United States Patent

[11] 3,568,591

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[21] Appl. No. **790,286**
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[45] Patented **Mar. 9, 1971**

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Continuation-in-part of application Ser. No. 766,875, Oct. 11, 1968, now abandoned.

[54] **AUTOMATIC TYING APPARATUS**
19 Claims, 26 Drawing Figs.

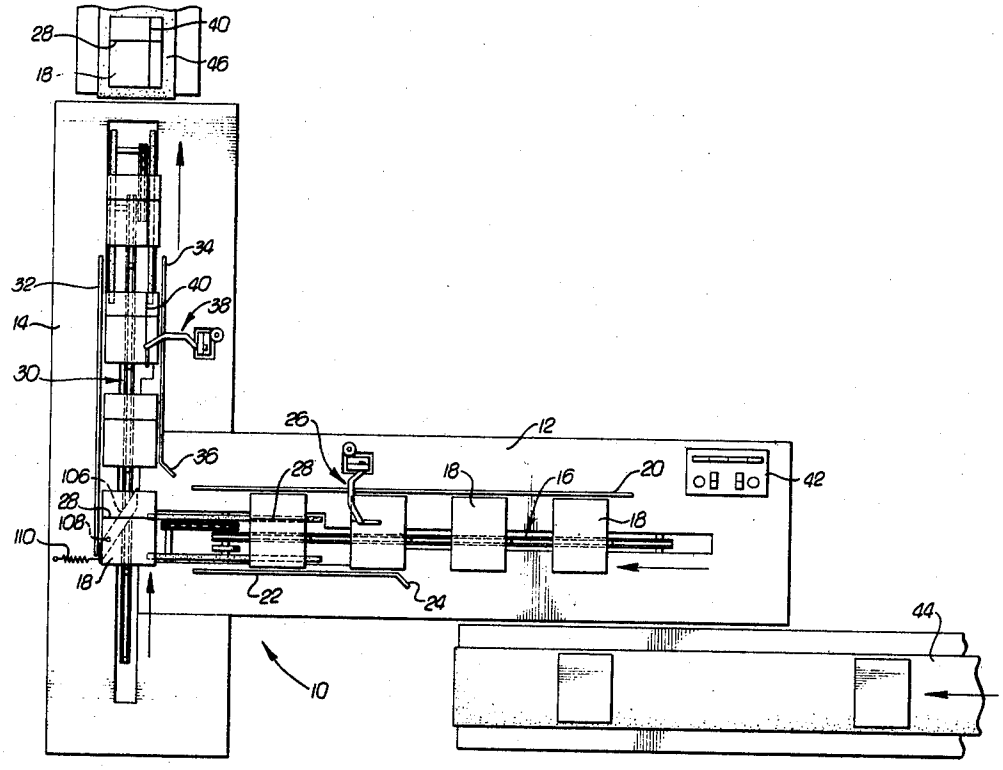
[52] **U.S. Cl.** **100/4,** 100/7, 100/17
[51] **Int. Cl.** **B65b 13/18**
[50] **Field of Search** ..... 100/2 (Cursory), 4 (Cursory); 100/2, 4, 7, 17, 18, 19

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Primary Examiner—Billy J. Wilhite
Attorney—Albert L. Gabriel

ABSTRACT: A conveyor system for automatically tying a series of bundles, such as stacks of magazines, while they are in continuous, uninterrupted movement. Movement of each bundle causes its leading edge to engage string suspended across its path and double the string back above and below the bundle to its trailing edge, where knotting mechanism knots and cuts the string while the bundle continues to move. Actuation of the knotting mechanism is accurately synchronized to each bundle for tight tying by actuation of the knotting mechanism through rapid-acting drive means energized by microswitch means actuated according to bundle position on the conveyor.



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10 Sheets-Sheet 1

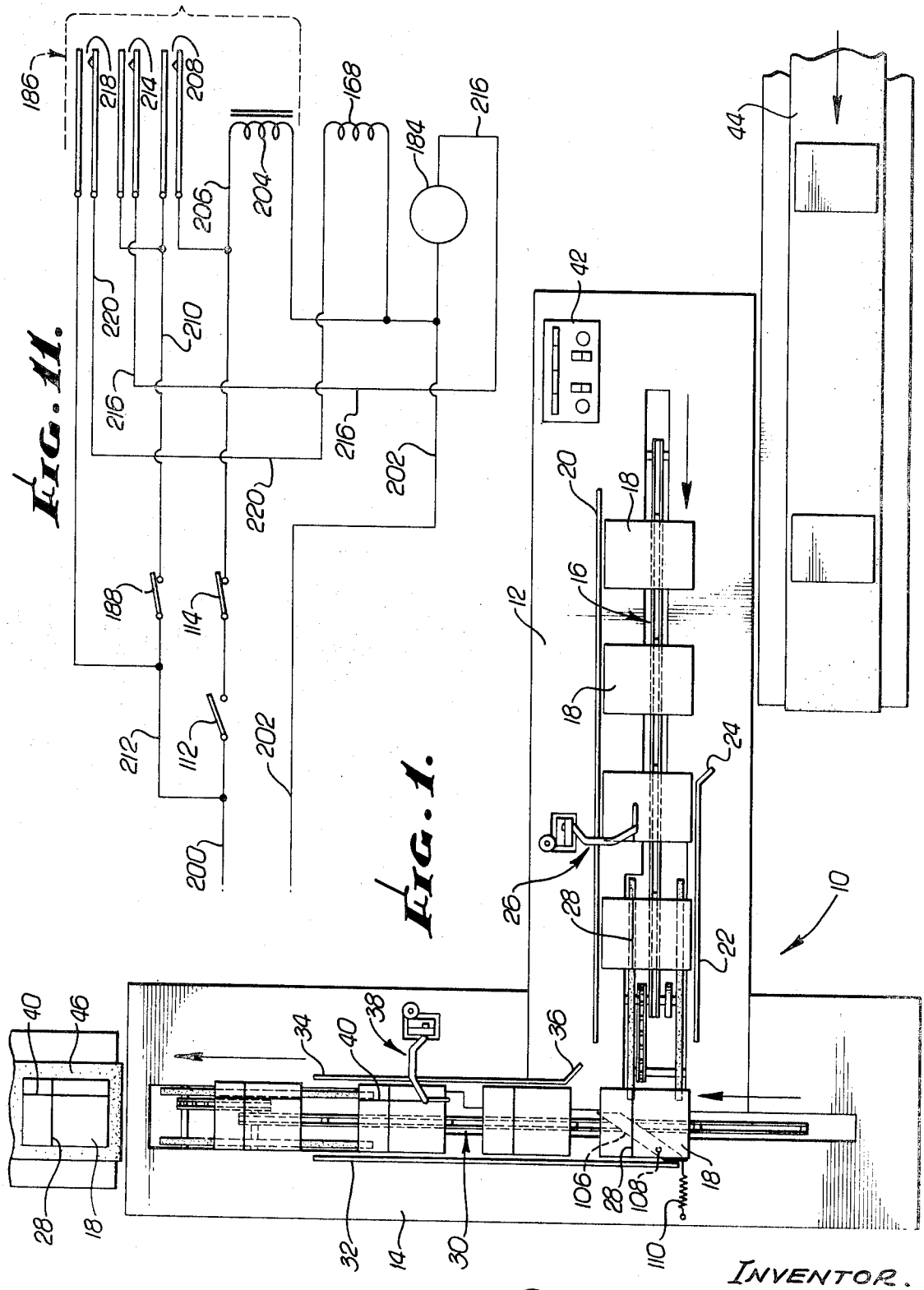


FIG. 11.

FIG. 1.

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FIG. 4.

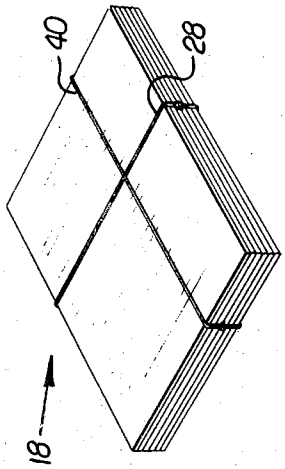
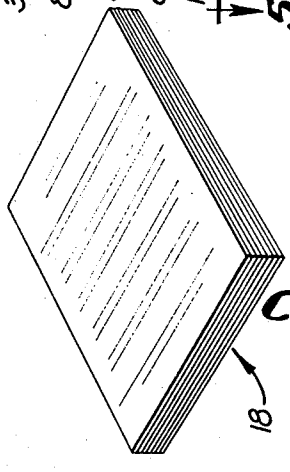


FIG. 2.

FIG. 3.



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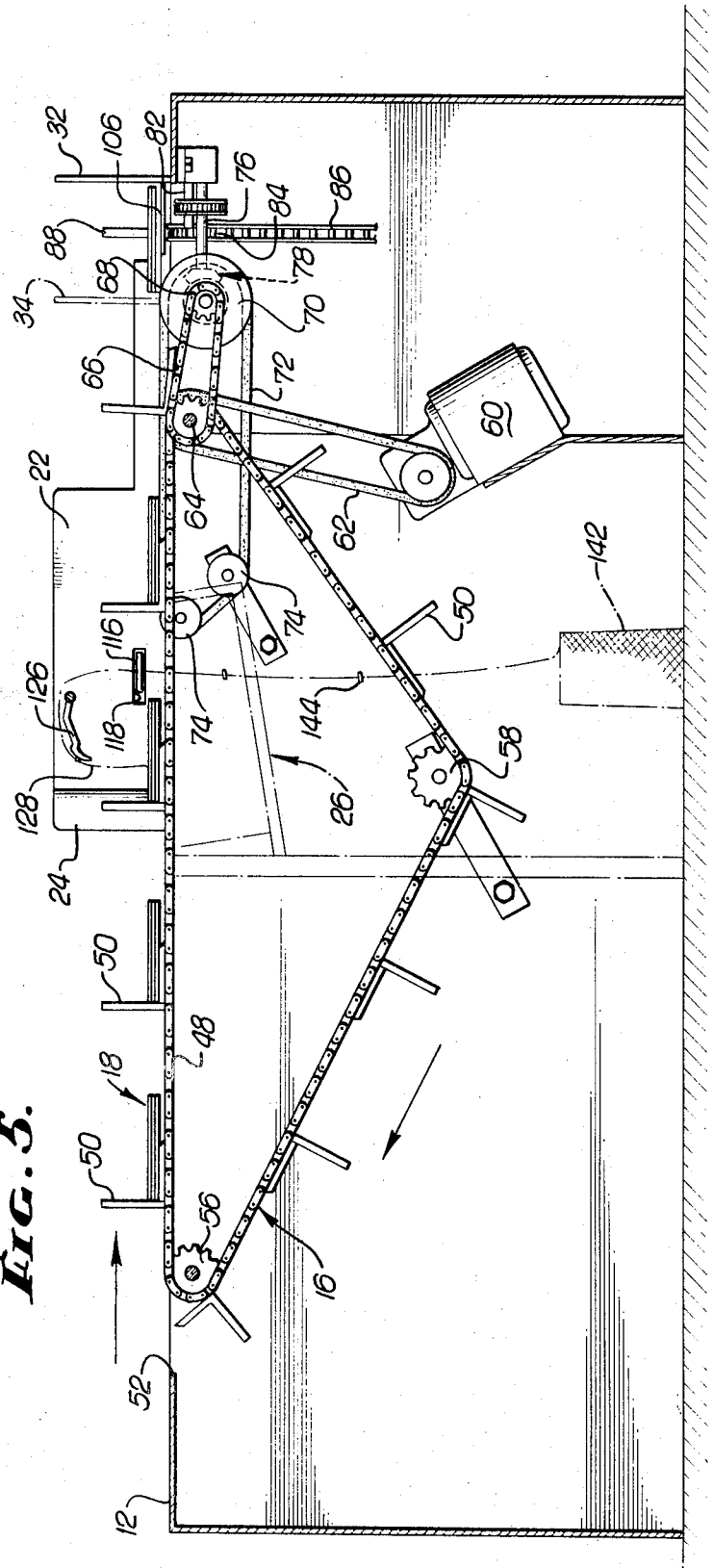


FIG. 5.

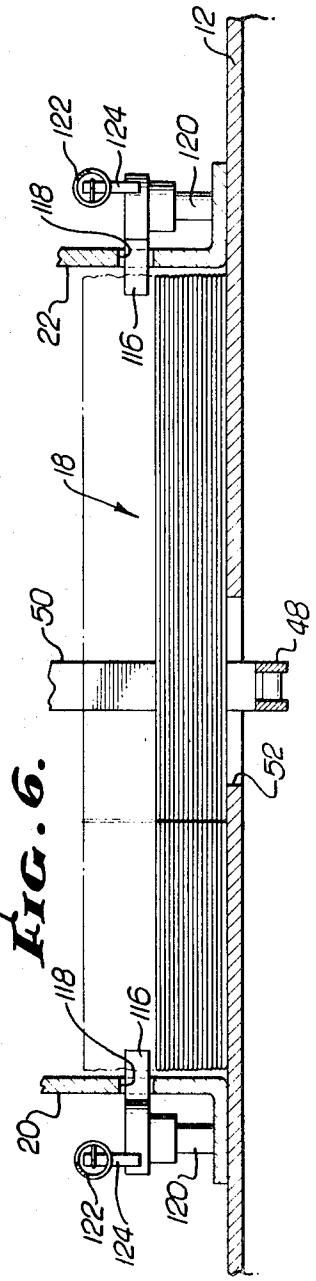


FIG. 6.

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FIG. 7.

