

Nov. 7, 1939.

A. SIMONS

2,178,674

METHOD AND APPARATUS FOR DRAWING STRIPS

Filed March 23, 1937

4 Sheets-Sheet 1

Fig. 1.

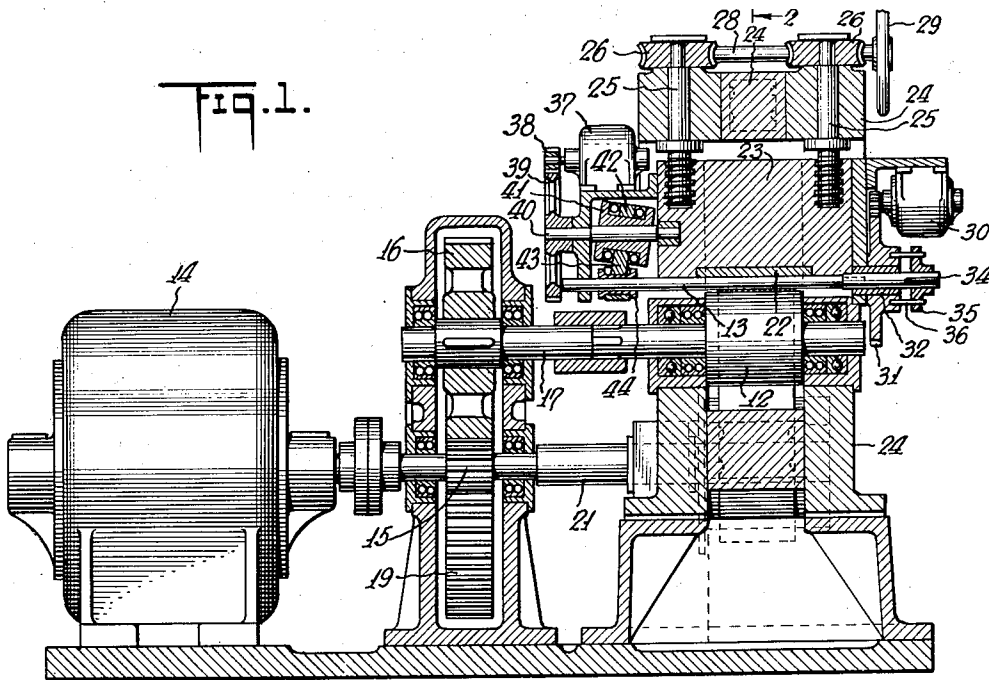
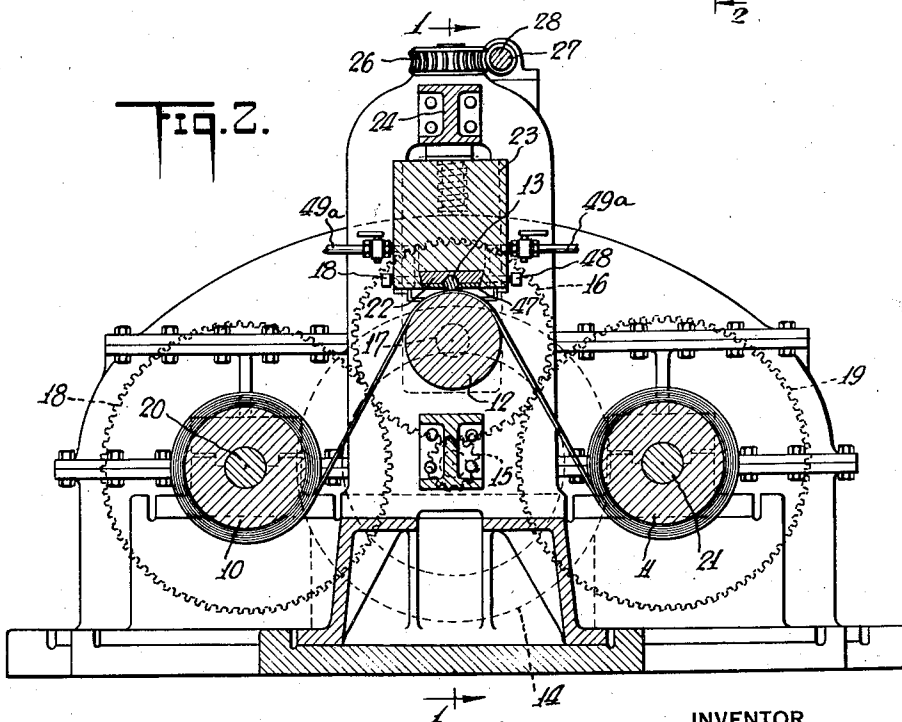


Fig. 2.



