Nov. 20, 1951 J. S. NACHTMAN 2,576,074

METHOD AND APPARATUS FOR CONTINUOUS STRIP METAL TREATMENT

Original Filed Feb. 18, 1939 3 Sheets-Sheet 1

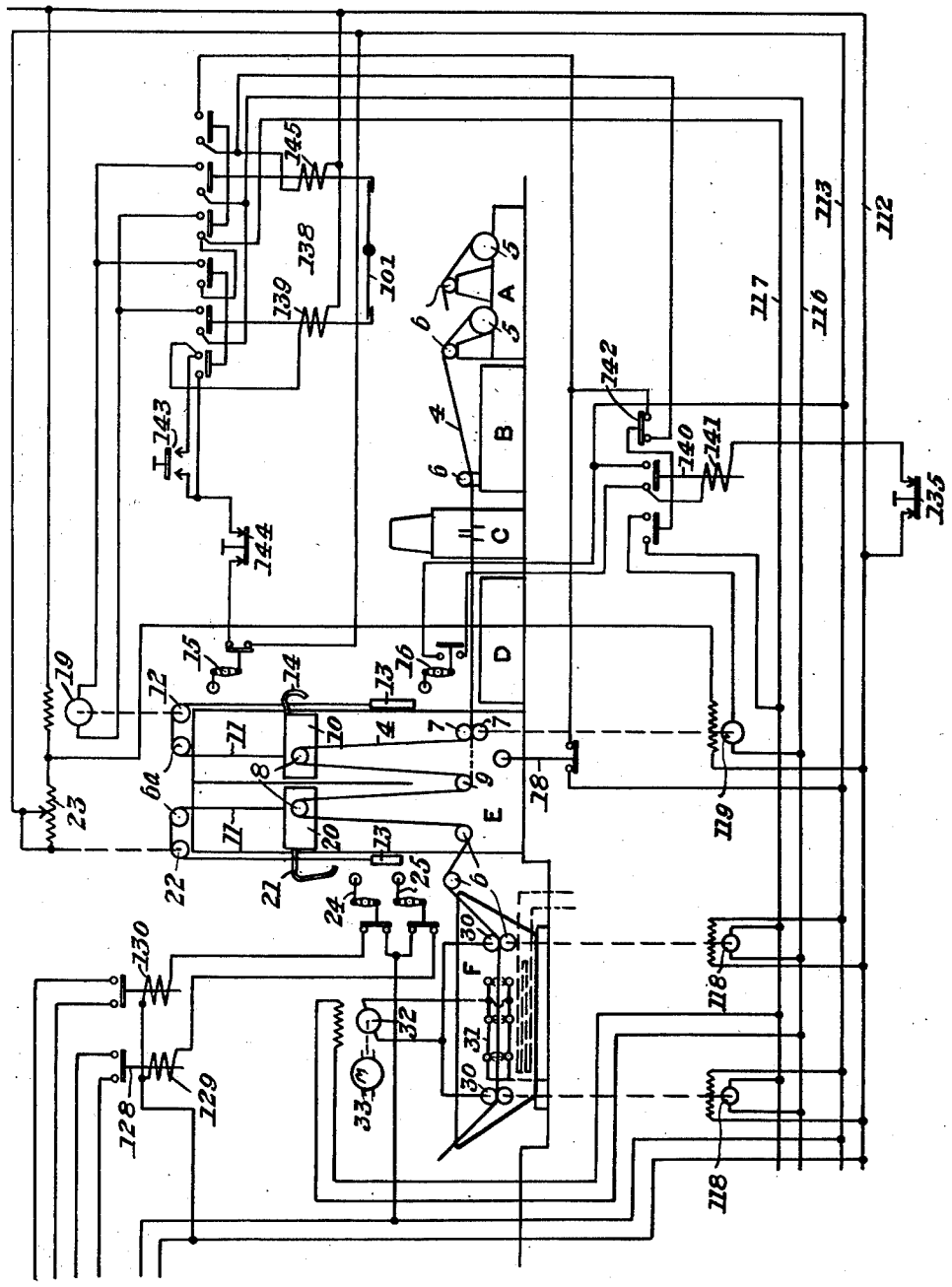


Fig. 1A.

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Original Filed Feb. 18, 1939 3 Sheets-Sheet 2