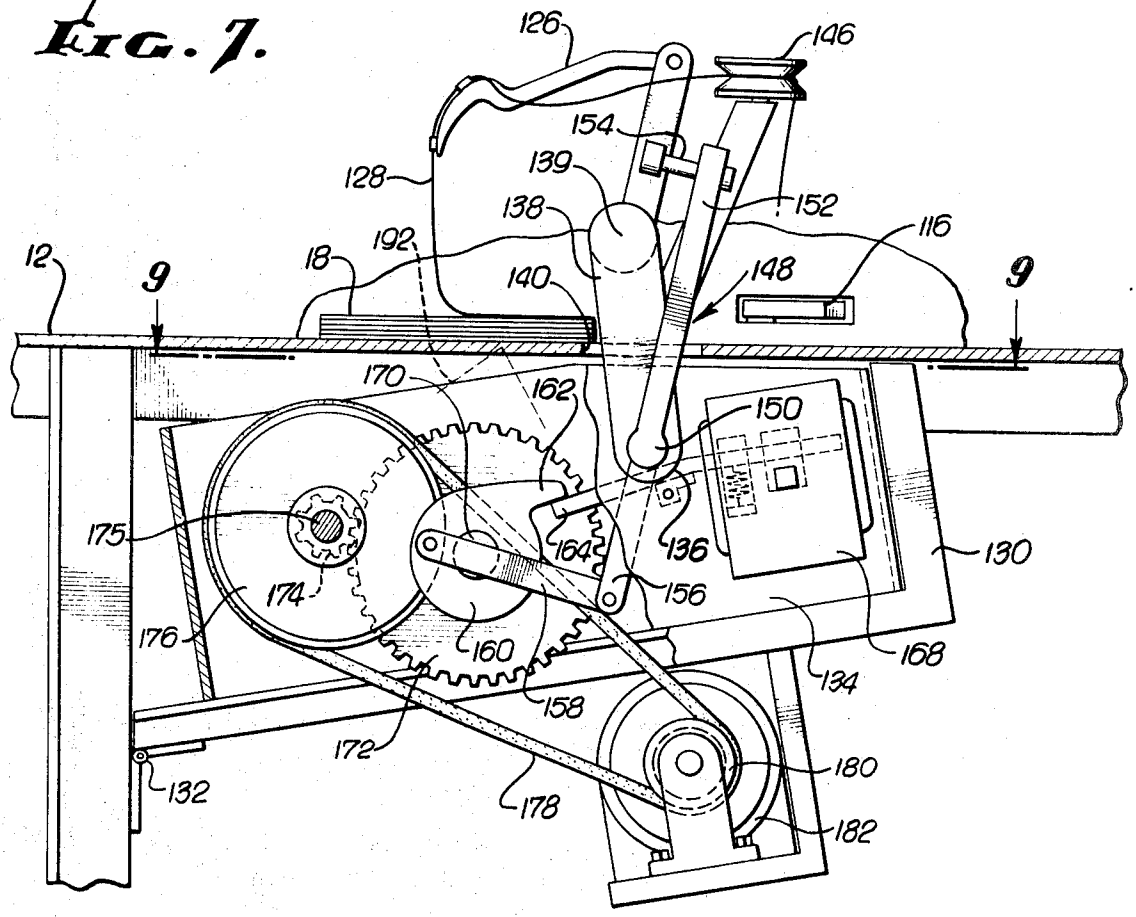
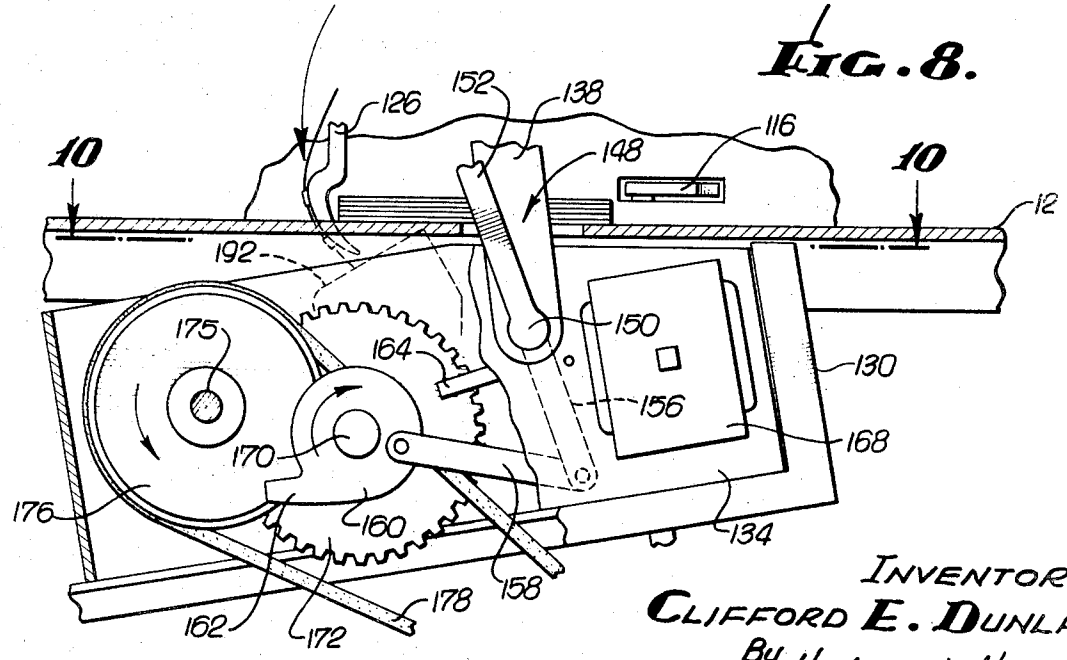


FIG. 8.



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FIG. 9.

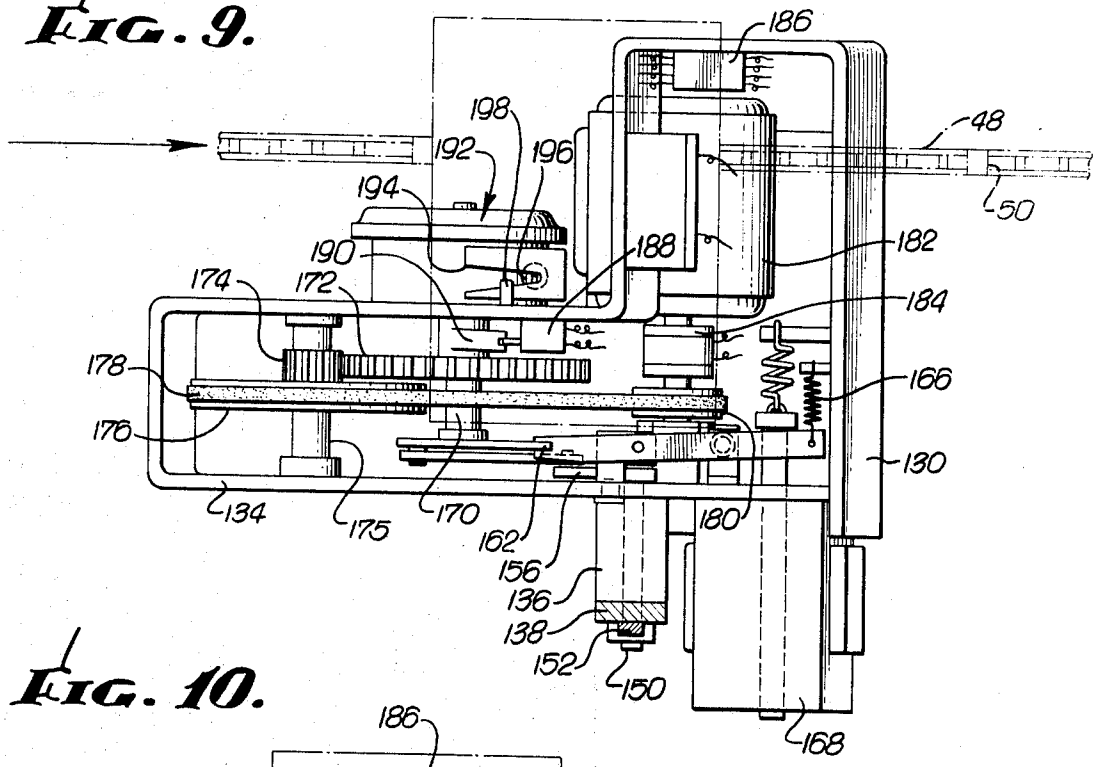
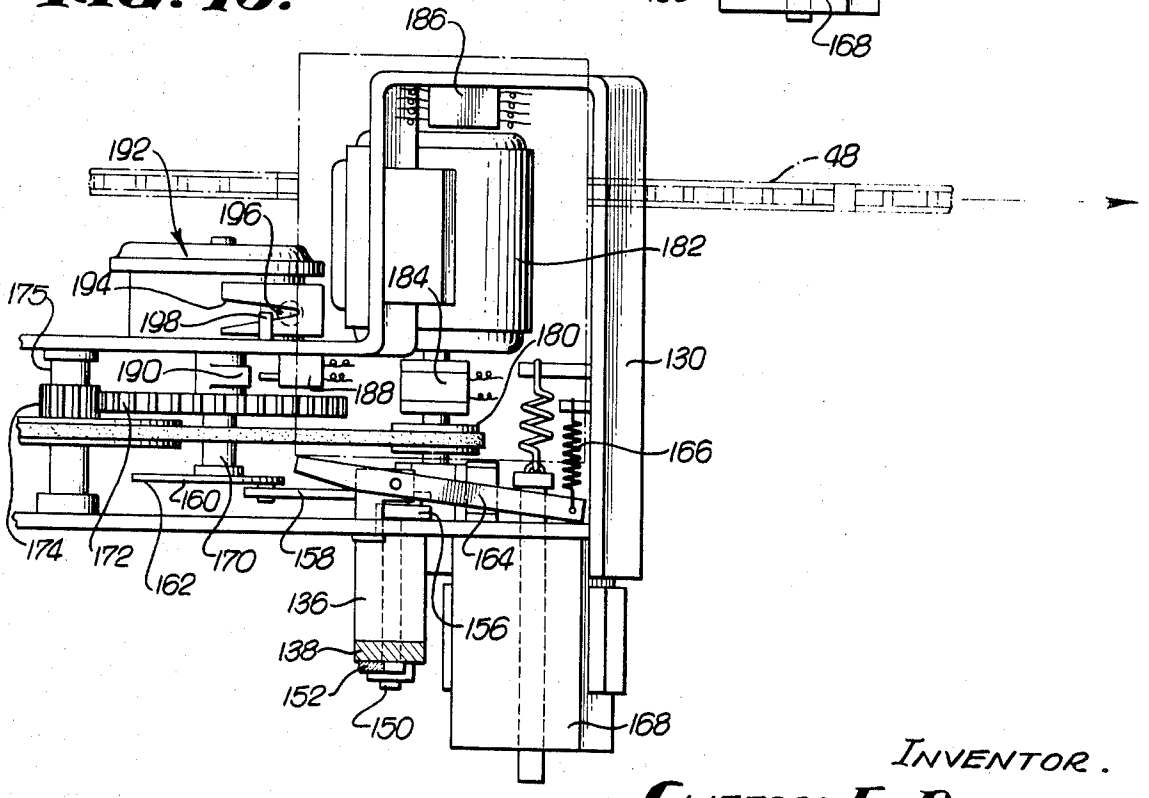


FIG. 10.



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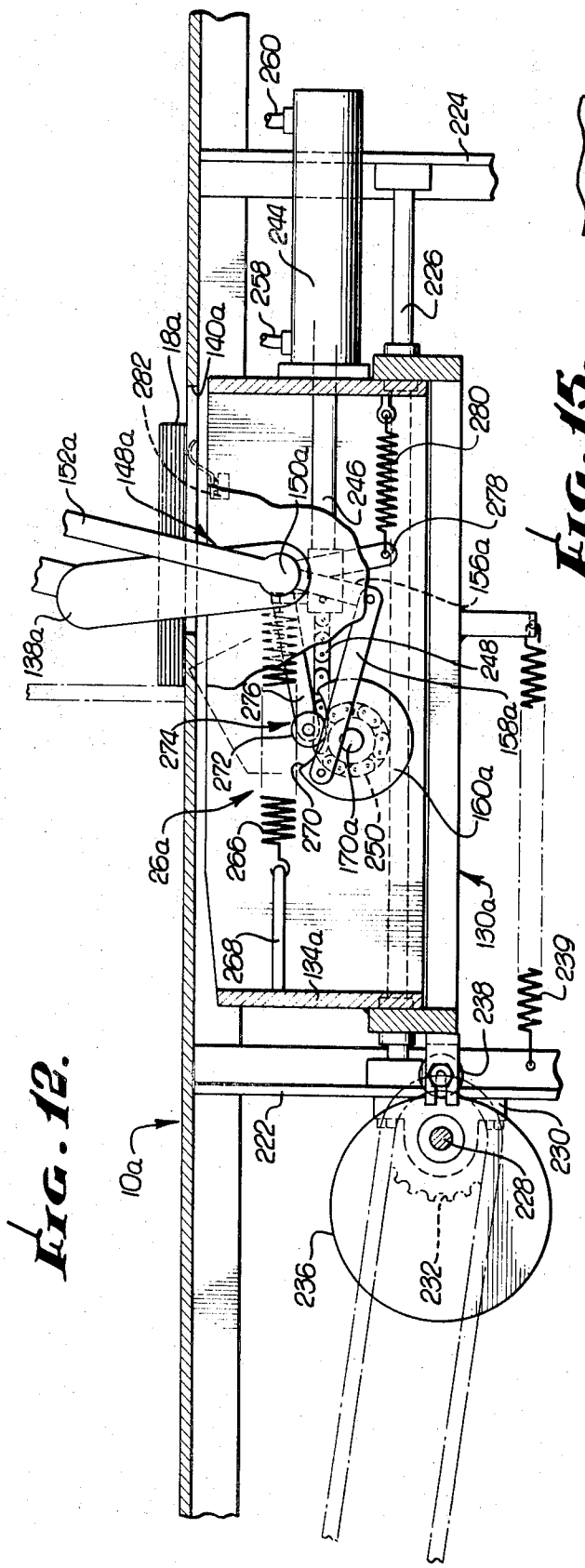


FIG. 12.

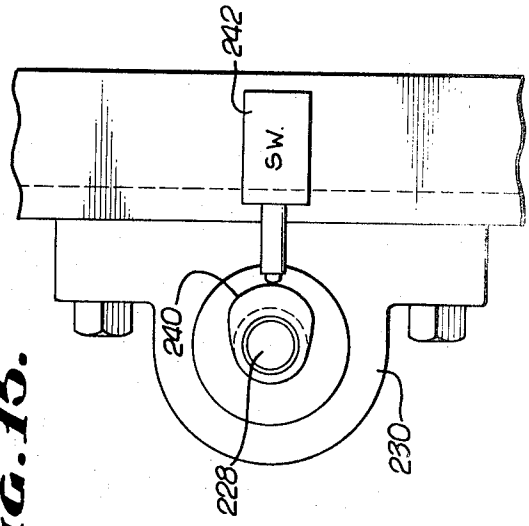


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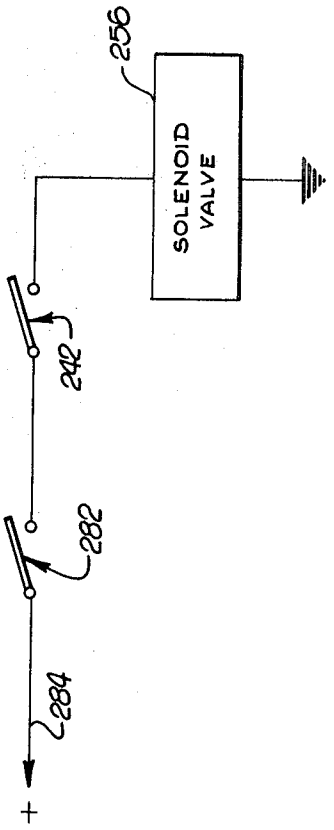


FIG. 16.