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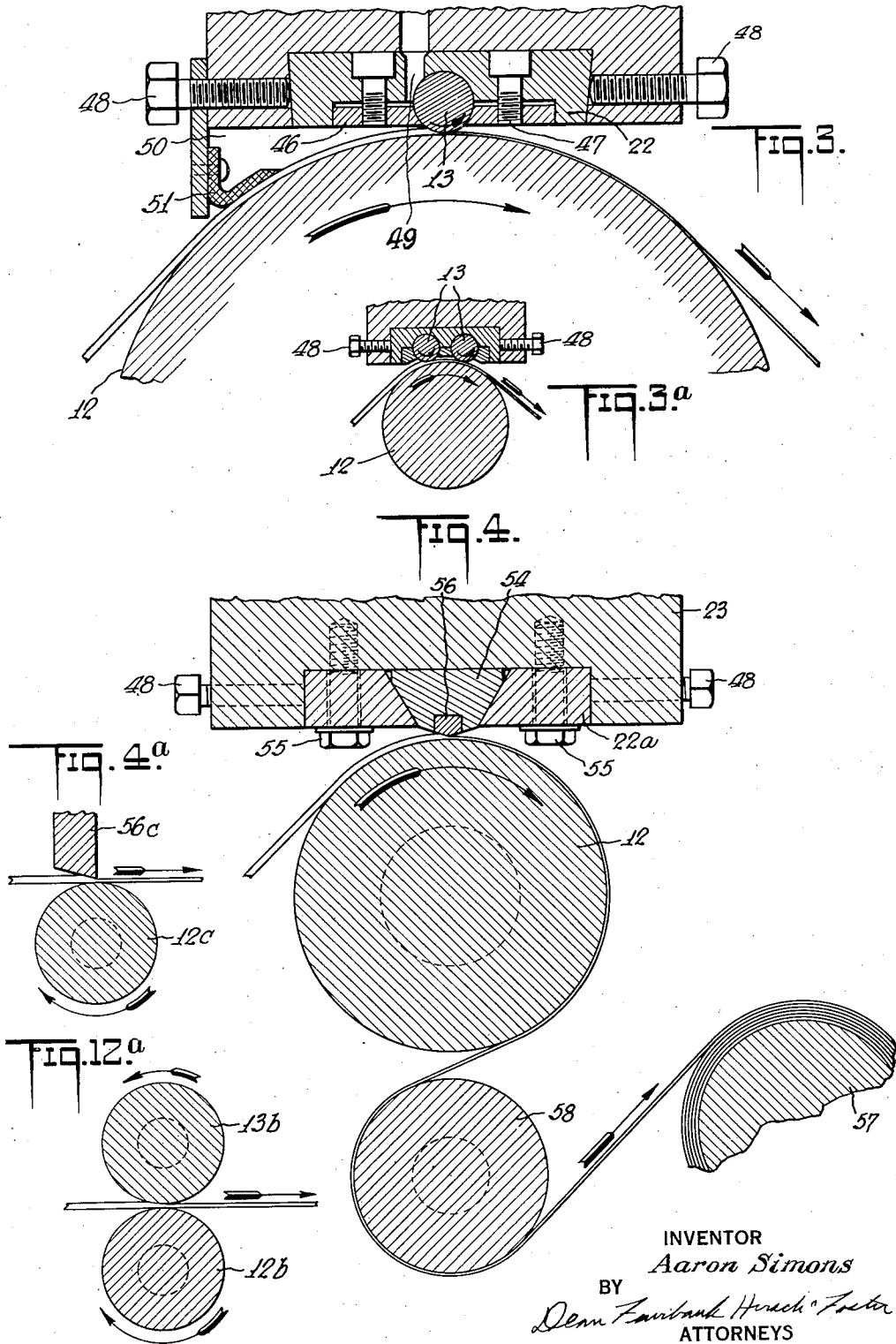
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4 Sheets-Sheet 2



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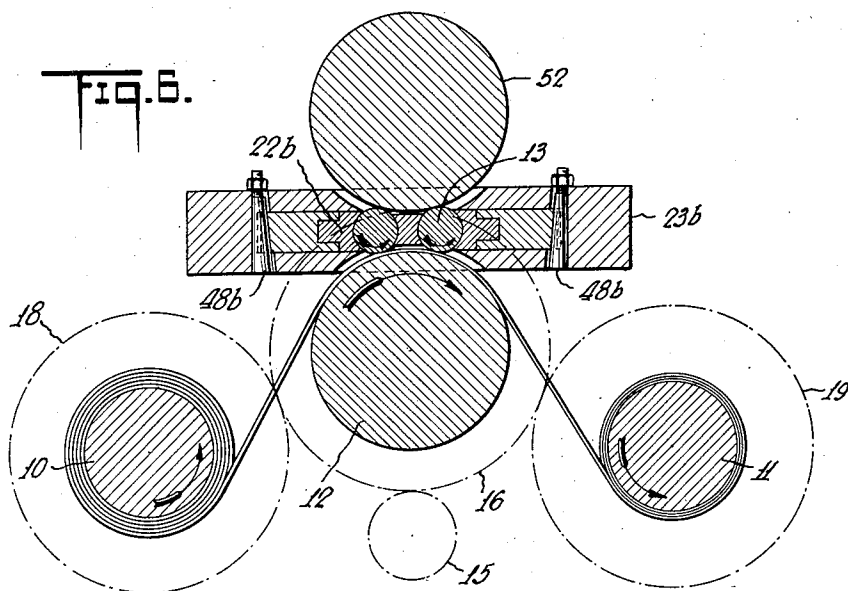
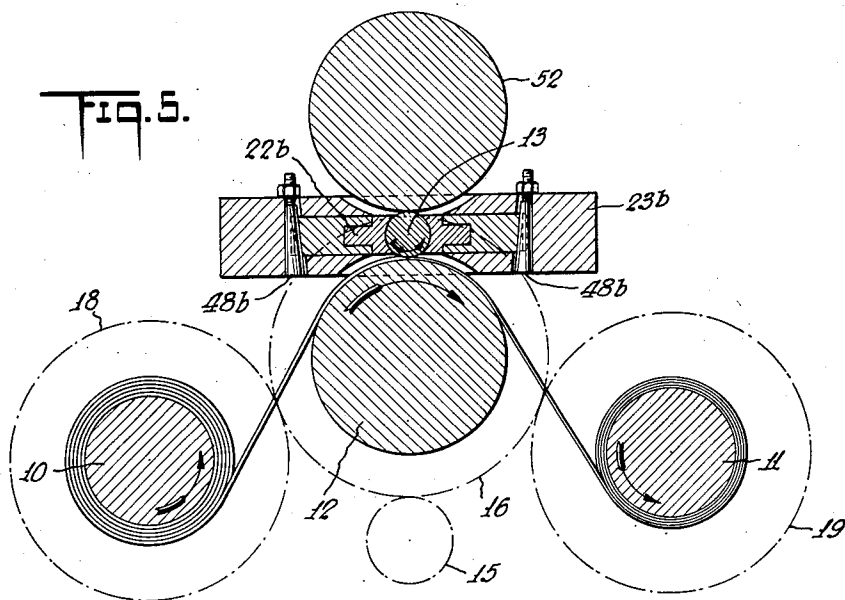
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METHOD AND APPARATUS FOR DRAWING STRIPS

