Sept. 12, 1967 H. LA TOUR 3,341,139

APPARATUS AND METHOD FOR ACCUMULATING METALLIC STRIP AND THE LIKE

Filed March 3, 1966

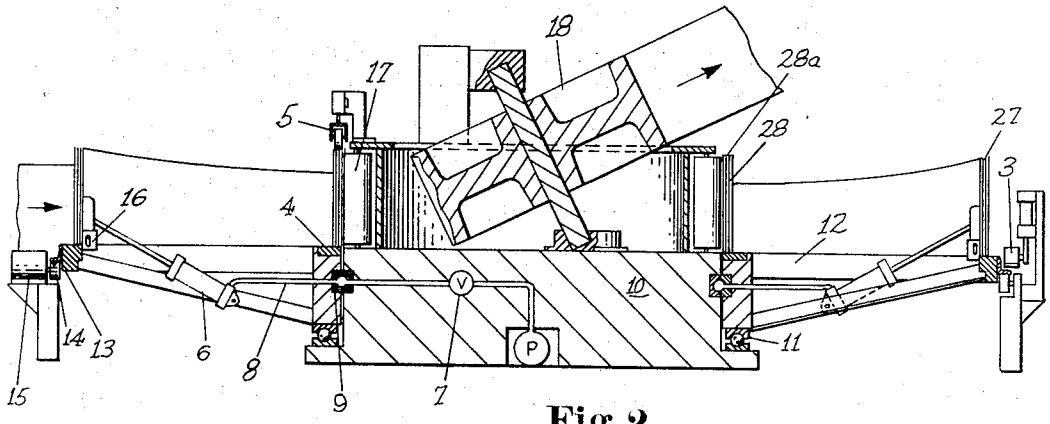

Fig. 2

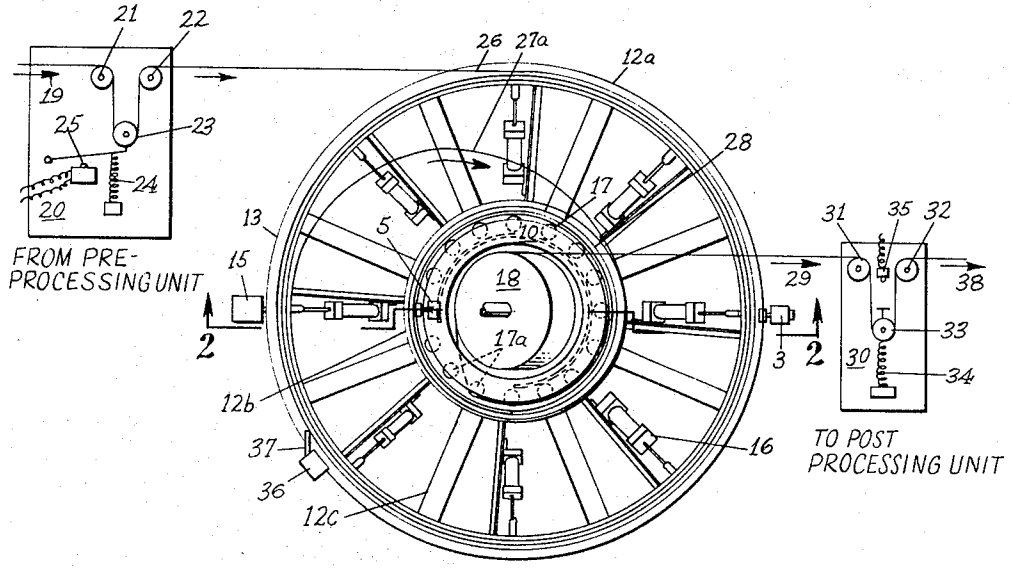

Fig. 1

INVENTOR

HARRY LA TOUR,

BY Yungblut, Melville, Strasser and Foster

ATTORNEYS

United States Patent Office 3,341,139
Patented Sept. 12, 1967

3,341,139

APPARATUS AND METHOD FOR ACCUMULATING METALLIC STRIP AND THE LIKE

Harry La Tour, Middletown, Ohio, assignor to Armco Steel Corporation, Middletown, Ohio, a corporation of Ohio

Filed Mar. 3, 1966, Ser. No. 531,581
10 Claims. (Cl. 242—55)

This invention is a continuation-in-part of Ser. No. 324,326 filed Nov. 18, 1963, now Patent No. 3,258,212, and relates to an improved apparatus and method 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the instant invention has to do with the solution to the problem of providing a continuous delivery of strip—usually withdrawn from a coil—to a processing line even though it is necessary to interrupt the feeding of the strip periodically in order to weld or otherwise secure the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.

Another important object of this invention is to provide a strip accumulating device that can be operated without the necessity of immersing the coiled strip in a lubricant.