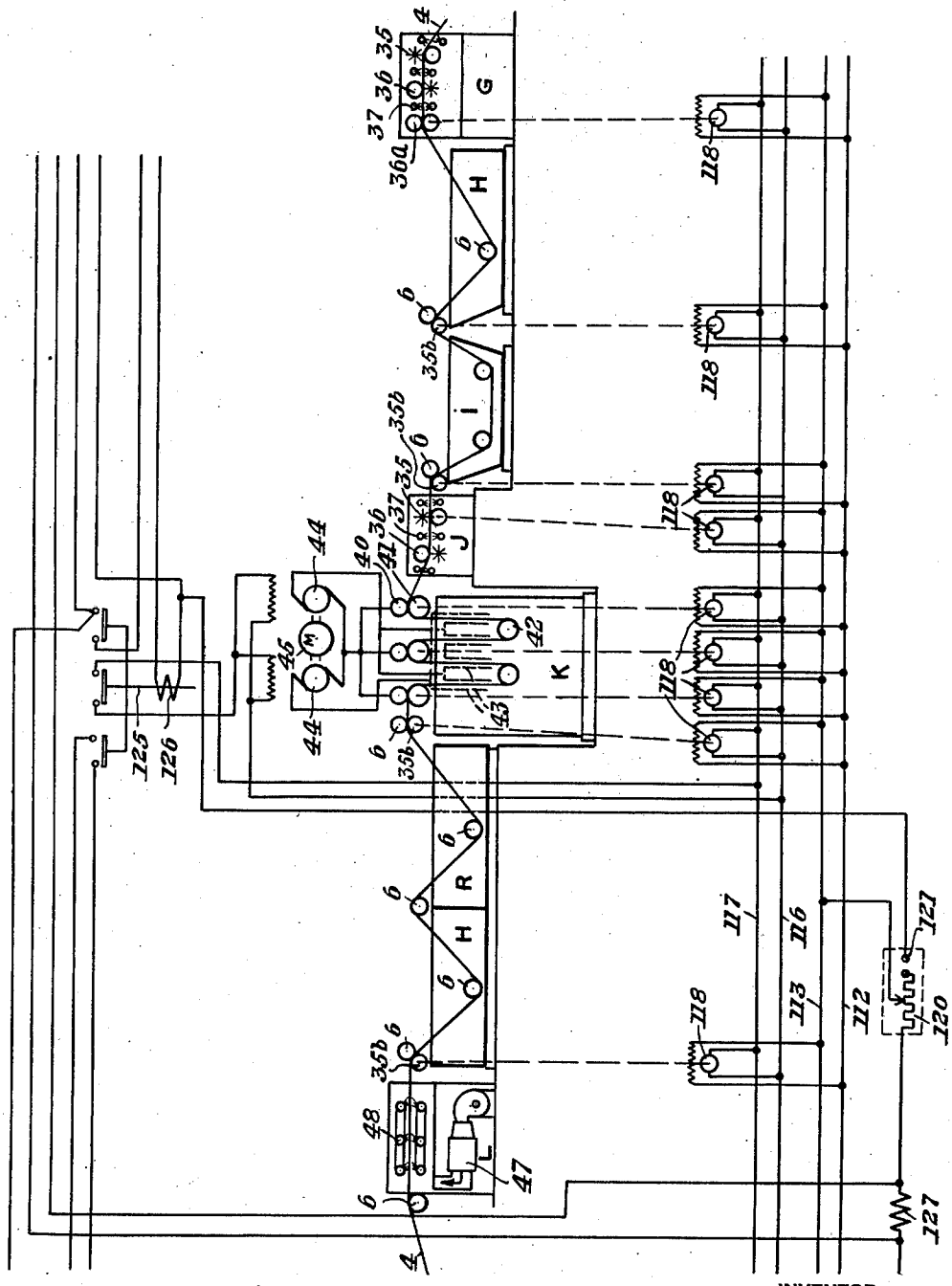


Fig. 1B.

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Original Filed Feb. 18, 1939 3 Sheets-Sheet 3

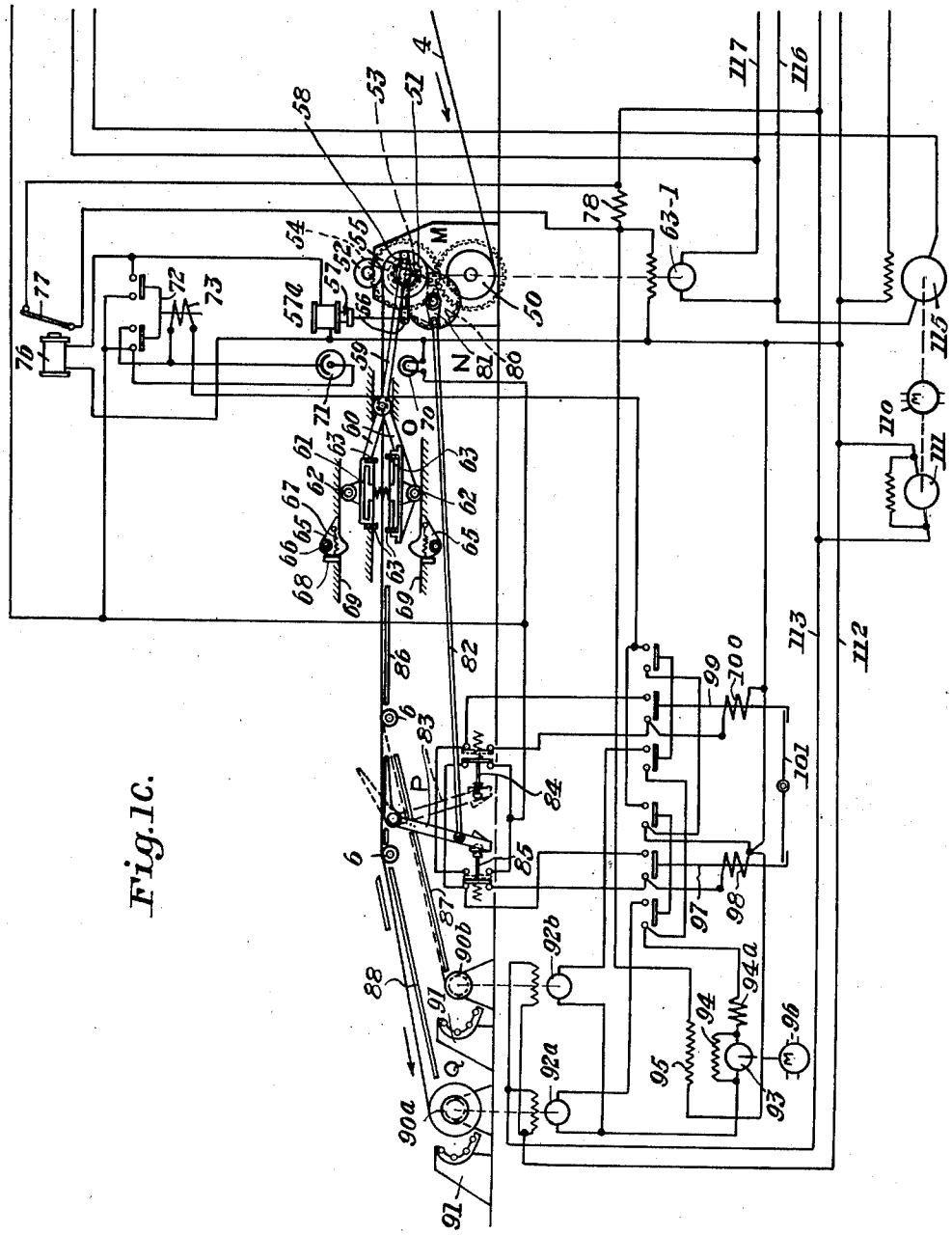


Fig.1C.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR CONTINUOUS STRIP METAL TREATMENT

John S. Nachtman, Youngstown, Ohio

Continuation of application Serial No. 257,107, February 18, 1939. This application June 11, 1946, Serial No. 675,897

9 Claims. (Cl. 204—28)

1

This application is a continuation of my prior application for Method and Apparatus for Continuous Strip Metal Treatment, filed February 18, 1939, Serial No. 257,107, now abandoned, which was a continuation-in-part of my application for Method of Continuously Tin Plating Ferrous Metal Stock, Ser. No. 133,911, filed March 30, 1937, now Patent No. 2,240,265, dated April 29, 1941.

