Nov. 29, 1938. F. H. SMITH ET AL 2,138,126

METHOD OF AND APPARATUS FOR DRAWING WIRE

Filed June 3, 1935 3 Sheets-Sheet 1

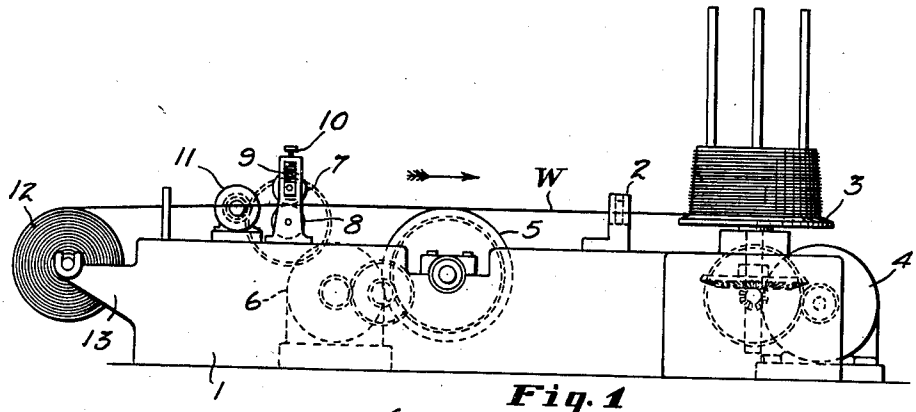

Fig. 1

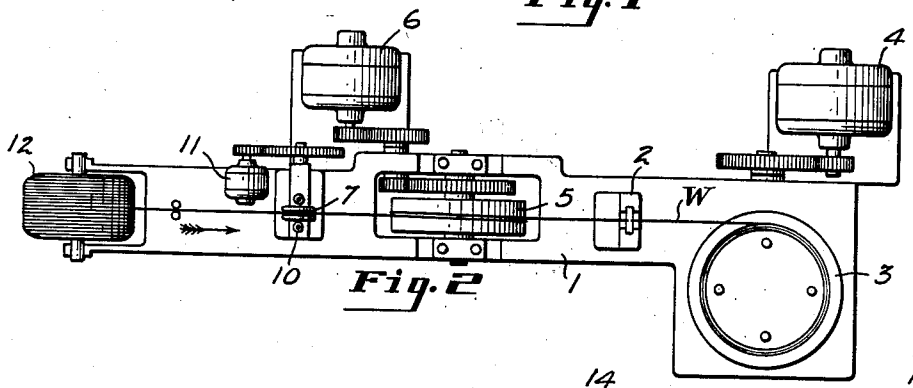

Fig. 2

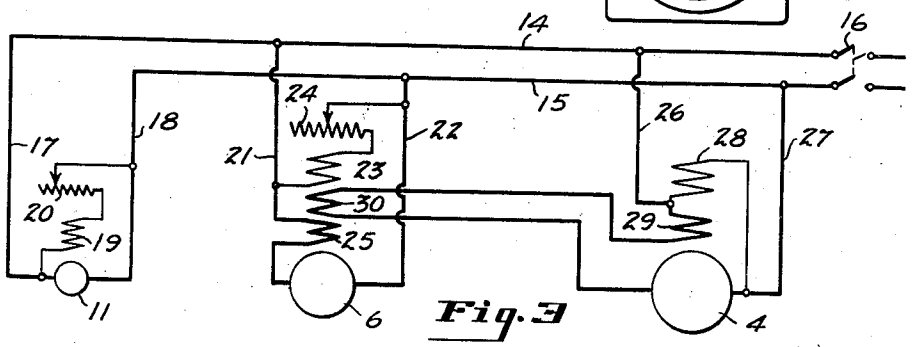

Fig. 3

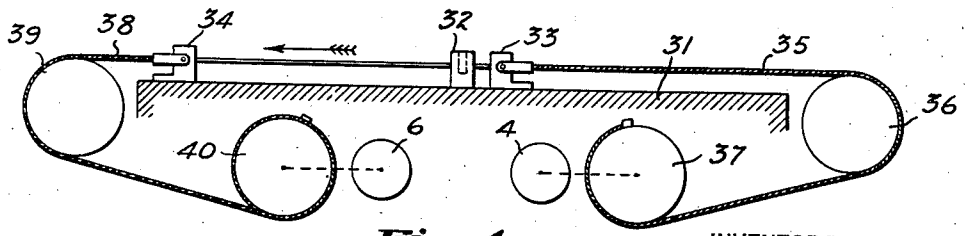

Fig. 4

INVENTORS
Frank H. Smith
Henry A. Stringfellow
BY Evans & McCoy
ATTORNEYS

Nov. 29, 1938. F. H. SMITH ET AL 2,138,126

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Filed June 3, 1935 3 Sheets-Sheet 2