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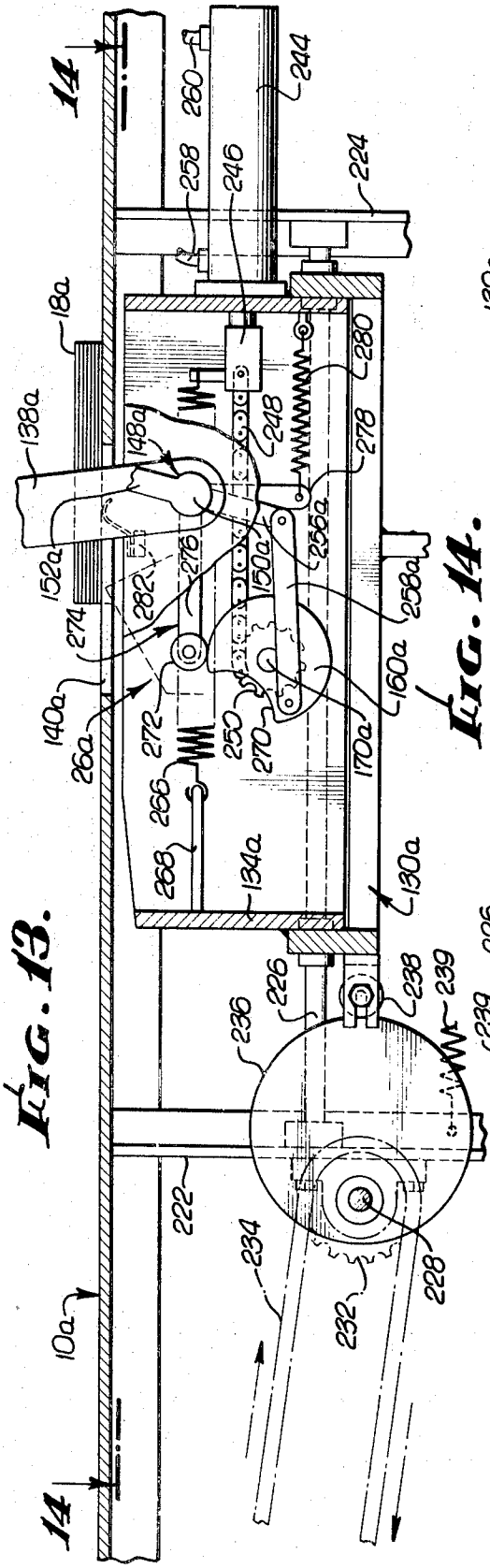


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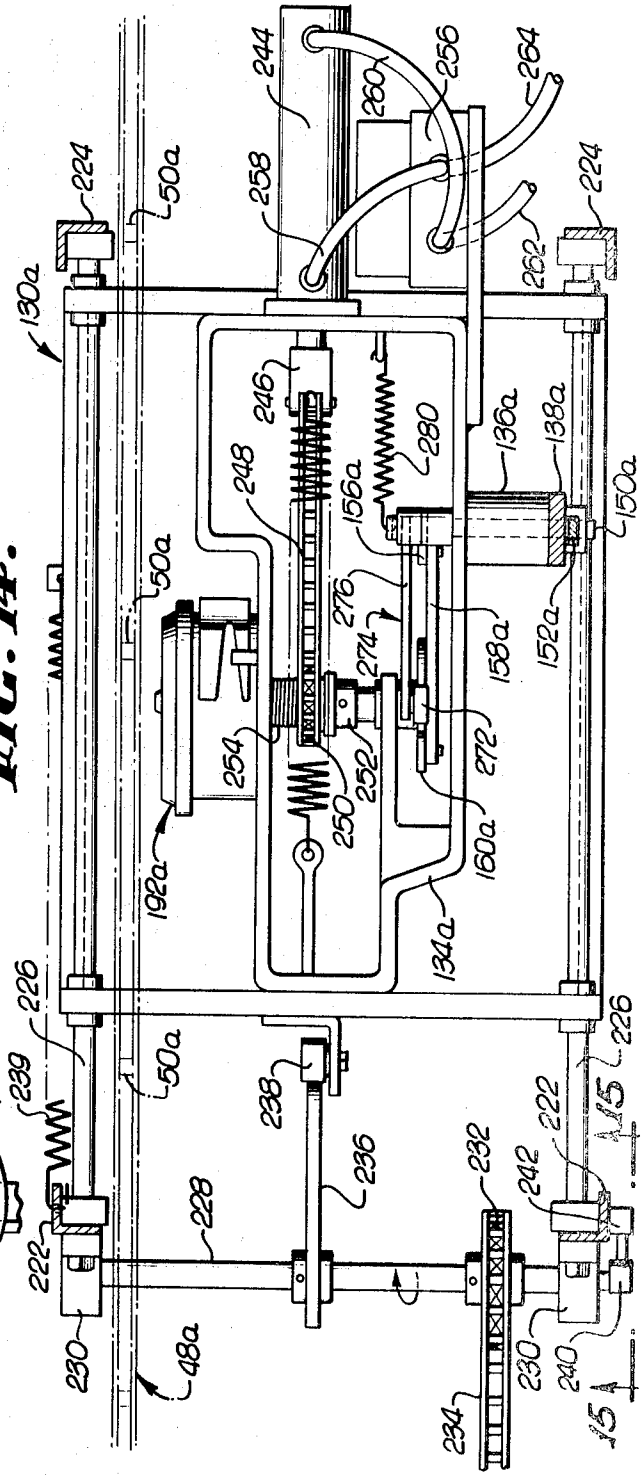


Fig. 14.

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FIG. 17.

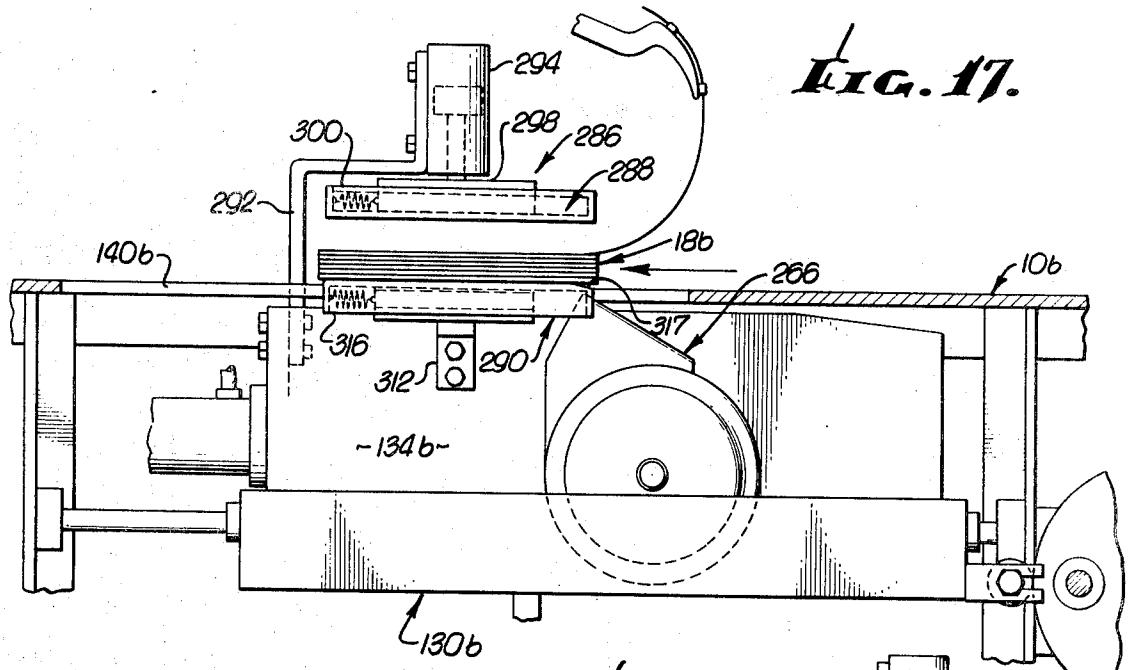


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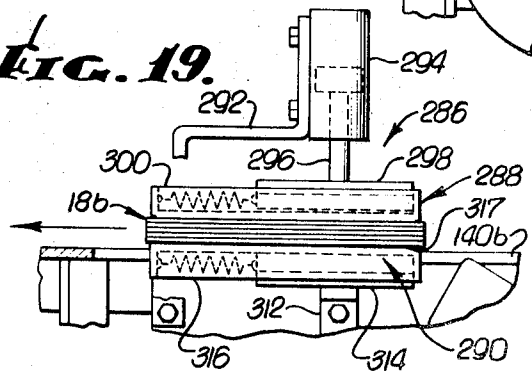


FIG. 18.

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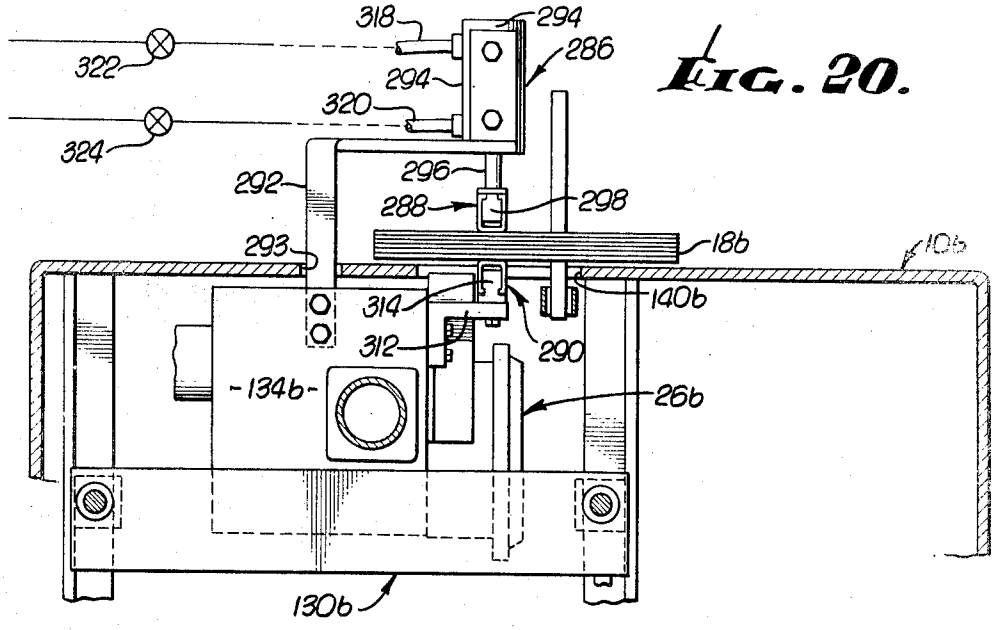


FIG. 20.

FIG. 21

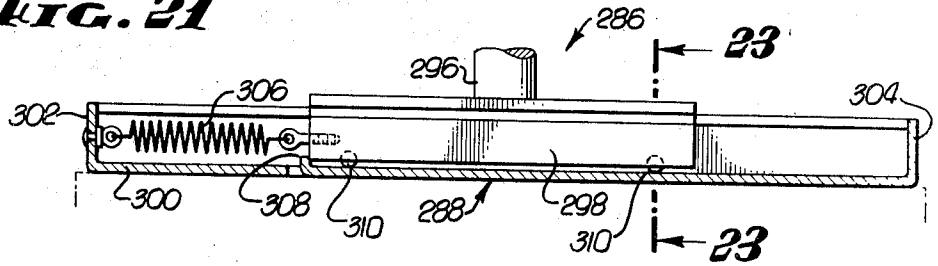


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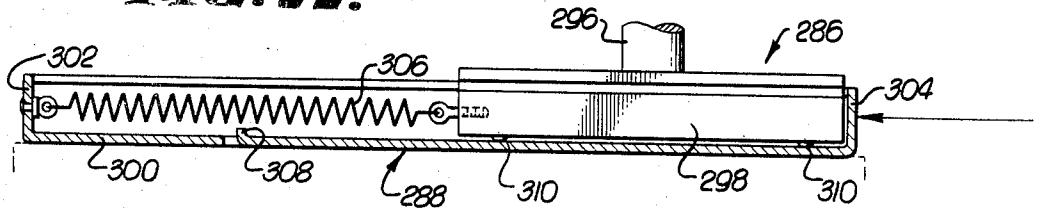
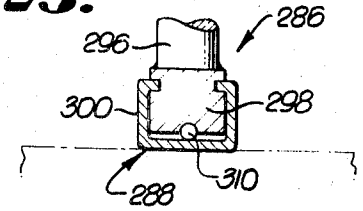


FIG. 23.



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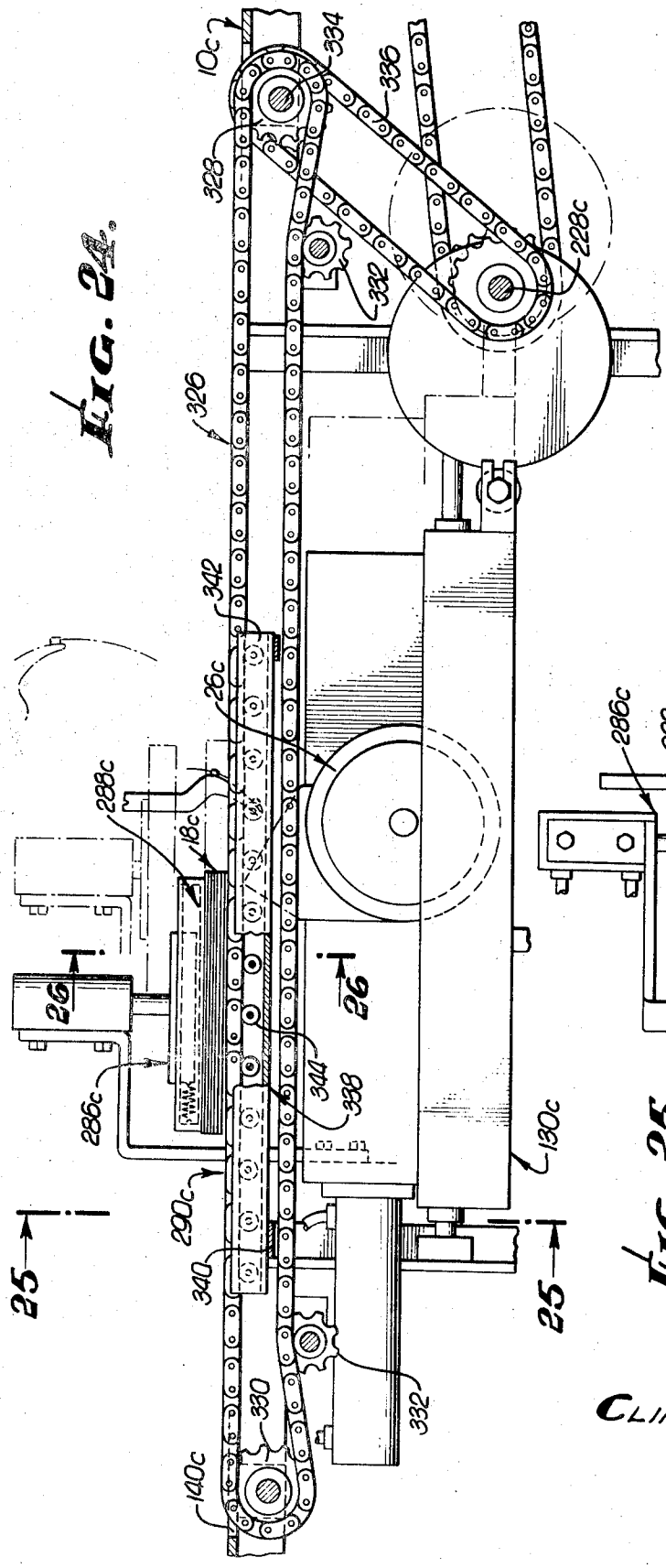


FIG. 24.

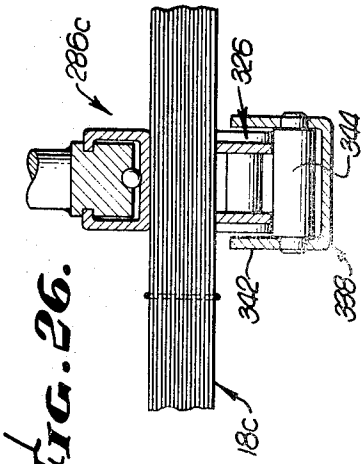


FIG. 26.

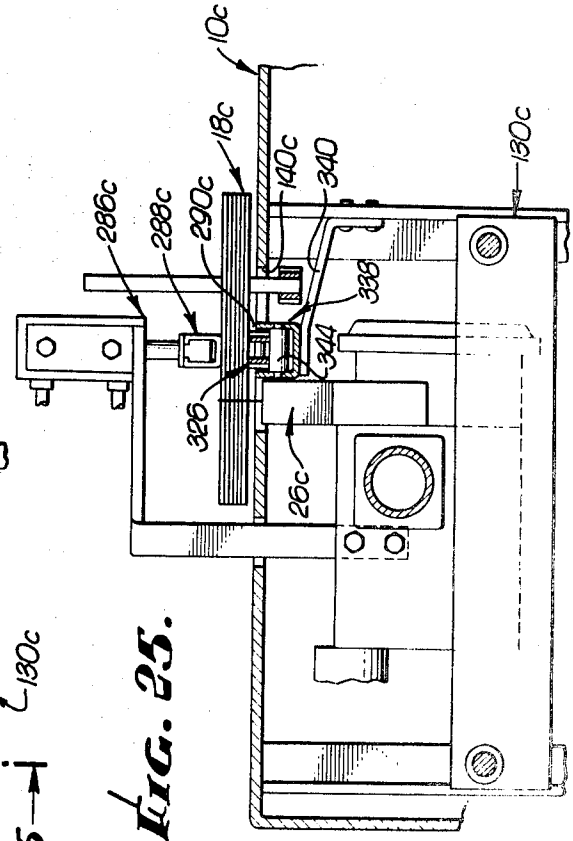


FIG. 25.