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4 Sheets-Sheet 3



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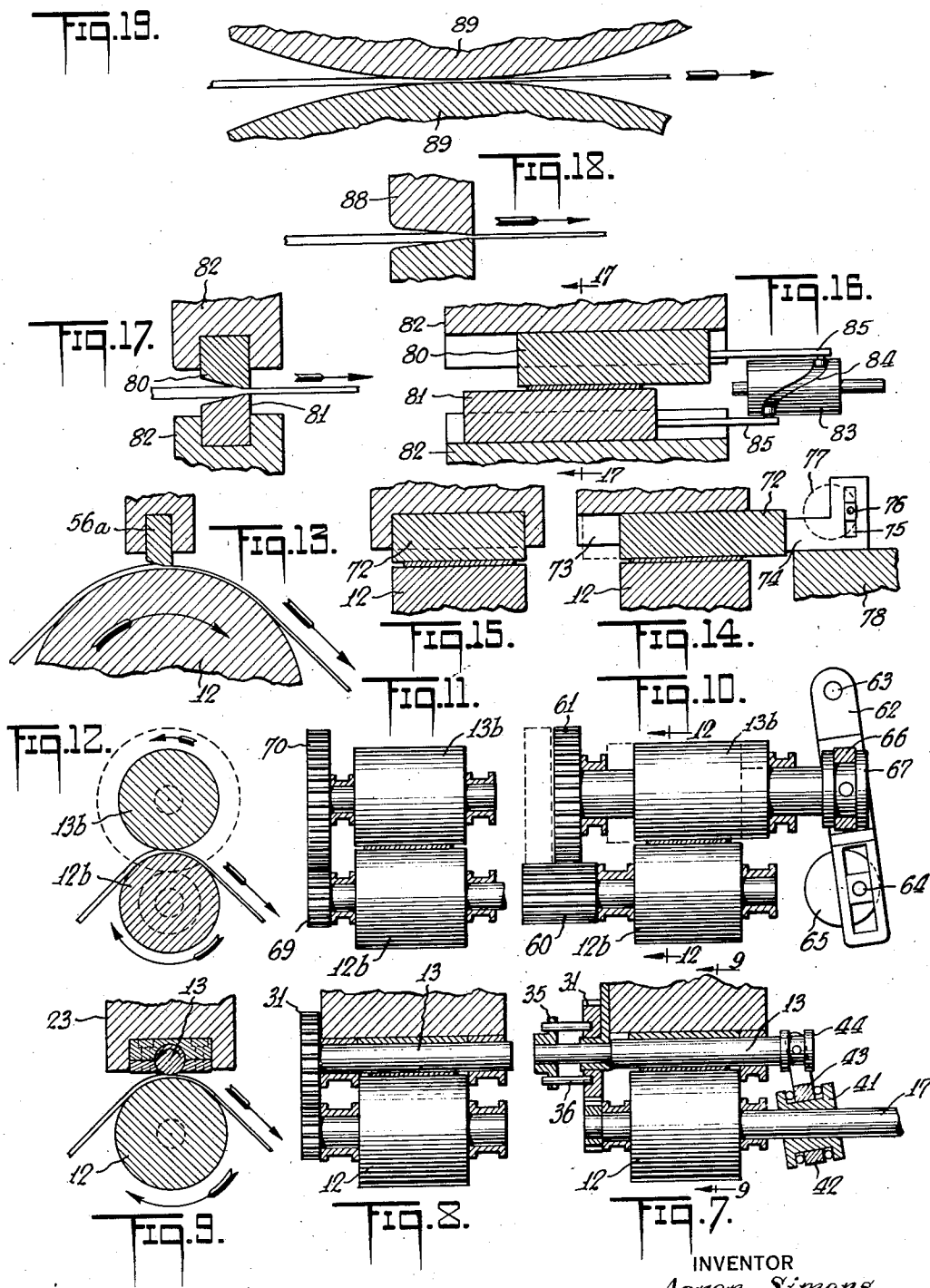
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METHOD AND APPARATUS FOR DRAWING STRIPS

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4 Sheets-Sheet 4



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METHOD AND APPARATUS FOR DRAWING STRIPS

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Application March 23, 1937, Serial No. 132,497

25 Claims. (Cl. 205—1)

5 This invention relates to methods and apparatus for reducing the thickness of metal stock to obtain thin, flexible products, and is applicable for use with non-ferrous metals, wrought iron, high carbon steel, low carbon steel and ductile alloys, such for instance as stainless steel.

10 The reduction in thickness is effected progressively along the length of the stock, and the final product may be in the form of a long, thin sheet or strip of any desired width, although the invention is particularly useful in connection with the manufacture of what is commonly known as metal strips.

15 Two different principles have heretofore been employed in effecting reduction in thickness. For wires there is commonly employed a stationary die having a somewhat conical aperture through which the wire is pulled, and the only power exerted is that required to pull the wire through. Such a stationary die may be employed for wire drawing because a wire, round in cross-section, has the minimum of surface for any given cross-sectional area, and has the maximum tensile strength in respect to the frictional surface resistance offered by the stationary die surface. Therefore sufficient tension may be imparted to the wire to pull it through the die without breaking the wire if only a comparatively small reduction in diameter be effected by the die.

20 It is impossible to effect a very large reduction in diameter, and it is necessary that there be a relatively small angle between the surface of the incoming wire and the surface of the die at the point where the two come into contact. The sliding movement of the wire on the die surface is substantially equal to the speed of movement of the wire.

25 In the drawings there is not only the surface frictional resistance of the oppositely inclined stationary die surfaces, but there is also a high internal frictional resistance due to the fact that the wire can pass through only by a redistribution of the grains or particles of the metal, and a wedging or pressing of them inwardly from the surface of one diameter to the surface of smaller diameter.

30 Stationary dies are not employed for drawing strips, due to the fact that a strip has small cross-sectional area compared to its surface, and a sufficiently high tension cannot be employed to pull the strip through a die having stationary die surfaces without liability of breaking or stretching the strip to further reduce its thickness.

35 For reducing the thickness of cold metal strips, it is common to employ a pair of rollers having

the speed of surface movement of the rollers substantially equal to the speed of travel of the strip. One roller may be driven and the other idle, or both may be driven, or both may be idle, in which latter case the rotation of the roller is effected solely by the pull on the strip. If there is no pull on the product the rollers will not feed the material through if the angle between the surface of the incoming material and the surface of the rollers is above a certain minimum. If the difference between the thickness of the stock and the minimum distance between the rollers be more than 1% of the diameter of either roller, the rollers will not feed the stock between them. If a pull be exerted on the material and this pull be utilized to rotate the rollers, the tension on the material is so great as to cause breakage if a large reduction in thickness is desired.

40 Where a pair of rollers is used and with their surfaces traveling at approximately the same speed as the material and either rotated by the material or positively driven, the rollers grip the material at the point where they come in contact with it and tend to crowd or push the material forward toward the narrowest gap between the rollers, and this compression tends to force the material to flow laterally as well as longitudinally and causes a widening or spreading action.