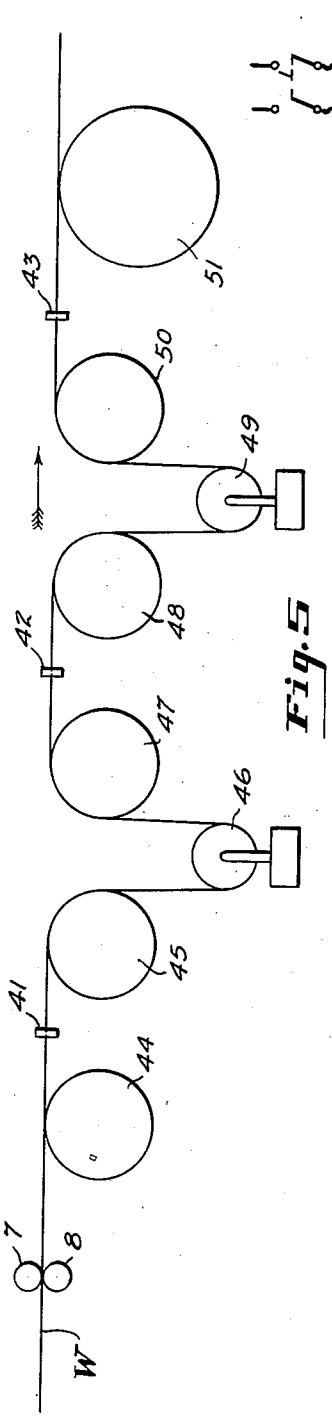

Fig. 5

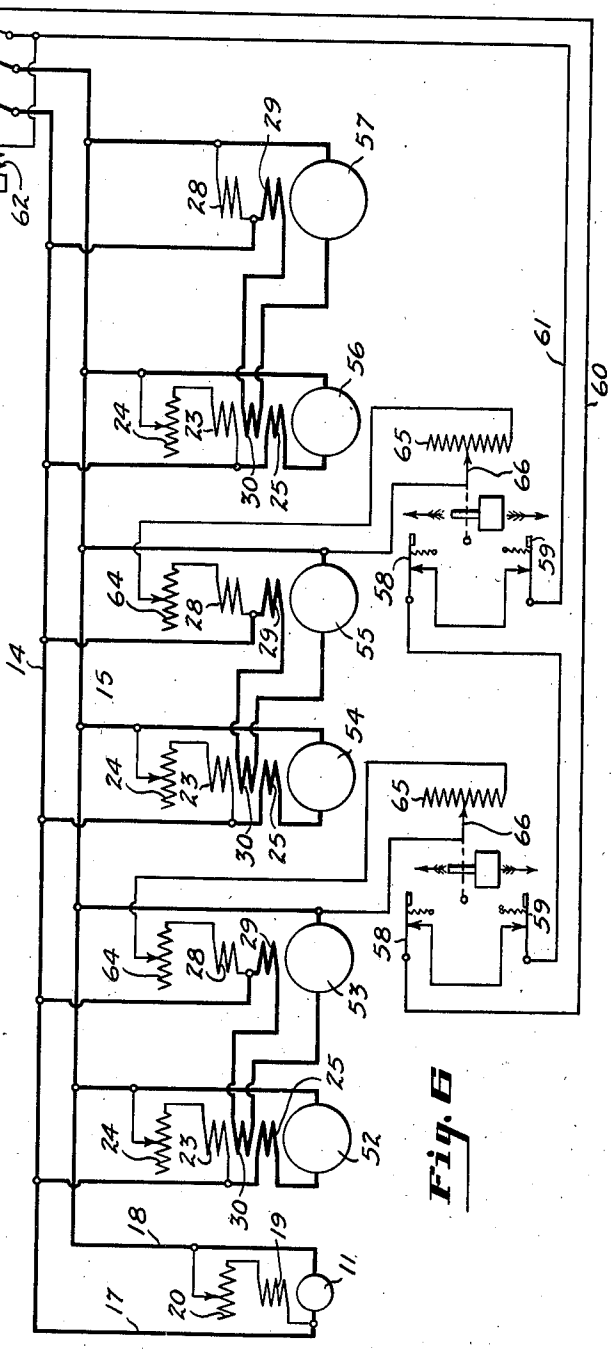

Fig. 6

INVENTORS
Frank H. Smith
Henry A. Stringfellow
BY Evans & McCoy
ATTORNEYS

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Filed June 3, 1935 3 Sheets-Sheet 3

