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AUTOMATIC GAUGE CONTROL SYSTEM FOR ROLLING MILLS

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Fig. 1.

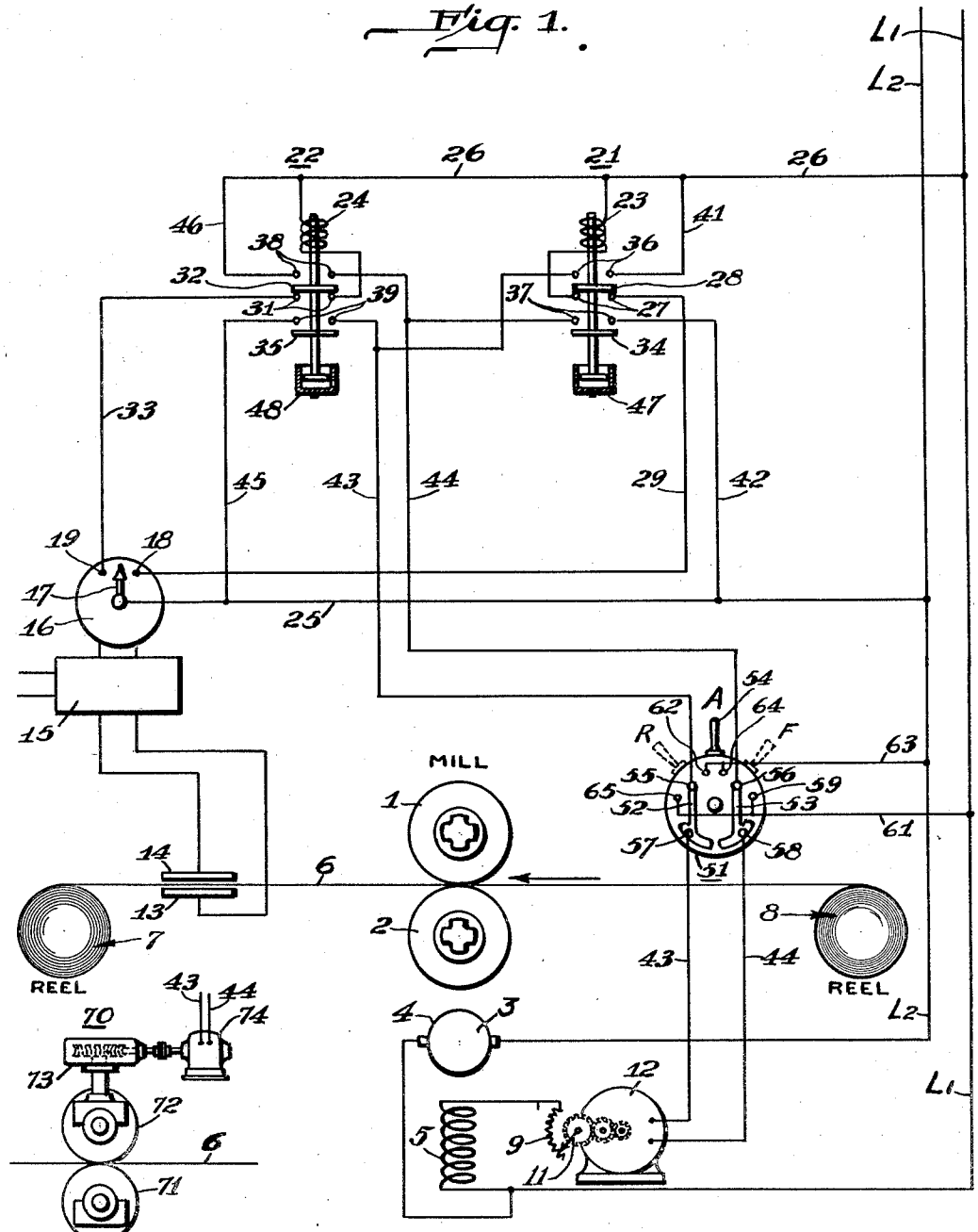


Fig. 2.

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AUTOMATIC GAUGE CONTROL SYSTEM FOR ROLLING MILLS

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2 Claims. (Cl. 80—56)

This invention relates to rolling mills, and more particularly to a system of control for governing the operation of mills of the type employed in the production of elongate sections of uniform shape, and especially mills of the class employed in the rolling of foils, comparatively thin sheets, strips and the like.

The primary object of the invention generally stated is to provide a system of control for governing the operation of rolling mills of the character referred to, which is adapted to automatically adjust the mills in such a way as to compensate for any variations in the rolling conditions tending to disturb the uniformity in shape or thickness of the sock being rolled.

