United States Patent [19]

Board et al.

[11] **3,926,385**

[45] **Dec. 16, 1975**

[54] **RETRACTABLE SAFETY BELTS**

[76] Inventors: **Richard G. Board,** 3000 Connecticut Ave., Washington, D.C. 20008; **Nelson H. Shapiro,** 640 Washington Bldg., Washington, D.C. 20005

[22] Filed: **Mar. 18, 1974**

[21] Appl. No.: **452,351**

Related U.S. Application Data

[60] Division of Ser. No. 409,266, Nov. 5, 1964, Pat. No. 3,817,473, and a continuation-in-part of Ser. No. 377,344, June 23, 1964, Pat. No. 3,289,970.

[52] **U.S. Cl.** **242/107.4;** 297/388

[51] **Int. Cl.** **B65h 75/48**

[58] **Field of Search** ..... 242/107 R, 107.2, 107.3, 242/107.4; 297/388; 280/150 SB

[56] **References Cited**

UNITED STATES PATENTS

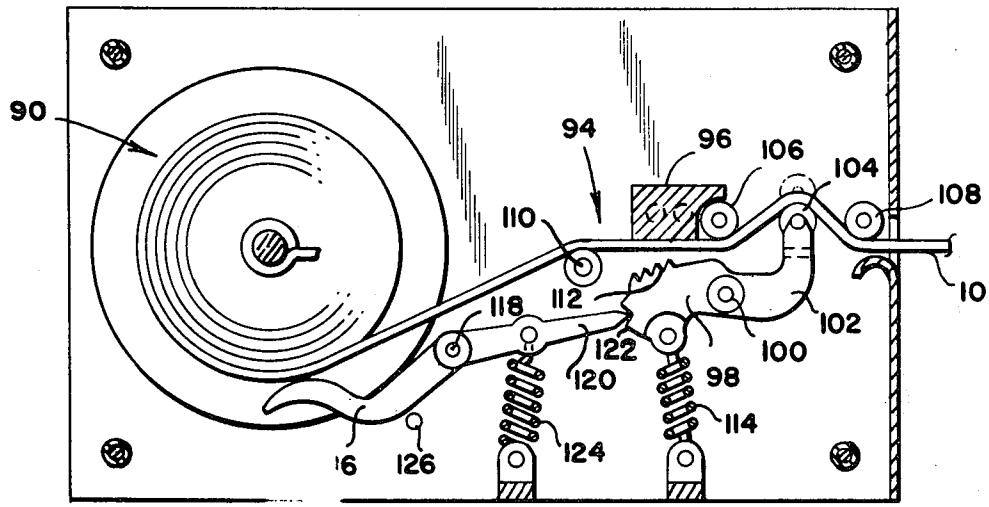
3,286,946	11/1966	Board	242/107.2
3,304,119	2/1967	Boedigheimer	297/388
3,338,532	8/1967	Board	242/107.4
3,409,949	11/1968	Kobrehel	297/388 X
3,819,126	6/1974	Stoffel	292/107.4

Primary Examiner—Edward J. McCarthy
Attorney, Agent, or Firm—Shapiro and Shapiro

[57] **ABSTRACT**

Retractable safety belt apparatus in which a strap is extended from a reel to a selected length and in which the apparatus is thereafter locked automatically to prevent further extension of the strap. Disclosed are: various mechanisms for controlling the operation of the extension-preventing device, including mechanisms driven by the reel and mechanisms responsive to strap tension; different types of strap claimps which open automatically during retraction of the strap and close automatically after desired extension of the strap, including a slider clamp and a clamp with a unidirectionally rotating clamp element; mechanisms which facilitate retraction of the strap; a mechanism which temporarily disables the extension-preventing device to permit the user to lengthen the belt after it has been fastened; and a belt fastener which ensures by a over-movement of fastener elements that the extended strap will always retract a bit after the belt is fastened.

14 Claims, 50 Drawing Figures



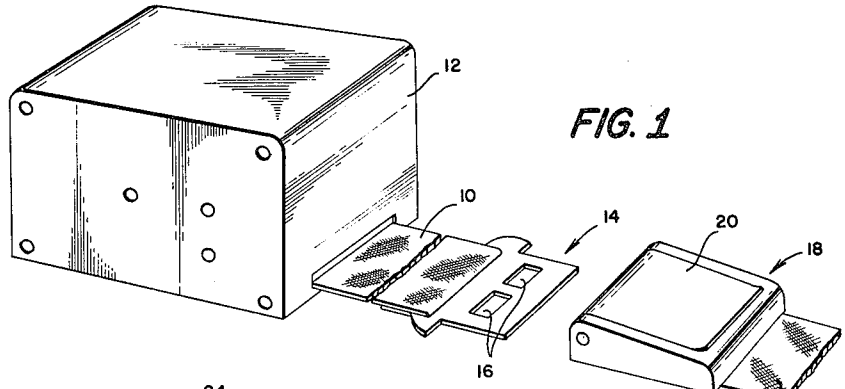


FIG. 1

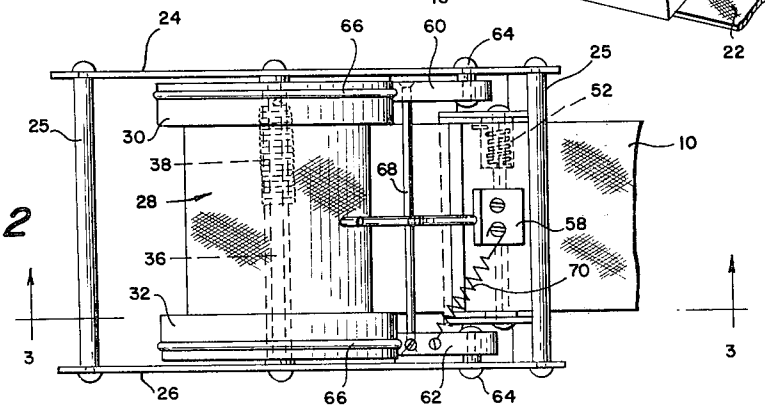


FIG. 2

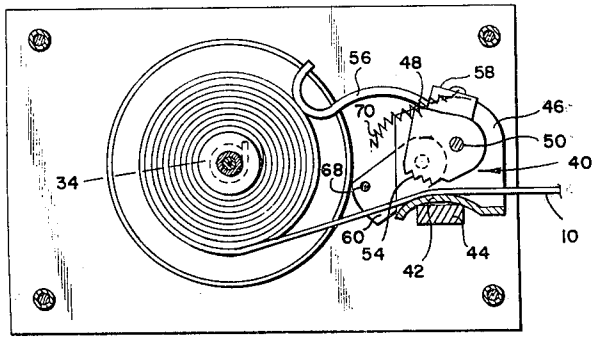


FIG. 3

FIG. 4

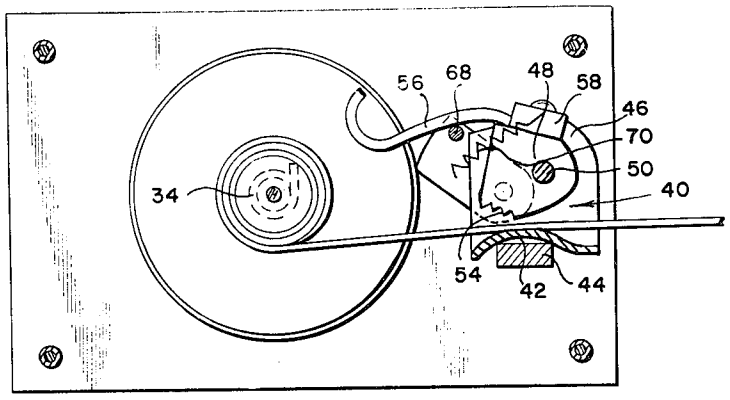


FIG. 5

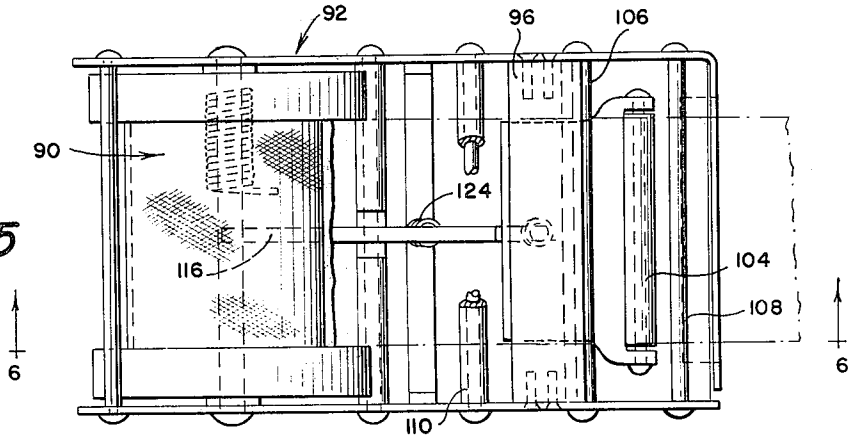


FIG. 6

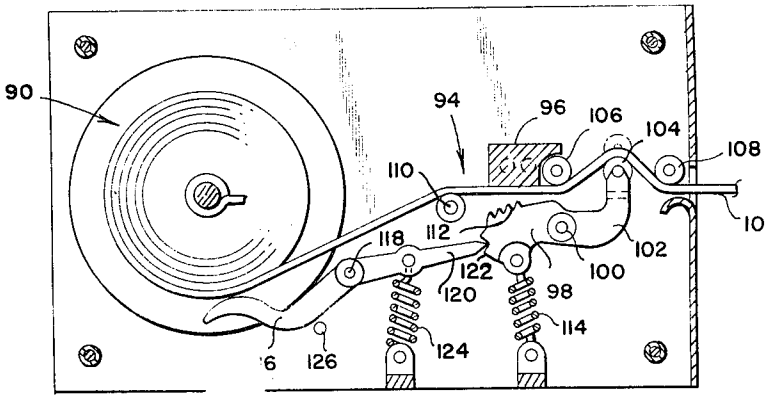


FIG. 4A

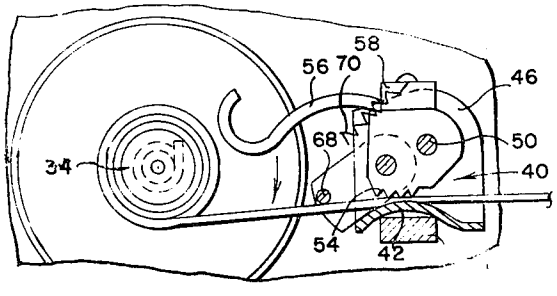


FIG. 7

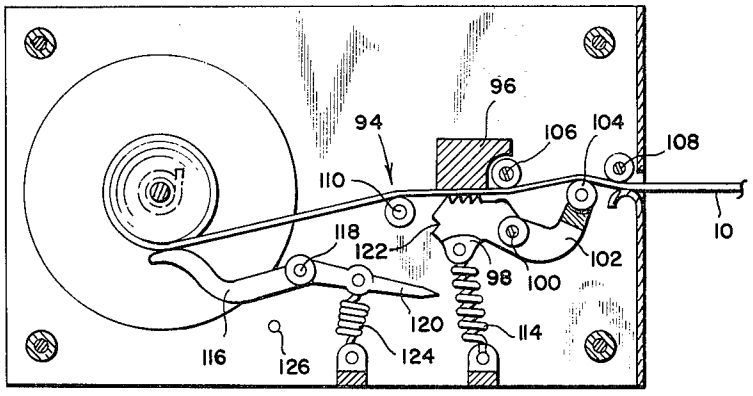


FIG. 8

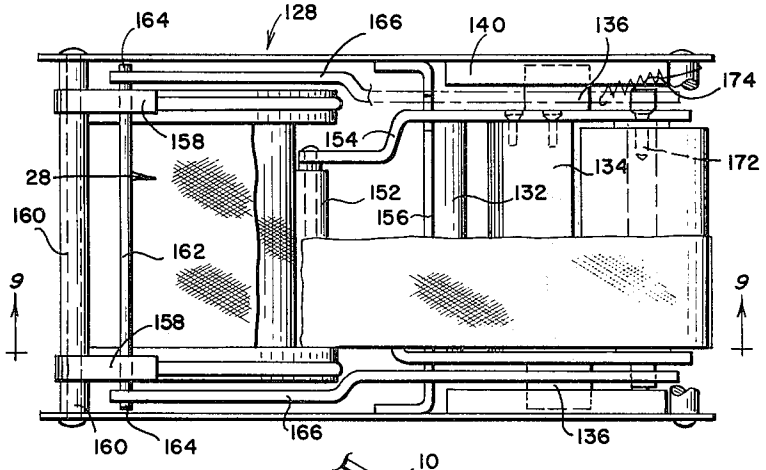
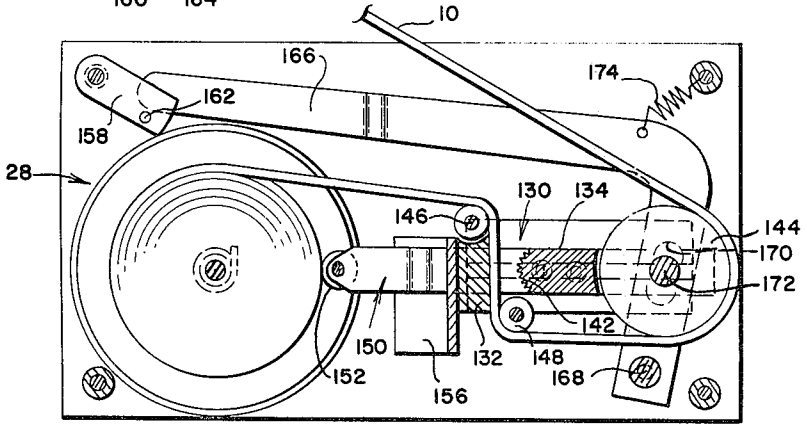


