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[54] **BALE SHAPE MONITOR FOR ROUND BALERS**

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[51] **Int. Cl.**[6] **A01D 75/00**

[52] **U.S. Cl.** **56/341**

[58] **Field of Search** .... 56/341, 16.4 R, 56/10.2 R, DIG. 15; 100/88; 33/555.1

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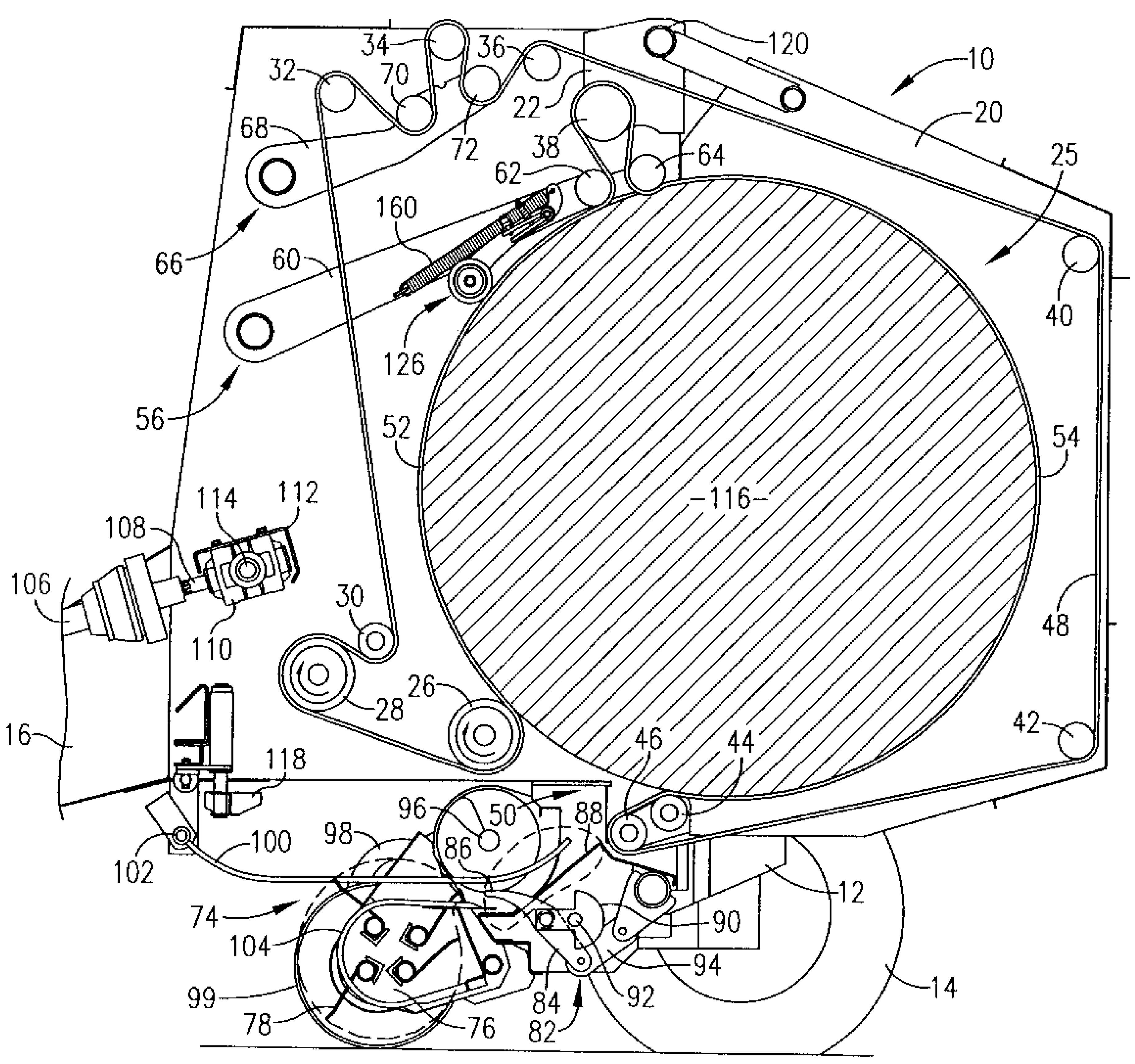
[57] **ABSTRACT**

A round baler includes a bale shape monitor for facilitating uniform bale formation. The bale shape monitor includes a pair of end sensors and an intermediate sensor. The end sensors sense the diameter of the bale at end locations adjacent opposite ends of the bale, while the intermediate sensor senses the diameter of the bale at an intermediate location spaced between the end locations. The monitor further includes a signal responsive to the sensors to indicate to the operator when the diameter of the bale at one of the end locations is less than the diameter at the intermediate location. The signal is electrically powered and includes a pair of switches, each of which is operably coupled between one of the end sensors and the intermediate sensor to operate an indicator when the diameter of the bale sensed at the corresponding end location is less than the diameter sensed at the intermediate location.

31 Claims, 4 Drawing Sheets



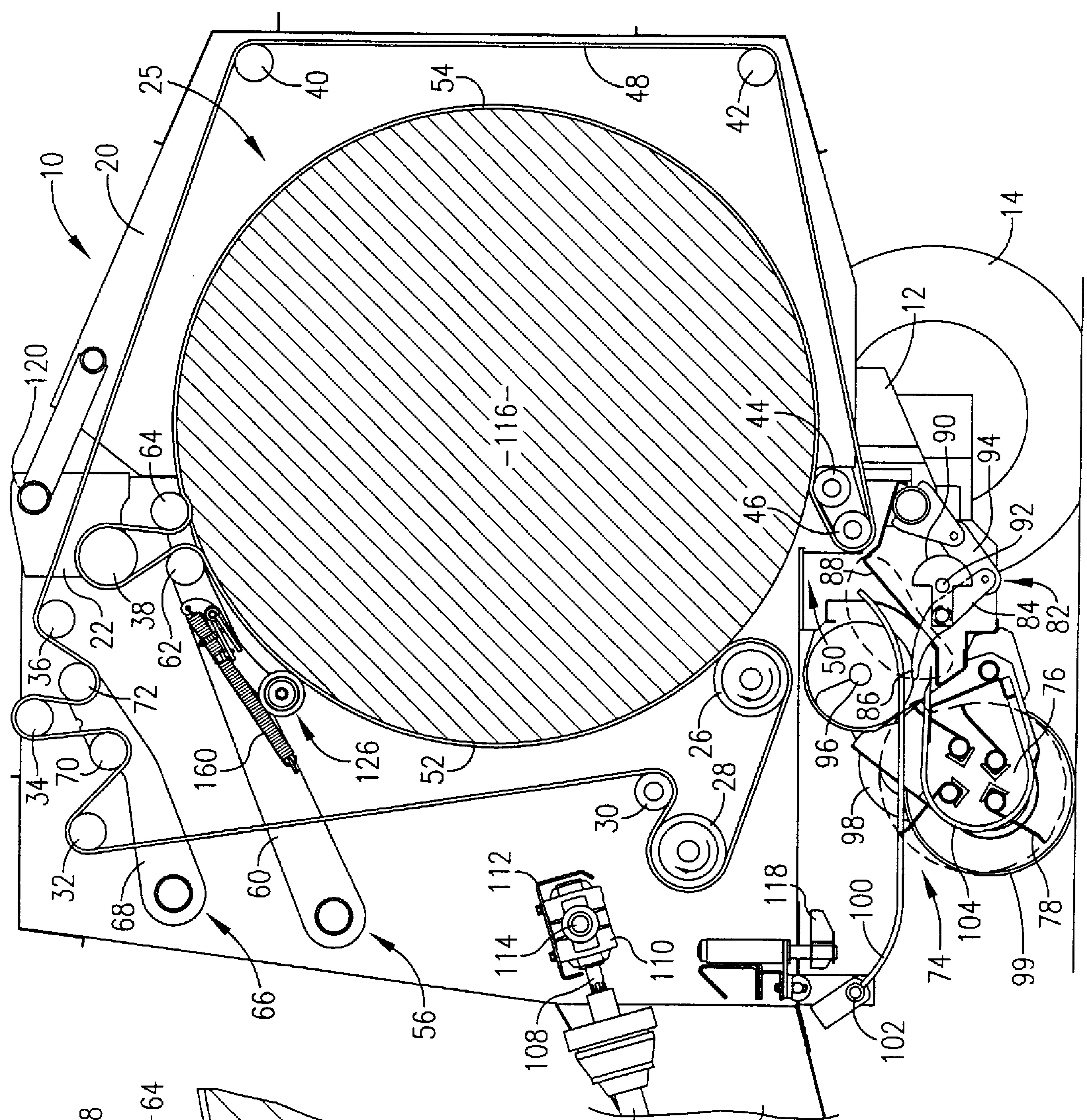


FIG. 1.

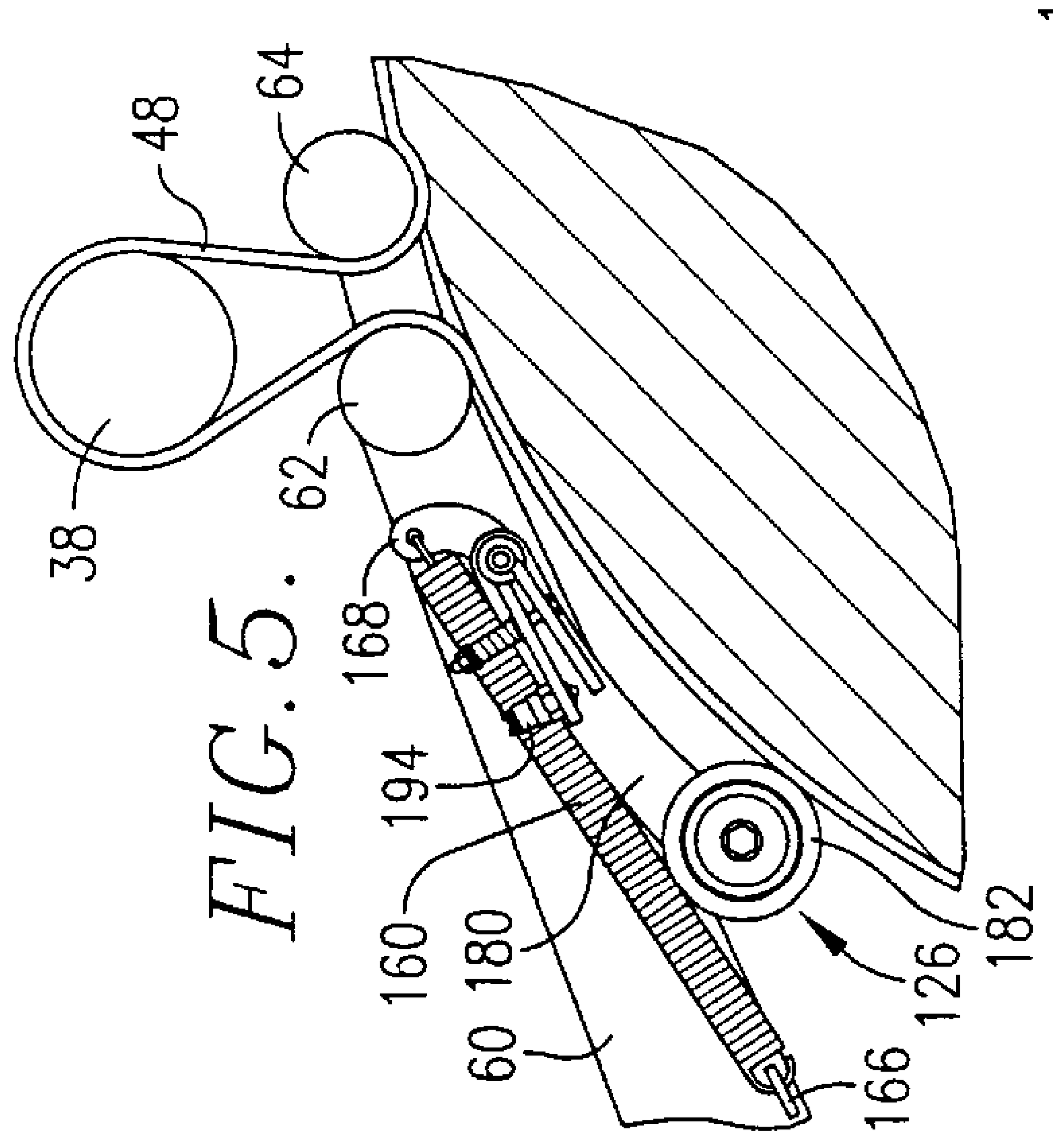


FIG. 5.

