Sept. 5, 1944. J. F. FERM 2,357,389

APPARATUS FOR FEEDING AND COILING CONTINUOUS STRIP MATERIAL

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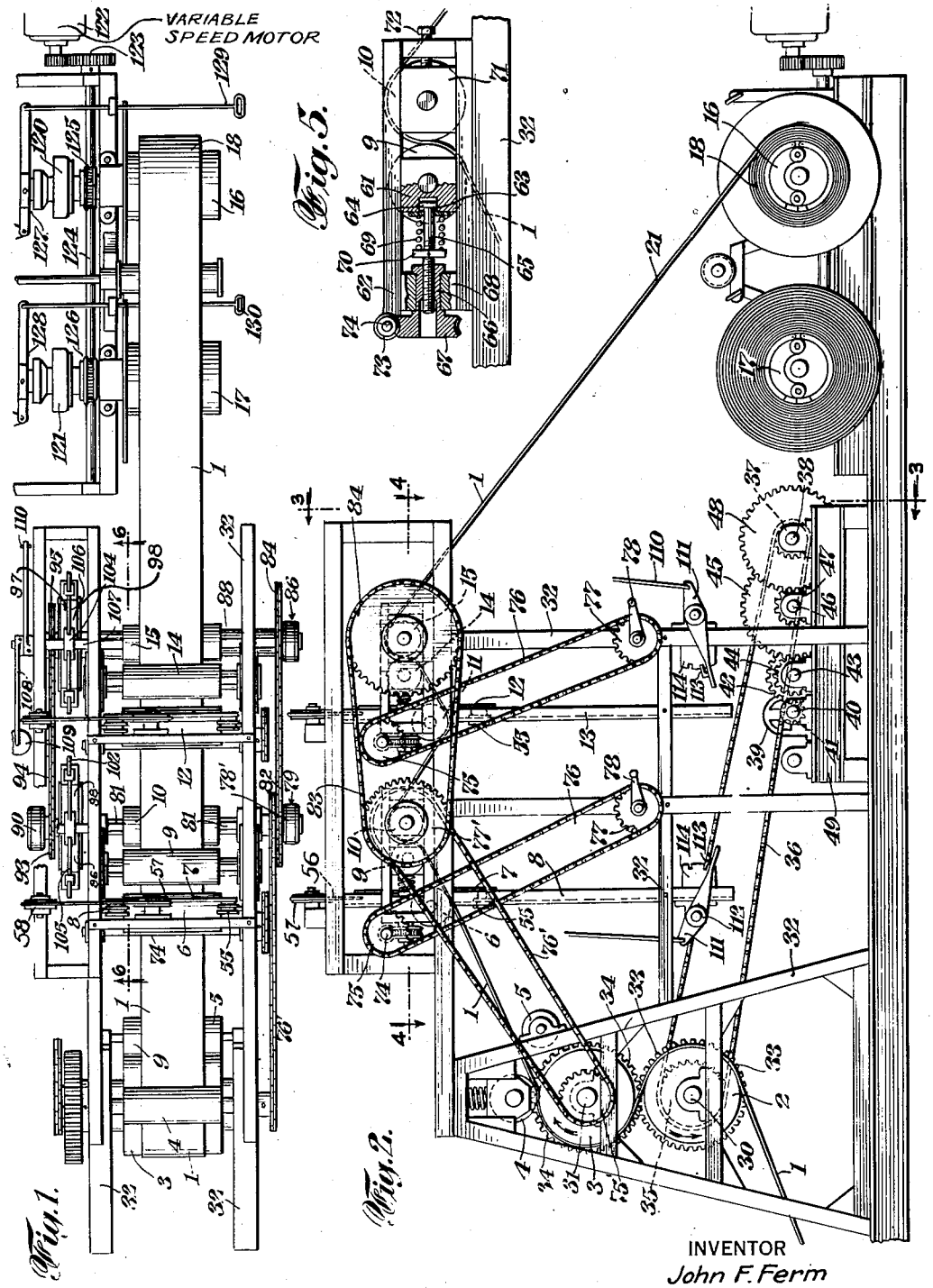


Fig. 1.

Fig. 2.

Fig. 3.

INVENTOR
John F. Ferm
BY
Wood, Cushy & Neal
ATTORNEYS

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APPARATUS FOR FEEDING AND COILING CONTINUOUS STRIP MATERIAL

Filed Aug. 2, 1940 6 Sheets-Sheet 2

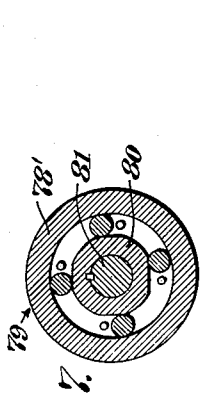


Fig. 7.

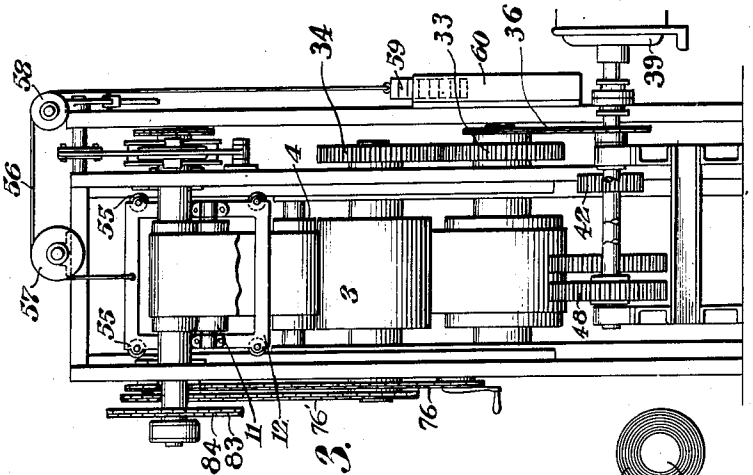


Fig. 3.

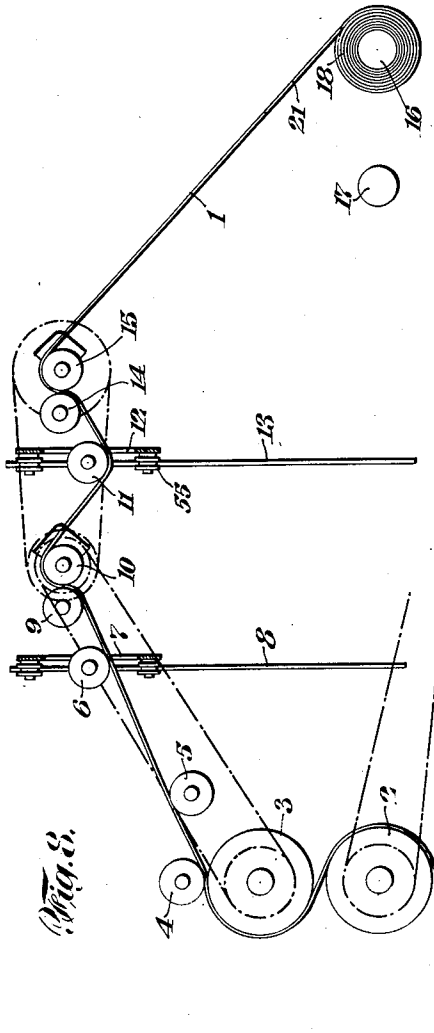


Fig. 8.

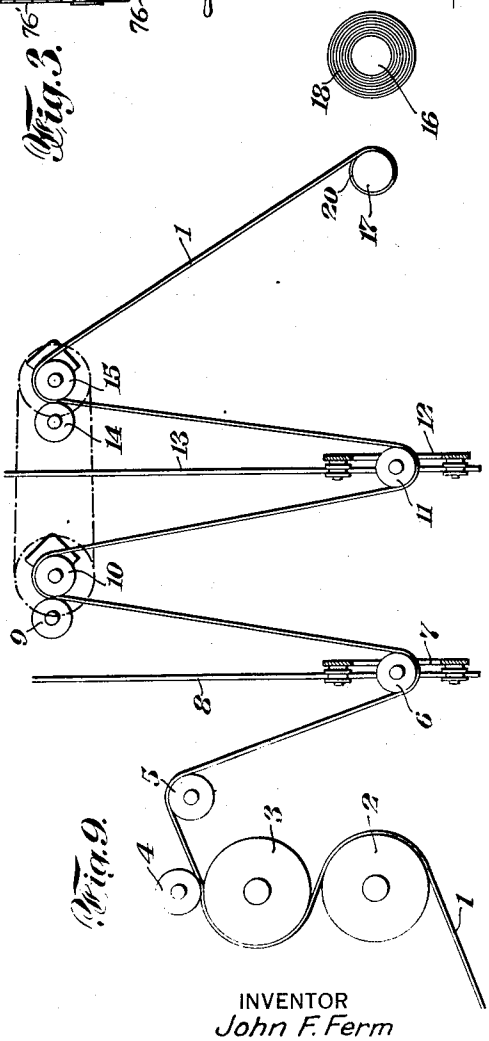


Fig. 9.