45 The surfaces of the rollers in approaching each other at the bite, act in substantially the same way as hammers, and only a comparatively small reduction in thickness can be obtained by a single pass between the rollers. For instance, in reducing a steel strip from 0.06 to 0.01 of an inch, about five passes are required. Furthermore, the pressure applied by the rollers effects a hardening of the metal, and with a strip of high carbon steel sometimes not more than two passes can be made without annealing before the next pass. The rollers act to spread the metal laterally as well as elongate it, and therefore trimming of the edges of the product is required, due to the fact that the spreading or widening is not uniform and the edges become rough.

50 Where material is placed between two die members moving in opposite directions and having sliding movement in opposite directions on the opposite surfaces of the material, very little force is required to move the material sideways or endwise, and therefore a strip may be pulled through with very little effort even through the oppositely disposed and oppositely moving members in surface contact therewith be exerting a very high pressure on the strip. This principle is utilized in carrying out the invention disclosed and claimed

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in my prior copending application 29,809, filed July 5, 1935, which has since issued into Patent 2,092,188, granted September 7, 1937.

5 In my present invention I utilize the principle of having a differential movement between the opposed die surfaces whereby the resistance to pull is reduced. My present invention is to be distinguished from the ordinary rolling machine in that there is a substantial relative movement
10 between the strip and each of the opposed pressure applying die surfaces.

My present invention is an improvement in dies rather than in rolling machines in that there is a sliding movement between the strip and both of the opposed die surfaces. It utilizes a relative
15 sliding movement characteristic of a die in such a way that the friction between the surface of the strip and the die surfaces is greatly reduced, and a strip may be pulled through the die to effect a very substantial reduction in thickness and with
20 a very much higher entrance angle between the strip and the die surfaces than is possible either with the ordinary rolling machine or with stationary dies. In other words, I utilize the principle of a wire drawing die for drawing strips and
25 accomplish this by effecting a relative movement between the opposed die surfaces and between the die surfaces and the strip. Such relative movement may be accomplished by having one die surface stationary and the other rotating faster
30 than the strip, or by having both die surfaces move with the strip, but one at a lower speed and the other at a higher speed than the strip. The relative speeds would be the same if that of one member is zero and that of the other is 400 feet
35 a minute as it would be if one were moving at 100 feet per minute and the other at 500 feet per minute.

As a result of my invention I am able to reduce the thickness of a strip to the desired extent by the use of far less expensive and more compact apparatus; with a smaller number of passes; with no spreading; and with a much
40 larger number of passes between successive annealing operations. The final product has a smoother surface, a better grain structure, and smooth edges which ordinarily do not require trimming.

In my improved apparatus the strip is pulled
50 between a pair of die members, at least one of which is in the form of a driven roller. This roller is driven at such speed that its surface in contact with one surface of the strip travels in the same direction as but at a higher speed
55 than the strip. The other die member in contact with the opposite surface of the strip may have a speed of travel with the strip very much lower than that of the strip, the low limit being zero speed. Thus the strip in moving between the
60 members travels slower than the contacting surface of one die member, and faster than the surface of the other die member, the speed of the strip being controlled solely by the pull on it. Thus the strip is advanced by the combined
65 action of the pull exerted on it, and the frictional engagement of the surface of the faster moving die member.

As a further important feature one of the die members, and preferably the one of lower or zero
70 speed, has a back and forth movement transversely of the strip. This acts not only to reduce the tension required to pull the strip, but also prevents the die member from becoming pitted
75 or grooved by any hard surface particles on the

strip, and thus prevents the formation of ridges on the surface of the strip.

The die member having a surface speed higher than the strip materially aids in advancing the latter, and as a further feature the area of surface contact of the faster moving member may be comparatively large, for instance, by having the strip wrapped partly around the die roller.

As a further feature the other die member has a comparatively small surface contact so that the reduction in thickness takes place while the strip is moving through a very narrow area, and takes place very rapidly with correspondingly high heating effect. The surfaces of the grains of the metal inside the strip are thus subjected to very great friction while moving in respect to each other during a very brief interval, and the resulting heating permits the rearrangement of the grains of metal with little or no deformation or elongation, and the grain structure of the strip before and after the reduction in thickness is not materially different. Thus the strip may be subjected to a relatively large number of passes, if great reduction in thickness is desired, and without the necessity for successive annealing operations.

As a continuous pull is exerted on the strip, this acts to remove the metal from between the contacting die members at the point where the strip is being heated by the action of the members, and thus there is little or no tendency of the metal to spread sideways and increase the width of the strip.

In constructions in which two rollers are used as the die members, a further feature is the use of rollers of different diameter, the slower one being, for instance, only one-third or one-sixth the diameter of the faster moving one.

As a further feature the small slower roller is supported against bending movement, with or away from the strip along the section contacting with the strip, so that there will be a uniform spacing between the die members, and the strip will be of the same thickness throughout its entire width. The strip in moving slower than the small roller, helps to turn the latter.

In my improved process a strip even of high carbon steel may be easily reduced from 0.06 to 0.01 inch in thickness by a single pass. Thus only a single pair of thickness reducing members is required as compared with four or five pairs of rollers now commonly required. The final product is made at less expense because of the cheaper and simpler equipment, no trimming is required, less annealing is required, and the product has a far better grain structure, with no substantial elongation or flattening of the grains, and without material hardening of the strip.

The invention, as to some of its features, may be utilized in some present types of strip rolling machines where the rollers are of the same size, the only change necessary being to provide proper strip pulling mechanism and changing the gearing to turn one roller faster than the strip and the other slower.

In all constructions the difference between the speed of the strip and the slow or zero speed die member is preferably greater than the difference between the speed of the strip and the fast moving die member. For instance, with a strip moving 400 feet per minute, the slow roller may have a surface speed of 200 feet per minute and the fast roller one of 500 feet per minute.