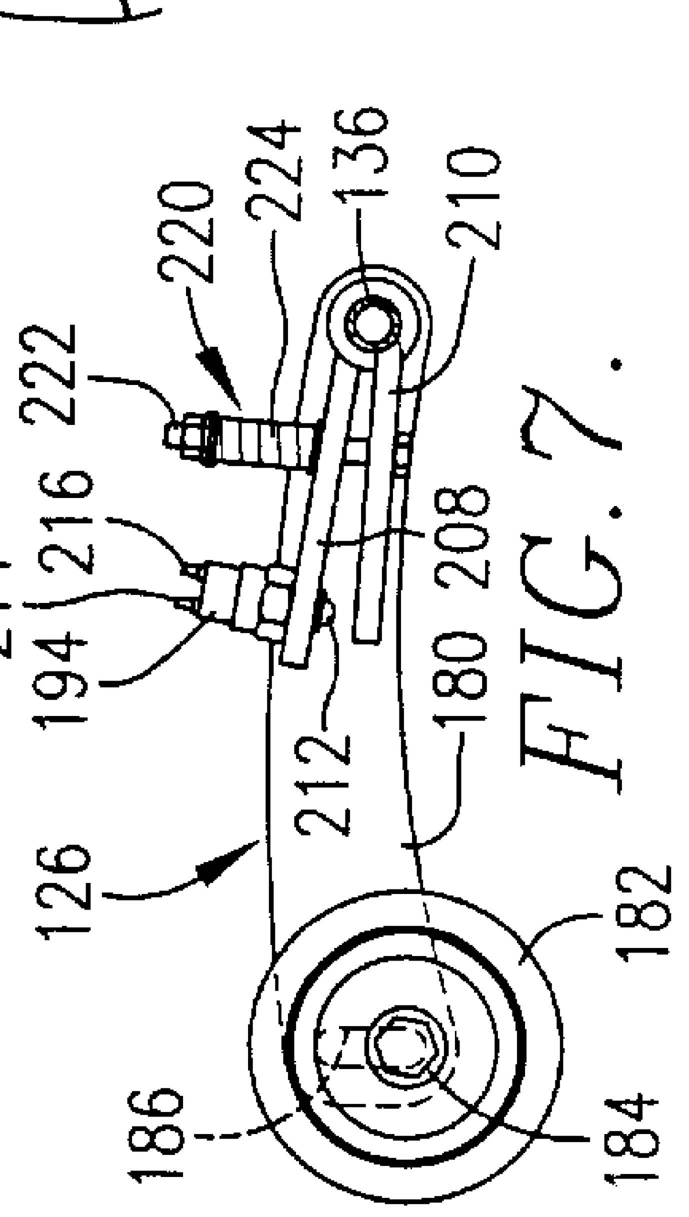


FIG. 7.

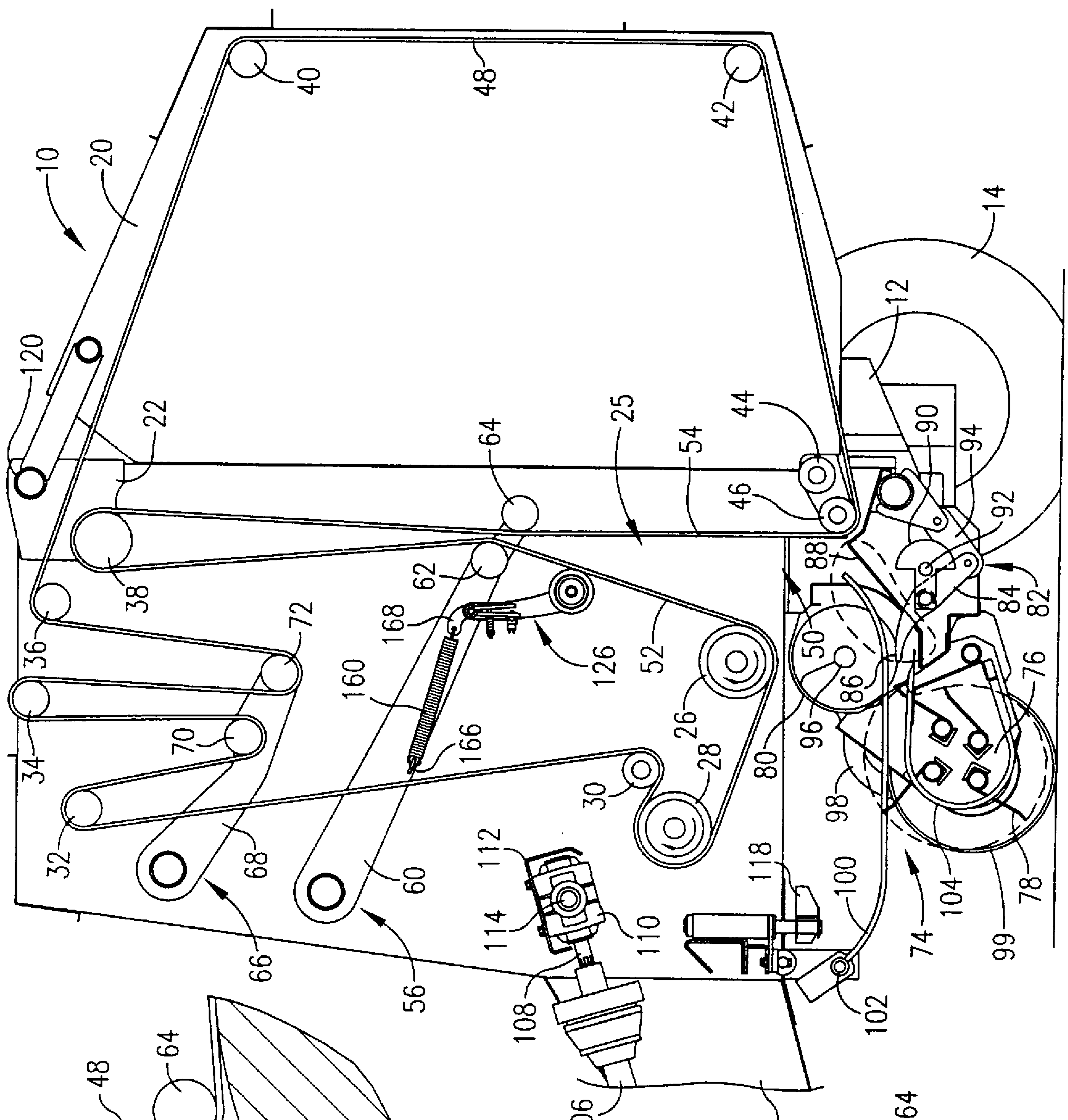


FIG. 2.

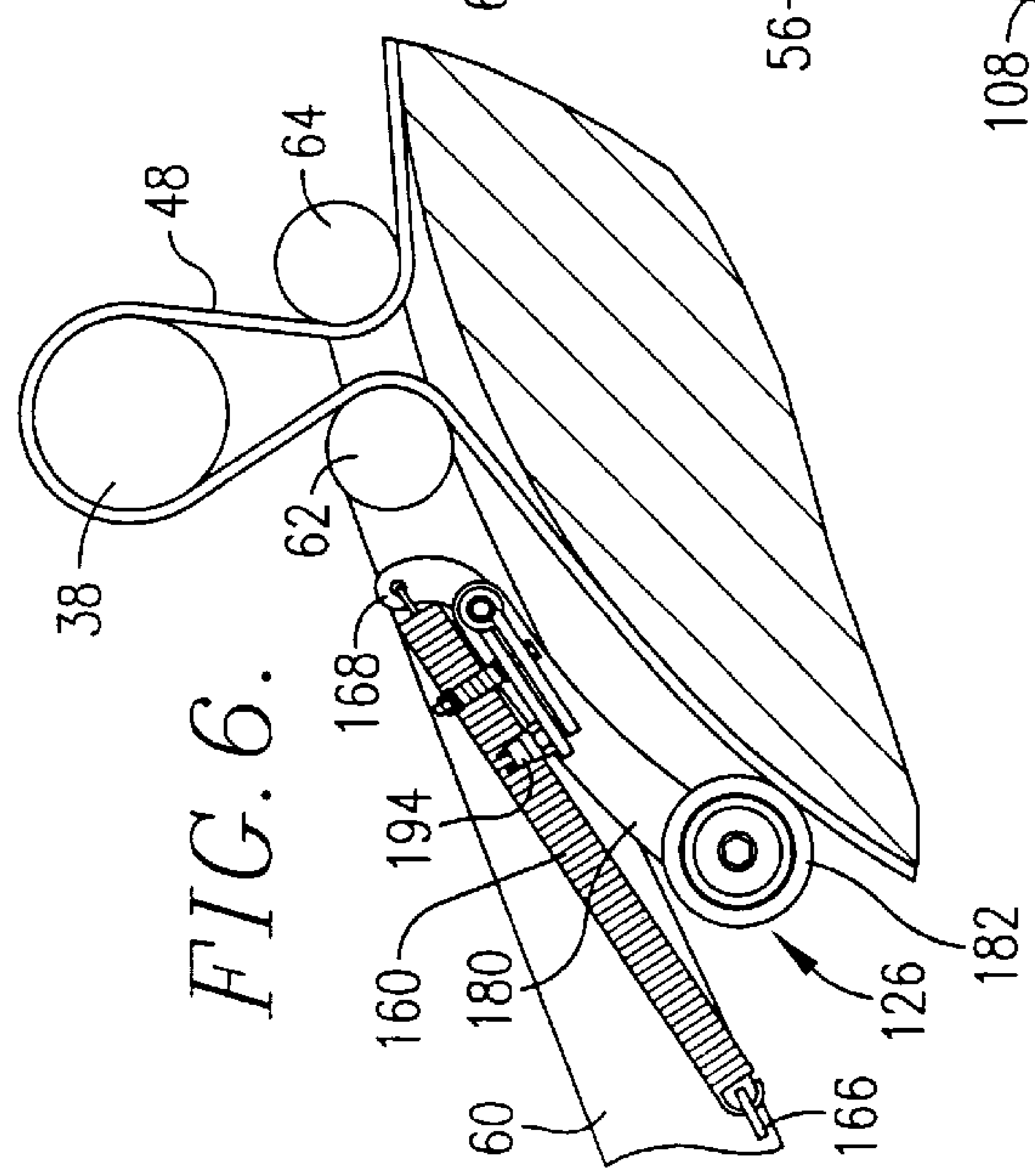


FIG. 6.

