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METHOD AND APPARATUS FOR ACCUMULATING METALLIC STRIP AND THE LIKE

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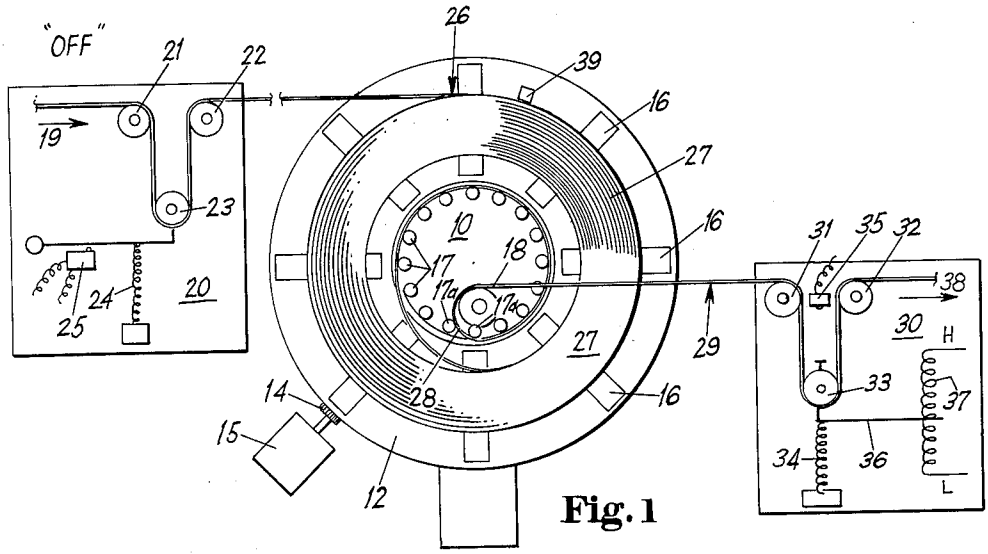


Fig. 1

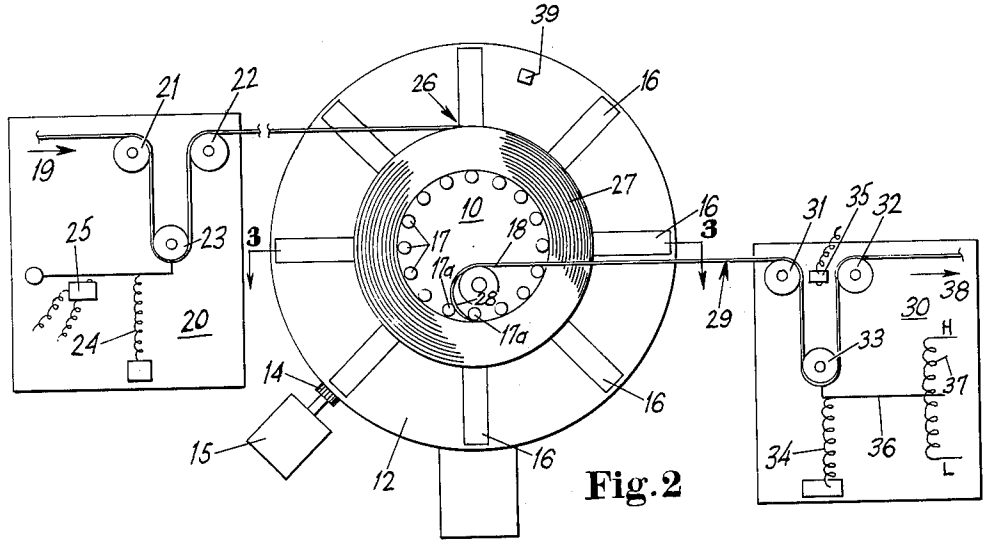


Fig. 2

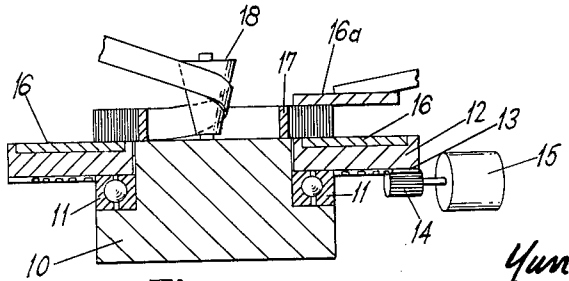


Fig. 3

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METHOD AND APPARATUS FOR ACCUMULATING METALLIC STRIP AND THE LIKE

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This invention relates to a method and apparatus for accumulating strip material, and while the invention is particularly adapted to the accumulation of metallic strip and will be so described, it is to be understood from the outset that the utility of the invention is not so limited and may be applied to diverse other strip materials wherein accumulation is desired.