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AUTOMATIC TYING APPARATUS

This application is a continuation-in-part of my copending application Ser. No. 766,875, filed Oct. 11, 1968, for Automatic Tying Apparatus and Method, now abandoned.

BACKGROUND OF THE INVENTION

Apparatus for automatically wrapping a bundle with string and then knotting and cutting the string has been known for many years. Apparatus of this type is illustrated and described in U.S. Pat. No. 1,629,841, issued May 24, 1927. While such apparatus is rapid and effective for automatically tying each bundle placed thereon, the operation thereof is nevertheless to a large extent manual, since each bundle must be manually placed on the apparatus before the tying is effected, and then must be manually removed from the apparatus after the tie has been made. While such stationary, one-shot automatic bundle tying apparatus is generally satisfactory for tying relatively small numbers of bundles, it has been found to be completely inadequate where large numbers of bundles must be tied in a relatively short period of time, as for example, where a magazine publishing house must tie several hundred thousand magazines per day in small bundles sorted according to postal zip codes for mailing.

Because of the slowness and high labor costs associated with such stationary bundle tying apparatus, there have been numerous attempts in recent years to provide a satisfactory bundle tying machine which is more fully automated by utilization of a conveyor system. Thus, several such conveyor type automatic bundle tying machines are currently on the market. These machines are essentially adaptations of conveyor handling to a manually operated, stationary tier of the general type disclosed in said U.S. Pat. No. 1,629,841.

While such currently available conveyor-type bundle tiers do provide a substantial improvement in bundle handling speed, they are extremely expensive, are undesirably complicated, and still are much too slow to meet the production requirements of many businesses. The net result is that today, despite the availability of such conveyor type machines, most bundles of magazines and the like are still tied by means of the hand-operated units.

Most of the problems associated with such current conveyor type automatic tying machines result from the fact that they utilize as the tying mechanism therein apparatus which is arranged to accomplish the tying and knotting functions at a generally stationary position of the bundle. Thus, in such current machines the conveyor moves each bundle to a particular position where the bundle is received by the tying mechanism, which then ties the bundle at that position and releases it to the conveyor. This means that each bundle in the assembly line has to be stopped at a tying station and retained there during the interval of time necessarily required for tying. This stopping of the bundles in the conveyor system for tying results in a substantial slowdown of production as compared with the speed capability of the conveyor system itself. Furthermore, the repeated stopping and starting of the main assembly line drives produces considerable wear on the drives, clutches and brakes, and requires an unduly complicated conveyor system.

SUMMARY OF THE INVENTION

In view of these and other problems in the art, it is an object of the present invention to provide a novel apparatus for tying a series of bundles of magazines or the like with string, wherein the bundles are automatically moved in sequence past one or more tying stations at which each bundle is tied with string while the bundle continues to be moved by the conveyor, without requiring that the conveyor be either stopped or slowed down, thereby greatly increasing the overall production rate of bundle tying and substantially simplifying the apparatus by eliminating the necessity for various mechanisms required to stop and restart the conveyor.

Another object of the invention is to provide for automatic conveyor type apparatus of the character described for tying bundles which utilizes the movement of the bundle on the conveyor means to pick up the string, which is suspended between a tying arm above the bundle and a knotting mechanism below the bundle, the leading edge of the bundle engaging the string and movement of the bundle along the conveyor causing the string to be folded or doubled back against the top and bottom of the bundle, with the string being knotted at the trailing edge of the bundle by cooperative action of the said tying arm and knotting mechanism while the bundle continues to move.

A further object of the invention is to provide an automated system of the character described for tying successive bundles, such as stacks of magazines or other bundles, with string, wherein conveyor movement of the bundle causes the bundle to pick up and fold the string thereover, and as the bundle continues to move, a string tying arm which is pivotally mounted above the bundle swings downwardly behind the moving bundle and, in cooperation with a fast-acting tying mechanism below the bundle, effects tying and cutting off the string at the trailing edge of the bundle while the bundle continues to move, the arm then pivoting back upwardly and suspending a length of the string between the arm and knotting mechanism in the path of the next succeeding bundle.

A still further object of the invention is to provide an automated tying system of the character described wherein actuation of the tying and knotting mechanism is accurately synchronized with the conveyor movement of each bundle through the use of microswitch means actuated according to bundle position on the conveyor to energize the tying and knotting means through rapid-acting drive means. Conventional hand-operated tying units such as that disclosed in said U.S. Pat. No. 1,629,841, employ a toothed clutch arrangement for driving the tying arm and knotter, and although such arrangement is satisfactory where tying is accomplished at a stationary location, there is of necessity an unpredictable amount of lost motion associated therewith which prevents sufficiently accurate timing for making a knot while the bundle is moving, without producing loose knots and frequent misties.

Another object of the present invention is to provide automatic bundle tying apparatus of the character described wherein the tying and knotting mechanism is mounted on carriage means which is mounted for reciprocal sliding movement in the longitudinal direction of the conveyor, such movement of the carriage means being synchronized with conveyor movement to bring the tying and knotting mechanism substantially up to conveyor speed proximate the time the knot is tied.

An additional and more general object of the invention is to provide a conveyor system for automatically tying a series of bundles which is much more rapid in operation than similar prior art devices, which ties the bundles tightly and effectively with far fewer post office complaints than similar devices of conventional design, and is simpler in construction, less expensive and substantially more durable than conventional apparatus employed for the same purpose. In this connection experimental operation of apparatus constructed in accordance with the present invention has reduced mistying complaints from the United States Post Office to less than one-fifth the complaints for similar bundles tied on hand-operated tying apparatus.

Typically, in the operation of apparatus of this general type, magazines will come off of a high-speed labeling machine sorted as to postal zip code, the magazines being stacked by the operator of the tying machine and placed on the conveyor. Conventional conveyor type automatic tying apparatus is capable of tying approximately 100,000 magazines per day with the assistance in the overall operation of seven people. Experimental operation of the present invention indicates that approximately 350,000 magazines can be tied per day with the overall assistance of only four people. While the maximum rate of operation of prior art conveyor type automatic tying equipment is approximately 1,200 bundles per hour, test apparatus made in accordance with the present invention handles more than 3,500 bundles per hour.

Further objects and advantages of the present invention will appear during the course of the following part of the specification, wherein the details of construction and mode of operation of a presently preferred embodiment are described with reference to the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view illustrating automatic tying apparatus according to the present invention which is adapted to secure successive bundles of magazines or the like with a pair of string ties at right angles to each other.

FIG. 2 is a top plan view similar to FIG. 1, but with the bundles removed from the apparatus and with portions broken away to illustrate further details of construction.

FIG. 3 is a perspective view illustrating a typical stack of magazines forming a bundle to be tied by the apparatus and method of the present invention.

FIG. 4 is a perspective view similar to FIG. 3, but illustrating the stack of magazines tied according to the method and apparatus of the present invention with a pair of string ties disposed substantially at right angles to each other.

FIG. 5 is a vertical section taken on the line 5–5 in FIG. 2.

FIG. 6 is a vertical section taken on the line 6–6 in FIG. 2.

FIG. 7 is an enlarged, fragmentary vertical section taken on the line 7–7 in FIG. 2 illustrating some of the details of construction of a first form of tying mechanism which forms a part of the apparatus, with the tying mechanism in its unactuated position.

FIG. 8 is a fragmentary sectional view similar to FIG. 7 but illustrating only a portion of the tying mechanism shown in FIG. 7, the tying mechanism being actuated to approximately the point of completion of a tie in FIG. 8.

FIG. 9 is an enlarged, fragmentary horizontal section taken on the line 9–9 in FIG. 7, further illustrating details of construction of said first form of tying mechanism in its unactuated position.

FIG. 10 is an enlarged, fragmentary horizontal section taken on the line 10–10 in FIG. 8 illustrating details of construction of said first form of tying mechanism in its unactuated position.

FIG. 11 is a wiring diagram illustrating a circuit arrangement suitable for controlling the action of said first form of tying mechanism.

FIG. 12 is a fragmentary longitudinal, vertical section similar to FIG. 7, but illustrating a second form of tying mechanism mounted for reciprocal sliding movement in the longitudinal direction of the conveyor, the tying mechanism being shown proximate the beginning of such a cycle of reciprocating movement.

FIG. 13 is a view similar to FIG. 12, but with the tying mechanism shown approximately halfway through the cycle of reciprocating movement.

FIG. 14 is a fragmentary, horizontal section taken on the line 14–14 in FIG. 13 further illustrating details of construction of said second form of tying mechanism.

FIG. 15 is an enlarged, fragmentary vertical section illustrating the cam-actuated switch which initiates the tying action of said second form of tying mechanism in response to bundle position on the conveyor.

FIG. 16 is a wiring diagram illustrating a circuit arrangement suitable for controlling the action of said second form of tying mechanism.

FIG. 17 is an enlarged, fragmentary vertical section similar to FIG. 12 but looking from the opposite side, illustrating bundle clamping apparatus which may be employed with the tying mechanism to positively secure each bundle against curling at its ends during tying, the tying mechanism being shown proximate the beginning of a tying cycle, with the clamping apparatus open.

FIG. 18 is a view similar to FIG. 12 but with the tying mechanism shown approximately halfway through its cycle of reciprocating movement, and the clamping apparatus closed or in clamping position.

FIG. 19 is a further fragmentation of FIG. 18, but with the tying mechanism shown further progressed in its cycle and the clamping jaws extended forwardly on the jaw supports.

FIG. 20 is a fragmentary, transverse, vertical section taken on the line 20–20 in FIG. 18.

FIG. 21 is a further enlarged, fragmentary, longitudinal section showing details of construction of the upper clamping jaw and support in the retracted position of the jaw.

FIG. 22 is a view similar to FIG. 21 but with the jaw in its fully extended position.

FIG. 23 is a cross-sectional view taken on the line 23–23 in FIG. 21.

FIG. 24 is a view similar to FIG. 18, but illustrating a modification of the bundle clamping apparatus wherein the lower clamping means comprises a secondary chain driven synchronously with the primary or pusher chain.

FIG. 25 is a fragmentary, transverse, vertical section taken on the line 25–25 in FIG. 24.

FIG. 26 is a further enlarged, fragmentary, cross-sectional view taken on the line 26–26 in FIG. 24.

DETAILED DESCRIPTION

Referring to the drawings, and at first particularly to FIG. 1 thereof, apparatus according to the invention includes table structure generally designated 10 having first and second table sections 12 and 14, respectively, arranged generally at right angles with respect to each other.

The first table section 12 includes a first conveyor mechanism 16 arranged longitudinally thereof adapted to receive a series of stacks 18 of untied magazines or other bundles to be tied, and to move such stacks 18 at regularly spaced intervals longitudinally along the first table section 12 in a direction toward the second table section 14. These untied stacks 18 are initially laterally oriented on the first table section 12 by being placed against a long guide rail 20 which extends generally vertically upwardly from the first table section 12, and as the stacks 18 progress along the first table section 12 they are properly laterally positioned for a first tying operation between said long guide rail 20 and a short guide rail 22 arranged parallel to the guide rail 20 and the conveyor mechanism 16. The short guide rail 22 has an outwardly bent entrance ramp 24 for guiding the moving stacks 18 of magazines or the like into position between the rails 20 and 22.

A first tying mechanism 26 is mounted on the first table section 12, having portions thereof disposed both below and above the moving stacks 18, the tying mechanism 26 being arranged to tie a first loop 28 of string about each stack 18 of magazines or the like. Typically, the stacks 18 are rectangular in shape, and preferably these will be arranged so that the short sides of the rectangle will be disposed adjacent the guides 20 and 22, and the long sides will be the leading and trailing edges as the stacks progress along the first table section 12. Thus, the first loop 28 of string applied to each of the stacks 18 will be the shorter of the two loops to be applied.

A second conveyor mechanism 30 is mounted on the second table section 14 and arranged longitudinally thereof, this second conveyor mechanism 30 being adapted to receive the stacks 18 of magazines having the single loop 28 of string thereon from the first conveyor mechanism 16, and then move the stacks 18 in regularly spaced sequence longitudinally along the second table section 14 at right angles to the direction of movement which the stacks 18 had on the first table section 12. Lateral positioning of the stacks 18 on the second table section 14 is determined by a long guide rail 32 longitudinally arranged on the second table section 14 toward the side thereof remote from the first table section 12. Thus, as the stacks 18 are discharged from the first conveyor mechanism 16 onto the second table section 14 and its conveyor mechanism 30, the movement laterally of the second table section 14 is stopped as the stacks 18 come against the long guide rail 32, and the second conveyor mechanism 30

then moves the stacks 18 sequentially along the second table section 14. The stacks 18 are correctly oriented for the tying operation the second table section 14 between the long guide rail 32 and a second, short guide rail 34 having an entrance ramp 36 for guiding the stacks 18 into position between the guide rails. A second tying mechanism 38 is mounted on the second table section 14, with portions thereof disposed both above and below the stacks 18. This second tying mechanism 38 ties a second loop 40 of string about each of the stacks 18 generally in the direction of movement of the stacks, or at right angles to the first loop 28 of string. In this manner, the stacks 18 are tied both laterally and longitudinally, so as to become securely tied bundles.

Operation of the apparatus is controlled from a suitable control panel diagrammatically shown at 42 on the first table section 12. Stacks 18 of magazines or other untied bundles are conducted to a position adjacent the beginning of the first conveyor mechanism 16 by means of an input belt conveyor 44 which may be of conventional construction, and from which the stacks 18 may be manually placed on the first table section 12 in position to be sequentially engaged and moved along the first table section 12 by means of the first conveyor mechanism 16. A similar output belt conveyor 46 may be arranged in alignment with the second table section 14 at the discharge end thereof, to automatically receive the fully tied bundles as they are discharged from the second conveyor mechanism 30.

Referring next to FIGS. 2, 5 and 6, these FIGS. illustrate details of structure and operation of the conveyor mechanisms 16 and 30. The first conveyor mechanism 16 includes a pusher chain 48 having a plurality of regularly spaced pusher posts projecting from the outer side of the chain generally normal to the direction of movement of the chain. A section of chain 48 extends generally at the level of the top of first table section 12 within a longitudinal slot 52 in table section 12, with pusher posts projecting generally vertically upward from the surface of table section 12 so as to each push a respective stack 18 of magazines or the like longitudinally along the top of table section 12. The chain 48 is arranged in a generally triangular loop about chain drive sprocket 54, which is substantially at table level, an idler sprocket 56 also substantially at table level, and a second idler sprocket 58 which is disposed substantially below table level between sprockets 54 and 56. A conveyor drive motor 60 is mounted on the table structure below the drive sprocket 54, applying rotary power through a belt 62 to chain drive shaft 64 upon which the drive sprocket 54 is mounted. During operation of the apparatus the drive motor 60 will be continuously operating so as to drive the chain 48 at a constant speed, whereby the successive stacks 18 of magazines or the like will be pushed along the table section 12 at a constant speed by the chain pusher posts 50, as best illustrated in FIGS. 1 and 5.