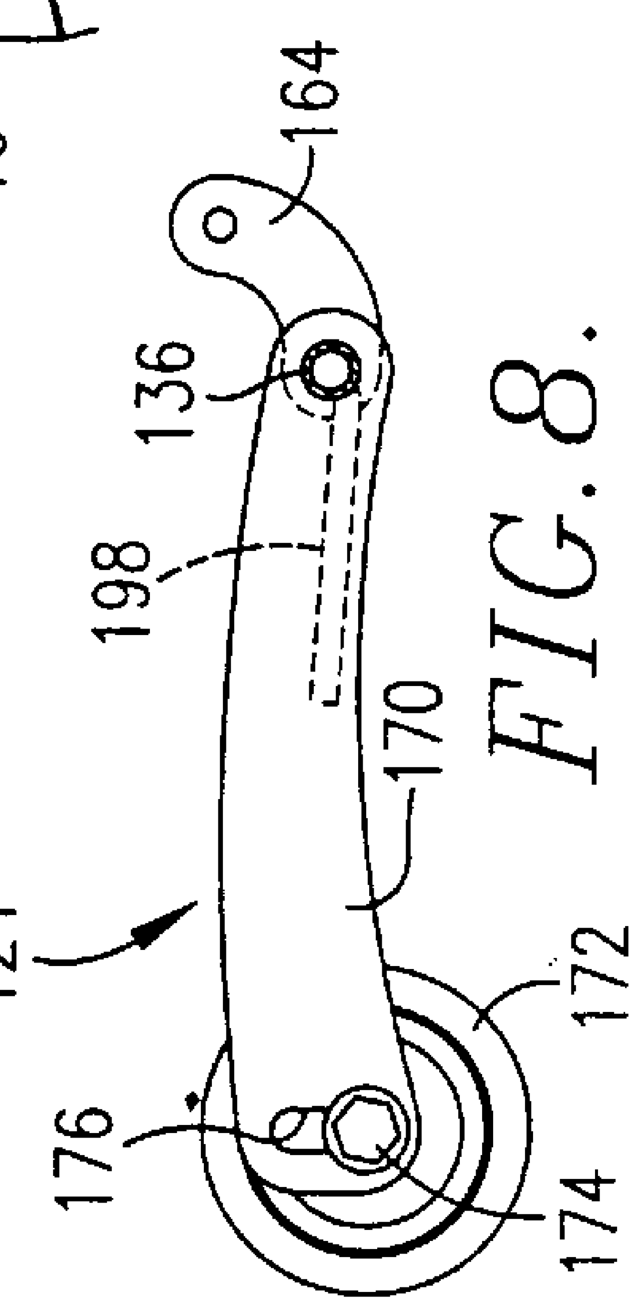


FIG. 8.

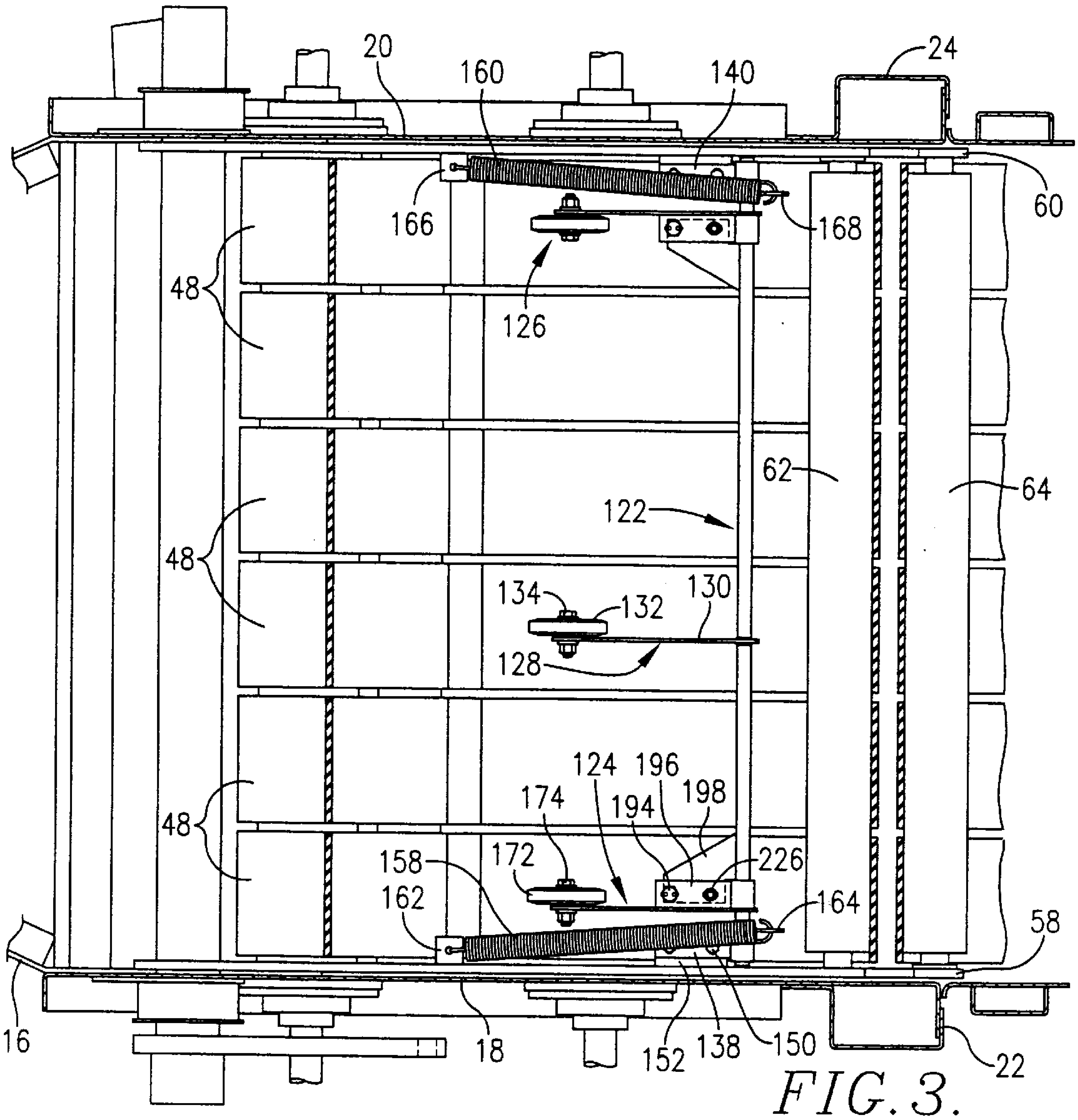


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FIG. 3.

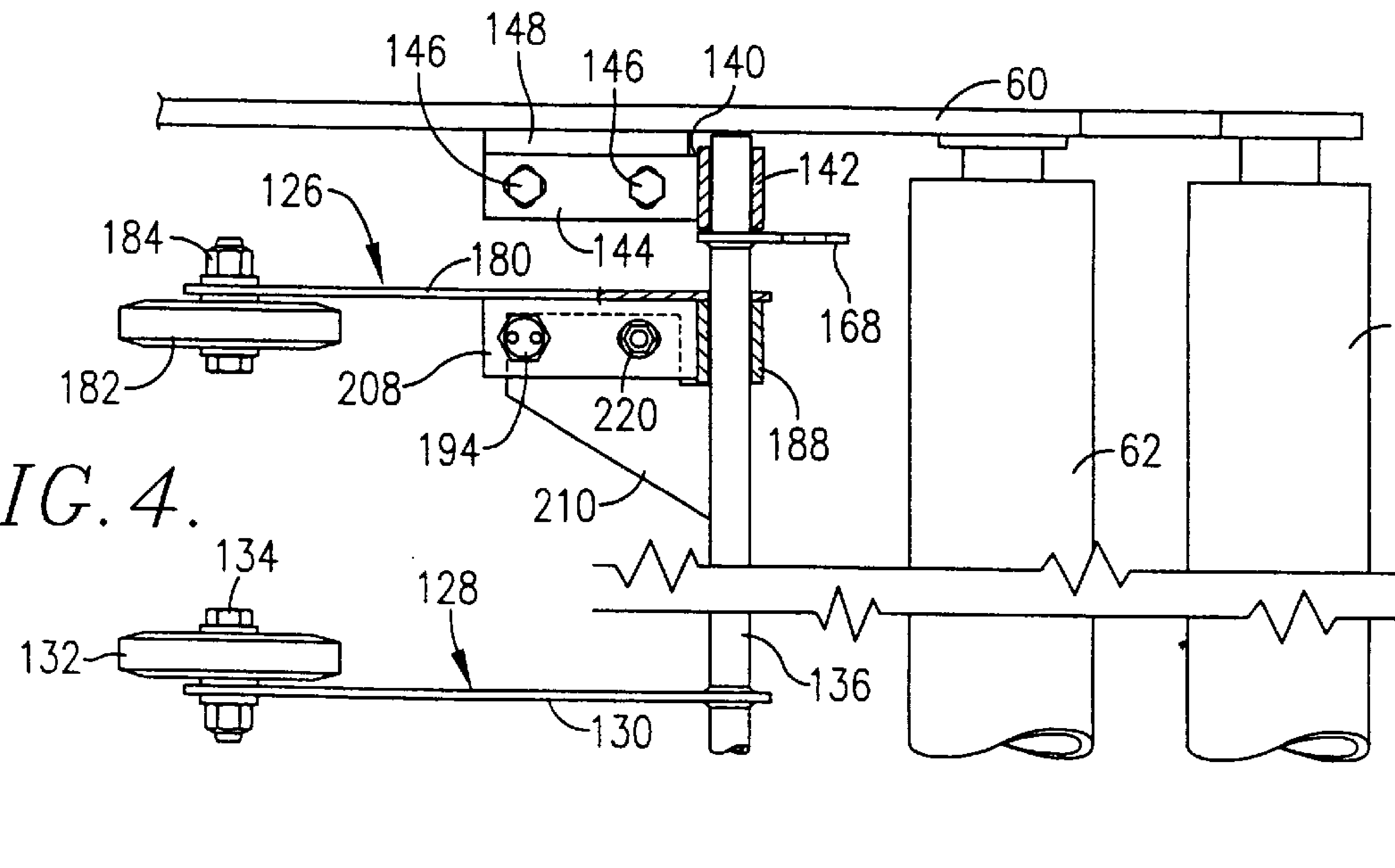

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FIG. 4.

FIG. 9.