A still further object of this apparatus is to exert a minimum of back tension on the feeding line by reducing the friction resulting from the relative movement of contiguous convolutions.

It is still another object of the invention to provide an 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 an intermediate loaded condition.

FIGURE 2 is an enlarged diagrammatic cross-sectional view taken on the line 2—2 of FIGURE 1.

Briefly, in the practice of the invention there is provided a table having a central circular fixed portion and an annular rotatable portion. The rotatable portion is provided with actuating means to initiate its rotation. Frictional contact of the strip being withdrawn from the rotatable portion maintains the rotation thereof during its periods of rotation. The rotatable portion is further provided with a plurality of retractable abutments which, when in operative position, contact and restrain a number of convolutions of strip material as it is coiled on the rotatable portion of the table. The fixed portion of the table is provided with an abutment or roll cage from which the coiled strip is fed from the device through 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 the preceding portions of the processing line is fed onto the outside of the storage coil as the table is rotated, and strip is paid off from the inside of the coil and fed to a succeeding portion of the strip processing line. In accordance with the present invention, a predetermined number of turns in the storage coil is maintained constant. When the supply of strip being fed to the coil is 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. At this point it may be helpful to facilitate understanding of the following description to point out that the coil has in effect, two sets of convolutions, the dispensing or innermost convolutions, and the accumulating or outermost convolutions. In no case should this be interpreted to mean two distinct coils, but rather a continuous coil in which the outermost set of convolutions is spaced from the innermost set. Now, as the strip is withdrawn from the inside of the coil while the table on which it is supported is held against rotation, the accumulating convolutions collapse inwardly one by one against the roll cage on the central stationary table as the coil is in effect tightened or made smaller in diameter. When all of the convolutions have collapsed so that the coil is tight, or if strip input is to be resumed, rotation of the table will be resumed so that while strip continues to be paid off from the inside of the coil as the table rotates, additional strip will be 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 expanded 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. When all of the inner or dispensing set of convolutions have been removed from the coil, they will have been replaced by a like number of outer or accumulated convolutions, whereupon the collapsing process will be repeated.

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. Rotating table **12** may be a planar surface with spaced openings, the need for which will be described later, or it may take on the appearance of a spoked wheel. The latter embodiment of the rotatable table may be defined by the outer annular ring **12***a* and inner annular ring **12***b* connected by a series of radial support members **12***c*. The annular rotatable table **12** may be provided with a flanged surface **13** at its periphery which will be contacted by an actuator **14** forming part of the rotation initiating means **15**, which means is adapted to be actuated by a tension limit control device, indicated generally at **30**. 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 micro switch 35. Thus, when all of the convolutions of the coil have collapsed to a tight condition against the roll cage, the tension on the exiting strip increases, as indicated at 29, and roll 33 is moved toward the switch 35, so that when contact is made with the switch 35, the rotation initiating means 15 is actuated and rotation of the table is begun. It should be apparent that means 15 may be any appropriate device suitable to "kick" the table and overcome its inertial resistance to rotate. For example, it may be a prime mover, a solenoid operated kicker, or a pneumatically operated kicker and may engage the table through a ring gear, a ratchet wheel, or a one-way clutch. Where relatively wide strip or heavy gauge stock is being handled, it will be advisable to use a prime mover to provide a portion of the table driving torque. Thus, a D.C. motor having high initial torque may be used to initiate rotation of the table, whereupon rotational movement of the table will be maintained by the pulling movement of the exiting strip supplemented by the motor which, under normal operating conditions, will supply a portion of the torque.

In a preferred embodiment of the invention, 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 cylindrical in configuration with its axis inclined from the vertical at an angle suitable to provide clearance of the exiting strip over the roll cage. Alternatively, the pay-off roll may be frusto conical in configuration with its smallest diameter lowermost and mounted perpendicular to the fixed table. In any case, the exiting strip will be initially directed upwardly in the manner illustrated (FIG. 2), whereupon its path of travel may be altered as desired by means of suitable sets of guide rolls disposed to provide any desired change in its path of travel.

