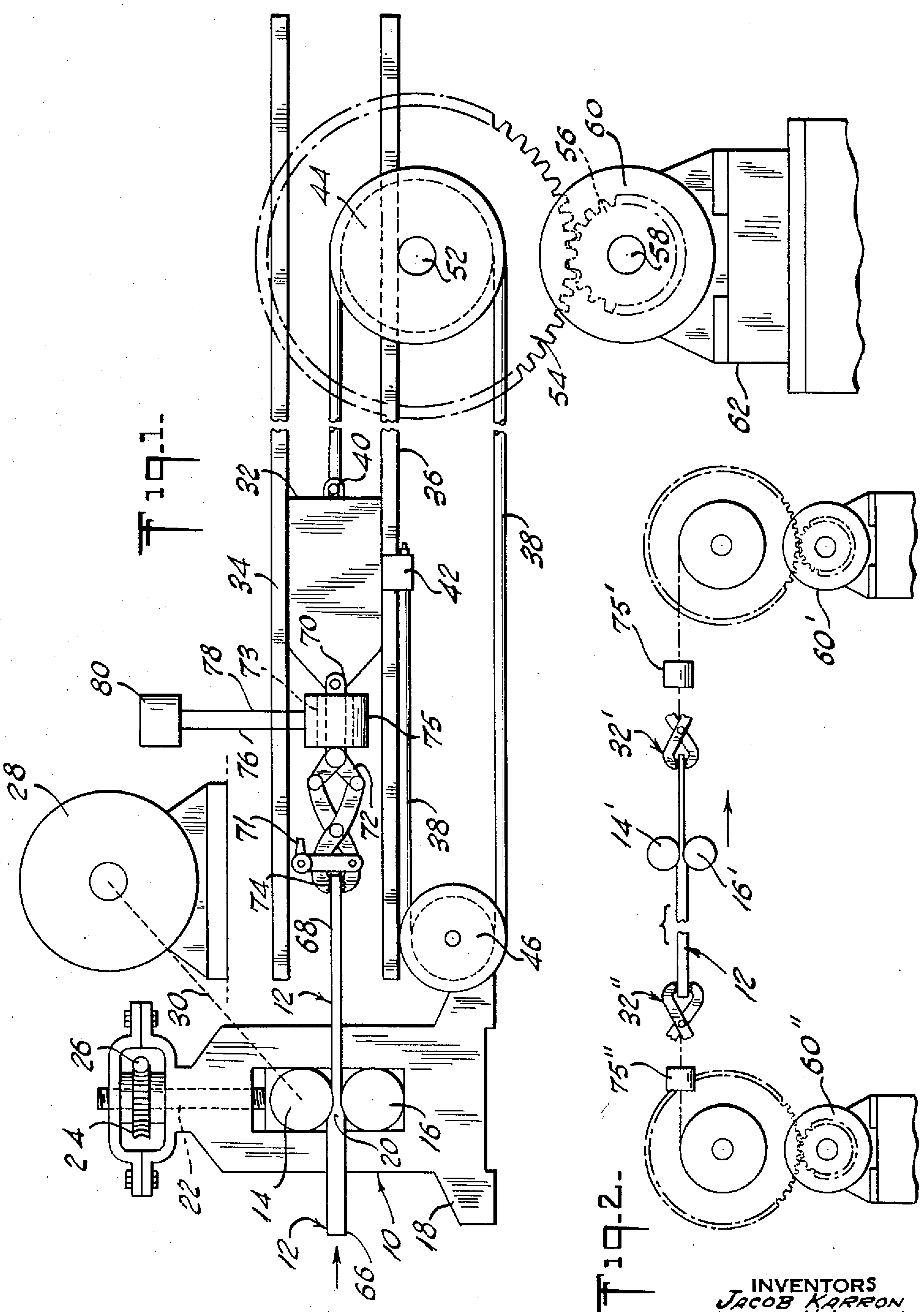
Aug. 8, 1961 J. KARRON ET AL 2,995,050

REDUCING THE CROSS-SECTION OF MATERIAL

Filed April 27, 1959 2 Sheets-Sheet 1



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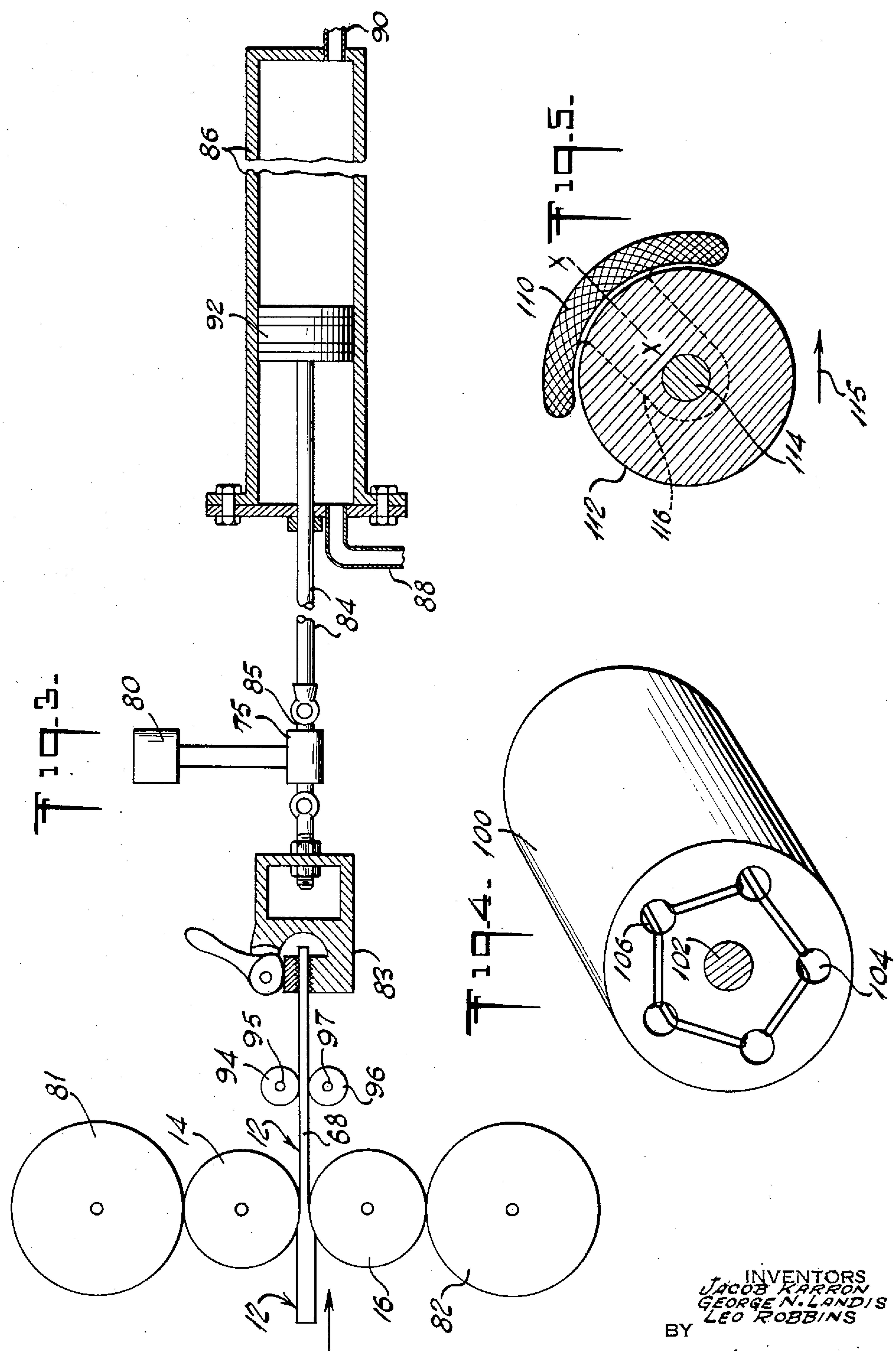

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REDUCING THE CROSS-SECTION OF MATERIAL

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This invention relates to new and useful improvements in the production of lengths of various cross section and, in particular, solid metal shapes such as sheets, rounds, squares, 5 beams and the like.

