March 18, 1969 J. P. FADDEN ET AL 3,433,398

MAGNETIC BRIDLE UNIT FOR WINDING STEEL STRIP

Filed April 10, 1967 Sheet 1 of 2

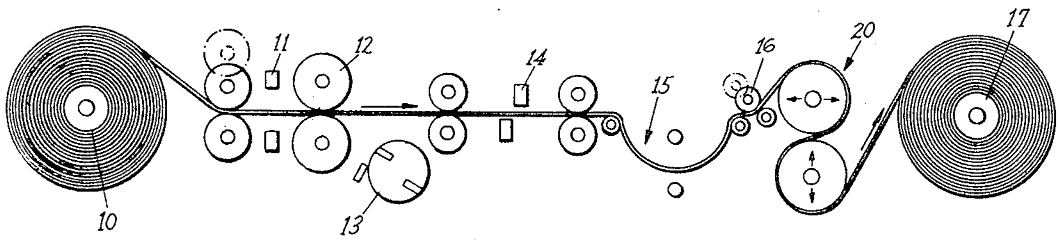

FIG. 1

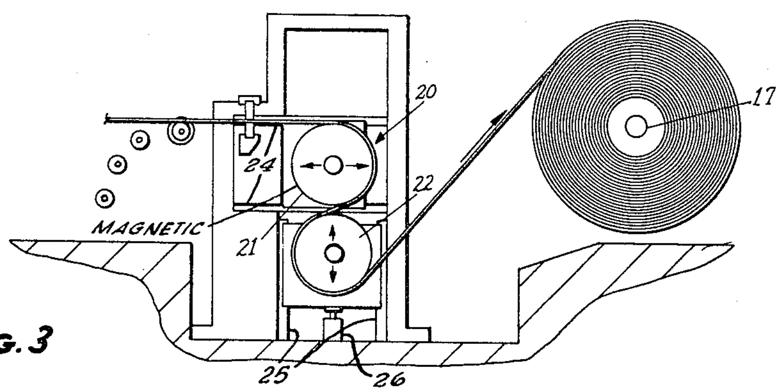

FIG. 3

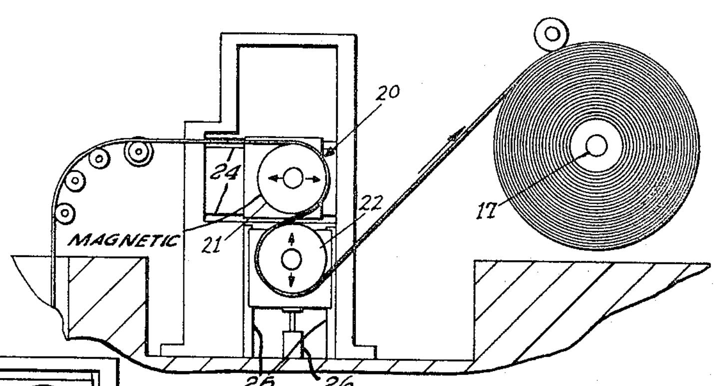

FIG. 2

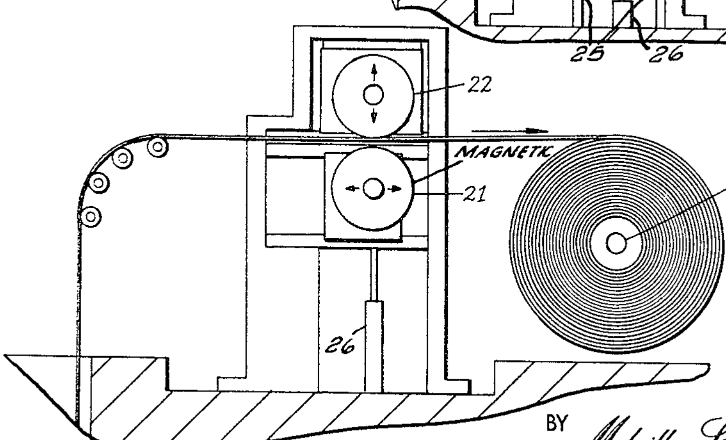

FIG. 4

INVENTOR/S
JAMES P. FADDEN &
FREDERICK L. MOORE,
BY Melville, Strasser, Foster and Hoffman
ATTORNEYS