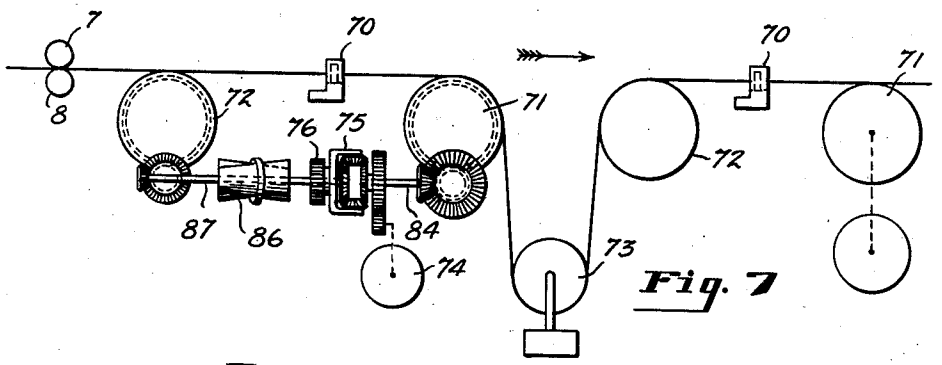

Fig. 7

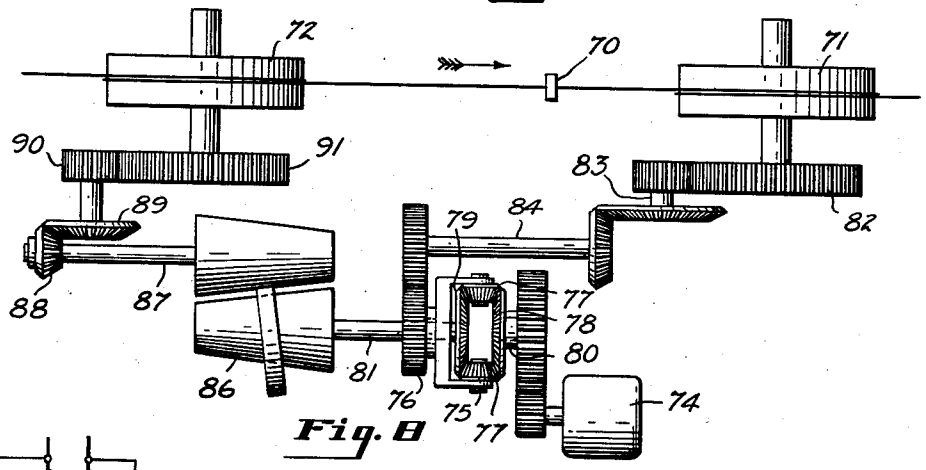

Fig. 8

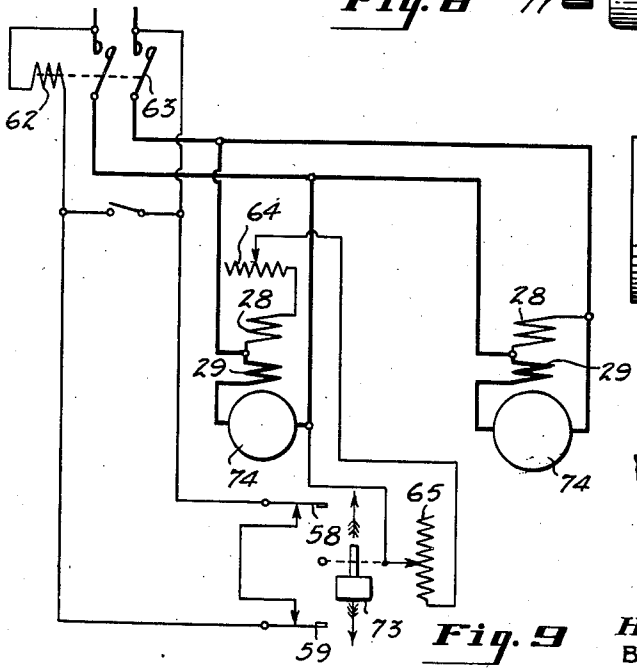

Fig. 9

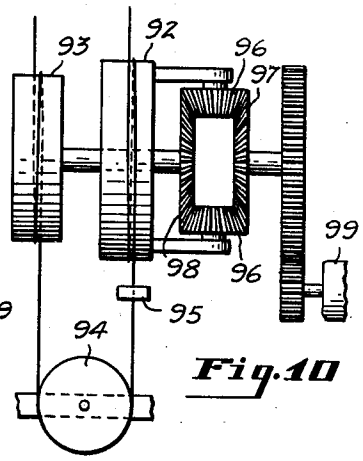

Fig. 10

INVENTORS
Frank H. Smith
Henry A. Stringfellow
BY Evans & McCoy
ATTORNEYS

Patented Nov. 29, 1938 2,138,126

UNITED STATES PATENT OFFICE

2,138,126

METHOD OF AND APPARATUS FOR DRAWING WIRE

Frank H. Smith, New York, N. Y., and Henry A. Stringfellow, St. Thomas, Ontario, Canada

Application June 3, 1935, Serial No. 24,666

18 Claims. (Cl. 205—14)

This invention relates to a method of and apparatus for elongating and reducing the cross-sectional area of wire, rod, bar, or other elongated metal bodies, solid or tubular, and particularly to a method of and apparatus for drawing wire, rods, bars, or other similar metal bodies, solid or tubular, through one or more reducing dies.

It has been demonstrated experimentally that if opposed forward pulling and retarding forces be maintained upon a wire or rod forwardly of and rearwardly of a reducing die through which the wire is being advanced, the resistance to forward movement imposed upon the wire by the die is reduced, and that the amount of reduction in die drag or load is proportional to the tension maintained in the wire or rod back of the die. It has been found that the tension imposed on the wire extending through a die may be increased to an extent such that only a very little lateral pressure is required to effect reduction of the wire and the load on the die is practically eliminated. The extent to which the drag of the die may be reduced is shown by the fact that it is possible to increase the tension of the wire to such an extent that the reducing die can be readily moved by hand along the wire to effect reduction of the wire, and this is true even when the die is of a size such as to effect a very substantial reduction in the cross-sectional area of the wire.

The experiments above referred to indicate the possibility of reducing the work required to be done by the die, and consequently reducing the rate of wear of the die by maintaining a retarding pull on the wire rearwardly of the die. There are, however, serious mechanical difficulties involved in the practical application of this principle to wire drawing machinery.

While the backward pull decreases the load on the die, the pull required to overcome the backward pull plus the drag of the die is usually materially greater than the pull required to draw the wire through the die without back tension.

Assuming the use of conventional drag applying devices such as brakes, attached weights or the like, the saving of wear on the die would usually be at the expense of additional power consumption due to the greater pull required to advance the wire against the drag of the die and the drag of the retarding devices.

An important object of the present invention is to provide a mechanism for simultaneously applying forward and retarding pulls in such manner that the applied forces are to a large extent balanced one against the other, so that the power required is but little more than the power required to overcome the reduced drag of the die, whereby a substantial saving in horsepower is effected as well as a reduction in the rate of wear of the die.

Other mechanical difficulties present themselves in the application of the principle to high speed wire drawing machines. It is obvious that the maximum tension to which the wire is subjected during the operation of the machine must never be in excess of the strength of the weakest portion of the wire which is being drawn. It is apparent that if a constant drag be imposed upon the wire back of the die, this drag must be considerably less than the theoretical amount that the wire could stand without breaking because of fluctuations in tension due to inertia of the mechanism, and due to the fact that portions of the wire may have considerably less tensile strength than other portions.