FIG. 9



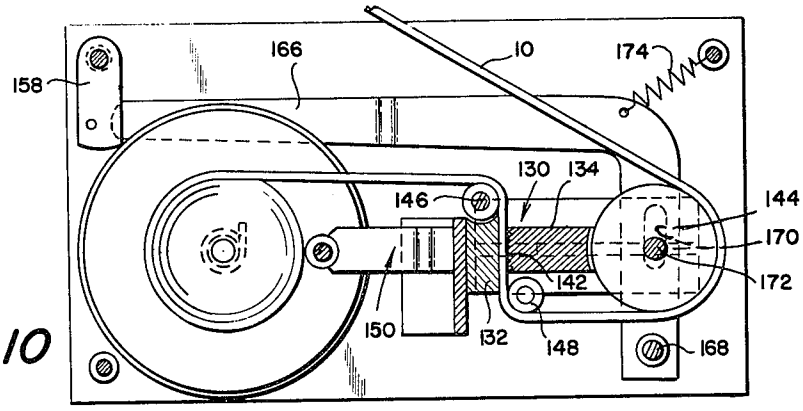


FIG. 10

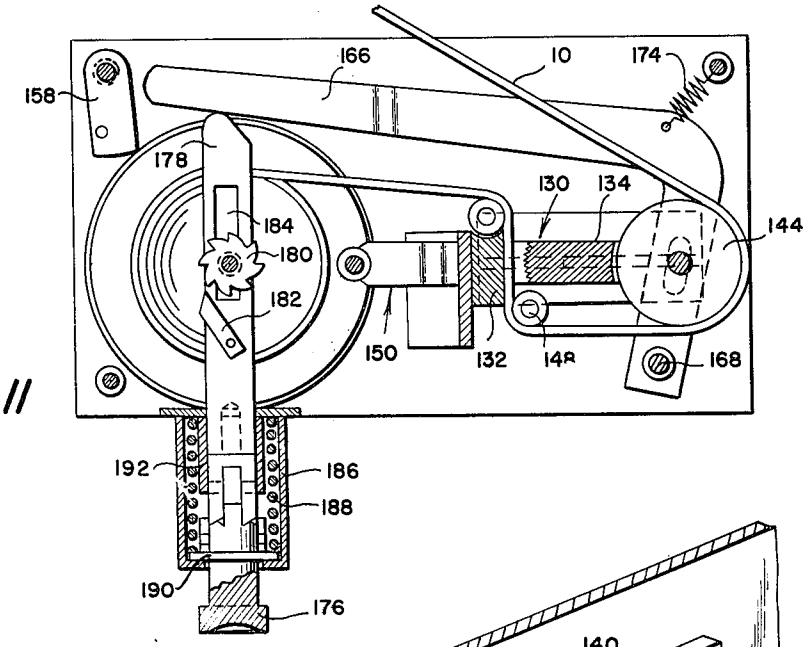


FIG. 11

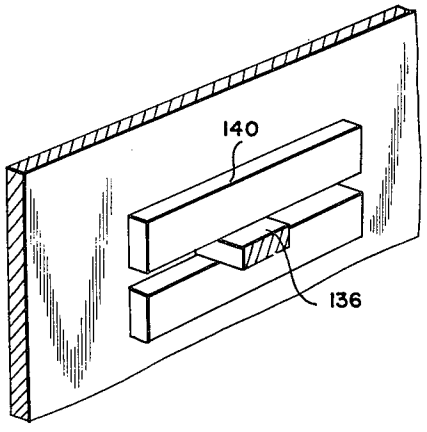


FIG. 12

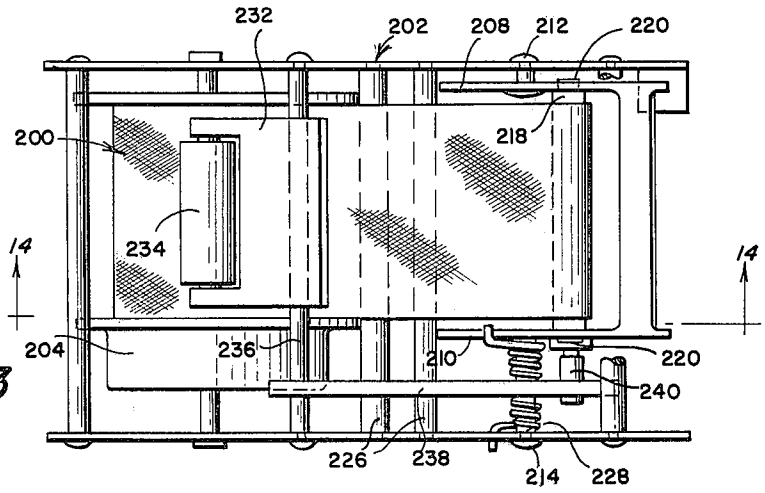


FIG. 13

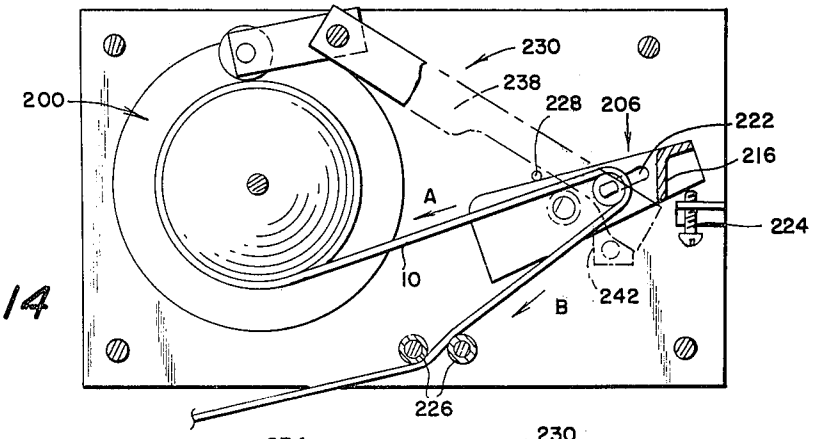


FIG. 14

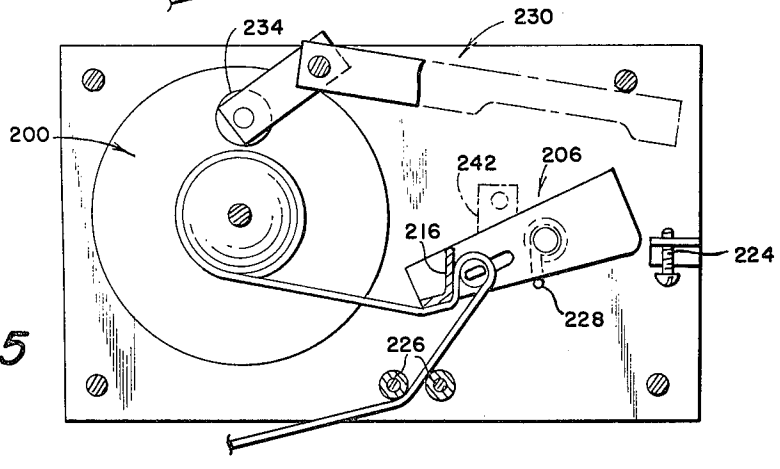


FIG. 15

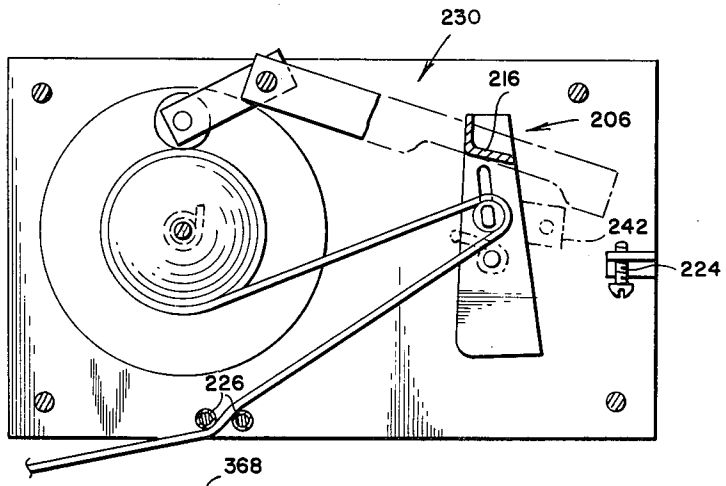


FIG. 16

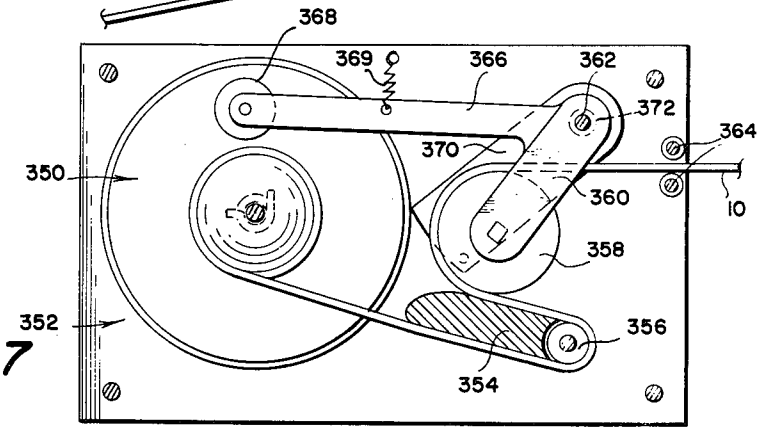


FIG. 17

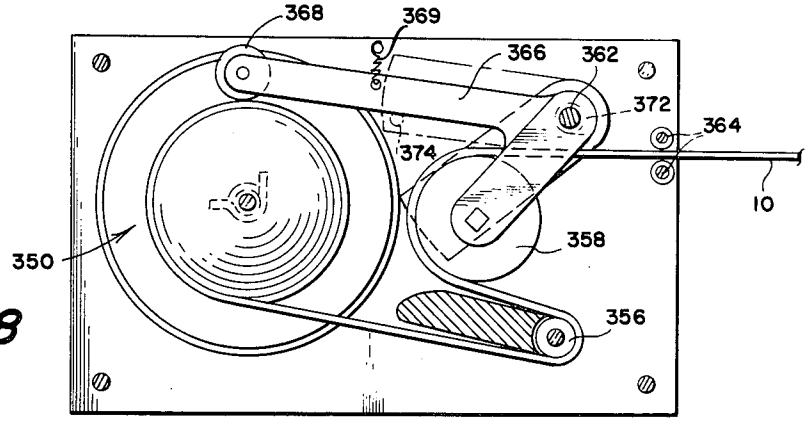


FIG. 18

FIG. 19

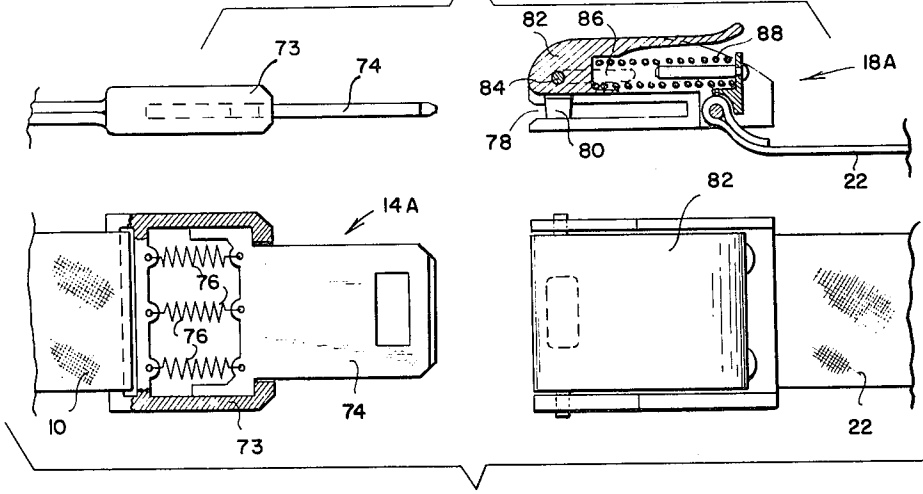
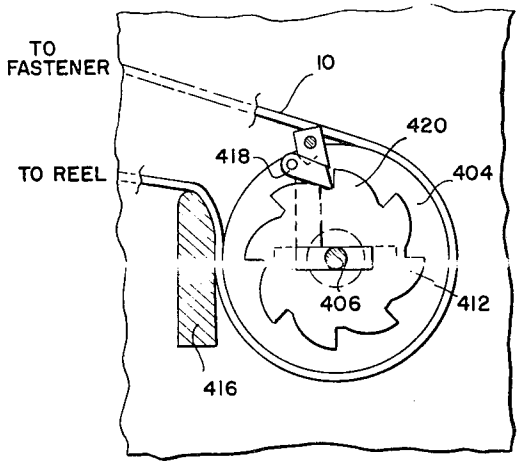