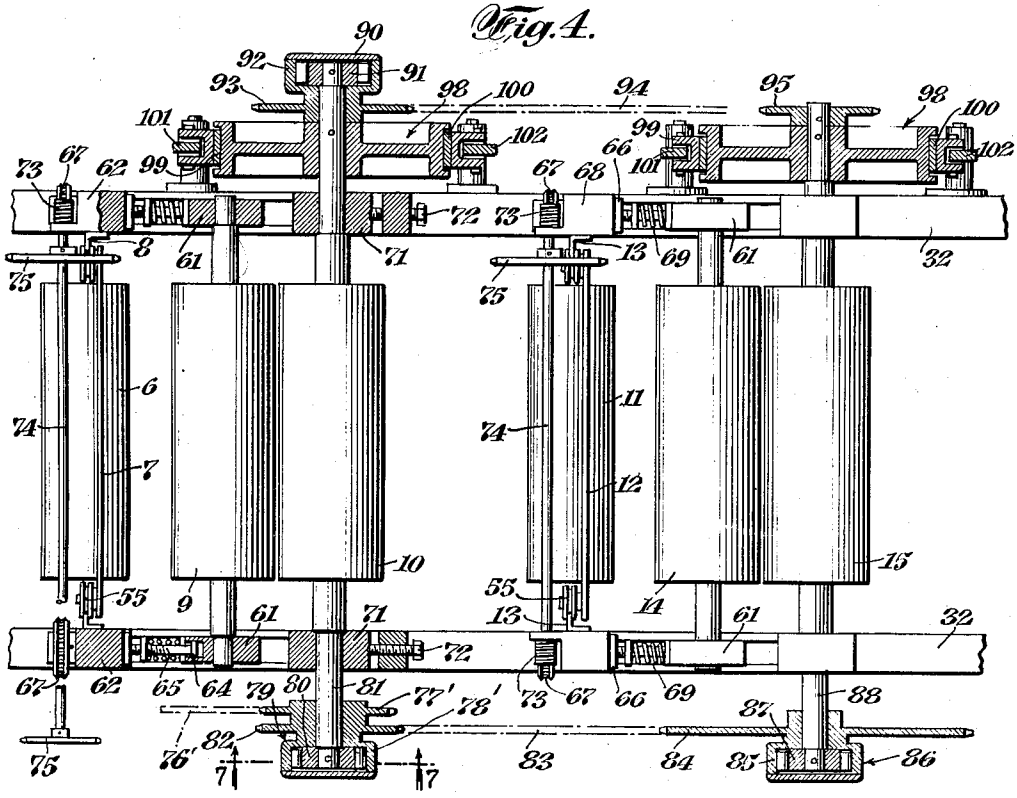
INVENTOR
John F. Ferm
BY Ward, Crosby & Head
ATTORNEYS

Sept. 5, 1944. J. F. FERM 2,357,389

APPARATUS FOR FEEDING AND COILING CONTINUOUS STRIP MATERIAL

Filed Aug. 2, 1940 6 Sheets-Sheet 3

Fig. 4.



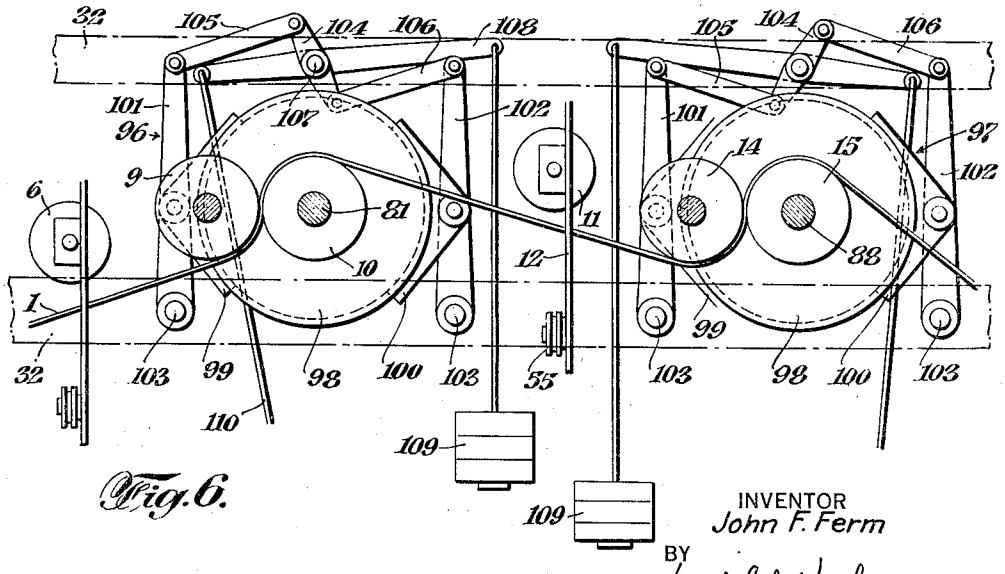


Fig. 6.

INVENTOR
John F. Ferm

BY
Wood, Cady & Head
ATTORNEYS

Sept. 5, 1944. J. F. FERM 2,357,389

APPARATUS FOR FEEDING AND COILING CONTINUOUS STRIP MATERIAL

Filed Aug. 2, 1940 6 Sheets-Sheet 4

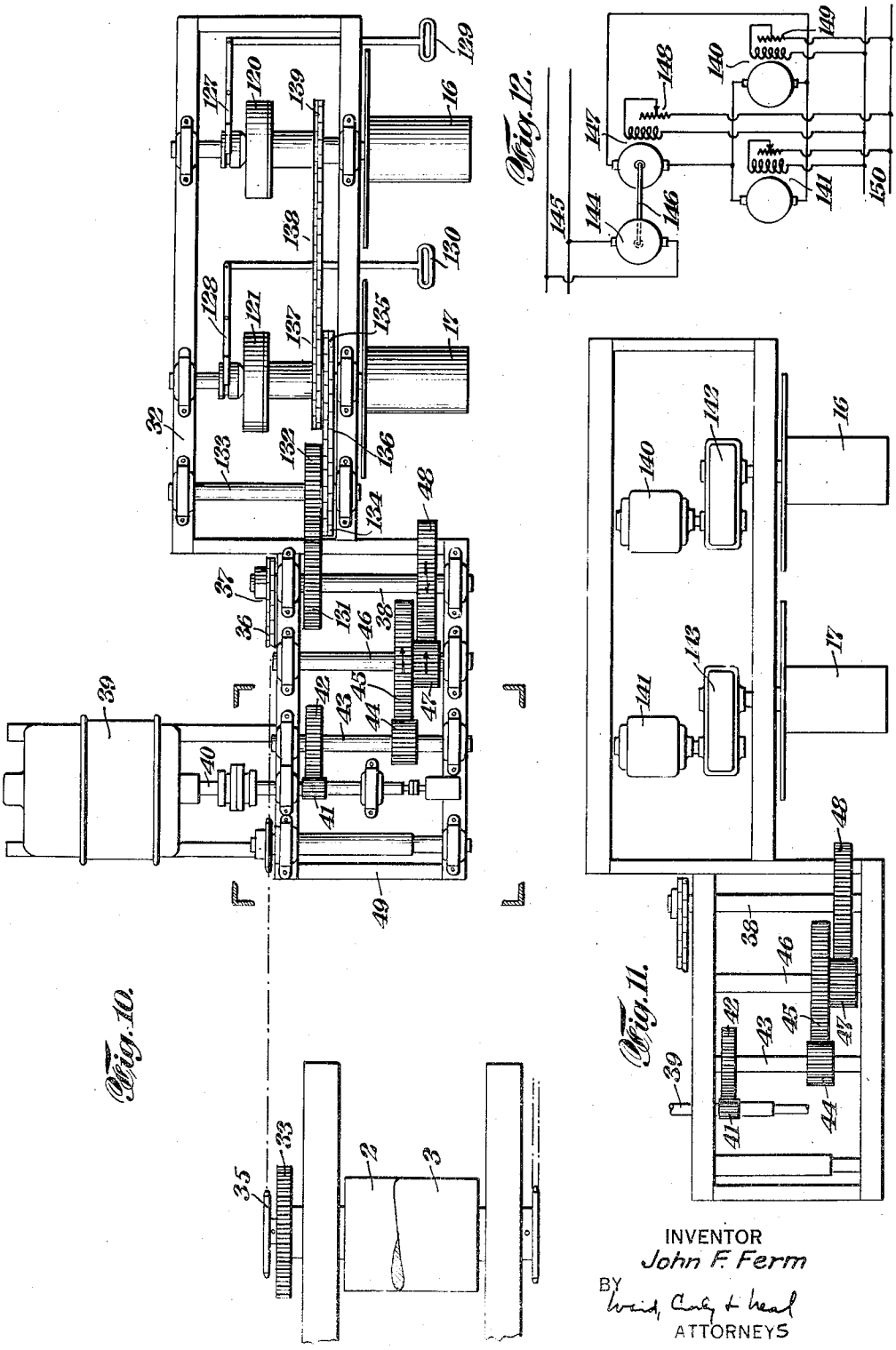


Fig. 10.

Fig. 12.

Fig. 11.