March 18, 1969 J. P. FADDEN ET AL 3,433,398

MAGNETIC BRIDLE UNIT FOR WINDING STEEL STRIP

Filed April 10, 1967

Sheet 2 of 2

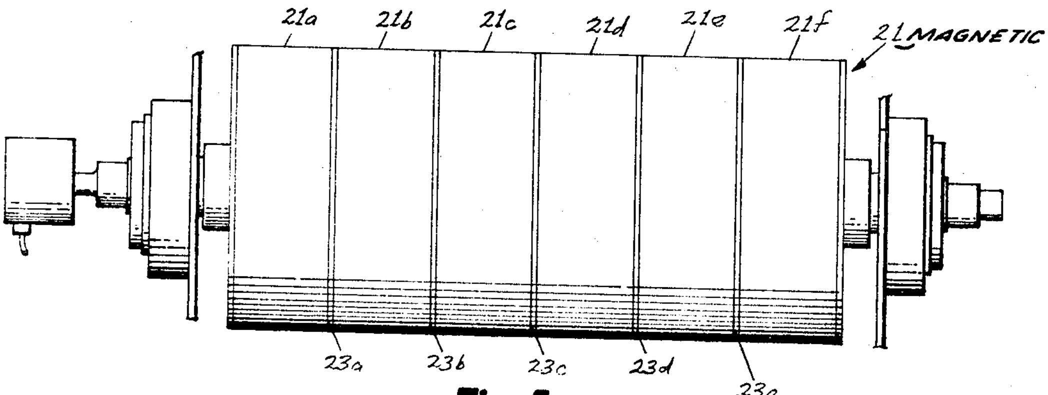

FIG. 5

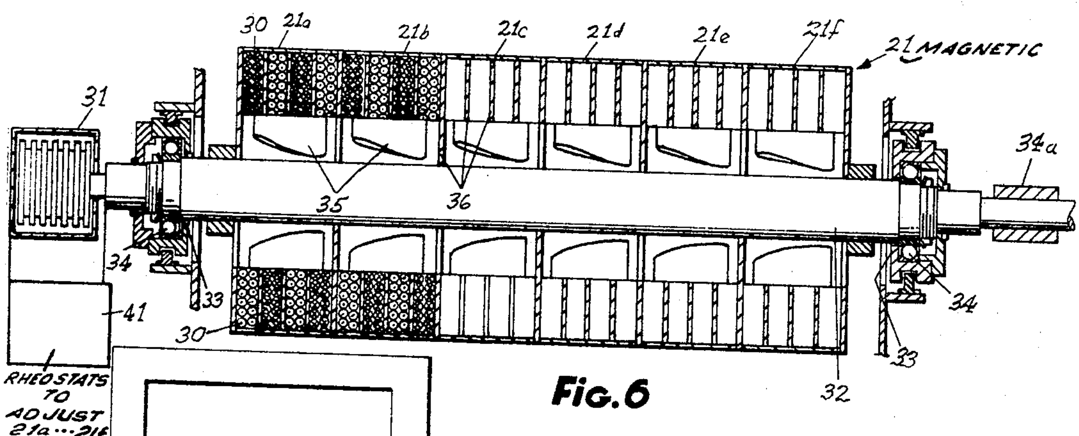

FIG. 6

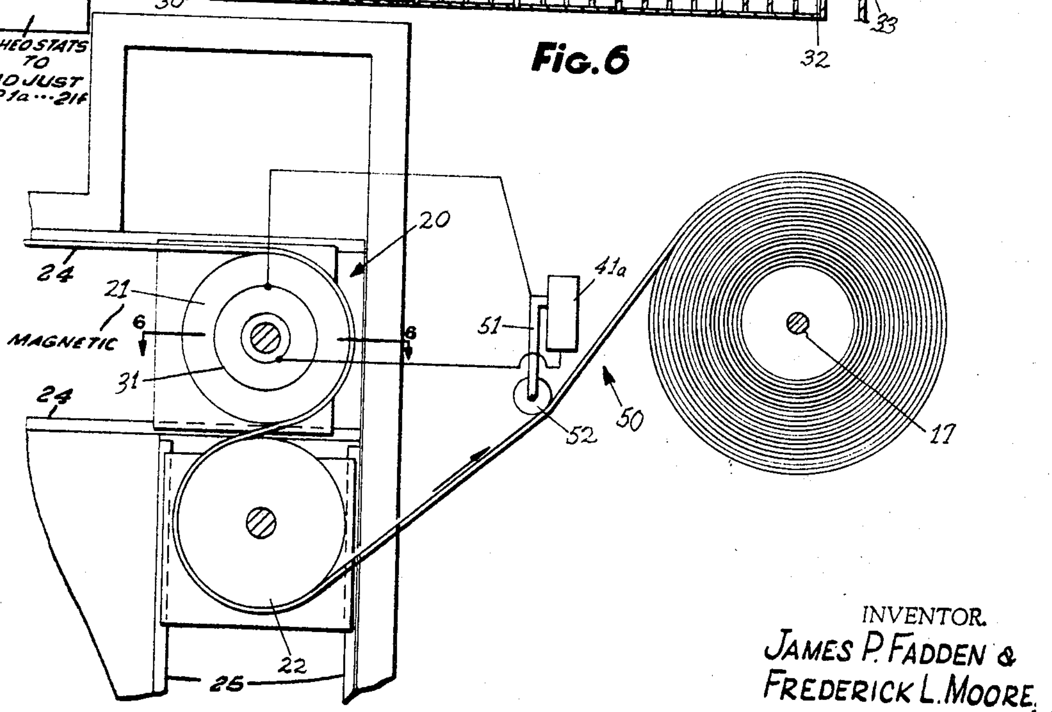

FIG. 7

INVENTOR.
JAMES P. FADDEN &
FREDERICK L. MOORE,

BY MELVILLE, STRASSER, FOSTER & HOFFMAN
ATTORNEYS

United States Patent Office 3,433,398
Patented Mar. 18, 1969

3,433,398
MAGNETIC BRIDLE UNIT FOR WINDING STEEL STRIP

James P. Fadden, South Point, Ohio, and Frederick L. Moore, Huntington, W. Va., assignors to Armco Steel Corporation, Middletown, Ohio, a corporation of Ohio

Filed Apr. 10, 1967, Ser. No. 629,591
U.S. Cl. 226—93 8 Claims
Int. Cl. B65h *17/18*

ABSTRACT OF THE DISCLOSURE

Apparatus for the control of tension in the winding of steel strip. More specifically, apparatus utilizing a bridle unit having an electromagnetic roll about which the single strip or multiplicity of strands pass prior to coiling on a take-up reel. The adjustable magnetic force of the bridle unit is sufficient to control and maintain a predetermined tension in each of the strands being wound on the take-up reel.

DISCUSSION OF PROBLEMS LEADING TO THE INVENTION

This invention finds particular application in an edge trimming or slitter line for coated strip having a non-metallic, or metal coating such as zinc, aluminum, tin, terne, or alloys thereof, where protection of the surface is a critical concern. This should not however be read as a limitation on the invention. Any magnetic material in strip form, whether coated or uncoated, may be processed in the manner taught herein. For convenience though, the invention will be described with respect to application on a metallic coated steel strip.