In the accompanying drawings:

Fig. 1 is a central vertical section through a

machine embodying my invention, said section being taken on the line 1—1 of Fig. 2,

Fig. 2 is a central vertical section taken on the line 2—2 of Fig. 1,

Fig. 3 is a sectional detail corresponding to a portion of Fig. 2, but on a very much larger scale,

Fig. 3a is similar to Fig. 3, but shows two of the slower moving die members,

Fig. 4 is a section similar to Fig. 3, but showing a non-rotatable upper die member and a modified form of strip pulling and reeling means,

Fig. 4a is a view similar to Fig. 4, but showing the strip passing through in a straight line rather than following a portion of the surface of the die roller,

Fig. 5 is a view similar to a portion of Fig. 2, but with the smaller rotatable die backed up by a larger idler pressure roller,

Fig. 6 is a view similar to Fig. 5, but showing the two small die rollers of Fig. 3a backed up by a pressure roller,

Fig. 7 is a section similar to a portion of Fig. 1, but showing a modified form of mechanism for driving and reciprocating the slower moving die member,

Fig. 8 is a section similar to Fig. 7, but showing a mechanism in which the slower moving die member is not reciprocated,

Fig. 9 is a section on the line 9—9 of Fig. 7,

Fig. 10 is a somewhat diagrammatic view showing rollers of the same size, but different speeds of rotation, one roller being longitudinally movable,

Fig. 11 is a section similar to Fig. 10, but in which neither roller moves endwise,

Fig. 12 is a section on the line 12—12 of Fig. 10,

Fig. 12a is a view similar to Fig. 12, but showing the strip disposed in a single plane,

Fig. 13 is a section similar to Fig. 4a, but in which a slightly different non-rotatable die member is used, and the strip follows a portion of the surface of the faster moving die member,

Fig. 14 is a somewhat diagrammatic longitudinal section through a construction in which a non-rotatable die member is moved back and forth transversely of the strip,

Fig. 15 is a section somewhat similar to Fig. 14, but in which no endwise reciprocation is employed,

Figs. 16 to 19 are sections showing constructions which do not embody the present invention, but which by contrast emphasize certain novel features of the present invention. In these figures:

Fig. 16 is a somewhat diagrammatic section in which neither of the die members has any surface movement lengthwise of the strip, but in which both move merely transversely of the strip,

Fig. 17 is a section on the line 17—17 of Fig. 16,

Fig. 18 is a section through an ordinary wire drawing die, and

Fig. 19 is a section through an ordinary strip rolling apparatus.

In the specific form of the machine illustrated in Figs. 1, 2 and 3, the flexible strip of sheet metal which is to be reduced in thickness is supplied from a suitable reel or drum 10 and is delivered between the die members and wound up on a second reel or drum 11. The die members include two rollers 12 and 13 spaced apart to a distance equal to the desired thickness for the delivered strip. The two rollers are of different sizes and are rotated at different speeds. They may be actuated from different sources of power.

The reel 11 is rotated at such speed that the strip is pulled between the die members at a faster speed than the surface speed of the roller 13 and slower than the surface speed of the roller 12. The roller 12 is shown as about six times the diameter of the roller 13, and the direction of movement of the strip to and from the gap between the rollers 12 and 13 is such that the strip follows along a considerable portion of the periphery of the roller 12. This large surface contact aids in the pull on the strip and also resists any tendency of the reciprocating small die member or roller to move the strip edgewise.

The mechanism illustrated for driving the rollers includes an electric motor 14 provided with a pinion 15 meshing with a gear 16 on the shaft 17 of the roller 12. The gear 16 meshes with gears 18 and 19 on shafts 20 and 21 respectively of the reels. The gears 18 and 19 are larger than the gear 16 so that they have a lower angular speed. Thus the shafts 20 and 21 rotate at a smaller number of revolutions per minute than does the shaft 17.

The sizes of the reels 10 and 11, the gears 18 and 19 and the roller 12 are such that the reel 11 exerts a positive pull on the strip, but the rate of travel of the strip is lower than the peripheral speed of the roller 12, and therefore the roller 12 by its frictional engagement with the strip tends to advance the strip, but is continually slipping in respect thereto due to its faster surface travel, and the strip aids in rotating the roller 13. Each reel is connected to its gear by a clutch (not shown), the clutch of the supply reel being disengaged and the clutch of the rewinder being engaged. Thus by reversing the motor and shifting the clutches the machine may pass the strip through, first in one direction and then in the other.

It is not necessary that there be any slip in the clutch to give a uniform speed of the strip. The strip speed may increase as the diameter of the reel of material increases, but at the start it should be faster than the die 13 and at the end slower than the die 12.

The roller 13 which may be made of tungsten carbide or have its surface coated with it, is mounted in a housing 22 which supports the roller along the entire portion of the length thereof which is opposed to the strip and prevents any upward or lateral bending movement between the bearings. Thus any desired amount of pressure may be exerted on the strip by the two rollers, but without liability of bending the roller 13 even if it be of small diameter and insuring the maintenance of uniform spacing between the rollers.

The housing permits the roller 13 to be very small and the smaller this roller the steeper will be the angle of the surfaces approaching the bite and shorter will be the time interval during which the reduction in thickness takes place, the greater the heating effect of internal friction and the less the necessity for later annealing.

The housing or bearing block 22 is mounted in an adjustable frame member 23 so that the spacing between the two rollers 12 and 13 may be varied at will. As shown, the main frame 24 of the machine is provided with a pair of vertically disposed shafts 25 held against longitudinal movement, but having their lower ends threaded into the frame member 23. These shafts may have worm wheels 26 at their upper ends and both meshing with worms 27 on a shaft 28 which may be rotated by a hand wheel 29 to raise or lower

the frame member 23 and the roller 13 carried thereby.

Mounted upon the frame member 23 there is provided means for rotating the roller 13 and also for moving it back and forth endwise. The mechanism for rotating the roller is illustrated as a small electric motor 30 having a pinion meshing with a gear 31 mounted on a bearing sleeve 32 supported by the frame member 23. The roller 13 has an extension 34 keyed to a plate 35 connected by parallel pins 36 to the gear wheel 31 so that the roller 13, its extension 34 and the plate 35 may be moved endwise without breaking the driving connections between the gear 31 and the roller 13.

For reciprocating the roller 13 there is provided an electric motor 37 having a pinion 38 meshing with a gear 39 on a shaft 40. This shaft has mounted thereon a collar 41 with a peripheral groove disposed in a plane at an angle to the axis of the shaft 40. Mounted in this groove and spaced from the sides thereof by suitable roller bearings is a second collar 42 provided with an arm 43 extending into a groove in a collar 44 on an extension of the roller 13. Thus as the collar 41 is rotated by the electric motor 37 the arm 43 on the collar 42 will swing back and forth in the direction of the axis of the shaft 40, and the roller 13 will be caused to move back and forth endwise.