This invention pertains to method and apparatus for continuously plating and/or treating elongated pieces of material such as strip, and more particularly, to new and improved methods and apparatus for treatment of strip metal.

In another aspect, my invention pertains to the feeding of discontinuous lengths of strip material in a continuous manner, and to the separation of continuous strip after treatment in such a manner that it can be collected in separate coils of a desired length.

In one phase, the invention especially pertains to the proper control and handling of metal strip being plated, and particularly, being electroplated. When I speak of "strip," it should be understood that I have reference to any suitable form or shape of material and that the principles of the invention are not limited to any particular type of material; of course, a flexible metal material which has been generally designated as metal strip is preferable. It will also be appreciated that certain phases of the present invention deal with the feeding, tensioning, handling, the joining and the separating of pieces of strip, while other phases deal particularly with a controlled continuous treatment of metal strip.

Where plating or electrode position forms part of the continuous process, the strip may be of any suitable metal. The same, of course, is true of the plated metal. However, for purposes of illustrating the invention, I have referred particularly to the electroplating of iron or steel strip with tin. In carry-out such a plating process, strip is supplied to the plating line in reels or coils of fairly great length. The process of preparing the strip for plating, washing, drying, etc., is preferably conducted continuously, one length of strip being suitably secured to another length of strip to form a continuous strip progression for the treating or plating line. It will be apparent that a number of strips may be fed through the apparatus or line at the same time in multiple.

I have found that additional problems have arisen in connection with a continuous treatment of strip from a commercial standpoint as compared to a laboratory standpoint. That is, the length of strip undergoing treatment at one time will be greater in the former case and its velocity of movement should be relatively high, much higher than possible heretofore prior to the present invention.

2

Heretofore, movement of the metal strip through the cleaning, pickling, and plating stages has been carried out solely by the pulling action of a wind-up reel or its equivalent that operates at the end of the plating line. I have discovered that in using such an apparatus, the plating of extremely thin strips or fine wires was not possible at high speeds, that is, I discovered that there was a progressive building up of tension in the strip and that this building up was particularly great in the case of a long plating line which is, of course, required in connection with high speed operation. High as well as unsuitable tension of the strip being treated, as well as "surging" of the line, not only tend to distort the strip but also to spoil the plating operation and the coating provided thereby. That is, I discovered that there are a number of factors involved in electroplating from the standpoint of conveying or moving the strip continuously past or through the necessary treatment zones that entered into the characteristics of the products as well as the effectiveness of the individual and collective treatments.

I also determined that it is important that substantially the same amount of metal should be deposited upon each unit area of the strip and that as long as the strip passes continuously through the plating line and apparatus at a uniform rate and the current employed in electrode position is constant, the plating thickness can be kept substantially uniform. In case the speed of the strip is varied, the electroplating current should be varied proportionally, and vice versa, in order to provide a uniform deposit.

In view of the above and other considerations, it has been an object of my invention to provide new and improved procedure and/or apparatus for plating suitable material such as metal strip.

Another object has been to provide a procedure and/or apparatus for continuous and uninterrupted treatment of a plurality of suitable lengths of strip metal or other suitable material.

Another object has been to provide procedure and/or apparatus for continuously and uninterruptedly moving strip through or past suitable treatment zones and for automatically segregat-

ing suitable lengths of the continuous strip thereafter.

A further object of my invention has been to provide new and improved procedure and/or apparatus for suitably tensioning and/or controlling strip material while it is being suitably treated and/or fed.

A further object has been to provide procedure and/or apparatus for suitably proportioning the tension, speed, and rate of treatment of material, particularly, while continuously moving the material.

A still further object of my invention has been to provide a commercially practicable continuous plating procedure for utilizing strip metal in coil form.

These and many other objects of my invention will appear to those skilled in the art from the description, the drawings, and the appended claims.

In the drawings:

Figures 1A, 1B, and 1C are side views in elevation partially sectioned and diagrammatic, which when placed end-to-end from right to left respectively, illustrate a preferred embodiment of my invention.

Summarized briefly, I provide metal strip in coil form, continuously unreel a given piece of strip from its coil, and continuously subject it to suitable treatments. Means is provided, a slack producer, for storing a suitable length of the strip and for continuously paying it out while the trailing end of an exhausted coil is welded, or in another suitable manner, secured to the leading end of a second or new coil strip. After the strip lengths of two coils have been thus joined or secured, the slack producing means is operated to take up a suitable length of the strip of the second coil in readiness for later joining its trailing end to the leading end of a third coil. In this manner, suitable individual lengths of material are continuously fed or passed through various plating operations which may include the steps of pickling, wet-mechanically cleaning, washing, electroplating, washing, and drying.

As it is advantageous to collect the treated strip in suitable lengths, possibly of substantially the same length as the individual coils at the beginning of the operation, I have provided apparatus that is automatically operable to select strip of suitable lengths and to sever the selected lengths and separately coil them. The operation is preferably carried out in such a manner that the tension of the strip being treated ahead of the apparatus is maintained at the desired value irrespective of other operation being done. That is, the tension of the continuous strip being severed and coiled into individual lengths is automatically controlled in such a manner as to not adversely affect the prior operations of the continuous plating line.

In the plating operations, I preferably provide suitably selected driven rolls that are interposed in such a manner as to suitably tension the strip for preceding and succeeding treating operations. The plating and/or pickling current employed is suitably proportioned to the rate of movement, or in other words, to the speed of the driven rolls in such a manner that a high efficiency and effectiveness of treatment is obtained.

Further, in accordance with the present invention, the steps of joining one coil to another, of continuously treating the strip, and of severing the strip and recoiling suitable severed lengths thereof, are all correlated in such a manner as to provide a substantially automatic combination providing a product of exceptionally high quality in suitable commercial lengths. It is believed that the combination accomplishes what has heretofore been impossible in the art and at the same time provide a product of markedly improved characteristics.

Referring particularly to the drawings, I have illustrated procedure and apparatus for carrying out my invention wherein movement of strip 4 is initiated from right to left in Figures 1A, 1B, and 1C, respectively. As shown particularly in Figure 1A, one or more coils or reels of strip metal 4 are paid out from positions 5 over suitable guide rolls 6 to the strip treatment line. In general, the illustrated layout includes, reading from right to left, a payout reel stand or support A, a guide table B, a welding mechanism C, a guide table D, a slack producer and surge control apparatus E, an electrocleaning apparatus F, a wet-mechanical cleaning unit G, a cold water rinse bath H, a pickling vat I, a wet-mechanical cleaner J, an electroplating means or unit K, cold and hot baths R and H, respectively, a drier L, a bridle stand or pull rolls M, a photoelectric control unit N, a shearing unit O, reel selector mechanism P, and a wind-up reel unit Q.