The invention is of particular importance as applied to the rolling of metal wherein a desired cross section may be formed by a number of progressive alterations imparted to the metal by passing it through a gap between adjacent rotatable parallel rolls spaced for compression of the metal. In such a process the magnitude of the gap between the rolls may be determined and made variable by a motor or hand operated screw-down device mounted on the mill stand upon which the rolls are supported. In the production of sheets of metal, for example, a comparatively thick and short slab is passed between rolls on a number of mill stands and the spacing of the rolls on successive stands will be progressively smaller, causing the metal to become thinner and longer. Alternatively, the metal may be repeatedly passed between the same rolls and before each recurrent pass the space between the rolls may be progressively decreased.

During a rolling operation the work-piece passing between the rolls exerts a considerable outward separating force upon the compressing rolls. This separating force produces stresses in members of the rolling mill stands resulting in unavoidable distortion detrimental to the accuracy of the process in that it influences the accuracy of the shapes produced. The separating force also causes considerable wear and friction in the bearings supporting the rolls as a consequence of which increased power and torque are required for rotation of the rolls.

To minimize the above distortion and wear in such a process, the mill stand and its components may be constructed very rigidly and the degree of cross sectional alteration per pass may be limited. These solutions to the problems posed by the separating force are costly and time-consuming. It is thus desirable to reduce the resistance of the work material to deformation. This would reduce the separating force upon the rolls for a given amount of work performed on the material, increase accuracy and hence increase the efficiency of the entire process.

In the rolling of metals, the process with which this invention is chiefly concerned, as in many other metal-working operations, heat is important in reducing the resistance of a metal to deformation. All rolled steel starts in the furnace where an ingot is heated to a very high temperature before rolling begins. However, heat has many effects on metals, not all of which may be desirable in a particular product. The final stages of some rolling must be done cold.

A feature contributing to the success of this invention in the alteration of the cross section of metal and the attendant increase in other dimensions is the application of a tensile force to the metal normal to the cross sectional plane which is being reduced. A metal subjected to a tensile stress is not only elongated in the direction of the tensile stress but the dimensional normal to the stress decreases. The unit loss in cross sectional width and thickness of a material compared to the unit gain in length is called Poisson's ratio. For steel this is approximately .3. As is well known in the art, if a metal while being rolled is also pulled forward, fore and aft, or just backward, the required separating force is reduced per unit work done on the metal due to the reduction in thickness created by the tensile force. However, such tension is still insufficient to overcome all the difficulties encountered when rolling.

It has been proposed to impart vibrations to material while it is being rolled but this has been done in such a manner and under such conditions that the resistance of the material to deformation has been reduced to a limited degree only.

It is, accordingly, an object of this invention to provide improved means and methods whereby the resistance of a material subjected to deforming forces is decreased to a minimum as it passes between the rolls in a mill stand.

It is a further object of this invention to provide relatively inexpensive means and methods of augmenting the pulling effect upon a workpiece being rolled while at the same time affording removal of dirt and scale from the surface of the product.

Further objects and advantages of the invention will be apparent as the specification proceeds.

In accordance with the invention in a rolling apparatus wherein material is passed between a pair of spaced rollers for cross sectional diminution by compression and wherein a pull means engaging the leading edge and/or the trailing edge of the material tensions the material being fed by the rolls, means are provided to vibrate the material at supersonic frequency. In accordance with the invention this means can take various forms and be located in many places. Preferably the vibrations are in the direction normal to the plane of compression of the rolls although other directions of vibrations are suitable, and are imparted by the tensioning means.

The invention results in a very substantial reduction of the work required to form the length of material during the shaping process since the vibrations greatly enhance the effect of the tensioning pull.

The various features of novelty which characterize the invention are pointed out with particularity in the claims forming a part of this specification. For a better understanding of the invention, its advantages and its objects reference should be had to the accompanying drawings and descriptive matter in which preferred embodiments of the invention are set forth.

In the drawings:

FIG. 1 is a largely schematic view illustrating rolling apparatus arranged in accordance with this invention.

FIG. 2 is a schematic view illustrating a modification.

FIG. 3 is a schematic view illustrating another modification of a portion of the arrangement of FIG. 1.

FIG. 4 is a schematic perspective view of a means for imparting vibration in accordance with the invention.

FIG. 5 illustrates a modification of the means shown in FIG. 4.

