March 21, 1967 TADEUSZ SENDZIMIR 3,310,255

SPIRAL LOOPER

Filed Nov. 9, 1964 5 Sheets-Sheet 1

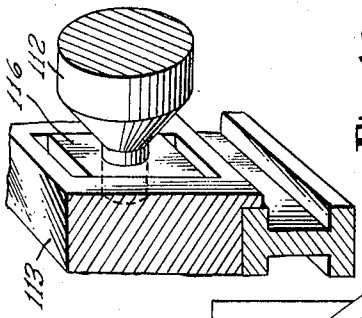


Fig. 1d

Fig. 1

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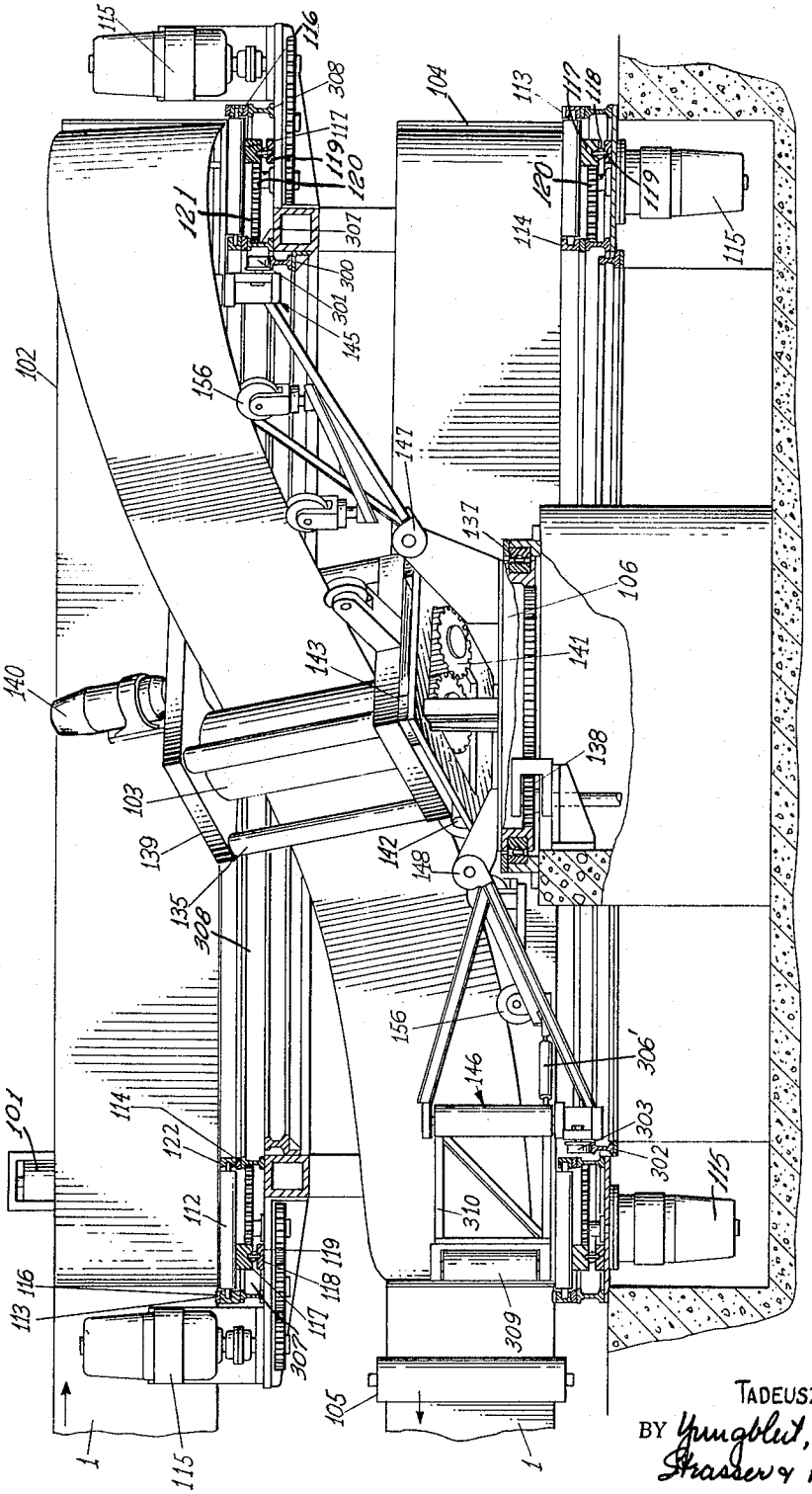


Fig. 2

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SPIRAL LOOPER

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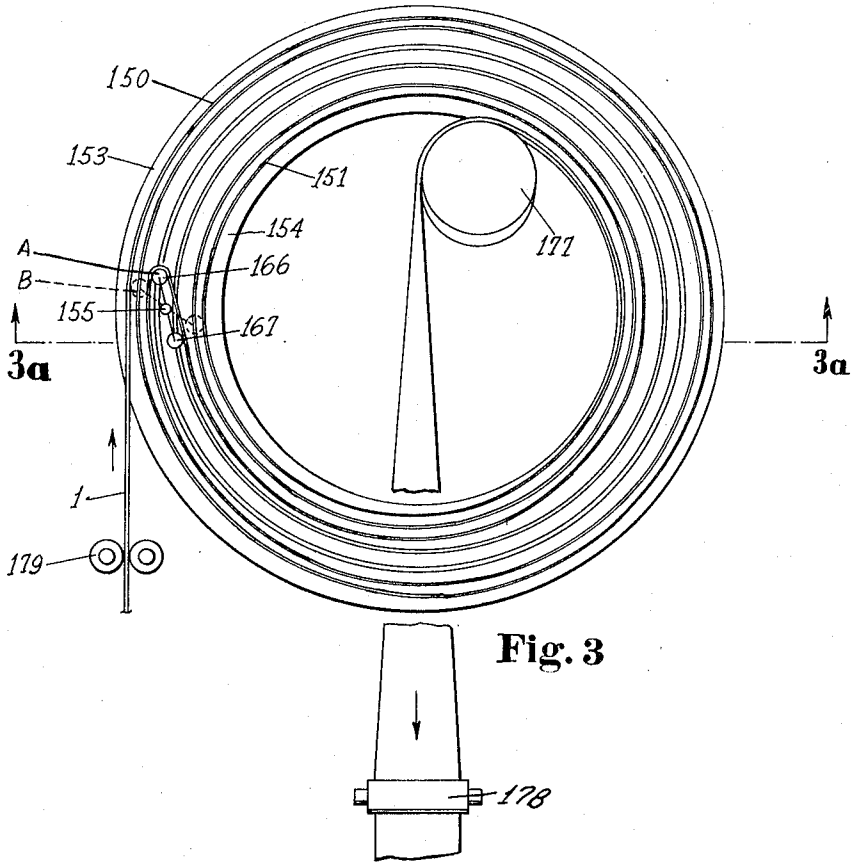