In carrying out the invention, the strip 4 is taken from one of the reels 5, is guided by suitable guide rolls 6 through the welder C over the table D to the pass of a pair of pinch rolls 7 of the slack producing unit E. The strip is then guided over an idler guide roll 8 of a primary, vertically-movable payout roll carriage 10, over a fixedly-positioned idler guide roll 9, over an idler guide roll 8 of a secondary, vertically-movable dancer-roll carriage 20, and then out over a suitable guide roll 6 to unit F. In normal operation, the position of the strip 4 is indicated by the dotted lines beneath the carriage 10 while the secondary carriage 20 is in some suitable position such as shown in the drawing. The full line position of the strip shown in Figure 1A is the normal position during welding of the trailing end of the strip of one coil to the leading end of the strip of a second coil.

The lower pinch roll 7 is indicated as being driven by a suitable motor 119 which is constructed and arranged as will be hereinafter more fully explained to provide a desired tension or pull upon the strip adjacent the entrance to the slack producer unit E.

The payout roll carriage 10 is counterbalanced by a rope or cable 11 having a counterweight 13 and is guided over a suitable guide roll 6a and a driven roll or cable-driving pulley 12. The pulley 12 is actuated by a reversible payout motor 19 to raise and lower the carriage 10 as will be hereinafter more fully described. In like manner, the secondary or dancer carriage 20 is counterweighted through the agency of a cable or rope 11 and counterweight 13; the rope 11 leaves over pulley guide 6a and rheostat control pulley 22. The pulley 22 is operably connected to an arm of an adjustable rheostat 23 in such a manner that automatic control is obtained over the pinch roll motor 119 and the payout motor 19 in response to oscillation or rotation of the pulley 22, and thus, dependent upon the position of the dancer roll carriage 20. The carriage 20 maintains a substantially constant tension in the strip, moves vertically in response to operation of the loop-producing carriage 10, and effectively "irons out" line surges without transmitting them.

The loop-producing carriage 18 is provided, as shown, with an extending switch-operating arm 14 that in its extreme upper position opens a normally-closed payout switch 15 and that in its extreme lower position closes a normally-open payout-start-limit switch 16. In like manner, the dancer roll carriage 20 is provided with a switch operating arm 21 that first opens a normally-closed emergency slow-down switch 24 and while holding this switch in such a position, opens an emergency-stop switch 25. An emergency-stop-limit switch 18 is positioned beneath the payout roll carriage 10 and is moved from its normally closed (make) position to an open position (break), if and when the carriage 10 moves to its extreme bottom position.

The strip continuously leaves the slack producer E as a continuous length having a suitable speed and tension. It is shown as then introduced into a suitable electrocleaning tank F having immersed and driven contact rolls 30 and immersed and cooperating guide rolls 6. Current is supplied by generator 32 that is preferably driven at a constant speed by a motor 33; the generator 32 is electrically connected with the contact rolls 30 and with a spray pipe assembly 31 positioned above and below the strip 4. The current supplied by the generator 32 may be varied in the conventional manner and is also preferably varied automatically to properly correspond to the conditions of operation as will subsequently be explained.

From the cleaning tank F, the strip 4 passes through a scrubber G having cooperating pairs comprising driven brushes 35, idler rolls 36, and driven squeegee rolls 36a. Rolls 36 may be driven, if desired, by a motor 118. The sprays for water of suitable temperature have been indicated by the numeral 37. The strip is then conveyed through a cold water wash tank H, between driven tension roll 35b and a cooperating guide roll 6, through a pickling bath I, between driven tension roll 35 and a cooperating roll 6, to a driven wet-mechanical cleaning unit J similar to the unit G previously described.

The strip 4 is now ready for immediate entry into the electroplating bath K and the operation is preferably carried out in such a manner that the cleaned strip will be covered with a coating of the wash fluid, preferably water, after it leaves the unit J until it enters the bath of the unit K. The number of plating elements, etc., of the unit K have been reduced in the drawing 1B, but it will be understood that any suitable number may be provided. The unit comprises idle and submerged guide rolls 42 above which are operably-mounted complemental roll pairs which comprise upper, contact and driven rolls 40, and lower, positioning rolls 41. Motors 118 actuate the rolls 40 to provide the necessary electrical contact with the strip and to prevent an undesirable building up of tension of the strip during movement through the bath K. As shown, the rolls 40 are connected to one terminal of a pair of plating generators 44 that are preferably driven at a constant speed by motor 45; and in this manner, the strip 4 is converted into a cathode as it passes in a multiplicity of loops through the bath of the plating unit K. Vertically-extending anodes 43 of plating material such as tin are disposed in the bath within the spaces afforded by the strip loops in such a manner that there are, in effect, two groups of anodes; one group will plate one side of the strip and the second group will plate the other side.

As shown, the groups are individually connected to the positive terminals of the generator armatures 44. The armatures of the motors 44 have, as indicated, a common return by way of the cathode contact rolls 40. Provision has been made, as will hereafter be fully explained, for automatically varying the generator field voltage in proper relationship with respect to variations in the speed of the strip.

The strip 4 leaves the plating apparatus unit K by way of a roll pair which consists of a driven tension and squeegee roll 35b, cooperating with a guide roll 6. It then enters and is guided through cold and hot cleaning baths R and H by suitable guide rolls 6; it is introduced into and leaves the baths by way of pinch roll pairs comprising a driven tension roll 35b and a guide roll 6.

The strip then passes through the drying unit L which may include a drier 47 and nozzles 48, and then enters the bridle stand apparatus M. The bridle stand apparatus or unit M is coordinated with a photo-cell unit N, a shear unit O, a selector unit P, and a coiling, reeling or wrapping unit Q, in such a manner that the desired tension of the strip is maintained ahead of the bridle stand while at the same time a suitable tension and/or feed of the strip is provided following the bridle stand during the selection of suitable lengths of strip, the severance of those lengths, and the coiling of those lengths into suitable coils. The bridle stand M is, in effect, set into operation through the agency of the photo-cell unit N. In this connection, I preferably punch a hole in the strip after welding one coil to another adjacent the unit C in order that a beam of light from the lamp 70 on one side of the strip will pass therethrough and transmit energizing light to the photo-electric cell 71. The cell 71 initiates a number of automatic operations. Of course, it will be apparent that any other suitable means may be employed in this connection for initiating the correlated operation of the units which will be hereinafter more fully explained.

