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WIRE DRAWING MACHINE

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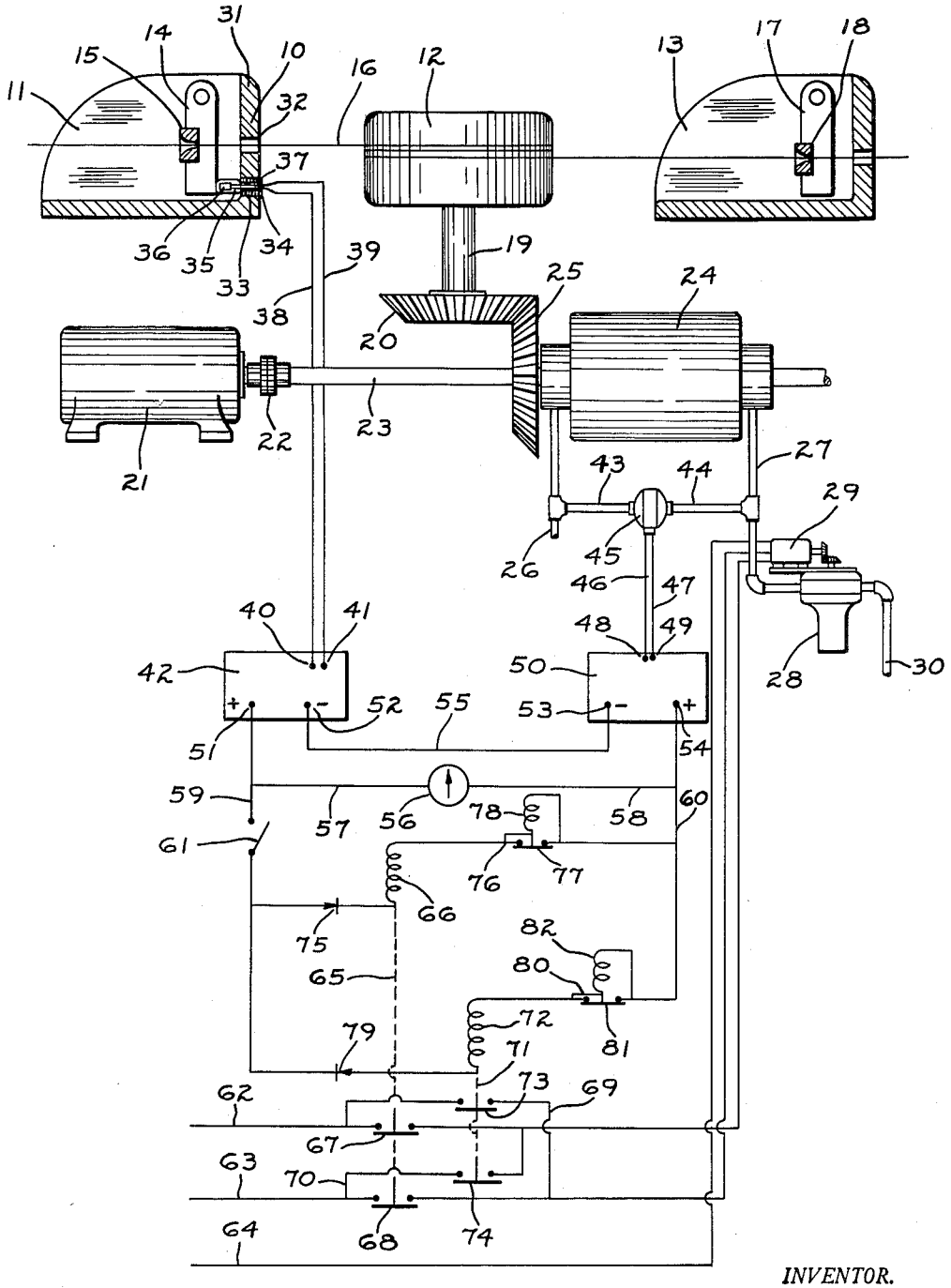


Fig. 1

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WIRE DRAWING MACHINE

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This invention relates generally to wire drawing machines, and more particularly to wire drawing apparatus, in which the tensions in the wire are maintained at a desired value within very close limits.