INVENTOR
John F. Ferm
BY
Wood, Cady & Head
ATTORNEYS

Sept. 5, 1944. J. F. FERM 2,357,389

APPARATUS FOR FEEDING AND COILING CONTINUOUS STRIP MATERIAL

Filed Aug. 2, 1940 6 Sheets-Sheet 5

Fig. 14.

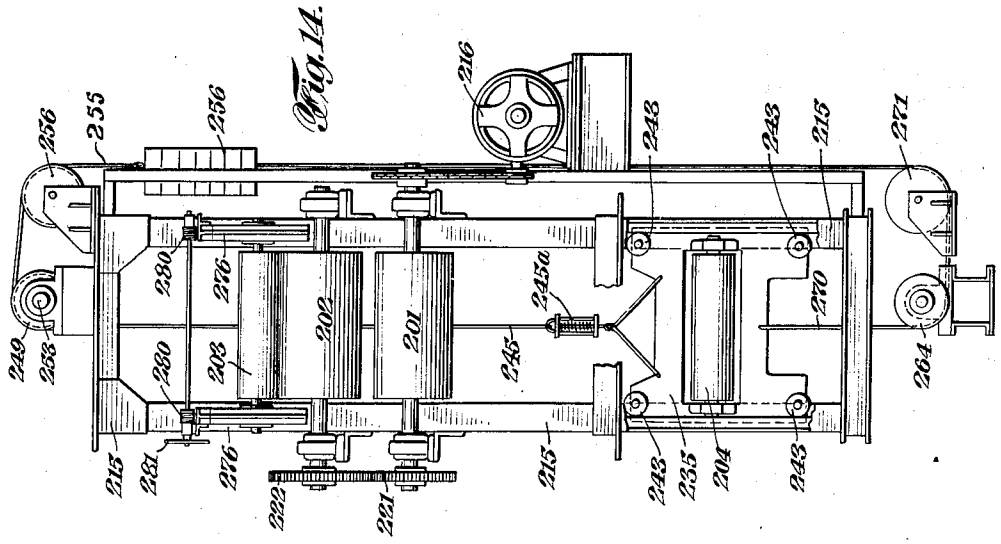
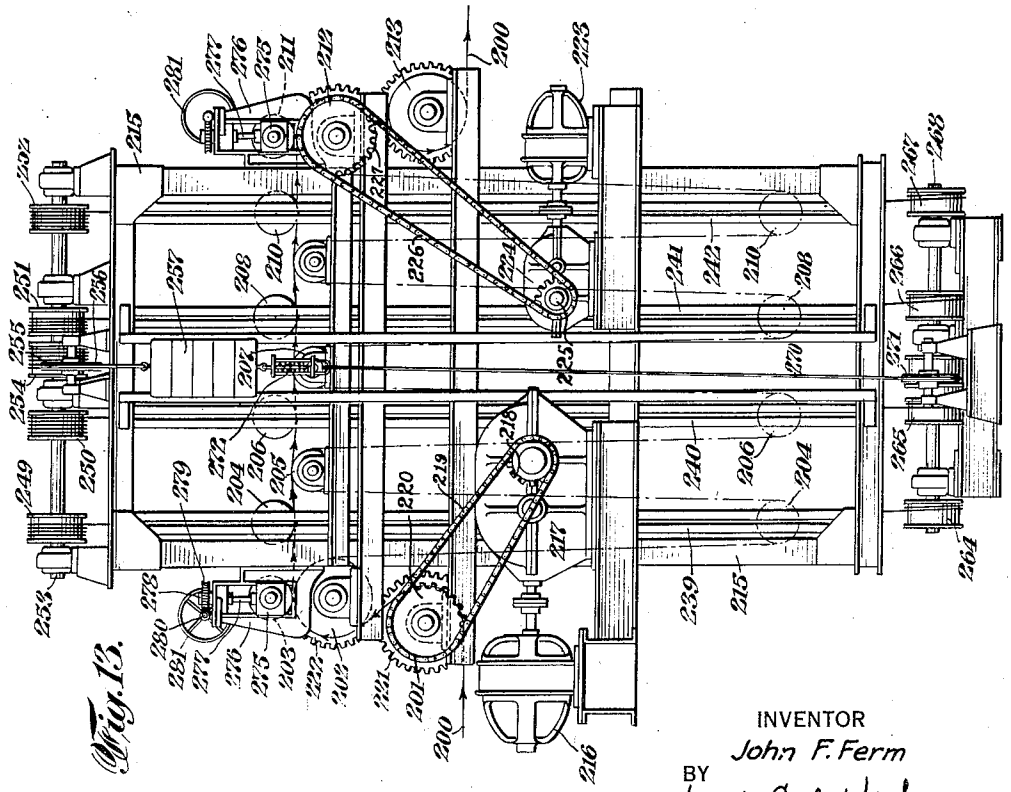


Fig. 13.



INVENTOR
John F. Ferm
BY
Wood, Cushman & Wood
ATTORNEYS

Sept. 5, 1944. J. F. FERM 2,357,389

APPARATUS FOR FEEDING AND COILING CONTINUOUS STRIP MATERIAL

Filed Aug. 2, 1940 6 Sheets-Sheet 6

Fig. 15.

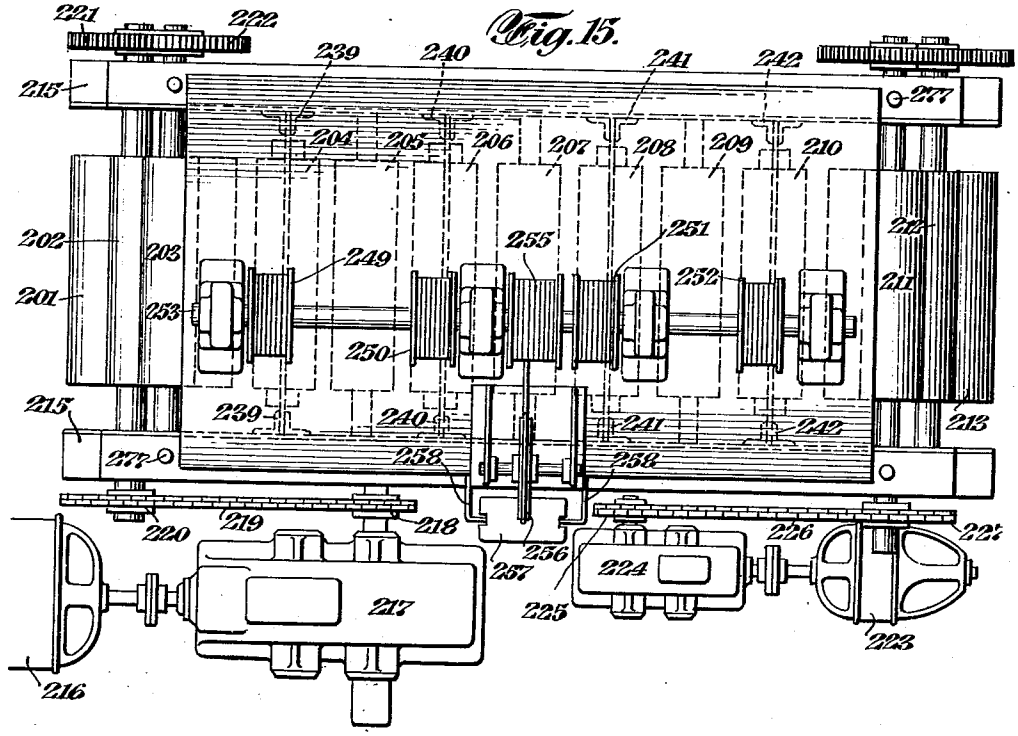
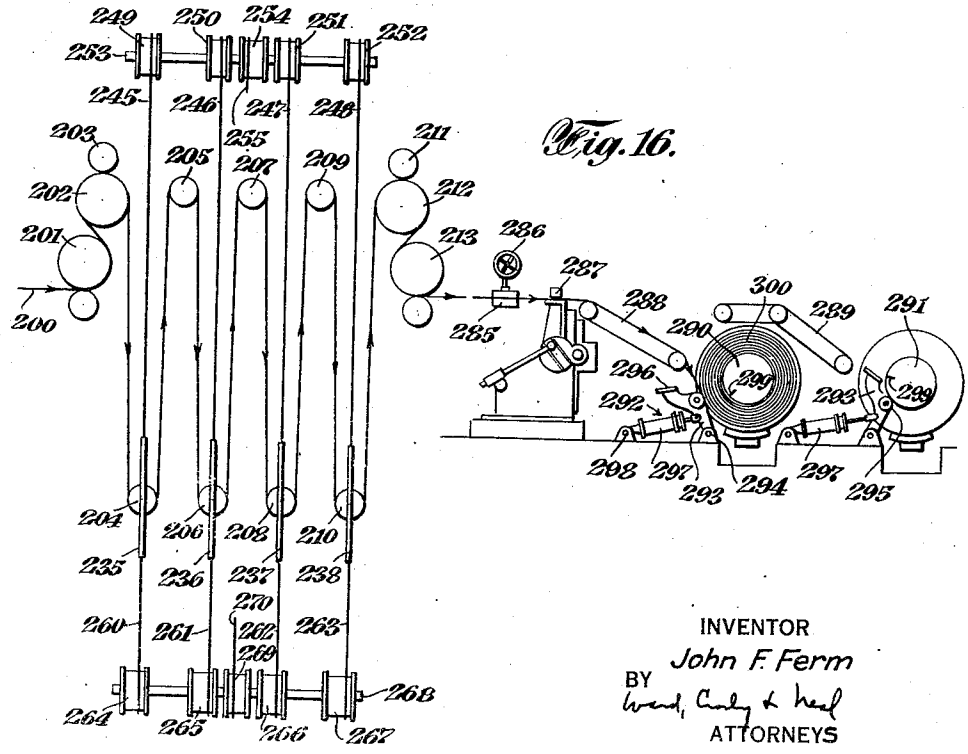


Fig. 16.