The rotatable table 12 is provided with a plurality of retractable coil restraining abutments or fingers 16. These abutments are pivotally mounted below the surface of table 12 or the plane formed by the upper surfaces of radial support members 12c. The abutments 16 are pivotally mounted for movement from an inoperative retracted position to an upwardly projecting operative position and are moved by air cylinders 6 or similar devices suitable for the purpose. In the disclosed embodiment, the abutments are spring biased to the inoperative position and air cylinders 6 are connected to a rotating air joint 9 through conduits 8 to which air under pressure is supplied from a source P. Until the time feeding of the strip to the processing unit substantially exhausts the innermost set of convolutions 28, the abutments 16 are maintained in the upwardly extending or operative position and hence interrupt the surface of rotatable table 12 so as to restrain the outermost set of convolutions 27 as they are wound onto the coil. Retracting movement of the abutments 16 is controlled by the strip edge itself contacting sensing elements 4 which contact the collapsed inner set of convolutions and act to release the abutments as the last of the inner convolutions is withdrawn from the inner portion of the coil. Such sensing elements will be operatively connected to the valve means 7 which may be a solenoid actuated valve operative to release the air pressure to the cylinders 6. Upon being retracted, the abutments no longer restrain the collapsing movements of said outermost convolution 27 of the coil against the rollers 17. The release of the outermost convolutions is not an explosive type reaction but more in the nature of a restrained inward peeling of one convolution, then another. It is advisable to provide the hold-down roller 5 to contact the uppermost edge of the dispensing innermost convolutions 28 to maintain proper positioning on the table and contact therewith so that the friction created by contact of the strip with the table 12 will maintain the rotation thereof as the strip is withdrawn. Rotation will automatically stop when the innermost convolutions are exhausted and the retracted abutments permit the collapsing of the outermost convolutions. However, if desired, the braking device 3 which is arranged to engage the contact surface 13 may be actuated, as by means of the sensing means 4, to stop the rotation of the table.

The strip being processed comes from a coil payoff 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, connected to the braking device 3, which acts as a stop switch for table 12. The control device may comprise the fixed rolls 21 and 22 and movable roll 23 urged away from the fixed rolls by a spring 24. A normally open micro switch, indicated at 25, is arranged to be contacted upon movement of 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. If there is a break in the incoming strip, the switch 25 will be actuated and the rotation of the table will be temporarily halted. At the same time, the switch 25 will act to close the valve 7 and hence vent the cylinders 6, thereby freeing the abutments to retract under the influence of their associated spring means. The accumulating convolutions of the coil are thus released for collapsing movement, and there is no interruption to the output feeding of the strip even though there has been a break in the incoming strip. The innermost dispensing convolution, indicated at 28*a*, is peeled off the inside of the convolutions 28 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 drawn from the device into a post strip processing line.

In the operation of the device, and assuming the storage coil 27 to be in the condition of FIGURE 1, that is, an intermediate loaded condition, let is 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 close the switch 25 to thereby actuate brake 3 and hence stop rotation of the table 12. The coil 27 will remain in position on the now stationary table 12 due to its own weight. However, the temporary interruption in no way affects the output feeding of the strip to the succeeding portions of the processing line at 38. Such interruption will also cause the abutments 16 to retract permitting the accumulating convolutions 27 to converge inwardly, so that the strip continues to be drawn from the device around the payoff roll 18. Since the table is no longer rotating the innermost convolution of the accumulating convolutions 27 will be contracted and peeled 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 circumference of the collapsing convolutions will be reduced, thereby providing continued strip output. This action continues until all the accumulating convolutions of the coil have collapsed onto the roll cage. 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 and at some predetermined level of tension, the tension sensing device 30 will cause the rotation initiating means 15 to "kick" table 12 to resume its rotation. As the table 12 begins to rotate, the now collapsed accumulating convolutions of the coil become the dispensing convolutions. The retracted abutments 16 will move to the operative position, causing strip being added to the coil to wind about the

abutments to form a new set of accumulating convolutions. When the dispensing set of convolutions is completely paid out, a new set of accumulating convolutions will have been formed and rotation of table **12** will be stopped.

It will be evident that the rotational speed of the table is directly related to the speeds or demands placed upon it by the post strip processing unit beyond **29**. Therefore, should an interruption occur in the post strip processing unit, the tension on the exiting strip will be reduced to zero. Resumed operation will cause an increase in tension which in turn will cause the table to resume rotation and the sensing means **30** will activate the "kicker" means **15**. It will be observed that as the table **12** rotates, the number of turns in the coil sets **27–28** 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. This may be thought of as a transfer of convolutions back and forth, i.e., from accumulating to dispensing and vice versa. Assume for illustration purposes only the following conditions for FIGURE 2. Table **12** is supplying the post processing unit at a rate of 30 ft./min. and contains ten collapsed dispensing convolutions having a mean circumference of 18 ft., and ten accumulating convolutions, averaging about 50 ft. in circumference. At this point the total accumulation is 680 ft. This total may vary, but the predetermined number of convolutions, twenty in this example, will remain constant. After one revolution, the total strip accumulated will be increased by the difference between the respective circumferences of the dispensing and accumulating convolutions. In the example given, the increase is approximately thirty-two feet. This build up will continue until rotation of table **12** is halted. 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 fully expanded storage coil will be such that the outer or accumulating convolutions will contain at least a unit length of strip, such as the entire contents of a standard length coil.