It is an important object of the present invention to provide a method of reducing wire, rod, bar, or similar metal bodies, solid or tubular, by maintaining a retarding force which is at all times proportional to the forward pull, whereby there will be a more gradual application of tension to the wire in starting the machine, the wire will be under proper tension at the instant it starts to move forward through the die, and the tension during operation is varied substantially in accordance with the strength of the portion of the wire passing through the die.

A further object is to provide a machine in which the tension applying devices may be adjusted before starting it into operation, and which minimizes fluctuations in the load on the die during operation.

A further object is to provide a machine which will apply a tension to the wire which is always below the elastic limit of the wire and which is automatically varied in accordance with the strength of different portions of the wire passing through the die. For example, when a soft section of the wire engages the die the pull necessary to draw the wire through the die is reduced and the back pull is reduced proportionately, thereby maintaining a tension in the wire proportional to the strength of the portion of the wire passing through the die.

A further object is to provide a pulling and tensioning mechanism in which the retarding device transmits power to the pulling device, thereby balancing the retarding force against the forward pulling force and applying tension to the wire with a minimum expenditure of power, so that the power required to operate the machine is sub-

stantially commensurate with the drag imposed by the die on the wire, and a substantial saving in power consumption is effected.

A further object of the invention is to provide a machine in which variations in the load on the pulling mechanism instantly and automatically effect corresponding variations in the load on the retarding mechanism.

A further object is to provide a mechanism in which the ratio of the loads on the pulling and retarding devices may be varied at will, and which will maintain a substantially fixed ratio between the loads of the two devices.

A further object of the present invention is to provide a machine in which it is unnecessary to impose the back pull or drag after the wire has begun to move through the die and in which the load on the die is substantially constant from the beginning to the end of the operation, so that the physical properties of the drawn wire are more uniform from end to end and from the surface to the center.

With the above and other objects in view the invention may be said to comprise the method and apparatus as illustrated in the accompanying drawings hereinafter described and particularly set forth in the appended claims, together with such variations and modifications thereof as will be apparent to one skilled in the art to which the invention appertains.

Reference should be had to the accompanying drawings forming a part of this specification, in which:

Figure 1 is a side elevation of a wire drawing machine embodying the invention;

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

Fig. 3 is a wiring diagram showing the connections for automatically controlling the retarding motor from the main pulling motor;

Fig. 4 is a side elevation of apparatus in which the invention is applied to rod, bar or tube drawing;

Fig. 5 is a side elevation showing diagrammatically the application of the invention to a machine in which a number of wire drawing units are arranged in tandem;

Fig. 6 is a wiring diagram showing the connections for controlling the retarding motors of the several units and for automatically varying the relative speeds of the pulling motors to compensate for variations in the relative speeds of the wire in successive units due to die wear or other causes;

Fig. 7 is a side elevation showing a modified form of wire drawing machine embodying the invention;

Fig. 8 is a plan view of one unit of the machine shown in Fig. 7;

Fig. 9 is a wiring diagram showing the motor controlling connections for the actuating motors; and

Fig. 10 shows a further modification of the invention.

In the modification of the invention shown in Figs. 1 to 3, the wire drawing mechanism is mounted upon a suitable bench or frame 1 and this mechanism includes suitable means for reducing the wire by lateral pressure such as a wire reducing die 2 fixed to the frame. A suitable wire pulling and coiling block 3 is mounted forwardly of the die, the block 3 being geared to a suitable electric driving motor 4. Rearwardly of the die 2 there is mounted a retarding drum 5 which is geared to a suitable retarding motor 6. Rearwardly of the retarding drum 5 there are a pair of pinch rollers 7 and 8, the upper roller 7 being pressed toward the roller 8 by means of a spring 9 the tension of which may be adjusted by means of a screw 10. The rollers 7 and 8 are geared to a suitable retarding motor 11. The wire W is fed from a spool or reel 12 mounted on a suitable bracket 13 at the rear end of the machine, the wire passing from the reel 12 or from a coil on the floor between the pinch rollers 7 and 8, making a plurality of turns around the retarding drum 5 and passing from the retarding drum 5 through the die 2 to the pulling block 3.

The retarding motor 11 is a small motor which applies its torque in a direction opposite that in which the pinch rollers 7 and 8 are rotated by the wire passing between them, and serves to impart a small initial drag to the wire sufficient to prevent slippage of the wire on the retarding drum 5 about which it is coiled. The retarding motors 6 and 11, and the pulling motor 4 receive their current from a common line, and since the retarding motors 6 and 11 are positively driven by the wire in a direction opposite that in which the electric current tends to drive them, these motors will feed current back into the line and thereby decrease the consumption of current from the main line, in effect counterbalancing a portion of the load on the pulling motor 4.

As shown in Fig. 3 of the drawings, motors 4, 6, and 11 are supplied with current from line wires 14 and 15, the master switch 16 being provided to interrupt the flow of current to the motors. The retarding motor 11 is connected through its armature by leads 17 and 18 to the line wires 14 and 15. The retarding motor 11 has a shunt field winding 19 connected to the leads 17 and 18 having a variable resistance 20 in series therewith which may be manually operated.

The retarding motor 6 is connected through its armature with the lines 14 and 15 by leads 21 and 22, and has a shunt winding 23 the excitation of which may be varied by means of a variable resistance 24 in series therewith, variable resistance 24 being manually adjustable to vary the excitation of the winding 23. The retarding motor 6 has also a series winding 25.

Pulling motor 4 is connected through its armature by leads 26 and 27 and has a shunt winding 28. The motor 4 also has a series winding 29 which is connected in series with an intermediate winding 30 of the retarding motor 6.