Fig. 3

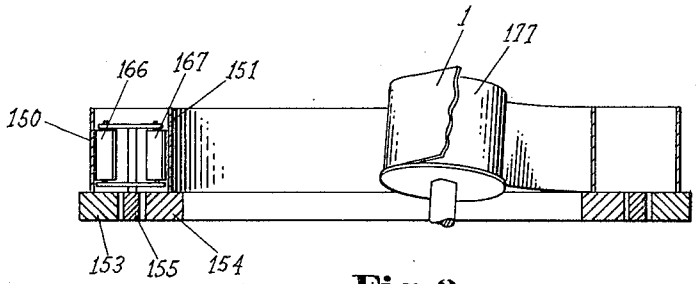


Fig. 3a

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SPIRAL LOOPER

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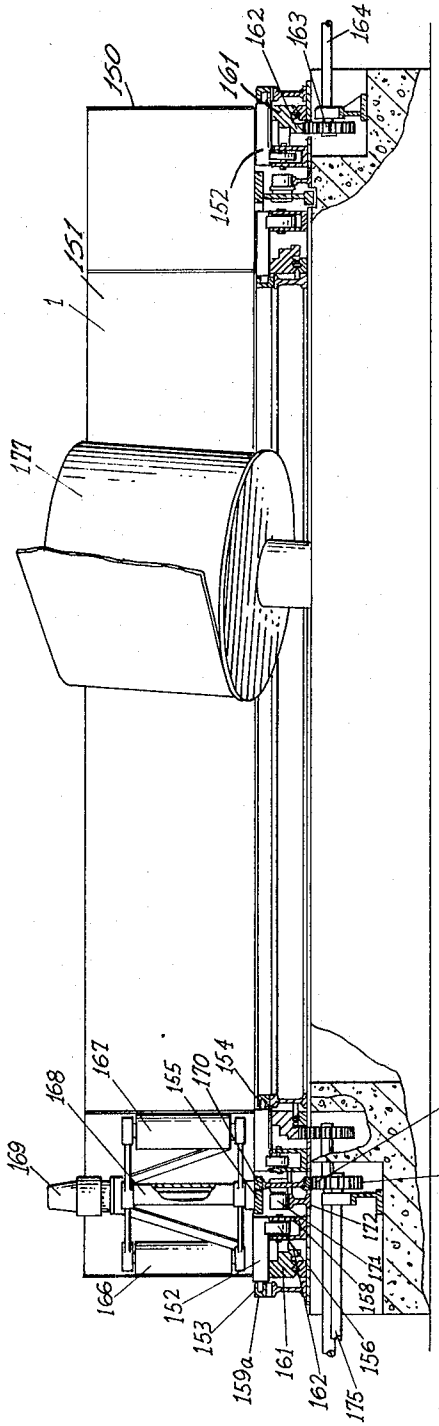