More specifically, the instant invention has to do with the solution to the problem of providing a continuous delivery of strip—usually withdrawn from a coil—to a processing line even though it is necessary to interrupt the feeding of the strip periodically in order to weld or otherwise secure the leading end of a new coil onto the trailing end of an exhausted coil. In order to accomplish such an operation, movement of the two parts to be secured together must be arrested while the ends are sheared and properly aligned and welded together. There may be all sorts of other reasons why the feed of strip may be interrupted for various periods of time either accidentally or intentionally and it is therefore the principal object of the present invention to provide an accumulating procedure and apparatus by means of which a substantial quantity of strip can be accumulated so that a continuous feed from the accumulated supply may be maintained even though the input of strip is temporarily halted.

It is a further object of the invention to provide a device which, when the feeding of the strip thereto is resumed following an interruption, will reaccumulate sufficient strip to permit another stoppage of feed while still delivering a continuous supply therefrom.

It is still another object of the invention to provide a particular apparatus by means of which the method herein disclosed may be carried out, which apparatus takes up a minimum of space since it is extremely compact and which requires a minimum capital investment.

These and other objects of the invention which will be described in more detail hereinafter are accomplished by that series of method steps and by that construction and arrangement of parts of which an exemplary disclosure is made herein. Other advantages than those discussed above will be apparent to one skilled in the art upon reading this specification and will be made apparent hereinafter.

Reference is made to the drawing forming a part hereof and in which:

FIGURE 1 is a somewhat diagrammatic plan view of the device for carrying out the invention with the accumulator coil in a loaded condition.

FIGURE 2 is a view similar to FIGURE 1 showing the situation after an interruption of input to the accumulator.

FIGURE 3 is a somewhat diagrammatic cross-sectional view taken on the line 3—3 of FIGURE 2.

Briefly, in the practice of the invention there is provided a table having a central circular fixed portion and an annular rotatable portion. A variable speed motor is provided to drive the rotatable portion in any desired manner. The fixed portion of the table is provided with an abutment or a roll cage from which strip is fed from the device to a strip processing line or the like.

The basic principle of the invention involves the provision on the rotatable table of a coil of said strip material of a predetermined number of turns. The coil will be disposed with the strip on edge and will be suitably supported and held in place on the table. Additional strip from the decoiler or from some preceding portion of the processing line is fed onto the outside of the storage coil and strip is paid off from the inside of the coil and fed to a succeeding portion of the strip processing line. According to a preferred embodiment of the present invention, the predetermined number of turns in the storage coil is maintained constant. When the supply to the coil is to be interrupted, the rotating table is stopped, but the strip continues to be paid off from the inside of the coil which is in an expanded condition, i.e. spaced outwardly from the roll cage. As this paying off continues, the innermost convolutions and gradually all the convolutions collapse inwardly against the roll cage as the coil is in effect tightened or made smaller in diameter. When strip supply to the storage coil is resumed, the table is rotated so that while strip continues to be paid off from the inside of the coil, additional strip is being wound onto the outside of the coil. Since the outside circumference of the coil is substantially greater than the inside circumference of the coil, the diameter of the coil will increase and the length of strip in the coil will also increase until the initial condition of the coil is reestablished. The action of the storage coil is in effect a cyclic tightening and loosening without a change in the number of turns in the coil.

Referring now in more detail to the drawings, the fixed portion of the table is indicated at **10** and it is provided with bearings **11** upon which the rotating annular table **12** is mounted. The annular rotatable table **12** may be provided with a ring gear **13** on its underside which may be engaged by a pinion **14** mounted on the shaft of the variable speed motor **15**. The variable speed motor will be controlled in a manner to be hereinafter described so that the speed of rotation of the table will be such that the strip will be supplied to the processing line at the required rate of speed. The rotatable table is preferably provided with coil supporting and positioning elements **16**, which in a preferred embodiment of the invention comprise flush mounted permanent magnets. However, the magnets need not be flush mounted and they may comprise other types of magnets, such as electro-magnets. In some instances the weight of the strip material will be sufficient to maintain it in position, in which instances the magnets may be eliminated and the coil supported directly on the table **12**. In other instances the elements **16** may comprise a cushioning material, such as rubber, which will frictionally engage and position the edges of the strip until the strip is displaced under positive force. In still other instances it may be desirable to provide a pressure pad **16***a* (FIGURE 3) positioned to contact the uppermost edge of the coil to thereby maintain the coil in proper position on the table. In a preferred embodiment the fixed portion of the table **10** is provided with an abutment means in the form of a roll cage constituted of a plurality of rollers **17** mounted on vertical axes disposed in a circle. Inside the roll cage there is provided a pay-off roll **18** which is preferably frusto-conical in configuration with its smallest diameter lowermost, the roll being mounted on a vertical axis so that the strip will be directed upwardly in the manner illustrated.