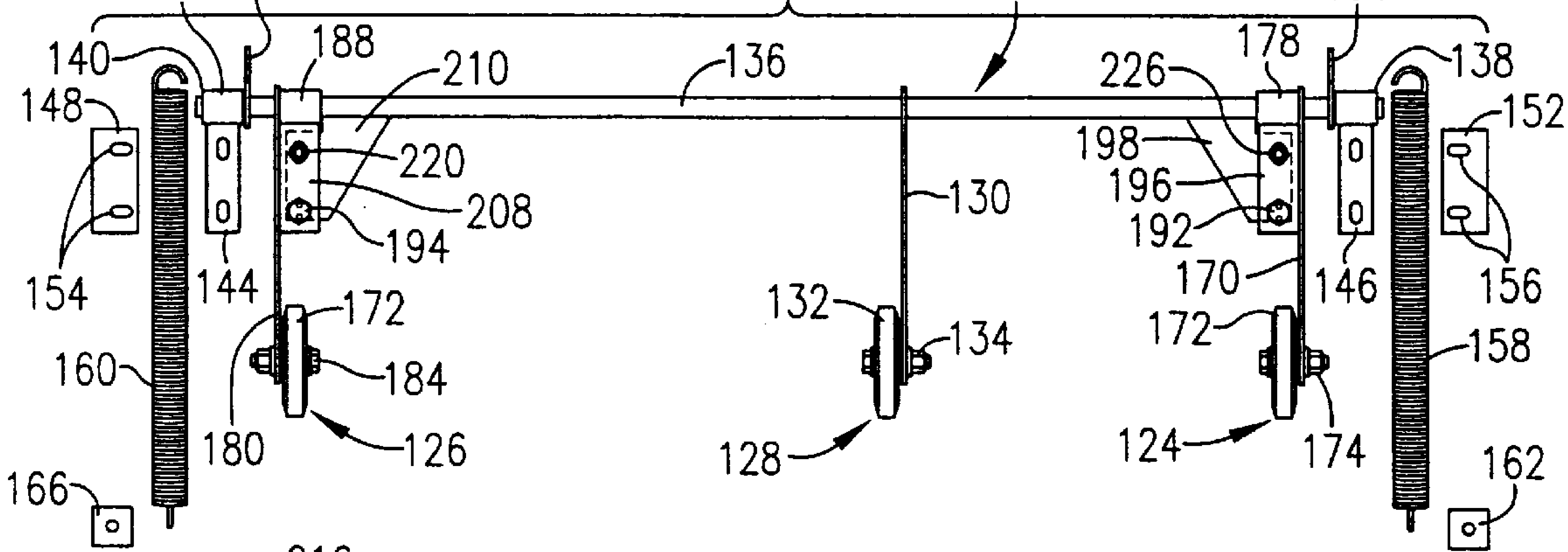


FIG. 10.

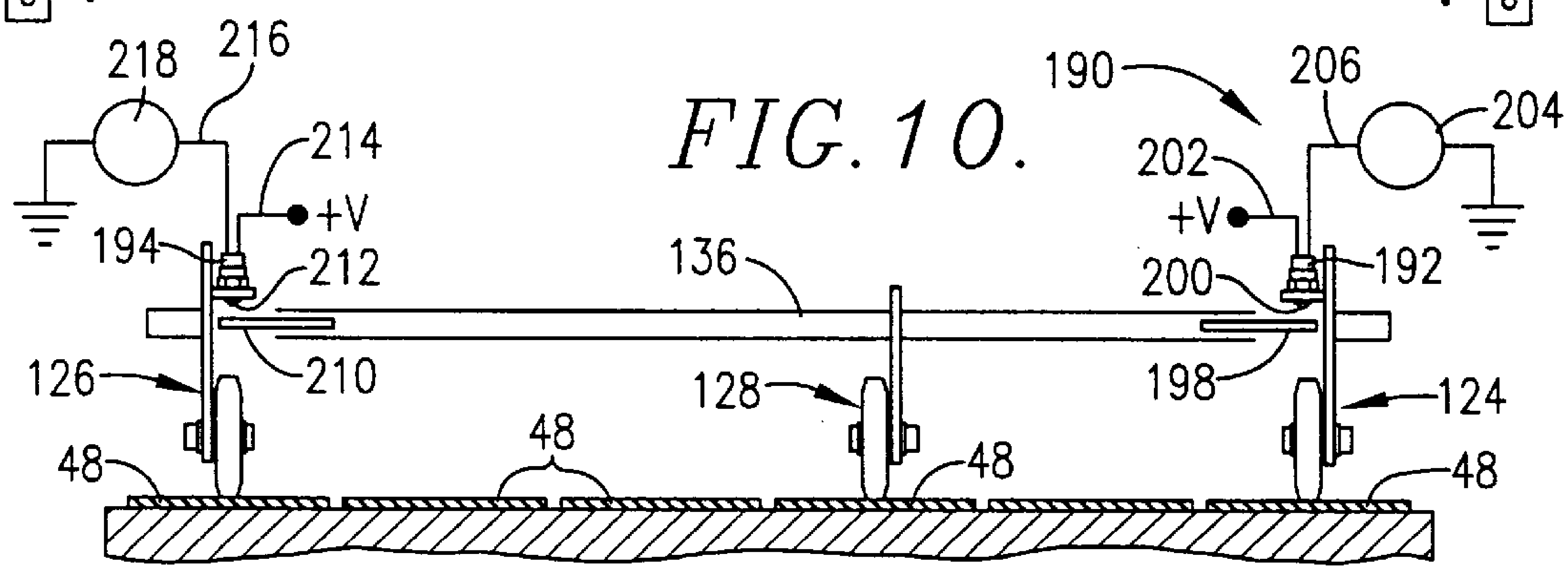


FIG. 11.

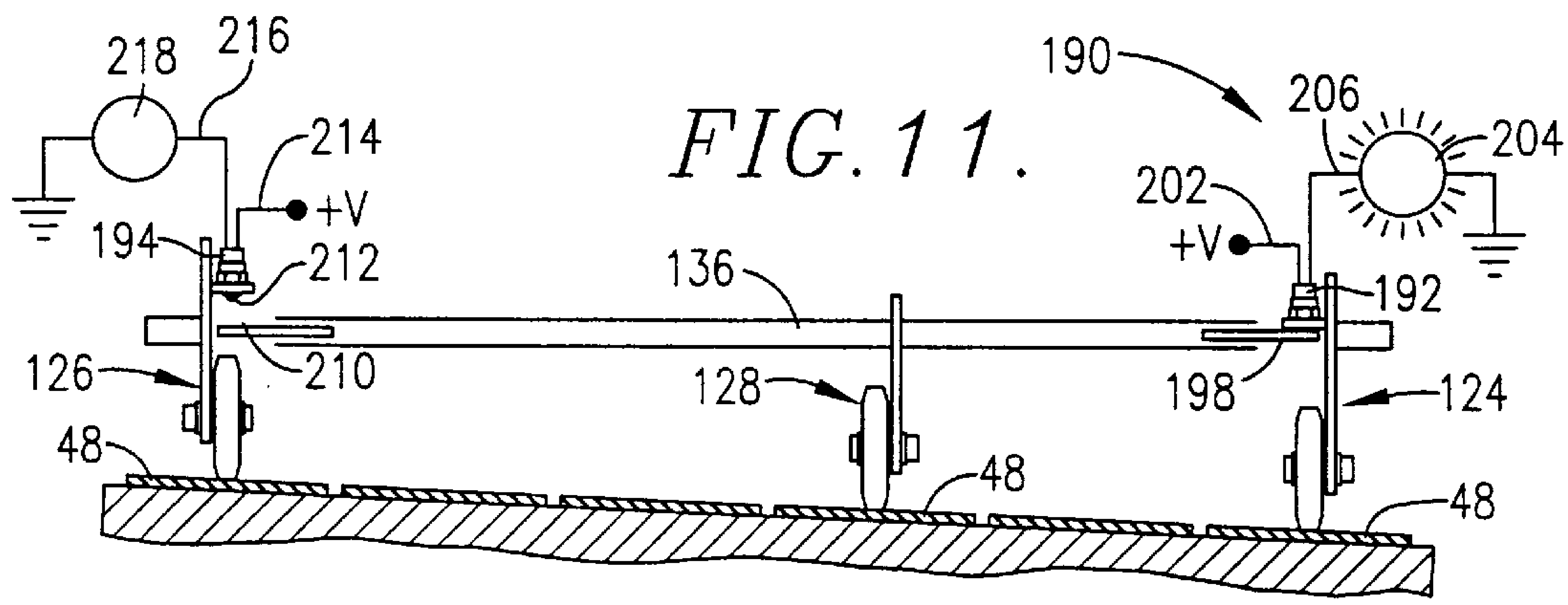
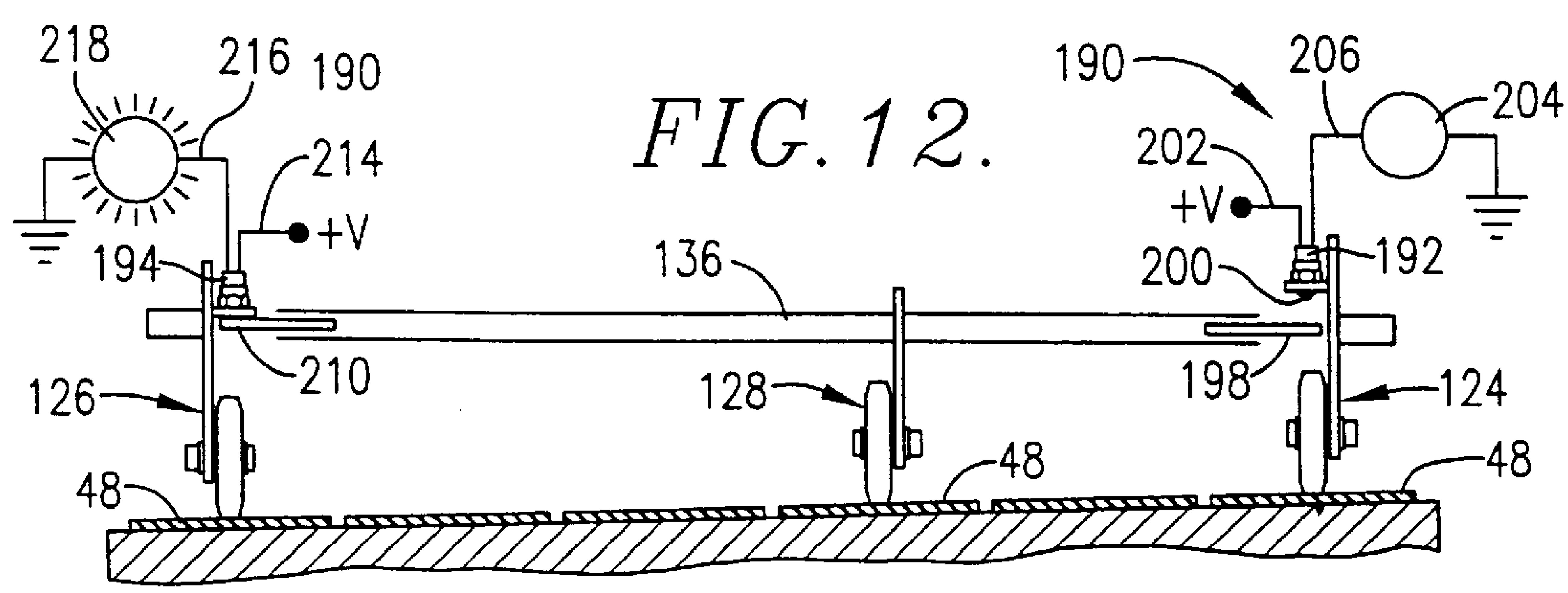


FIG. 12.