Fig. 4

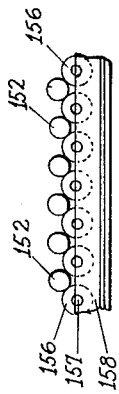


Fig. 4a

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SPIRAL LOOPER

Filed Nov. 9, 1964 5 Sheets-Sheet 5

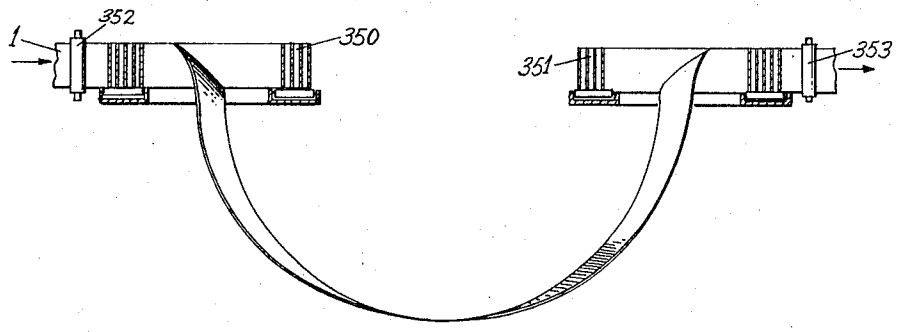


Fig.5

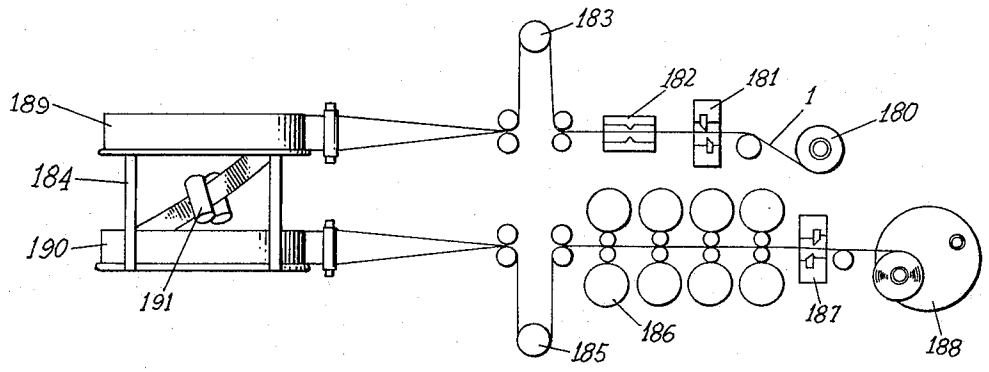


Fig.6

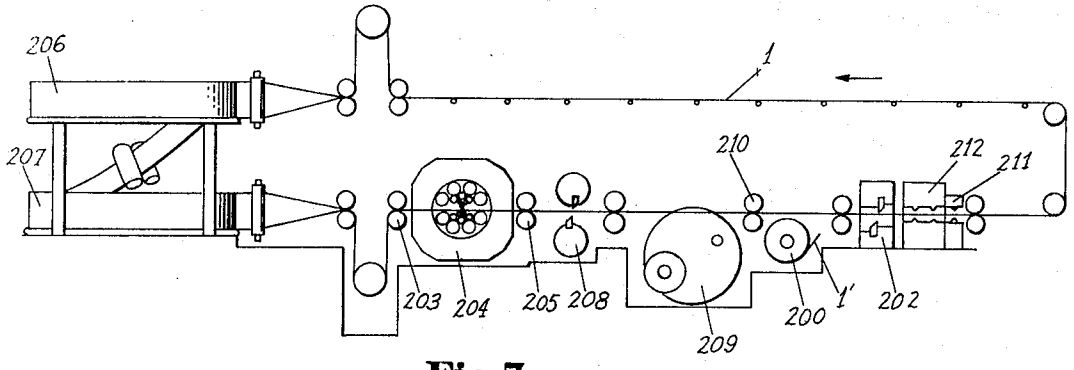


Fig.7

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3,310,255

SPIRAL LOOPER

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Filed Nov. 9, 1964, Ser. No. 409,853
16 Claims. (Cl. 242—78.1)

This invention deals with the problem of "looping" or accumulating endless lengths of strip material in such a way that the entry of the strip material into the looper is not immediately related to its withdrawal therefrom. For example, in the continuous galvanizing of iron or steel strips, it is necessary to accumulate a sufficient length of the material to permit the coating apparatus to operate continuously while the trailing end of a strip is stopped long enough to permit the welding or other attachment to it of the leading end of the next succeeding strip. This has hitherto been accomplished either by providing a festooning looper, or by providing a looping car operating on tracks and acting to draw out a loop of the strip material of substantial length, and to feed material out of the loop during such time as the trailing end of a loop must be held stationary.

The above expedients have been space-consuming and relatively cumbersome. Moreover, they have been limited as to capacity, and therefore effective to permit stoppage of any part of the strip material for a short time only. Thus, if the welding operation is interrupted it will be necessary to stop the coating operation, and vice versa. It is an object of the invention to provide a looping means in which a very large quantity of the strip material can be accumulated.

The invention will be described in connection with the accumulation of metal strip for treatments such as annealing, coating or rolling, it being understood that metallic strip and the various treatments to which such strip may be subjected do not constitute a limitation upon the invention excepting as set forth in the appended claims.

Because of the ability of the looping means of this invention to store variable quantities of strip in motion which are 100 times larger, or even more, than is practicable today, the invention has important applications in the strip forming and processing industries. For instance, in annealing or coating lines used in continuous galvanizing, an endless length of strip is moved through such lines at constant speed while the entering strip must be stopped at the end of each coil for welding its end to the end of the next coil as above noted. The loopers used at present permit a stoppage of 2 to 3 minutes only; whereas with the aid of the apparatus shown herein, it is possible to build up a continuous length of strip sufficient for a whole night shift, thus making presence of the welding crew superfluous.

It has hitherto been suggested to lead strip material, resting on edge, tangentially into a spiral configuration, thus forming a loose coil, and then to lead it out of the inner wrap of said coil. The strip will be moving forward in the direction of its length as it is fed into the coil, and for this reason it is preferable to propel the coil at a plurality of points, e.g., by applying drive to supporting rollers forming a roller bed and disposed radially to the wraps. However, applicant has found that it is possible with certain precautions as described below, to run such spiral coils when feeding the strip into the inner wrap of the coil and withdrawing it tangentially from the outer wrap. This has made it possible to provide in a looper a plurality of such loose coils operating in succession, whereby the capacity of the looper can be greatly increased. The invention will be described in an exemplary embodiment embracing two

loose coils, it being understood that this number does not constitute a necessary limitation.

An object of the present invention, therefore, is the provision of means and a method for storing variable lengths of strip material while in lengthwise motion by leading it in succession, first, through an inward progressing coil and, second, through an outward progressing coil configuration, one of them being wound clockwise and the other counter-clockwise, both coils being disposed, supported and driven substantially as hereinafter described.

An essential condition is the correct method of leading the strip out of the first and into the second coil, for obtaining variability of storage capacity of both coils irrespective of whether the entry and exit speeds of the strip are the same or whether either the entry or exit speed drops to zero or to any intermediate value. It is an object of the invention to provide such a method together with means for carrying it out.

These and more specific objects of the invention which are pointed out hereinafter or will be apparent to one skilled in the art upon reading these specifications, are accomplished by that process and apparatus of which certain exemplary embodiments will now be described. Reference is made to the accompanying drawings wherein:

FIGURE 1 is a partial top plan view of the co-axial superposed embodiment of the invention.

FIGURE 2 is an elevational view with parts in section of the co-axial superposed embodiment of the invention, with the guide rolls shown in position B.

FIGURE 3 is a schematic plan view of the co-axial, even-level modification of the invention.

FIGURE 3*a* is a schematic vertical section of the embodiment of FIGURE 3 on line 3*a*—3*a* thereof, with looping rolls shown in position B.

FIGURE 4 is a schematic vertical section of the co-axial, even-level embodiment of the invention, showing the constructional details.

FIGURE 4*a* is a detail elevational showing of the roller support as used in the embodiment of FIGURE 4.

FIGURE 5 is a vertical sectional view of a modification with juxtaposed coils on the same level.

FIGURE 6 is a diagrammatic view of an application to a tandem cold strip mill.

FIGURE 7 is a diagrammatic view of an application to a single stand strip mill.