The strip being processed comes from a coil pay-off means (not shown) which may be a decoiler or some preceding portion of the strip processing line, the strip being advanced therefrom as indicated by the arrow **19**. As the strip is advanced, it passes through a tension limit control device indicated generally at **20** which, in effect, comprises a "stop" switch for the motor **15**. It may comprise the fixed rolls **21** and **22** and the movable roll **23** urged away from the fixed rolls by a spring **24**. A normally

closed microswitch, generally indicated at **25**, is associated with the roll **23**. The strip is threaded around the rolls **21**, **22** and **23** in the manner shown and fed onto the storage coil at **26**. The storage coil itself is indicated generally at **27**. The innermost convolution, indicated at **28**, is, as it were, peeled off the inside of the coil **27** and caused to pass around the rolls **17** of the roll cage and exit between an adjacent pair of the rolls, indicated at **17***a*, whereupon the strip passes around the pay-off roll **18** and is fed out of the device, as indicated at **29**. It is then preferably fed through another tension limit control device, indicated generally at **30**, which incorporates both an "on" switch for the motor **15** and also rheostat means for controlling the speed of the motor and hence the speed of rotation of the table **12**. The control device **30** may comprise the fixed rolls **31** and **32** and the movable roll **33**, the device having a tension spring **34** biasing the roll **33** relative to the microswitch **35**. The roll **33** is also operatively connected to an arm **36** forming a part of the rheostat **37** which, in this instance, comprises a slide wire resistor. The strip finally passes to a succeeding portion of the strip processing line, as indicated by the arrow **38**.

Electrical connections are provided between the microswitches **25** and **35** and the variable speed drive motor **15** to start and stop and control the speed thereof, as will be described hereinafter. The details of the connections has not been shown because they are within the skill of the worker in the art.

In the operation of the device and assuming the storage coil **27** to be in the condition of FIGURE 1, that is, the loaded condition, let it be assumed that the supply of strip to the coil at **26** is now interrupted, as where the trailing end of the strip is released by the decoiler. This of course reduces the tension on the strip being supplied at **19** and the relaxed strip releases the roll **23** to the influence of spring **24** which serves to open the switch **25** to thereby stop the motor **15** and hence stop rotation of the table **12**. The coil **27** will remain in position on the now stationary table **12** due either to its own weight or to the positioning elements **16**. However, such interruption in no way affects the feed of strip to the succeeding portions of the processing line at **38**, and hence the strip continues to be drawn from the device around the pay-off roll **18**. Since the table is no longer rotating the innermost convolutions of the coil **27** will be contracted and pulled inwardly so as to collapse against the cage of rolls **17**. As the feed-out continues, succeeding convolutions collapse and slide radially inward as the coil is in effect tightened. In so doing, and due to the stationary condition of the table, the coil will retain the original number of turns but the entire diameter of the coil will be reduced. This action continues until all the convolutions of the coil originally on the table have collapsed onto the roll cage, which is the condition shown in FIGURE 2. It will be evident that as the successive convolutions or turns collapse and slide radially inwardly there will be an ever increasing tension exerted by the exiting strip on the movable roll **33** which will cause the roll to move toward the switch **35** against the resistance of spring **34**. However, spring **34** will be so chosen that it will resist the increased tension on the strip until essentially the condition of FIGURE 2 is reached, at which time there will be a sharp increase in tension, and such sharp increase will overcome the restraining force of spring **34** and the resultant movement of roll **33** will cause switch **35** to be actuated to start the drive motor **15** and thereby resume rotation of the table **12**.

It will be noted that as the roll **33** moves toward the switch **35**, the arm **36** will move toward the "H" or high end of the rheostat **37**, which is a part of the starting circuit to motor **15**, so that when switch **35** is actuated, the motor **15** will be under the influence of the rheostat and will be operated thereby, initially at a relatively high speed.