A coupler chain 66 transmits rotary power from the chain drive shaft 64 to a shaft 68 upon which a pair of spaced pulleys 70 are mounted. The pulleys 70 drive a pair of advancer belts 72 which are looped over the pulleys 70 and also over respective idler pulleys 74. The advancer belts 72 are driven materially faster than the pusher chain 48, preferably about twice as fast, and after the tie has been made by the tying mechanism 26, each of the stacks 18 of magazines or the like will be pushed by a respective pusher post 50 onto the advancer belts 72, which will take up the partially tied stack 18 and move it forwardly on the first table section 12 away from the respective pusher post 50 so as to clear the post 50 so that it may turn downwardly over the drive sprocket 54. The advancer belts 72 advance the partially tied stack 18 onto the second table section 14 into alignment with the second conveyor mechanism 30.

Power is supplied to the second conveyor mechanism 30 from the first conveyor mechanism 16 so that the two conveyor mechanisms are synchronized, whereby when a partially tied stack 18 of magazines or the like is dispensed by the advancer belts 72 from the first conveyor mechanism 16 onto the second conveyor mechanism 30, each of the partially tied stacks will be moved between the spaced pusher posts of the second conveyor mechanism into position for being picked up by a respective pusher post of the second conveyor mechanism. Rotary power is supplied to a transversely arranged shaft 76 through a bevel drive 78 from the shaft 68. Shaft 76 drives a coupler chain 80, which in turn drives a shaft 82 upon which chain drive sprocket 84 is mounted. The sprocket 84 drives the pusher chain 86 of the second conveyor mechanism 30 from which regularly spaced pusher posts 88 extend, the posts 88 projecting upwardly from longitudinal slot 90 within which the chain 86 is disposed. The pusher chain 86 is arranged in a triangular loop similar to that of the first pusher chain 48, with the horizontal upper part of the chain 86 being engaged over the drive sprocket 84 near the leading end of the second table section 14 and an idler sprocket 92 near the trailing end of second table section 14. Idler sprocket 92 is mounted on and drives a shaft 94 which applies rotary power through a coupler chain 96 to a shaft 98 upon which a pair of advancer pulleys 100 are mounted. The pulleys 100 drive a pair of advancer belts 102 which are supported between pulleys 100 and idler pulleys 104, the advancer belts 102 are being driven materially faster than the pusher chain 86 so as to pull the fully tied stacks 18 of magazines or the like forwardly away from the pusher posts 88 to allow the posts to turn downwardly over the sprocket 92. The advancer belts 102 dispense the fully tied stacks 18 of magazines or the like, one of which is illustrated in FIG. 4, onto the output belt conveyor 46.

In order to prevent the partially tied bundles 18 from becoming entangled with the second pusher chain 86 as the bundles are being dispensed onto the second conveyor mechanism 30 by the advancer belts 72 of the first conveyor mechanism 16, an elongated chain cover plate 106 is normally disposed over the second pusher chain 86 in the region of the second table section 14 where the partially tied stacks 18 are dispensed, as best illustrated in FIGS. 1 and 2. This chain cover plate 106 is pivotally supported on the second table section 14 by means of a pivot pin 108, and extends obliquely across the second pusher chain 86, being biased to this covering position as illustrated in FIGS. 1 and 2 by means of a tension spring 110. This oblique positioning of the chain cover plate 106 causes the cover plate to completely guard the partially tied stacks or bundles 18 from the second chain 86, while at the same time allowing the chain cover plate 106 to be cammed and deflected by each of the pusher posts 88 to allow the posts 88 to pass by the cover plate 106, and as soon as each of the posts 88 clears the cover plate 106, the biasing spring 110 will snap the cover plate 106 back into its protective position as illustrated in FIGS. 1 and 2. While the chain cover plate 106 has been shown and described as being deflected out of the way by the pusher posts 88 and returned to its initial, covering position by the spring means 110, it is to be understood that alternatively the chain cover plate 106 may be actuated by cams means (not shown) driven by the same rotary drive means which drives the two pusher chains 48 and 86.

Actuation of the tying mechanism 26 to effect the string tie about each stack 18 of magazines or the like as it progresses along the first table section 12 is commenced by engagement of the leading edge of the stack 18 with a first microswitch 112 which is normally open, so as to close the microswitch 112 and thereby energize a cycling relay to be described hereinafter which causes a full cycle of operation of the tying mechanism 26. By thus commencing the actuation of tying mechanism 26 pursuant to direct engagement of the microswitch 112 by the particular stack 18 to be tied, accurate synchronization of the tying mechanism 26 to each individual stack 18 is accomplished, and tight, secure tying can thereby be achieved. The cycling relay which is energized by actuation of the microswitch 112 has a holding circuit associated therewith, to be described in detail hereinafter, which holds the cycling relay closed for a complete cycle of operation of the tying

mechanism 26, the tying mechanism 26 automatically causing release of the cycling relay upon completion of a single tying cycle.

Spaced a short interval downstream of the microswitch 112 is a second, normally closed microswitch 114 which is quickly engaged and actuated by the stack 18 of magazines or the like immediately after the stack causes closure of the first microswitch 112. The second microswitch 114 is in the same circuit as the first microswitch 112, and upon actuation the second microswitch 114 opens this circuit so that continued operation of the tying mechanism 26, and in particular the timing of the completion of this operation of tying mechanism 26, is entirely dependent upon the holding means of the cycling relay that is directly associated with the tying mechanism 26.

Since the actuation of tying mechanism 26 is thus initiated by engagement of the leading edge of the stack 18 of magazines or the like with microswitch 112, while the actual knotting is accomplished by the tying mechanism 26 at the trailing edge of stack 18, it will be apparent that the positioning of microswitches 112 and 114 longitudinally of the first table section 12 will be adjusted according to the width of the stack 18 of magazines or the like. Accordingly, suitable means (not shown) is provided for longitudinal adjustment of the positions of microswitches 112 and 114. The electrical circuit diagrammatically illustrated in FIG. 11 is arranged for automatic actuation of the tying mechanism 26 in response to engagement of the microswitch 112 by the leading edge of the stack 18. However, if desired, the microswitches 112 and 114, and correspondingly the circuit arrangement associated therewith for actuating the tying mechanism 26, may be modified to initiate actuation of the tying mechanism 26 upon release of one of the microswitches at the trailing edge of the stack of magazines, in which case there would be no requirement for adjustment of the longitudinal positions of the microswitches 112 and 114 on the first table section 12 to accommodate variations in the width of the stack 18.

The second tying mechanism 38, which is associated with the second table section 14, is arranged to be independently actuated by a second pair of microswitches corresponding to the microswitches 112 and 114, actuation of the second tying mechanism 38 being achieved through a second circuit arrangement similar to the one shown in FIG. 11.

It has been found in experimental operation of apparatus like that shown and described herein that if a stack of magazines to be tied is too thin, as for example less than 1 inch in thickness, it has a tendency to curl in the direction of movement during the tying operation, whereby the loops of string tied about the stack will not have the correct lengths, and tying will not be as effective. This problem has been overcome in the apparatus by the provision of a pair of opposed anticurling ears 116 pivotally mounted proximate the respective guide rails 20 and 22 so as to project inwardly toward each other through respective slots 118 in the rails 20 and 22. These anticurling ears 116 are pivotally mounted on respective posts 120 extending vertically upwardly from the table, so as to swing horizontally spaced approximately 1 inch above the level of table section 12. The ears 116 are biased by respective springs 122 which are engaged between suitable tabs 124 on the ears 116 and the respective guide rails 20 and 22. The springs 122 normally bias the ears 116 to the positions best illustrated in FIGS. 2 and 6, wherein the free ends of the ears 116 will overlap a thin stack 18 of magazines less than approximately 1 inch in thickness, such as the stack 18 illustrated in FIG. 6, thereby preventing any portion of the stack 18 from curling upwardly at its edges as the stack passes under the free ends of the ears 116. However, such curling is not a problem with stacks of magazines greater than about 1 inch in thickness, and the side edges of such stacks will simply engage the obliquely arranged ears 116 and deflect the ears out of the way as the stacks pass by. It will be noted that the ears 116 are longitudinally positioned on the first table section 12 in the region where the tying string is doubled back over each stack of magazines and the tie is applied, since it is the purpose of the ears 116 to prevent curling of thin stacks of magazines during the actual tying operation.

The general longitudinal positioning of the tying mechanism 26, and in particular of the tying arm 126 forming a part thereof which extends laterally over the guideway for the stacks of magazines or the like formed between the guide rails 20 and 22, is best illustrated in FIG. 2. The tying arm 126 provides means for feeding the string 128 which is also shown in FIG. 2, and the tying arm 126 during a tying operation is adapted to pivot downwardly and forwardly so as to follow the trailing edge of each stack 18 of magazines or the like in the manner which is best illustrated by the sequence of FIGS. 7 and 8 of the drawings so as to apply the knot immediately at the trailing edge of each stack.

Reference will now be made to FIGS. 7, 8, 9 and 10, which illustrate the tying mechanism 26 in some detail, and in particular illustrate the power train of the tying mechanism 26 including a novel magnetic clutch and brake combination, the operation of which is controlled by the cycling relay to precisely synchronize the knotting of the string with respect to each bundle as it passes by the tying mechanism 26 on the first table section 12. It is to be understood that the tying mechanism 28 associated with the second table section 14 embodies similar details of construction.

The tying mechanism 26 is mounted on a subframe 130 that is supported under the top of the first table section 12, and may include a hinge 132 as part of its mounting to permit easy access to the mechanism thereof, The subframe 130 has a sidewall 134 upon which a hub 136 is mounted, the hub 136 projecting laterally outwardly from the sidewall 134, and having its axis arranged generally horizontally and normal to the path of travel of the pusher chain 48 as best illustrated in FIGS. 9 and 10. A support post 138 is fixedly supported at its lower end to the outer end of hub 136, and projects upwardly at a slight rearward tilt through an opening 140 in the top of table section 12, the tying arm 126 being pivotally supported on the upper end of the support post 138 to swing about a pivot axis 139. The pivotal movement of tying arm 126 is from an upper most, inoperative position as illustrated in FIG. 7 in which the stacks 18 of magazines or the like can pass underneath the tying arm, anticlockwise as viewed in FIGS. 7 and 8 to a lowermost position as shown in FIG. 8 wherein the free end of the tying arm 126 engages a receiver or knotter portion of the tying mechanism under the top of table section 12 to complete the tie. After the knot has been tied at the trailing edge of each stack 18 of magazines or the like, the tying arm 126 pivots clockwise as viewed in FIGS. 7 and 8 back from the lowermost, operative position of FIG. 8 to the uppermost, inoperative position of FIG. 7. The actual knotting part of the cycle is extremely fast, and as the free end of the tying arm 126 moves into its final position to effect the knotting as generally illustrated in FIG. 8, this forward tip of the tying arm 126 has a forward component of movement; i.e., a component of movement to the right as viewed in FIG. 8; and in this way the tying arm 126 in effect follows the trailing edge of the stack 18 of magazines or the like. The net result is that a very tight, secure tie is effected.

Referring now to FIG. 5 in addition to FIGS. 7 through 10, the string 128 is supplied from a roll 142 thereof which may be placed on the floor below the tying mechanism 26, or otherwise supported under the tying mechanism 26. The string 128 is fed from roll 142 through a sequence of eyelets 144 to the tying arm 126, the string being fed along the tying arm 126 to a position proximate the free end thereof, and then in the uppermost, inoperative position of the tying arm being suspended from the tip of the tying arm generally vertically downwardly to the receiver or knotter mechanism disposed under the top of table section 12, whereby forward movement of a stack 18 of magazines or the like along the first table section 12 will cause the leading edge of this stack to engage the suspended length of string, and the string will double back over the top and under the bottom of the stack as the stack

continues to move forwardly or to the right as viewed in FIGS. 7 and 8. Then, actuation of the tying mechanism 26 which was initiated by engagement of the stack 18 with microswitch 112 causes the tying arm 126 to swing downwardly from the position of FIG. 7 to the position of FIG. 8 to complete the tie by knotting together the two portions of the string which were doubled back over the top and under the bottom of the stack. To facilitate the feeding of string at a controlled tension as the string doubles back over the top and under the bottom of the stack 18, a feed roller 146 is mounted on the support post 138, and the string 128 is looped about the roller 146 before it is led to the free end portion of the tying arm 126. This allows feeding of the string 128 in much the same manner as thread is fed to the reciprocating needle of a sewing machine.

The reciprocating pivotal movement of tying arm 126 is effected through a lever generally designated 148. The lever 148 includes as a part thereof a fulcrum shaft 150 which extends axially through the hub 136, the lever 148 including an upper lever arm 152 that is integrally connected to the outer end of fulcrum shaft 150 and projects upwardly beyond the upper end of support post 138 and is operatively connected proximate its upper end to the tying arm 126 by means of a link 154 which is pivoted both to the upper lever arm 152 and the tying arm 126. The lever 148 also includes a lower lever arm 156 integrally connected to the fulcrum shaft 150 at the inner end of the shaft and extending downwardly therefrom. Pivotally connected to the lower level arm 156 proximate its lower end is a link 158, the other end of which is eccentrically pivotally connected to a brake wheel 160. The brake wheel 160 is adapted to make a single revolution for each tying cycle, and the eccentric connection of link 158 with the brake wheel 160 causes the brake wheel to drive the lever 148 and hence the tying arm 126 through a full reciprocating cycle during this single revolution of the brake wheel 160.

Brake wheel 160 has a stop projection 162 thereon which is normally engaged against a brake lever 164 in the inoperative position of the tying mechanism 26 as illustrated in FIGS. 7 and 9, the brake lever 164 being biased to this position by means of brake return tension spring 166.

Movement of the brake lever 164 from the inoperative or stop position illustrated in FIGS. 7 and 9 to an operative or release position as illustrated in FIGS. 8 and 10 is effected by energization of a brake solenoid 168. This action of solenoid 168 causes the lever 164 to shift laterally out from under the stop projection on brake wheel 160, thereby allowing the brake wheel 160 to be driven clockwise as viewed in FIGS. 7 and 8 by the shaft 170 upon which brake wheel 160 is mounted. Shaft 170 has a relatively large diameter gear 172 affixed thereto, the gear 172 being driven by a relatively small spur gear 174 integral with a shaft 175 upon which a relatively large pulley 176 is also integrally mounted. The pulley 176 is driven by a belt 178, which in turn is driven by relatively small pulley 180. Rotary power is supplied to the pulley 180 by a constantly running motor 182 through a magnetic clutch 184.

It will be apparent that the belt drive from pulley 180 to pulley 176 and the gear drive from gear 174 to gear 172 will result in a substantial overall gear reduction between the tying mechanism drive motor 182 and the brake wheel 160. This allows the tying mechanism drive motor 182 to operate freely at constant speed while providing the power necessary to actuate the tying mechanism. This gear reduction also allows the brake solenoid 168 to release the brake before substantial movement of the brake wheel 160, while nevertheless permitting the brake solenoid 168 and the electrically actuated magnetic clutch 184 to be in the same electrical circuit and to be substantially simultaneously energized in response to closure of microswitch 112 and the consequent energization of the cycling relay 186 which is mounted on the tying mechanism subframe 130. In addition to the relatively rapid rate of rotation in the power train at the magnetic clutch 184 as compared with the relatively slow rate of rotation at the brake wheel 160 as a factor in allowing the brake to release despite substantially simultaneous energization of brake solenoid 168 and magnetic clutch 184, further assurance can also be provided that the brake will not inadvertently lock up by provision of a brake solenoid 168 of a type which will act slightly faster in causing the brake to release than the magnetic clutch 184 will act to complete the drive coupling from the motor 182 to the pulley 180.