A continuous wire drawing machine may consist of a plurality of revolving blocks each connected to a common, driven jack-shaft by a clutch whose torque transmission characteristics may be changed as desired. It is the usual practice to operate such a machine with the application of a fixed torque to each block, the value of the required torque being determined by the particular drafting schedule, the size of the wire, desired back-pull, etc. For a particular drafting schedule with a given wire size, the established back-pull at each die, determined by the torque transmitted to the preceding block, will remain constant provided the wire characteristics at the position, such as diameter and hardness, remain the same. However, the established back-pulls will increase or decrease with an increase or decrease of the initial wire diameter, for instance. If the wire variation is extreme, the back-pull may increase to a value that will cause the wire to break or, conversely, may decrease to a value that will develop slack wire with subsequent wire breakage when the slack is suddenly taken up. The present invention obviates these difficulties, as will be evident from the description which follows.

It is therefore an outstanding object of the present invention to provide a wire drawing machine in which the torque delivered to the blocks is such as to maintain constant wire tensions throughout the machine.

A further object of this invention is the provision of apparatus for controlling the torque delivered to the first drawing block of a wire drawing machine as a means of maintaining constant back-pull throughout the machine regardless of changes in qualities, such as diameter, of the entering wire.

Another object of the invention is the provision of an apparatus for use with a hydraulic wire drawing machine for regulating the torque transmission to the first block in response to the die reaction at the first die.

A still further object of the invention is the provision of apparatus for maintaining within very close limits the torque transmission to a block of a wire drawing machine at a value sufficient, with the assistance of the back-pull on the following die, to overcome the resistance to drawing of the preceding die, but not enough to change the back-pull on the following die.

It is another object of this invention to provide a torque control apparatus for wire drawing which contains no elements which are subject to inertia, whereby it responds almost instantaneously to indications of change of wire quality.

Another object of this invention is the provision of apparatus of the type described which is relatively inexpensive and which can be used in conjunction with existing machines.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to certain of its structural forms, as illustrated by the accompanying drawing, in which:

The single figure is a somewhat diagrammatic view of a wire drawing machine embodying the present invention.

Referring to the drawing, a wire drawing machine, designated generally by the reference numeral 10, comprises a first die box 11, a block 12, and a second die box 13. The first die box 11 is provided with a hinged die holder 14, to which is fastened a die 15, through which a wire 16 passes for the reduction thereof. Similarly, the die box 13 is provided with a die holder 17 and a die 18. The block 12, which, in the preferred embodiment, is the first block in the machine, is generally cylindrical and is provided with a downwardly extending drive shaft 19 keyed to its upper end to the block and at the lower end to a bevel gear 20. A main motor 21 is connected through a coupling 22 to a main jack-shaft 23, which extends the full length of the wire drawing machine and underlies the blocks. The jack-shaft passes through a hydraulic slip clutch 24 and is keyed to the input element thereof. The clutch 24 is of the type having input and output elements, the torque transmitted from the input to the output element by the hydraulic fluid being proportional to the differential hydraulic pressure across the clutch. In other words, the clutch is a pump in which the output element is the reaction member and the torque transmitted to the reaction member is in proportion to the resistance to flow of the fluid. Such a clutch is shown in the patent to Morgan No. 2,185,416 issued January 2, 1940. The output element of the clutch 24 is keyed to a bevel gear 25 which is coaxial with the main jack-shaft and which is situated to mesh with the gear 20. Hydraulic fluid, originating in a distributing pump, not shown, enters the clutch 24 through an entrance conduit 26 and, after entering into the reaction between the input and output elements of the clutch, is discharged through an exit conduit 27. The exit conduit is connected to the inlet side of a pressure relief valve 28 which is provided with a motor 29 which determines the setting of the valve. The valve 28 determines the pressure which is to build up on the exit side of the clutch 24 and, thus, determines the torque which will be transmitted through the clutch from the main jack-shaft to the block 12. The valve discharges through a conduit 30 to a reservoir, not shown. The motor 29 is geared to the valve setting mechanism and, by actuating the motor, one is able to move the valve mechanism in such a manner that the valve will open at a selected differential pressure. The differential pressure will be equal to the back pressure on the clutch 24, less the inlet pressure, since the valve discharges to atmospheric pressure.