INVENTOR
John F. Ferm
BY
Wood, Cushy & Head
ATTORNEYS

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UNITED STATES PATENT OFFICE

2,357,389

APPARATUS FOR FEEDING AND COILING CONTINUOUS STRIP MATERIAL

John F. Ferm, Midland, Pa., assignor, by mesne assignments, to Crucible Steel Company of America, a corporation of New Jersey

Application August 2, 1940, Serial No. 349,569

10 Claims. (Cl. 242—80)

This invention relates to method and apparatus for handling strip material, particularly cold metal strip, and more especially for forming coils or reels from continuous strip as it emerges from processing apparatus through which the strip must be fed continuously and at a constant speed.

In certain applications involving the continuous processing of metal strip, such, for example, as the tin plating and brightening of steel strip in a continuous process, the strip must be fed continuously through the processing apparatus, i. e., cleaning and plating baths, brightening apparatus, etc., at a substantially constant speed. For convenience, in further handling, however, it is often required that the strip be formed into coils or reels of a certain size as it emerges from the processing apparatus. The latter is necessarily an intermittent and time-consuming operation, involving as it does cutting the strip when one coil is finished, and securing the free end to a winding block to start a new coil. During the interval required for this change-over and in the absence of special precautions, the material emerging from the processing apparatus will accumulate in folds, producing injury to the strip through bending, scratching, etc.

The present invention provides a mechanism for taking up the slack during this change-over period, and for maintaining the strip under continuous tension, free from folds and excessive bending, the apparatus operating in such manner that whereas the strip is fed into the input end of the mechanism at the relatively high speed with which it emerges from the processing apparatus, it is fed from the output end thereof at a sufficiently low and controlled rate of speed to permit of cutting the strip and starting a new coil without the accumulation of any substantial slack between the mechanism and the winding block. During the change-over period, the material accumulated in the mechanism referred to, is taken up between a series of rolls which are relatively displaceable in a direction preferably transverse to that in which the strip is fed. When the change-over is complete and the new coil started, a relatively high rate of feed at the output end of the mechanism is resumed and the strip material accumulated therein, fed onto another winding block at a rate sufficiently high to cause the laterally displaced rolls to be returned to their normal positions, whereupon the normal rate of feed of the strip is resumed throughout the mechanism.

In the accompanying drawings:

Figs. 1 and 2 are, respectively, a plan view and a side elevation of one form of the invention; while Fig. 3 is an end elevation thereof taken substantially at 3—3 of Fig. 2.

Fig. 4 is an enlarged section at 4—4 of Fig. 2; while Fig. 5 is a detail in side elevation and partly in section of one of the roll assemblies shown in Fig. 4.

Fig. 6 is an enlarged semi-schematic view substantially along 6—6 of Fig. 1 and illustrating the construction and operation of certain braking arrangements employed in the Figs. 1 to 3 inclusive modification.

Fig. 7 is a section at 7—7 of Fig. 4 illustrating more or less diagrammatically an overrunning type of clutch employed in conjunction with the Fig. 4 roll assemblies.

Fig. 8 is a diagrammatic view illustrating in side elevation and with extraneous apparatus removed, the relative position of the strip and associated rolls over which the strip passes in the apparatus of Figs. 1 to 3 inclusive, as viewed at a time when one coil or reel is completed and ready to be severed from the strip; while Fig. 9 is a similar view showing the relative positions of the strip and rolls after severance of the strip from one coil or reel and upon commencing the strip feed upon a new coil or reel.

Fig. 10 is a plan view showing a modified form of drive for the apparatus of Figs. 1 to 3 inclusive, characterized in the use of a single motor for driving the entire apparatus including the winding blocks, as compared to the use of separate motors for driving the slack take-up unit and the winding blocks in the modification of Figs. 1 to 3, inclusive.

Fig. 11 is another plan view showing a still further modification for operating the apparatus wherein individual motors are employed for driving the slack take-up unit and the winding blocks; while Fig. 12 is a schematic electrical circuit diagram showing a Ward-Leonard arrangement for controlling the speeds of the winding block motors in the Fig. 11 modification.

Fig. 13 is a view in side elevation of another form of the invention; Fig. 14 a view thereof in end elevation as viewed from the left in Fig. 13; and Fig. 15 is a plan view of Fig. 13; while Fig. 16 is a diagrammatic view, somewhat similar to Figs. 8 and 9, illustrating in side elevation and with extraneous parts removed, the relative position of the strip and associated rolls over which it passes, in the apparatus of the Figs. 13 to 15, this view also illustrating certain additional apparatus for feeding the strip onto the winding blocks.

Referring to the modifications of Figs. 1 to 9 inclusive, and more particularly to Figs. 1 and 2; the strip 1 enters the mechanism at the extreme left and passes as an S loop about and between bridle rolls 2, 3, emerging between the latter and a cooperating spring supported pressure idler roll 4, from whence the strip passes over an idler roll 5, under a "dancer" idler roll 6 journaled to a frame or carriage 7 vertically displaceable on guide rails 8 as explained hereinafter. From this point, the strip passes between a pair of pinch rolls 9, 10, and over roll 10, thence under a second "dancer" idler roll 11, journaled to a frame or carriage 12 vertically displaceable on guide rails 13, the assembly 11, 12, 13 being identical with 6, 7, 8. The strip then passes between a pair of pinch rolls 14, 15 like 9, 10, and over roll 15 and is fed thence onto a collapsible core winding block 16 or 17 into the form of a coil or reel, as at 18. Fig. 8 shows more clearly and with appurtenant parts removed, the path of the strip through the mechanism and the rolls over which it passes.

Owing to the complexity of the apparatus, it will be helpful before passing to a detailed description thereof, to consider briefly its general mode of operation at this point and with reference to the simplified showings of Figs. 8 and 9. Fig. 8 illustrates the normal feed of the strip through the mechanism, that is to say, during intervals when the winding of a coil or reel, such as 18, onto a winding block, such as 16, is well under way. Fig. 9 on the other hand illustrates the feed immediately following the completion of one reel, such as 18, and the starting of a new reel, such as 20.

Irrespective of whether the apparatus is in the condition of Fig. 8 or 9, the bridle rolls 2, 3 are power-driven at a constant speed such as to feed the strip 1 into the mechanism at the same rate that it emerges from the preceding processing apparatus (not shown). Normally or in the condition of Fig. 8, no further power feed is applied to the strip until it reaches the winding block 16, which, however, is power-driven at such speed as to wind the strip onto reel 18 at the same surface speed that it is fed from the bridle rolls 2, 3, thereby to maintain adequate tension on the strip to prevent the accumulation of any slack between the bridle rolls 2, 3 and the winding block 16. Under this condition, all of the intermediate rolls 4, 5, 6, 9, 10, 11, 14, 15 function merely as idler rolls to guide the strip through the apparatus, the vertically displaceable dancer rolls 6, 11 being maintained in the elevated positions shown in Fig. 8 by the tension exerted on the strip by the driving power applied to winding block 16.

When, however, a reel such as 18 has been wound to the requisite diameter, the drive is removed from winding block 16. Tension on the strip between roll 15 and the winding block is thus lowered. Immediately this occurs, rolls 10 and 15 of the pinch rolls 9, 10 and 14, 15 become automatically operative as drive rolls, in a manner explained below, to feed the strip at a relatively low rate over roll 15 and such as to permit the starting of a new reel 20 on the alternate winding block 17 without accumulation of any appreciable slack between roll 15 and the winding block.

Since, however, the strip continues to be fed at the initial constant and relatively high rate of speed over the bridle rolls 2, 3, the strip is thereby caused to accumulate between these rolls and the now slowly driven pinch rolls 9, 10 and 14, 15. This accumulation is automatically taken up by descent of the dancer rolls 6, 11 and their carriages 7, 12 under gravity, along the vertical carriage guides 8, 13 to form loops in the strip transverse to its general direction of feed, as illustrated in Fig. 9, wherein the function of the idler roll 5 in forming a loop in the strip between rolls 5, 6, 10 corresponding to a similar loop simultaneously formed between rolls 10, 11, 15, will be apparent.

During the interval afforded by descent of the dancer rolls, the strip being wound onto coil 18 is severed at a nearby point 21, and the severed end being fed from pinch roll 15, is attached to the alternate winding block 17 and power gradually applied thereto until the new coil 20 is well started. Thereupon the coil block is speeded up sufficiently to take up the slack provided by loops 5, 6, 10 and 10, 11, 15, to thereby return the dancer rolls 6, 11 to their normal elevated positions, owing to the increased tension exerted on the strip between the winding block and the bridle rolls. When this condition obtains, the coil block is thereafter driven at the same surface speed as the bridle rolls, and in the manner explained below.

