Feb. 1, 1944. F. B. CROSBY 2,340,646

METAL ROLLING

Filed Oct. 31, 1941 2 Sheets-Sheet 1

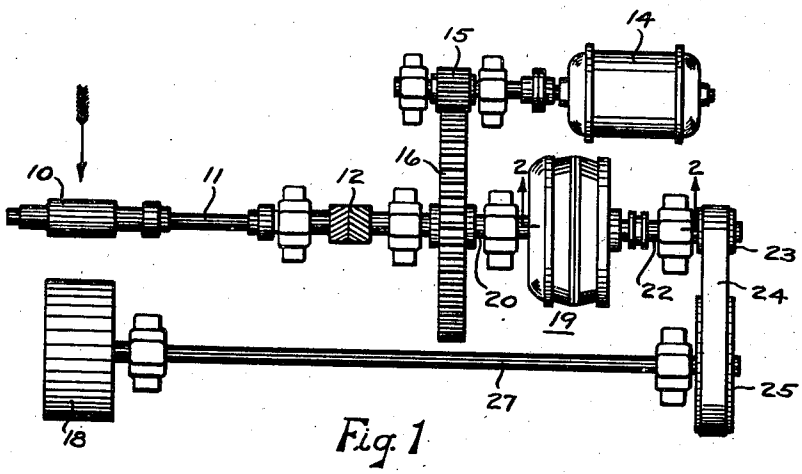


Fig. 1

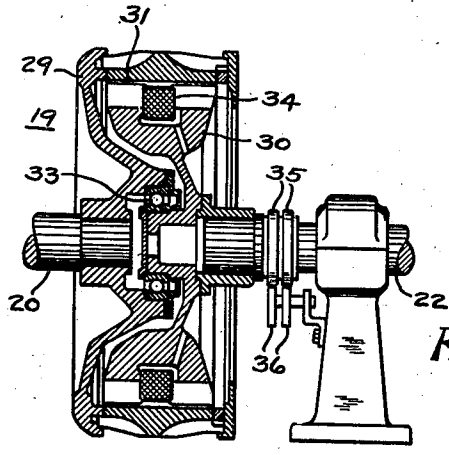


Fig. 2

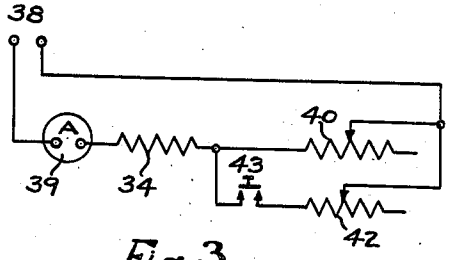


Fig. 3

INVENTOR
FRED B. CROSBY
BY Albert G. Blodgett
ATTORNEY

Feb. 1, 1944. F. B. CROSBY 2,340,646

METAL ROLLING

Filed Oct. 31, 1941 2 Sheets-Sheet 2

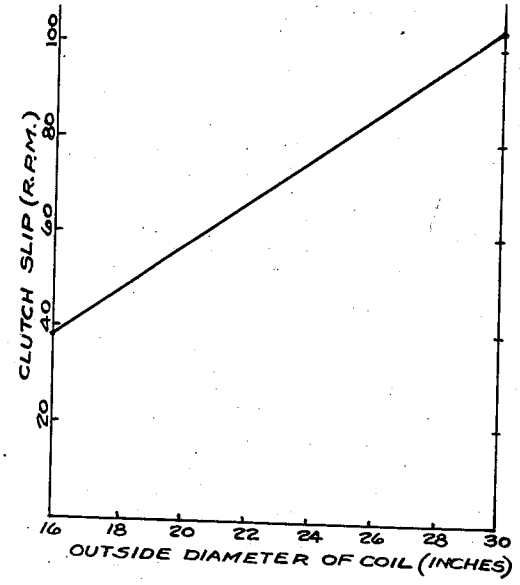


Fig. 4

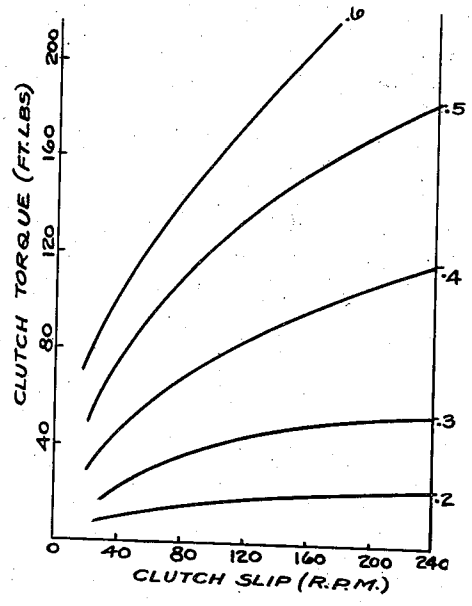


Fig. 5

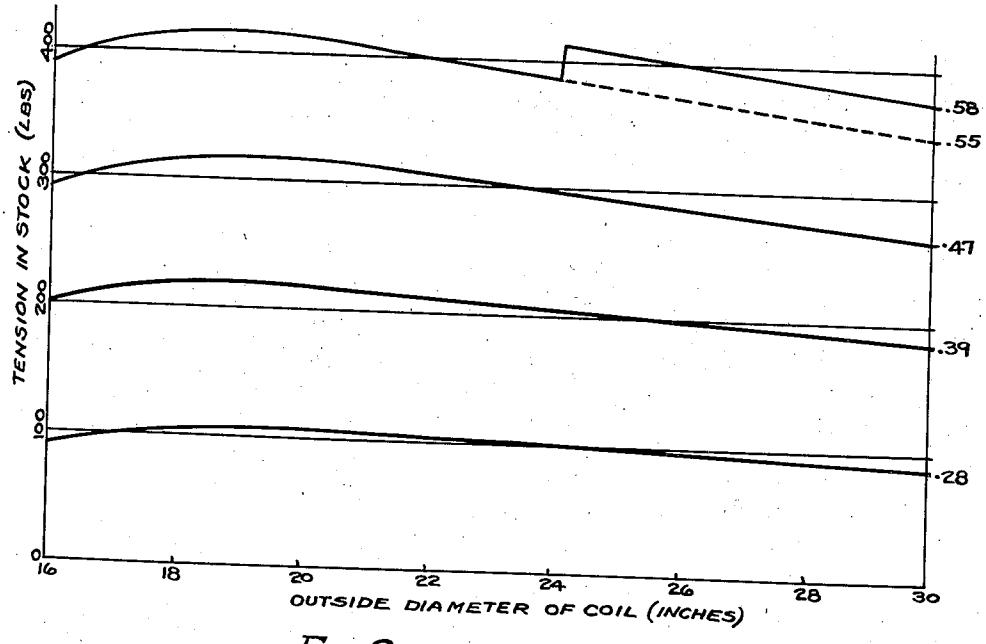


Fig. 6

INVENTOR
FRED B. CROSBY
BY Albert G. Blodgett
ATTORNEY

Patented Feb. 1, 1944 2,340,646

UNITED STATES PATENT OFFICE

2,340,646

METAL ROLLING

Fred B. Crosby, Worcester, Mass., assignor to Morgan Construction Company, Worcester, Mass., a corporation of Massachusetts

Application October 31, 1941, Serial No. 417,257

6 Claims. (Cl. 80—32)

This invention relates to metal rolling, and more particularly to apparatus for rolling and coiling flat metal strips.

In the production of long flat strips of metal it is a common practice to wind the stock into spiral coils as it issues from the rolling mill. It has been found that the process is facilitated and an improved product obtained by maintaining a considerable tension in the stock between the mill rolls and the drum or reel on which the coil is formed. To prevent variations in the thickness and other characteristics of the stock it is important that the tension remain substantially uniform throughout the formation of the entire coil. This has been recognized, and certain electrical apparatus has been developed which will operate with a high degree of satisfaction to maintain the tension at a desired value. However such apparatus is so complicated and expensive as to render its use economically unjustified except in connection with large mills in which very high production rates are maintained. Consequently it has become customary, in connection with the smaller mills, to employ a relatively inexpensive continuously slipping friction drive for the reels, for example a belt and pulley drive or a friction clutch. Since such mechanisms are required to slip continuously during the build-up of the coil, they waste large amounts of power and they wear out very rapidly. Furthermore, they transmit a substantially constant torque to the reel, and since the diameter of the coil increases continuously during its formation the result will be continuous and very serious reduction in the stock tension. For example, assume that in a particular installation strip is to be rolled and formed into coils with an inside diameter of 16 inches and an outside diameter of 30 inches, the reel being driven by a slipping friction clutch which transmits a torque of 1600 inch-pounds. At the start of the coil the tension in the strip will be 200 pounds, but by the time the 30 inch diameter is reached this tension will have dropped to approximately 107 pounds. With such an apparatus it will be impossible to produce a strip of uniform characteristics through its length.