The die box 11 is provided with a back wall 31 through which passes an aperture 32 for the wire 16 and a threaded aperture 33 in the lower portion thereof. A plug 34 is threaded in the aperture 33 and is provided with a non-threaded, reduced portion 35 which protrudes inwardly of the box toward the lower portion of the die holder 14. On the surface of the reduced portion is fastened a strain gage 36. The strain gage is of the type containing an electrical resistance, the value of this resistance changing with the expansion and contraction of an object to which the gage is attached. Such a gage is shown and described in the patent to Simmons No. 2,292,549 issued February 23, 1940. However, a strain gage may be used in which the electrical property which changes with strain is inductance or capacitance. The gage is fastened to the cylindrical surface of the

reduced portion 35 of the plug and is operative to indicate any change in length of the portion when it is subjected to axial stress. A keyway 37 is formed in the side of the plug 34 and lead wires 38 and 39 from the gage are seated therein. The bottom of the keyway is deeper than the root of the thread on the plug by an amount sufficient for the lead wires to lie below the crests of the threads in the aperture 33. The lead wires 38 and 39 are, of course, electrically connected to the opposite ends of the resistance of the gage and their other ends are connected to the input posts 40 and 41, respectively, of an analyzer 42 of a well-known type. The analyzer contains an element similar to an ohmmeter which measures a resistance placed across the posts 40 and 41. This element produces a voltage signal proportional to the resistance and this signal is amplified by another element of the analyzer. The amplifier element is selected for linear response, so that the signal appearing across output posts 51 and 52 of the analyzer is proportional to the resistance of the strain gage 36.

A branch conduit 43 is attached to the entrance conduit 26 of the clutch 24, while another branch conduit 44 is connected to the exit conduit 27. These conduits are connected to opposite sides of a differential pressure gage 45. This gage is of a well-known type having an internal diaphragm dividing the interior of the gage housing into two chambers. A resistance-type strain gage similar to the gage 36 is fastened to the surface of the diaphragm to indicate deformation due to differential pressure on opposite sides thereof. Thus, the gage 45 will indicate the differential pressure of the hydraulic fluid in the clutch 24 between input and output, this differential pressure being proportional to the torque transmitted by the clutch. Lead wires 46 and 47, originating on the opposite ends of the resistance element of the gage 45, have their other ends attached to the input posts 48 and 49 of an analyzer 50 which is similar in construction to the analyzer 42. The analyzers 42 and 50 have the usual gain control for adjusting the degree to which they amplify the signals originating in them, so that, irrespective of the value of voltages impressed on the input posts, the output signals of the amplifiers can be adjusted to be very nearly equal. The output post 51 of the amplifier has a positive polarity, while the post 52 has a negative polarity; the output post 53 of the amplifier 50 has a negative polarity; while the post 54 has a positive polarity. A common wire 55 connects the posts of negative polarity 52 and 53. A voltmeter 56 is connected by means of lead wires 57 and 58 to wires 59 and 60 which, in turn, are connected to the positive posts 51 and 54 of the amplifiers. A main switch 61 is connected in series with the wire 59 adjacent the point of its connection with the lead wire 57.

Three power lines 62, 63 and 64 are connected at one end to the motor 29 of the valve 28 and at the other end to a source of three-phase power, not shown. A four-pole, single-throw relay 65, having an actuating coil 66, is connected to the power lines, so that one set of contactors 67 is interposed in the line 62, while the other set of contactors 68 is interposed in the line 63. The contactors 67 and 68 are normally open; that is to say, they interrupt the lines in which they lie when no current passes through the coil 66. A jumper wire 69 connects the line 62 on the power source side of the contactors 67 to the line 63 on the motor side of the contactors 68. A similar jumper wire 70 connects the line 63 on the power source side of the contactors 68 to the line 62 on the motor side of the contactors 67. A four-pole, single-throw relay 71, having an actuating coil 72, is connected to the jumper wires so that a set of contactors 73 is interposed in the wire 70. The contactors 73 and 74 are normally open in that they do not allow current to pass through their respective jumper wires when actuating current is not passing through the coil 72. The actuating coil 66 of the relay 65 is connected in series with a current rectifier 75 and a current-limiting device 76. The current-limiting device 76 is of a well-known type having a set of contactors 77 and a coil 78 connected in parallel with the contactors, so that a small amount of the current passing through the device is shunted into the coil 78; when the total current passing through the device is such that a predetermined value is reached, the coil 78 opens the contactors 77. The rectifier 75, the coil 66 and the device 76 are connected across the wires 59 and 60 so that current may pass in one direction only from the wire 59 to the wire 60, but, if the current exceeds a predetermined value for which the device 76 is set, the contactors 77 will open, thus interrupting the flow. A current rectifier 79, the actuating coil 72 and a current-limiting device 80 are connected in series across the lines 59 and 60. The current-limiting device 80 is provided with a set of contactors 81 and an actuating coil 82 and operates in a manner similar to the device 76. The rectifier 79 is connected to permit the flow of current therethrough in the direction opposite to that permitted by the rectifier 75, so that current will flow from the wire 60 to the wire 59, but only to an amount determined by the device 80.