In a typical metal coating operation, such as the Sendzimer method, the steel strip is passed through an oxidizing furnace in which a very thin and uniform coating of oxide is provided on the strip surface. The strip then passes through a reducing furnace to reduce the oxide coating. Following this the strip passes through a cooling zone of the furnace, then by way of a protective hood directly into a bath of the coating metal. The coating metal quickly solidifies on the steel strip core forming a relatively soft but tightly adherent coating.

Galvanized, aluminized and otherwise coated materials have gained wide acceptance in industrial and commercial applications by reason of the rather low cost corrosion protection offered by the coated material. If scratches were to appear on the normally smooth coating the product could not be used in many applications where surface appearance is of great importance. Therefore, it is imperative that all of the material handling operations following the coating are carried out with the foregoing considerations in mind. Obviously, if the customer or warehouse desired an untrimmed coil, there would be little need for this invention. These situations are quite limited—the standard requirements are generally trimmed and/or slit coils. For example, a coil might be trimmed and slit into several separate coils of a few inches width.

The prior art attempts to wind the various strands of the slit coil without loose winding were ineffective. To secure tight coils for later shipment requires the maintenance of tension on all of the slit strands. Some practitioners used a pinching effect, however, this sometimes caused the strands to mistrack and overlap. Others employed a drag device which led to scratches on the surface, while still others suggested slipping mandrels with paper cores. Further, variations in gauge from edge to edge result in differential tension in the slit coils. These

ineffective methods for processing slit coils meant rehandling—and rehandling increased production costs.