It is accordingly the main object of the invention to provide a comparatively simple and inexpensive apparatus for rolling and coiling strip metal stock with a substantially uniform tension.

It is a further object of the invention to provide an apparatus which will roll and coil strip metal stock with a substantially uniform tension and which will be efficient in operation and free from wear.

It is a further object of the invention to provide a simple, inexpensive and dependable apparatus adapted to roll and coil strip metal stock with a substantially uniform tension and so constructed that the tension may be readily adjusted in a simple manner.

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.

Referring to the drawings illustrating one embodiment of the invention and in which like reference numerals indicate like parts,

Fig. 1 is a somewhat diagrammatic plan view of an apparatus for rolling and coiling strip metal stock;

Fg. 2 is an enlarged section on the line 2—2 of Fig. 1;

Fig. 3 is an electrical wiring diagram;

Fig. 4 is a chart showing the manner in which the slip of a clutch (forming part of the apparatus) varies during the formation of a coil of strip stock;

Fig. 5 is a chart showing the manner in which the torque exerted by the clutch varies with its slip; and

Fig. 6 is a chart showing the manner in which the tension exerted on the stock varies during the formation of a coil.

The embodiment illustrated includes a roll stand (Fig. 1) for the production of flat strip metal and comprising a pair of cylindrical work rolls 10 (one only being shown). This roll stand may be of the four-high type. Each work roll 10 is connected by a spindle 11 to a pinion 12 in known manner. The pinions are driven by means of an electric motor 14 connected thereto by a pinion 15 and a gear 16. At the delivery side of the rolls 10 there is mounted a rotatable drum or reel 18 on which the stock may be wound as it issues from the rolls, to form a spiral coil. In order to drive this reel I provide an eddy current clutch 19 having an input shaft 20 connected to the gear 16 and an output shaft 22 having a pulley 23 thereon. This pulley is connected by a belt 24 to a pulley 25 mounted on a shaft 27 which is directly connected to the reel 18.

The eddy current clutch 19 is a well known mechanism, and its construction is shown particularly in Fig. 2. As illustrated, this clutch comprises a rotatable input member 29 secured

to the shaft 20, and a rotatable output member 30 secured to the shaft 22. The input member 29 surrounds and encloses the output member 30, there being a slight air gap 31 between these parts. To ensure that the air gap will remain uniform, a pilot ball bearing 33 is provided between the central portions of the members 29 and 30. The output member 30 is provided with a coil 34 which is connected by conductors (not shown) to a pair of slip rings 35 carried by the shaft 22 and of course insulated therefrom. These rings are engaged by brushes 36 so that electric current may be supplied to the coil to energize the same.

As shown in Fig. 3, the coil 34 is energized from a suitable source 38 of direct current, there being an ammeter 39 and a rheostat 40 in series with the coil. A second rheostat 42 is arranged to be connected in parallel with the rheostat 40 by merely closing a normally open switch 43, which is shown as of the push button type. The ammeter 39 will indicate the rate of flow of the exciting current through the coil.

Energization of the coil 34 creates a magnetic field, and the lines of magnetic flux pass through the peripheral portions of the two members 29 and 30. If the input member 29 is rotating at a higher speed than the output member 30, the metal parts will cut across these lines of flux, and electrical eddy currents will be induced. The direction of flow of these eddy currents will be such, with respect to the magnetic field, that they will create a magnetic drag which will tend to check the relative motion between the input and output members, thereby transmitting torque to the output member tending to rotate this member in the same direction as the input member is rotating. Not only does this torque increase with an increase in the exciting current, but it also increases with an increase in the clutch slip, i. e., the difference between the speeds of the input and output members. This relationship is shown in Fig. 5 for one particular size and construction of eddy current clutch, the figures at the right-hand ends of the several curves indicating the corresponding exciting currents in amperes.