The operation of the invention will be evident in view of the above discussion. The wire 16 passes through the die 15 and the aperture 35 and is wrapped around the block 12 from which it passes through the die 18. From there it continues through the wire drawing machine in the usual manner. With the machine operating at normal speed and with the back-pulls established in accordance with the size of the wire and other factors, the apparatus is balanced for this normal condition. This is done by opening the switch 61 and adjusting the gain controls of the analyzers 42 and 50 to the point where the voltmeter 56 registers zero. When this is done, the voltage appearing across the posts 51 and 52, due to the strain on the gage 36, is equal to the voltage appearing across the posts 53 and 54 due to the strain on the gage 45. After the apparatus has been balanced in the manner described, the switch 61 is closed. Any change in strain on the gage 36, due to increase in die reaction because of changes in wire size, etc., will cause a corresponding unbalance in the voltages on the outputs of the analyzers 42 and 50. This unbalance will be indicated on the voltmeter 56. If the wire size increases, the die reaction on the first die 15 will increase. This will cause the die holder 14 to swing about its hinge so that the lower portion will press with greater force against the end of the plug 34. The pressure of the die holder causes a compression of the reduced portion 35 only, since the remainder of the plug is threadedly held in the aperture 33 in the back wall 31 of the die box 11. The compression of the reduced portion of the plug is transmitted to the gage 36, since the two are firmly fastened together. The compression of the gage 36 produces a change in its electrical resistance and the analyzer recognizes this change by producing an increase in voltage across the output posts 51 and 52. This means that the original balance is upset and a voltage difference exists between the wires 59 and 60. Consequently, current passes from the wire 59 to the wire 60 through the rectifier 75, the coil 66 of the relay 65, and the current-limiting device 76. Passage of current through the coil 66 closes the normally open contacts 67 and 68, whereupon current passes through the power lines 62, 63 and 64 to the motor 29. Actuation of the motor changes the setting of the pressure relief valve 28, so that it produces a greater back-pressure on the clutch 24. This causes the clutch to transmit greater torque to the block 12. The net result is that the torque transmitted to the block 12 is increased enough to compensate for the increase in die reaction due to increase in wire size. When the motor 29 has changed the valve 28 a certain amount, the differential pressure across the clutch

24 will be increased, this increasing the differential pressure across the gage 45 and increasing its electrical resistance. The fact that the electrical resistance of the gage 45 has increased is noted by the analyzer 50, whereupon the voltage appearing across the output posts 53 and 54 is increased. When this voltage increases sufficiently to balance the voltage across the posts 51 and 52, current will cease to flow through the coil 66 and the contacts 67 and 68 of the relay 65 will open, thus stopping the transmission of power to the motor 29.

A decrease in die reaction due to a drop in wire size, for instance, will cause the apparatus to function to reduce the torque transmitted to the block 12. In this case, the current resulting from the unbalance of the system will flow from the wire 60 to the wire 59 through the current-limiting device 30, the coil 72 of the relay 71 and the rectifier 79. The contactors 73 and 74 will close, causing current to pass through the power lines to the motor 29, but with the opposite polarity so that the motor rotates in the opposite direction to that described above. Such a rotation of the motor reduces the pressure to which the pressure relief valve 28 is set, so that the back-pressure on the clutch is reduced and that torque transmitted to the block 12 is reduced. The current-limiting devices 76 and 30 prevent the apparatus from trying to compensate for extraordinary changes in die reaction.

While certain novel features of the invention have been shown and described and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes in the forms and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent is:

1. Apparatus for use with a wire drawing machine having a die and a block, the said block being driven by a variable-torque actuating means, comprising means for obtaining a signal proportional to the torque transmitted to the block by the actuating means, means for obtaining a signal proportional to die reaction, means for adjusting the torque transmitted to the block by the actuating means, means for initially balancing the two signals, and means responsive to unbalance of the signals to actuate the said adjusting means.

2. Apparatus for use with a wire drawing machine having a die and a block, the said block being driven by a variable-torque actuating means, comprising means for obtaining an electrical signal proportional to die reaction, means for obtaining an electrical signal proportional to the torque transmitted to the block by the actuating means, means for adjusting the torque transmitted to the block by the actuating means, means for initially balancing the two signals, means responsive to unbalance of the signals to actuate the said adjusting means.