The above describes the operation only in broad outline to facilitate an understanding as to the ensuing detailed description of the apparatus, following which the operation will be reviewed and amplified to include certain additional features best reserved until then.

Considering now the detailed construction of the apparatus whereby the above outlined mode of operation is effected, the constant speed drive for the bridle rolls 2, 3 is effected as follows: Referring to Figs. 1, 2, 3 and 10, rolls 2, 3 are keyed respectively to shafts 30, 31 journaled to a framework 32. Also keyed to these shafts respectively are the intermeshing gears 33, 34, whereby application of drive to one roll drives the other. Roll 2 is driven by a sprocket 35 keyed to shaft 30, this sprocket in turn being driven by a chain 36 passing at its opposite end over a sprocket 37, keyed to a shaft 38, the latter being driven by an electrical motor 39 through the sequence consisting of the motor driven power shaft 40, gear 41 keyed thereto, the latter meshing with a gear 42 keyed to a shaft 43, to which is also keyed a gear 44 meshing with a gear 45, the latter being keyed to a shaft 46 which also carries a gear 47 meshing with a gear 48 keyed to shaft 38 carrying sprocket 37. Shafts 38, 40, 43 and 46 are journaled as shown to a frame 49. It will be observed that the gear and sprocket sequence and ratios are such as to provide a continual speed reduction in passing from the motor drive shaft to the bridle rolls.

The details of the dancer roll assemblages 6, 7, 8 and 11, 12, 13 are shown in Figs. 1, 2, 3 and 4. The rolls 6, 11 are, as stated, journaled to frames 7, 12 provided with guide rolls, such as 55, operating in the vertical guides 8, 13, whereby the dancer rolls may move up and down. Each frame 7, 12 has attached to its upper end a cable, such as 56, Fig. 3, which passes over suitable sheaves, as at 57, 58, and extends downwardly over the side of the apparatus to a weight 59 operating in a tubular guide 60. These weights only partially counterbalance the weights of the dancer rolls and their frame members, so that the dancer rolls move downwardly to form the loops 5, 6, 10 and 10, 11, 15, Fig. 9, during in-

tervals requiring slack take-up when the tension on the strip is lowered.

The detailed construction and operation of the pinch rolls 9, 10 and 14, 15 will be explained with reference to Figs. 1 to 3 and the enlarged details thereof, Figs. 4 to 6. Since these pairs of rolls are identical in construction and assembly throughout as well as in function, an explanation as to one set will suffice for both except as noted below, Fig. 5 showing for convenience, rolls 9, 10. Referring to Figs. 4 and 5, roll 9, preferably having a surface covering of rubber, is so mounted as to be resiliently adjustable toward and away from roll 10 for adjusting, as required, the pressure exerted on strip 1 as it passes between these rolls. To this end, roll 9 is journaled to end blocks 61, which are slidably supported for horizontal movement in guide frames 62, the latter carried by the main frame 32. Each block 61 is provided with a recess 63 into which freely fits a flanged terminus 64 of a rod 65, the opposite end of which is threaded through a sleeve-like hub 66 of a worm gear 67, said hub being journaled through a bearing 68 carried by frame 62. Block 61 is resiliently urged toward roll 10 by means of a helical spring 69 surrounding rod 65 and interposed between block 61 and a washer 70 secured to the rod. Roll 10 is in turn journaled through end blocks 71 which are fixedly adjusted in relation to blocks 61 by means of adjusting bolts 72 threaded through the frame 62. With this arrangement, rotation of worm wheel 67 in one direction or the other will resiliently adjust roll 9 toward or away from roll 10 to vary, as required, the pressure thereby resiliently applied to strip 1 in passing between these rolls.

For so rotating worm wheels 67, the latter engage worms 73 mounted on shafts 74 to which are also secured sprockets 75 from which chains 76 extend to sprockets 77 journaled to the frame 32 and provided with adjusting crank handles 78. In practice, handles 78 are initially adjusted to provide the desired pressure between the pinch rolls and are thereafter ordinarily left undisturbed.

As explained above in connection with the operation of the apparatus, pinch rolls 9, 10 and 14, 15 function merely as idler rolls so long as driving power is applied to the winding block 16 or 17 to reel the strip thereon at a relatively high surface speed, corresponding to that at which it is fed over bridle rolls 2, 3, but become automatically operative on severance of the strip, as at 21, to feed the strip at a relatively low rate, about half that of the bridle rolls in the present construction, and such as to permit the formation of the loops 5, 6, 10 and 10, 11, 15, Fig. 9, by descent of the dancer rolls 6, 10. When so operated, the pinch rolls are, moreover, driven at such relative rates as to concurrently form equal loops 5, 6, 10 and 10, 11, 15. After the loops have been thus formed and a new coil started on another winding block to which driving power is applied at a rate such as to take up the loops and restore the normal operation of Fig. 8, the pinch rolls will additionally so operate automatically as to concurrently take up the loops at substantially the same rate, so that the loops disappear simultaneously. The mechanisms for effecting these operations will now be described with reference more particularly to Figs. 1, 2 and 4.

As explained above, bridle rolls 2, 3 are driven by motor 39 through the gear and chain sequence extending to roll 2 and the intermeshing gears of rolls 2, 3. Keyed to the shaft of roll 3 is a sprocket 75' carrying a chain 76' passing over a sprocket 77' coaxial with pinch roll 10. Referring to Figs. 4 and 7, sprocket 77' is integral with the outer member 78' of an overrunning clutch 79 of a standard construction as shown in Fig. 7, the inner member 80 of which clutch is keyed as shown to a projecting end of shaft 81 supporting pinch roll 10. Also integral with sprocket 77', as shown in Fig. 4, is a second sprocket 82 carrying a chain 83 which passes over a sprocket 84 coaxial with pinch roll 15. Sprocket 84 is in turn integral with the outer member 85 of an overrunning clutch 86 similar to 79, and the inner member 87 of which is keyed to a projecting end of shaft 88 supporting pinch roll 15.

In the operation of clutches 79, 86, the outer members are driven at all times at relatively low rates of speed by the speed reduction ratio chain and sprocket sequences 75', 76', 77' and 82, 83, 84 extending back to the driven bridle roll 3. The outer clutch members thus tend to drive their inner members at all times at correspondingly low rates of speed, but will actually do so only during intervals that the strip 1 is not being pulled at a greater speed over the pinch rolls 10, 15 by power applied to the winding block 16 or 17, since otherwise these clutches will be overrunning and rolls 10, 15 merely idling with respect thereto. Accordingly, so long as the winding block is being driven to reel the strip thereon at the same or a greater speed than it is fed over the bridle rolls 2, 3, clutches 79, 86 will be overrunning and rolls 10, 15 idling with respect thereto. When, however, the strip is severed, as at 21, to start a new reel, clutches 79, 86 will automatically engage to feed the strip at the low speed of their driven outer members 78', 85, thereby to permit the dancer rolls 6, 11 to descend and form loops in the strip, as shown in Fig. 9. In the construction shown, the diameters of sprockets 75' and 77' are such as to drive the pinch rolls 9, 10 at about five-eighths the surface speed of the bridle rolls.

Also the diameter of sprocket 84 is greater than that of sprocket 82 whereby pinch roll 15 is driven through clutch 86 more slowly than pinch roll 10 is driven through clutch 79. This is done in order that the dancer rolls 6 and 11 will descend at the same rate, concurrently to form equal loops at 5, 6, 10 and 10, 11, 15, Fig. 9, the sprocket ratios being suitably chosen to this end. With pinch rolls 9, 10 clutch driven as aforesaid at about five-eighths the surface speed of the bridle rolls, the ratio of sprockets 82, 84 should be so chosen that pinch rolls 14, 15 will be clutch driven at about one-fourth the surface speed of the bridle rolls, in which event the surface speed of pinch rolls 9, 10 will lie about midway between that of the bridle rolls and that of pinch rolls 14, 15, in order to form equal loops.

A similar problem arises on subsequently taking up the loops after a new reel has been started. That is to say, when the severed end of the strip has been secured to the alternate winding block and power applied thereto to speed up the strip feed, loop 10, 11, 15, Fig. 9, would be taken up faster than loop 5, 6, 10, if pinch rolls 10, 15 functioned merely as idler rolls during the slack take-up interval, as would be the case in so far as the operation of clutches 79, 86 is concerned, both of which would then be overrunning. To obviate this difficulty and referring again to Fig. 4, the shaft 81 of pinch roll 10 is provided at its opposite end with a second overrunning clutch 90, like 79, the inner member 91 of which is keyed to shaft 81, and the outer member 92 of which is

integral with a sprocket 93 carrying a chain 94 extending at its opposite end about a second sprocket 95 keyed to shaft 88 of pinch roll 15. As shown in the drawings, sprocket 93 has a slightly larger diameter than sprocket 95, whereby the outer member 92 of clutch 90 is driven by pinch roll 15 but at a lower speed of rotation.