As the table **12** begins to rotate the innermost convolution of the coil will be payed out, thereby continuing the feed-out of the strip and at the same time tending to reduce the tension on the exiting strip. While such reduction in tension permits the roll **33** to move away from switch **35**, the circuit to motor **15** will nonetheless remain operative and only the setting of rheostat **37** will change. As tension decreases the arm **36** will move toward the "L" or low end of the rheostat, with corresponding reduction in the speed of rotation of the table **12**. It will be evident that as the speed of rotation decreases so will the feed-out speed of strip exiting at **29**, and should the feed-out speed at **29** be less than the demand speed at **38**, strip tension again will be increased and the movable roll **33** will act to advance the arm **36** toward the high end of the rheostat, thereby increasing the speed of the motor and hence the speed of rotation of table **12**, which will deliver sufficient additional strip to meet the demand at **38**. Conversely, should the feed-out speed at **29** exceed the demand at **38**, strip tension will lessen and the arm **36** will move toward the low end of the rheostat, thereby slowing down the speed of rotation of the table. In effect the control device **30** will insure the maintenance of uniform tension on the strip **38** by controlling the rate of table rotation and hence the rate of strip feed-out at **29** to equal the rate at which strip is being used at **38**. In this connection, it will be observed that as the table **12** resumes rotation, the number of turns in the coil **27** will remain constant because turns will continue to be removed from the inside of the coil as new turns are added to the outside, and for each turn removed from the inside a new turn is added to the outside. However, since there is a substantial difference between the inner circumference and the outer circumference of the coil, there will be a build up in diameter of the successive turns or convolutions and the total length of strip in the coil will be increased until the condition of FIGURE 1 is again achieved. The maximum diameter of the storage coil will be predetermined in accordance with the requirements of use, and the diameter of the table will be sized accordingly. Normally, the size of the expanded storage coil will be such that it will contain at least a unit length of strip, such as the entire contents of a standard length coil. The table **12** will be of a diameter to readily accommodate the maximum diameter of the storage coil and it may be provided with a limit switch **39**, which may be conveniently embedded in the table and positioned for contact by the undersurface of the storage coil in the event it is overwound. The limit switch, when actuated, will act to de-energize motor **15** and stop the rotation of the table **12**, whereupon the innermost convolution of the storage coil will again be caused to collapse against the cage of rolls **17** in the manner previously described.

It should be apparent from the foregoing that the accumulator will be essentially automatic in operation and will cycle between the loaded and collapsed conditions of the storage coil. While normally the controls **20** and **30** will act to start and stop the cycle, it is also contemplated that the unit could be stopped at any time or place in its operating cycle. For example, if the processing line at **38** were halted for any reason, the entire line would be interlocked so that the accumulator would be stopped until the processing of the strip were resumed. In addition, manual controls would be provided for use when needed.

It will be understood that the delay time which may be provided will depend upon a number of variables, such as strip gauge, strip speed, number of turns in the storage coil, and the relative diameters of the expanded and collapsed coil. By way of example, in an embodiment of the invention presently in use in the manufacture of tubing, a coil of strip one inch wide having a thickness of .028" is wound into a coil having 400 turns. The roll cage diameter or inside diameter of the collapsed coil is 24" and the inside diameter of the coil in the ex-

panded condition is 48". With the strip speed in the processing line of 300' per minute, a delay time of more than eight minutes is achieved. In other words, in this particular example the supply of strip to the device may be interrupted for more than eight minutes while the strip continues to be supplied to the processing line at a constant speed of three hundred feet per minute. In order to achieve such a delay time with a conventional loop car system, a run of nearly half a mile would be required. It will be clear from the foregoing example that the device of the present invention occupies a very small area since the outside diameter of the expanded storage coil is only about six feet.

While the strip width and gauge may be varied widely, it is nonetheless a simple matter to determine the dimensions of the storage coil which must be provided to give any desired time delay for a particular speed of strip feed. The following equation may be used for such purpose:

$$T=\frac{\pi N}{V}(D-d)$$

wherein:

T=delay time in minutes
N=number of turns in coil
V=velocity of line in inches per minute
D=inside diameter of expanded coil
d=inside diameter of collapsed coil

It will also be understood that many modifications may be made without departing from the spirit of the invention. Thus, if the strip is quite thin and wide, it may be necessary to provide resiliently mounted idler rolls to keep the coil standing on edge without falling. It will also be understood that instead of a cage of rolls as described above, a single large roll could be used similar to the roll **18** but of a diameter at its lowermost end roughly equal to the diameter of the roll cage shown.