Referring to FIG. 1, there is shown an embodiment of this invention as used for rolling sheet metal. A mill stand generally designated **10** is adapted to reduce the thickness of a metal sheet generally designated **12** by passage between rolls **14** and **16** rotatably mounted for feeding and compressing engagement at vertically spaced positions in the mill stand frame **18**. The spacing or gap **20** between the rolls **14** and **16** is variable by means of a screw **22** vertically movable in the frame **18** by rotation and adapted to adjust the vertical position of the upper roll **14**. A worm wheel **24** engaging the screw **22** is meshed with a warm **26** which may be rotated by hand or power means for adjustment. The rolls **14**, **16** are connected to a motor **28** by intermediate connection **30** for rotation.

A carriage **32** is mounted on a pair of horizontal rails

34 and 36 for movement transverse to a plane through the axes of rolls 14 and 16. The rails 34 and 36 extend from the region of the mill stand 10 a distance somewhat greater than the desired length of the final sheet metal product. Movement of the carriage 32 is accomplished by a flexible cable 38 secured to the carriage at points 40 and 42. The cable 38 passes from point 40 around a drum 44 at the end of the rails remote from the mill stand to an idler sheave 46 rotatably mounted near the end of the rails adjacent the mill stand, and then to point 42. The cable 38 is in engagement with the drum 44 for movement therewith. The drum 44 is mounted on a horizontal shaft 52 parallel to the axes of rolls 14 and 16 for rotation together with a large gear 54 which is in mesh with a pinion 56 mounted on a horizontal shaft 58. A motor 60 supported on a base 62 is operatively connected to shaft 58 to rotate the pinion gear 56, the large gear 54 and the drum 44 engaging the cable 38.

The metal sheet 12 has an initial thickness as shown at 66. After the metal has been compressed and moved through the rolls to the right in FIG. 1, the thickness of sheet 12 will be smaller as indicated at 68.

Mounted on carriage 32 is an intermediate link 70 which is connected through a toggle 72 to a clamp 74 provided with a lock 71. Link 70 comprises magnetostrictive material, for example, ferrous metals, nickel, or an alloy thereof such as stainless steel. The clamp 74 when closed holds the leading edge of the metal sheet 12 and imparts a tensional force to the metal in consequence of movement of the carriage 32 away from the mill stand 10. A magnetostrictive coil 75 is supported on link 70 by means such as a bushing 73. Coil 75 is adapted to cause contraction and expansion of link 70 transverse to the axial direction of rolls 14 and 16, and thus impart oscillatory motion to the metal sheet in the direction toward and away from the mill stand, i.e., perpendicular to the thickness of the metal. Leads 76, 78 connect the coil or vibrator 75 to an oscillator 80 which supplies electronic oscillations at ultrasonic frequency to the coil. Other vibrators based on principles other than magnetostriction may be used to supply the desired vibration. However, the frequency of the vibration should be ultrasonic.

The operation of the arrangement is alike for each pass of metal through the rolls. At the beginning of each pass the carriage 32 is moved to a location at the end of the rails 34 and 36 adjacent to the mill stand 10. The gap 20 between the rolls 14 and 16 is adjusted by means of the screw 22, the worm wheel 24 and the worm 26 to a magnitude dependent upon the thickness 66 of sheet 12 before the pass, the desired reduction in thickness, and the general capabilities of the arrangement. In any case, the gap 20 between the rolls is less than the thickness 66 of the existing sheet 12. The leading edge of sheet 12 is moved into the nip of the rolls from the left side in FIG. 1 and upon exit to the other side is inserted in the clamp 74 which is closed and secured in operating position by its lock 71. As the rolls are turned the sheet advances to the right. Simultaneously the motor 60 actuates the drum 44 and cable 38 and thus moves the carriage 32 away from the mill stand 10, with power sufficient to create a stress in the sheet. As set forth hereinbefore, this stress will reduce the resistance of the sheet 12 to deformation across its thickness. During this time the magnetostrictive vibrator 75 is connected to its oscillator 80 and imparts a vibration in the plane of the metal to and from the rolls 14 and 16. This will further reduce the resistance of sheet 12 to deformation across its thickness and, in combination with the stress created by pulling, will lead to most favorable conditions.

Further, the agitation of the metal 12 caused by the magnetostrictor gives rise to a descaling of the metal which would otherwise have to be accomplished in a separate step. The accumulation of scale and dirt frequently encountered on the surface will be shaken loose by the vibrations and the changing internal stresses within the material.