By adjusting the variable resistance 24 the ratio of the torque of the retarding motor to the torque of the pulling motor may be adjusted. The torque of the retarding motor is also affected by the torque of the pulling motor through the intermediate winding 30. If the load on the pulling motor 4 is decreased less current passes through the series windings 29 and 30, and the decrease in current through the winding 30 decreases the torque of the retarding motor 6. Any increase or decrease in the load on the pulling motor 4 will increase or decrease the current through the winding 30 of the motor 6, producing a porportional increase or decrease in the torque of the motor 6. Motors 4 and 6 may be provided with the usual starting connections designed to gradually apply the load so that in starting the machine into operation the opposed torque of the two motors will be gradually increased, gradually increasing the tension of the wire until the torque of the motor 4 sufficiently over-balances the torque of the retarding motor

6 to cause the wire to advance through the die. During operation the motor 4 operates at a substantially constant speed and the windings of the two motors 4 and 6 are so proportioned and so interconnected that there is a substantially proportional variation in the torques of the two motors.

By providing a variable retarding pull which varies with the load on the main motor, it is possible to maintain a backward pull more nearly equal to the forward pull with a correspondingly lighter load on the reducing die by reason of the fact that fluctuations in tension such as would be caused by a constant speed motor acting against the drag of the die and a constant retarding force such as the back pull of a dead weight are not imposed upon the wire. The load on the die may be made very low since the forward and backward pulls are directly controlled by the resistance of the die to the passage of the wire therethrough and instantly responsive to variations in die resistance.

At the beginning of the drawing operation the forward end of the wire is pulled through the die 2 far enough for engagement with the pulling block 3. The motors 4 and 6 are so adjusted that the motor 6 applies a torque to the retarding drum 5 somewhat less than the torque applied to the pulling block 3 by the motor 4. When the current is applied to the motors the torque of the motors 4 and 6 gradually increases proportionately until the excess torque of the motor 4 is sufficient to rotate the block 3 and advance the wire through the die. During operation the motor 4 rotates at substantially constant speed with whatever variations in load there may be due to the resistance of the die to passage of different portions of the wire being drawn. If one portion of the wire is softer than other portions the load on the pulling motor 4 will decrease while the soft portion of the wire is passing through the die, the reduction in the current through the winding 29 of the motor 4, due to decreased load, will effect a proportionate reduction in the torque of the retarding motor 6, so that the tension in the wire is decreased and the breaking of wire in a weak portion thereof is avoided.

The variation in the retarding force exerted on the wire also tends to lessen the amount of fluctuation in the load on the reducing die due to inequalities in the physical properties of the wire being drawn. By reason of the fact that a substantially fixed ratio less than unity is maintained between the retarding and pulling forces, it is unnecessary to make fine adjustments for wires of different tensile strength. A ratio of retarding force to pulling force which will effect the desired reduction in load on the die with one wire will reduce the load on the die by a substantially proportional amount in drawing wires having a tensile strength considerably higher or considerably lower. With a weight or brake for maintaining a constant tension back of the die it would be necessary to carefully adjust the back tension with reference to the tensile strength of the wire being drawn.

Figure 4 of the drawings shows the invention applied to the drawing of rods, bars, tubes or like metal bodies of definite length. This machine is provided with a suitable bed 31 to which is affixed a reducing die 32 and upon which are mounted two slides 33 and 34, the slide 33 being mounted for longitudinal movement forwardly of the die 32, the slide 34 being mounted for longitudinal movement rearwardly of the die 32.

The rod, bar or tube to be drawn is reduced at one end sufficiently to be inserted in the die 32 and this end is inserted through the die and anchored to the slide 33. A cable or chain 35 is attached to the slide 33, extends over a sheave 36 at the forward end of the bed 31 and is attached to a reel 37. A cable or chain 38 is attached to the slide 34, extends over a sheave 39 at the rear end of the bed 31, and is attached to a reel 40. Pulling and retarding motors 4 and 6, interconnected as shown in Fig. 3 of the drawings, actuate the reels 37 and 40, the retarding motor 6 exerting a back pull on the rod, bar or tube through the reel 40 which is always proportional to the load imposed upon pulling motor 4.

In Figs. 5 and 6 of the drawings the invention is shown applied to a multiple unit wire drawing machine. In the multiple unit wire drawing machine as many dies as desired may be provided through which the wire is drawn successively, three such dies, 41, 42, and 43 being shown in the drawing. The wire W passes from a spool, reel or coil between pinch rollers 7 and 8, is coiled about a retarding drum 44, and passes through the first die 41. Forwardly of the die 41 the wire is coiled about a pulling block 45 and passes downwardly from the block 45 through a suitable slack take-up device such as a weighted sheave 46 and upwardly and around a retarding drum 47. Forwardly of the retarding drum 47 the wire passes through the second reducing die 42 and around a second pulling block 48, the wire passing from the pulling block 48 downwardly beneath a second weighted sheave 49 and upwardly around a third retarding drum 50, passing through the third die 43 and around a third pulling block 51. The wire may pass from the pulling block 51 to a reel, may be coiled on the block 51 or may pass through as many additional dies as are provided in the machine, each die being in a separate drawing unit provided with a pulling block and a retarding drum, a slack take-up device being provided between each pair of successive wire drawing units of the machine. Pinch rollers 7 and 8 are geared to a retarding motor 11 and connected in the line exactly as in the single unit machine shown in Figs. 1, 2, and 3. The retarding drum 44 is geared to a retarding motor 52 which corresponds substantially to the retarding motor 6 in the single unit machine. The pulling block 45 is geared to a driving motor 53 which corresponds substantially to the driving motor 4 in the single unit machine. The retarding drum 47 is geared to a retarding motor 54, and the pulling block 48 is geared to a driving motor 55. The retarding drum 50 is geared to retarding motor 56 and the pulling block 51 is geared to a driving motor 57. The driving and retarding motors of each wire drawing unit of the multiple machine are connected in substantially the same way as in the single unit machine, so that the torque of each retarding motor varies with the load imposed upon the driving motor.