During the slack take-up period, that is, when the strip is being pulled at a relatively high surface speed over roll 15 by the driving power applied to the winding block, roll 15 will be driven by the strip at such a high speed that its clutch 86 will overrun. Also roll 15 will drive the outer member 92 of clutch 90 at such a high speed through the sprocket and chain sequence 93, 94, 95, as to cause this clutch to engage, and thereby to drive roll 10 at a lower speed than roll 15, but nevertheless at a speed sufficiently high to cause the opposite clutch 79 on roll 10 to overrun, so that during this interval, roll 10 will be driven exclusively by roll 15, but at the lower speed referred to, and such as to cause the loops 5, 6, 10 and 10, 11, 15, Fig. 9, to be taken up at the same rate, the diameters of sprockets 93, 95 being suitably chosen to this end. When now the loops have been completely removed by return of the dancer rolls 6, 11, to their uppermost limit, as shown in Fig. 8, the speed of roll 10 will be increased until it equals that of roll 15, due to the fact that both rolls will now be driven by the strip owing to its increased tension on the rolls, in consequence of which clutch 90 will overrun. And since clutches 79 and 86 were previously overrunning as explained, all clutches will now overrun and continue to do so until the speed of the strip is greatly reduced and the loops again formed, such as would occur on severing the strip to start the next reel.

During the slack take-up operation, that is, while the dancer rolls are being returned from the positions of Fig. 9 to those of Fig. 8, some provision must be made to apply sufficient back tension on the strip being coiled on the winding block to assure a tightly wound coil, inasmuch as during this interval the pinch rolls and dancer rolls are idling, while the bridle rolls can apply no back tension owing to the intervening slack. To take care of this contingency, the shafts of pinch rolls 10, 15 are provided, as shown in Figs. 1, 2, 4 and 6, with manually operated brakes 96, 97, the brake drums 98 of which are keyed to the pinch roll shafts 81, 88 respectively. Cooperating with each of drums 98 is a pair of oppositely disposed brake shoes 99, 100, pivoted respectively to brake arms 101, 102, the lower ends of which are in turn pivoted, as at 103, to the framework 32, and the upper ends of which are linked to a torsion arm 104 through the linkages 105, 106, the torsion arm being keyed to a shaft 107 journaled to frame 32. Also keyed to shaft 107 is a brake arm 108, one end of which carries a weight 109 which serves to hold the brake shoes in braking engagement with the associated drum when the braking mechanism is free to act. The braking action is applied or removed by means of a cable 110, the upper end of which is connected to the opposite end of the brake arm 108 from that suspending the weight 109, the lower end of said cable being attached to one end of an arm 111, Fig. 2, pivoted at an intermediate point 112 from the frame 32, the opposite end of arm 111 being provided with a suitable detent latch 113 engaging the detent rack 114 carried by frame 32 and which is provided with suitable stops as shown for adjustably positioning arm 111. In this way, a desired degree of braking may be applied to the shafts of pinch rolls 10, 15 during the slack take-up operation.

In the modification of Figs. 1 and 2, the winding blocks 16, 17 are driven through suitable variable speed drives, such as slip clutches 120, 121, to which driving power is applied from a rheostat controlled, variable speed motor 122, through a suitable reduction gear chain 123, driving a worm shaft 124, the latter engaging worm wheels 125, 126 individual to clutches 120 and 121 respectively. Each clutch is provided with a suitable control mechanism, as at 127, 128, actuated by handles 129, 130, for variably engaging the clutch to provide the winding speed required at any given instant, or for completely releasing the clutch to disengage the winding block from the source of driving power.

Having fully described the modification of the invention illustrated in Figs. 1 to 9, inclusive, its operation will now be reviewed, starting at an instant when the winding of a coil of strip is well under way as shown in Fig. 2 by coil 18 on winding block 16. At such time, the dancer rolls 6, 11 are in the elevated positions shown in Fig. 8, and the rotative speed of the winding block 16 is so adjusted by means of its slip clutch 120 and the associated control handle 129, that the strip is being wound on the winding block 16 at the same surface speed that it is being fed over the bridle rolls 2, 3, the latter driven at a constant speed by motor 39 as above explained. Also the pinch rolls 10, 15 are running at the same surface speed as the bridle rolls 2, 3, so that all of the clutches 79, 86, 90 associated therewith are overrunning. Therefore the pinch rolls are merely idling, no drive being applied to the strip between the bridle rolls 2, 3 and winding block 16, the strip, however, being maintained under appropriate tension to hold the dancer rolls in the elevated positions shown in Fig. 8 by the driving power applied from motor 122 to the winding block 16. The brakes 96, 97 associated with the pinch rolls 10, 15 are disengaged.

As the winding proceeds, the surface speed at which the strip is being wound onto coil 18 must remain the same as the constant surface speed of the bridle stand rolls, regardless of the increasing diameter of the coil. This is automatically compensated for by slippage in the friction clutch 120, which increases as the coil increases in size. To avoid excessive slippage as the coil increases in diameter, the operator periodically reduces the speed of the adjustable speed motor 122. This reduced slippage in the friction clutch, decreases the wear of friction parts and thereby increases the life of these parts.

When the desired amount of strip has been wound on coil 18, the operator disengages clutch 120 to stop rotation of winding block 16, whereupon owing to the consequent reduction in speed of the pinch rolls 10, 15, their overrunning clutches 79, 86 engage to drive these rolls at the relatively low rates to speed above referred to, thus producing a progressively increasing length of strip in the intermediate zones between the pinch rolls and the bridle rolls 2, 3, driven at constant speed. The dancer rolls 6, 11 accordingly descend under the combined weights of these rolls and their carriages, to progressively increase the path of travel of the strip in the zones referred to by formation of the loops 5, 6, 10 and 10, 11, 15, as shown in Fig. 9. As above explained, the loops are formed equally owing to the speed reduction provided by the chain

and sprocket drive 82, 83, 84 between clutches 79, 86, whereby roll 15 is clutch driven at a lesser speed than roll 10. Clutch 90 at the opposite end of pinch roll 10 is now overrunning.

During the interval that the dancer rolls are thus descending to form the loops referred to, and the strip is being fed slowly over the pinch rolls, the operator cuts the strip, as at 21, and attaches the severed end to the alternate winding block 17. Thereupon clutch 121 is engaged by manipulation of the control handle 130 and speed control rheostate of motor 122 adjusted to initiate rotation of winding block 17 at a speed faster than the clutch-driven speed of the output pinch roll 15. The brakes 96, 97 associated with the pinch rolls, are now engaged by manipulation of the detent handles 113, thereby to apply sufficient tension to the strip being wound on the winding block 17, to pull the convolutions of the strip tightly about the block. Thereupon the rheostat of motor 122 is adjusted to increase the speed of the winding block 17 in excess of the normal rate of feed of the bridle rolls 2, 3, to thereby take up the loops between the bridle and pinch rolls. The increased tension thus exerted on the strip between the winding block 17 and the bridle rolls 2, 3 causes the dancer rolls 6, 11 to be gradually returned from their lower positions as shown in Fig. 9 to their normally elevated positions as shown in Fig. 8. The increased surface speed thus imparted to pinch roll 15 by the strip being pulled over it, causes its clutch 86 to overrun, and also causes clutch 90 to engage in consequence of the increased speed imparted to its outer member 92, by the chain and sprocket drive 93, 94, 95. Pinch roll 10 is accordingly driven by roll 15 but at a lower rate of speed than roll 15, owing to the speed reduction provided by sprockets 95, 93, whereby, as above explained, the loops 5, 6, 10 and 10, 11, 15 are taken up at the same rate. During this interval, the opposite clutch 79 associated with pinch roll 10 is overrunning, as is also clutch 86 associated with pinch roll 15, as above explained.

When the dancer rolls have thus been returned to their elevated positions, the increased tension exerted on the strip will automatically drive the pinch roll 10 at the same surface speed as pinch roll 15, whereupon clutch 90 also starts overrunning, and continues to do so along with clutches 79 and 86, so long as the strip continues to be wound on block 17 at substantially the same surface speed as it is feed from the bridle rolls 2, 3. The sequence of operations above described will, of course, be repeated when coil 20 on winding block 17 has been reeled up to the desired diameter.

In the modification of Figs. 1 to 3, separate motors 39, 122 are provided for the slack take-up unit and the winding blocks respectively. In the modification of Fig. 10 on the other hand, the single motor 39 serves both functions. To this end, shaft 38 driven from the motor 39 through a gear train 41, 42, 44, 45, 47, 48 as above explained, also drives through intermeshing gears 131, 132 a shaft 133 journaled to frame 32, which shaft carries a sprocket 134 driving sprocket 135 through chain 136 coaxial with winding block 17. Integral with sprocket 135 is a second sprocket 137 which drives through chain 138 the sprocket 139 coaxial with winding block 16. Sprocket 135 drives winding block 16 through its slip clutch 121 while sprocket 139 drives winding block 16 through its slip clutch 120. In this modification, as in that of Fig. 1, the slip clutches 120, 121 are provided with suitable control mechanisms 127, 128 operable by handles 129, 130 for variably engaging or disengaging the clutches as desired.