FIG. 2 illustrates a modification in which the mill 14′, 16′ is of the reversing type and cooperates with two pulling mechanisms generally indicated at 32′, 32″. These pulling mechanism may be of the design shown in FIG. 1, except for their motors 60′, 60″ which are adapted to create a pulling effect at the leading and trailing ends of the sheet and are operable in both directions of movement of the reversible mill. For example, D.C. motors may be used and connected for regenerative braking. If, in operation, the mill moves sheet 12 forward in the direction shown by the arrow in FIG. 2, motor 60′ and mechanism 32′ exert a pull at the forward end of the sheet. Pulling mechanism 32″ is taken along and causes motor 60″ to rotate. At this time, the motor 60″ is controlled in a manner such that it will operate as a generator and due to regenerative braking will tend to hold the trailing end of sheet 12 back and in effect exert a rearward pull thereon as is well known in the art. Consequently, sheet 12 will be under tension in front of mill 14′, 16′ as well as at the rear thereof and this will also be true upon reversal of the mill. According to the invention, both of the pulling mechanism 32′, 32″ include vibrating devices 75′, 75″ so that tensile stresses and vibrations will be combined to reduce the resistance of sheet 12 to deformation in a most effective manner.

FIG. 3 is an illustration of another modification of the arrangement shown in FIG. 1. The rolls 14 and 16 are engaged by conventional parallel back up rolls 81 and 82. These latter rolls are larger than the former and exert compressive force normal to the faces of the sheet 12 placed between the rolls. Clamp 83, grasping the leading edge of sheet 12, is connected to a piston rod 84 by means of an intermediate rod or link 85 comprising magnetostrictive material. Oscillator 80 and magnetostrictive coil 75 will cause rod 85 to contract and expand horizontally transversely to the axial direction of the rolls and thereby vibrate the sheet 12 in its plane towards and away from the rolls. A hydraulic cylinder 86 is supplied with fluid through pipes 88 and 90 and controls the motion of the piston rod 84 by means of a piston 92. Here, instead of the carriage in FIG. 1, the tensile force to the right is applied by the piston 92 in the cylinder 86. The cylinder 86 and piston rod 84 are sufficiently long to handle the desired length of the finished product. A pair of driven, rotatable pinch rolls 94 and 96 are mounted on parallel axes 95 and 97 and arranged to nip the sheet in feeding engagement between the clamp 83 and the rolls 14 and 16 and exert additional tensile force by pulling the metal 12 to the right. The tensioning by the pinch rolls will in this embodiment be in addition to the tensioning by the piston rod. In general the operation is otherwise similar to that described in connection with FIG. 1.

A further modification is possible by omission of the clamp 83, the hydraulic motor 84, 86, 92, and the magnetostrictive vibrator 75. In this way the metal 12 passes from the bite of the rolls to the pinch rolls 94 and 96, which are in feeding engagement. The driven pinch rolls 94 and 96 will provide tension in the sheet between the mill stand rolls 14 and 16 and the pinch rolls. Vibration of the pinch rolls 94 and 96 in a horizontal plane, for example, by vibration of their respective axles 95 and 97 with the aid of a magnetostrictive transducer, may be used to impart horizontal supersonic oscillatory movement to the metal sheet in the direction to and from the rolls 14, 16. Here again, the vibrations will minimize the resistance of the metal sheet to deformation and in cooperation with the pull exerted by the pinch rolls will reduce the quantity of work required to roll the sheets to a desired shape and size. This embodiment is particularly useful when working materials of long length. It is especially helpful because the pinch rolls are fixedly located with respect to rolls 14, 16 thus preventing dampening of the vibrations which might occur to a certain extent if the vibrator receded a great distance from the rolls **14, 16**.