It will also be apparent that during the formation of a coil, the outside diameter of the coil will increase at a steady rate, while the peripheral speed of the coil will remain equal to the speed of delivery of the stock by the rolls 10. Consequently, the rate of rotation of the drum 18 relative to that of the rolls 10 must decrease while a coil is being formed, and this necessarily involves a corresponding increase in the slip of the clutch 19. This relationship is shown in Fig. 4, and it may be ascertained by calculation for any particular installation. For example, let us assume that the rolls 10 are 4.25 inches in diameter, the drum 18 is 16 inches in diameter, and the ratio of the pulleys 25—23 is 2.94 to 1. If now the rolls 10 are driven at 180 revolutions per minute, the delivery speed of the stock will be approximately

$$\frac{180\times 4.25\pi}{12}=200 \text{ feet per minute}$$

The speed of the drum 18 at the start of each coil will be

$$\frac{200\times 12}{16\pi}=47.7 \text{ R. P. M.}$$

the speed of the clutch output member 30 will be $2.94\times 47.7=140.2$ R. P. M., and the clutch slip will be $180-140.2=39.8$ R. P. M. Similarly, by the time the coil has reached a diameter of 30 inches the speed of the drum will have decreased to

$$\frac{200\times 12}{30\pi}=25.47 \text{ R. P. M.}$$

the speed of the clutch output member will be $2.94\times 25.47=74.9$ R. P. M., and the clutch slip will be $180-74.9=105.1$ R. P. M. The clutch slip for intermediate diameters of the coil is indicated by the straight line shown in Fig. 4 and joining the two points determined by calculation.

In the operation of the invention the slip of the clutch 19 will increase during the growth of the coil, as explained above, and for a given excitation of the clutch the torque transmitted thereby will increase as shown in Fig. 5. Consequently the torque transmitted to the drum 18 will increase continuously as the coil increases in diameter, thereby counteracting the tendency for the tension in the stock to decrease because of the increased moment arm through which it resists the drum rotation. As a result it is possible to maintain a substantially constant tension in the stock by merely setting the rheostat 40 to produce the desired excitation current, as indicated by the ammeter 39, and leaving this adjustment unchanged during the formation of the coil. In Fig. 6 the actual stock tensions which will be maintained with various excitation currents and one particular clutch are shown by the curves, the figures at the right-hand ends of the curves indicating the excitation current in amperes. Thus, if the operator wishes to maintain a stock tension of 100 pounds, he will adjust the rheostat 40 to give an ammeter reading of .28, and as shown by the curve the tension will be held with considerable accuracy. With the higher values of exciting current there is a tendency for the tension to decrease appreciably as the coil approaches its maximum diameter. For example, the chart indicates that an exciting current of .55 ampere will produce a tension of about 400 pounds during the formation of the first part of the coil, but this tension will decrease to about 350 pounds as the 30 inch diameter is reached. While in many cases such a decrease is not important, the results may be improved by utilizing the rheostat 42 and switch 43. With the switch 43 open the rheostat 40 will be adjusted to produce an exciting current of .55 ampere, and with the switch 43 closed the rheostat 42 will be adjusted to increase this current to .58 ampere. The operator will close the switch 43 as each coil reaches a diameter of about 24 inches, and during the formation of the remaining portion of the coil the tension will be that indicated by the .58 excitation curve, which is a considerably closer approximation to the desired 400 pound line.

From the above disclosure it will be apparent that the invention provides an apparatus which will roll and coil strip metal under tension, and maintain this tension with sufficient accuracy for the great majority of installations. Furthermore, the apparatus is comparatively simple and inexpensive, and thoroughly dependable in service, there being no slipping friction surfaces subject to rapid wear and deterioration.

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

1. Apparatus for rolling and coiling flat metal strips comprising a rolling mill, a reel arranged to wind the stock delivered by the mill into spiral coils while maintaining a tension on the stock, an eddy current clutch having an input member

and an output member, common means to drive the rolling mill and the input member in a predetermined speed relationship, and driving connections from the output member to the reel.