Various modifications may be made in the control system which governs the starting and stopping of the table **12**. For example, various additional safety devices may be included, inclusive of additional switch means forming a part of control device **20** which would stop the rotation of table **12** in the event of excessive tension on roll **23**, as where the supply of strip at **19** would be stopped for any reason. Similarly, tension responsive switch means may be provided to stop feeding movement of the strip at **38** in the event of a malfunction in the operation of the table **12**. It will be understood that the limit control devices **20** and **30** are exemplary only and that other forms of sensing and control devices may be employed. For example, instead of the tension device **20**, a strip end detector could be employed to sense the trailing end of the strip supply. Such device could comprise a photoelectric cell or a spring biased switch arm riding in contact with a surface of the strip. Instead of the limit control **30**, a sensing device may be so located on the table **12** that it would actuate the table drive when all but the outermost convolution or two of thestorage coil had collapsed onto the roll cage, thereby affording lead time to assure that the table will resume rotation before the fully solid condition of the storage coil is reached. Variable hydraulic or pneumatic valve means may be employed instead of the rheostat means **37**, and either hydraulic or pneumatic drive means may be employed in place of motor **15**, and/or hydraulic or pneumatic means employed to move pinion **14** radially with respect to ring gear **13** to vary the speed of rotation of table **12**. Alternatively, a continuously running drive motor may be employed in conjunction with clutch and brake means for varying the speed of rotation of the table.

It will be clear that in the event the strip would be subject to scratching or undue friction when the laps slide over each other during collapse of the coil, the entire coil could be immersed in a lubricant. Many applications will suggest themselves to those skilled in the art where the apparatus and method of the present invention could be used to provide a time delay. Among such applications, for example, would be for what might be termed continuous box annealing, wherein the coil would be disposed in a furnace and every element of the strip would be subject to the furnace temperature for a predetermined length of time. In such an arrangement, the advantages of open coil annealing could easily be achieved by the use of a spacing wire between convolutions of the coil.

The invention having now been fully described, what is claimed as new and what it is desired to protect by Letters Patent is:

1. The method of providing a continuous strip supply in spite of intermittent strip feed, which includes the steps of providing a coil having a predetermined number of convolutions, continuously withdrawing strip from the inside of said coil, intermittently feeding additional strip to the outside of the said coil and, during periods of strip feed to said coil, rotating said coil about its axes to build up the diameter of said coil and the length of strip in said coil, and holding said coil against rotation during periods of no strip feed to said coil, thereby tightening the convolutions and reducing the diameter of said coil and hence the length of strip in said coil, while maintaining said predetermined number of convolutions in said coil.

2. The method of providing a continuous strip supply in spite of intermittent strip feed, which comprises the steps of providing a coil containing a predetermined number of convolutions, continuously withdrawing strip from the inside of said coil, intermittently feeding additional strip to said coil and, during periods of strip feed to said coil, rotating said coil about its axis to build up the diameter of said coil and the length of strip in said coil, including the step of varying the speed of rotation of said coil in accordance with the speed at which strip is withdrawn therefrom, and holding said coil against rotation during periods of no strip feed to said coil, thereby tightening the convolutions and reducing the diameter of said coil and hence the length of strip in said coil, while maintaining said predetermined number of convolutions in said coil.

3. The method claimed in claim **2** including the step of stopping rotation of said coil when the outside diameter of the coil has reached a predetermined limit.

4. The method claimed in claim **3** wherein, when said coil is held against rotation, the convolutions thereof are caused to collapse inwardly against an abutment, and wherein rotation of said coil is resumed when substantially all of the convolutions in the coil have collapsed against the abutment.

5. A strip accumulating device comprising an annular rotatable table surrounding a central stationary table, said rotatable table having an uninterrupted upper surface for receiving a coil of strip the convolutions of which also surround said stationary table, a fixed annular abutment on said stationary table against which the convolutions of the coil collapse as strip is withdrawn from the inside of the coil, said rotary table being adapted to be selectively started and stopped, whereby, when said table is rotated, strip may be withdrawn from the inside of the coil while additional strip is added to the outside of the coil, and when said table is stationary, the continued withdrawal of strip from the inside of the coil will cause the convolutions thereof to shrink and collapse onto said abutment so that the feeding of the strip will continue even though additional strip is not being added to the coil, actuating means for initiating rotation of the rotatable table when substantially all of the convolutions in the coil have collapsed against said abutment, and means for stopping rotation of the table when the length of strip in the coil has been materially increased.