The strip 4 after leaving the drier unit L is guided by roll 6 into the bridle stand M and over three rubber covered rolls 50, 51, and 52 that serve to drive and tension the strip and to keep it in check during the cutting and take-off operations. Roll 50 is operably geared (see Figure 1C) to the roll 51. Rolls 50, 51, and 52 grip and draw the strip; roll 51 is driven by a suitable motor 63—1 that is preferably under automatic speed control as will be explained later. A one-revolution mechanical clutch 54 is mounted on the shaft 55 of the driven bridle-stand roll 51. Clutches of this character are per se well known, being operable upon actuation to intercouple the clutch with the shaft 55 for a period of a single revolution of the latter; the clutch thereafter returns to its initial position for subsequent actuation. The clutch 54 is provided with an arm 56 that is connected by a link to the magnetic core 57 of a magnetic solenoid 57a in such a manner that when the solenoid 57a is energized to lift its core 57, the arm 56 is oscillated to produce clutch engagement.

The clutch 54 also carries a crank arm 58 and a gear 53, both of which are positively driven through one revolution by the shaft 55 upon actuation of the clutch. The crank arm 58 is pivotally connected to one end of a connecting rod 59, the other end of which is pivotally connected by a common axis to a pair of shear arms 60 of the shear mechanism O. A crosshead guide is

provided for confining this axis to horizontal movement in the plane of the strip 4. The other ends of the shear arms 60 carry shear blade supports 61 that are operably mounted above and below the plane of the strip and have rollers 62 for guiding them between a pair of horizontally-extending rails 69. A compression spring is positioned between the upper and lower supports 61 normally to urge them apart or out of an operating position with respect to the strip 4. Pairs of cutting blades 63 are mounted upon the adjacent opposite ends of the upper and lower supports 61 in such a manner that they can be thrust towards each other to cut a suitable size piece out of the strip 4, preferably corresponding substantially to the area of weld between the strip of two coils. Thus, the shearing action preferably is timed in such a manner that the overlapped and/or welded terminals or ends of a pair of joined strips are cut in this operation.

A cam element 65 is pivotally mounted at 66 and is provided with a cam face extending beyond the upper and lower rails 69 for operating the shear mechanism. The cams 65 are normally retained in abutment with a fixed stop 68 by a tension spring 67 that is connected between the cam and the stop. As the rollers 62 of the shear carriages 61 travel over the cams 65 to the left, the latter are prevented from swinging by the stop 68 and the shear support carriages 65 and their associated blades are thrust towards each other sufficiently to compress the spring interposed therebetween to cause the blades 63 to sever a section of the strip. Return movement of the shear 63 to its original position illustrated is permitted by the springs 67 without cutting the strip a second time; that is, the cams are permitted to turn about their pivot points 66 when the rolls 62 of the shear carriages are returned to their original position from left to right in the drawing in Figure 1C. The cams 65 are thus forced to swing counter-clockwise on their pivots 66 until the rollers 62 have cleared them.

The reel selector mechanism or unit P is operated or actuated by the gear 53 which is in mesh with a larger gear 80; the ratio is preferably two to one such that the gear 80 will turn half a revolution upon each actuation of the one-revolution clutch 54. A crank arm 81 is operably mounted on the gear 80 and is pivotally connected to a selector unit operating link 82; the link is, in turn, pivotally connected to a pivotally-mounted operating and strip-selecting lever means 83. As shown, the lever 83 has an upper portion that terminates in a selector plate that can be swung to one or the other of two strip guiding positions as illustrated in full and broken lines of Figure 1C. In the full line (lower) position, the plate of the lever or selector element 83 cooperates with a guide roll 6 and stationary guides 86 and 88 to guide and permit the strip 4 to pass to the lefthand wind-up reel 90*a* of the unit Q. In this position, the lower switch portion of the selector element 83 has moved the coil motor selector switch 85 to the position shown in such a manner that the motor 92*a* is actuated to wind up the lefthand reel 90*a*. At the same time, the right-hand motor selector switch 84 is pressed to the full line position, by its compression spring opening the line to the armature of the right-hand coil wind-up motor 92*b*. Thus, the right-hand motor 92*b* and its associated coiler 90*b* are stationary at this time.

When the selector arm 83 has been moved to its extreme right position, the lefthand selector switch 85 opens the armature circuit of the left-hand wind-up motor 92*a* and closes the armature circuit of the righthand motor 92*b* through the agency of the righthand selector switch 84, see the dotted line position of this latter switch. In this position, the deflector plate portion of the lever 83 is raised to intercept the oncoming severed strip end and to direct it over guide plate 87 to the righthand coiling reel 90*b*. Actuation of the selector mechanism P closely follows and is timed to the shearing step which takes place during the first quarter revolution of the mechanical clutch. For each full cycle shearing operation, there is thus only a one-half cycle operation of the selecting mechanism. In the case of both of the coils 90*a* and 90*b*, a belt wrapper mechanism 91 of conventional design is operable to catch an oncoming end of a severed strip and to start it around the empty reel or drum as it is turned by its motor 92*a* or 92*b* for reception of the elongated strips. Such belt wrappers are well known and form per se no part of the present invention.

The actuating or motor drive

In order to simplify the understanding of the operation of the present layout, I have designated the driving motors which are employed for driving the various contact, pinch, and/or tension rolls by the numeral 118. The fields of the motors 118 as well as the fields of the wind-up motors 92*a* and 92*b*, of the slack-producer pinch roll motor 119, of the payout carriage drive motor 19, of the bridle stand motor 63—1, and a separately-excited field 95 of generator 93 are supplied with current by a suitable constant voltage generator 111, Figure 1C, connected to constant voltage supply lines 112 and 113. A constant speed motor 110 drives the generator 111 as well as a variable voltage generator 115. The armature of the variable voltage generator 115 is connected to the current supply lines 116 and 117 which, in turn, provide the current for actuating the armatures of the motors 118, 119, 19, and 63—1. The separately-excited field of the generator 115 is controlled by resistance 127 and control rheostat 120 to vary the current supplied to the mains 116 and 117. It will also be noted that the fields of the electrocleaning generator 32 and of the electroplating generator armatures 44 are connected to the current supply mains 116 and 117 in such a manner that their field excitation will vary in proportion to the speed of the motors above-mentioned.