Various other types of mechanism may be employed for effecting the reciprocation of the roller 13 and the distance through which it reciprocates may be varied through comparatively wide limits. Various other means might be employed for rotating the roller 13, as for instance, it might be driven directly from the motor 14, but whatever mechanism be employed it should be such that the peripheral speed of the roller 13 is very much lower than the speed of travel of the strip, and as previously noted, the speed of travel of the strip is lower than the peripheral speed of the roller 12.

The main object of rotating the roller 13 is so that it will continuously present a fresh portion of its surface to the strip, and the liability of uneven wear is reduced to a minimum.

The main objects in reciprocating the roller 13 are to prevent uneven wear on the surface thereof, to insure the strip being drawn to uniform thickness throughout its entire width, and to minimize the liability of any pitting or grooving of the roller 13 such as might occur from harder portions or grit particles on the surface of the strip.

It will be noted that in the construction illustrated the reduction of thickness of the strip is due primarily to the pulling of the strip between the two die surfaces presented by the rollers 12 and 13, but that the pull required is reduced by the action of the roller or die member 12 tending to advance the strip. The strip is not increased in width by the crushing or spreading action of the two die members as the pull is exerted on the strip at the nip of the rollers where the strip is hot from the internal friction of the grains of the metal due to the rapid reduction in thickness which is taking place.

In case the roller 13 or its bearing block 22 becomes unduly worn, these parts may be readily removed and replaced. Wear as well as friction is reduced by the application of a lubricating liquid to the surface of the strip which comes in contact with the roller 13. As shown more in detail in Fig. 3, the bearing block 22 may be formed of two sections, the lower section 46

being held in place by screw bolts 47 extending through slots to firmly support the roller 13. The bearing block 22 may be laterally adjusted and detachably supported in a dove tail groove by screw bolts 48.

If lubricant is desired, the lubricant may be delivered to the upper surface of the strip at a point in advance of the nip of the two rollers. This may be delivered through a conduit 49 and may be retained in a chamber 50 by means of a wiper or packing 51. I have shown such a packing only at one side in Fig. 3, but if it is desired to make the machine reversible so that the strip may be fed through in either direction this may be duplicated on the other side of the nip of the rollers, and two of the lubricant pipes 49a may be employed, one at each side, as indicated in Fig. 2.

In Fig. 3 the relative speeds of surface travel of the two rollers, and the speed of the strip, are indicated by the relative lengths of the three arrows appearing on this figure.

In my improved machine the reduction in the thickness may be accomplished progressively, for instance by employing two of the rollers 13 for one roller 12. In Fig. 3a I have shown a construction substantially the same as that shown in Fig. 3 except that there are two of the rollers 13, both rotating at the same speed but so positioned that one of them is slightly nearer to the surface of the roller 12 than is the other.

The relative speeds of the rollers 12 and 13 and the strip may be the same as referred to in connection with Fig. 3, but there will be a slightly different degree of slip between the two rollers 13 and the strip, both of such rollers running at a lower speed than the speed of strip travel.

The same principle illustrated in Fig. 3a may be employed in either of the other forms herein-after described, that is, the die member of lower or even zero speed may be used in multiple in connection with the faster moving die member to accomplish a plurality of successive reductions for a single pass of the strip.

In the construction shown in Fig. 4 the lower die member is in the form of a roller 12 similar to that above described, while the frame member 23 carries the housing or bearing block 22a in which is slidably mounted a die carrier 54. The opposite surfaces of this member and the housing or bearing block 22a are preferably inclined so that the die carrier 54 will be held in place, and the proper amount of clearance be permitted through the action of screw bolts 55 and 48 to permit the reciprocation of the die carrier. The die 56 is preferably in the form of a bar of very hard material, such for instance as tungsten carbide or tool steel. As this die member cannot move in the direction of movement of the strip, it may be considered as having zero movement in that direction.

The pull on the strip is exerted by a winding reel 57, and in case it be desired to have the speed of endwise movement remain constant or the pull remain constant, the drive for such reel may include a friction clutch.

The rate of endwise travel of the strip in respect to the rate of surface speed of the die roller 12 is indicated by the relative lengths of the two arrows appearing on this figure. In other words, the die member 12 moves at a somewhat higher speed than does the strip. To give greater surface friction of the strip on the surface of the roller, and thus facilitate the advancing movement of the strip by such friction, the strip

may follow along over one half of the periphery of the roller 12 and may pass around an idler 58 on the way to the reel.

The die roller 13 shown in Figs. 1, 2 and 3 and the die member 56 shown in Fig. 4 are adapted for operation of the machine in either direction, that is, by reversing the direction of rotation of the rollers, the strip may be passed through from the right of Figs. 2, 3 and 4 instead of from the left. If the machine be so designed that the strip is to pass through in only one direction then the die member may have a surface inclined in only one direction as shown by the die member 56c in Fig. 4a and cooperating with a die roller 12c similar to the roller 12 above described. The strip may pass through in a single plane instead of following the surface of the roller 12c.

In Figs. 1, 2 and 3 the smaller and slower moving die member 13 is supported against movement away from the strip as well as in the direction of the strip by the housing 22. In many respects it is preferable to use the housing merely to hold the roller die against lateral movement and use a large stiff roller to back up the small one which might otherwise bend under high pressure. In Fig. 5 I have shown a construction which may be similar in all respects to Fig. 2 except that the housing 22b is open at the top so that the die roller 13 may engage, be backed up, and supported, and rotate a large idler roller 52. The housing 22b may be held in place and adjusted laterally in respect to a carrier 23b by bolts 48b tapered and engaging inclined surfaces so that by loosening one and tightening the other the roller die may be moved slightly sideways to slightly vary the spacing from the roller 12 or bring the rollers to true parallelism, there being several of these pairs of bolts spaced apart lengthwise of the roller die 13. This construction has the further advantage that the parts 13, 22b, 23b and 48b may be made up as a unit and installed between the two rollers of an ordinary strip roller, and by appropriate changes in the driving gears for the rollers and the addition of a proper strip pulling mechanism, the old machine may be changed into one embodying my present invention.