In the practice of this invention, a necessary condition is that when the guide which leads the strip material into the second spiral coil is moved lengthwise of the strip in the direction of its travel, thus reducing the length of strip stored in such second coil, a substantially equal length of strip is removed from the first coil, by a similar movement of its withdrawing guide, so that no twist is imposed on the strip around its longitudinal axis.

While always operated in tandem, the twin coils may be disposed in a variety of convenient positions of one in relation to the other. If they are disposed co-axially, either one above the other, FIGURES 1 and 2, or within each other on the same level as in FIGURES 3 and 4, the guide which withdraws strip from the first coil can be combined into one instrumentality with the guide which leads the same strip into the second coil. If, on the contrary, the twin coils are in side-by-side relationship either on the same or on different levels, the two guides must be synchronized so as to prevent the strip length extending between them from being cumulatively twisted.

FIGURES 1 and 2 illustrate one embodiment of the invention. The strip 1 is introduced into driven entry pinch rolls 101 on the upper level of the apparatus where

it is guided and fed forwardly to form a loose coil or spiral 102 converging from the outer towards the inner wraps. The strip 1 is withdrawn from the interior of coil 102 and fed by central pinch rolls 103 into the inner wrap of a second loose coil or spiral 104 (see FIGURE 2), on the lower level of the apparatus, the latter spiral advancing from the inner towards the outer wraps. Upon reaching the outer wrap, the strip 1 is free to be removed, for instance tangentially, by exit rolls 105 preferably situated beneath the entry pinch rolls 101.

The guiding apparatus, indicated generally in FIGURES 1 and 2 at 135, provided for the purpose of delivering strip 1 from the inner wrap of the upper coil 102 into the inner wrap of the lower coil 104, (including the central pinch rolls 103), is rotatively mounted on a turntable 106 which is stationary as long as the velocities of the entry pinch rolls 101 and the exit pinch rolls 105 remain the same.

The situation just outlined is one in which the strip will be entering and leaving the looper at the same speed. Both coils or spirals will be rotating. The upper coil 102 will be having additional wraps or convolutions of the strip material formed upon its outer circumference, while the lower coil will be having strip material withdrawn from it by the removal of its outer wraps or convolutions. The guiding or transfer apparatus generally indicated at 135 (which will not be revolving) will act to transfer strip material from the inner wraps of coil 102 to the inner wraps of coil 104, the strip material moving in the direction of the arrows in FIGURE 1. But if the velocity of the entry pinch rolls 101 is higher than the velocity of the exit pinch rolls 105, the turntable 106 must be rotated clockwise. By reference to the figures it will be seen that one complete revolution of the turntable 106 will add one complete wrap to the upper coil or spinal 102 and also one complete wrap to the lower coil or spiral 104. This is possible because at the same time one or both of the coils or spirals will also be rotating.

The situation just described is one in which additional strip material is being accumulated in the looper. This may be done either by driving coil 102 at a higher speed than coil 104, or by stopping the rotation of coil 104 as, for example, upon a stoppage of the treatment apparatus which receives the strip material from the looper. Both coils or spirals will "grow" in the sense of acquiring more wraps or convolutions.

Conversely, if the speed of the exit pinch rolls 105 exceeds the speed of the entry pinch rolls 101, or if the entry pinch rolls 101 should stop completely, the turntable 106 will have to be turned counter-clockwise. Here, one complete revolution of the turntable 106 will shorten the stored quantity of strip by one full inner wrap in upper coil 102 and also will remove one full inner wrap from lower coil 104. It can continue to do so, wrap after wrap, until both the upper coil 102 and the lower coil 104 are depleted. This again is possible because one or both of the coils or spirals will be rotating.

The situation just described is one in which the strip material paid out of the looper is greater in amount than the strip material fed to the looper, or a situatiton in which strip material is being paid out of the looper to keep the subsequent treatment apparatus operating, while no strip is being fed into the looper, e.g., during a welding operation. While the condition lasts, both coils or spirals will be diminishing in the sense of containing fewer wraps or convolutions.

The coils 102 and 104 are both supported and propelled in the forward direction by means of their lower edges which rest on circular tables or beds of rollers 112, the necks of which are located in self-aligning bearings 116 and 122 mounted in circular cages comprising outer rings 113 and inner rings 114 respectively.

The bearings 116 provided for the outer necks of rollers 112 are free to move vertically in slots (not shown) provided in the ring cage 113, so that the weight of rollers 112 and hence also the corresponding portion of the weight of coil 102 or 104 rest on a ring 117, concentric with cage 113, 114 and supported by rollers 118 running in grooves in the ring 117 and in a lower supporting race 119, which is mounted directly or indirectly on the frame of the machine.

The ring 117 is driven by one or more pinions 120 (in FIGURE 2) from a power source or sources, e.g., motors 115, by engaging teeth 121 provided on the inner periphery of ring 117. For the purpose of transmitting power by friction to the carrying rolls 112, it is preferable to place the supporting ring 117 not too far from the outer cage 113, because even in coil 102 or 104 consisted of a few wraps only at any given time, there will be enough weight to add to the weight of the rollers 112 themselves, to assure a substantially slipless drive of the rolls 112 and, therefore, the forward propulsion of the coils. The inner end of the rolls 112 are located in bearings 122 provided in the cage 114 in such manner that they support the corresponding portion of the weight of rollers 112 and of the lesser part of the coil 102 or 104. The cage elements 113 and 114 are shown as resting upon circular beams 307 and 308 on the machine frame. Once the strip 1 is guided into the spiral configuration necessary to form coil 102 or 104, its wraps or convolutions have a natural tendency to converge towards the center of the coils since the rollers 112 are cylindrical and have a constant peripheral speed which corresponds to the forward speed of strip 1. But as the diameter of the wraps becomes smaller, and as they approach the diameter of the inner wrap, the angular velocity of the strip 1 rotating around the common axis of the apparatus becomes greater and, therefore, there is a minute relative movement between adjacent wraps of the coils. For reasons of compactness of the apparatus, in attempting to store a large moving mass of steel strip in a relatively small space, it is desirable to assure the coils 102 and 104 are substantially round, with their individual wraps just loose enough to assure freedom such relative motion. If the coils are too tight, the internal friction will impede the movment of the strip from the outer wrap towards the inner wrap. If they are too loose, valuable space and capacity is lost. The behavior of the strip when guided into a spiral coil will be affected to a large extent by its gauge, its relatixe stiffness, weight and other characteristics. The coefficient of friction with the rollers will depend on its edge surface condition.