The armatures of wind-up motors 92 are supplied with current by a generator 93 that is driven by a suitable motor 96 and has a separately-excited field 95 and a shunt self-excited field 94 and a differential series field 94*a*. A lefthand contactor mechanism 97, Figure 1C, having three pairs or sets of contact points, controls the supply of actuating current to the armature of the lefthand wind-up motor 92*a* from the generator 93 which is preferably driven at a constant speed and delivers a normally constant horsepower output. As shown, it is provided with differentially-compounded field coils 94, 94*a*, and 95. The righthand contactor 99 is in like manner provided with three pairs of contact points for controlling the supply of current from the supply generator 93 to the motor 92*b*.

The photo-cell control

When the photo-cell 71 is energized by receiving light from the source 70 through a hole in,

or through an intentionally placed irregularity on the strip 4, it will energize a holding coil 73 of a control relay 72 that, in turn, energizes the solenoid of a time delay relay 76. When the time relay 76 is energized, it will open a normally-closed contact 77 and insert resistance 78 into the circuit feeding the field of the bridle stand motor 63—1 and the separately excited field 95 of the wind-up motor generator 93. This will increase the pull on the strip exercised by the bridle stand motor 63—1 as applied to the rollers 51 and 52 and will decrease the pull on the right, or left, wind-up motor 92*a* or 92*b*, as the case may be, to thus effect a low tension pull (enough to take up slack) by the righthand reel 90*b* upon the strip that is to be sheared. That is, the throwing of the resistance 78 in the separately excited field 95 of the generator 93 will decrease the current supplied by it to the wind-up motor 92*a* or 92*b*.

The contactor 72 on closing will also energize the coil of the solenoid 57*a* to raise the magnetic core 57 and oscillate the arm 56 and produce an engagement of the one-revolution mechanical clutch 54, which operates the shear as previously explained. Assume for the purpose of this discussion that the strip is being fed to the lefthand coiler 90*a* and that the selector switch 85 is closed to actuate the lefthand wind-up motor 92*a*. Then, the strip 4 will be severed by the actuation of the clutch 54 and the shear mechanism O; the selector arm 83 will be moved to the right by the operative engagement between the clutch gear 53 and the operating wheel 80. The righthand movement of the selector arm 83 will cause the holding coil 98 to be de-energized and the holding coil 100 to be energized. Thus, the switch contact points of the contactor 97 will be opened and those of the contactor 99 will be closed to actuate the armature of the righthand wind-up motor 92*b*, and thus, the righthand wind-up reel 90*b*. Simultaneously therewith, the selector plate moves the cut end of the strip down along the guide 87.

During the time that the switch selector arm 83 is leaving switch 85 and is moving towards switch 84, both contactors 97 and 99 will be open and the armatures of both of the wind-up motors 92 will be de-energized. Mechanical interlocking means 101 is provided for preventing a simultaneous closure of both contactors 97 and 99, but permitting a simultaneous opening of them. The opening of the switch contact points of the lefthand contactor 97 will de-energize the relay coil 73, the coil of the time delay relay 76, and the coil of the clutch operating solenoid 57*a*. The coil of the time delay relay 76, however, will not close its contact 77 immediately, but will remain open for a definite time period following the de-energization of its coil. This time delay is sufficient to keep the resistance 78 in the field of the motor 63—1 and the field 95 of the generator 93, while the selector lever 83 moves from its lefthand position and closes the righthand selector switch 84. This, of course, energizes the coil 100 of the righthand contactor 99 and closes the switch contact points thereof to insert the righthand wind-up motor 92*b* in the operating circuit. The leading end of the strip 4 upon reaching the reel of 90*b* will be wrapped around the reel block several times by the belt wrapper 91 and then the wrapper will be withdrawn. At this time, the contact arm 77 of the time relay 76 will open, short-circuiting the field resistance 78 and increasing the strength of the field of the bridle stand motor 63—1 and the separately excited field 95 of the wind-up motor actuating generator; this will result in a decrease of pull on the strip at the bridle roll stand due to the motor 63—1 and at the same time an increase in pull of the wind-up motor 92*b* as applied to the wind-up reel 90*b*.

Starting or initiating the operation of the line

The apparatus is started by first moving adjustable arm of start rheostat 120, see Figure 1B, to contact point 121. At this time, a resistance 127 is connected between the rheostat 120 and the separately-excited field of the variable voltage generator 115. The closing of the contact point 121 directly connects the holding coil 126 of a general line contactor switch 125 to the motor field current supply line 113; the other side of the coil 126 is directly connected to the line 112. The energization of the general line contactor switch 125 closes its three pairs or sets of contact points, the left set of which connects the switch side of the armature of the generator 115 to the motor armature and generator field current supply line 117, the center set of which energizes the separately excited fields of the plating generators 44 through the lines 116 and 117, and the right set of which connects the side of the relay coil 126 that was closed by the rheostat 120 to the line 113 through an emergency stop contactor 128, Figure 1A. Thus, the contactor 125 will remain closed when the arm of the starting rheostat 120 is moved off point 121 to the left of Figure 1B and suitably resistance-adjusted to provide a desired strength of field for the generator 115.

It will be noted that the closing of the righthand switch points of the contactor 125 also closes the connection between the line 113 and one side of the light source 70, Figure 1C, and of the selector circuit P which includes the switches 84 and 85 and contactors 97 and 99. In other words, it will appear that the excitation of the field 95 of the wind-up motor supply generator 93 will depend upon the position of the righthand pair of contact points of the contactor 125, and that the wind-up motors 92*a* and 92*b* will be actuated depending upon the position of the selector arm 83 to initiate the actuation of one of the wind-up reels 90*a* or 90*b*. The closing of the point 121 of start rheostat 120, in addition to energizing the armatures of the various motors such as 118, 119, 63, and 92, also, as previously set forth, energizes the fields of generators 93, 44, and 32. After the starting has been accomplished, the arm of the rheostat 120 may be moved along the resistance to control the voltage of the field of generator 115 to set it to provide a desired voltage for the armatures of the various motors as well as for the fields of the electroplating and electrocleaning generators 44 and 32, respectively.