FIG. 20

FIG. 21



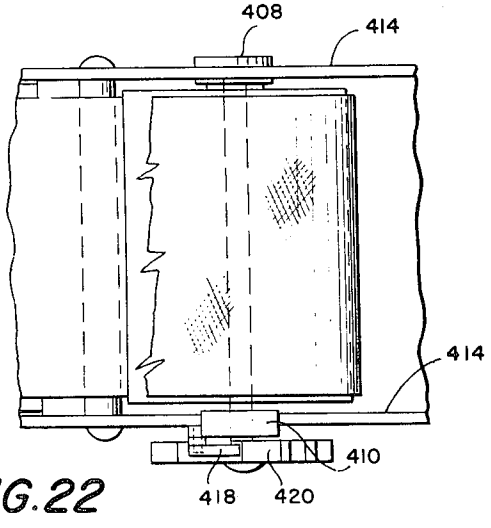


FIG. 22

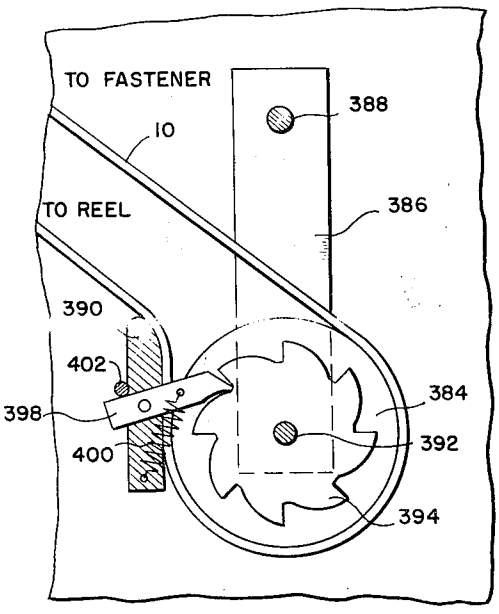


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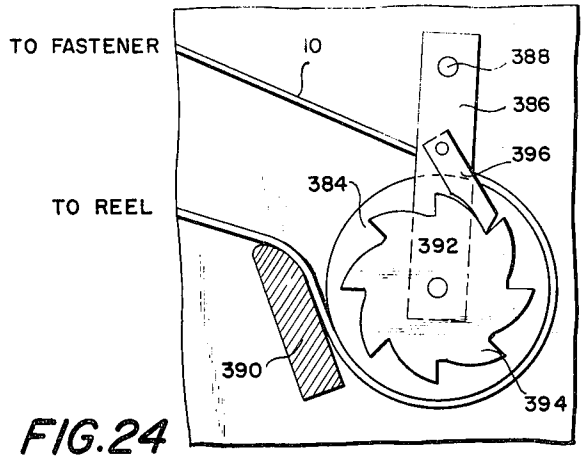


FIG. 24

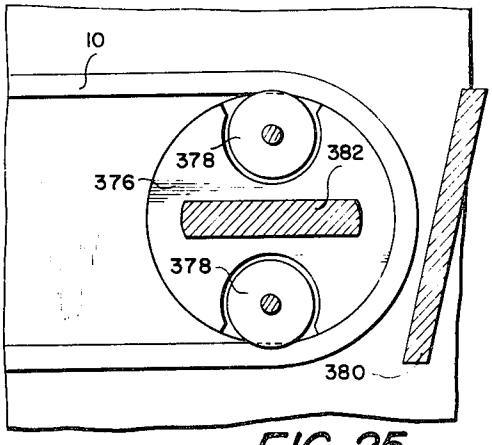


FIG. 25

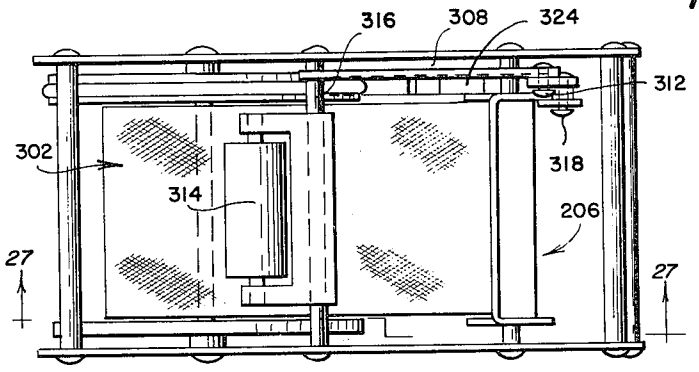


FIG. 26

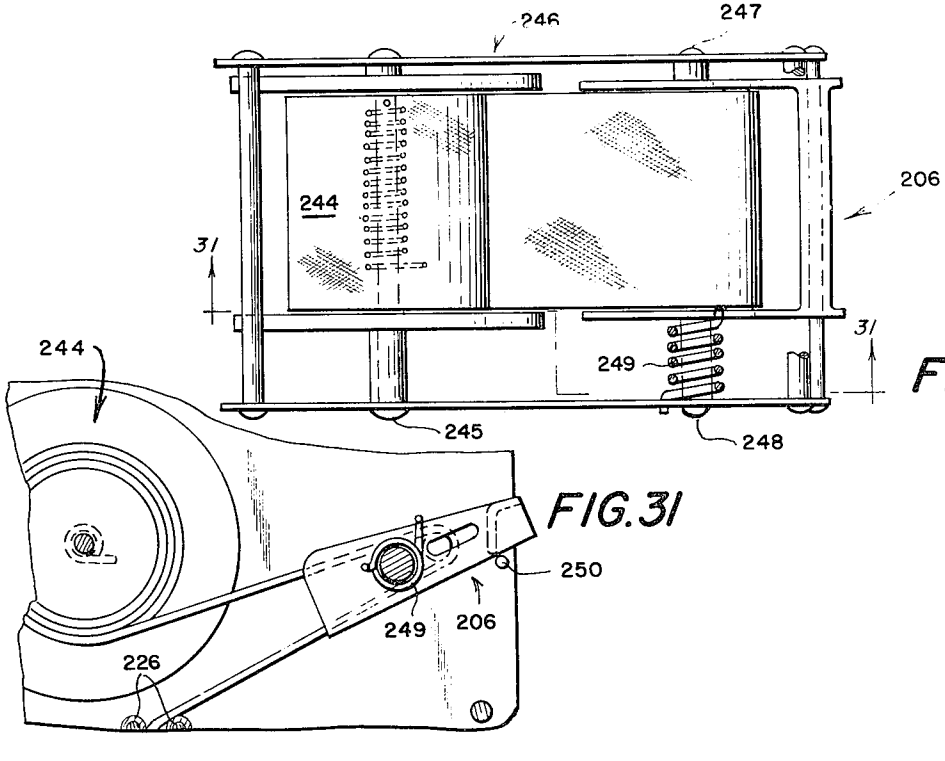


FIG. 30

FIG. 31

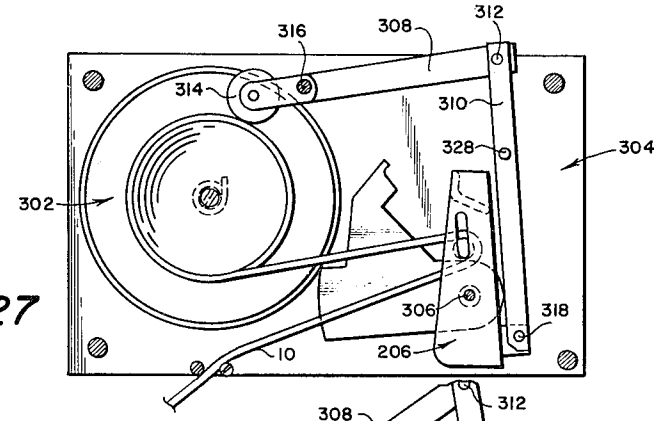


FIG. 27

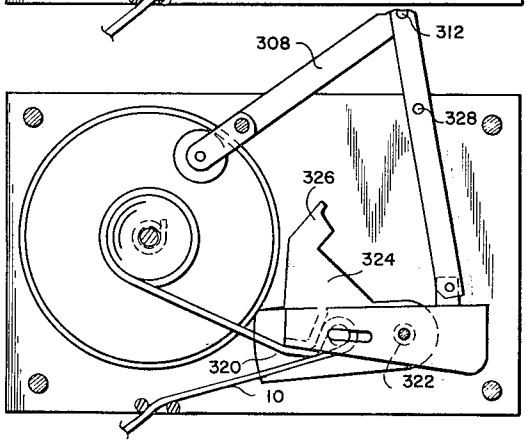


FIG. 28

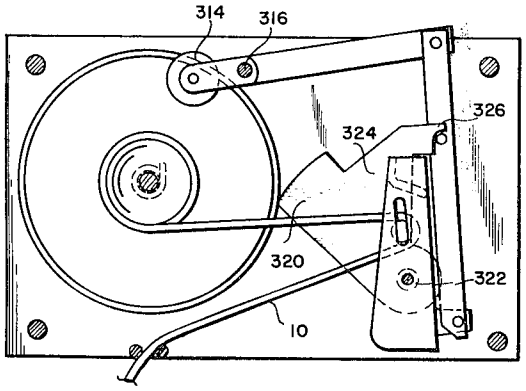


FIG. 29

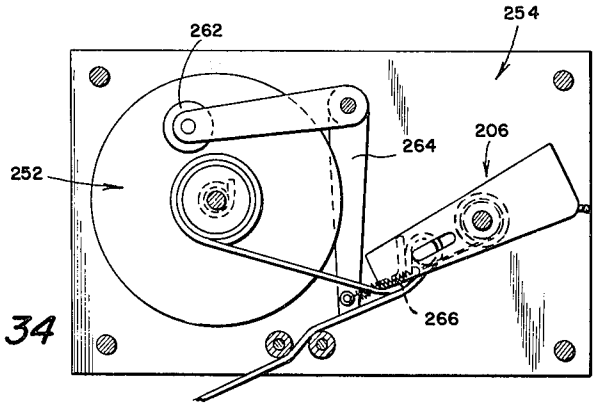


FIG. 34

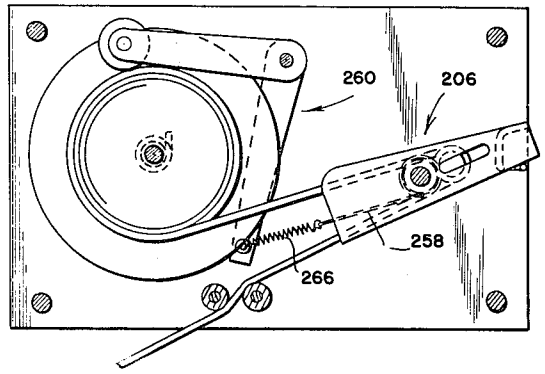


FIG. 33

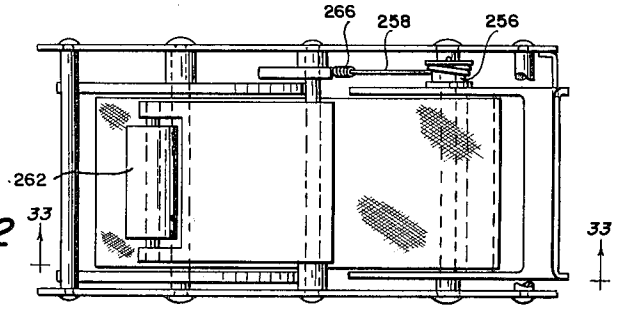


FIG. 32

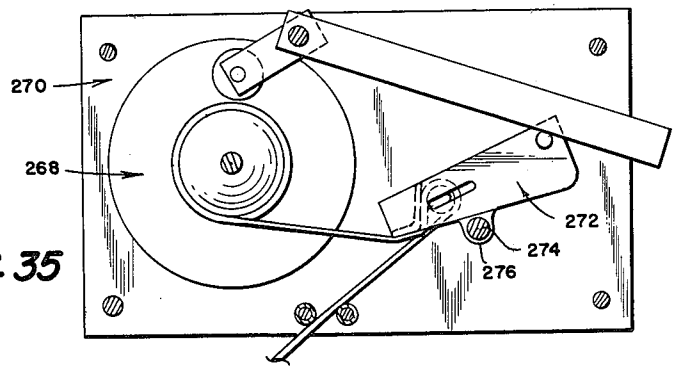


FIG. 35

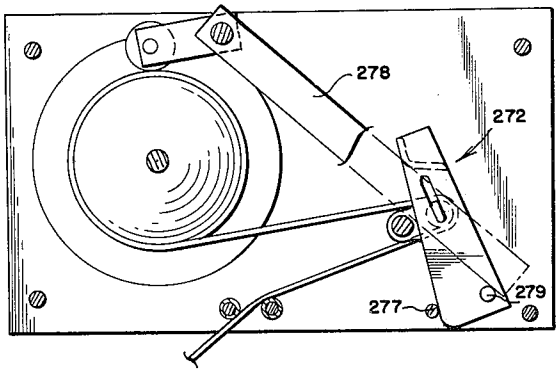


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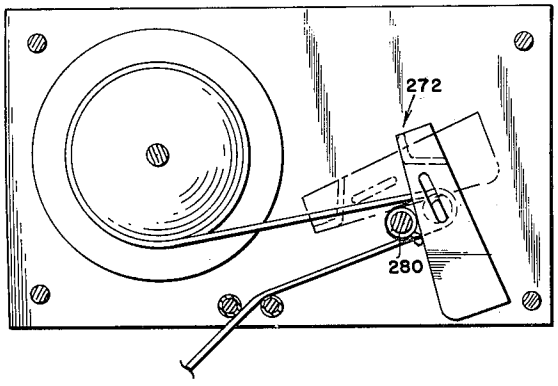