Accordingly, it is a primary object of this invention to provide an improved means of rewinding coated steel whereby costs are lowered and quality improved.

A further object of this invention is the provision of apparatus for winding a plurality of strands of a slit coil into separate tight coils despite variations in gauge. Another object of the invention being a magnetic bridle roll capable of maintaining the same tension on all of the slit strands.

A still further object of this invention is the provision of a means for applying tension to a strip of steel without marring the finish thereof.

An additional object of this invention is the provision of means for winding several strands of a slit coil without mistracking of the strands.

Another object of this invention is the provision of a method for processing a slit coil of steel wherein the tension on the slit portion of the coil is substantially reduced prior to separation, then selectively increased subsequent thereto.

Further objects and advantages will become apparent to those skilled in the art upon reading this description, especially when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic diagram of a proposed trimming and slitting of a steel coil utilizing the magnetic bridle unit as taught herein.

FIGURE 2 is an enlarged partial schematic diagram showing the relationship of the strip to the bridle unit and the winding reel for an edge trimming and slitting operation.

FIGURE 3 is a schematic diagram similar to FIGURE 2 showing the indicated relationship during an edge trimming operation.

FIGURE 4 is a schematic diagram similar to FIGURES 2 and 3 showing the bridle unit in a substantially inoperative position.

FIGURE 5 is a top view of the magnetic bridle roll showing a plurality of sections, each section having a plurality of zones with separators between zones.

FIGURE 6 is a sectional view, taken through the axis of the roll, of a typical magnetic section forming part of the magnetic roll as described herein.

FIGURE 7 illustrates schematically one means by which the tension of a strip of steel may be automatically regulated.

BRIEF SUMMARY OF INVENTION

Briefly, in the practice of this invention, a strip of steel, which may have a coating thereon, is subjected to a trimming and slitting operation. An abbreviated sequence of steps to secure trimmed and slit strands from a coil are (1) payoff, (2) slit and trim, (3) separate, and (4) rewind. To separate the several strands, back tension at the strand separator should be released so that the separator can guide the various strands apart. On the other hand, tension must be restored subsequent the separator to effect a tight winding of the several strands.

The re-establishment of the back tension is achieved with the present invention by the use of a pair of bridle rolls, one of which is magnetic. The bridle rolls, hereinafter referred to as the bridle unit, are placed at about the pass line in the processing unit to permit, in effect, a weaving of the strip thereabout. The magnetic roll is the first of the pair of bridle rolls around which the strip passes. Thus, the strip, with the rolls in an operative position, follows an "S" path.

A bridle roll operates as a capstan and requires some back tension to be multiplied by a second roll; the magnetic roll supplies the initial back tension. While it should be acknowledged at this point that the relative position of the two rolls and their size will affect the tension on the strip, a variable magnetizing force in the roll itself is contemplated as the primary tensioning means.

The magnetic roll to be utilized in this case is an electro-magnetic roll, preferably a multi-section roll, each of which may contain several magnetic zones or poles. That is, it resembles a horizontal stack of identical washers. By this arrangement of parts, it is contemplated that each section can be automatically or manually controlled to provide the magnetizing force desired. For example, with the use of slip rings to maintain a constant electrical contact with each magnetic section, and by the use of a means to vary the current such as by a rheostat, the adjustments in the magnetizing forces may be readily effected. It should therefore be apparent that the effect of the magnetic roll is to provide the initial back tension on the strip or strand, and to maintain a predetermined level of tension in all the strands. As the tension level is reached, the strip or strand will begin to slip around the roll. For example, in a slitting operation yielding several strands, should any of the strands by virtue of variations in gauge start to loose wind, the magnetic force through the remaining strands can be reduced allowing them to slip until the tension on all strands is equal and full tension is regained. It thus becomes obvious that a slit coil can be rewound into a plurality of tight coils without the use of a pinch effect or some type of drag device which could otherwise mar the surface.

One expedient to avoid certain of the foregoing problems would be to roll the steel coils to the final size desired, thereby eliminating the need for slitting. Economically, this is not practical, especially for narrower widths. In view of this practical necessity, it might be helpful to review the slitter operation as represented by the schematic diagram of FIGURE 1.