In the multiple unit machine the relative rate of travel of the wire through successive units will vary somewhat due to unequal wear on the dies. The weighted sheaves 46 and 49 provide a compensating means which will take up various lengths of wire between successive units, synchronize the units so that there will be no slip between the wire and any pulling block, and impose sufficient tension upon the wire between

the units to prevent slippage of the wire on either the pulling block behind or the retarding drum ahead of the sheave.

The movable take-up device may be utilized to operate limit switches 58 and 59 which are connected by leads 60 and 61 to a solenoid 62 which operates a master switch 63 to discontinue the flow of current to the motors and stop the machine, the switches 58 and 59 being so arranged that closure of either switch will actuate the solenoid 62 to stop the machine. If the wire should break, one of the weighted sheaves will fall and operate the limit switch 59 to stop the machine. Should a die break, the rate of travel of the wire back of that die will increase, raising the weighted sheave at the rear of the unit in which the die is broken and operating the upper limit switch 58 to stop the machine.

In order to avoid the necessity of stopping the machine at intervals to readjust for unequal travel of the wire, means may be provided for automatically varying the speed of the pulling motors to maintain a uniform travel of the wire through the units. As shown in Fig. 6 each pulling motor has two variable resistances 64 and 65 in series with its shunt winding 28, the variable resistance 64 being manually adjustable and the variable resistance 65 being controlled by one of the weighted sheaves 46 or 49 each of which carries the controller arm 66 of one of the variable resistances 65. Variable resistances 65 under the control of the vertically movable weighted sheaves automatically increase or decrease the speeds of the respective pulling motors to maintain uniform travel of the wire. As the weighted sheave moves downwardly, the speed of the adjacent pulling motor is decreased, and as the sheave moves upwardly, the speed of the motor is increased. The manually adjustable variable resistances 64 may be adjusted from time to time to establish speeds of rotation such that there will be a minimum amount of movement of the weighted sheaves.

Figs. 7, 8, and 9 of the drawings show a modification of the invention in which the proportional torque of the retarding drum is maintained by driving connections from a single motor to the pulling and retarding drums.

In this machine a plurality of reducing dies 70 are provided. A pulling block 71 is provided in advance of each die and a retarding drum 72 is provided rearwardly of each die. Between successive units a weighted controlling sheave 73 is suspended from the pulling and retarding drums. The pulling block and retarding drum of each unit are geared to a single motor 74 through a differential 75 which includes a combined case and ring gear 76 which carries bevel pinions 77 which mesh with bevel gears 78 and 79 fixed to axially aligned shafts 80 and 81. The pulling drum is geared to the ring gear 76, a gear 82 on the pulling drum shaft being connected by suitable gearing through shafts 83 and 84 to the ring gear.

The retarding drum is geared to the shaft 81 through a suitable change speed device 86 which is preferably of the type capable of effecting small changes of speed ratio, a change speed device of the friction cone type being shown. The driving connection from the change speed device to the retarding drum 72 is through shaft 87, bevel gear 88, bevel gear 89 and spur gears 90 and 91.

The driving connections from the pulling block 71 to the ring gear 76 and from the retarding drum to the gear 79 are such that the ring gear 76 and gear 79 turn in the same direction when the block 71 and retarding drum 72 are turning in the same direction. The gear ratios may be such that when the pulling block 71 and retarding drum 72 are turning at the relative speeds at which they rotate during the drawing operaton the gears 76, 78 and 79 rotate in unison. As the motor 74 is started into operation the bevel gear 78 will exert a thrust on one side of each pinion 77 tending to move the ring gear in a direction to move the pulling drum 71 forwardly. Movement of the ring gear and drum 71 is resisted, however, by the wire and die 70. The pinions 77 therefore exert a thrust in the opposite direction on the gear 79 which is equal to the thrust applied to the pinions by the gear 78. This opposite thrust on the gear 79 tends to turn the drum 72 in a backward direction which movement is opposed by the forward pull on the wire applied from the ring gear.

Each pinion 77 acts as a lever, fulcruming at one end on a tooth of the gear 79, having power applied thereto by a tooth of gear 78 and applying a thrust to the ring gear 76 at the axis of the pinion 77 midway between the power and fulcrum points. The thrust on the ring gear is, therefore, double the thrust applied by the gear 78 and the thrust on the gear 79 is equal to the thrust applied by the gear 78. The force applied to the pulling block 71 is, therefore, greater than the opposed thrust on the drum 72 and when the applied force is increased sufficiently the pulling drum 71 will move forwardly drawing the wire through the die.

The thrust on the gear 79 tending to rotate the drum 72 rearwardly is always proportional to the thrust applied to the ring gear and the retarding back pull on the wire is always proportional to the load on the pulling block.

By varying the ratio between the shaft 81 and the drum 72 the back pull may be varied. Variations in the gear ratio may cause the gear 79 to turn faster or slower than the gear 78 and this will vary the speed of operation of the machine, the speed of the ring gear 76 being equal to one-half the algebraic sum of the speeds of the gears 78 and 79. Travel of the wire at the desired speed may be maintained by adjusting the speed of the motor 74 through its controller to compensate for changes in the gear ratio between the drum 72 and the differential gear 79.