FIG. 37

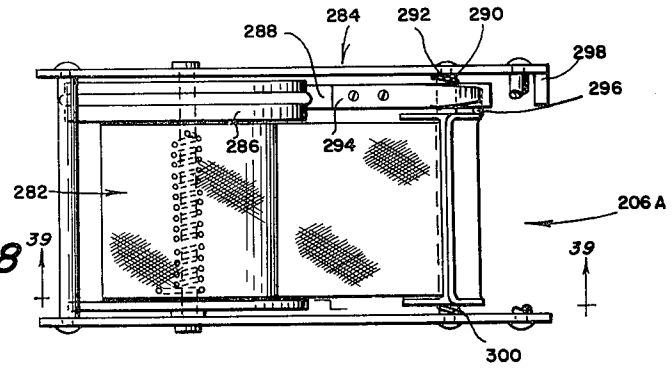


FIG. 38

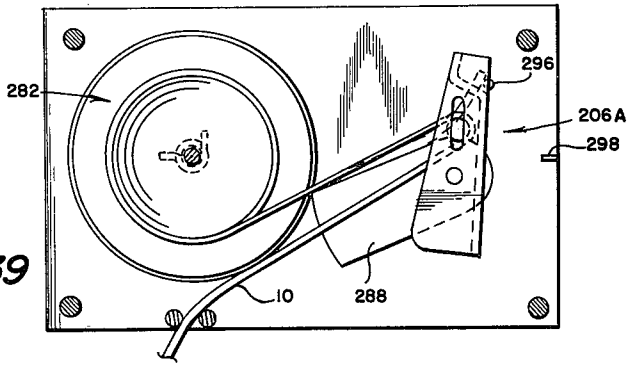


FIG. 39

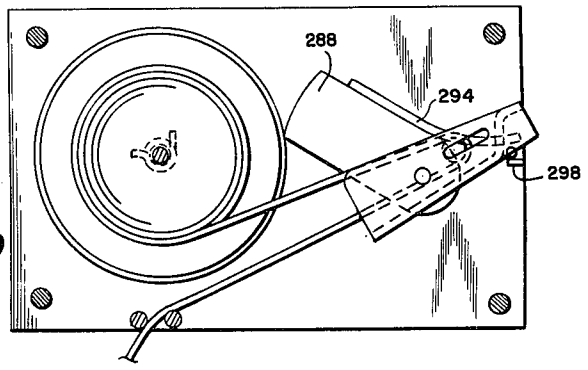


FIG. 40

FIG. 41

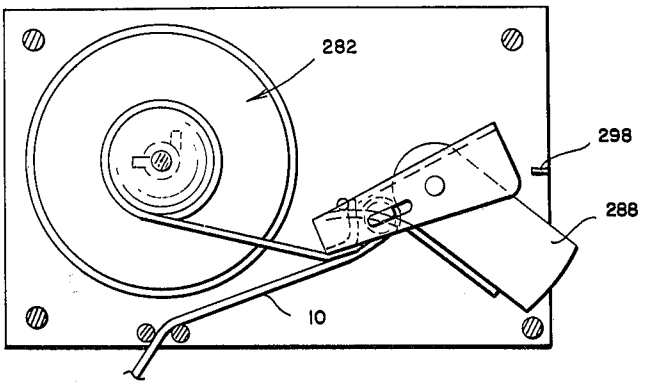


FIG. 42

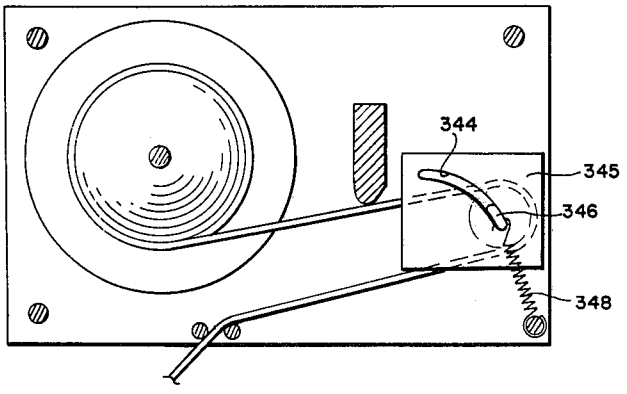


FIG. 43

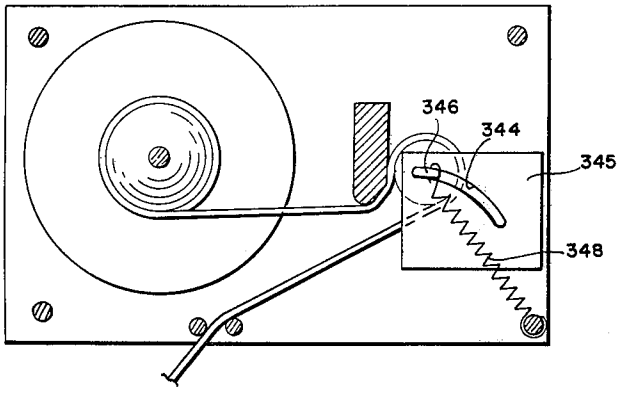


FIG. 44

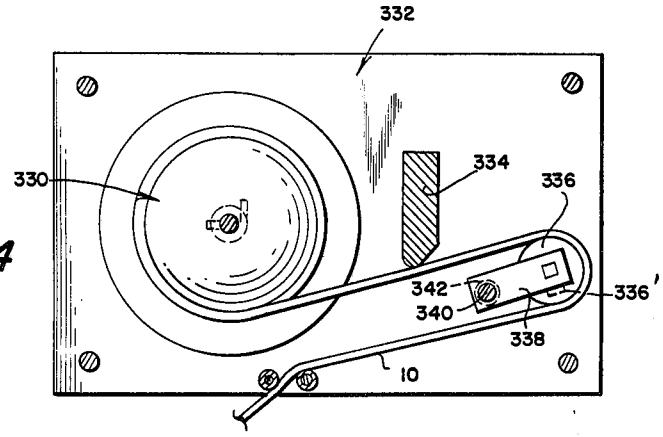


FIG. 45

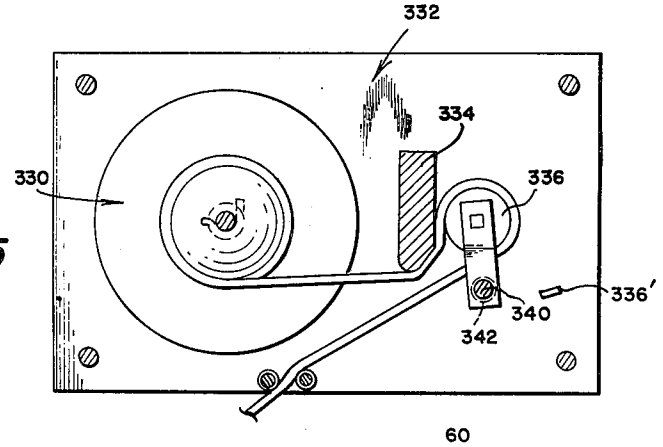
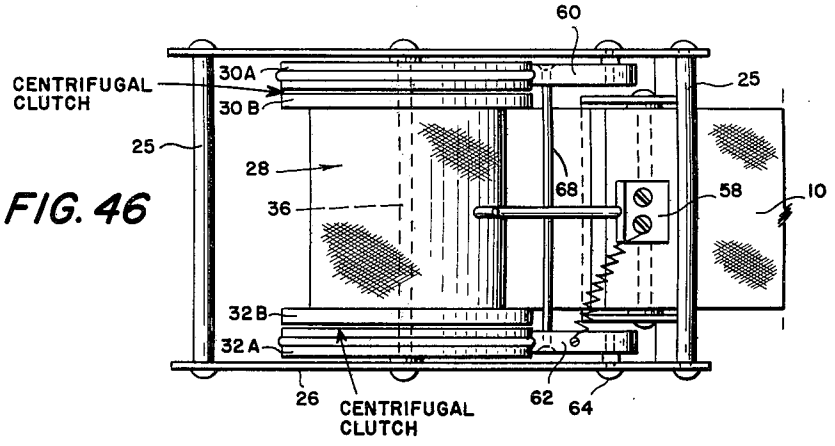


FIG. 46



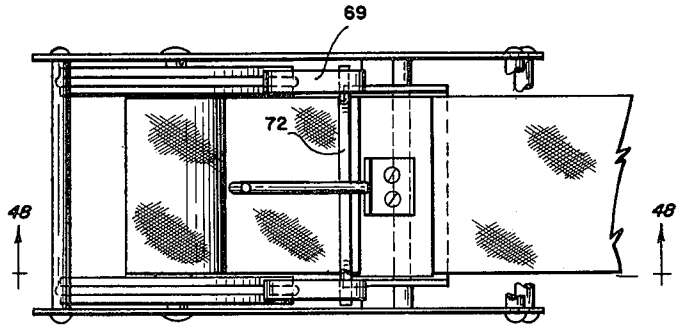


FIG. 47

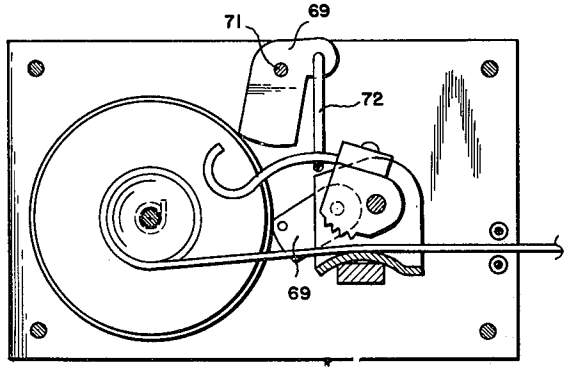


FIG. 48

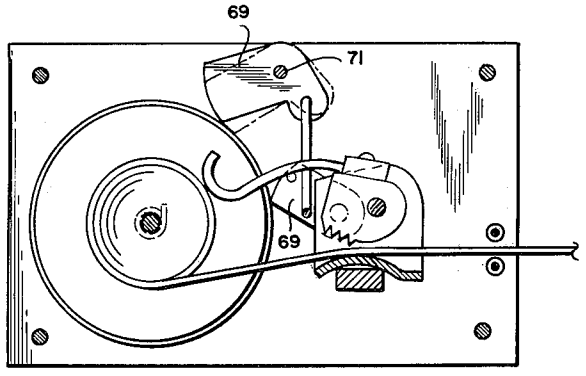


FIG. 49

RETRACTABLE SAFETY BELTS

This is a divisional application of Ser. No. 409,266, filed Nov. 5, 1964, now U.S. Pat. No. 3,817,473, and a continuation-in-part of Ser. No. 377,344, now U.S. Pat. No. 3,289,970, filed June 23, 1964 for *Retractable Safety Belts*.

This invention relates to retractable safety belts and more particularly to so-called retractable seat belts for use in automotive vehicles.

The foregoing copending application discloses and claims retractable seat belt apparatus in which a strap having a fastener member at a free end thereof may be grasped by the user and extended from a retraction device to place the strap in user-restraining position, whereupon further extension of the strap is prevented automatically in response, for example, to the cessation of extensile movement or to slight retractile movement of the strap. At the user-restraining position the strap may have any selected length within a wide range of lengths, so as to accommodate varying conditions of user size and clothing. The fastener member is engaged with a mating fastener member in order to complete the belt. When the fastener members are disengaged, the strap retracts automatically. The present application discloses and claims improvements and modifications in such apparatus and discloses and claims related apparatus.

It is accordingly a principal object of the invention to provide improved retractable seat belt apparatus and the like.

Another object of the invention is to provide improved retractable seat belt apparatus in which a strap may be readily extended to any selected length within a wide range of lengths, locked automatically against further extension, and retracted automatically when released.

A further object of the invention is to provide improved apparatus for clamping and for controlling the clamping of a strap and the like.

Another object of the invention is to provide improved apparatus for holding a clamp open during extension of a strap to a desired length and for automatically permitting the clamp to close thereafter.

Still another object of the invention is to provide improved apparatus for retractable seat belts and the like which is responsive to changes in tension of a strap.

Another object of the invention is to provide improved apparatus for facilitating retractile movement of a strap through a clamp which prevents extensile movement.

Yet another object of the invention is to provide improved apparatus for ensuring some retraction of a strap after extension thereof to a selected length in order to condition a strap clamp to prevent further extension of the strap.

An additional object of the invention is to provide improved retractable seat belt apparatus and the like employing a clamp of the type in which a strap is wound about a clamping pin for exerting a force thereon to clamp the strap in response to an extensile pull.

Still another object of the invention is to provide, in apparatus of the foregoing type, improved means for holding the clamping pin in an open position during extension of the strap to a desired length.

A further object of the invention is to provide retractable seat belt apparatus which is normally locked against extension when in user-restraining position but which incorporates means for permitting extension without unfastening the belt, while preventing retraction, so that the user may have ready access to his pockets.

A principal object of the invention is to provide retractable seat belt apparatus and the like having a strap clamp with a clamping pin about which the strap is trained, the clamp being turned automatically to a position at which the clamp is open when the strap is retracted, remaining in that position during extension of the strap, and being turned automatically to a position at which the clamp is closed when the extensile movement of the strap ceases.

An additional object of the invention is to provide apparatus of the foregoing type requiring only a spring for moving the clamp to its open position when the strap is retracted.

Still another object of the invention is to provide retractable seat belt apparatus of the foregoing type which utilizes variations in the forces in the strap extending from the clamping pin to provide the desired locking action.

Yet another object of the invention is to provide improved retractable seat belt apparatus and the like employing a feeler mechanism for sensing the amount of strap wound upon a retraction reel and for controlling a strap clamp accordingly.

Still another object of the invention is to provide retractable seat belt apparatus employing a sector driven by a retraction reel for controlling the operation of a strap clamp.