2. Apparatus for rolling and coiling flat metal strips comprising a rolling mill, a reeel arranged to wind the stock delivered by the mill into spiral coils while maintaining a tension on the stock, an eddy current clutch having a rotatable input member, a rotatable output member, and an electro-magnetic coil, the clutch being constructed to transmit a torque which increases with increased clutch slip without change in the excitation current through the coil, common means to drive the rolling mill and the input member in a predetermined speeed relationship, and driving connections from the output member to the reel, the various parts being so constructed and arranged that as the diameter of each coil of stock increases the clutch slip will increase, thereby increasing the torque applied to the reel and maintaining a substantially uniform tension on the stock.

3. Apparatus for rolling and coiling flat metal strips comprising a rolling mill, a reel arranged to wind the stock delivered by the mill into spiral coils while maintaining a tension on the stock, an eddy current clutch having a rotatable input member, a rotatable output member, and an electro-magnetic coil, the clutch being constructed to transmit a torque which increases with increased clutch slip without change in the excitation current through the coil, common means to drive the rolling mill and the input member in a predetermined speed relationship, and driving connections from the output member to the reel of such a speed ratio that at the start of each coil, with the peripheral speed of the reel equal to the delivery speed of the stock, there will be a considerable clutch slip which will increase continuously during the formation of the coil, thereby increasing the torque applied to the reel and maintaining a substantially uniform tension on the stock.

4. Apparatus for rolling and coiling flat metal strips comprising a rolling mill, a reel arranged to wind the stock delivered by the mill into spiral coils while maintaining a tension on the stock, an eddy current clutch having a rotatable input member, a rotatable output member, and an electro-magnetic coil, the clutch being constructed to transmit a torque which increases with increased clutch slip without change in the excitation current through the coil, a rheostat in series with the coil, a second rheostat associated with the first rheostat, a switch associated with the second rheostat, common means to drive the rolling mill and the input member in a predetermined speed relationship, and driving connections from the output member to the reel of such a speed ratio that at the start of each coil, with the peripheral speed of the reel equal to the delivery speed of the stock, there will be a considerable clutch slip which will increase continuously during the formation of the coil, thereby increasing the torque applied to the reel, the said switch providing a means whereby the operator may increase the excitation of the clutch coil by a predetermined amount after the coil of stock has been partially completed and thus increase still further the torque applied to the reel

5. Apparatus for rolling and coiling flat metal strips comprising a rolling mill, a reel arranged to wind the stock delivered by the mill into spiral coils while maintaining a tension on the stock, an eddy current clutch having a rotatable input member, a rotatable output member, and an electro-magnetic coil, the clutch being constructed to transmit a torque which increases with increased clutch slip without change in the excitation current through the coil, a rheostat in series with the coil, a second rheostat in parallel with the first rheostat, a switch in series with the second rheostat, common means to drive the rolling mill and the input member in a predetermined speed relationship, and driving connections from the output member to the reel of such a speed ratio that at the start of each coil, with the peripheral speed of the reel equal to the delivery speed of the stock, there will be a considerable clutch slip which will increase continuously during the formation of the coil, thereby increasing the torque applied to the reel, the said switch providing a means whereby the operator may increase the excitation of the clutch coil by a predetermined amount after the coil of stock has been partially completed and thus increase still further the torque applied to the reel.

6. Apparatus for rolling and coiling flat metal strips comprising a rolling mill, a reel arranged to wind the stock delivered by the mill into spiral coils while maintaining a tension on the stock, the reel being located close to the mill, and the stock traveling directly from the mill to the reel, an eddy current clutch having a rotatable input member, a rotatable output member, and an electro-magnetic coil, the clutch being constructed to transmit a torque which increases with increased clutch slip without change in the excitation current through the coil, common means to drive the rolling mill and the input member in a predetermined speed relationship, and driving connections from the output member to the reel of such a speed ratio that at the start of each coil, with the peripheral speed of the reel equal to the delivery speed of the stock, there will be a considerable clutch slip which will increase continuously during the formation of the coil, thereby increasing the torque applied to the reel and maintaining a substantially uniform tension on the stock.

FRED B. CROSBY.