Applicant has found that, with cylindrical rollers 112, he can easily control the relative tightness of the coils by moving the rolls 112 slightly off the radial position. This is preferably done by turning ring 113 on a sliding bearing 122 on the support rail 308 through a small angle and thereby shifting the axis of all rolls 112 simultaneously and uniformly. An exemplary embodiment of such a device in adjustable form is shown in FIGURE 1, as a cylinder 125 connected between the ring 113 and its supporting rail 307, and operated electrically, hydraulically or otherwise.

If it is desired to produce a looser coil, this result may also be attained by slightly tapering the rollers 112 so that their diameter at the end which supports the inner wrap of the coil is a few percent larger than the other end. However, such proportioning of diameters is fixed and cannot be adjusted.

There are cases when it is desirable to provide a wider spacing between individual wraps of the coils, especially when certain processing operations are to be performed on the strip during its progress through the coil and which make access to the whole surface of strip necessary. Such operations may be, for instance, oiling, painting, drying, and heating. Especially in the case of heating such as annealing, space is required between individual wraps or convolutions large enough to allow free passage of the furnace atmosphere therebetween.

For such cases, applicant prefers to use supporting rolls 131*a* with a profile diagrammatically shown in FIGURE

1. These rolls are provided with a series of circular spaced ribs **131** deep enough to engage the edges of the individual wraps of strip in the coil but not so deep that these rolls cannot carry their share of the weight of the strip. It suffices to have only several of such guiding rolls around the periphery of the roller beds supporting the coils, for example, one such guide roll for every three cylindrical rolls as shown in the left quadrant of FIGURE 1.

The lower coil **104** is supported, propelled and guided in exactly the same way as coil **102** above described.

The guiding apparatus generally indicated at **135**, which serves to pick up the inner wrap of coil **102** and guide it slantwise downwardly and into the inner wrap of coil **104**, comprises the turntable **106** rotating on bearing means **137** and driven by pinion **138** from a power source, not shown.

On the turntable structure **106** is mounted the pinch roll stand **139** having suitable bearings, not shown, for the pinch rolls **103**. One pinch roll is driven, for instance, by a gear motor **140** (FIGURE 2), and the other may be driven from the first one by directly mounted gears **141**.

The angle of the rolls **103** with the vertical is preferably slightly adjustable; and for this purpose the pinch roll stand **139** can be hinged on the turntable **106** by means of a shaft **142** so that by changing the thickness of spacers **143**, the corresponding angle can be varied.

In this exemplary embodiment of the invention, turntable **106** carries an upper guide cradle **145** and a lower guide cradle **146** attached to it by hinges **147** and **148** respectively, so that the weight of such cradles is carried, in the case of upper cradle **145** by a circular rail **300** on the machine frame by means of rollers **301**, and in the case of lower cradle **146** by a circular rail **302** on the machine frame by means of rollers **303**. The cradle **145** carries a guide roll **304** on a swingable arm **305** (see FIGURE 1) actuated by e.g., an electric cylinder **306** with suitable controls, and similarly, the lower cradle **146** carries a vertical guide roller **309** on an arm **310** (see FIGURE 2). These rollers guide the strip out of and into the inner wraps of their respective coils **102** and **104** and are moved by the cylinders **306** and **306'**, so as to always maintain a position adjacent to the corresponding wrap, irrespective of the diameter thereof, their positions ranging between the positions marked A and B. In addition to this, the cradles **145** and **146** carry other guides, as the nature of the strip may require, such as a series of diabolo-shaped rolls **156** disposed on a curve which the strip is to assume and acting to support and guide its lower edge.

From the above explanation it will be evident that in order to achieve a strip accumulation effect, it is necessary to form at least two interconnected and cooperating coils. The arrangement of these coils may be varied. They can be located in a superposed position, as already described, or concentrically within each other, or juxtaposed in side-by-side relationship.

FIGURES 3 and 3*a* illustrate schematically an exemplary concentric arrangement, in which two coils **150**, **151** of different diameters are located within each other. Each of these coils rests on independently driven circular roller tables **153**, **154**. In the space between the roller tables there is provided an independently rotatable looping roll arrangement **155**, the function of which is similar to that of the turntable **106** in the already described superposed coil arrangement.

FIGURES 4 and 4*a* show the construction of the arrangement schematically indicated in FIGURES 3 and 3*a*. Since both roller tables **153**, **154** are similar and differ solely in diameters and the disposition of elements, only one need be described. Rollers **152** are supported at one end on casters **156** which may be, e.g., in the form of roller element bearings, mounted on shafts **157** in a frame **158** (see FIGURE 4*a*). The other end of each of the rollers is mounted in a bearing **159***a*, preferably of a self-aligning type, to permit skewing as described in connection with the superposed coil arrangement. To permit a constant frictional contact between the roller **152** and the part **161** so as to obtain the drive, these bearings should be mounted so as to be slightly movable in the vertical plane. As already stated with reference to apparatus shown in FIGURES 1 and 3, the drive is supplied to the rollers **152** by means of the upper race **161** of a circular bearing. The bearing may be of the X-roller type as known in the art. Race **161** is provided along its circumference with the teeth of a gear rack **162** in mesh with a pinion **163** mounted on shaft **164** which is rotated by a suitable drive not shown, e.g., a gear motor. One or more such drives may be used around the circumference of the rack **162**.

The looping roll arrangement **155** consists of two vertical rollers **166**, **167**, mounted in a suitable frame, which is angularly displaceable around the axis of the vertical shaft **168** by an actuating mechanism **169**. The looping roll arrangement **155** is mounted on a circular frame **170**, concentric with the roller tables **153**, **154** and traveling on rollers **171** along a circular rail **172**. The lower part of the frame **170** is provided with a gear rack **173** in mesh with a pinion **174** mounted on shaft **175** rotatable by a drive, not shown. One or more of such drives may be used along the circumference of rack **173**.