Another object is to provide a control system capable of accomplishing the aforementioned objective, which is simple of construction, easy and comparatively inexpensive to install, economical and dependable in operation, and in addition requires but little attention.

A more particular object is to provide a system of control for mills used in rolling of stocks, such as foils, fine gauge sheets and the like, which are sufficiently thin that their thickness is varied by variations in the speed of the mill rolls, the system being adapted to automatically vary the speed of the mill in response to variations in thickness of the stock and in such a way as to maintain the thickness of the stock substantially uniform over its entire length.

These and various other objects, as well as the various other novel features and advantages of the invention, will be more apparent when the following detailed description is read in conjunction with the accompanying drawing, of which Fig. 1 is a schematic diagram of a control system embodying the invention as applied to a mill for rolling comparatively fine gauge stocks such as thin sheets, strips and foils; and Fig. 2 a view of a rolling mill equipped with a motor operated screw down and indicating the manner in which the system shown in Fig. 1 may be applied to the screw down motor.

Referring now to the drawing, the invention is illustrated more particularly in its applicability to the control of mills employed in the rolling of fine gauge stocks, such as thin sheets, strips, foils and the like, in which connection it has been practiced. It has been found in the rolling of such materials, particularly aluminum foil, that the thickness of the stock may be varied by varying the speed of the mill rolls, and in converse relation. According to this invention, apparatus is provided for controlling the operation of the driving motor of a mill in such a way as to automatically compensate in roll speed for variations in rolling conditions tending to produce irregularities in the thickness of the stock being rolled.

The mill shown in Fig. 1 of the drawing comprises merely a pair of working rolls 1 and 2 to which a motor 3, consisting of an armature 4 and field windings 5, is suitably coupled. Between these rolls a piece of stock 6 is passed in the usual fashion with its opposite ends engaged upon a pair of winding and unwinding reels 7 and 8, respectively. To afford a simple form of speed control for motor 3, its field windings and armature are connected in shunt circuit relation with each other to the source of current employed for operating the mill, which is represented here by a pair of line conductors L_1 and L_2. By reason of such arrangement, as is well known, the speed of the motor may be readily varied by simply varying the amount of current permitted to flow through the field windings. To accomplish this end, a rheostat 9 is connected in the field winding circuit and equipped with a bridging member 11 adapted for rotary movement. This bridging member is in turn coupled to a small reversible rheostat motor 12 which is employed to facilitate the regulation of motor 3, as will apepar more clearly hereinafter.

In accordance with the invention, provision is made for automatically governing the operation of motor 3 in response to variations in thickness of the stock 6 as it issues from the mill, and in in such a way as to maintain the uniformity of the stock gauge substantially constant, or in other words in such a way as to prevent the mill from producing stock which departs in thickness from a preselected gauge.

One way of providing such a control is that afforded by the use of an electric condenser arranged to be responsive to the variations in thickness occurring in the stock as it issues from the mill. Such a condenser is formed by the electro-conducting plates 13 and 14 mounted to extend in parallel relation on opposite sides of the stock 6 as it issues from rolls 1 and 2. As is well known, the capacity of such a device is dependent upon the effective area of its plates, the distance between them, and the nature of its dielectric. With this in view, the area and spacing of plates 13 and 14 are maintained constant, and they are so arranged in the path of travel of the stock that as the later issues from rolls 1 and 2 it passes between them without making contact therewith. Thus, the dielectric,

and consequently the capacity of the condenser, is varied directly as the thickness of the stock passing between its plates.

While various methods and means may be used for measuring the electrical capacity of plates 13 and 14, and for operating control means in response to changes therein due to changes in the dielectric, occasioned by changes in thickness of stock 6, one method which is particularly sensitive and well suited for the present purposes, comprises utilizing the condenser formed by these plates as a tuning element for a high frequency oscillatory circuit, wherein changes in capacity of the condenser are adapted to act to vary the frequency, and, conversely, the wave length of the circuit. These changes, as is well known in the art, and particularly in the field of radio telegraphy, are adequately capable in a circuit of this nature of operating indicating and control mechanism, such as contemplated by this invention, and, by reason thereof, afford a very sensitive and dependable way of controlling the operation of rheostat motor 12 and thereby the operation of motor 3 in response to variations in the thickness of the stock. Such a method and mechanism for practicing the invention in the manner referred to is clearly illustrated and described in U. S. Patent No. 1,708,073, issued April 9, 1929 to A. Allen. In view of such knowledge, and because the oscillatory circuit does not in itself form a part of this invention, it is merely shown here in blank, as indicated at 15 in the drawing, no further description thereof being deemed necessary for the purpose of this description.