A still further object of the invention is to provide retractable seat belt apparatus in which a relatively small pivotal movement of a strap clamp is sufficient to place the clamp in open or closed position.

An additional object of the invention is to provide retractable seat belt apparatus and the like employing improved pivoting or sliding clamp apparatus.

A still further object of the invention is to provide, in retractable seat belt apparatus and the like, improved means for reducing undesired friction in the movement of a strap past a clamp element.

To summarize briefly, and without intent to limit the scope of the invention, a preferred embodiment of the invention employs in conjunction with a retraction reel, a strap clamp which moves automatically to an open position when the strap is retracted, which remains in that position when the strap is extended to a desired length, and which thereafter moves automatically to a closed position at which extension is prevented, the strap retracting automatically when unfastened.

The foregoing and other objects, advantages, and features of the invention, and the manner in which the same are accomplished will become more readily apparent upon consideration of the following detailed description of the invention taken in conjunction with the accompanying drawings, which illustrate preferred and exemplary embodiments, and wherein:

FIG. 1 is a perspective view illustrating the external appearance of housing, strap, and fastener components of a typical embodiment of retractable seat belt apparatus in accordance with the invention;

FIG. 2 is a plan view illustrating one embodiment of apparatus which may be contained within the housing shown in FIG. 1;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a similar sectional view illustrating a different condition of the apparatus;

FIG. 4A is a similar sectional view illustrating still another condition of the apparatus;

FIG. 5 is a plan view of another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5;

FIG. 7 is a similar sectional view illustrating another condition of the apparatus;

FIG. 8 is a plan view illustrating another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 9 is a sectional view taken along line 9—9 of FIG. 8;

FIG. 10 is a similar sectional view illustrating another condition of the apparatus;

FIG. 11 is a similar sectional view illustrating a modification;

FIG. 12 is a perspective view of a detail of the apparatus of FIGS. 8–11;

FIG. 13 is a plan view of another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 14 is a sectional view taken along line 14—14 of FIG. 13;

FIG. 15 is a similar sectional view illustrating another condition of the apparatus;

FIG. 16 is a similar sectional view illustrating still another condition of the apparatus;

FIG. 17 is a sectional view of another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 18 is a similar sectional view illustrating a different condition of the apparatus;

FIG. 19 is an elevation view, partly in section, illustrating improved fastener apparatus which may be employed in the invention;

FIG. 20 is a plan view, partly in section, of the apparatus of FIG. 19;

FIG. 21 is a sectional view of a detail of strap clamping apparatus in accordance with one concept of the invention;

FIG. 22 is a plan view of the apparatus of FIG. 21;

FIG. 23 is a sectional view of a modified form of clamp apparatus;

FIG. 24 is a sectional view of still another form of clamp apparatus;

FIG. 25 is a sectional view of yet another form of clamp apparatus.

FIG. 26 is a plan view of still another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 27 is a sectional view taken along line 27—27 of FIG. 26;

FIG. 28 is a similar sectional view illustrating another condition of the apparatus;

FIG. 29 is a similar sectional view illustrating still another condition of the apparatus;

FIG. 30 is a plan view of another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 31 is a sectional view taken along line 31—31 of FIG. 30;

FIG. 32 is a plan view of another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 33 is a sectional view taken along the line 33—33 of FIG. 32;

FIG. 34 is a similar sectional view illustrating another condition of the apparatus;

FIG. 35 is a sectional view of another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 36 is a similar sectional view illustrating a different condition of the apparatus;

FIG. 37 is a sectional view of a modified form of apparatus which may be contained within the housing of FIG. 1;

FIG. 38 is a plan view of another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 39 is a sectional view taken along line 39—39 of FIG. 38;

FIG. 40 is a similar sectional view illustrating another condition of the apparatus;

FIG. 41 is a similar sectional view illustrating still another condition of the apparatus;

FIG. 42 is a sectional view of another embodiment of apparatus which may be contained within the housing of FIG. 1;

FIG. 43 is a similar sectional view illustrating another condition of the apparatus;

FIG. 44 is a sectional view of another embodiment of the apparatus which may be contained within the housing of FIG. 1;

FIG. 45 is a similar sectional view illustrating a different condition of the apparatus;

FIG. 46 is a plan view of a modification of the apparatus of FIG. 2;

FIG. 47 is a plan view of still another modification of the apparatus of FIG. 2;

FIG. 48 is a sectional view taken along line 48—48 of FIG. 47; and

FIG. 49 is a similar sectional view illustrating another condition of the apparatus.

Referring to the drawings, as shown in FIG. 1 a retractable seat belt of the invention may comprise a strap 10 of suitable material, such as nylon webbing, adapted to be extended from a housing 12 and to be retracted into the housing. The housing may be supported upon the floor of a vehicle, in any convenient orientation, at one side of a seat, or if the seat is strongly anchored to the floor, the housing may be supported directly upon the seat. A free end of strap 10 is provided with a fastener member 14, which in the form shown, is a conventional tongue having locking openings 16. The tongue is adapted to engage a mating fastener member 18, such as a conventional buckle into which the tongue is inserted to complete the belt. As is well known in the art, when the tongue is inserted into the buckle, locking abutments of the buckle enter the openings 16 of the tongue to retain the fastener members in locked engagement until a release element, such as a pivoting lever 20, is operated. Buckle 18 may be connected to another strap, 22, the remote end of which (not shown) may be anchored to the floor (or to the seat) at the opposite side of the seat. Under appropriate circumstances strap 22 may be dispensed with and the mating fastener member 18 may be supported directly upon the seat or otherwise anchored to the floor.

In accordance with the invention it is desired that the strap **10** be readily extensible from the housing **12** to place the strap in user-restraining position, then be locked against further extension automatically, and finally be retracted into the housing when released. Moreover, it is desired that strap **10** be capable of extension to any desired length within a wide range of lengths, so that all adjustments in length to accommodate different size users and different clothing conditions may be made by the strap **10.** Strap **22** may then be kept very short or may be eliminated as indicated above.

FIGS. **2, 3, 4** and **4A** illustrate one embodiment of an apparatus which may be employed in the housing **12** in order to accomplish the foregoing purposes. As shown in FIG. **2,** a frame comprising a pair of side plates **24** and **26** supports a retraction reel **28.** The frame may be secured to or form part of the housing and should be anchored to the floor or, under appropriate circumstances, to the seat. The reel comprises a pair of end discs **30** and **32** joined by a sleeve hub **34,** the end discs being provided with suitable bearings, as is well known in the art, for rotatably supporting the reel upon a pin **36** which extends through the sleeve hub with substantial space therebetween. A spring motor for winding the reel may comprise a helical torsion spring **38** which is slipped over the pin **36** with substantial free play. One end of the spring may be secured to an end disc or the sleeve hub and the other end to the pin **36,** so that the spring is wound as the reel is turned relative to the pin. Other well known types of retracting reels may also be employed.

Strap **10** has the end remote from fastener member **14** attached to the hub of the reel so that the strap may be wound upon the reel by the reel spring for retraction and may be extended from the reel while winding the spring. In the form shown the strap is trained from the bottom of the reel.

In order to prevent extension of the strap a clamp **40** is employed. In the form shown the clamp comprises a convexly contoured clamping plate **42** supported by a cross bar **44** between the side plates **24** and **26.** Plate **42** has a pair of side members **46** which along with plate **42** constitute a yoke for supporting a pivoting clamp member **48.** Clamp member **48** is supported upon a pin **50** extending between the side members. A torsion spring **52** received within a bore at one end of the pivoting clamp member, and having its respective ends connected to one of the side members **46** and to the clamp member, biases the clamp member toward a position at which a clamping surface **54** engages the strap **10** as shown in FIG. **4A.** The clamping surface may be roughened, knurled, or longitudinally grooved so as to facilitate the clamping action, as well known in the art. Clamping surface **54** is shaped so as to increase the clamping pressure in response to extensile strap pull. This is accomplished by suitably shaping the clamping surface, as by making the trailing edge of the clamping surface a greater distance from the pivot **50** than the leading edge. The clamp per se is well known in the seat belt art, being utilized in the buckle of airplane type or metal-to-webbing type belts.

From the foregoing description it is apparent that if clamp **40** is held open, the strap may be extended freely, and if clamp **40** is held closed, extension will be prevented. Because of the design of the clamp, as indicated above, retractile movement of the strap tends to drag the clamp open against the bias of spring **52** so as to permit the strap to be retracted even when the clamp has moved to the closed position shown in FIG. **4A.** This action is facilitated by contouring the teeth or corrugations of the clamping surface so that they are inclined rearwardly for ready engagement with the strap when the strap is extended but to minimize engagement when the strap is retracted.

In order to open the clamp so that the strap may be extended to the desired length a feeler **56** is employed for sensing the amount of strap wound upon the reel. In the form shown the feeler comprises a lever arm extending from the pivoting clamp element **48,** being secured to the top thereof by a small block **58.** It will be seen that when the reel is sufficiently filled the strap thereon engages the free end of the feeler and lifts the feeler so as to turn the clamp member **48** to open it as shown in FIG. **3.** When the strap is sufficiently extended from the reel, the feeler is free of the strap as shown in FIG. **4A,** and the clamp is permitted to close. The feeler may be shaped so as to engage the strap wound upon the reel within a predetermined range of wound strap. For example, the feeler may engage the strap until the strap has been withdrawn from the reel about eighteen inches and then be free of the strap.

The feeler opens the clamp to permit initial extension of the strap but will not maintain the clamp open after initial extension. In order to maintain the clamp open until the strap has been extended approximately to its user-restraining length an additional mechanism is employed. In the form shown this mechanism comprises one or more sectors **60, 62** driven by the reel. The sectors are pivotally supported by stub shafts **64** upon the side plates of the frame and engage the periphery of the end discs of the reel, which may be provided with rubber O-rings **66** preferably seated in grooves on the peripheral surface of the end discs. The sectors are connected by a pin **68,** so that they move in unison and are provided with a tension bias spring **70,** one end of which may be connected by a screw to the top of one sector and the other end of which may be connected by a screw to the block **58.**

When the strap is extended, the reel turns counterclockwise as shown in FIG. **4,** lifting the sectors and engaging pin **68** with the undersurface of the feeler in order to hold the clamp open even after the feeler loses contact with the webbing. At this position the lower edge of the sector surface is just maintained in contact with the reel, presenting a slight drag on the reel. The strap is extended to approximately the desired length, and the tongue **14** (FIG. **1**) is engaged with the buckle **18.** In so doing it is almost impossible to avoid extending the strap slightly more than the length required when the tongue and buckle are later snugly against the user's body. Thus, after the tongue is engaged with the buckle, strap **10** is always retracted slightly, the reel turning in a retractile direction, clockwise in FIG. **4A.** When this occurs, the sectors turn away from the feeler, permitting the clamp to close. Any further extensile movement of the strap is now prevented. As shown in FIG. **4A** the sectors may actually lose contact with the reel by a slight amount and come to rest upon the supporting bar **44,** the tension in bias spring **70** being negligible at this time. Thus, in a collision, even if the strap were to slip slightly through the clamp before the clamp engaged firmly there would be no possibility of the sectors being driven by the reel to open the clamp.

If now the tongue is disengaged from the buckle, the reel retracts the strap, dragging it through the clamp, which opens slightly due to the retractile movement, and eventually the feeler **56** engages the strap as shown in FIG. **3**, turning the clamp element **48** clockwise in that figure to open the clamp more fully. This turning movement of the clamp element increases the tension in bias spring **70** enough to engage the upper edge of the sectors with the reel, but the drag on the reel is minimal. When the strap is extended again, the sectors are immediately raised to the position of FIG. **4**.

The amount of retractile movement of strap **10** required to permit the clamp to close is very slight, of the order of ¼ inch, and depends upon how much webbing remains on the reel and the relative radii of the reel and the sectors. The mechanical advantage of the feeler and the sectors determines the back pressure upon the reel, which has been found to be quite low. By utilizing a roller at the end of the feeler engaging the strap, as will be later described, the drag upon the reel created by the feeler is further reduced.

FIGS. **47–49** illustrate a modification in which the clamp is additionally opened when a strap is retracted a predetermined amount so as to facilitate flow of the strap through the clamp during further retraction. As shown, this may be accomplished by providing additional sectors **69** driven by the reel. These sectors are supported on stub shafts **71** from the side plates of the frame and have a bail **72** pivotally suspended therefrom at the side of the stub shafts remote from the reel. While the strap is being extended, the sectors **69** are in the full line position of FIG. **49**, and there is substantial space between the bail **72** and the feeler. The slight retractile movement of the strap required to permit the clamp to close is not sufficient to engage the bail with the feeler, the sectors **69** moving to the phantom line position. However, further retractile movement causes the bail to lift the feeler very slightly but enough to facilitate the retractile movement of the strap through the clamp. If the strap is permitted to retract sufficiently to engage the bail **72** with the feeler and then is pulled again in an extensile direction, the slight extensile turning movement of the reel will disengage bail **72** from the feeler and permit the clamp to close instantly. The lifting movement of the feeler by the bail **72** is preferably made insufficient to create enough tension in bias spring **70** to engage sectors **60** and **62** with the reel. The relative degrees of rotation of the pairs of sectors may be controlled by varying their radii and/or by engaging the pairs of sectors with different diameter portions of the reel; the end discs may be stepped down accordingly to provide shoulders for engaging the respective pairs of sectors.