BALE SHAPE MONITOR FOR ROUND BALERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to round balers and, more particularly, to an improved bale shape monitor for facilitating uniform bale formation by the baler.

2. Discussion of Prior Art

In most instances, the crop windrow picked up by a round baler tends to be narrower than the overall length of the baling chamber. The baler must consequently be steered left and right as it pulled across the field so that an equal amount of crop material is delivered along the length of the chamber during the bale cycle; otherwise, the baler will likely form an asymmetrical bale having an uneven diameter from one end to end the other end. For example, if the baler is positioned relative to the windrow so that a disproportionate amount of crop is delivered to the left end of the baling chamber, the bale will almost definitely have a conical shape, with the left end of the bale having a greater diameter and density than the right end. In any case, nonuniform bale formation results in unsightly bales that are difficult to sell, stack and tie. Moreover, nonuniform bale formation often damages or, at the very least, places undue wear on the bale forming components.

Even the most skillful baler operator has difficultly in tediously weaving the baler from side to side for ensuring even delivery of crop material between the sidewalls of the baler. Accordingly, bale shape monitors have been developed to assist the operator with uniform bale formation. Conventional bale shape monitors typically include indicators placed within the cab of the tractor to signal to the operator when the bale is not being properly shaped. Traditional indicators include bale shape displays which represent the shape of the bale from end-to-end or at certain locations along the length of the bale. A more common indicator includes so-called "driving lights" which signal to the operator when to steer left, steer right or simply drive forward. Additionally, some balers have even been equipped with a steering mechanism for automatically steering the baler left and right in response to the bale shape sensed by the monitor.

The indicators mentioned above are traditionally operated by one or more sensors on the baler. In round balers having an expandable baling chamber defined in part by a plurality of endless elements (e.g., a belt-type baler), the sensors are associated with the endless elements adjacent the sidewalls of the baler. Each end sensor is often positioned along a stretch of the corresponding element to detect when the stretch becomes slackened. It will be appreciated that the elements are traditionally tensioned by a single slack takeup mechanism, and accordingly, slackening of one of the elements relative to the remaining elements indicates that the area of the baling chamber bound by the one element is receiving less crop material than the others. Alternatively, the ends sensors are positioned along stretches of the elements defining the baling chamber so as to directly sense the diameter of the bale. The operator may consequently steer the baler left or right depending upon the diameter of the bale sensed adjacent the ends thereof.

However, these known expedients are problematic. Particularly, conventional bale shape monitors have complex and relatively expensive constructions. Additionally, a number of conventional monitors are not dependable and do not accurately sense the shape of the bale. For example, with monitors having a sensor for detecting the slack condition of one of the endless elements, the shape of the bale may not be accurately detected because of uneven stretching between the elements. Moreover, no baler has heretofore been provided with a monitor which effectively compares the diameter of the bale adjacent the ends thereof to the diameter of the bale at an intermediate location spaced between the ends, so that the operator is signaled when the ends are deficient relative to the middle of the bale. As will subsequently be described, this significantly simplifies the construction of the monitor and more accurately detects bale shape to improve uniform bale formation.

OBJECTS AND SUMMARY OF THE INVENTION

Responsive to these and other problems, an important object of the present invention is to provide a round baler with an improved bale shape monitor for facilitating uniform bale formation. Another important object of the present invention is to provide a bale shape monitor that is more dependable yet less expensive and complex in construction than conventional monitors. More particularly, an important object of the present invention is to provide a bale shape monitor that effectively compares the diameter of the bale adjacent the ends thereof to the diameter adjacent the middle of the bale. Yet another important object of the present invention is to provide such a bale shape monitor which signals to the operator when the diameter adjacent one of the ends of the bale is less than the diameter at the middle of the bale.

In accordance with these and other objects evident from the following description of a preferred embodiment of the invention, the round baler includes a pair of end sensors and an intermediate sensor. The end sensors sense the diameter of the bale at end locations adjacent opposite ends of the bale, while the intermediate sensor senses the diameter of the bale at an intermediate location spaced between the end locations. The monitor further includes a signal responsive to the sensors to indicate to the operator when the diameter of the bale at one of the end locations is less than the diameter at the intermediate location.

It has been determined that the middle of the bale (i.e., the portion of the bale spaced substantially equally between the sidewalls of the baler) rarely has less density or a smaller diameter than both ends of the bale. As the baler is weaved along the windrow, crop material is essentially continuously delivered to the middle of the baling chamber. This is due to the fact that the incoming crop material will naturally propagate to the middle of the baling chamber. Furthermore, because of the width of traditional windrows, crop material is virtually constantly delivered to the middle of the baling chamber, even when the windrow is intentionally picked up along one side of the baler. Accordingly, it is highly unlikely that the middle of the bale will be deficient relative to both ends of the bale, as long as the baler is weaved along the windrow. In other words, there is little risk of a bale having a so-called "hourglass shape".

The present invention is specifically designed to prevent the more likely situation of the bale having a so-called "egg or football shape", wherein the ends of the bale have less density and a smaller diameter than the middle of the bale. The claimed bale shape monitor essentially compares the diameter of the bale sensed by the end sensors to the diameter of the bale sensed by the intermediate sensor, and signals the operator when the former is less than the latter. As will be apparent from the following description, the inventive bale shape monitor is relatively more dependable, yet more simple and inexpensive in construction, than conventional devices.

Other aspects and advantages of the present invention will be apparent from the following detailed description of the preferred embodiment and the accompanying drawing figures.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

A preferred embodiment of the invention is described in detail below with reference to the attached drawing figures, wherein:

FIG. **1** is a fragmentary, side elevational view of a round baler with the left sidewall and various other parts being removed to illustrate internal details of construction including the bale shape monitor constructed in accordance with the principles of the present invention, with the baler containing a full-size bale;

FIG. **2** is a fragmentary, side elevational view of the round baler similar to FIG. **1**, but illustrating the bale forming components in their initial start-up configuration (i.e., with the baling chamber empty);

FIG. **3** is an enlarged, fragmentary, horizontal sectional view looking downwardly at the front half of the baler, particularly illustrating the location of the end sensors and the intermediate sensor between the sidewalls of the baler;

FIG. **4** is an enlarged, fragmentary, horizontal sectional view of the upper end of the right retainer arm and a portion of the bale shape monitor, particularly illustrating the structure for mounting the sensors to the arm;

FIG. **5** is an enlarged, fragmentary side elevational view of the right retainer arm and a portion of the bale shape monitor, particularly illustrating the position of the right end sensor and the condition of the signal when the diameter adjacent the right end of the bale is substantially similar to the diameter at the middle of the bale;

FIG. **6** is an enlarged, fragmentary side elevational view similar to FIG. **5**, but illustrating the position of the right end sensor and the condition of the signal when the diameter adjacent the right end of the bale is less than the diameter at the middle of the bale;

FIG. **7** is an enlarged, side elevational view of the right end sensor and the portion of the signal associated therewith;

FIG. **8** is an enlarged, side elevational view of the left end sensor and other parts of the bale shape monitor;

FIG. **9** is an enlarged, top plan view of the parts of the bale shape monitor which are mounted to the baler;

FIG. **10** is schematic view of the bale shape monitor, particularly illustrating the condition of the monitor when the bale has a generally uniform diameter from end to end;

FIG. **11** is a schematic view of the bale shape monitor similar to FIG. **10**, but illustrating the condition of the monitor when the diameter of the bale adjacent its left end is less than the diameter at the middle of the bale; and

FIG. **12** is a schematic view of the bale shape monitor similar to FIG. **10**, but illustrating the condition of the monitor when the diameter of the bale adjacent its right end is less than the diameter at the middle of the bale.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning initially to FIG. **1**, the round baler **10** selected for illustration generally includes a chassis or frame **12** that is supported for travel by a pair of ground wheels **14** (only the right ground wheel being shown in the drawings figures). A tongue **16** projects forwardly from the chassis **12** for connection with a towing vehicle (not shown). The chassis **12** carries a pair of upright, laterally spaced sidewalls **18** and **20** (see also FIG. **3**) which cooperate to define a space within which bale forming and bale wrapping operations may be carried out as the baler is advanced across a field. A pair of left and right frame members **22** and **24** extend upwardly from the chassis **12** to assist with supporting the sidewalls **18** and **20** in their upright disposition.

In the present embodiment, the baler **10** includes a number of rolls and belts that cooperate with the sidewalls **18**,**20** to define an internal baling chamber **25** that assumes different shapes and sizes throughout the bale-forming cycle. Particularly, the baler **10** has a plurality of laterally extending, stationary rolls including a rear drive roll **26**, a front drive roll **28**, and a plurality of idler rolls **30**,**32**,**34**,**36**,**38**,**40**,**42**,**44**,**46**. The stationary rolls **26**–**46** are arranged between the sidewalls in a generally circular pattern (when viewing FIGS. **1** and **2**) for guiding a plurality of laterally spaced, endless belts **48**, as the belts are driven linearly during bale formation and wrapping. As perhaps best shown in FIG. **3**, the illustrated baler **10** includes six of the belts **48**. The rear drive roll **26** and the idler roll **46** are located generally at the bottom of the baling chamber **25** and are spaced apart in a generally fore-and-aft direction to define a non-compressive, chamber inlet opening **50** therebetween. As the bale grows progressively larger, the idler roll **44** eventually cooperates with the idler roll **46** to define the rear boundary of the inlet opening **50**, for purposes which will subsequently be described. The belts **48** are looped under the rear drive roll **26**, under the tailgate-mounted idler roll **46**, and over the large upper idler roll **38** so that the belts present a pair of generally upright belt stretches **52** and **54** when the baling chamber **25** is empty at the beginning of a bale-forming cycle (see FIG. **2**).

The bale forming mechanism further includes a belt guiding or retaining assembly **56** having a pair of vertically swingable arms **58** and **60** located inside the baler adjacent the sidewalls **18** and **20**. The arms **58**,**60** support two idler rolls **62** and **64** in a position to directly overlie the bale during its formation within the chamber **25**. Further, the arms **58**,**60** are yieldably biased downwardly so that the rolls **62**,**64** exert pressure against the top of the bale as it is formed. The rolls **62** and **64** are spaced apart by a distance which is much less than the width of the inlet opening **50**, and the vertical belt stretches **52** and **54** are confined between the rolls **62** and **64** in such a manner that the belt stretches **52**,**54** converge toward one another as the rolls **62**,**64** are approached. Since the rolls **62**,**64** are essentially directly above the inlet opening **50**, the rolls **62**,**64** cause the chamber **25** to assume a generally vertical, triangular configuration when the chamber **25** is empty and the arms **58**,**60** are in their lowermost position as shown in FIG. **2**. With the drive rolls **26** and **28** rotating in a clockwise direction as depicted in FIGS. **1** and **2**, the front belt stretch **52** moves in a downward direction, while the rear belt stretch **54** moves in an upward direction, when the chamber **25** is empty at the beginning of a new bale forming cycle. A slack control arm assembly **66** located in the upper front portion of the baler **10** includes a pair of vertically swingable arms **68** (only one being shown) that support idler rolls **70** and **72**. As those of ordinary skill in the art will appreciate, the assembly **66** controls the amount of slack paid out to the belts **48** as the bale grows within the chamber **25**.