For automatically effecting the control of motor 12 in response to variations in circuit 15, produced by variations in capacity of the condenser, a galvanometer 16 is responsively arranged in that circuit. On this galvanometer there is provided a circuit controlling bridging member 17 which is adapted to be actuated by the galvanometer in the customary fashion of the ordinary indicating pointer or needle. Associated with this bridging member 17 are a pair of adjustable contact members 18 and 19. In use the galvanometer is so adjusted that bridging member 17 remains midway between contact members 18 and 19 when the stock issuing from the mill, or in other words that disposed between plates 13 and 14, has the desired gauge. Contact members 18 and 19 in turn are adjusted to permit the allowable plus and minus gauge tolerances in the product being rolled. To assist the adjustment of the contact members, the scale of the meter is preferably calibrated in thousandths of an inch in place of the usual millivolts, thereby reading directly in thousandths of an inch gauge, plus or minus as the case may be.

For assisting galvanometer 16 in the control of motor 12, a pair of reversing relays 21 and 22 are provided, and these equipped with actuating coils 23 and 24, respectively. For exciting these coils, they are connected to contact members 18 and 19, respectively, of the galvanometer, and to line conductor L_1, and the bridging member 17 of the galvanometer is connected by a conductor 25 to line conductor L_2. The circuit provided for relay coil 23 is extended from line conductor L_1 by way of a conductor 26, through the coil itself, a pair of interlock contact members 27 on relay 21, by way of a bridging member 28, and a conductor 29 to contact member 18. In a similar fashion a circuit for relay coil 24 is extended from line conductor L_1 through conductor 26, the coil itself, a pair of interlocking contact members 31 on relay 22, by way of a bridging member 32, and a conductor 33 to contact member 19.

In accordance with this arrangement, when the thickness of stock 6 is changed sufficiently in one direction or the other to cause the member 17 to be moved into engagement with one or the other of contact members 18 or 19, the coil of the relay associated with such contact members is excited, and the relay operated thereby is actuated. For rendering motor 12 operable in response to such operation of these relays, they are provided with an additional pair of bridging members 34 and 35, and cooperating contact members 36 and 37 on relay 21, and cooperating contact members 38 and 39 on relay 22. Contact members 36 and 37 on relay 21 are included in a circuit formed by conductors 41 and 42, and conductors 43 and 44, respectively, extending from line conductors L_1 and L_2 to motor 12. Similarly, contact members 39 and 38 on relay 22 are connected in a circuit formed by conductors 45 and 46, and conductors 43 and 44, respectively, also extending from line conductors L_1 and L_2 to motor 12. When closed, relay 21 consequently completes a circuit from line conductor L_1 to conductor 43, and line conductor L_2 to conductor 44, whereby motor 12 is excited for rotation in one direction, and when relay 22 is closed these connections are reversed, causing the motor to be rotated in the opposite direction. Hence, if the thickness of the stock varies sufficiently to cause the bridging member 17 to engage one of the contacts 18 or 19 the speed of motor 3 is automatically increased or decreased to compensate for such variation, by reason of motor 12 being thereby operated in one direction or the other to increase or decrease the amount of resistance included by rheostat 9 in the circuit of the field windings 5, depending upon which of the relays 21 or 22 is actuated. The aforementioned circuits are, of course, so connected that the motor 3 is always varied in a direction to maintain the thickness of the stock uniform.

A further feature of the system resides in the provision of means for preventing excessive changes in the mill speed and hunting action in the operation of the mill and rheostat motor. For this purpose, as will be observed by tracing the circuits employed for exciting the actuating coils 23 and 24 of relays 21 and 22, respectively, bridging members 28 and 32, respectively, are arranged to function as interlocks and to interrupt the relay actuating circuits as soon as the relays are closed. These interlocking arrangements are augmented in this connection by dash pots 47 and 48, which are mounted in the customary fashion upon the relays 21 and 22, respectively, and adapted to adjustably delay the opening of the relays but not to interfere with their closing. To insure such operation, the relay coils 23 and 24 are adapted to positively close the relays when excited, and the dash pots to retard the opening of the circuits so established until after a preselected period determined by the setting of the dash pots after the actuating coil circuits are broken. Consequently, the speed of the mill motor is varied in steps depending in extent upon the time delay afforded by the dash pots. This feature will be more fully appreciated when it is con-

sidered that changes in speed of the mill motor may in many instances lag somewhat the change of current flow effected in field windings 5 by rheostat 9 in response to movement of bridging member 11 by motor 12. While dash pots, of the aforementioned character, form a very simple and effective means of accomplishing the end for which they are intended, it is to be understood that various other forms of mechanism may be utilized for this purpose. A very efficient, dependable and sensitive type of delay mechanism susceptible of such use is that described and illustrated in U. S. Patent No. 1,753,983, granted to W. G. Cook, April 8, 1930.