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 control elements **30** and **20** will coact 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. Alternatively, a sensing device **36** with a spring biased arm **37** could be positioned to sense the collapse of the outermost convolution in the accumulating coil set, such sensing means acting to energize the rotation initiating means **15**. 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 exemplary embodiment of the invention, a coil of strip 17 inches wide having a thickness of 0.060 inch is wound into a coil having 20 turns. The roll cage diameter or inside diameter of the collapsed coil is 6 feet and the average diameter of the coil in the expanded condition is 11 feet. With a strip speed in the processing line of 50 feet per minute, a delay time of more than 6 minutes is achieved. In other words, in this particular example the supply of strip to the device may be interrupted for more than 6 minutes while the strip continues to be supplied to the processing line at a constant speed of 50 feet per minute. In order to achieve such a delay time with a conventional loop car system, a run of 150 feet 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 onl about 11 feet.

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

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

where:

T=delay time
N=number of turns in coil
V=velocity of line output
D=mean diameter of accumulating convolutions
d=mean diameter of collapsed dispensing convolutions

It will also be understood that modifications may b made without departing from the spirit of the invention Thus, if the strip is quite thin and wide, it may be neces sary to provide resiliently mounted idler rolls to kee the coil standing on edge without falling. Various modifi cations may be made in the control elements whic govern the starting and stopping of the table **12**. For ex ample, various additional safety devices may be included inclusive of additional switch means forming a part o control device **20** which would stop the rotation of tabl **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 **29** in the event of malfunction in the operation of the table **12**. It will be understood that the control device **20** is exemplary only and that other forms of sensing and control devices may be employed. For example, instead of the tension devices **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.

It should now be apparent that this invention has in effect divided the convolutions of the coil so that the number of laps sliding over one another has been greatly reduced during each operating cycle. "Dry" operation is therefore facilitated. However, one skilled in the art may find it appropriate for a particular application to subject or even immerse the coil 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 could be disposed in a furnace and every element of the strip would be subject to the furnace temperature for a predetermined length of time.

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

1. The method of providing a continuous strip supply in spite of intermittent strip feed, which comprises the steps of:

(a) providing a continuous coil having a predetermined number of convolutions,
(b) dividing said continuous coil into an inner set of convolutions and an outer set of convolutions lying in spaced relation to each other,
(c) continuously withdrawing strip from the inside of said innermost set of convolutions,
(d) intermittently feeding additional strip to the outside of said outermost set of convolutions by rotating said coil during periods of strip feed to said coil while holding said outermost set of convolutions in spaced relation to said intermost set of convolutions to thereby build up the diameter of said outermost set of convolutions and the length of strip in said coil,
(e) holding said coil against rotation during periods of no strip feed to said coil, and during such periods

of no strip feed to said coil, releasing said outermost set of convolutions for inward collapsing movement to replace the innermost set of convolutions withdrawn from said coil.

2. In a strip accumulating device:

(a) an annular rotatable table surrounding a central stationary table, said rotatable table having a planar supporting surface for receiving a coil of strip,

(b) convolutions of which surround said stationary table,

(c) a fixed annular abutment on said stationary table against which convolutions of said coil collapse as strip is withdrawn from the inside of said coil,

(d) retractable abutments mounted for movement relative to rotatable table, said abutments being spaced outwardly from said central stationary table and radially disposed with respect thereto, said abutments being mounted for movement from a retracted position in which the planar supporting surface of said rotatable table remains uninterrupted to an operative position in which said abutments interrupt the planar surface of said table so that convolutions of the coil may be wound thereabout upon rotation of said rotatable table,

(e) means for starting and stopping rotation of said table, and

(f) means for moving said retractable abutments from one position to the other.

3. The strip accumulating apparatus of claim 2 wherein the planar surface of the rotatable table is defined by a series of radially extending support members.

4. The strip accumulating apparatus of claim 3 including inner and outer annular rings connecting the ends of said radial support members.

5. The strip accumulating apparatus of claim 2 wherein the means for stopping rotation of the table includes sensing means operative to stop rotation of said table when the trailing end of the strip from the pre-processing unit is reached.

6. The strip accumulating apparatus of claim 2 wherein the said fixed annular abutment comprises a series of vertical rolls.

7. The strip accumulating device of claim 6 including a cylindrically shaped pay-off roll angled from the vertical and disposed in the center of said series of rolls.

8. The strip accumulating apparatus of claim 2 wherein the means to initiate rotation of the table includes tension sensing means operative to start rotation of said table when a predetermined tension on the exiting strip is reached.

9. The strip accumulating device of claim 8 where the table rotating means comprises a prime mover to at least initiate rotation of said table.

10. The strip accumulating device of claim 2 wherein the means to initiate rotation of the table includes a contact sensing means operative to start rotation of said table when contact with the collapsing strip is broken.

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FRANK J. COHEN, *Primary Examiner.*

W. S. BURDEN, *Assistant Examiner.*