Alternatively, vibration may be imparted to the pinch rolls **94** and **96** by means such as illustrated in FIG. 4. In this modification, each of the pinch rolls includes a driven cylinder **100** containing magnetostrictive material which, if desired, may be of laminated construction. The cylinder **100** which is mounted for rotation upon an axle **102** has longitudinal holes **104** through which windings **106** extend to form a magnetostrictive coil, the axis of each winding being radially disposed with respect to cylinder **100**. The windings **106** are connected to a source of electronic oscillations at supersonic frequency by means of slip rings and brushes (not shown) so that during operation, the naturally round surface of cylinder **100** will alternately be distorted magnetostrictively and restored to its round shape. If metal emerging from rolls **14, 16** (FIG. 3) is placed in the nip of a pair of pinch rolls modified as shown in FIG. 4, the metal will be tensioned in the feeding direction by rotation of the cylinders **100**, and at the same time distortion of the surface of each cylinder **100** will produce the desired vibration in the metal.

FIG. 5 shows a pinch roll arrangement wherein a magnetostrictive coil **110** is disposed outside a rotatable cylinder **112** containing magnetostrictive material and mounted on supporting means such as an axle **114**. The axis X—X of coil **110** is disposed radially of the roll cylinder **112**. With respect to the workpiece, the direction of the axis X—X of coil **110** may be normal or inclined and may be adjustable so that at least components of the vibrations are disposed along the direction of metal feed. In FIG. 5, the axis X—X is disposed at an acute angle to the direction of metal feed which is indicated at **115**. The coil **110** may be supported on the axle **114** as indicated at **116**. Here again, a workpiece fed from a mill stand to the nip of a pair of such pinch rolls is tensioned by rotation of the pinch rolls and vibrated at supersonic frequency by the action of these rolls.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be otherwise embodied without departing from these principles.

We claim:

1. Apparatus for reducing the cross section of a solid material comprising means for compressing and feeding the material, means adapted to tension the material transverse to the cross section in the direction of feed, and ultrasonic vibrating means mounted on said tension means adapted to impart ultrasonic vibrations to the material.

2. Apparatus for rolling sheets of metal comprising a plurality of parallel rolls rotatably mounted in feeding engagement adapted to compress and feed metal placed therebetween, clamping means adapted to grasp the leading edge of the metal, motor controlled carriage means connected to said clamping means and movable transverse to a plane through the axes of said rolls to tension the metal between said rolls and said carriage along the feeding direction, and ultrasonic vibrating means acting on said clamping means and adapted to impart ultrasonic vibrations to the metal having components along said feeding direction.

3. Apparatus for reducing the cross section of a material comprising means for compressing and feeding the material, means adapted to tension the material in the direction of feed, and an ultrasonic magnetostrictive vibrator connected to said tensioning means to impart ultrasonic vibrations to the material along the direction of feed.

4. In a reversible metal rolling mill, a plurality of rotatable rolls for compressing and feeding metal placed therebetween, a first tensioning device to grasp one end of the metal, a second tensioning device to grasp the other end of the metal, said tensioning devices being adapted to pull the leading end of the metal in the direction of feed and to exert a rearward pull on the trailing end thereof, and ultrasonic vibrating means connected to said tensioning devices to impart ultrasonic vibrations to the metal along its direction of feed.

5. In a sheet metal rolling apparatus having a plurality of rotatable compressing and feeding rolls, a pair of guide rails transverse to said rolls, a carriage mounted on said guide rails, motor means operatively connected to said carriage, clamp means on said carriage adapted to grip and tension the metal fed from said rolls in the direction of feed, and an ultrasonic magnetostrictive vibrator associated with said carriage adapted to impart ultrasonic vibrations to the material along the feeding direction.

6. A sheet metal rolling apparatus comprising a plurality of parallel rotatable rolls in feeding engagement adapted to compress and feed the metal placed in their bite, clamp means adapted to hold the leading edge of the metal fed by said rolls, a hydraulic cylinder, a piston movably mounted in said cylinder connected to said clamp, said clamp means in response to motion of said piston being adapted to tension the metal along the feeding direction, and a plurality of pinch rolls in feeding engagement adapted to tension and ultrasonically vibrate the metal along the feeding direction.

7. A rolling apparatus comprising a plurality of parallel rotatable rolls in feeding engagement adapted to compress and feed a workpiece placed in their bite, a clamp adapted to hold the leading edge of the workpiece fed from said rolls, cylinder and piston means secured to said clamp and adapted to tension the workpiece along the feeding direction, and a magnetostrictive transducer between said clamp and said piston means adapted to vibrate said clamp and the workpiece in the feeding direction at ultrasonic frequency.

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