In Fig. 6 I have shown the same principle as in Fig. 5 but with the backing roller 52 acting to back up two smaller roller dies of the type shown in Fig. 3a. As the pressure on the pressure roller 52 tends to spread the roller dies 13 apart, the housing need not include a lateral support between the two roller dies 13. By adjusting the housing laterally one die 13 may be brought nearer the die 12 and the other farther from it, and thus relative amounts of reduction effected by each die 13 may be varied.

In Fig. 7 I have shown a somewhat different mechanism for operating the slower moving die member. Here the reciprocating mechanism 41, 42, 43, 44 may be similar to that shown in Fig. 1, but instead of being operated from a separate shaft is operated directly from the shaft 17 of the die roller 12. The pinion 38 for operating the gear 39 of the slower moving die member 13 is directly on the shaft 17 instead of being on the shaft of a separate motor, and the same mechanism 35, 36 or any other suitable mechanism may be provided for permitting the reciprocation without interfering with the driving movement.

In Fig. 8 a mechanism is shown similar to that shown in Fig. 7 except that no reciprocating

mechanism is employed for driving the slower moving die member 13.

In Fig. 10 there is shown a mechanism somewhat similar to that shown in Fig. 7, except that the die members 12b and 13b are of the same size but operate at different speeds. The driving connections between them include a long pinion 60 on the shaft of the die member 12b meshing with a gear 61 on the shaft of the endwise movable die member 13b. The endwise movement of the latter may be effected by a link 62 mounted on a pivot 63 and having its opposite ends moved back and forth by means of a crank pin 64 on a crank disc 65. Intermediate of the ends of the lever is a collar 66 held in the groove of a collar 67 on the shaft of the die member 13b and pivoted in the lever 62.

In Fig. 11 there is shown the driving connections which may be employed for actuating the die rollers 12b and 13b of the same size, but of different speeds. This involves a pinion 69 on the shaft of one die roller and of smaller diameter than the latter and meshing with a gear 70 on the shaft of the other die roller and larger than the latter.

It will be understood that in all of these forms means are provided for exerting a pull on the strip so that the latter will move faster than the speed of surface travel of one die member and slower than the speed of surface travel of the other die member.

In Fig. 12a the parts may all be the same as in either Fig. 10 or 11 or as in Fig. 7 or Fig. 8, but I have shown the strip being pulled straight through rather than following a portion of the surface of the faster moving roller die.

In the construction shown in Fig. 14 the die member 12 is a driven roller while the die member 72 is non-rotatable. It is mounted to slide back and forth endwise across the surface of the strip and may be supported in a groove 73. Merely as an example of means which may be employed for effecting reciprocation, there is shown an arm 74 extending from one end of the die member and having a slot 75 transversely thereof and receiving the eccentric pin 76 of a crank disc 77. The arm may be guided upon any suitable support 78.

The construction shown in Fig. 15 may be similar in all respects to that shown in Fig. 14 except that the die member 72 is not reciprocated.

In these figures the die member 72 may be of hardened or tool steel, and need not have an insert of tungsten carbide or the like as indicated in Fig. 4.

In Fig. 4a the die member is shown as having a flat surface at an angle to the plane of movement of the strip and terminating at a comparatively sharp edge. This is not essential as I may employ a non-rotatable die member 56a as shown in Fig. 13, and in which the portion on contact with the strip has an inclined cam or pivotal surface, and also a surface portion substantially parallel to the surface of the strip in contact therewith.

In Figs. 16 and 17 I have shown a type of construction which may be substantially the same as that set forth in application and patent heretofore identified. Here there are two die members 80 and 81 mounted to reciprocate in opposite directions, and in contact with opposite surfaces of the strip being pulled between them, but they have no movement with the strip. They may be mounted in grooves or in any other suitable man-

ner on carriers 82, and any means may be employed for effecting this reciprocation. As shown a cylinder 83 is provided with a cam groove 84 and mounted between arms 85 connected to the die members so that as the cylinder 83 rotates the die members so that as the cylinder 83 rotates the die members are moved back and forth. Due to this transverse movement of the die members a very much lower pull on the strip is required to effect this longitudinal movement and this reduction in thickness than would be the case were the die members 80 and 81 stationary.

In my present invention I utilize this same principle of relative movement of the die members, but the relative movement is longitudinally of the strip, although it may also be transversely of the strip.

In Fig. 18 I have shown somewhat diagrammatically an ordinary wire drawing die in which the surfaces of the apertured die member 88 are stationary and the wire is moved solely by the pull exerted on it, while in Fig. 19 I have shown somewhat diagrammatically an ordinary rolling machine in which the surfaces of the rollers 89 move with the strip and at substantially the same speed. Both may be driven or both may be idle, or one may be driven and the other idle, but regardless of whether the rollers be turned by the strip or be driven to rotate the strip the surface speed of the rollers remains substantially the same as that of the strip. If the rollers be turned by the strip they must be relatively much smaller in diameter than as shown.

In the construction shown in Fig. 10 the die members are rotatable, and of the same diameter, and only one is moved transversely of the strip. In Fig. 16 the members are non-rotatable, but both are moved back and forth across the strip. Obviously the mechanism for reciprocating both die members as shown in Fig. 16 may be employed to reciprocate both of the rotatable die members shown in Fig. 10, instead of that illustrated in Fig. 10. Analogous reciprocating mechanism may be employed for reciprocating both instead of only one of the rotatable die members shown in Figs. 1 and 7.

It will be understood that in connection with the various illustrations in Figs. 7, 8, 10 and 11, suitable means will be provided to compensate for the slight adjustment of the dies one with respect to the other especially in construction machines which are adapted for use on different types and kinds of workpieces or strips. However, where the machines are operated on workpieces or strips of the same dimensions for producing predetermined reductions therein, the need for material adjustments will not be required.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of reducing the thickness of a strip, which includes pulling the strip endwise between a driven roller member and a coating member at a speed less than that of the surface speed of the roller member and greater than any surface speed of the other member in the direction of travel of the strip.

2. The method of reducing the thickness of a strip, which includes pulling the strip endwise between a driven roller member and a coating rotatable member at a speed less than that of the surface speed of the roller member and greater than any surface speed of the other member in the direction of travel of the strip, and moving

the coating member back and forth transversely of the direction of movement of the strip.