The baling chamber **25** is obviously located well above and off the ground. Therefore, some means must be provided for picking up crop material as the baler moves across the field and for delivering the picked-up material into the chamber **25**. In the illustrated embodiment, the baler **10** is constructed in accordance with the principles of open throat, vertical chamber baling, such that the incoming crop material is not to be subjected to any significant compression until it passes through the inlet opening **50** and is fully received within the baling chamber **25**. Thus, that part of the crop flow path upstream from the chamber **25** is open and non-compressive and may be described as an open throat **74** through which the picked-up crop material passes on its way to the baling chamber **25**.

In the illustrated embodiment, the crop material is picked up off the ground by a standard resilient rotary rake tine assembly **76** located below and forwardly of the chamber **25** and its inlet opening **50**. The assembly **76** is positioned along the lower portion of the throat **74** and cooperates with the rear drive roller **26** in helping to define the throat **74**. The resilient rake tines **78** of the assembly **76** describe a somewhat circular path of travel as shown in phantom lines in FIGS. **1** and **2**, although the tines **78** actually are cam-operated and are caused to retract along the rear stretch of their path of travel.

If the rake tine assembly **76** selected for use is wider than the chamber **25** in a direction transverse to the path of travel of the machine, the picked-up material must be converged toward the center of the baler **10** by center-gathering stub augers **80** (only one being shown in FIGS. **1** and **2**) or the like before being delivered into the chamber **25**. One suitable stub auger construction for accomplishing this function is disclosed in co-pending application Ser. No. 08/731,764, filed Oct. 18, 1996 and titled "Down Turning Stub Augers on Wide Pick-Up for Round Balers". If the rake tine assembly **76** is the same width as the chamber **25**, a center-gathering mechanism is not needed.

A rigid tooth feeder **82** is positioned below and in vertical alignment with the inlet opening **50** between the resilient rake tine assembly **76** and the lower idler roll **46** along the lower stretch of the throat **74**. The feeder **82** is spaced below the rear drive roll **26** and helps to define the throat **74**. In the preferred embodiment, the feeder **82** takes the form of a fork **84** having a series of transversely spaced, rigid teeth **86** that move in a generally kidney-shaped path of travel illustrated in phantom lines in FIGS. **1** and **2**. The teeth **86** project into the throat **74** during a stuffing stroke along the upper half of their path of travel and retract down out of the throat **74** during a return stroke along the lower half of their path of travel. A slotted ramp **88** spanning the distance between the resilient tine assembly **76** and the lower idler roll **46** provides a floor for the throat **74** in the vicinity of the rigid tooth feeder **82** and serves as a stripper plate through which the teeth **86** may retract to release the crop material at the rear end of the path of travel of the teeth **86**.

The fork **84** is pivotally supported by a rotating carrier **90** that rotates continuously about a transverse horizontal axis **92**. The fork **84** is connected near its mid-point to the carrier **90** and has its lower extended end pivotally connected to a control link **94** pivotally coupled with the chassis **12**. Thus, although the carrier **90** rotates in a circular path of travel, the fork **84** is constrained to move in its kidney-shape path of travel as illustrated. As shown in FIGS. **1** and **2**, the idler rolls **46** and **44** cooperate with the ramp **88** when the bale in chamber **25** grows larger than a starting core to define an eased path along which incoming crop material travels as it enters the chamber **25** as disclosed in co-pending application Ser. No. 08/731,395, filed Oct. 18, 1996, and titled "Eased Inlet Tailgate Roll Arrangement for Variable Chamber Round Baler". This configuration of the inlet opening **50** provides an aggressive nip between the belts **50** and the bale to facilitate the addition of crop material to the bale during the bale-forming cycle.

Contrary to prior open throat, vertical chamber constructions, the baler **10** has no starter roll located in the chamber **25** behind the rear drive roll **26**. However, also contrary to prior open throat vertical chamber constructions, the baler **10** has the rigid tooth feeder **82** disposed below the open bottom of the chamber **25** in vertical alignment with the inlet opening **50**. Consequently, the rigid tooth feeder **82** is positioned for projecting crop materials into the chamber **25** during successive stuffing strokes, whether such materials comprise only incoming materials received from the resilient tine assembly **76** or also materials that may have fallen down out of the chamber **25** during the early stages of bale core starting. The no starter roll construction of the illustrated baler **10** is the subject of copending application Ser. No. 08/896,720, filed Jul. 18, 1997, and titled "Vertical Chamber, Open Throat Round Baler Having No Starter Roll".

In the illustrated embodiment, the resilient rake tine assembly **76** is mounted on the chassis **12** for up and down swinging movement about a transverse axis **96** (FIGS. **1** and **2**) which coincides with the axis of rotation of the stub augers **80**. Gauge wheels **99** (only the right wheel being shown) secured to the resilient rake tine assembly **76** by inverted, generally U-shaped arms **98** (only a portion of one of the arms being shown in FIGS. **1** and **2**) ride along the ground to cause the resilient tine assembly **76** to swing up or down as necessary to accommodate changes in ground contour. It will be noted that in the illustrated embodiment, the stub augers **80** and the rigid tooth feeder **82** do not pivot with the resilient tine assembly **76** but are instead mounted in fixed positions on the chassis **12**. However, it is within the scope of the present invention to have all three of the components comprising the rake tine assembly **76**, the rigid tooth feeder **82** and the stub augers **80** constructed as part of a header unit swingably attached to the chassis **12**. In the illustrated embodiment, the gauge wheels **99** are attached to the resilient tine assembly **76** in the manner disclosed and claimed in co-pending application Ser. No. 08/733,758, filed Oct. 18, 1996, and titled "Over-the-top Support Arm for Pick-up Gauge Wheel of a Baler".

As shown in FIGS. **1** and **2**, the baler **10** is provided with a standard windguard **100** overlying the resilient rake tine assembly **76**. The windguard **100** is pivoted to the chassis **12** at pivot **102** and is biased by gravity to lie against the wrapper **104** of the resilient tine assembly **76** and the ramp **88** associated with the rigid tooth feeder **82**. As incoming crop material flows through the throat **74**, the windguard **100** is raised off the wrapper **104** and the ramp **88** by the moving crop material. However, the windguard **100** provides no significant compaction of the crop material.

As illustrated in FIGS. **1** and **2**, power for operating the components of the baler is delivered by a driveline **106** associated with the tongue **16**. The front end of the driveline **106** is adapted for connection to the power take-off shaft (not shown) of the towing vehicle, while the rear end of the driveline **106** is coupled with the input shaft **108** of a right angle gear box **110** on a transverse structural member **112** of the chassis **12**. The output shaft **114** of the right angle gear box **110** is coupled in the usual manner with the various drives for the baler components.

When the bale is fully formed within the chamber **25** as illustrated by the bale **116** in solid lines in FIG. **1**, it may be wrapped by a suitable wrapper before being discharged from the baler. In the illustrated embodiment, a twine dispenser **118** is located adjacent the front of the baler above the windguard **100** for wrapping the finished bale with twine during the wrapping cycle of the machine. Once wrapped, the bale may be discharged from the baler by operating a pair of lift cylinders (not shown) on opposite sides of the machine to elevate the rear half of the sidewalls **18,20** and the rolls **40,42,44,46** supported thereon. The rear half of the machine thus functions as a tailgate that is attached to the front half and pivots relative thereto about an upper pivot **120** at the top of the baler **10**.

BALE SHAPE MONITOR

During the bale-forming cycle, the rotary rake tine assembly **76**, stub augers **80** and the tooth feeder **82** cooperatively deliver material picked up from a crop windrow (not shown) to the baling chamber **25**. Generally speaking, with a few exceptions (e.g., the crop material picked up outboard of the sidewalls **18,20** and converged centrally by the stub augers **80**), the crop material is delivered to the baling chamber **25** at generally the same lateral location relative to the sidewalls **18,20** at which the windrow was picked up off the ground by the rotary rake tine assembly **76**. For example, when the baler **10** is positioned relative to the windrow so that crop material is picked up by the center portion of the rotary rake tine assembly **76**, the crop material is in turn delivered generally to the middle of the baling chamber **25**. Because most crop windrows are traditionally narrower than the length of the baling chamber **25**, the baler **10** must be skillfully weaved from side to side for ensuring even delivery of crop material between the sidewalls **18** and **20**; otherwise the bale will likely have a nonuniform shape, with the diameter of the bale varying from end to end. This is tedious and tiresome for even the most experienced bale operators.

Accordingly, the baler **10** is provided with an improved bale shape monitor **122** for facilitating uniform bale formation. The illustrated monitor **122** effectively compares the diameter of the bale adjacent its ends to the diameter at the middle of the bale, and signals the operator when the one of the end diameters is less than the middle diameter. As will be apparent from the following description, the monitor **122**, which is constructed in accordance with the principles of the present invention, has a relatively simple and inexpensive, yet dependable construction.

As perhaps best shown in FIG. **3**, the monitor **122** includes a pair of end sensors **124** and **126** for sensing the diameter of the bale adjacent the sidewalls **18** and **20**. It may be said that each of the sensors **124** or **126** senses the bale diameter at an end location adjacent one of the ends of the bale. The monitor **122** further includes an intermediate sensor **128** spaced substantially equally between the end sensors **124,126** for sensing the diameter at the middle of the bale. The intermediate sensor **128** senses the bale diameter at an intermediate location spaced between the end locations. In this respect, the monitor **122** is provided with means for sensing the bale diameter at three locations spaced along the length of the bale. The bale diameter sensed at each end location is continuously gauged relative to the bale diameter sensed at the intermediate location so that the operator is notified whenever one of the end locations has a smaller diameter than the intermediate location, as will be further described. This construction is particularly effective in assisting the operator with weaving of the baler **10** along the windrow so as to avoid the formation of bales having an egg or football shape.

In the illustrated embodiment, the intermediate sensor **128** is in the form of a shiftable diameter gauge associated with one of the centermost belts of the baler **10**. Particularly, the intermediate sensor or gauge **128** includes an arm **130** swingably mounted to the baler **10**, and a feeler wheel **132** mounted to one end of the arm **130** by a nut-and-bolt assembly **134** (see FIG. **3**). A bearing assembly (not shown) contained within the wheel **132** serves to journal the latter on the nut-and-bolt assembly **134** for relative rotational movement. The wheel **132** is preferably formed of a rubber material, although other suitable materials, such as plastic or metal, may be used.

The location of the intermediate sensor **128** is such that the wheel **132** rides against the front stretch **52** of the third belt spaced from the left sidewall **18**. As perhaps best shown in FIG. **3**, the wheel **132** is located substantially equally from the sides of the belt so as to reduce the risk of disengagement therebetween should there be any problems with belt tracking. Those of ordinary skill in the art will appreciate that the location of the wheel **132** along the backside of the front stretch **52** ensures that the diameter at the middle of the bale is positively sensed by the intermediate sensor **128**. That is to say, the wheel **132** engages one of the belt stretches **52** defining the baling chamber **25** so that the location of the wheel **132** directly corresponds to the diameter of the bale. The intermediate sensor **128** may alternatively be located adjacent the rear of the baling chamber **25**, with the wheel **132** engaging one of the centermost belts along the rear stretch **54** thereof, if desired. It is also noted that the term “middle” as used herein shall be interpreted to mean a location spaced generally equally between the ends of the bale. With respect to the illustrated embodiment, the diameter of the middle of the bale is sensed even though the wheel **132** for the intermediate sensor **128** is spaced slightly leftward of the center of the baler. Of course, the principles of the present invention are equally applicable to a baler having an odd number of belts (e.g., seven belts) so that the wheel for the intermediate sensor is closer to the center of the baling chamber than depicted in the drawing figures. In fact, such a construction may allow the intermediate location to be spaced virtually equally from the sidewalls (i.e., from the ends of the bale).