6. The strip accumulating device claimed in claim 5 including means for varying the speed of rotation of said rotatable table.

7. The strip accumulating device claimed in claim 5 wherein the means for stopping rotation of the table includes sensing means operative to stop rotation of said table as the trailing end of the length of strip being added to the coil during rotation of the table is reached.

8. The strip accumulating device claimed in claim 7 wherein the means for stopping rotation of said table also includes switch means operative to stop rotation of the table when the outside diameter of the coil reaches a predetermined limit.

9. A strip accumulating device comprising an annular rotatable table surrounding a central stationary table, said rotatable table having an uninterrupted upper surface for receiving a coil of strip the convolutions of which also surround said stationary table, a cage of rolls mounted on said stationary table and disposed in a circle about the axis of rotation of said rotatable table, drive means for rotating said rotatable table in a direction to add additional strip to the outside of the coil, means operatively connected to said drive means for selectively starting and stopping rotation of said rotatable table, whereby, when said table is rotated, strip may be withdrawn from the inside of the coil while additional strip is added to the outside of the coil, and when said table is stationary, the continued withdrawal of strip from the inside of the coil will cause the convolutions thereof to shrink and collapse onto said cage of rolls so that the feeding of the strip from the coil will continue even though additional strip is not being added to the coil, the means for starting and stopping rotation of said rotatable table comprising a first sensing means operative to initiate rotation of said table when substantially all of the convolutions in the coil have collapsed against said cage of rolls, and a second sensing means operative to stop rotation of the table when the length of strip in the coil has been materially increased.

10. The strip accumulating device claimed in claim 9 wherein a pay-off roll is disposed within the said cage of rolls, so that strip withdrawn from the inside of the coil may be passed at least partially around said cage of rolls and thence between two adjacent ones of said rolls of said cage and around said pay-off roll.

11. The strip accumulating device claimed in claim 9 wherein the drive means for rotating said rotatable table includes a variable speed motor, wherein said first named strip sensing means acts to start said motor when a predetermined strip tension is exceeded, said first named strip sensing means including means operative to vary the speed of said motor in accordance with the tension exerted on the strip withdrawn from the coil.

12. The strip accumulating device claimed in claim 11 wherein the said second sensing means for stopping rotation of said table comprises means for sensing the tension of strip being added to the coil, said second sensing means being operative to stop said motor when the tension of the strip being added to the coil falls below a predetermined value.

13. A strip accumulating device for use in a strip processing line to provide continuous delivery of strip from said device in spite of intermittent supply of strip to said device, said device comprising an annular rotatable table surrounding a central stationary table, said rotatable table having an uninterrupted upper surface for receiving a coil of strip the convolutions of which also surround said stationary table, said central stationary table having a fixed abutment thereon, a coil having a predetermined number of convolutions disposed on said rotatable table, means for intermittently rotating said rotatable table to wind additional convolutions onto said coil as convolutions are withdrawn from the inside of said coil around said abutment, whereby when said table is rotating, the number of convolutions of said coil remain constant but the diameter of said coil increases and the length of strip in said coil increases, and when said table is stationary, the withdrawal of strip from the inside of said coil causes the convolutions thereof to shrink and collapse onto said abutment so that the outer diameter of said coil is reduced and the length of strip in said coil is reduced but the number of convolutions remains unchanged, actuating means for initiating rotation of the rotatable table when substantially all of the convolutions in the coil have collapsed against said abutment, and means for stopping rotation of the table when the length of strip in the coil has been materially increased, and means associated with said rotatable table to releasably maintain a coil thereon.

14. The strip accumulating device claimed in claim 13 wherein said coil maintaining means comprises magnetic means associated with said rotatable table.

15. The method of providing a continuous strip supply in spite of intermittent strip feed, which includes the steps of providing a coil of strip containing a constant number of convolutions, continuously withdrawing strip from the inside of said coil, intermittently rotating said coil about its axis to build up the diameter of said coil and the length of strip in said coil during periods of strip feed to said coil, and holding said coil against rotation during periods of no strip feed to said coil, thereby tightening the convolutions and reducing the diameter of said coil and therefore the length of strip in said coil, including the step of maintaining said coil in a lubricant.

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