3. The method of reducing the thickness of a flat strip, which includes positively pulling the strip endwise between a pair of die members, and rotating one of said die members about an axis parallel to one surface of the strip and with a peripheral speed greater than the positive pulling speed of endwise movement of the strip.

4. The method of reducing the thickness of a strip, which includes positively pulling the strip endwise between a pair of die members, rotating one of said die members about an axis parallel to the surface of the strip, reciprocating the other die member transversely of the strip, and the rate of endwise travel of the strip due to the pulling being less than the rate of surface speed of the rotatable die member.

5. The method of reducing the thickness of a strip, which includes pulling the strip endwise between a pair of die members, rotating both of said die members about axes parallel to the surface of the strip, and reciprocating one of said die members transversely of the strip, the speed of movement of the strip being faster than the speed of surface travel of one of the rotatable die members and slower than that of the other.

6. The method of reducing the thickness of a strip, which includes pulling it between a pair of rollers, and positively driving said rollers, one with a surface speed greater than that of the strip, and the other with a surface speed less than that of the strip.

7. The method of reducing the thickness of a strip, which includes pulling it between a pair of rollers, and positively driving said rollers, one with a surface speed greater than that of the strip, and the other with a surface speed less than that of the strip, the roller having the larger surface speed being of greater diameter than the one having the lower surface speed.

8. The method of reducing the thickness of a strip, which includes pulling it between a pair of rollers, and positively driving said rollers, one with a surface speed greater than that of the strip, and the other with a surface speed less than that of the strip, and moving one of said rollers axially back and forth transversely of the strip.

9. The method of reducing the thickness of a strip, which includes pulling the strip endwise between a driven roller member and a coating member at a speed less than that of the surface speed of the roller member and greater than any surface speed of the other member in the direction of travel of the strip, the roller member having comparatively large surface contact with the strip, and the coating member having comparatively small surface contact with the strip.

10. The method of reducing the thickness of a strip, which includes pulling the strip endwise between a driven roller member and a coating member at a speed less than that of the surface speed of the roller member and greater than any surface speed of the other member in the direction of travel of the strip, the roller member having a greater surface contact with the strip than has the coating member.

11. The method of reducing the thickness of a strip, which includes pulling it between a pair of die members, one of said members having an arcuate surface curved about a center parallel to the surface of the strip, a considerable portion of which surface is in contact with the strip and which is moved at a higher rate of speed in the

direction of strip travel than the strip whereby frictional engagement of the member with the strip tends to aid in advancing the strip.

12. An apparatus for reducing the thickness of a strip, which includes a roller and a coating die member, means for positively rotating said roller, and means for pulling the strip at a speed less than the surface speed of the roller.

13. An apparatus for reducing the thickness of a strip, which includes a roller and a coating die member, means for positively rotating said roller, means for pulling the strip at a speed less than the surface speed of the roller, and means for reciprocating the coating die member transversely of the strip.

14. An apparatus for reducing the thickness of a strip, which includes a pair of rotatable die members, means for positively rotating said members at different surface speeds, and means for pulling the strip therebetween at a speed greater than the surface speed of one member, and less than that of the surface speed of the other member.

15. An apparatus for reducing the thickness of a strip, which includes a pair of rotatable die members, one being of more than twice the diameter of the other, means for pulling a strip between the members at a speed different from the speed of surface travel of either of said members, and means for holding the portion of the smaller member in contact with the strip and preventing it from bending away from or with the strip.

16. An apparatus for reducing the thickness of a strip, which includes a pair of rotatable dies, means for pulling a strip between said members at a speed different from the speed of surface travel of either of said members, and a housing engaging the portion of the smaller member in contact with the strip and preventing it from bending away from or with the strip.

17. An apparatus for reducing the thickness of a strip, including a pair of rotatable die members of different diameters, means for positively rotating said members and imparting to the larger member a surface speed greater than that of the smaller member, and means for pulling a strip between said members and at a speed greater than the surface speed of the smaller member and less than the surface speed of the larger member.

18. An apparatus for reducing the thickness of a strip, including a pair of rotatable die members, means for positively rotating them about parallel axes and at different rates of peripheral speed, and means for pulling a strip between said members at a speed greater than that of one of the members and less than that of the other member.

19. An apparatus for reducing the thickness of a strip, including a pair of rotatable die members, means for positively rotating them about parallel axes and at different rates of peripheral speed, means for pulling a strip between said

members and at a speed greater than that of one of the members and less than that of the other member, and means for moving one of said members back and forth transversely of the strip.

20. An apparatus for reducing the thickness of a strip, including a rotatably driven die member, a non-rotatable die member parallel thereto, and means for pulling the strip between said die members at a speed lower than that of the surface speed of the rotatable die member.

21. An apparatus for reducing the thickness of a strip, including a relatively large rotatable die member, a plurality of coating die members at different distances from the surface of said first mentioned die member, means for pulling a strip between said first mentioned die member and said series of coating die members to effect successive reductions in thickness of said strip, and means for rotating said rotatable die member with a surface speed substantially faster than the speed of travel of the strip.

22. An apparatus for reducing the thickness of a strip, including a relatively large rotatable die member, a plurality of smaller coating die members at different distances from the surface of said first mentioned die member and rotatable about normally fixed axes, means for pulling a strip between said first mentioned die member and said series of coating die members to effect successive reductions in thickness of said strip, and a backing roller to hold the smaller die members from bending away from the larger one.

23. An apparatus for reducing the thickness of a strip, including a pair of rotatable die members of different diameters, means for positively rotating said members and imparting to the larger member a surface speed greater than that of the smaller member, means for pulling a strip between said members and at a speed greater than the surface speed of the smaller member and less than the surface speed of the larger member, and a backing roller to prevent the smaller member from bending away from the strip.

24. The method of reducing the thickness of a strip, which includes pulling it between a pair of rollers and positively driving said rollers, one with a surface speed greater than that of the strip, the other with a surface speed less than that of the strip, and backing and reinforcing the slower driven roller throughout the length thereof.

25. The method of reducing the thickness of a strip, which includes pulling the strip between a large diameter roller and two small diameter rollers cooperating with the large diameter roller at circumferentially spaced intervals in the passage of the strip between said rollers, positively driving all of said rollers, operating the large diameter roller at a surface speed greater than the feed of said strip between the rollers, and operating the small diameter rollers at surface speeds lower than the feed of said strip.

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