3. Apparatus for use with a wire drawing machine having a die and a block driven by a variable-torque clutch, comprising a first gage associated with the die and having an electrical quality which changes in proportion to die reaction, a first analyzer connected to the gage and producing an electrical signal proportional to the said change in electrical quality, a second gage associated with the clutch and having an electrical quality which changes in proportion to the torque transmitted by the clutch to the block, a second analyzer connected to the gage and producing an electrical signal proportional to the said changes in electric quality of the second gage, means for balancing the two signals during normal, predetermined operation of the machine, an adjusting apparatus for changing the torque transmitted to the block by the clutch, and means responsive to unbalance of the two signals to actuate the adjusting apparatus.

4. Apparatus for use with a wire drawing machine having a die and a block driven by variable-torque means, comprising: a first gage associated with the die and having an electrical property which varies with die reactions, a first analyzer connected to the gage and measuring the electrical property of the gage, a second gage associated with the variable-torque means and having an electrical property which varies with the torque transmitted to the block, a second analyzer connected to the second gage and measuring the electrical property of the second gage, means for comparing the measurements obtained by the analyzers, the variable-torque means being connected to the comparing means and responsive to inequalities indicated thereby to change the torque transmitted to the block.

5. Apparatus for use with a wire drawing machine having a die and a block driven through a clutch, comprising: a first gage associated with the die and having an electrical quality which varies with die reaction, a first analyzer connected to the gage and producing an electrical signal proportional to the said electrical quality of the gage, a second gage associated with the clutch and having an electrical quality which varies with the torque transmitted by the clutch to the block, a second analyzer connected to the second gage and producing an electrical signal proportional to the said electrical quality of the second gage, means for balancing the two signals during normal, predetermined operation of the machine, a motor-driven apparatus for adjusting the torque transmitted to the block by the clutch, a relay responsive to unbalance of the two signals to permit power to be transmitted to the motor for actuating the adjusting apparatus to compensate for said unbalance.

6. Apparatus for use with a wire drawing machine having: a die, a block on which wire is wound after leaving the said die, a hydraulic slip clutch connected to the block for transmitting power thereto, the torque transmitted by the clutch being proportional to the pressure drop therethrough, comprising a relief valve for determining the pressure drop in hydraulic fluid passing through the clutch, a motor for adjusting the relief valve, relays having coils and contactors through which the said motor is connected to a source of power for the actuation thereof, a first strain gage connected to said die and having an electrical property whose value is proportional to the die reaction, a first analyzer connected to the first gage for measuring the value of the said electrical property and producing an electrical signal whose value is proportional to the said value of the electrical property, a second gage associated with the clutch and having an electrical property, the value of which is proportional to the pressure drop through the clutch, a second analyzer connected to the second gage for measuring the value of the said electrical property thereof and producing an electrical signal whose value is proportional to the value of the electrical property, means for equalizing the signals produced by the analyzers during normal, predetermined operation of the machine, an excess in value of one signal over the other causing current to flow through the coil of one of the relays for the actuation thereof.

7. Apparatus for use with a wire drawing machine having a die, a block on which the wire is wound after leaving the said die, a hydraulic slip clutch connected to the block for transmitting power thereto, the torque transmitted by the clutch being proportional to the pressure drop therethrough, and a relief valve for determining the pressure drop in hydraulic fluid passing through the clutch, comprising: a motor for adjusting the pressure at which the relief valve will pass fluid, a first relay having a coil and contactors through which the said motor is connected to a source of power for the actuation thereof in one direction, a second relay having a coil and contactors through which the said motor is connected to the source of power for the actuation thereof in the other direction, a strain gage connected to said die and having an electrical property which varies with

the die reaction, a first analyzer connected to the strain gage for measuring the value of the said electrical property and producing an electrical output signal whose value is proportional to the value of the electrical property, a differential-pressure gage connected across the clutch and having an electrical property the value of which is proportional to the pressure drop through the clutch, a second analyzer connected to the differential-pressure gage for measuring the value of the electrical property thereof and producing an electrical output signal whose value is proportional to the value of the electrical property, means for equalizing the signals produced by the analyzers, the output signal of each analyzer appearing across two connecting posts, the posts of like polarity being connected, the coil of the first relay being connected in series with a rectifier across the other two posts, the coil of the second relay being connected in series with another rectifier across the other two posts, the rectifiers connected to pass current in opposite directions, so that inequalities in the signals will produce passage of current through a relay coil for actuating the motor in the proper direction to compensate for the unbalance.

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