In the modification of Figs. 11 and 12, the winding blocks 16, 17 are individually driven by separate variable speed motors 140, 141 through suitable gear trains indicated at 142, 143. Referring to Fig. 12, the motor speeds are controlled by a Ward-Leonard arrangement, according to which a motor 144, ordinarily of the alternating current type and driven from an alternating current line 145, drives directly over shaft 146, the armature of a direct current generator 147 having connected in parallel therewith as shown, the armatures of motors 140, 141. The shunt fields of the generator and motors are connected through suitable rheostats, as at 148, 149, across a direct current power line 150. Thus by varying the rheostat 148 in the generator field, the voltage impressed by the generator on the motor armatures can be correspondingly varied to adjust the speeds thereof in conformity therewith. Also the speeds of the motors can be further adjusted by varying the rheostats, such as 149, in their shunt fields respectively. Accordingly, with this arrangement, no slip clutches or other variable speed drives are required between the motors and the winding blocks, as the speed of each motor can be continuously varied from zero to a desired maximum value, by merely adjusting the field rheostats referred to.

In the operation of this system, the generator rheostat is set to give the maximum speed desired for motors 140, 141, and the speeds of these motors thereafter adjusted from zero to the maximum by varying their shunt field rheostats. In addition to operating motors 140, 141 in parallel from generator 147, either motor may be operated independently of the other by a suitable control. It is also to be understood, of course, that the motor driving the entire line at the bridle stand, may be connected to another generator which is connected to motor 144 in the same manner as motors 140, 141, whereby the Ward-Leonard control may be extended to all motors.

Figs. 13 to 16 inclusive show a modification of the invention which is much simpler mechanically than those previously described. Referring to these drawings and especially to Fig. 16 depicting the strip feed schematically, the strip 200 enters the slack take-up unit at the left, Figs. 13, 16, and loops S shaped about input bridle rolls 201, 202, passing thence between bridle roll 202 and the associated pressure idler roll 203, thence alternately under and over successive idler rolls 204 to 210 inclusive, thence between pressure idler roll 211 and an output bridle roll 212, and thence out of the mechanism as an S loop about bridle rolls 212, 213.

The bridle rolls 201, 202, 212, 213, and the idler rolls 205, 207, 209, are journaled to the supporting framework for the mechanism indicated generally at 215. Also supported on framework 215 is an electrical motor 216 for driving the input bridle rolls 201, 202, through suitable reduction gears indicated at 217, and the sprocket and chain drive 218, 219, 220, extending therefrom to bridle roll 201, whence roll 202 is driven through the intermeshing gears 221, 222. Similarly the output bridle rolls 212, 213, are driven by a separate electrical motor 223, through suitable reduction gears indicated at 224, the sprocket and chain drive 225, 226, 227, and the intermeshing gears 228, 229.

The idler rolls 204, 206, 208, 210 are journaled

respectively to carriages 235, 236, 237, 238, as indicated in Fig. 16 and as shown in detail for roll 204 and carriage 235 in Fig. 14, which carriages are vertically displaceable in guides 239, 240, 241, 242 respectively, Figs. 13 and 15, each guide comprising, as shown in Fig. 15, a pair of spaced angle bars secured to frame 215, and each carriage, as shown at 235 in Fig. 14, being provided at its corners with rollers 243 operating in the slots thus formed by the spaced angle bar guides.

Attached to the upper ends of carriages 235, 236, 237, 238 respectively are cables 245, 246, 247, 248, the upper portions of which are wound respectively about drums 249, 250, 251, 252, with the wound cable ends secured to the drums respectively. The means of cable attachment to the carriage is shown more particularly in Fig. 14, there being interposed between the cable and the carriage a torsion spring, as at 245a, to impart a certain resiliency to the cable support. All of the drums aforesaid are keyed to a common shaft 253, journaled to frame 215. Also keyed to the shaft is another drum 254, about which a cable 255 is wound with the wound end thereof secured to the drum, the opposite end passing to the rear of the apparatus, Fig. 14, over a sheave 256 and thence downwardly for attachment to the upper end of a counterweight 257, provided with vertical slots along the sides for guiding the weight in vertical guides 258, Fig. 15.

Also secured to the lower ends of the carriages 235, 236, 237, 238 respectively are cables 260, 261, 262, 263, which are wound about drums 264, 265, 266, 267 keyed to a common shaft 268, the latter journaled to frame 215, with the wound ends of the cables secured to these drums respectively. Also keyed to shaft 268 is another drum 269 about which is wound a cable 270 with the wound end of the cable secured to the drum, the opposite end passing to the rear of the apparatus, Fig. 14, under a sheave 271 and thence upwardly for attachment to the underside of the counterweight 256, through a resilience-imparting torsional spring 272, Fig. 13.

For adjusting the pressure of the idler rolls 203, 211 on the input and output bridle rolls 202, 212 respectively, each pressure roll is journaled to end blocks, as at 275, Fig. 13, slidably displaceable in frame members, as at 276, the end blocks being vertical adjustable by rods, as at 277, threaded through a sleeve-like hub 278, journaled to frame member 276, of a worm wheel 279 engaging a worm 280 likewise journaled to frame 276 and actuated by a hand wheel 281, the construction being similar to Fig. 5.

Referring to the simplified showing of Fig. 16, the strip 200 after passing over the output bridle rolls 212, 213, is fed through adjustable guides 285 operated in unison by a hand wheel 286, thence through a cutting head 287, thence over a belt conveyor system 288 or 289 operating on idler or power driven rolls, to a winding block 290 or 291. Conveyor 288 can be raised by means not shown to a horizontal position when delivering the strip to winding block 291. Associated with each winding block 290, 291 is a pneumatically operated mechanism, such as 292, which is utilized in starting a new coil or reel. This mechanism comprises an angle arm 293 pivoted at its lower end 294 to a fixed support, and carrying at the angle thereof a roller 295, the upper end of the angle arm terminating in a flat surface 296 over which the strip is fed. The arm is rotated about its pivotal support 294 by a pneumatic piston 297 pivotally supported at 298.

In the operation of this mechanism, a severed end of the strip is inserted in a slot 299 of the winding block, the piston 298 being pneumatically actuated to rotate the angle arm 293 about its fixed pivotal support 294 until the roller 295 thereof engages the winding block. Driving power is thereupon applied to the winding block to rotate it in the counter-clockwise direction indicated by the arrow, so that when the slot 299 containing the strip engages the roller 295, the roller will uniformly bend the strip flat against the outer surface of the winding block, and will thereafter hold the strip tightly against the winding block, as the latter continues to rotate, thereby to form a tightly wound coil. As the coil increases in size with continued rotation of the winding block, the arm 293 is automatically rotated counter-clockwise as shown for winding block 290, with the roller 295 thereof continuing to ride on the outer surface of the coil as shown.

The winding blocks 290, 291 are preferably power driven by individual motors arranged as shown in Fig. 11, and electrically connected as shown in Fig. 12, to provide variable speed control by the Ward-Leonard arrangement. Also motor 216 driving the main line and motor 223 of the slack take-up unit, are likewise preferably electrically connected to separate generators, which latter are in turn connected to motor 144 of the motor generator set 144, 147, in the same manner as the winding block motors 140, 141, whereby the Ward-Leonard variable speed control may be also applied to motors 216, 223.

In the operation of the system shown in Figs. 13 to 16 inclusive, the input bridle rolls are driven at all times at a constant speed by motor 216, to feed the strip into the slack take-up unit at the same surface speed with which it is fed from the preceding processing apparatus, not shown. During intervals that the winding of the strip onto a reel, such as 300, is well under way, motor 223 is set to feed the strip over the output bridle rolls 212, 213, at the same surface speed that it is being fed over the input bridle rolls. At the same time, driving power is applied to the winding block 290 to wind up the strip at the same speed that it is being fed from the output bridle rolls. In order to assure the winding of a tight coil, however, the motor driving the winding block 290 is set so that it tends to run slightly faster than motor 223, so that the output bridle rolls apply a slight braking action to the winding block motor, thereby to maintain adequate tension on the strip being wound onto this block.

With the input and output bridle rolls thus feeding the strip to and from the slack take-up unit at the same surface speed, the tension exerted on the strip between these bridle rolls will maintain the dancer rolls 204, 206, 208, 210 in their elevated positions as indicated by the dashed line circles 204, 210 in Fig. 13, so that the strip traverses a substantially horizontal path through the apparatus in passing from the input bridle roll 202 to the output bridle roll 212.

When, however, a coil, such as 300, has been wound to the proper diameter, and a new coil must be started on the alternate winding block 291, the motor driving winding block 290 is stopped, and at the same time motor 223 driving the output bridle rolls is also stopped momentarily, to stop the output feed of the strip.

The strip is then cut by the cutting device 287, and motor 223 started again at a relatively low rate of speed to feed the severed end of the strip slowly over the conveyor 289 to the alternate winding block 291, to which the severed end of the strip is attached and the new reel started in the manner above described.

During the interval that motor 223 is thus stopped or operating at a slow speed, the strip will accumulate between the input and output bridle rolls, owing to the fact that the input bridle rolls continue to operate at constant speed. Tension on the strip between the input and output bridle rolls is accordingly reduced, so that the dancer rolls 204, 206, 208, 210, descend under the combined weights of these rolls and their carriages 235 to 238 inclusive, thereby to take up the accumulated strip in the form of loops, as shown in Fig. 16, between the dancer rolls and the adjacent bridle or idler rolls 202, 205, 207, 209, 212, as the case may be.