DETAILED DESCRIPTION

A coil of steel, weighing as much as 30 tons, and perhaps one having a coating thereon, is placed on the payoff reel **10**. As the strip unwinds, the leading edge is fed between the side controls **11** which prevent shifting in the slitter **12**. The slitter **12**, the particular construction of which is not intended to be a limitation on this invention, may comprise a series of spaced apart circular knives mounted on stationary arbors, the outermost knives being spaced a short distance inside the edges of the steel strip. The primary function of these outer knives is to trim the rough and uneven edges. The chopper **13**, disposed below the passline of the strip, breaks the edge trimmings into convenient scrap sizes of about 2 to 6 inches. The shear **14** is used to trim the trailing edge of the coil as it passes therethrough.

Where the sole operation is merely one of trimming a single coil, the loop pit **15** can be bypassed or eliminated. However, in a slitting operation it performs a very necessary function. Difficulty is encountered in separating the several strands of a strip when the strands are subjected to any degree of tension. There is a tendency, for example, for the strands to overlap. The loop pit **15**, after the slitter **12** not only allows the strands to hang freely without tension, it provides sufficient room for the differences in length of the strands so that a uniform winding of the several slit strands will occur. Without the back tension, the strand separator **16**, which may be merely steel inserts, can guide the several strands apart.

The back tension must be re-established in the strip to ensure a tight and uniform rewinding of the strands on the winding reel **17**. This is affected through the use of a bridle unit **20** placed between the separator **15** and reel **17**.

The bridle unit **20**, which forms a critical part of this invention, is illustrated schematically in several operating positions in FIGURES 2–4. Bridle unit **20** comprises a multisection magnetic roll **21** and a second roll **22** parallel thereto which is preferably rubber coated. This latter relationship, to which adjustments are contemplated, can be accomplished through the use of a pair of swing arms connecting the axes of the respective rolls, or by the movement of the respective rolls in a vertical or horizontal direction. Further it is contemplated that the relationship of the two rolls may be varied so long as the magnetic roll is the first in contact with the strip, and, the two rolls remain parallel. FIGURES 2 and 3 are similar in that they depict the identical relationship of one roll to the other. However, as noted earlier, the loop pit **15** need only be used in slitting operations. Where the operation is limited to edge trimming, we can dispense with the free-hanging loop as illustrated in FIGURE 3. But in either case, the bridle unit is shown in its normal operating position to ensure a uniform tension in the winding strip.

Through the illustrations just descraibed, it should be apparent that the magnetic roll is the first of a pair of bridle rolls forming the bridle unit **20**, around which the strip passes. A bridle unit is operated as a horizontal capstan and requires some back tension, which may be supplied by a drag generated by the magnetic roll **21**, to be multiplied by a second roll **22** as fitted with an adjustable brake. Such brakes are conventional and well known to the practitioner in the art. It should further be apparent from this arrangement that as changes are made in the relationship between the two rolls, corresponding changes will occur in the ability of the rolls to supply tension to the strip. For example, FIGURE 4 shows the rolls in an inoperative position. That is, the second roll **22** is functioning merely as a deflector roll in the rewinding operation. The magnetic roll **21** may or may not come in contact with the steel strip. By rotating the second roll **22** in a clockwise direction about the axis of the magnetic roll **21**, or in the alternative, shifting them in a horizontal and/or vertical direction by means of a hydraulic system, the steel strip comes into increasing contact with the respective roll surfaces, thereby increasing the tension supplying ability of the bridle unit **20**. The shifting of the respective rolls may be effected in the direction shown by means including guides **24** and **25**, and hydraulic cylinder **26**. A lower operating limit to achieve the capstan effect can be considered at the point at which the strip contacts the two rolls in a total arc of at least 180°. The foregoing mechanical adjustment of the rolls is not to be considered as the primary tension adjusting means. Further, it may be supplemented by or replaced by changing the braking power of the rolls. The primary tensioning means, the variable magnetizing force of magnetic roll **21**, will be described hereinafter.

The mechanical adjustable features noted above would be sufficient to secure the desired tension by itself if we had to deal only with single strands or unslit coils. Even if we were to eliminate any concern over surface scratches, problems will continue to arise in slit coils due to uneven gauge across the strip. For example, as the strands are rewound, the heavier gauge strands would be tighter than the lighter gauge strands. It therefore became necessary to devise a means for maintaining a uniform tension in the several strands without introducing further problems which might affect the surface.