The control of the motor 74 to maintain a fixed rate of wire travel may be manual or may be automatic. For automatic control it is only necessary to interconnect the motor controller with the shifting element of the speed change device or to interconnect the motor controller with a speed responsive device such as a governor geared to the pulling block.

During operation a fixed speed ratio would usually be maintained, and the only change in speed would be a very slight increase in the speed of travel of the wire as the die openings are enlarged due to wear.

Fig. 10 shows a simplified form of differential drive wire drawing mechanism comprising a pulling block 92, a retarding drum 93, a fixed sheave 94 and a die 95. The pulling block and retarding drum are axially aligned and the wire is coiled oppositely on the two drums. The pulling block 92 is the cage of a differential which is rotatable with respect to the retarding drum 93 and which carries bevel pinions 96 which mesh with bevel gears 97 and 98 coaxial with the block.

The bevel gear 97 is geared to a motor 99 and the bevel gear 98 and the retarding drum 93 are fixed to the same shaft and rotate together.

If a force be applied to the gear 97 tending to turn it in the direction in which the pulling block 92 must rotate to pull the wire through the die, an equal and opposite thrust is transmitted through pinions 96 to the gear 98 tending to rotate the retarding drum in a direction opposite that in which the gear 97 is tending to rotate. This puts a tension on the wire tending to turn the pulling drum 92 backwardly, but the forward thrust on the pulling block is twice the applied thrust due to the lever action of pinions 96 and exerts a pulling force on the wire greater than the backward pull of the retarding drum. When sufficient forward thrust is exerted by the gear 97 the pulling block 92 will begin to move forwardly and pull the wire through the die. As the wire is being drawn the reactive thrust of the pinions 96 on the gear 98 will maintain a back pull on the wire proportional to the forward pull exerted by the pulling drum 92. The diameter of the retarding drum determines the ratio of the back pull to the forward pull and this ratio may be made to be any desired ratio less than unity by substituting retarding drums of different diameters.

The relative speed of motors driving successive units of the machine may be controlled in exactly the same way as in the multiple unit machine illustrated in Figs. 5 and 6. As shown in Fig. 9, the slack take-up sheave 73 controls a variable resistance 65 which varies the speed of the motor 74 as previously described in connection with the machine illustrated in Figs. 5 and 6 and limit switches 58 and 59 are provided to stop the machine upon breakage of the wire or one of the dies.

Various experiments have been made which indicate that a substantial reduction in the drag of the reducing die on wire may be obtained by exerting a back pull on the wire rearwardly of the die. There has been, however, insofar as we are aware, no practical application of the principle in wire drawing machines.

There are several outstanding advantages in the method herein disclosed. The method of the present invention not only decreases the load on the die with a corresponding increase in the life of the die, but also effects a material saving in the power required for the drawing operation. Machines embodying the present invention have great flexibility and require a minimum amount of manual adjustment during operation due to the automatic variation of the retarding pull on the wire. With any given fixed ratio less than unity between the retarding force and the load on the pulling drum, the tension applied to any wire being drawn will approximate a predetermined percentage of the tensile strength of that wire and it is not necessary to make fussy adjustments to adapt the machine to work on wires of different tensile strengths.

Since the tension is automatically reduced while softer portions of a wire are passing through the die, a tension more nearly approaching the elastic limit of the wire may be maintained.

The automatic variation of tension greatly reduces the amount of variation in the drag or load imposed upon the die during the operation of the machine, tending to maintain a substantially constant load on the die.

Furthermore, it is to be understood that the particular form of apparatus shown and described, and the particular procedure set forth, are presented for purposes of explanation and illustration and that various modifications of said apparatus and procedure can be made without departing from our invention as defined in the appended claims.

We claim:

1. The method of elongating and reducing the cross-sectional area of rod, wire, or similar elongated metal bodies which comprises applying opposed longitudinal pulling forces to the body at longitudinally spaced points, imparting a longitudinal movement to the body, reducing the cross-sectional area of the body and retarding longitudinal movement thereof by applying lateral pressure thereto between the points at which the opposed pulling forces are applied, and maintaining a substantially fixed ratio less than unity between the opposed pulling forces during longitudinal movement of the body.

2. The method of elongating and reducing the cross-sectional area of rod, wire, or similar elongated metal bodies which comprises applying opposed longitudinal pulling forces to the body at longitudinally spaced points, reducing the cross-sectional area of the body and retarding longitudinal movement thereof by applying lateral pressure thereto between the points at which the opposed pulling forces are applied, and maintaining a substantially fixed ratio less than unity between the opposed pulling forces, and increasing the opposed pulling forces proportionately until said body is caused to travel forwardly and be progressively reduced in cross section.

3. The method of elongating and reducing the cross-sectional area of rod, wire or similar elongated metal bodies which comprises reducing the size of an end portion of the body and inserting the same through a restricted passage, applying a forward pulling force to the body forwardly of the restricted passage and a retarding force to the body rearwardly of the restricted passage, maintaining a substantially fixed ratio less than unity between the retarding and pulling forces, and increasing said forces proportionately until the body is caused to move forwardly through the restricted passage.

4. The method of elongating and reducing the cross-sectional area of rod, wire, or similar elongated metal bodies which comprises reducing the size of an end portion of the body and inserting the same through a reducing die, applying a forward pulling force to the body forwardly of the reducing die and a retarding force to the body rearwardly of the reducing die, maintaining a substantially fixed ratio less than unity between the retarding and pulling forces, and increasing said forces proportionately until the body is caused to move forwardly through the reducing die.