Operation of continuous feeding while welding

When the coil 5 of the strip 4 being paid out is nearly exhausted, the operator will press slack control (make) switch 143, Figure 1A, which will energize lefthand holding coil 139 of contactor 138. The energization of the coil 139 will, in turn, close three sets or pairs of contact points, the left set of which permits the switch 143 to be released (opened) without de-energizing the coil 139, the center set of which and the righthand set of which connect opposite sides of the armature of a payout motor 19 to the current supply mains 116 and 117. The motor 19 is thus actuated to turn the pulley 12 and raise the payout

roll carriage 10 to provide a reserve or loop of the strip 4. When the payout carriage 10 reaches the top of its travel, it will be stopped automatically by payout switch 15 which is opened by the extending arm 14.

After the strip coil 5 is completely paid out, the operator will press a stop-payout switch (break) button 135 that will de-energize holding coil 141 of a pinch roll control contactor 140; this, in turn, will disconnect the armature of the pinch roll motor 119 from the current supply line 117. It will be noted that the left and center pairs of contacts of controller 140 are of the "make" type while the righthand set or pair are of a "break" type; thus, the latter will "make" at this juncture to energize holding coil 145 of contactor 138 through line 113 and the closed contacts of stop-limit switch 18. The actuation of holding coil 145 will, in turn, close three sets or pairs of switch contacts, the first two of which reverse the current supply leads 116 and 117 to the armature of the payout motor 19 and the third or righthand set will close the holding circuit in parallel with contacts 142. The payout carriage control motor 19 will thus be actuated in a reverse direction to lower the payout carriage 10, and to feed the strip to the plating line as needed by progressively decreasing the size of the loop beneath the carriage. The dancer roll carriage 20 will automatically regulate the speed of the payout motor 19 through the operative connection of the pulley 22 with the field current control rheostat 23 to give a uniform payout of strip to the plating line. Push "break" switch 144 provides for an emergency stop of motor 19 when carriage 10 is being raised.

The operator will weld the leading end of a new coil of strip to the trailing end of the exhausted coil at the welder C while the carriage 10 is being moved downwardly. As the carriage 10 approaches its lower position, it will reclose the (normally open) payout-start-limit switch 16 and current will flow from the supply line 113 to the coil 141 of the contactor 140 to energize the coil and close its first and second pairs of contacts (from left to right). Its right set 142 are opened. The opening of the contacts 142 has no effect, as it is paralleled by the holding circuit on switch 145. The closing of the "make" pairs of contacts of the contactor 140 connects the armature of the pinch roll motor 119 to the supply line 117, thus initiating its movement. It will be noted that rheostat 23 also controls the speed of motor 119 through the agency of its field excitation.

When the payout carriage 10 has reached its lowest position, it will be stopped automatically by stop-limit switch 18. That is, the carriage strikes the switch 18 and "breaks" or opens it. Should any emergency condition arise whereby the motor 119 would fail to start at the time the payout carriage 10 recloses the payout start limit switch 16, the carriage 10 will continue on to the bottom and stop, and since the line is receiving strip and no further strip can be paid out by the carriage 10, the dancer roll carriage 20 will lower automatically. As the dancer roll carriage 20 reaches the emergency slow-down switch 24, its extending arm 21 will "break" or open it, and this will, in turn, de-energize emergency slow-down contactor coil 130, opening its contact points and inserting resistance 127, see Figure 1B, in the field of variable-voltage line current supply generator 115, see Figure 1C; this will bring the strip driving motors 118, the pinch roll motor 119, the bridle stand motor 63—1, etc., down to a creeping speed and will cut down the field energization of the generators 32 and 44 in proportion thereto. If the emergency is such that the dancer roll 20 continues to move downwardly, its arm 21 will continue to hold the switch 24 open and additionally will open or "break" the emergency stop switch 25 which will, in turn, de-energize contactor coil 129. The opening of the lefthand portion of the contactor 128 through the de-energization of the coil 129 will, in turn, cause a de-energization of the coil 126 of the contactor 125 and an opening of the entire line circuit. Thus, the generators are de-energized and the motors are stopped. The plating line only can then be started by raising the dancer roll frame 20 to its normal operating position.

In accordance with a preferred operation, the pinch roll motor 119 as well as the bridle stand motor 63—1 are normally driven to provide a "drag" tension. During severance of the strip at O, the motor 63—1 is adjusted by field control 78 to increase its torque to provide a forward pull on the strip 4; the wind-up motor 92*a* or 92*b* is changed from a forward to a substantially zero pull (enough to take up slack). It, therefore, follows that the shearing operation is accomplished under conditions of minimum tension. I have found that this is highly desirable to prevent tearing and distorting of the strip and also to permit an uninterrupted continuation of the plating operations or line treating operations and to initiate the coiling of a new section or length of the strip that is being fed. It is apparent that the automatic control of the present invention makes possible a high flexibility of operation such that the desired arrangements can be carried out regardless of the particular operations involved. I have found that the strip can be tensioned properly during the treating operations and that line surges such as may arise particularly in a long line can be eliminated successfully without affecting the treating operations; in this connection, the novel operation and/or arrangement of the dancer and payout roll apparatus is important.

When the trailing end of one coil is to be welded to the leading end of a new coil at the unit C, the pin roll motor 119 is then preferably adjusted in effect, to tension the strip or hold it back in the direction of its normal movement; this gives the welder an opportunity to attach quickly the two coil ends together and thereafter normal operation again may be assumed.

Although for the purpose of illustration, I have applied my invention to an electroplating line and have used a particular type of layout preferably employing direct current roll-driving motors for simplicity of control and operation, it will be apparent to those skilled in the art that other suitable arrangements and connections may be employed as well as any suitable type of motivating means without departing from the spirit and scope of the invention as indicated in the appended claims. It will also appear that the present invention makes possible a substantially complete automatic operation of a series of treating steps upon a piece of material that is provided in suitable separate lengths and that after treatment again may be cut and gathered into suitable lengths without disturbing the continuous operation of the treatment line. It will also be apparent that the invention makes possible a suitable practicable control and tensioning

of the strip on the basis of any particular treatment to which it is to be subjected at any point along the line, regardless of prior or after types of treatments. In view of these and other considerations, it is felt that the present invention should not be limited to particular details and structural parts but that suitable modifications, additions, substitutions, omissions, etc., may be made without departing from the spirit and scope of the invention. For example, if it is desired that strip be cut to length after treatment in the line, a leveller, flying shear, and piler may be used in place of reels 90a and 90b and their associated apparatus. Obviously, in such a case, the bridle stand motor 83—1 will be adjusted to provide a forward torque, and leveller, shear, and piler motors will have connections similar to that of motors 118.