A cylindrically shaped, transverse bar **136** is provided for swingably supporting the arm **130** of the intermediate sensor **128** on the baler **10**. As shown in FIGS. **3** and **4**, the arm **130** is fixed to the bar **136** by suitable means, such as welding, at a position laterally aligned with one of the centermost belts. Adjacent opposite ends of the bar **136** are bearing supports **138** and **140** for rotatably supporting the bar **136** on the belt retaining arms **58** and **60**. As shown in FIG. **4**, the right bearing support **140** comprises a sleeve **142** rotatably receiving the right end of the bar **136**, and a support plate **144** projecting from the sleeve **142**. A pair of nut-and-bolt assemblies **146** serve to fasten the support plate **144** to a bracket **148** fixed to the right retaining arm **60** adjacent the rolls **62** and **64**. The left bearing support **138** is similar in construction to the right bearing support **140** and therefore will not be described in detail. It is sufficient to explain that the left bearing support is similarly fastened by a pair of nut-and-bolt assemblies **150** to a bracket **152** projecting inwardly from the left retaining arm **58** (see FIGS. **3** and **9**). A pair of holes **154** provided in the right bracket **148** for receiving the nut-and-bolt assemblies **146** have an elliptical shape to accommodate for manufacturing errors, etc. The left bracket **152** is likewise provided with elliptically shaped holes **156**.

The intermediate sensor **128** is consequently mounted on the retaining arms **58** and **60** for swinging movement therewith. This convenient construction maintains the proximity between the baling chamber **25** and the support structure for the intermediate sensor **128** so as to reduce the size and cost of the intermediate sensor.

The wheel **132** of the intermediate sensor **128** is yieldably biased against the corresponding belt by a pair of tension springs **158** and **160** located adjacent opposite ends of the bar **136**. As perhaps best shown in FIG. **3**, the left spring **158** is connected between a tab **162** fixed to the left retaining arm **58** to project inwardly therefrom and a crank **64** projecting from the left end of the bar **136**. It will be noted that the tab **162** and crank **64** each include a small hole for removably receiving the respective hook-shaped end of the spring **158**. The right spring **160** is likewise associated with a tab **162** fixed to the right retaining arm **60** and a crank **164** fixed to the right end of the bar **136**. In this respect, the springs **158** and **160** cooperate to yieldably urge the bar **136**, and thereby the arm **130**, in a direction that causes the wheel **132** to be pressed against the front stretch **52** of the corresponding belt for maintaining contact therebetween in virtually all chamber conditions. Because the location of the arm **130** and wheel **132** constantly coincide with the shape of the bale underlying the corresponding belt, the intermediate sensor **128** continuously senses the bale diameter at the middle of the bale.

Each of the end sensors **124** and **126** is also in the form of a shiftable bale diameter gauge. Furthermore, the end sensors **124** and **126** similarly engage the front stretch **52** of the belts, but do so along the endmost belts of the baler **10**. Because of these similarities, it will be appreciated that the same caveats and alternatives noted above with respect to the intermediate sensor **128** likewise apply to the end sensors **124** and **126**.

The left end sensor **124** includes a swingable arm **170** and a rotatable wheel **172** mounted adjacent one end of the arm **170** by a nut-and-bolt assembly **174**. The wheel **172** is journaled on the nut-and-bolt assembly **174** for relative rotational movement by a bearing assembly (not shown) contained within the wheel **172**. As shown in FIG. **8**, the arm **170** is provided with an elongated hole **176** for receiving the nut-and-bolt assembly **174**, for purposes which will subsequently be described. Fixed to the opposite end of the arm **170** is a cylindrical collar **178** for supporting the arm **170** on the bar **136**. The collar **178** loosely receives the bar **136** so as to allow relative movement therebetween. However, as will further be described hereinbelow, swinging movement of the arm **170** relative to the bar **136** is limited so that the springs **158** and **160** also serve to yieldably urge the arm **170** in a clockwise direction (viewing FIG. **8**) for causing the wheel **172** to be yieldably pressed against the front stretch **52** of the leftmost belt. Additionally, the location of the collar **178** along the length of the bar **136** is similarly maintained so that the wheel **172** presses against the leftmost belt at a point spaced equally between the sides of the belt.

The right end sensor **126** is structurally and functionally similar to the left end sensor **124**, and it is therefore sufficient to explain that the right end sensor **126** includes a swingable arm **180** and a rotatable wheel **182** mounted to one end of the arm **180** by a nut-and-bolt assembly **184**. As shown with phantom lines in FIG. **7**, the arm **180** includes an elongated hole **186** for receiving the nut-and-bolt assembly, which facilitates calibration of the monitor **122** as will subsequently be described. A collar **188** fixed to the opposite end of the arm **180** and received on the bar **136**, as perhaps best shown in FIG. **4**, serves to swingably support the arm **188** on the bar **136**. The wheel **182** of the right sensor **126** yieldably presses against the front stretch **52** of the rightmost belt at a point spaced equally between the sides of the belt (see FIG. **3**).

In view of the foregoing, the position of the arm **170** and wheel **172** of the left end sensor **124** directly corresponds with the location of the leftmost belt as it moves responsive to bale growth, so that the left end sensor **124** senses the diameter of the bale underlying the leftmost belt (i.e., the diameter adjacent the left end of the bale). Similarly, the position of the arm **180** and wheel **182** of the right end sensor **126** directly corresponds with the location of the rightmost belt so that the right end sensor **126** senses the diameter of the bale underlying the rightmost belt (i.e., the diameter adjacent the right end of the bale). It will be appreciated that the end sensors **124** and **126** are not necessarily limited to being associated with the endmost belts of the baler **10**; that is, in some baler constructions, it may be sufficient to associate the end sensors with a belt that is only proximate to the adjacent baler sidewall. For example, the bale diameter may be sufficiently detected by associating the end sensors **124** and **126** with a belt spaced inwardly from one or more of the other belts. Furthermore, it is entirely within the ambit of the present invention to utilize a pair of end sensors and an intermediate sensor with other variously constructed endless elements (e.g., chains) that cooperate with the baler sidewalls to define the baling chamber.

The illustrated bale shape monitor **122** further includes a signal generally referenced by the numeral **190** in FIGS. **10–12**. The signal **190** is responsive to the sensors **124,126, 128** for indicating when one of the end sensors **124** or **126** detects a bale diameter that is less than the bale diameter sensed by the intermediate sensor **128**. As will be apparent from the following description, the signal **190** cooperates with the sensors **124,126,128** to effectively compare the diameter at each end location to the diameter at the intermediate location and signal the operator when the former is less than the latter.

The signal **190** includes a pair of switches **192** and **194**, one of which (switch **192**) is associated with the left end sensor **124** and the other of which (switch **194**) is associated with the right end sensor **126** (see FIG. **3**). In the illustrated embodiment, the switches **192** and **194** comprise standard normally open, ball-type switches, although the principles of the present invention are equally applicable to various other switch constructions, such as normally closed switches. In any case, activation of the switch shall be interpreted to mean that the state of the switch has been changed (e.g., if the switch is normally open as depicted in the illustrated embodiment, activation of the switch involves closing the switch so that the circuit path is completed). As will subsequently be described, the left switch **192** is operably coupled between the left end sensor **124** and the intermediate sensor **128** in such a manner that the switch **192** is activated as the sensors **124** and **128** shift relative to one another when the bale diameter adjacent the left end of the bale is less than the bale diameter at the middle of the bale. The right switch **194** is similarly coupled between the right end sensor **126** and the intermediate sensor **128** to be activated when the left end of the bale has a smaller diameter than the middle of the bale.

As perhaps best shown in FIG. **3**, the left switch **192** is supported on a plate **196** projecting from the collar **178** so that the switch **192** swings with the arm **170** of the left end sensor **124**. A somewhat trapezoidal shaped switch activating member **198** is fixed to the bar **136** so that swinging of the member **198** corresponds with swinging of the arm **130** of the intermediate sensor **128**. As shown in FIG. **3**, the support plate **196** for the switch **192** and the activating member **198** are partially superimposed. Accordingly, if the support plate **196** swings sufficiently downwardly as a result of the diameter adjacent the left end of the bale being less than the diameter at the middle of the bale, the ball or contact **200** (see FIGS. **10–12**) of the left switch **192** engages the member **198** to thereby activate the switch **192**. As shown in FIGS. **10–12**, the switch **192** is connected to a power source by a lead **202** and to an indicator **206** by a lead **208**. Accordingly, when the activating member **198** contacts the ball **200**, the circuit path between the power source and the indicator **206** is completed, and the indicator **206** is thereby operated.

Similar to the left switch **192**, a support plate **208** serves to similarly fix the right switch **194** relative to the right arm **180** so that the switch **194** and the arm **180** swing together, as perhaps best shown in FIG. **7**. A switch activating member **210** projecting from the bar **136** is configured to engage the ball or contact **212** of the switch **194**, when the bale diameter adjacent the right end of the bale is less than the diameter at the middle of the bale. A lead **214** connects the right switch **194** with a power source, which may be the same power source connected to the left switch **192**, and a second lead **216** connects the switch to an indicator **218**, whereby the indicator **218** is operated when the switch **194** is activated.

Connected between the support plate **208** and the switch activating member **210** is a spring biasing mechanism **220**. As perhaps best shown in FIG. **7**, the mechanism **220** includes a nut-and-bolt assembly **222** and a compression spring **224** for yieldably biasing the support plate **208** toward the switch activating member **210**. It will be noted that the illustrated compression spring **224** is retained between the nut of the assembly **222** and the support plate **208**, although the spring may alternatively be retained between the bolt head and the switch activating member **210**. In any event, the mechanism **220** serves to limit swinging movement of the support plate **208** relative to the activating member **210**. In other words, swinging of the support plate **208** (and the right arm **170**) in a clockwise direction (when viewing FIG. **7**) is limited relative to the switch activating member **210** by the compressibility of the spring **224** and the length of the nut-and-bolt assembly **222**. Because the activating member **210** is yieldably biased in a counterclockwise direction by the springs **158,160**, the support plate **208** and the right arm **180** are also biased in that same direction so that the wheel **182** yieldably presses against the rightmost belt. Furthermore, with the activating member **210** being fixed relative to the arm **130** of the intermediate sensor **128**, swinging movement of the right arm **180** is also limited relative to the position of the intermediate arm **130**. It is also noted that the compression spring **224** assists the springs **158** and **160** in causing the wheel **182** of the right end sensor **126** to be yieldably pressed against the rightmost belt. In addition, the spring **224** ensures contact between the ball **212** of the switch **194** and the activating member **210** when the diameter adjacent the right end of the bale is less than the diameter at the middle of the bale. With the support plate **208** being fixed to the right arm **180** and the switch activating member **210** being fixed to the bar **136**, the mechanism **220** also serves to maintain the location of the right end sensor **126** along the bar **136**.