FIGURE 5 is a top view of the magnetic roll **21** showing the several sections **21*a*–21*f***. It should be understood that the number of sections shown in FIGURE 5 is merely for purposes of illustration and does not constitute a limitation on this invention. Practical considerations such as gauge, width of strands, and width of roll, among other factors, will determine primarily the number of zones selected. If for example, the single coil was being slit into approximately two inch steel strappings, narrow sections would be desirable. FIGURE 5 further shows the positioning of non-magnetic inserts **23*a*–23*e*** between the respective sections forming magnetic roll **21**. Their purpose will become clear in the discussion covering the manner by which the sections are selectively adjusted.

Assume for the purposes of illustration, the use of a six-section magnetic roll, such as shown in FIGURE 5, in the system represented by FIGURE 1. Further assume a section width of 6½ inches, and a coil initially40 inches wide to be cut into three strands 13 inches wide. As the material is fed into the slitter **12**, one inch of material is lost as edge scrap. The resulting three strands then pass between the strand separators **16**, through the bridle unit **20** and onto the winding reel **17**. It will be apparent that as the strands pass around the magnetic roll **21**, each strands contacts only two sections. Thus, by selectively magnetizing the sections common to one strand, the tension on said one strand may be changed independently of the remaining strands.

It should be understood at this point that the selection of a six-section roll is purely arbitrary. Further, it is not necessarily a requirement that the number of sections be multiples of the number of slit strands. Actually, the latter is a more typical situation. In fact, a large number of sections means greater flexibility in the adjustments which can be made.

Since it is quite common to find heavier gauges in the center, it would be obvious that the center strand would produce a large coil and one that weighs more. Therefore, in any given revolution of the windup reel **17**, more steel would be wound on the center strand than on the outer strands. As a consequence, the outer strands, in the absence of some tensioning device, would loose wind. Utilizing the bridle unit **20**, as taught herein, the outer sections **21*a*, 21*b* 21*e*** and **21*f*** would be energized to a higher magnetic force to maintain a predetermined tension on the outside strands. Conversely, if the magnetic roll **21** were operating at its maximum magnetic force, the force of the inner sections **21*c*** and **21*d*** would be correspondingly reduced to restore and maintain the predetermined tension on the outer strands, i.e., by permitting greater slippage of the middle strands. In either case, the magnetic force of zones **21*c*** and **21*d*** would be lower to permit the center strand to slip thereabout. By this means, a uniform tension will be supplied to each strand resulting in not one but three tight and uniform coils.

While the magnetic roll **21** forms an essential part of the bridle unit, such rolls are known per se. For example, a magnetic roll suitable for the practicing of this invention is illustrated in section in FIGURE 6. As described hereinabove, the magnetic roll **21** is characterized by a plurality of sections, each containing on the order of four zones. Structurally the zone may be a continuous annular chamber containing a multiplicity of wire windings **30** in coil form, such that when energized there will be produced a magnetic field about the windings. And, each of said sections are individually controlled through the use of a segmented connection ring called a commutator, indicated generally at **31**. The operation of a commutator is known and readily obtainable from electrical handbooks. Briefly, however, the ends of the coiled windings **30**, are connected to the segments of a split conductor ring. The segments are so connected to the shaft **32** that they are insulated from each other and from the shaft **32**. Fixed carbon contacts or brushes provide the external electrical connection to the segments.

The shaft **32** of magnetic roll **21** rides in the housing guides **33** on bearings **34**. Shaft **32** is free wheeling to the extent that it is not driven, however, a drag is generated in the system by the friction caused by the brake **34*a***. The vanes **35** have been provided to help cool the windings **30**. As a separator **36** between each of the magnetic zones, non-magnetic stainless steel, such as the A.I.S.I. 300 series stainless steels, have been found to be quite suitable.

The control center for rendering the bridle unit **20** operative and magnetized may be conveniently placed near the bridle unit. It is contemplated that the system can be automatic or manually operated, thus, this position will afford an excellent visual inspection of the unit as well as the relative tension on the several strands leaving the bridle unit **20**.