The latching circuit of cycling relay 186 includes a normally closed stop switch 188 which is engaged and opened by a cam projection 190 on shaft 170 upon completion of a tying cycle, thereby releasing the cycling relay 186, allowing the brake lever 164 to be returned to its unactuated or locking position as illustrated in FIGS. 7 and 9 wherein it engages the stop projection 162 on brake wheel 160, and causing disengagement of the magnetic clutch 184, setting up the tying mechanism for its next cycle of operation.

The tying mechanism also includes a receiver or knotter 192 which is driven off of shaft 170 and which includes a guide slot 194 adapted to receive the free end of the tying arm 126. A shuttle 196 within the receiver or knotter 192 effects virtually instantaneous tying of the knot.

It has been found in experimental use of the present invention that the free downward swinging movement of the tying arm 126 to follow the rearward edge of the stack of magazines or the like being tied causes the tying arm 126 to have considerable momentum when it enters the guide slot 194, whereby the tying arm 126 has a tendency to impact against and damage the relatively fragile shuttle 196. Accordingly, as a part of the present invention a tying arm limiting bar 198 has been provided on the receiver 192 so as to terminate this swinging movement of the tying arm 126 just short of the shuttle 196. Such limiting bar 198 has been found to provide complete protection to the shuttle 196 against against damaging impacts.

The receiver or knotter 192 may be of the conventional type employed in manually operating tying machines, as for example the type referred to in said U.S. Pat. No. 1,629,841. A modern version of such receiver or knotter which has been found satisfactory in the present invention is employed in the Saxmayer bundle tier manufactured by National Bundle Tyer Co., of Blissfield Michigan.

Referring now to FIG. 11 which is a wiring diagram of a suitable circuit for operating each of the tying mechanisms 26 and 38, electrical power is furnished through a pair of powerlines 200 and 202, and it will be seen that in the normal or unactuated condition of the tying mechanism with microswitch 112 open as illustrated in FIG. 11, the power circuit from lines 200 and 202 to relay coil 204 of the cycling relay 186 will be open. This circuit includes on the one side of relay coil 204 the power line 200, open microswitch 112, closed microswitch 114 and conductor 206; and on the other side of relay coil 204 the powerline 202.

The cycling relay 186 includes normally open holding contacts 208, one of which is connected to conductor 206, and the other of which is connected through a conductor 210 and the normally closed cam actuated stop switch 188 and a further conductor 212 to the powerline 200.

A second pair of contacts of the cycling relay 186 is the clutch contacts 214, one of which is connected to conductor 210 and the other of which is connected through a conductor 216 to one side of the magnetic clutch 184, the other side of which is connected to input powerline 202.

A third pair of contacts of cycling relay 186 is the brake contacts 218, one of which is connected to conductor 212, and the other of which is connected through a conductor 220 to one side of brake solenoid 168, the other side of which is connected to the input powerline 202.

Operation of the circuit illustrated in FIG. 11 is as follows: the normal condition of the circuit is illustrated in FIG. 11, wherein the microswitch 112 is open, the microswitch 114 is closed and the cam actuated stop switch 188 is also closed. The open microswitch 112 prevents current from flowing through relay coil 204, and accordingly all three pairs of relay contacts 208, 214 and 218 are open, whereby the brake sole-

noid 168 and magnetic clutch 184 are unenergized, and the tying mechanism 26 is in the inoperative condition illustrated in FIGS. 7 and 9.

When the leading edge of a stack 18 of magazines or the like engages and closes microswitch 112, the circuit to relay coil 204 is instantaneously closed, and consequent energization of relay coil 204 causes all three pairs of contacts 208, 214 and 218 to close. Closure of the holding contacts 208 causes continued energization of relay coil 204 to be independent of the microswitches 112 and 114, since one side of relay coil 204 is connected to powerline 202, and the other side is connected through conductor 206, holding contacts 208, conductor 210, cam actuated stop switch 188 (which is normally closed) and conductor 212 to the powerline 200. This energization of brake solenoid 168 will actuate brake lever 164 to release the brake wheel 160, and energization of the magnetic clutch 184 will connect the continuously running motor 182 to the power train so that a tying cycle as heretofore described will commence and progress.

Shortly after the initiation of the tying cycle by closure of microswitch 112 as heretofore described, the leading edge of the stack 18 of magazines or the like will engage and open the normally closed microswitch 114, which then makes continued operation of the tying mechanism dependent entirely upon the holding circuit for the cycling relay coil 204 which includes the holding contacts 208 and the normally closed cam actuated stop switch 188. By this means, deenergization of the tying mechanism can be accurately timed to the completion of a full cycle of operation thereof. Such deenergization occurs when the cam 190 engages and opens the stop switch 188, which opens the holding circuit and deenergizes the relay coil 204. This immediately releases all three pairs of relay contacts 208, 214 and 218, thus releasing the brake solenoid 168 to allow brake lever 164 to again engage the brake wheel 160, releasing the magnetic clutch 184 to disconnect the motor 182 from the rest of the power train, and opening the holding circuit of relay coil 204 so that the relay coil 204 can again be energized only through closure of microswitch 112 by the next succeeding stack 18 of magazines or the like to be tied. By placing the microswitch 112 ahead of microswitch 114 in the conveyor path, as a stack 18 leaves the tying station, it will first release the microswitch 112 so as to open microswitch 112 before the stack releases microswitch 114 to close the latter microswitch. By this means, the circuit which includes microswitches 112 and 114 will remain open once a stack of magazines or the like has caused microswitch 114 to open, until a next succeeding stack engages and closes the microswitch 112 to initiate another cycle of operation of the tying mechanism.

FIGS. 12 to 16 of the drawings illustrate a second form of the invention which is embodied in the same general overall conveyor system as the first form of the invention shown in FIGS. 1 to 11, but which differs from the first form by having each of the two tying mechanisms mounted on carriage means which is arranged for reciprocal sliding movement in the longitudinal directing of the respective conveyor, such movement of the carriage means being synchronized with conveyor movement to bring the tying mechanism substantially up to conveyor speed proximate the time the knot is tied. By this means a tight loop of string can be tied about the moving bundle as it passes the tying station with a much greater lineal conveyor speed than that which can be employed with the first form of the invention shown in FIGS. 1 to 11, thereby permitting a substantial increase in the overall bundle tying production rate with the use of the second form of the invention illustrated in FIGS. 12 to 16.

The second form of the invention also differs from the first form by employing simplified power means for driving each of the tying mechanisms. Additionally, the second form of the invention differs from the first form by initiating each tying cycle through microswitch means that is operated by cam means associated with the respective conveyor, so that each tying cycle is synchronized with a respective pusher post of the conveyor instead of with an actual stack of magazines. These differences considerably simplify the electrical circuitry required for timing and actuation of the tying mechanisms, and permit bundles of any size to be tied without requiring adjustment of microswitch positions.

FIGS. 12 to 16 illustrate only those portions of one of the conveyor mechanisms and its associated tying mechanism which embody changed features over those of the first form illustrated in FIGS. 1 to 11. The remaining structure not illustrated in FIGS. 12 to 16 is essentially the same as the structure shown in FIGS. 1 to 6.

Referring now to the structural details illustrated in FIGS. 12 to 16, table structure 10*a* is shown in the region of the modified tying mechanism 26*a*. The table structure 10*a* includes a pair of generally vertical, laterally spaced frame members 222 ahead of the tying mechanism 26*a*, and a second pair of generally vertical, laterally spaced frame members 224 behind the tying mechanism 26*a*. A pair of parallel slide bars 226 are supported between the respective pairs of frame members 222 and 224, the bars 226 being arranged in the longitudinal direction of the conveyor associated with table structure 10*a*, and being located in a generally horizontal plane below and parallel to the surface of table structure 10*a*. The subframe 130*a* upon which the tying mechanism 26*a* is supported is in the form of a carriage that is supported on the parallel slide bars 226 for reciprocal sliding movement in the longitudinal direction of the conveyor. Suitable bearing means may be employed for the sliding engagement of the carriage 130*a* on the bars 226, such as recirculating ball bearing means (not shown), for freedom of the sliding movement.

Power for reciprocally driving the carriage 130*a* is supplied to a power input shaft 228 that is rotatably mounted in bearings 230 supported on the frame members 222. A sprocket 232 on shaft 228 is driven by a chain 234, the chain in turn being driven by a sprocket that may be mounted on one of the shafts associated with the conveyor mechanism, as for example on the same shaft as the sprocket 56 on the left-hand side of FIG. 5. Thus, the shaft 228 will be driven at a substantially constant speed and will be in synchronism with the conveyor mechanism that is associated with the tying mechanism 26*a*.

Fixedly secured upon the shaft 228 for rotation therewith is an eccentric cam wheel 236 which engages a cam follower roller 238 supported on the carriage 130*a*. A carriage return spring 239 is engaged between the carriage 130*a* and the table structure 10*a* so as to continuously bias the cam follower roller 238 against the eccentric cam wheel 236. By this means, the eccentric cam wheel 236 will drive the carriage 130*a* reciprocally on the slide bars 226 in a direction parallel to the direction of movement of the associated conveyor, with such reciprocal movement being synchronized to the movement of the conveyor.

Mounted on one end of the shaft 228 to the outside of the respective bearing 230 is a switch actuator cam 240 which engages a switch 242 so as to periodically close and open the switch 242 in synchronism with the periodic reciprocal movement of the carriage 130*a* and with the associated conveyor. The switch 242 is the actuator switch for initiating a tying cycle of the tying mechanism 26*a*, and hence the cam 240 is timed relative to the conveyor and to the eccentric cam wheel 236 so that knotting of the string by the tying mechanism at the trailing edge of each bundle will be effected when the carriage 130*a* is moving forwardly in its reciprocating cycle at substantially the same speed as the forward movement of the conveyor.

Referring now to some of the structural details of the modified form of tying mechanism 26*a* as illustrated in FIGS. 12, 13 and 14, the carriage 130*a* embodies wall structure 134*a* upon which a hub 136*a* is mounted so as to project laterally outwardly with its axis generally horizontal and normal to the direction of conveyor travel. Support post 138*a* is fixedly supported at its lower end to the outer end of hub 136*a* projecting upwardly at a slight rearward tilt through opening 140*a* in the

top of table structure 10*a*. The hub 136*a* and support post 138*a* are the same as the corresponding hub and support post members 136 and 138, respectively, of the first form of the invention as illustrated in FIGS. 7 to 10. Additionally, the modified form of the invention as shown in FIGS. 12 to 14 employs the same tying arm 126 and means for feeding the string thereto as the first form, as best shown in FIG. 7, and hence the tying arm and string feeding means are not shown in the FIGS. of the drawings which illustrate the modified form of the invention.

It will be noted by a comparison of FIGS. 12 and 13 on the one hand and FIGS. 7 and 8 on the other hand, that the opening 140*a* in the table through which the support post 138 of the modified form extends is considerably longer than the corresponding opening 140 of the first form. This additional length of the opening 140*a* is to accommodate the reciprocating movement of the modified tying mechanism 26*a*.

As with the first form of the invention, reciprocating pivotal movement of the tying arm that is pivotally connected to the upper end of support post 138*a* is effected through a lever generally designated 148*a*, which includes as a part thereof a fulcrum shaft 150*a* extending axially through the hub 136*a*. The lever 148*a* includes an upper lever arm 152*a* that is integrally connected to the outer end of fulcrum shaft 150*a* and projects upwardly beyond the upper end of support post 138*a* and is operatively connected proximate its upper end to the tying arm by means of a link in the same manner as the upper lever arm 152 is connected by link 154 to tying arm 126 in FIG. 7.

The lever 148*a* also includes a lower lever arm 156*a* integrally connected to the fulcrum shaft 150*a* at the inner end of the shaft and extending downwardly therefrom. Pivotally connected to the lower lever arm 156*a* proximate its lower end is a link 158*a*, the other end of which is eccentrically pivotally connected to a crank wheel 160*a* which, in the modified form of the invention, replaces the brake wheel 160 of the first form of the invention.

Crank wheel 160*a* is supported on a transverse shaft 170*a* which is driven a single revolution each time the tying mechanism actuator switch 242 is closed, so as to drive the crank wheel 160*a* through a single revolution and move the tying mechanism 26*a* through a single tying cycle.

Such periodic rotation of the shaft 170*a* through a single revolution is, in the modified apparatus shown in FIGS. 12 to 16, accomplished by electrically energized pneumatic power drive means including a pneumatic cylinder 244 from which piston rod 246 projects. A pull chain 248 is connected to the piston rod 246, and is engaged around a sprocket 250 coaxially disposed about the shaft 170*a* and operatively connected to the shaft 170*a* through a one-tooth clutch 252. A spring 254 coiled about the shaft 120*a* serves to return the chain 248 and clutch 252 to their initial positions after the completion of each actuating stroke of the pneumatic cylinder 244.

Pneumatic cylinder 244 is preferably but not necessarily a double acting cylinder, the operation of which is controlled by a rotary, two-position solenoid valve 256 which, in turn, is shifted between its two positions by the closing and opening of the tying mechanism actuating switch 242. With pneumatic cylinder 244 of the double acting type, a pair of air conduits 258 and 260 extend from the solenoid valve 256 to opposite ends of cylinder 244. Air pressure and exhaust conduits 262 and 264, respectively, are connected to the solenoid valve 256, air pressure being supplied to the conduit 262 by any suitable conventional air pressure source (not shown).

A piston stabilizer spring, in the form of a helical tension spring, is connected at one end to the piston rod 246 and at its other end to a suitable bracket 268 attached to the carriage 130*a*. This stabilizer spring 266 is employed in the capacity of a dampener to slow down the piston and prevent it from moving too freely and quickly during portions of the stroke when the load on the piston is light. Actuation of the tying mechanism 26*a* through a complete tying cycle involves wide variations in the amount of actuating force that is required, and because of the relatively large amount of actuating force required in some parts of the cycle, as for example when the string is being cut at the end of the cycle, the pneumatic cylinder 244 must be substantially overrated as compared with the average power required. Because of such overrating there is a tendency for the piston to move too quickly during light load portions of the cycle, and if it were not for the dampening effect of the stabilizer spring 266 the timing would become rather critical because of variations therein resulting from heat and friction factors.

The periphery of crank wheel 160*a* provides a cam 165 is circular except for a cutaway cam recess portion 270 therein. A cam follower wheel 272 is mounted on a lever 274, the wheel 272 being mounted at the free end of one arm 276 of the lever 274, the wheel 272 being biased downwardly against the peripheral cam surface on crank wheel 160*a* by a coil tension spring 280 operatively engaged between the free end of the other lever arm 278 and the carriage 130*a*. During each cycle of operation of the tying mechanism 26*a*, the pneumatic cylinder 244 will, through the piston rod 246, pull chain 248, sprocket 250, clutch 252 and shaft 170*a*, pull the crank wheel 160*a* around from an initial position as illustrated in FIG. 12 wherein the cam follower wheel 272 is seated in the cam recess 270, to a final position as illustrated in FIG. 13 which is substantially short of a full revolution, and then the inertia of the tying mechanism will move the crank wheel 160 *a* through the remainder of a whole revolution, with the pressurized engagement of cam follower wheel 272 in the cam recess 270 stopping such inertial movement when the crank wheel 160*a* has returned to its initial position as illustrated in FIG. 12. Thus, the combination of the peripheral, recessed cam on the crank wheel 160*a* and the lever-mounted, spring-biased cam follower wheel 272 engaged thereagainst, serves as stop means for arresting movement of the tying mechanism 26*a* at the completion of a full cycle of operation, and in the proper position for commencement of a succeeding cycle of operation.