Inside the inner coil **151** is shown an idler roll **177** over which the strip is removed from the system by means of pinch rolls **178**.

In operation, the strip **1** is fed by pinch rolls **179** into the outer wrap of coil **150** whence it travels towards the inside of the same coil **150**, around the vertical roller **166**, and then around roller **167** into the outerwrap of the inner coil **151**. It then again travels toward the inside of the coil **151** and is removed from the system by pinch rolls **178** over an idler roll **177**. The angular adjustment of the looper **155** between positions A and B in FIGURE 3 serves to guide the strip and lay the wraps, as described below.

To remove or add a wrap from or to coils **150** and **151** respectively, the circular frame **170** is rotated through one revolution, similarly to the turntable **106** in FIGURE 1. One complete revolution of the looper **155** in the direction in which the strip advances on the outer roller table **153** will add one wrap to the outside of the inner coil **151** and one wrap to the inside of the outer coil **150**. By rotating the frame **170** in the opposite direction, one wrap each will similarly be removed.

FIGURE 5 shows an arrangement in which the two cooperating coils **350** and **351** are arranged in side-by-side position. It is understood that they both rest on roller tables similar in design to those in FIGURES 1 and 2. Strip **1** is fed into the outside wrap of coil **350** by pinch rolls **352**, travels toward the inside wrap and then drops in a free loop and is directed into the inside wrap of coil **351**, where it travels toward the outside wrap, from which it is continuously removed by pinch rolls **353**.

In order to obtain a smoother travel of the strip, which might otherwise exhibit a flipping motion, it is preferred to impose a 180° twist to the strip, as shown in FIGURE 5.

A rotating device, not shown, but similar to the ones previously described, may be provided for simultaneously adding or removing wraps in the respective coils.

Certain advantages of this invention over the orthodox looping methods and machines will be evident from some exemplary applications of it to rolling mills.

FIGURE 6 shows schematically a coil preparation line, followed by the spiral looper and a tandem mill. The strip **1** is unwound from a payoff reel **180**, squared off in the shear **181**, and butt welded in the welder **182** to form a long, continuous strip. It then passes through a conventional looper type apparatus **183**, which serves to absorb the inertia during the stoppages due to strip weld-

ing. The strip then passes into the already described superposed coil arrangement 184, from which it exists at a lower level and proceeds over another looper type apparatus 185 into a tandem mill 186. The finished strip is then coiled on a high-speed coiler 188 and cut to suitable lengths, as it issues from the mill, by means of shear 187.

In cold mills running at, say, 5000 f.p.m., an interruption for welding a new coil, even if it lasts only a few minutes, will deplete the coils 189 and 190 of several tons of strip material. But under the present invention, the normal complement of strip material may be restored to the system 184 by feeding strip 1 into coil 189 at a higher speed than the payoff speed of coil 190, the difference going into the inner wraps of both coils, while the guiding apparatus 191 revolves in the direction of the incoming strip.

Due to the fact that the strip accumulated in the coils 189 and 190 can be of significant weight and, therefore, of high inertia, the purpose of the conventional looping devices 183 and 185 is also to allow the rotating masses of the heavy coils to be brought to a gradual stop, in case of a sudden stoppage of the rolling line. The looping devices 183, 185 would also serve for taking up a small difference in speed between the payoff 180, coiler 188 and the coils 189 and 190.

Another entirely novel possibility of rolling a large length of strip, using a single rolling stand, is shown in FIGURE 7.

The strip rolling mill 204 has a looper consisting of coils 206 and 207 in accordance with the present application, provided to feed strip 1 into and out of it, said strip being welded into one closed loop. The elongation of the strip due to reduction by mill 204 is completely taken up by the looper.

In order to simplify description, let us assume that the looper 206, 207 is filled with a strip which has just been rolled by mill 204 except for the last pass. The strip is cut by a flying shear 208 and threaded into a coiler 209 which winds the coil while mill 204 is taking the last pass on the said strip. Since the capacity of the looper 206, 207 is usually many times larger than the capacity of the reel of the coiler 209, when one coil is filled, the flying shear 208 is operated again and a new coil is started on the other reel of the coiler 209 and this can be continued until the whole length of strip stored in looper 206, 207 is exhausted.

In the meantime, the trailing end of strip 1, after it has been cut by shear 208 is advanced to the spot-welder 211 where it is lapped with the leading end of a new strip 1' delivered from decoiler 200 and tackwelded onto it, so that it can be uncoiled by advancing the already rolled strip 1. In this way, the new strip 1' can be fed into and threaded through the looper 206, 207. However, since this operation is done at a slower speed than the rolling of the last pass on strip 1, it is preferred to start threading the looper 206, 207 with the new strip when there is relatively small quantity of the thin already rolled strip 1 left in it.

The strip continues to be rolled in the last pass on mill 204 until the tack-welded joint of strips 1 to 1' reaches the rollbite, whereupon the mill is opened and the strip is further advanced by means of pinch rolls 205, so that the tackwelded joint can be cut out of the strip by shear 208 as the trailing end of strip 1 is coiled. The leading end of the unrolled strip 1' having passed through the looper and the mill, is then further advanced through pinch rolls 210 until it meets the last end of the same strip. Said leading and last ends are sheared square by the shear 202 and are then butt welded together by the welder 212. The mill 204 is now closed for the first pass and from now on the rolling process can proceed automatically using, by way of example, a conventional thickness gauge to produce a signal to operate the screwdown

for each following pass, according to a predetermined rolling program.

The described apparatus and method enable the mill 204 to perform the same service on the strip of material as if it were used as a reversing mill with a coiler on each side of it, but with certain important advantages. In the first place the mill remains in continuous operation in one direction. It need not be shut down at the conclusion of an operation on a single coil, nor need it be threaded each time a fresh coil is to be treated. Thus the productivity of the mill is greatly increased. Moreover, the scrap loss which is entailed in removing and discarding the unrolled ends of each individual coil is obviated.

The skilled worker in the art will understand in the light of these teachings that the capacity of the spiral looper will be at least sufficient to take care of the elongation of the strip material as it is rolled in the mill.