Owing to the fact that the dancer rolls are suspended from cables 245 to 248 inclusive, wound about and secured to the drums 249 to 252 inclusive, and the fact that these drums are all keyed to a common shaft to which is also keyed drum 254 supporting, by cable 255, the counterweight 257, it will be evident that all of the dancer rolls descend under gravity at the same rate against the counter-balancing effect of the counterweight 257, whereby the strip accumulating between the input and output bridle rolls is taken up in equal loops by the dancer rolls. Moreover, as the dancer rolls thus descend and pull the counterweight upward, the latter will, by exerting a corresponding pull on its lower cable 270, rotate its lower drum 269, and with it shaft 268 and drums 264 to 269 thereon in such direction as to wind up on the latter the slack otherwise produced in cables 260 to 263 owing to descent of the dancer rolls.

Reverting now to the winding block, when the new reel has been well started in the manner explained, the motor driving winding block 291 is speeded up, as is also motor 223 driving the output bridle rolls, sufficiently to feed the strip over the output bridle rolls at a greater surface speed than it is being fed over the input bridle rolls. Tension accordingly increases on the strip between input and output bridle rolls, causing the dancer rolls to rise and thus remove the loops formed in the strip. As the dancer rolls are thus elevated by virtue of the increased strip tension, they apply tension through their carriages to their lower cables 260 to 263, which in turn exert torque on drums 264 to 267, and the common shaft 268 keyed thereto, whereby the shaft is rotated in such direction as to wind up on drum 269 the cable 270 secured to the lower side of the counterweight. The counterweight accordingly descends and in so doing, applies tension to its upper cable 255 causing drum 254 to rotate and with it drums 249 to 252 in such direction as to unwind the cable from drum 254 and to wind up the cables on drums 249 to 252. It will be apparent that during this operation, the dancer rolls must rise together to take up the loops equally, due to the fact that the lower drums are keyed to a common shaft.

When the dancer rolls have been returned to their normal elevated positions, as shown in Fig. 13, motor 223 is slowed down until the strip feed over the output bridle rolls is the same as that over the input bridle rolls, and correspondingly the driving power applied to the winding block 291 is adjusted sufficiently to maintain the proper tension on the strip between the output bridle rolls and the winding block.

I claim:

1. Apparatus for forming continuous strip material into coils, comprising: input and output strip feeding means and interposed means including relatively displaceable rolls over which the strip is fed for taking up in the form of loops and maintaining under tension, the strip accumulating therein during intervals that the output feed is slower than the input feed, and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input, intermittently actuated coil winding means for reeling up the strip issuing from said output means, a drive for said input means maintained at a substantially constant speed, a variable speed drive for said coil winding means, and power driven means including an overrunning clutch for automatically driving said output strip feeding means at a substantially slower speed than said input means during intervals that said coil winding means is inoperative.

2. Apparatus for forming continuous strip material into coils, comprising: input and output strip feeding means and interposed means including relatively displaceable rolls over which the strip is fed for taking up in the form of loops and maintaining under tension, the strip accumulating therein during intervals that the output feed is slower than the input feed, and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input, intermittently actuated coil winding means for reeling up the strip issuing from said output means, a drive for said input means maintained at a substantially constant speed, a variable speed drive for said coil winding means, power-driven means including an overrunning clutch for automatically driving said output means at a substantially slower speed than said input means during intervals that said coil winding means is inoperative, and optionally operable braking means provided on an output strip feeding means for increasing strip tension at said coil winding means.

3. A device for feeding continuous strip material, comprising: input and output strip feeding means, and interposed means for taking up and maintaining under tension the strip accumulating therein during intervals that the output feed is slower than the input feed, and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input feed, said interposed means including a series of relatively displaceable rolls over which the strip is fed for taking up said accumulated material in the form of loops therebetween, together with means for displacing the alternate said rolls at equal rates and for thereafter restoring said rolls at equal rates, whereby said loops are formed and taken up equally, intermittently actuated, variable speed, coil winding means for reeling up the strip issuing from said output means, means for driving said input strip feeding means at substantially constant speed, and means for driving said output strip feeding means at reduced speed during intervals that said coil winding means is inoperative for accumulating said strip under tension between said relatively displaceable rolls during such intervals.

4. A device for feeding continuous strip mate-

rial, comprising: input and output strip feeding means, and interposed means for taking up and maintaining under tension the strip accumulating therein during intervals that the output feed is slower than the input feed and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input feed, said interposed means including a series of rolls journaled respectively in alternately fixed and vertically displaceable bearing members, between which rolls said strip is fed for taking up said accumulated material in the form of loops therebetween, and power-driven means including overrunning clutches for driving the rolls having fixed bearings at a relatively low rate of speed, and reduction ratio drives between said clutches proportioned to cause said displaceable bearing members to fall and rise at equal rates, whereby said loops are formed and taken up equally.

5. A device for feeding continuous strip material, comprising: input and output strip feeding means, and interposed means for taking up and maintaining under tension the strip accumulating therein during intervals that the output feed is slower than the input feed and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input feed, said interposed means including a series of idler rolls journaled respectively in alternately fixed and vertically displaceable bearing members between which rolls said strip is fed for taking up said accumulated material in the form of loops therebetween, and means including upper and lower drum members having cables wound thereabout and secured thereto and extending respectively to said vertically displaceable bearing members and to a vertically displaceable counterweight, for causing said displaceable bearing members to fall and rise at equal rates, whereby said loops are formed and taken up equally.

6. Apparatus for forming continuous strip material into coils, comprising: input and output strip feeding means and interposed means including relatively displaceable rolls over which the strip is fed for taking up in the form of loops, the strip accumulating therein during intervals that the output feed is slower than the input feed, and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input feed, intermittently actuated, variable speed, coil winding means for reeling up the strip issuing from said output means, means for driving said input strip feeding means at substantially constant speed, and means for driving said output strip feeding means at reduced speed during intervals that said coil winding means is inoperative, for accumulating the strip under tension between said relatively displaceable rolls during such intervals.

7. A device for feeding continuous strip material, comprising: input and output strip feeding means, and interposed means for accumulating a reserve of the strip therein under tension during intervals that the output feed is slower than the input feed and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input feed, said interposed means including a series of rolls journaled respectively in alternately fixed and vertically displaceable bearing members between which rolls the strip is fed for taking up said accumulated material in the form of loops therebetween, and means including upper and lower drum members having cables wound thereabout and secured thereto and extending respectively to said vertically displaceable bearing members, for causing the same to fall and rise at equal rates, whereby said loops are formed and taken up equally.

8. A device for feeding continuous strip material, comprising: input and output strip feeding means, and interposed means for accumulating a reserve of the strip therein under tension during intervals that the output feed is slower than the input feed and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input feed, said interposed means including a series of rolls journaled respectively in alternately fixed and vertically displaceable bearing members between which rolls the strip is fed for taking up said accumulated material in the form of loops therebetween, and means including upper and lower drum members having cables wound thereabout and secured thereto and extending respectively to said vertically displaceable bearing members, for causing the same to fall and rise at equal rates, whereby said loops are formed and taken up equally, means for driving said input means at substantially constant speed, and means for driving said output means at variable speed for accumulating and paying out said reserve as aforesaid.

9. A device for feeding continuous strip material, comprising: input and output strip feeding means, and interposed means for accumulating a reserve of the strip therein under tension during intervals that the output feed is slower than the input feed and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input feed, said interposed means including a series of rolls journaled respectively in alternately fixed and vertically displaceable bearing members between which rolls the strip is fed for taking up said accumulated material in the form of loops therebetween, means including upper and lower drum members having cables wound thereabout and secured thereto and extending respectively to said vertically displaceable bearing members, for causing the same to fall and rise at equal rates, whereby said loops are formed and taken up equally, intermittently actuated, variable speed, coil winding means for reeling up the strip issuing from said output means, means for driving said input strip feeding means at substantially constant speed, and means for driving said output strip feeding means at variable speed for accumulating said strip reserve at intervals that said coil winding means is inoperative and for thereafter paying out said reserve.

10. A device for feeding continuous strip material, comprising: input and output strip feeding means, and interposed means for accumulating a reserve of the strip therein under tension during intervals that the output feed is slower than the input feed and for thereafter paying out the strip so accumulated during intervals that the output feed is faster than the input feed, said interposed means including a series of rolls journaled respectively in alternately fixed and vertically displaceable bearing members between which rolls the strip is fed for taking up said accumulated material in the form of loops therebetween, means including upper and lower drum members having cables wound thereabout and secured thereto and extending respectively to said vertically displaceable bearing members, for causing the same to fall and rise at equal rates, whereby said loops are formed and taken up equally, means for driving said input strip feeding means at substan-

tially constant speed, means for driving said output strip feeding means at variable speed, means including an intermittently actuated, variable speed, coil winding block for reeling up the strip issuing from said output means, said winding block containing a slot for insertion of the strip to start a coil, and having associated therewith a power-actuated roller adapted to resiliently engage the winding block for uniformly bending the strip at the slot to start a new coil, and for thereafter maintaining pressure on the strip being wound.

JOHN F. FERM.