The power stroke of the pneumatic cylinder 244 is directed to the right as viewed in FIGS. 12, 13 and 14, the piston rod 246 moving from the position illustrated in FIG. 12 to the position illustrated in FIGS. 13 and 14 during the power stroke. The power stroke is defined by the actuation of switch 242 by cam 240, the power stroke commencing when the cam 240 closes switch 242, and the power stroke terminating when the cam 240 causes the switch 242 to again open. At the completion of this power stroke, the return spring 254 on shaft 170*a* returns the clutch 252 and pull chain 248 to their initial positions ready for a succeeding cycle of operation, and since the clutch 252 is an overrunning-type of clutch, such return does not in any way interfere with the continued inertial movement of the tying mechanism and hence of the shaft 170*a* and crank wheel 160*a*. If a single-acting pneumatic cylinder is employed, the return spring 254 will, upon returning the pull chain 248 to its initial position, also return the piston rod 246 to its initial position. However, with a double-acting pneumatic cylinder such as the cylinder 244 illustrated in the drawings, the piston and piston rod will be forcibly returned to their initial positions by air pressure provided from solenoid valve 256 through conduit 260 to the right-hand side of the piston as viewed in the drawings when the switch 242 is opened at the end of a power cycle. With the double-acting pneumatic cylinder 244, the power stroke is effected by admission of air under pressure from solenoid valve 256 through conduit 258 to the left-hand side of the piston as viewed in the drawings when the switch 242 is closed.

The tying mechanism 26*a* also includes a receiver or knotter 192*a* which is driven off of the shaft 170*a* but is otherwise the same as the knotter 192 shown in FIGS. 9 and 10.

A microswitch 282 is supported on table structure 10*a* in the path of each stack 18*a* of magazines that is being moved by a respective pusher post 50*a* attached to conveyor chain 48*a*. The microswitch 282 is in series with switch 242 in the power-line 284 which provides electrical energy to solenoid valve 256 as illustrated in the wiring diagram of FIG. 16, wherein

one side of solenoid valve 256 is connected to powerline 284 through the two switches 242 and 282, and the other side of solenoid valve 256 is connected to ground. The microswitch 282 is normally open, but is closed upon engagement thereof by a stack 18*a* of magazines or the like. In this manner, the circuit for solenoid valve 256 will only be closed by closure of the cam actuated switch 242 for operation of tying mechanism 26*a* if there is a stack 18*a* of magazines or the like in position to be tied, which stack will have closed the microswitch 282 prior to the time that the tying mechanism actuator switch 242 closes to initiate a tying operation. However, if one of the conveyor pusher posts 50*a* moves by the tying station without a stack 18*a* of magazines or the like in front of it, the microswitch 282 will remain unactuated, and hence the circuit to solenoid valve 256 will remain open despite the cam actuated closure of switch 242, so that the tying mechanism 26*a* will not go through a tying cycle.

The cam shaft 228 upon which the cam wheel 236 and the switch actuator cam 240 are supported is synchronized with the conveyor chain 48*a* so that the eccentric cam wheel 236 will drive the tying mechanism carriage 130*a* up to substantially the same speed as the conveyor chain 48*a* is moving as each pusher post 50*a* pushes a stack 18*a* of magazines or the like over the carriage, and the switching cam 240 is timed to cause the tying mechanism 26*a* to effect the knotting action at the trailing edge of the stack 18*a* of magazines at substantially the same instant that the carriage 130*a*, and hence the tying mechanism 26*a*, reach the approximate speed of movement of the conveyor chain 48*a*. By such timing the string can be tied tightly despite relatively fast movement of the stack 18*a* of magazines along the table structure 10*a*, since at the exact instant of knotting there is not substantial tendency for the stack 18*a* to move away from the knotting mechanism.

FIGS. 17 to 23 of the drawings illustrate a third form of the invention which is substantially the same as the second form that is shown in FIGS. 12 to 16, but has added thereto bundle clamping apparatus adapted to apply clamping pressure against opposite sides of the bundle adjacent to where the string is being tied during the tying operation. This is important if the bundles are composed of magazines or the like of a type which tend to spread apart of fluff up, in which case the clamping pressure will hold the magazines or the like tightly together so as to assure that they are tied tightly.

In this form of the invention the table structure 10*b* is substantially the same as table structure 10*a* of FIGS. 12 to 16, except for additional length of the opening 140*b* in the table to accommodate movement of the lower portion of the bundle clamping apparatus.

The carriage 130*b* of this third form of the invention is substantially the same as the carriage 130*a* of the form shown in FIGS. 12 to 16, except for the addition of the bundle clamping apparatus generally designated 286 with is supported on carriage 130*b* for longitudinal reciprocating movement therewith. The bundle clamping apparatus 286 is adapted to apply positive clamping pressure to opposite sides of each bundle, such as stack 18*b* of magazines, during the tying operation.

Bundle clamping apparatus 286 includes upper and lower elongated clamping jaws 288 and 290, respectively, which are longitudinally arranged so as to be parallel to each other and also parallel and adjacent to the string where the latter is doubled back against the top and bottom surfaces of the stack 18*b*. The upper clamping jaw 288 is arranged for vertical movement into and out of clamping position while the lower clamping jaw 290 has a substantially fixed vertical position.

The support means for supporting the upper clamping jaw 288 includes an arm 292 which is fixedly secured to the wall 134*b* of carriage 130*b* at a point on the latter that is substantially laterally offset relative to the clamping jaws 288 and 290 so as to allow clearance for longitudinal movement of the stack 18*b* past the tying station. Arm 292 extends upwardly through a longitudinally arranged slot 293 in the table, and thence rearwardly and laterally, and at its free end has a pneumatic cylinder 294 fixedly secured thereto. The cylinder 294 is arranged with its axis generally vertically oriented so that the piston rod 296 projects vertically downward therefrom. Integrally mounted on the lower, free end of the piston rod 296 is upper jaw support bar 298 which is generally horizontally disposed, with its axis arranged generally parallel to the direction of movement of the stack 18*b* of magazines or the like.

The upper clamping jaw 288 includes a channel-shaped body 300 which is longitudinally slidably mounted on the jaw support bar 298, with the flat, bottom surface of the channel facing downwardly so as to be engageable against the upper surface of the stack 18*b* of magazines or the like. The channel-shaped body 300 has forward and rearward end walls 302 and 304, respectively, the body 300 being considerably longer than the jaw support bar 298 to allow longitudinal sliding movement of the body 300 on the support bar 298 from a retracted position as illustrated in FIGS. 17 and 21, forwardly to an extended position as illustrated in FIGS. 19 and 22. The body 300 is biased rearwardly to its normal or retracted position as illustrated in FIGS. 17 and 21 by means of a coil tension spring 306, and the retracted position is defined by a stop tang 308 which projects inwardly from the body 300 so as to be engageable against the forward end of the jaw support bar 298. Freedom of longitudinal sliding movement of the channel-shaped body 300 on the jaw support bar 298 despite substantial clamping pressure is assured by the provision of a plurality of ball bearings 310 which are engageable between the body 300 and the support bar 298, the ball bearings preferably being seated in suitable recesses 311 in the lower surface of support bar 298 so as to ride along the flat bottom surface of the channel 300.

The support means for lower clamping jaw 290 includes an arm 312 which is fixedly secured to the wall 134*b* of carriage 130*b* and which has fixedly secured at its free end a jaw support bar 314 over which the the channel-shaped body 316 of the lower clamping jaw 290 is longitudinally slidably mounted. The details of construction of the lower clamping jaw 290 are substantially the same as those of the upper clamping jaw 288 as heretofore described, except for the addition of a small inclined ramp 317 at the rearward end of the lower jaw body 316 to facilitate the sliding movement of stack 18*b* of magazines or the like onto the lower clamping jaw 290.

The vertical clamping and unclamping movements of the upper clamping jaw 288 are synchronized with the actuation of the tying mechanism 26*b* so that when the tying mechanism 26*b* is inoperative the upper jaw 288 is in an uppermost, release position as illustrated in FIG. 17, and when the tying mechanism 26*b* is energized, the upper clamping jaw 288 is actuated, being shifted downwardly into pressurized engagement against the bundle 18*b* as illustrated in FIGS. 18, 19 and 20. The actual vertical positioning of the upper clamping jaw 288 in this clamping position is determined by the thickness of the bundle 18*b*, the upper clamping jaw 288 being arranged to be moved downwardly into engagement with the bundle 18*b* and then to apply a predetermined amount of downward force against the bundle which is sufficient to assure that the bundle will be tight when it is tied, as for example a force of about 40 to 50 pounds. When actuation of the tying mechanism 26*b* is completed and the tying mechanism becomes deenergized, the upper clamping jaw 288 is likewise released, being shifted back up to its release position as shown in FIG. 17.

Such synchronization of the clamping and unclamping movements of the upper clamping jaw 288 with the energization and deenergization of the tying mechanism 26*b* may be accomplished by the simple expedient of pneumatically coupling the cylinder 294 in parallel with the pneumatic cylinder which drives the tying mechanism 26*b*. Thus, referring to FIGS. 13 and 14 which show the pneumatic drive arrangement for the tying mechanism 26*a*, which is the same pneumatic arrangement that is employed with the tying mechanism 26*b*, the air conduit 318 which provides air under pressure to the cylinder 294 above the piston is operatively

connected to the air conduit 258 leading from solenoid valve 256 to one side of the pneumatic cylinder 244, while air conduit 320 leading to pneumatic cylinder 286 below the piston is operatively connected to the air conduit 260 leading from solenoid valve 256 to the other side of the cylinder 244.

The amount of downward force of the upper clamping jaw 288 against the bundle 18*c* is controlled in this pneumatic system by providing a pressure regulator valve 322 in the air conduit 318. Preferably, this pressure regulator valve 322 is adjustable so that the amount of clamping force can be adjusted according to the particular requirements. A similar pressure regulator valve 324 may be provided in the air conduit 320 to control the retracting force that is applied to the upper clamping jaw 288.

While a pneumatic system has been shown and described for providing the clamping and unclamping movements of the upper clamping jaw 288, it is to be understood that the jaw 288 may alternatively be actuated by hydraulic or electrical means, or may even be mechanically driven from same source of mechanical power which drives the main pusher chain and which reciprocally drives the carriage 130*b*, without departing from the present invention.

The forward slidability of clamping jaw bodies 300 and 316 on their respective support bars 298 and 314 permits the clamping action to be effective while at the same time allowing lost motion to permit the stack of magazines or the like to progress forwardly at conveyor speed at the beginning of a tying cycle before the carriage 130*b* and hence the jaw support bars 298 and 314 have reached the speed of the magazines, and also at the end of the cycle before the clamping jaws have been released, but when the carriage 130*b* and hence the jaw support bars 298 and 314 commence to slow down relative to the movement of the stack of magazines or the like. Thus, when the tying cycle first commences, and air under pressure is introduced into pneumatic cylinder 294 through conduit 318 to actuate the bundle clamping apparatus 286, the clamping jaw bodies 300 and 316 will be at their rearwardmost positions as illustrated in FIGS. 17 and 21. Then, in the beginning portion of the tying cycle while the carriage 130*b* is catching up in speed with the stack 18*c* of magazines or the like the clamping jaw bodies 300 and 316 will be moved a short distance forwardly along their respective jaw support bars 298 and 314. Then, near the end of the tying cycle as the carriage 130*b* begins to slow down relative to the stack 18*c* of magazines or the like, the clamping jaw bodies 300 and 316 will be moved a short distance farther forward on their respective support bars 298 and 314. For illustrative purposes the bodies 300 and 316 have been shown at their forwardmost positions in FIGS. 19 and 22; however, during normal operation of the apparatus the bodies will not be required to undergo this much forward movement. Finally, as the tying cycle is being completed by inertial movement of the tying mechanism, air under pressure will be introduced into the pneumatic cylinder 294 through air conduit 320 to release the clamping apparatus 286, and as soon as the gripping pressure is released, the clamping jaw bodies 300 and 316 will be sprung back to their initial, retracted positions as illustrated in FIGS. 17 and 21, so as to be ready for another cycle of operation.

Although the pneumatic cylinder 294 has been illustrated as a double-acting cylinder, it is to be understood that it can be made single-acting, the air pressure providing the actuation and clamping force, with spring means providing for the upward withdrawal movement of the upper clamping jaw 288.

It will be noted from FIGS. 17 to 20 that the lower clamping jaw 290 protrudes slightly above the upper surface of the table 10*b*. This assures positive gripping of the stack 18*b* of magazines or the like between the clamping jaws 288 and 290 without interference from the table structure 10*b*, so that the clamping apparatus 286 will be effective in holding the stack tightly together and straight in the region adjacent to where the string is tied.

FIGS. 24 to 26 illustrate a modification of the apparatus shown in FIGS. 17 to 23 wherein the lower clamping jaw 290 of FIGS. 17 to 23 is replaced by lower clamping means in the form of a chain which is driven at the same speed as the pusher chain which moves the stacks of magazines or the like along the table.

The table structure 10*c* of the modified apparatus shown in FIGS. 24 to 26 has a longitudinal opening 140*c* therein which is somewhat more extended than in the apparatus of FIGS. 17 to 23 in order to accommodate the chain that is employed as the lower clamping means. The tying mechanism 26*c* is substantially the same as the tying mechanism 26*b* of FIGS. 17 to 20 except for the provision of adequate clearance in the end walls of carriage 130*c* to allow passage of the chain and its support track therethrough.

The bundle clamping apparatus of FIGS. 24 to 26 is generally designated 286*c*, and serves the same function as the bundle clamping apparatus 286 of FIGS. 17 to 23, namely, to clamp together and tighten stacks 18*c* of magazines or the like which tend to spread outwardly or fluff up. The upper clamping jaw 288*c* is identical to the upper clamping jaw 288 of FIGS. 17 to 23, and is actuated by the same means and in the same manner as the upper clamping jaw 288 of FIGS. 17 to 23.

The lower clamping means in the modification illustrated in FIGS. 24 to 26 is generally designated 290*c*, and includes a continuous chain loop 326 which is supported on a drive sprocket 328 to the rear of carriage 130*c* and an idler sprocket 330 located forwardly of carriage 130*c*. The lower half of the chain loop 326 is held upwardly out of the way of the mechanism within carriage 130*c* by means of a pair of idler sprockets 332 adjacent the respective sprockets 328 and 330. All of the sprockets 328, 330 and 332 are rotatably mounted on the table structure 10*c*, the drive sprocket 328 being mounted on a transverse drive shaft 334 which is driven by means of a power transfer chain 336 from the power input shaft 228*c* corresponding with power input shaft 228 shown and described in detail in FIGS. 13 and 14 of the drawings. By this means the upper half of chain loop 326 is continuously driven in the forward, longitudinal direction at the same speed as the pusher chain which moves the stacks of magazines or the like forwardly along the table structure 10*c*. The upper half of chain loop 326 protrudes slightly above the upper surface of table 10*c* and is in vertical alignment with the upper clamping jaw 288*c* so that when the upper clamping jaw 288*c* is actuated and moved downwardly to the position shown in FIGS. 24 to 26, a stack 18*c* of magazines or the like will be securely clamped between the upper clamping jaw 288*c* and the portion of chain 326 that is disposed immediately below the stack 18*c* of magazines or the like. The upper clamping jaw 288*c* permits lost motion in the longitudinal direction in the same manner as described in detail hereinabove in connection with the upper clamping jaw 288 of FIGS. 17 to 23; however, there will be no relative longitudinal shifting between the upper half of the chain loop 326 and the stack 18*c* of magazines or the like since they are moving at the same longitudinal speed.