In the arrangement of FIGURE 7 the mill 204 may operate at full speed at all times, excepting for a slowing down when the tack-welded portion approaches the mill, and this results in considerable saving. Once the flying shear 208 has cut the finished strip 1 and the leading end of it has been engaged in the coiler 209, the mill 204 can continue to roll the strip 1 at full speed, taking the last pass on it. In the meantime, the new strip 1' will be fed into the system from a coil or coils at 200. If several coils of unrolled strip are fed into the system, the trailing end of one new coil may be butt-welded to the leading end of the new coil. When the first mentioned tack-weld reaches the mill 204, the mill may be opened to pass the tack-weld which may then be cut out by the flying shear 208, as previously described. The leading end of the new strip supply may be butt-welded in the device 212 to the trailing end of the same supply. Now, the system will be filled with an endless strip supply which can be rolled continuously through the mill 204 for as many passes as the strip will take without an intermediate anneal. It is easy for the operator to time the described operations in such a way as to have the looper 206, 207 filled with the new strip supply 1' by the time the trailing end of strip supply 1 goes through the mill, thus saving all time losses. But if for any reason, the various operations cannot be so timed during a run, the looper 206, 207 will take up any portion of the strip supply which cannot immediately be processed, and the only disadvantage will be a corresponding time loss.

Thus the apparatus described herein permits the treating of a large quantity of strip at high speed and in an endless length. While rolling has been indicated as one of the treatments, the utility of the invention is not so limited but is broad enough to encompass many treatments including muffle annealing, (where the looping means could be enclosed in a muffle or furnace), continuous annealing (where a continuous furnace through which the strip passes might be included in the line), hot metal coating, polishing, cleaning and degreasing, electrolytic coating and the like. Where the strip material is handled in the form of an endless loop, advantage may be taken of the so-called "Moebius effect" by imparting to the strip a 180° turn in forming the closed loop. Where a closed loop is formed by turning one of the end portions of the strip material through 180° before joining the ends together, the strip has in effect only one side, so that it is possible to apply a treatment means, such for example, as a coater, to one side only of the strip and yet to coat both sides of the strip by running the closed loop twice through the apparatus.

It has been explained above that when the linear velocity of the strip fed into the looper does not equal the linear velocity of the strip withdrawn from the looper, it is necessary to revolve the guiding means used to conduct the strip material from the first loose coil configuration to the second loose coil configuration, in one direction or the other depending upon whether the coil configurations are growing or diminishing. Such guiding

means may, for example, include the turntable **106**, the pinch rolls **103**, the frame elements, and the movable rolls **304** and **309** in the embodiment of FIGURES 1 and 2.

Since the rotation of the loose coil configurations may vary with respect to each other from equal high speed angular velocities to conditions in which one or the other of the loose coil configurations is stopped while the other continues to rotate, it will be evident that there will be a wide variation in the rotational speed of the guiding means. It is possible to arrive at the correct rotational speed of the guiding means by a mathematical formula which takes into account the angular velocities of the loose coil configuration.

However, in the practical operation of the apparatus of this invention, no such calculation is necessary. The speed and direction of revolution of the guiding means will be correct so long as the strip follows the path shown in FIGURE 1 without developing either slackness or such tension as might tend to cause the strip to leave the guiding diabolo rolls **156**. An operator watching the apparatus can easily control the speed and direction of revolution of the guiding means by noting the behavior of the strip material and varying the speeds and directions of motion of the driving means for the turntable **106** and the pinch rolls **103**.

Automatic operation is easily attained by mounting proximity gauges of known character on the frame elements **145** and **146** in such a way as to detect any departure of the strip from the indicated paths between rollers **304** and **309** respectively and the pinch rolls **103**. These proximity gauges can be connected by electrical circuitry of known character with drive motors for the turntable and the pinch rolls.

Modifications may be made in the invention without departing from the spirit of it.

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

1. In a spiral looper mechanism, means for forming a moving strip of material into a first spiral coil by adding the said material to the coil to form convolutions thereof, means for forming a second spiral coil from strip material withdrawn from the first spiral coil so that said material so withdrawn forms convolutions of the second spiral coil, means for selectively rotating the said spiral coils at the same and at different speeds, a guide means for conducting the said strip material from the first spiral coil to the second spiral coil, and means for selectively revolving the said guiding means with respect to the said spiral coils, so that the said strip material may be fed into said first spiral coil and withdrawn from said second spiral coil at equal linear speeds, in which event the said guiding means remains stationary, and so that said strip material may be accumulated in the said spiral coils by feeding the said strip into the first spiral coil at a greater linear speed than the speed of withdrawal of the strip material from the second spiral coil, with the revolving of the said guide means in one direction, and so that the strip material may be depleted in the said spiral coils by withdrawing the material from the second spiral coil at a greater linear speed than the speed of feeding the said strip material into the first spiral coil, upon revolving the said guide means in the opposite direction.

2. The structure claimed in claim **1** wherein the said spiral coils have inner and outer convolutions including means for feeding the said strip material into the outer convolution and withdrawing it from the inner convolution of the first spiral coil, and means for feeding the said strip material into the inner convolution and withdrawing it from the outer convolution of the second spiral coil.

3. The structure claimed in claim **2** wherein the said guide means comprises a turntable, a cage mounted on said turntable, driven pinch rolls mounted in said cage, frame members mounted on said turntable and extending from opposite sides thereof so as to revolve with said turntable, one of said frames having an end portion extending into the interior of said first spiral coil and the other of said frames having an end portion extending into the interior of the second spiral coil, arms pivoted so as to be swingable on the ends of said frame members, rollers journaled on the distant ends of said arm members, means for urging said arms outwardly away from said turntable so as to bring said rollers into contact with the interior convolutions of said coils respectively, and means for selectively driving said turntable in opposite directions and for holding said turntable against revolution.

4. The structure claimed in claim **1** wherein the said spiral coils have inner and outer convolutions, and including means for feeding the said strip material into the outer convolution and withdrawing it from the inner convolution of both coils.