I claim:

1. In a method of continuously electroplating coiled discontinuous metallic strip with coating of metal, the steps of unreeling said discontinuous metallic strip from supply coils, joining the discontinuous strips end to end, conveying the joined strips uninterruptedly under tension through a loop variable in response to tension changes and then in a fixed path through an electroplating operation by applying propulsive power to the strip after said electroplating operation, automatically segregating the plated strip into discontinuous lengths and automatically recoiling said discontinuous lengths, establishing a predetermined tension in the strip by applying power to the strip between the unreeling coils and said variable loop, and automatically regulating the rate of unreeling strip by controlling the magnitude and direction of the tension-establishing power in response to variations in said variable loop due to tension changes.

2. In a method of continuously electroplating coiled discontinuous metallic strip with coating of metal, the steps of unreeling said discontinuous metallic strip from supply coils, joining the discontinuous strips end to end, conveying the joined strips uninterruptedly under tension through a loop variable in response to tension changes and then in a fixed path through an electroplating operation by applying propulsive power to the strip after said electroplating operation, automatically segregating the plated strip into discontinuous lengths and automatically recoiling said discontinuous lengths, establishing a predetermined tension in the strip by applying power to the strip between the unreeling coils and said variable loop, accumulating a portion of the unreeling strip in a storage loop between the point of applying the tension-establishing power and the electroplating operation while automatically regulating the rate of unreeling strip from said coils by controlling the magnitude and direction of the tension-establishing power in response to variations in said variable loop due to tension changes, stopping a portion of the unreeled strip between the storage loop and said supply coils and simultaneously starting paying out strip from the storage loop through the electroplating operation, and automatically regulating the rate of such paying out from the storage loop in response to variations in said variable loop due to tension changes.

3. In a method of continuously electroplating a metallic coating on metal strip supplied in discontinuous lengths from coils requiring a varying pull, the steps of moving the strip from the coils continuously at predetermined speed in a fixed path through an electroplating operation by applying propulsive power to the strip after the electroplating operation, establishing a predetermined tension in the strip passing through said electroplating operation by applying power to the strip between said electroplating operation and said supply coils, and automatically regulating the magnitude and direction of said tension-establishing power in response to tension changes in the strip portion between the point of applying said tension-establishing power and said electroplating operation to compensate for the varying pull of the supply coils and maintain said predetermined tension in said strip portion.

4. In the method as defined in claim 3, the step of applying propulsive power to the strip within the electroplating operation in an amount equal to the power required to prevent a building up of tension in the strip in said electroplating operation.

5. In the method as defined in claim 3, the step of automatically regulating the electroplating current in the electroplating operation in direct proportion to the strip speed to give a uniform thickness of electroplated coating.

6. In a method of continuously electroplating metal strip supplied from coils, the steps of unreeling strip from said coils continuously at a predetermined speed through a fixed path in an electroplating operation by applying propulsive power to the strip after the electroplating operation, establishing a predetermined tension in the strip passing through said electroplating operation by applying power to the strip between said electroplating operation and said supply coils, accumulating a portion of the unreeling strip in a storage loop between the point of applying said tension-establishing power and the electroplating operation in preparation for attaching a new supply coil to the end of an unreeled coil, then adjusting said tension-establishing power to stop the strip momentarily for attaching said new coil and simultaneously starting paying out strip from said storage loop, and then while starting unreeling from said newly attached coil automatically regulating said tension-establishing power in response to tension changes in the strip portion between the point of applying power and said electroplating operation.

7. In apparatus for continuously electroplating continuous strip metal, an electroplating unit for continuously electroplating the moving strip, means for propelling the strip continuously under tension at predetermined strip speed from separate coils through the electroplating unit, motor drive means for paying out the strip from the coils to said electroplating unit, a movable carriage for maintaining a variable loop in the strip between the payout drive means and the electroplating unit, a movable strip storage carriage between the payout drive means and the electroplating unit, means for driving selectively said storage carriage to create a storage loop and to pay out strip therefrom, and means operatively connecting the storage carriage drive to said variable loop carriage for automatically regulating the rate of payout from the storage loop in response to variations in the variable loop due to tension changes therein.

8. In apparatus for treating a continuous length of metal strip, a support for holding a coiled length of metal strip, pull rolls spaced from said support for pulling strip from said support through said apparatus, electroplating means be-

tween said pull rolls and said support, a first cleaning means between said electroplating means and said support for cleaning said strip before electroplating, a second cleaning means between the pull rolls and the electroplating means for cleaning the strip after electroplating, loop forming means between the support and the first cleaning means for forming a storage loop in said strip, a motor for driving said pull rolls continuously and at a substantially constant speed to pull said strip from said support through said first cleaning means, electroplating means and second cleaning means in succession, means including rolls engaging the strip between the support and the first cleaning means for applying drag tension to said strip, welding mechanism adjacent said support for joining successive lengths of metal strip to form a continuous strip, control means for stopping said strip at said welding mechanism during the joining of successive lengths, said pull rolls and motor withdrawing strip from said storage loop and pulling said strip through the first cleaning means, electroplating means and second cleaning means at substantially constant speed while said strip is stopped at said welding mechanism and means following said pull rolls on the discharge side opposite said support for cutting said strip into predetermined lengths while said strip is being continuously moved by said pull rolls through said first cleaning means, electroplating means and second cleaning means.

9. A method of electroplating a continuous length of metal strip, comprising essentially the steps of supplying metal strip in discontinuous lengths, then welding such lengths of strip together end to end with good contact between successive lengths to form a continuous strip, then forming a storage loop of the continuous strip, then cleaning the continuous strip, then electroplating the cleaned continuous strip, then cleaning the electroplated strip, pulling said strip through said first cleaning, electroplating and second cleaning steps continuously and at substantially constant speed, stopping the portion of said strip being joined during the welding operation while withdrawing strip from said storage loop, applying drag tension to said strip between the supply and the first cleaning operation, continuously moving the strip through the first cleaning, electroplating and second cleaning operations under predetermined tension and cutting the cleaned electroplated strip into predetermined lengths while continuously moving said strip through the first cleaning, electroplating and second cleaning operations.

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