For the initial setup, a motorized system such as known and used on apparatus of this size, may be employed to place the movable rolls into the operating position. It should also be clear that other means just as suitable may be applied to this system; therefore, the recited modes are in no way intended to form a limitation on this invention.

Since as explained earlier, the magnetic roll **21** must be electro-magnetic, a rheostat or plurality of rheostats **41** for each section of **21*a*–21*f*** is provided as part of the control center—this regulates the electrical current and therefore the magnetizing force of the particular section. In the event the number of sections far exceed the number of strands being rewound, it is comtemplated that adjacent rheostats can be coupled to ensure equal magnetizing force in adjacent sections. For automatic operation, a tension detection device **50**, shown in FIGURE 7 may be placed between the bridle unit **20** and the rewind reel **17**. For example, the arm **51** of the roller **52**, adapted to ride on the rewinding strand, may be provided as illustrated in FIGURE 7 to vary the resistance of the rheostat **41*a*** and therefore the current energizing the electro-magnet in the corresponding section in response to slack. It should be obvious then that as the tension in the rewinding strand decreases, the roller **52** is extended or lowered—this in turn reduces the resistance of the rheostat in the circuit. Accordingly, the flow of current increases resulting in increased magnetic pull of zone **21*a***. The tension in each of the respective strands can then be restored to and maintained at a predetermined value by additional devices such as taught above.

Having described the physical limitations and importance of the bridle unit taught herein, let us look at some exemplary factors on a steel coil processed according to the system described above.

Magnetic roll data

(a) Eleven magnetic sections, approximately 6⅜ inches width.
(b) Four magnetic zones per section.
(c) Diameter—30 inches.
(d) Width—70 inches.
(e) Weight of magnetic roll unit—13,000 pounds.
(f) Power—10,000 watts at 115 v.-D.C.

With the above described roll operating on 16 gauge steel strip at a speed of 300 f.p.m. it was determined that said roll had a holding force of 5 pounds per square inch.

Since modifications, such as a permanently magnetic roll where versatility in the system is unnecessary, or the addition if means for demagnetization of the magnetic roll, i.e., purging with A.C. current, or reversing polarity, may be made in this system without departing from the spirit and scope of this invention, no limitation is intended to be imposed herein except as set forth in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A bridle unit for the control of tension in the winding of steel strip between a pay-off reel and a take-up reel comprising, an electromagnetic roll movable in one direction, a second roll parallel to said electromagnetic roll and movable in a direction perpendicular thereto, said second roll in its operative position being offset from said electromagnetic roll, and means for energizing at least the surface of said electromagnetic roll, whereby as said steel strip rides the respective rolls between the pay-off reel and

the take-up reel, the holding force of said bridle unit is sufficient to maintain the steel strip at a predetermined level of tension.

2. The bridle unit claimed in claim 1 wherein said electromagnetic roll comprises a plurality of sections, said sections being spaced apart along the axis of said roll and containing at least one electromagnet therein.

3. The bridle unit claimed in claim 2 wherein said means for energizing the electromagnetic roll includes means for selectively varying the magnetizing force of each of said sections, said last named means including a plurality of variable D.C. power supplies.

4. The bridle unit claimed in claim 3 wherein each of said D.C. power supplies is varied by a rheostat.

5. The bridle unit claimed in claim 4 wherein said rheostats may be selectively controlled such that adjustments are effected in only a predetermined number of sections.

6. The bridle unit claimed in claim 5 including a non-magnetic spacer between each of said sections.

7. The bridle unit claimed in claim 1 including means for adjusting the relative position of said electromagnetic roll and said second roll.

8. The bridle unit claimed in claim 7 wherein said second roll is provided with a rubber coating on its surface.

References Cited

UNITED STATES PATENTS

1,546,330	7/1925	Ullrich.	
3,150,419	9/1964	Aurich.	
1,230,941	6/1917	Sundh	242—78.3
1,263,419	4/1918	James	242—75.2
1,386,813	8/1921	Townsend	242—75.2
2,691,819	10/1954	Felton et al.	242—78.1
2,723,085	11/1955	Conti	242—56.9
2,755,917	7/1956	Koerner	226—93

FOREIGN PATENTS

1,166,523	3/1964	Germany.

NATHAN L. MINTZ, *Primary Examiner.*

U.S. Cl. X.R.

226—114, 195; 242—75.2