The chain 326 is backed up by a chain support track 338 located immediately underneath the chain in the region where the clamping action occurs. The track 338 is stationarily supported on the table structure by suitable arm means 340, and includes a longitudinally arranged, upwardly facing channel member 342 which has a series of transversely arranged rollers 344 supported therein at regularly spaced intervals along it length. The chain 326 has flat, straight upper and lower surfaces in the region where the clamping action is effected, so that the chain will smoothly ride in a straight line along the rollers 344 and will present a straight, flat upwardly facing clamping surface against which the stack 18*c* of magazines or the like is clamped.

While the instant invention has been shown and described herein in what are conceived to be the most practical and preferred embodiment, it is recognized that departures may be

made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims.

I claim:

1. Bundle tying apparatus which comprises support means having a tying station thereon, conveyor means on said support means arranged to move a series of bundles sequentially past said tying station, tying mechanism proximate said station comprising first and second tying elements located generally on opposite sides of the path of travel of said bundles, a source of supply of string fed through said second element and retained by said first element to extend across said path in front of each bundle whereby the leading edge of the bundle engages the string and movement of the bundle causes first and second portions of the string to be doubled back along respective opposite sides of the bundle to the trailing edge thereof, said tying mechanism being cyclically operable to knot said string portions together, energizing means for initiating a cycle of operation of said tying mechanism according to bundle position in said path so that said tying mechanism will knot said string portions together proximate said trailing edge of the bundle as the bundle passes said station, and bundle clamping means mounted on said support means proximate said tying station, said clamping means comprising a normally open pair of opposed clamping jaws located generally on opposite sides of the path of travel of said bundles, and cyclically operable jaw drive means connected to at least one of said jaws for closing said jaws into clamping engagement against said opposite sides of each bundle when the bundle is at the tying station and opening the jaws as said bundle leaves the tying station and the next bundle enters the tying station, said jaws being movable in the direction and at substantially the speed of movement of each bundle while the jaws are in clamping engagement therewith.

2. Bundle tying apparatus as defined in claim 1, wherein said tying mechanism is supported on carriage means mounted for reciprocal sliding movement in the longitudinal direction of said conveyor means, and carriage drive means connected to said carriage means and synchronized with said conveyor means for applying said reciprocal sliding movement to said carriage means, said carriage drive means moving said carriage means in the same direction as the movement of said conveyor means proximate the time said knotting is effected, at least one of said jaws being supported on said carriage means for reciprocal movement therewith in the longitudinal direction.

3. Bundle tying apparatus as defined in claim 2, wherein said driven jaw is supported on said carriage means.

4. Bundle tying apparatus as defined in claim 3, wherein the other jaw is supported on said support means independent of said carriage means and comprises a chain synchronized with said conveyor means.

5. Bundle tying apparatus as defined in claim 3, wherein both of said jaws are supported on said carriage means.

6. Bundle tying apparatus as defined in claim 3, wherein said driven jaw comprises a longitudinally arranged support bar and an elongated jaw body longitudinally slidably mounted thereon, said body being rearwardly biased on said bar, and being forwardly slidable on the bar against said biasing to accommodate lost motion between the carriage means and the bundle.

7. Bundle tying apparatus as defined in claim 1, wherein said tying mechanism includes pneumatically operable drive means, said jaw drive means also being pneumatically operable and being coupled to said tying mechanism drive means for synchronization therewith.

8. Bundle tying apparatus which comprises support means having a tying station thereon, conveyor means on said support means arranged to move a series of bundles sequentially past said tying station, tying mechanism proximate said station comprising first and second tying elements located generally on opposite sides of the path of travel of said bundles, a source of supply of string fed through said second element and retained by said first element to extend across said path in front of each bundle whereby the leading edge of the bundle engages the string and movement of the bundle causes first and second portions of the string to be doubled back along respective opposite sides of the bundle to the trailing edge thereof, said tying mechanism being cyclically operable to knot said string portions together, and energizing means for initiating a cycle of operation of said tying mechanism according to bundle position in said path so that said tying mechanism will knot said string portions together proximate said trailing edge of the bundle as the bundle passes said station, said tying mechanism including pneumatically operable drive means having a rotatable drive shaft coupled to the tying mechanism, and pneumatic cylinder means operatively connected to said drive shaft through clutch means, said pneumatic cylinder means being operable in response to said energizing means to apply limited rotational movement to said drive shaft so as to drive the tying mechanism through a single cycle of operation.

9. Bundle tying apparatus as defined in claim 8, wherein the operative connection between said pneumatic cylinder means and said drive shaft includes a pull chain connected to the pneumatic cylinder means, a sprocket coaxial with said drive shaft and over which said pull chain is engaged, and an overrunning clutch connection between said sprocket and said drive shaft.

10. Bundle tying apparatus as defined in claim 8, which includes a cam wheel having a recess therein mounted on said drive shaft, and cam follower means spring-biased into engagement with said cam wheel, engagement of said can follower means in said cam wheel recess stopping movement of said drive shaft and hence of said tying mechanism at the end of a tying cycle.

11. Bundle tying apparatus which comprises support means having a tying station thereon, conveyor means on said support means arranged to move a series of bundles sequentially past said tying station, tying mechanism proximate said station comprising first and second tying elements located generally on opposite sides of the path of travel of said bundles, a source of supply of string fed through said second element and retained by said first element to extend across said path in front of each bundle whereby the leading edge of the bundle engages the string and movement of the bundle causes first and second portions of the string to be doubled back along respective opposite sides of the bundle to the trailing edge thereof, said tying mechanism being cyclically operable to knot said string portions together, energizing means for initiating a cycle of operation of said tying mechanism according to bundle position in said path so that said tying mechanism will knot said string portions together proximate said trailing edge of the bundle as the bundle passes said station, said tying mechanism being supported on carriage means mounted for reciprocal sliding movement in the longitudinal direction of said conveyor means, and carriage drive means connected to said carriage means and synchronized with said conveyor means for applying said reciprocal sliding movement to said carriage means, said carriage drive means moving said carriage means in the same direction as the movement of said conveyor means proximate the time said knotting is effected.

12. Bundle tying apparatus as defined in claim 11, wherein said carriage drive means comprises cam means on said support means driven from the same power source as said conveyor means and cam follower means on said carriage means.

13. Bundle tying apparatus which comprises support means having a tying station thereon, conveyor means on said support means arranged to move a series of bundles sequentially past said tying station, tying mechanism proximate said station comprising first and second tying elements located generally on opposite sides of the path of travel of said bundles, a source of supply of string fed through said second element and retained by said first element to extend across said path in front of each bundle whereby the leading edge of the bundle engages the string and movement of the bundle causes first

and second portions of the string to be doubled back along respective opposite sides of the bundle to the trailing edge thereof, said tying mechanism being cyclically operable to knot said string portions together energizing means for initiating a cycle of operation of said tying mechanism according to bundle position in said path so that said tying mechanism will know said string portions together proximate said trailing of the bundle as the bundle passes said station, said tying mechanism including electrically operable drive means, and said energizing means including electrical switch means operatively connected to said drive means and disposed partly in said path of travel so as to be directly actuated by the respective bundles, said switch means including microswitch means directly actuated by the respective bundles, and cycling relay means energized by said microswitch means, said cycling relay means controlling both the initiation and the completion of said cycle of operation of the tying mechanism.

14. Bundle tying apparatus as defined in claim 13, wherein said drive means includes a continuously running electric motor, a normally disengaged magnetic clutch and a normally engaged solenoid-operated brake, said cycling relay means, upon energization thereof, energizing said brake solenoid to release said brake and energizing and thereby engaging said magnetic clutch.

15. Bundle tying apparatus as defined in claim 13, wherein said cycling relay includes a holding circuit that is closed upon energization of said cycling relay to hold the cycling relay in its energized state through said cycle of operation of the tying mechanism and normally closed cam-operated switch means in said holding circuit which is opened by a cam in said drive means to define completion of said cycle of operation of the tying mechanism.

16. Bundle tying apparatus which comprises support means having a tying station thereon, conveyor means on said support means arranged to move a series of bundles sequentially past said tying station, tying mechanism proximate said station comprising first and second tying elements located generally on opposite sides of the path of travel of said bundles, a source of supply of string fed through said second element and retained by said first element to extend across said path in front of each bundle whereby the leading edge of the bundle engages the string and movement of the bundle causes first and second portions of the string to be doubled back along respective opposite sides of the bundle to the trailing edge thereof, said tying mechanism being cyclically operable to knot said string portions together, and energizing means for initiating a cycle of operation of said tying mechanism according to bundle position in said path so that said tying mechanism will knot said string portions together proximate said trailing edge of the bundle as the bundle passes said station, said first tying element comprising a knotter and said second tying element comprising a tying arm having said string fed from the free end thereof, said tying arm being mounted for reciprocal swinging movement during a cycle of operation of the tying mechanism, the free end thereof swinging from an inoperative position spaced from said path forwardly in the path immediately behind a bundle to an operative knotting position engaged with said knotter, and then swinging back out of the path to said inoperative position, said knotter including a bobbin that is quickly movable to effect tying of a knot upon engagement of said free end of said tying arm with said knotter, and limiting bar means on the knotter engageable by said tying arm to limit the extent of penetration of the tying arm into the knotter and thereby prevent the tying arm from impacting against the bobbin.

17. Bundle tying apparatus which comprises support means having a tying station thereon, conveyor means on said support means arranged to move a series of bundles sequentially past said tying station, tying mechanism proximate said station comprising first and second tying elements located generally on opposite sides of the path of travel of said bundles, a source of supply of string fed through said second element and retained by said first element to extend across said path in front of each bundle whereby the leading edge of the bundle engages the string and movement of the bundle causes first and second portions of the string to be doubled back along respective opposite sides of the bundle to the trailing edge thereof, said tying mechanisms being cyclically operable to knot said string portions together and energizing means for initiating a cycle of operation of said tying mechanism according to bundle position in said path so that said tying mechanism will knot said string portions together proximate said trailing edge of the bundle as the bundle passes said station, said first tying element comprising a knotter and said second tying element comprising a tying arm having said string fed from the free end thereof, said tying arm being mounted for reciprocal swinging movement during a cycle of operation of the tying mechanism, the free end thereof swinging from an inoperative position spaced from said path forwardly into the path immediately behind a bundle to an operative knotting position engaged with said knotter, and then swinging back out of the path to said inoperative position, said support means including an elongated, generally horizontal surface defining said path of travel at least in part, said conveyor means including a series of pusher members adapted to push said bundles sequentially along, said surface, said knotter being located generally below said surface with said surface apertured proximate the knotter to receive the tying arm, and said tying arm being pivotally mounted above said surface with the free end thereof swingable downwardly and forwardly behind each bundle into engagement with the knotter, said conveyor means including a continuous chain loop disposed principally below said surface and having an upper section thereof disposed adjacent and generally parallel to said surface, said surface having a longitudinally extending slot therein, and said pusher members comprising pusher posts projecting outwardly from said chain loop so that the posts on said upper section of the chain, project upwardly through said slot and above said surface, said conveyor means also including a continuous belt loop having an upper section that is generally parallel to said upper section of the chain loop but is offset downstream therefrom so that part of said belt section is side-by-side with a downstream end portion of said chain section, said belt having a materially greater lineal speed than said chain, whereby bundles which have been tied at said tying station and are being moved by said pusher posts near the downstream end of said chain section are engaged by said belt section and moved downstream away from their respective chain pusher posts to provide clearance for said posts to turn downwardly through said slot at the downstream end of said chain section.

18. Bundle tying apparatus which comprises support means having a tying station thereon, conveyor means on said support means arranged to move a series of bundles sequentially past said tying station, tying mechanism proximate said station comprising first and second tying elements located generally on opposite sides of the path of travel of said bundles, a source of supply of string fed through said second element and retained by bundle first element to extend across said path in front of each bundle whereby the leading edge of the bundle engages the string and movement of the bundle causes first and second portions of the string to be doubled back along respective opposite sides of the bundle to the trailing edge thereof, said tying mechanism being cyclically operable to knot said string portions together, energizing means for initiating a cycle of operation of said tying mechanism according to bundle position in said path so that said tying mechanism will knot said string portions together proximate said trailing edge of the bundle as the bundle passes said station, said first tying element comprising a knotter and said second tying element comprising a tying arm having said string fed from the free end thereof, said tying arm being mounted for reciprocal swinging movement during a cycle of operation of the tying mechanism, the free end thereof swinging from an inoperative position spaced from said path forwardly into the path immediately behind a bundle to an operative knotting position engaged with said knotter, and then swinging back out of the path to said in-

operative position said support means including an elongated, generally horizontal surface defining said path of travel at least in part, said conveyor means including a series of pusher members adapted to push said bundles sequentially along said surface, said knotter being located generally below said surface with said surface apertured proximate the knotter to receive the tying arm, said tying arm being pivotally mounted above said surface with the free end thereof swingable downwardly and forwardly behind each bundle into engagement with the knotter, a pair of spaced, longitudinally arranged guide rails extending upwardly from said surface so as to further define said path of travel, and a pair of anticurling ears mounted proximate said tying station adjacent the respective guide rails spaced upwardly from said surface, said ears being biased toward operative positions wherein they project generally horizontally inwardly from said guide rails over said surface to hold bundles thin enough to fit under the ears down generally flat against said surface during tying, said ears having respective cam surfaces thereon engageable by side portions of bundles too thick to pass under the ears for camming said ears out of the way of such bundles.

19. Bundle tying apparatus which comprises support means having a tying station thereon, conveyor means on said support means arranged to move a series of bundles sequentially past said tying station, tying mechanism proximate said station comprising first and second tying elements located generally on opposite sides of the path of travel of said bundles, a source of supply of string fed through said second element and retained by said first element to extend across said path in front of each bundle whereby the leading edge of the bundle engages the string and movement of the bundle causes first and second portions of the string to be doubled back along respective opposite sides of the bundle to the trailing edge thereof, said tying mechanism being cyclically operable to knot said string portions together energizing means for initiating a cycle of operation of said tying mechanism according to bundle position in said path so that said tying mechanism will knot said string portions together proximate said trailing edge of the bundle as the bundle passes said station, second conveyor means on said support means oriented generally normal to said first mentioned conveyor means, said second conveyor means being located with respect to said first mentioned conveyor means so that once-tied bundles are delivered from the downstream end of said first mentioned conveyor means onto said second conveyor means from one side thereof whereby said once-tied bundles are moved sequentially by said second conveyor means with the string tie on each bundle disposed generally normal to the direction of movement, a second tying station on said support means adjacent to said second conveyor means and past which said once-tied bundles are moved by said second conveyor means, second tying mechanism proximate said second station comprising a pair of tying elements located generally on opposite sides of the path of travel of said bundles as they are moved by said second conveyor means, second tying mechanism proximate said second station comprising a pair of tying elements located generally on opposite sides of the path of travel of said bundles as they are moved by said second conveyor means, a second source of supply of string fed through one of said pair of elements and retained by the other of said pair to extend across said last mentioned path in front of each bundle whereby the leading edge of each bundle engages said second string and movement of the bundle causes portions of said second string to be doubled back along respective opposite sides of the bundle, generally at right angles to said first and second portions of said first mentioned string, to the trailing edge of the bundle, said second tying mechanism being cyclically operable to knot said second string portions together, second energizing means for initiating a cycle of operation of said second tying mechanism according to bundle position in said last mentioned path so that said second tying mechanism will knot said second string portions together proximate said trailing edge of the bundle as the bundle passes said second station, and a cover plate adapted to extend over a portion of said second conveyor means generally in line with said first mentioned conveyor means, said cover plate being movable between a covering position over said portion of the second conveyor means when a bundle is being delivered thereto from said first mentioned conveyor means wherein said cover plate prevents entanglement of the bundle with said second conveyor means as the bundle moves onto said second conveyor means, and an uncovering position wherein the plate permits engagement of the bundle by said second conveyor means.