FIGS. **19** and **20** illustrate the manner in which strap fastener members may be modified to ensure sufficient retraction of the strap to operate the clamp of a retraction-responsive apparatus. As shown, either or both parts of the fastener couple may be constructed so as to provide lost motion. Thus the tongue fastener member **14A** may have a shell **73** into which the tongue proper **74** may telescope. The shell is attached to the strap **10** and the tongue is normally urged out of the shell, as by compression springs **76**. Thus if the tongue is inserted in a conventional buckle, the resistance to insertion created by the latch members of the buckle will cause the shell **73** to telescope about the tongue **74** before the tongue is forced into the buckle. After the tongue has been engaged with the buckle, the shell will be free to move in the reverse direction under the bias of springs **76** to create some slack in the strap **10**, which will be taken up by the retraction reel.

The same type of telescoping action may take place in the buckle **18A**. When a tongue is inserted into the opening **78**, the latch abutment **80** will retreat along the buckle shell along with the release lever **82**, the pivots **84** of which slide in slots **86** in the sides of the buckle shell as a spring **88** is compressed. Finally the insertion pressure exerted by the tongue will be sufficient to turn the abutment **80** upward against its usual bias spring, not shown, to permit the tongue to slip under the abutment so that the abutment may enter the opening in the tongue. Then the tongue is moved reversely by spring **88** so as to create slack in strap **10** which is taken up by the retraction reel. Other types of lost motion fastener members may also be employed to create slack to be retracted.

FIG. **46** illustrates a modification of the apparatus of FIG. **2** in which the end discs of the reel are split into two parts **30A, 30B,** and **32A, 32B**. The B parts are fixed to the hub of the reel and turn integrally therewith, while the A parts are coupled to the B parts by centrifugal clutches contained within the end discs. The clutches may be of any conventional type well known in the art for coupling a pair of rotary members when one of them is turned and for decoupling the members when that one stops. Under these circumstances the sectors **60** and **62** will not move up to engage the feeler **56** until the reel proper has turned somewhat, the feeler **56** holding the clamp open until the sectors take over this function. When the reel ceases its extensile movement, the disc portions **30A** and **32A** will be decoupled therefrom, so that the pressure of the feeler upon the sectors, due to the bias spring **52** of the clamp, will permit the sectors to move down, turning the disc portions **30A** and **32A** relative to the reel and closing the clamp without requiring retractile movement of the strap.

FIGS. **5, 6,** and **7** illustrate another embodiment of the apparatus which may be placed in housing **12** of FIG. **1**. A retraction reel **90**, which may be of the type previously described, is rotatably supported upon a frame **92**. The strap **10** extends from the bottom of the reel past a clamp **94** comprising a fixed clamp plate or block **96** and a pivoting clamp element **98**. Element **98** is pivotally supported at one side of a shaft **100** extending between the side plates of the frame and has a lever arm **102** at the opposite side of shaft **100** supporting a strap guide roller **104** arranged to indent the strap. Guide rollers **106,** and **108** are rotatably supported upon the frame at opposite sides of roller **104**, so that the strap passes reversely about roller **104**. An additional guide roller **110** may be provided to guide the strap across the fixed clamp element **96**.

When the strap is extended, the resulting tension in the strap exerts a pressure on roller **104** and turns lever arm **102** so as to bring the clamping surface **112** of clamp element **98** into engagement with the strap, overcoming a return spring **114**, which maintains the clamping surface **112** away from the strap when there is reduced tension in the strap.

A feeler **116** is pivotally supported by a pin **118** upon the frame and has an arm **120** arranged to interfere with the movement of clamp member **98** when sufficient strap is wound upon the reel. As shown, the free end of arm **120** may enter a small notch **122** formed in the surface of clamp member **98**. A return spring **124**

tends to move the arm **120** away from engagement with the clamp element **98**, as shown in FIG. **7**. This figure illustrates the position of the parts when the strap has been extended and placed in user-restraining position, the tension in the strap causing the clamp to close. If now the belt is unfastened and strap **10** released, the pressure on roller **104** will be decreased sufficiently to permit the spring **114** to open the clamp to the phantom line position of FIG. **6**, and the strap will retract. As the strap builds up upon the reel, the feeler will be turned from the position illustrated in FIG. **7** to the position illustrated in FIG. **6**, where it will interfere with movement of clamp element **98** if the clamp element is moved toward its closed position. If the strap **10** is now extended, the pressure on roller **104** will bring notch **122** into engagement with the end of arm **120**, and the feeler will be moved against a stop **126** so as to prevent the clamp from closing. By the time that the strap has been extended to user-restraining position, the feeler will have lost contact with the strap wound upon the reel. If the tension in the strap is momentarily reduced, as by a slight retractile movement at the fastener end, springs **114** and **124** will turn clamp element **98** and arm **120** sufficiently to disengage the arm from the notch **122**. The feeler will then turn to the position shown in FIG. **7**, and the clamp will be free to close as shown in response to renewed tension in the strap.

The amount of clamping pressure is a function of the relative distances between roller **104** and pivot **100** and between clamping surface **112** and pivot **100** and is also a function of the angle at which the strap is trained about the roller **104**. These parameters may be adjusted to produce the desired clamping pressure, and the clamping surfaces may be roughened to increase friction.

FIGS. **8, 9, 10** and **12** illustrate another embodiment of the apparatus which may be placed in housing **12** of FIG. **1**. In this embodiment the reel **28** of FIG. **1** is supported upon a frame **128**, and strap **10** is trained from the top of the reel past a clamp **130**. The clamp comprises a fixed clamp element or plate **132** supported between the sides of the frame and a movable clamp element **134**. The movable clamp element is a slider having lateral ears **136** arranged to slide in slots **138** defined by blocks **140** attached to the side plates of the frame. The sliding movement is for the purpose of bringing the clamping surface **142** into and out of engagement with the strap **10** adjacent to the clamp element **132**. Clamping surface **142** (and/or the surface of the plate **132**) may be grooved or otherwise roughened. The slider constitutes a yoke for the support of a roller **144**. Strap **10** is trained from the top of the reel over a roller **146**, past the clamp element **132**, under a roller **148**, and reversely around roller **144**. Tension in strap **10** (when it is extended to the left in FIG. **9**) exerts a force upon the roller **144** tending to move the roller and the attached slider structure toward the clamp element **132** for clamping the strap.

To open the clamp when the strap is retracted sufficiently a feeler **150** is employed. The feeler may comprise a roller **152** supported between a pair of arms **154** which extend through slots in a bracket **156** supporting the clamp element **132** upon the frame and which are fixed to the slider. It is apparent that as the webbing builds up upon the reel and engages the roller **152** the clamp will be forced open. This occurs during retraction, when there is little tensile force exerted by the strap upon roller **144**.

To maintain the clamp open while the strap is extended to user-restraining position, sectors **158** driven by the reel are employed. The sectors are pivotally supported upon the frame, as by a pin **160** extending between the sides of the frame and may be joined by a pin **162** having ends **164** which project beyond the sectors. Pin **162** is adapted to engage the ends of bell cranks **166**, which are pivotally supported upon the frame at **168** and are preferably connected for unitary movement. The bell cranks are provided with slots **170** which receive pins **172** extending laterally from the slider. The effective lever arm of the bell cranks between the pins **172** and the ends of the bell cranks engaged by the sectors is much longer than the lever arm between pins **172** and fulcrums **168**, so that there is a substantial mechanical advantage. A spring **174** may be employed to assist in opening the clamp.

FIG. **10** illustrates the appearance of the apparatus after the strap has been extended and the clamp has been closed. Any extensile pull exerted upon the strap merely closes the clamp more tightly. If the belt is now unfastened, the tension in strap **10** will be significantly reduced, and the clamp will open sufficiently to permit the strap to be retracted by the reel, which will turn counterclockwise in FIG. **10**. The clamp opening may be facilitated by the spring **174**, but the strap will slip through the clamp in retraction even without the spring. Such slipping may be aided by the shaping of the clamping surface **142** as described in connection with the embodiment of FIG. **3**.

During retractile movement of the reel, the sectors will merely exert a slight drag upon the reel while remaining in the position shown in FIG. **10**. The weight of the sectors will maintain them in this position, but a light bias spring may also be employed for this purpose. As the webbing builds up upon the reel, the feeler opens the clamp more fully to the position illustrated in FIG. **9**.

If now the strap is extended, the sectors **158** will turn to the position shown in FIG. **9** holding the bell cranks in the position shown, with the lower edges of the sectors just engaging the O-rings upon the periphery of the end discs of the reel. The bell cranks will thus remain in this position even after the feeler has lost contact with the webbing. When the strap reaches its desired length, extensile rotation of the reel stops, and the reel is free to turn in a retractile direction if slack is created in the strap. It will be observed that movement of roller **144** to the left in FIG. **9** creates slack on both sides of the roller. Such slack is taken up by the reel, which turns counterclockwise in FIG. **9** so as to move the sectors **158** to the position shown in FIG. **10**. The locking of the clamp is thus automatic upon cessation of extensile movement of the strap and need not be accompanied by any retractile movement of the portion of the strap across the user's lap. The slack created by movement of the roller **144** to the left must of course be accompanied by sufficient rotation of the reel to permit the sectors **158** to release the bell cranks, which in turn permits the movement of the roller **144** to the left.

FIG. **11** illustrates a modification which permits opening of the belt, as for example to permit the user to withdraw change from a suit pocket when approaching a toll booth, without requiring that the belt be unfastened. While this structure has been illustrated in connection with the embodiment of FIGS. **8–10**, it will be apparent that the same principle may be employed in other embodiments of the invention.

The structure accomplishes the dual purpose of 1) opening the clamp, and 2) preventing retraction of the belt while the clamp is opened. In the illustrative embodiment the mechanism comprises a push button **176** which is pressed to release the clamp and to prevent retractile movement of the reel. The push button may operate a sliding post **178** which lifts the bell cranks so as to open the clamp.

One of the end discs of the reel has fixed thereto a ratchet wheel **180** arranged to engage a pawl **182** supported by the post **178,** a slot **184** being provided in the post to permit its linear movement. When the pawl is engaged with the ratchet wheel, the reel can turn in an extensile direction, but not in a retractile direction. When the pawl is disengaged from the ratchet wheel, the normal movement of the reel is not affected. Thus when the push button is pressed, the clamp is opened, so that the user may simply withdraw additional strap from the reel to create slack, and this slack will not be taken up by the reel until the push button is released.

In order that the push button need not be held in manually, a latch mechanism, such as the type employed for extending the tips of ball point pens or the type employed in push button switches, may be employed to hold the post **178** in its upward position until the push button is pressed again (or simply pulled out), whereupon the post is released. This mechanism is conventional and comprises a sleeve **186** projecting from the frame and in which the push button reciprocates. The sleeve contains a coil compression spring **188** arranged to be compressed by a shoulder **190** fixed to the push button and to maintain the push button projected from the sleeve **186.** Post **178** fits within an inner sleeve **192** and is movable axially relative to the push button. In the usual manner the post is held in and released alternately for successive actuations of the push button, the operation being accomplished by cooperatively rotating cam teeth.

FIGS. **13–16** illustrate another embodiment of the apparatus which may be contained within the housing **12** of FIG. **1.** A retraction reel **200** is rotatably supported upon the frame **202.** In the form shown the retraction reel is driven by a constant force spring motor **204,** as for example a "Negator" type motor manufactured and sold by Hunter Spring, Inc., although a spring motor of the type previously described may also be utilized. The strap **10** extends from the bottom of the reel past a clamp **206** for preventing extension of the strap. The clamp comprises a U-shaped assembly with side plates **208** and **210** supported by stub shafts **212** and **214** upon the side plates of the frame for turning movement. The bight of the U-shaped assembly is constituted by a plate **216** which forms one of the clamp elements, the other clamp element being constituted by a knurled pin **218** arranged to move toward and away from element **216.** The pin is cylindrical and is provided with flattened ears **220** slidable in slots **222** formed in the side plates **208** and **210** of the clamp. The ears may be of generally rectangular configuration so as to permit sliding movement of the pin but prevent rotation thereof about its axis.

Strap **10** is trained from the bottom of the reel, between the clamp elements, and reversely around clamping pin **218.** The entire clamp assembly may be turned between the position illustrated in FIG. **14,** at which the clamp elements are remote from the reel with respect to the pivotal axis, and the position illustrated in FIG. **15,** at which the clamp elements are adjacent to the reel. In the position of FIG. **14** the clamp is open, while in the position of FIG. **15** the clamp is closed. An adjustable set screw **224** threaded into a bracket upon one of the side plates of the frame limits the movement of the clamp assembly when it is in the position of FIG. **14.** Strap **10** passes from the clamp assembly between a pair of frame-supported rollers **226,** which ensure that the angle of the strap portion from pin **218** to the rollers in FIG. **14** is predetermined.

The applicants have discovered that if the clamp assembly is placed in a position approximating that shown in FIG. **14** when the strap is retracted, the clamp assembly will remain in this position while the strap is extended to the desired length and will automatically flip toward the position of FIG. **15** when the extensile movement ceases. This behavior is believed to stem from the force vectors acting upon the flights of strap at opposite sides of the pin **218.** Thus as shown in FIG. **14,** there is a force vector A pulling upon pin **218** as the result of the retraction force of the reel, and there is a force vector B pulling upon the pin **218** as the result of the extensile pull by the user. The force vector A is limited by the retraction spring of the reel, while the force vector B is substantially greater than the force vector A during extension of the belt, because it is necessary to overcome the friction of the belt passing around the pin **218.** For example vector A may have a magnitude of one **1b,** while vector B may have a magnitude of 2½ lbs. during extension.