5. The method of drawing wire, rod, or the like, which comprises applying a pulling force to the wire or rod to advance the same through a reducing die, applying a retarding force to the wire rearwardly of the die which bears a substantially fixed ratio less than unity to the forward pulling force, and maintaining said fixed ratio between the retarding force and forward pull by varying the retarding force proportionately with respect to variations in forward pull.

6. The method of drawing wire, rod, or the like, which comprises inserting the forward end of the wire or rod through a reducing die, applying a pulling force to the wire or rod for-

wardly of the die, applying a retarding force to the wire or rod rearwardly of the die, maintaining a substantially fixed ratio less than unity between the retarding and pulling forces, and increasing the pulls proportionately until the wire or rod is caused to travel forwardly through the die.

7. The method of drawing wire, rod or the like which comprises inserting the forward end of the wire or rod through a reducing die, applying a forward pulling force to the wire or rod forwardly of the die and simultaneously applying an opposed retarding force less than the pulling force to the wire or rod rearwardly of the die, proportionately increasing the pulling and retarding forces until the wire or rod is moved forwardly through the die, moving the wire forwardly at a substantially constant speed, and increasing or decreasing the retarding force as the pulling force is increased or decreased.

8. Apparatus for reducing and elongating wire, rod or similar elongated metal bodies which comprises pulling and retarding means engageable with the body at spaced points, means forming a restricted passage for the body between said pulling and retarding means, means for actuating said pulling and retarding means, and means controlling said actuating means to proportionately vary the forces exerted on the body by the pulling and retarding means to maintain a substantially fixed ratio less than unity between the retarding and forward pulling forces whereby the resistance to forward movement of the body through the restricted passage may be overcome and a forward movement may be imparted to the body by increasing the pulling and retarding forces proportionately.

9. Apparatus for drawing wire, rod or the like comprising a reducing die, pulling means forwardly of the die, retarding means rearwardly of the die, means for actuating said pulling and retarding means, and means for controlling the actuating means to simultaneously and proportionately vary the forces exerted by the pulling and retarding means and for maintaining a substantially fixed ratio less than unity between the retarding and forward pulling forces.

10. Apparatus for drawing wire, rod or the like comprising a reducing die, pulling means forwardly of the die, retarding means rearwardly of the die, means for actuating said pulling and retarding means, means for controlling the actuating means to simultaneously and proportionately vary the forces exerted by the pulling and retarding means and for maintaining a substantially fixed ratio less than unity between the retarding and forward pulling forces, and means for varying the ratio between the retarding and forward pulling forces.

11. Apparatus for drawing wire, rod or the like comprising a reducing die, a pulling mechanism including an actuating motor acting on the wire or rod forwardly of the die, a retarding mechanism including an actuating motor acting on the wire or rod rearwardly of the die, and means for controlling the retarding motor to automatically decrease the torque thereof upon a decrease in the torque of the pulling motor.

12. Apparatus for drawing wire, rod or the like comprising a reducing die, a rotatable pulling element engageable with the wire or rod forwardly of the die, a rotatable retarding element engageable with and actuated by the wire or rod rearwardly of the die, means for applying torque in opposite directions to the pulling and retarding elements, and means varying the torque of the retarding element in accordance with variations in the torque of the pulling element to maintain a substantially fixed ratio between the retarding and forward pulling forces exerted on the wire or rod.

13. Apparatus for drawing wire, rod or the like comprising a reducing die, a rotatable pulling element engageable with the wire or rod forwardly of the die, a rotatable retarding element engageable with and actuated by the wire or rod rearwardly of the die, means for applying torque in opposite directions to the pulling and retarding elements, means varying the torque of the retarding element in accordance with variations in the torque of the pulling element to maintain a substantially fixed ratio between the retarding and forward pulling forces exerted on the wire or rod, and means controlling said torque varying means to change the ratio of the retarding and forward pulling forces exerted on the wire or rod.

14. A wire drawing machine comprising a plurality of reducing dies, a pulling device forwardly of each die, means for actuating each pulling device, means operated by the wire between successive dies for controlling the relative speeds of operation of the pulling devices, a retarding device rearwardly of each die, and means for controlling the retarding devices to vary the retarding force exerted thereby proportionately to variations in the load on a pulling device.

15. A wire drawing machine comprising a plurality of reducing dies, a pulling device forwardly of each die, means for actuating each pulling device, means operated by the wire between successive dies for controlling the relative speeds of operation of the pulling devices, a retarding device rearwardly of each die, means for controlling the retarding devices to vary the retarding force exerted thereby proportionately to variations in the load on a pulling device and for stopping the machine upon a variation in speed of travel of the wire such as occasioned by breakage of the wire or breakage of the die.

16. A wire drawing machine comprising a plurality of reducing dies, a wire pulling block forwardly of each die, a retarding drum rearwardly of each die, a movable member engaging the wire between a pulling block and a retarding drum, and means controlled by movements of said movable member to vary the relative speed of successive pulling blocks.

17. A wire drawing machine comprising a plurality of reducing dies, a wire pulling block forwardly of each die, a retarding drum rearwardly of each die, a movable member engaging the wire between a pulling block and a retarding drum, means controlled by movements of said movable member to vary the relative speed of successive pulling blocks, and means connecting each pulling drum with the retarding drum next in the rear thereof to apply a torque to the retarding drum opposed to the torque of the pulling block and bearing a substantially fixed ratio thereto.

18. A wire drawing machine comprising a plurality of reducing dies through which the wire passes, means in advance of each die for exerting a forward pulling force on the wire, means at the rear of each die for applying a retarding force to the wire, and means interposed between the pulling means in advance of one die and the retarding means at the rear of the next die to take up slack in the wire.

FRANK H. SMITH.
HENRY A. STRINGFELLOW.