In addition to the automatic control for motor 12, a master switch 51 is provided and arranged in the circuit of conductors 43 and 44, for rendering the mills readily controllable, at the will of the operator, such control being desirable for various purposes, such as for threading the mill and other ordinarily irregular operations. As illustrated, switch 51 comprises a pair of bridging members 52 and 53, which have arc-shaped segmental portions at their lower ends and vertical bands extending upwardly therefrom. These are mounted on a support equipped with a handle 54, and are adapted, when in the position indicated in full line in the drawing, to complete the circuit from relays 21 and 22 to motor 12 formed by conductors 43 and 44 through their engagement with contact members 55 and 56, and 57 and 58. In the dotted position F, bridging member 53 makes contact with a contact member 59 connected by a conductor 61 with line conductor L_1, and bridging member 52 makes contact with a contact member 62 connected by a conductor 63 with line conductor L_2. In the dotted position R, bridging member 53 makes contact with a contact member 64 connected to conductor 63, and bridging member 52 makes contact with a contact member 65 connected to conductor 61. In all positions the arc-schaped segments on the lower ends of bridging members 52 and 53 engage contact members 57 and 58. Consequently, when handle 54 is in the full line position shown, automatic control is afforded, and, when in either of the dotted positions F and R, manual control is provided. In these latter positions, by reason of the aforementioned circuit connections between power lines L_1 and L_2 and switch 51, the motor 12 is energized to operate in different directions, depending upon which position the switch is in, inasmuch as the current flow to the motor is thereby reversed.

Referring to Fig. 2, a mill 70 is shown comprising a pair of working rolls 71 and 72 which are equipped with a screw down connection 73 and a screw down motor 74 for adjusting the roll pass. In mills employed for rolling materials having their thicknesses in excess of those referred to more particularly hereinbefore, and which are not materially affected by variations in rolls speeds, screw down devices of this nature are employed to determine the thickness of the products. As will be readily appreciated by those skilled in the art, mills of this latter type may be governed through the use of motor 74 in accordance with this invention with the same results as the mill shown in Fig. 1, by merely applying the system shown in Fig. 1 to motor 74. This may be done by connecting the conductors 43 and 44 to motor 74 instead of to motor 12, and the system so connected will function in the same manner as set forth hereinbefore, and will produce the same general results in mill operation.

While the advantages of the invention as set forth and indicated in the foregoing are quite obvious, they will be more fully appreciated when thought is given to the difficulties prevalent in the method and means employed in the past for accomplishing these ends. For example, it has been the prevailing practice heretofore to utilize manual control for governing the operation of such mills, and to depend for satisfactory results upon the services of skilled operators. By reason of such practice, not only is the quality and uniformity of the product dependent upon the skill of the operators, but, in addition, the cost of production and labor problems and difficulties incident hereto are greatly enhanced.

With this invention no skilled attendants are required for the mills, and the regulation afforded is entirely automatic, whereby the uniformity of the product is more dependably and accurately maintained.

According to the provisions of the patent statutes, we have explained the principal and mode of operation of our invention and have illustrated and described what we now consider to represent its best embodiment. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

1. The combination with a sheet rolling mill, of a system for controlling the thickness of sheet rolled thereby, comprising a motor coupled to said mill, means for varying the speed of said motor, a pair of electro-conducting plates arranged in spaced relation on opposite sides of the path of travel of sheet issuing from the mill, said plates forming a condenser the capacity of which is varied in accordance with the thickness of sheet passing therethrough, electro-responsive means adapted to be actuated by changes in the capacity of said condenser, and means operated by said electro-responsive means for automatically controlling the operation of said mill motor speed varying means to maintain the thickness of sheet uniform.

2. The combination with a rolling mill, of a system for controlling the thickness of stock rolled thereby, comprising a driving motor coupled to said mill, a motor operated rheostat for controlling the speed of said mill motor, means responsive to variation in the thickness of stock issuing from the mill for controlling the operation of said motor operated rheostat whereby to vary the speed of the mill to maintain the thickness of the stock uniform.

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