The resultant force upon the pin **218** is dependent upon the magnitudes of forces A and B and upon their direction. If there is a component of this resultant force tending to produce a turning moment about the axis of the stub shafts **212** and **214,** the clamp assembly will tend to turn in the appropriate direction. When the apparatus is in the position of FIG. **14** and an extensile pull is exerted upon the strap, the resultant force produces a moment which keeps the clamp assembly against the stop **224.** As the strap is extended, the amount of strap on the reel decreases, and the angle between vectors A and B increases in a direction tending to favor movement of the clamp assembly away from the stop. When extensile movement ceases, the vector B decreases in magnitude, because there is no longer any pull to overcome the friction about the pin **218.** The resultant force then shifts toward vector A, creating a turning moment which causes the clamp assembly to turn toward the position of FIG. **15,** whereupon the clamp closes because of the pull upon the pin exerted by the strap. Slack created during the movement of the clamp assembly is taken up by the reel.

The most favorable position of the clamp assembly in FIG. **14** may be selected by adjustment of the stop screw **224.** If the clamp assembly is permitted to turn too far clockwise as viewed in FIG. **14,** it will not turn back to the position of FIG. **15** reliably or it will require that the strap be permitted to retract a bit from the fastener end in order to reduce the tension sufficiently to produce the desired flipping of the clamp assembly. If the clamp assembly is not permitted to turn clockwise far enough, it will turn back toward the locked position of FIG. **15** prematurely. However, it has been found that there is a substantial range of adjustment of the stop pin **224** which permits reliable behavior of the type desired.

Some mechanism must be provided to move the clamp assembly to the position of FIG. **14** before the strap is extended. In the form shown this mechanism

comprises two parts: first, a spring **228** for turning the clamp assembly of the order of 100° to the position shown in FIG. **16** when the belt is unfastened, and second, a feeler **230,** for turning the assembly the remainder of the way to the position of FIG. **14** when the reel fills. Spring **228** is shown as a torsion spring, although coil tension springs have also been found to work effectively when the angle of pull is appropriately selected. The torsion spring is positioned about the stub shaft **214** and has one end inserted through a hole in a side wall of the frame and the other end engaging an edge of the clamp assembly. When the assembly reaches the position of FIG. **16,** it loses contact with the corresponding end of the spring, which has now unwound. The feeler may comprise a yoke **232** (FIG. **13**) supporting a roller **234** which engages the webbing. The yoke is fixed to a shaft **236** which turns upon the side plates of the frame and which is fixed to an arm **238.** The arm engages a roller **240** supported by a lug **242** at one side of the clamp assembly at a location chosen to optimize the turning moment exerted by the arm **238** upon the roller **240.** The undersurface of arm **238** may be tapered and otherwise contoured as shown to facilitate this action and to clear stub shaft **214** and spring **228.** By making arm **238** long relative to the yoke **232,** a small movement of roller **234** relative to the axis of the reel will create a substantial movement at the end of arm **238** adjacent to the roller **240.** The back pressure exerted by roller **234** upon the reel is not great, because the feeler operates when the belt is released and there is little force tending to oppose the motion of the clamp assembly.

When the belt is unfastened, the clamp assembly turns from a position approximately that of FIG. **15** to the position of FIG. **16** under the action of the spring **228.** Pin **218** moves along the slots **222** so as to release the clamp and facilitate retractile movement of the strap. The strap winds upon the reel until roller **234** is lifted far enough to engage arm **238** with the roller **240,** whereupon the feeler moves the clamp assembly from the position of FIG. **16** to the position of FIG. **14.** If now the strap is extended, the clamp assembly remains in the position of FIG. **14,** as described above, until the extensile movement of the strap ceases, whereupon the clamp assembly automatically flips toward the position of FIG. **15,** the feeler having lost contact with the webbing upon the reel and being ineffective. Any further extensile pull upon the strap merely tightens the clamp, turning the clamp assembly down to the position of FIG. **15.** The clamp assembly does not quite reach this position until the strap is pulled extensilely, because the tension in the strap portion adjacent to the reel exerts a slight lifting force, as does the spring **228.** Spring **228** is made just strong enough to turn the clamp assembly when the strap is retracted, and its action is readily overcome by the reel force when the fastener end of the strap is held. The locking action of the clamp may be increased by moving rollers **226** to the left in FIG. **15,** and/or by increasing the downward slope of slots **222** to the left. Also, the clamping plate **216** may be knurled.

The apparatus shown in FIGS. **13–16** is influenced by the weight distribution of the clamp assembly, which affects the relationship of the forces tending to maintain the clamp assembly in the position of FIG. **14** or to flip the assembly toward the position of FIG. **15.** It has been found, for example, that the apparatus will operate very well when turned up-side-down, provided that the stop **224** is adjusted to compensate for the change in gravitational forces. Of course, the clamp assembly may be balanced, so that gravitational forces have no effect upon its operation.

FIGS. **30** and **31** illustrate a modified embodiment of the invention, which is preferred for simplicity. The apparatus illustrated, which may be placed in the housing **12** of FIG. **1,** comprises a retraction reel **244** rotatably supported upon a frame **246.** The reel may be of the conventional type wound by a helical torsion spring, as described in connection with the embodiment of FIG. **3,** for example. A clamp assembly **206** of the type previously described is pivotally supported upon the side plates of the frame by means of stub shafts **247** and **248.** A torsion spring **249,** which may be wound about stub shaft **248,** has its ends connected respectively to a side plate of the frame and a side plate of the clamp assembly **206** and exerts a torsional force upon the clamp assembly to bring the clamp assembly to the open position of FIG. **31** against a stop **250,** which may be adjustable as indicated previously, to limit the rotation of the clamp assembly. The strap **10** is trained from the bottom of the reel through the clamp and the rollers **226** in the manner previously described.

A reel of the type indicated at **244** is characterized by the fact that the force exerted upon the strap decreases as the spring unwinds during retraction of the strap. The tension in the strap between the reel and the clamp assembly may decrease substantially to zero when the strap is fully retracted and the driving spring of the reel is substantially unwound. Under these conditions very little force is required to turn the clamp assembly to the position of FIG. **31,** the tension in the portion of the strap between the clamp assembly and the fastener at the free end of the strap also being very low. Thus a torsion spring **249** of relatively little torque will move the clamp assembly to the position of FIG. **31** when the strap is fully retracted.

When the strap is extended, the clamp assembly remains against the stop **250** because of the tension in the portion of the strap between the clamp assembly and the fastener, as described in connection with the embodiment of FIG. **13.** However, when the extensile movement ceases, the tension in the portion of the strap between the clamp assembly and the fastener decreases, the tension in the portion of the strap between the clamp assembly and the reel having increased during the winding of the reel spring and the angle between the flights of strap having increased because of the decrease in effective reel diameter. The result is that upon cessation of the extensile movement of the strap the clamp assembly automatically flips to its closed position, counterclockwise in FIG. **31,** as described in connection with the embodiment of FIG. **13.** Extensile pull upon the strap now merely turns the clamp assembly further counterclockwise and firmly locks the clamp. The torsion spring **249** is not strong enough to prevent closing pivotal movement of the clamp assembly, the reel spring easily overcoming torsion spring **249** to produce this movement.

When the fastener is released by the user, the torsion spring **249** turns the clamp assembly clockwise somewhat from its closed position, and the strap easily slips through the clamp as it is wound upon the reel. Finally, when the reel force has dropped sufficiently, the torque of spring **249** is sufficient to turn the clamp assembly fully clockwise against the stop **250** as shown in FIG. **31.**

Torsion spring **249** should have the minimum force required to turn the clamp assembly to its open position at the end of the retractile movement of the strap when the reel force is very low. The bearing friction for the pivotal movement of the clamp assembly should be kept low, so that the clamp assembly can turn very freely. Thus the light torsion spring **249** is sufficient to turn the clamp assembly when desired but does not interfere with the locking action.

The apparatus of FIGS. **30** and **31** operates very effectively with a constant force reel, such as the type employing a Negator spring previously mentioned, if the spring force is permitted to drop substantially to zero when the strap is fully retracted. This may be accomplished by permitting the Negator spring to unwind substantially to its end when the strap is fully retracted. Under these circumstances the force upon the strap is substantially constant except in the end region of the retraction. The use of such a motor has the advantage of substantially full retractile force during retraction except at the very end of the retractile movement.

The apparatus of FIGS. **30** and **31** works very effectively with a clamp assembly **206** obtained from the buckle of a seat belt manufactured by B'Way Seat Belt Co., Model No. 500, which uses an ordinary knurled clamp pin of the type common in the seat belt industry. The portion of the buckle between the side plates was removed, except for the stationary clamp plate and the movable clamp pin.

The angle between the flights of the strap at opposite sides of the clamp assembly is influenced by the amount of webbing wound upon the reel, by the position of the rollers **226,** and by the relative positions of the turning axes of the reel and the clamp assembly. With the general arrangement of the parts shown in FIGS. **30** and **31** it is a simple matter to locate the stop **250** at a point which permits the clamp assembly to remain open reliably while the strap is extended and yet to flip reliably to its closed position when extensile movement of the strap ceases. The weight distribution of the clamp assembly influences its turning movement to a minor extent, and if desired this may be obviated by balancing the clamp assembly about its pivotal axis. The apparatus of FIGS. **30** and **31** operates very effectively when inverted from the position shown, with the strap being pulled from the rollers **226** at the top of the apparatus, when the stop **250** is adjusted accordingly. If desired, the torsion spring **249** may be a constant torque type, such as the Negator type springs described previously, with the torque chosen so as to be just sufficient to turn the clamp assembly to its open position when the strap is in its full retracted position.

The apparatus of FIGS. **30** and **31** can also be made to operate with the strap trained from the top of the reel. However, under these circumstances, the change in angle of the portion of the strap adjacent to the reel as the reel empties works against the desired flipping action of the clamp assembly from its open to its closed position. The change in the magnitude of the tensile forces when extensile movement ceases must be sufficient to produce the desired flipping action even with the unfavorable angular change. Since with the ordinary helical reel spring the reel force will increase as the reel empties and the angle decreases, there is an inherent compensation. If desired, the angle of the strap leaving the reel may be made independent of the amount of strap on the reel, by using guide rollers, and merely the change in magnitude of the tensile forces utilized to produce the desired action.

FIGS. **32–34** illustrate a modification in which a feeler alone is utilized for moving the clamp assembly to its starting position. In this embodiment a retraction reel **252,** which may be of a type previously described is supported upon a frame **254,** the strap **10** extending from the bottom of the reel past a pivotally supported clamp assembly **206** of the type previously described. As shown in FIG. **32,** one end of the clamp assembly is fixed to a pulley **256** to which is attached a cable **258** having its other end connected to a feeler **260.** The feeler may be of the type previously described having a roller **262** for engaging the webbing upon the reel when the reel is sufficiently filled and for moving an arm **264,** to the lower end of which the cable is connected. The connection may include a tension spring **266.** The cable is trained under the pulley **256** to the feeler, so that when arm **264** moves to the left in FIG. **34** near the end of retraction, the pulley is turned in a direction to move the clamp assembly from the position of FIG. **34** to the position of FIG. **33** against a stop. If the strap is now extended, the feeler loses contact with the strap upon the reel, and the cable **258** slackens. The clamp assembly remains in the position of FIG. **33** until the extensile movement ceases, whereupon the clamp assembly turns automatically toward the position of FIG. **34,** at which the clamp is locked against extensile strap movement.

Although the clamp is locked against extensile strap movement in this position, the strap may nevertheless be retracted through the clamp when the belt is unfastened. The pressure exerted by the strap portion adjacent to the reel upon the bottom of the clamp assembly tends to move the clamp assembly counterclockwise somewhat to facilitate the release of the clamp and the movement of the strap therethrough. The clamp assembly does not move to the position of FIG. **33** until most of the webbing is wound upon the reel. Spring **266** permits additional movement of the feeler after the clamp assembly has moved to the position of FIG. **33.**

FIGS. **35–37** illustrate a modification of the clamp assembly which may be employed to provide a smaller angle of rotation between the closed and opened positions of the clamp. In this embodiment a retraction reel **268** of a type previously described is rotatably supported upon a frame **270.** A clamp assembly **272** substantially the same as the clamp assembly **206** previously described (except for its pivotal arrangement) is supported for pivotal movement upon the side plates of the frame by means of stub shafts **274,** one at each side, which receive ears **276** depending from the side plates of the clamp assembly. By moving the pivotal axis of the clamp assembly below the clamping pin in the closed position the clamp assembly may turn between its closed and open positions by approximately ninety degrees of rotation, a stop **277** being provided to limit the motion at the open position. Movement of the clamp assembly to its open position may be accomplished, for example, by a feeler mechanism **278** of the general type described in connection with FIG. **13,** the feeler engaging a roller **279** appropriately located on one of the side plates of the clamp assembly. A torsion spring **280** may be employed, as indicated in the modification of FIG. **37,** to produce this movement in the manner described in conjuntion with FIGS. **30** and **31.** Alternatively, the torsion spring may produce part of the movement, and the feeler the remainder of the

movement as in the embodiment of FIG. 13, and a sector may be employed as in FIG. 40 described hereinafter. Moreover, the clamp assembly may be balanced for movement about its pivotal axis.

FIGS. 38–41 illustrate a modification in which a sector is employed to maintain the clamp assembly in open position while the strap is extended. A retraction reel 282 rotatably supported upon a frame 284 has an end disc 286 arranged to drive a sector 288 freely supported upon a stub shaft 290 on a side plate of the frame. A clamp assembly 206A (similar to 206, but shown with a cross-plate) may turn about the same pivotal axis as the sector but freely thereof. The strap 10 is trained from the bottom of the reel through the clamp in the manner previously described. The sector is biased up to the position of FIG. 39 by a torsion spring 292 and has an arm 294 arranged to engage a lug 296 extending from a side plate of the clamp assembly. The lug may also serve to engage a stop 298 to limit the movement of the clamp assembly in its open position. The clamp assembly may be turned to its open position by any suitable means, such as a torsion spring 300, when the strap is retracted. Alternatively the clamp assembly may be placed in this position by a feeler alone or in conjunction with spring 300.