5. The structure claimed in claim wherein the said spiral coils have inner and outer convolutions, and including means for feeding the said strip material into the outer convolution and withdrawing it from the inner convolution of both coils, and wherein the said first spiral coil and the said second spiral coils are concentric, the second spiral coil lying within the first spiral coil.

6. The structure claimed in claim **1** wherein the said coils are located in side-by-side juxtaposition, and wherein each coil has a guiding means.

7. The structure claimed in claim **1** wherein said coils are coaxial, and wherein one of said coils is located above the other.

8. The structure claimed in claim **1** wherein the said spiral coils rest for rotation on annular tables characterized by substantially radially extending rollers and inner and outer ring members in which end portions of said rollers are journaled, there being beneath said rollers a lower ring element in frictional contact with said rollers and serving to support at least a portion of the weight of said rollers and the spiral coil resting thereon, and means for applying power to the said lower ring whereby to drive said rollers and the coil resting thereon frictionally.

9. The structure claimed in claim **1** wherein the said spiral coils rest for rotation on annular tables characterized by substantially radially extending rollers and inner and outer ring members in which end portions of said rollers are journaled, there being beneath said rollers a lower ring element in frictional contact with said rollers and serving to support at least a portion of the weight of said rollers and the spiral coil resting thereon, and means for applying power to the said lower ring whereby to drive said rollers and the coil resting thereon frictionally, and means for moving one of the said inner and outer rings with respect to the other whereby to cock the said rollers slightly out of the radial position.

10. The structure claimed in claim **1** wherein the said spiral coils rest for rotation on annular tables characterized by substantially radially extending rollers and inner and outer ring members in which end portions of said rollers are journaled, there being beneath said rollers a lower ring element in frictional contact with said rollers and serving to support at least a portion of the weight of said rollers and the spiral coil resting thereon, and means for applying power to the said lower ring whereby to drive said rollers and the coil resting thereon frictionally, and means for moving one of the said inner and outer rings with respect to the other whereby to cock the said rollers slightly out of the radial position, said rollers being so mounted in said bearings that at least one end of each roller is capable of movement transverse a plane defined by the upper surfaces of said inner and outer rings so as to allow transference of the weight of the said spiral coils and said rollers to the said lower ring.

11. The structure claimed in claim **1** wherein the said spiral coils rest for rotation on annular tables characterized by substantially radially extending rollers and inner and outer ring members in which end portions of said

rollers are journaled, there being beneath said rollers a lower ring element in frictional contact with said rollers and serving to support at least a portion of the weight of said rollers and the spiral coil resting thereon, and means for applying power to the said lower ring whereby to drive said rollers and the coil resting thereon frictionally, and means for moving one of the said inner and outer rings with respect to the other whereby to cock the said rollers slightly out of the radial position, said rollers being so mounted in said bearings that at least one end of each roller is capable of movement transverse a plane defined by the upper surfaces of said inner and outer rings to allow transference of the weight of the said spiral coils and said rollers to the said lower ring, certain, but less than all of said rollers being characterized by circumferential ribs tending to maintain a spacing between the convolutions of the said spiral coils.

12. A method of storing a variable length of strip material while part at least of the said strip material is in lengthwise motion, the said method consisting in deflecting the said strip material into a spiral coil configuration having inner and outer convolutions to one of which said strip is fed, withdrawing the said strip from the other of said convolutions and guiding it to form a second spiral coil configuration having inner and outer convolutions to one of which the said strip is fed and from the other of which said strip is withdrawn, while employing guiding means to transfer the strip material from the first mentioned spiral coil configuration to the second spiral coil configuration, and, in the event of unequal linear speeds of feeding and withdrawal, moving said guiding means in a selected direction whereby, as required, to cause said strip material to accumulate in said spiral coil configurations and to cause said spiral coil configurations to become depleted.

13. A method of storing a variable length of strip material some portion at least of which is in lengthwise motion, said method consisting in first deflecting the said strip material into a spiral coil configuration forming toward its center and having innermost and outermost convolutions, guiding the innermost convolution out of said spiral coil configuration into a second spiral coil configuration forming away from its center, said second spiral coil configuration having innermost and outermost convolutions, leading the outermost convolution of the second spiral coil configuration away from said configuration so as to withdraw material therefrom, guiding the said strip material from the first mentioned coil configuration to the second coil configuration by guide means, and moving the said guide means lengthwise of the said strip material in the direction of its travel, whereby to reduce the length of strip material stored in the second spiral coil configuration while reducing in the same operation and by a substantially equal length the strip material

stored in the first mentioned spiral coil configuration, the said strip material passing between said configurations without a substantial twist around its longituidnal axis.

14. A rolling method which comprises joining coils of strip material end to end by butt-welding, accumulating the strip material in a spiral looper, withdrawing an end of said strip material from said looper and passing said strip through a rolling mill and joining it to an end of a coil of same strip material, whereby to form an endless loop, continuing to pass said strip material through said mill and through said spiral looper for a number of passes one less than the number required, beginning the last pass and immediately severing said strip material between said rolling mill and a coiler into which one end of said strip material is introduced and coiling it as it comes out of said mill, joining the leading end of a coil of fresh unrolled strip to the end of previously rolled strip and passing the strip material so joined into the spiral looper at low speed while withdrawing said strip material from said looper at high speed until said joint will reach said mill, then opening said mill to allow the joint to pass therethrough, readjusting said mill to roll said fresh strip material while severing and discarding said joint, and thereafter joining the leading end of said fresh strip material to an end of a coil of same strip material, thus forming a closed loop and repeating the said cycle of operations.

15. In apparatus for the purpose described, the combination of a treatment device and the spirit looper claimed in claim 1 hereof, means for transferring strip material to said looper and said treatment device, two shears, a welding means, a decoiler, and a coiler all located between said treatment device and said spiral looper whereby said treatment device may be operated continuously upon an endless supply of said strip material.

16. In apparatus for the purpose described, the combination of a treatment device and the spiral looper claimed in claim 1 hereof, including a means for joining strip material to form a closed loop within said apparatus, and means for forming a 180° twist before closing said loop in said material so that the said twist is included in the said loop, the said treatment device acting upon one side of the said strip material.

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