During retractile movement of the reel, the sector 288 is lightly in contact with the reel in the position of FIG. 39, but the clamp assembly may be moved to the position of FIG. 40 independently of the sector by the means described above. When the strap is extended, the sector moves to the position of FIG. 40, arm 294 engaging the lug 296, with the lower edge of the sector just contacting the reel (or O-ring) as shown. When extensile movement of the reel ceases, the reel may turn in a retractile direction, turning the sector with it. The clamp assembly follows the sector as shown in FIG. 39, the slack created in the strap by movement of the clamp assembly being taken up by the reel. The clamp assembly may move to the locked position of FIG. 41, forcing the sector away from the reel against the light bias spring of the sector. With the arrangement of this embodiment, the clamp assembly need not be turned as far clockwise to its open position. If a feeler is employed in moving the clamp assembly to its open position, the pressure of the feeler may be utilized to hold the clamp assembly in this position until the sector has moved sufficiently to become effective. In other words, if the pressure of the feeler were released, in the absence of a sector the clamp assembly would move to locked position even at the commencement of the extensile movement of the strap. Similarly, when a torsion spring is employed to move the clamp assembly to its open position, it may have only sufficient force to hold the clamp assembly in this position when the strap is fully retracted and the angle between the flights of strap is small.

FIGS. 26–29 illustrate an embodiment of the apparatus which may be placed in the housing 12 of FIG. 1 employing a feeler to move a clamp assembly to an open position, at which the assembly would immediately move to the locked position if the feeler were released, and employing a sector to latch the feeler in position and prevent its release. In this embodiment a retraction reel 302 is supported upon a frame 304, the strap 10 being trained from the bottom of the reel past a clamp assembly 206. The assembly is pivotally supported upon the frame at 306 and is arranged to move through approximately ninety degrees between the positions illustrated in FIGS. 27 and 28. A feeler mechanism comprises a pair of links 308 and 310 pivotally connected at 312 at one end thereof. The other end of link 308 supports a roller 314 for sensing the amount of webbing upon the reel as previously described. The linkage is pivotally supported upon the frame at 316. The other end of link 310 is pivotally connected at 318 to a lug on one of the side plates of the clamp assembly. The linkage moves between the positions of FIGS. 28 and 27 and causes corresponding movement of the clamp assembly. A sector 320 is driven by an end disc of the reel, the sector being biased up against the disc in the position of FIG. 27 by a torsion spring 322. The sector has a latch arm 324 provided with a tooth 326 arranged to be inserted over a pin 328 extending from the side of link 310.

The feeler mechanism places the clamp assembly in the position of FIG. 27 when the strap is sufficiently retracted, the sector merely dragging upon the reel lightly during retractile movement of the reel. When the strap is extended, the sector immediately moves to the position of FIG. 29 and inserts the tooth 326 above pin 328. Thus, when the feeler loses contact with the webbing upon the reel, the sector prevents movement of the feeler linkage which would permit the clamp assembly to turn to the locked position of FIG. 28. However, when extensile movement has ceased, the reel may turn in a retractile direction, turning the sector so as to release the feeler linkage and permit the clamp assembly to turn to the locked position of FIG. 28. Slack is created automatically by the turning of the clamp assembly from the position of FIG. 27, thereby permitting the reel to turn to take up the slack and to move the sector to release the feeler mechanism. The friction between pin 328 and locking tooth 326 may be reduced by providing a roller upon the pin, so that the tooth may be readily withdrawn notwithstanding pressure exerted thereon by the pin as the clamp assembly tries to close. Also, if desired, retractile movement of the reel may be facilitated by a slight slackening of the strap at the fastener end.

FIGS. 44 and 45 illustrate an embodiment of the invention somewhat similar to FIG. 37 but in which one of the clamp elements remains fixed relative to the reel. In this embodiment a retraction reel 330 of a type previously described is rotatably supported upon a frame 332. Clamp plate 334 is fixed between the side plates of the frame. The knurled clamping pin 336 is fixed between a pair of arms 338 at opposite sides thereof pivotally supported by stub shafts 340 upon the side plates of the frame, the arms 338 and the pin 336 forming an inverted U. A light torsion spring 342 may be employed to turn the pin assembly to the open position of FIG. 44 in which the assembly comes to rest against a stop 336, when the strap is retracted. The pin assembly remains in this position during extension of the strap 10 to the desired length and moves to the closed position of FIG. 45 when extensile movement ceases.

FIGS. 42 and 43 illustrate a similar embodiment in which the pin 336 is supported for sliding movement in arcuate slots 344 by means of curved ears 346, a tension spring 348 being employed to return the pin to its open position of FIG. 42. The movement of the pin to its closed position of FIG. 43 is essentially the same as in FIGS. 44 and 45.

FIGS. 17 and 18 illustrate an embodiment of the invention in which a feeler mechanism and a sector are employed to control the operation of a clamp having a

pin which moves toward and away from a plate along an arc. In this embodiment a retraction reel **350** of a type previously described is supported for rotation upon a frame **352.** The strap **10** passes from the bottom of the reel around a clamping plate **354** fixed between the side plates of the frame, a roller **346** being provided to reduce friction in the passage of the strap around the plate. The strap then passes about **356** pin **358,** which may be knurled, and which is rigidly supported between a pair of yoke arms **360** suspended upon a shaft **362** for pivotal movement. After passing between the plate **354** and the pin **358** and reversely about the pin, the strap extends between rollers **364** to the fastener at the free end. A feeler **366** is fixed to the yoke defined by the arms **360** and the pin **358** and has a roller **368** for engaging the webbing upon the reel to turn the clamp to the open position of FIG. **18** when the reel is full. A spring **369** may be employed to assist in moving the clamp to its open position. A sector **370,** which is supported for free pivotal movement about the axis of pivotal movement of the arms **360,** engages one of the end discs of the reel and is driven thereby. A torsion spring **372** tends to maintain the sector engaged with the end disc when the sector is in its lower position as shown in FIG. **17.**

When the strap is extended, the clamp has been moved to the open position of FIG. **18** by the feeler, and the sector is driven by the reel so as to cause a pin **374** thereon to engage the underside of the feeler and hold the clamp open as long as the strap is extended. If then the strap is relaxed, the reel retracts sufficiently to permit the sector to release the feeler, and any pull upon the strap thereafter closes the clamp more tightly. When the belt is unfastened, the strap slips through the clamp (spring **369** may be employed to open the clamp slightly) and the strap is retracted.

The mechanical advantage of the feeler and the sector may be increased by shortening the arms **360** relative to the length of the feeler arm and the length of the sector.

FIGS. **21–25** illustrate apparatus for reducing undesired friction at a clamp pin in embodiments where the pin moves along an arcuate path toward and away from a clamping plate or where the pin moves along a straight path toward and away from a clamping plate. As shown in FIG. **25** a pin **376,** which may be a knurled pin employed in a clamp assembly, such as the clamp assembly **206** of FIG. **13,** is provided with inset rollers **378** at the surfaces thereof remote from the fixed plate **380** against which the strap **10** is to be clamped. The pin has ears **382** at opposite ends thereof to provide the desired sliding movement in slots (not shown) of the clamp assembly. Friction is thus maintained in the region between the pin and the plate but is reduced elsewhere.

FIG. **24** illustrates a pin **384** supported upon arms **386** at the ends thereof for pivotal movement about an axis **388** toward and away from a fixed clamp plate **390.** In this case the pin **384,** which may be knurled, is permitted to turn in one direction. This is accomplished by rotatably supporting the pin at **392** upon the arms **386** and providing the pin with a ratchet wheel **394** fixed thereto, the ratchet wheel having a cooperating pawl **396** pivotally supported upon a corresponding arm **386.** It will be apparent that the pin **384** is free to turn in a retracting direction but is prevented from turning in an extending direction, so that the pin acts as if fixed upon the arms **386** during clamping of the strap against extension.

FIG. **23** illustrates a modification in which the pin may turn in either direction when it is not in clamping position adjacent to the plate **390.** In this case the pawl **398** is pivoted upon the clamping plate (in a slot thereof) and is engaged with the ratchet wheel **394** only when the ratchet wheel is moved with the pin **384** into clamping engagement with the plate **390.** At this point retractile rotation of the pin **384** is still possible, but extensile rotation is prevented. The pawl is provided with a bias spring **400** and a stop **402.** If the pawl were simply a fixed tooth, both extensile and retractile rotation of the pin **384** would be prevented when the pin is in clamping position. Pawl **398** must not be long enough to hold the pin **384** away from the clamping plate **390.** It will be apparent that the principle illustrated in FIG. **23** may also be employed if the pin **384** moves rectilinearly with respect to the plate **390,** rather than along an arcuate path.

FIGS. **21** and **22** illustrate a modification in which a pin **404,** which may be a knurled sliding pin of a clamp assembly of the type previously described, is permitted to rotate in a retracting direction. The pin is rotatably supported by means of a shaft **406** upon a pair of ears **408** and **410,** which slide in slots **412** in the side plates **414** of the clamp assembly to permit movement of the pin toward and away from a fixed clamp plate **416.** one of the ears supports a pawl **418** for engagement with a corresponding ratchet wheel **420** secured to the shaft **406** which turns with the pin **404.** It will be apparent that the pawl and ratchet mechanism permits rotation of the pin in a retracting direction but not in an extending direction.

While preferred embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that changes can be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims. Accordingly, the foregoing embodiments are to be considered illustrative, rather than restrictive of the invention, and those modifications which come within the meaning and range of equivalency of the claims are to be included therein.

We claim:

1. A retractable seat belt comprising a retraction reel, a strap connected to said reel for retraction and extension, clamp means for preventing extension of said strap, said clamp means comprising a pair of clamp elements, one of said elements being movable relative to the other, said one element comprising a slider, said strap being trained from said reel between said clamp elements and around said slider reversely whereby tension in said strap exerts a force upon said slider tending to move said one clamp element toward the other, means responsive to the amount of strap wound upon said reel for moving said one clamp element away from the other, and means for maintaining said one clamp element away from the other until said strap is extended to a desired length.

2. The retractable seat belt of claim **1,** further comprising guide means for guiding said strap between said clamp elements in a direction transverse to the movement of said slider, said slider having a roller around which said strap is trained.

3. The retractable seat belt of claim **1,** the last-mentioned means comprising a lever arranged for pivotal movement about a fulcrum, said lever being coupled to

said slider adjacent to said fulcrum, and means responsive to movement of said reel for engaging said lever remote from said fulcrum and turning it to move said slider.

4. The retractable seat belt of claim **1,** the last-mentioned means comprising a sector driven by said reel.

5. The retractable seat belt of claim **1,** further comprising bias means for urging said one clamp element away from said other clamp element.

6. In a retractable seat belt, retraction means, a strap connected to said retraction means for retraction and extension, clamp means for preventing extension of said strap, means for rendering said clamp means ineffective until said strap is extended to a selected length and for thereafter rendering said clamp means effective to prevent extension of said strap, said retraction means tending to retract said strap when said strap has been extended to said selected length, and means for temporarily rendering said clamp means and said retraction means ineffective after said strap has been extended to said desired length, whereby said strap may be further extended without retraction, and for thereafter rendering said clamp means and said retraction means effective again whereby said strap will be automatically retracted to said selected length.

7. The seat belt of claim **6,** the last-mentioned means comprising pawl and ratchet means temporarily engageable to prevent retractile movement of said retraction means and means for opening said clamp means concurrently with the engagement of said pawl and ratchet means.

8. A retractable seat belt comprising retraction means, a strap connected to said retraction means for retraction and extension, said strap having a fastener member at a free end thereof, a mating fastener member adapted to engage the first-mentioned fastener member to place said belt in user-restraining position means for preventing extension of said strap, means for rendering said extension-preventing means ineffective while said strap is being extended to a desired length, means responsive to retractile movement of said strap thereafter for rendering said preventing means effective, and means associated with said fastener members for causing at least a portion of the first-mentioned fastener member to move in an extending direction beyond said user restraining position in order to engage the mating fastener member and thereafter to move in a retracting direction to provide said retractile movement.

9. In a retractable seat belt and the like having a strap adapted to be extended and retracted, clamping means for preventing extension of said strap, said clamping means comprising a pair of clamp elements, one of said elements being movable toward and away from the other of said elements, said strap being trained between said elements and around said one element, said one element being supported for rotation in at least one direction when said one element is away from the other element, and means for preventing rotation of said one element in a direction corresponding to extensile movement of said strap when said elements are brought together to clamp said strap.

10. The apparatus of claim **9,** said one element comprising a roller and said preventing means comprising a ratchet wheel attached to said roller and a pawl adapted to engage said ratchet wheel.

11. The apparatus of claim **10,** said pawl being supported for movement with said one element toward and away from said other element and permitting rotation of said roller in said one direction only.

12. The apparatus of claim **11,** said ratchet wheel being supported for movement toward and away from said pawl as said roller moves toward and away from said other element and being located for engagement with said pawl when said roller is adjacent to said other element and for preventing extensile rotation of said ratchet wheel.

13. The apparatus of claim **9,** said one element being supported for pivotal movement toward and away from said other element.

14. The apparatus of claim **9,** said one element being supported for reciprocative movement toward and away from said other element.

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