Because swinging movement of the right arm **180** relative to the intermediate arm **130** is limited, there may be instances in which the wheel **182** of the right end sensor **126** disengages the rightmost belt. This may occur because the diameter adjacent the right end of the bale is severely deficient relative to the diameter at the middle of the bale, whereby the right end arm **180** is swung completely toward the baling chamber relative to the intermediate arm **130**. It will be appreciated that such swinging of the right end arm **180** relative to the intermediate arm **130** is limited by the interengagement between the switch **194** and the activating member **210**. Accordingly, even in this situation, the right end sensor **126** continues to "sense" the bale diameter adjacent the right end of the bale as being less than the diameter at the middle of the bale.

Although not shown in detail, a similar spring biasing mechanism **226** is connected between the support plate **196** and the activating member **198** associated with the left end sensor **124** (see FIG. **3**). The mechanism **226** is structurally and functionally similar to the mechanism **220** associated with the right end sensor **126**. For the sake of brevity, the mechanism **226** will not be described in detail.

As indicated above, the arms **170** and **180** of the end sensors **124** and **126** are provided with elongated holes **176** and **186**, respectively, which allows the operator to calibrate the bale shape monitor **122**. The arm **130** of the intermediate sensor **128** is likewise provided with an elongated hole (not shown) which facilitates such calibration. It will be appreciated that calibration of the monitor **122** may be required as a result of manufacturing inaccuracies, uneven belt stretching, etc.

In the illustrated embodiment, the nut-and-bolt assembly **174** of the left end sensor **124** is located at the bottom of the hole **176** (see FIG. **8**), and the nut-and-bolt assembly **184** of the right end sensor **126** is similarly located at the bottom of the hole **186** (see FIG. **7**). Although not illustrated, it will be appreciated that the nut-and-bolt assembly **134** of the intermediate sensor **128** is located at the top of the slotted hole. This configuration ensures that there is a gap between the switches **192** and **194** and the switch activating members **198** and **210**, respectively, when the diameter of the bale at the corresponding end location is substantially similar to the bale diameter at the middle of the bale. That is to say, this configuration reduces the likelihood of inadvertent operation of the indicators so as to further facilitate uniform bale formation. However, if for some reason calibration is required or an asymmetrical bale is desired, the nut-and-bolt assemblies may be shifted within the respective holes so as to vary the position of the wheel relative to the arm. For example, the nut-and-bolt assemblies **174** and **184** of the end sensors **124** and **126** may be shifted to the top of the holes **176** and **186**, respectively, to promote formation of a bale having an hourglass shape.

The indicators **204** and **218**, which are illustrated schematically in FIGS. **10–12**, preferably comprise so-called "driving lights". In this respect, the indicators **204** and **218** are illuminated to alert the operator when the diameter adjacent the corresponding end of the bale is less than the diameter at the middle of the bale. The indicators **204** and **218** may be arranged side-by-side on a display panel (not shown), with the position of the indicators **204** and **218** corresponding to the location of their respective switches **192** and **194**, so that the operator quickly associates illumination of one of the indicators with a deficiency along the corresponding end of the bale. For example, if the diameter of the bale adjacent the left end is less than the diameter of the middle of the bale, the left indicator **204** is illuminated. On the other hand, the position of the indicators **204** and **218** on the display panel may be reversed, and the indicators may be provided with indicia for signaling the operator to steer the baler in a direction which would cause more crop material to be delivered to the deficient end. For example, the indicator **204** associated with the left switch **192** may include the wording "steer right", so that the operated is alerted to steer the baler **10** righwardly for delivering relatively more crop material to the left side of the baling chamber **25**. Preferably, the display panel supporting the indicators **204** and **218** is located within the cab of the towing vehicle (not shown). Moreover, the principles of the present invention are applicable to various other indicator constructions. For example, the indicators **204** and **218** may comprise an audible signal, such as a speaking sound stating "steer left" or "steer right", if desired. In addition, the monitor may include a third indicator (not shown) which is coupled to the switches **192** and **194** for signaling the operator to drive forward when both switches are not activated.

At the start of the bale-forming cycle, all of the sensors **124,126,128** are in a position best exemplified by the location of the right end sensor **126** depicted in FIG. **2**. As crop material is progressively added to the baling chamber **25**, the belt stretches **52** and **54** move away from one another in a generally circular manner, and the retaining arms **58** and **60** swing upwardly and carry with them the sensors **124, 126,128**. However, the sensors **124,126,128** maintain contact with the respective belts for sensing the diameter of the bale underlying the belt. The bale forming components and the sensors **124,126,128** will eventually be disposed in the manner depicted in FIG. **1**, which corresponds with a uniformly shaped, fully formed bale **116**. If one of the ends of the bale has a diameter less than the diameter of the middle of the bale at any time between the start and finish of the bale-forming cycle, the bale monitor **122** will alert the operator of this condition so that the necessary corrections may be made.

For example, when the bale diameter adjacent the right end of the bale is substantially equal to the bale diameter at the middle of the bale, the switch **194** associated with the right end sensor **126** will not be activated, as depicted in FIGS. **5** and **10–11**. However, if the bale diameter adjacent the right end of the bale is less than the bale diameter at the middle of the bale, the arm **180** of the right end sensor **126** will swing toward the baling chamber **25**, while the arm **130** of the intermediate sensor **128** remains relatively stationary. This relative movement causes the right switch **194**, which is fixed relative to the right arm **180**, to engage the switch activating member **210**, which is fixed relative to the intermediate arm **130**, so as to activate the switch **194** and thereby operate the indicator **218** (see FIGS. **6** and **12**). In effect, the bale diameter adjacent the right end of the bale is compared to the diameter at the middle of bale by the monitor **122**, and the operator is alerted when this comparison reveals that the diameter at the end location is less than the diameter at the intermediate location. As depicted in FIG. **11**, the monitor **122** is similarly configured to alert the operator when the diameter adjacent the left end of the bale is relatively less than the diameter at the middle of the bale.

The preferred forms of the invention described above are to be used as illustration only, and should not be utilized in a limiting sense in interpreting the scope of the present invention. Obvious modifications to the exemplary embodiments, as hereinabove set forth, could be readily made by those skilled in the art without departing from the spirit of the present invention. For example, the bale shape monitor **122** may be utilized as a retrofit attachment for existing round balers. It will be appreciated that FIG. **9** conveniently illustrates the components of the monitor **122** which are attached to the baler.

The inventors hereby state their intent to rely on the Doctrine of Equivalents to determine and assess the reasonably fair scope of the present invention as pertains to any apparatus not materially departing from but outside the literal scope of the invention as set forth in the following claims.

What is claimed is:

1. In a round baler including an expandable baling chamber which increases in size as a cylindrical bale is formed therein, a bale shape monitor comprising:

an end diameter sensor for sensing the diameter of the bale at an end location adjacent one of the ends of the bale;

an intermediate diameter sensor for sensing the diameter of the bale at an intermediate location spaced laterally inwardly from the end location; and

a signal responsive to the diameter sensors to indicate when the diameter at the end location is less than the diameter at the intermediate location.

2. In a round baler as claimed in claim **1**; and

a second end diameter sensor for sensing the diameter of the bale at a second end location adjacent the end of the bale opposite from the first mentioned end location,

said intermediate location being spaced between the end locations,

said signal being further responsive to the second end and intermediate diameter sensors to indicate when the diameter at the second end location is less than the diameter at the intermediate location.

3. In a round baler as claimed in claim **2**,

each of said diameter sensors including a shiftable bale diameter gauge which shifts as the bale diameter changes.

4. In a round baler as claimed in claim **3**,

said gauge comprising a swingable arm and a roller rotatably supported adjacent one end of the arm to be positioned against the baling chamber.

5. In a round baler as claimed in claim **4**,

said gauge including biasing mechanism coupled with the arm for yieldably biasing the roller toward the baling chamber.

6. In a round baler as claimed in claim **3**,

said signal including a pair of indicators, each of which is associated with one of the end diameter sensors for signaling when the diameter of the bale at a corresponding one of the end locations is less than the diameter at the intermediate location.

7. In a round baler as claimed in claim **6**,

said indicators being operable independently of one another.

8. In a round baler as claimed in claim **7**,

said signal being electrically powered and including an electrical circuit having a pair of switches,

each of said switches being associated with one of the end diameter sensors to operate a respective one of the indicators when the diameter of the bale at the corresponding end location is less than the diameter at the intermediate location.

9. In a round baler as claimed in claim **8**,

each of said indicators comprising a light.

10. In a round baler as claimed in claim **8**,

said gauge of each of the end diameter sensors cooperating with the gauge of the intermediate diameter sensor to present a pair of corresponding gauges which are operably coupled with a respective one of the switches for activating said respective one of the switches as the gauges shift relative to one another when the bale diameter at the corresponding end location is less than the diameter at the intermediate location.

11. In a round baler as claimed in claim **10**,

said respective one of the switches being fixed relative to one of the gauges of the corresponding pair, and including a contact which serves to activate the switch when engaged,

said signal including a switch activating member fixed relative to the other of the gauges of the corresponding pair for engaging the contact as the gauges shift relative to one another when the bale diameter at the corresponding end location is less than the diameter at the intermediate location.

12. In a round baler including a plurality of laterally spaced endless elements disposed between a pair of sidewalls for cooperatively defining an expandable baling chamber which increases in size as a cylindrical bale is formed therein, a bale shape monitor comprising:

a pair of end diameter sensors associated with respective ones of the elements to sense the diameter of the bale at end locations adjacent opposite ends of the bale;

an intermediate diameter sensor associated with one of the elements spaced between said respective ones of the elements to sense the diameter of the bale at an intermediate location spaced between the end locations; and

a signal responsive to the diameter sensors to indicate when the diameter of the bale at one of the end locations is less than the diameter at the intermediate location.

13. In a round baler as claimed in claim **12**,

each of said diameter sensors including a shiftable bale diameter gauge associated with a respective one of the elements, with the gauge being shifted as the bale diameter changes at the respective one of the elements.

14. In a round baler as claimed in claim **13**,

said gauge comprising a swingable arm and a roller rotatably supported adjacent one end of the arm,

said roller being engageable with the respective one of the elements.

15. In a round baler as claimed in claim **14**,

said gauge including biasing mechanism coupled with the arm for yieldably biasing the roller against the respective one of the elements.

16. In a round baler as claimed in claim **13**,

said signal including a pair of indicators, each of which is associated with one of the end diameter sensors for signaling when the diameter of the bale at a corresponding one of the end locations is less than the diameter at the intermediate location.

17. In a round baler as claimed in claim **16**,

said indicators being operable independently of one another.

18. In a round baler as claimed in claim **17**,

said signal being electrically powered and including an electrical circuit having a pair of switches,

each of said switches being associated with one of the end diameter sensors to operate a respective one of the indicators when the diameter of the bale at the corresponding end location is less than the diameter at the intermediate location.

19. In a round baler as claimed in claim **18**,

each of said indicators comprising a light.

20. In a round baler as claimed in claim **18**,

said gauge of each of the end diameter sensors cooperating with the gauge of the intermediate diameter sensor to present a pair of corresponding gauges which are operably coupled with a respective one of the switches for activating said respective one of the switches as the gauges shift relative to one another when the bale diameter at the corresponding end location is less than the diameter at the intermediate location.

21. In a round baler as claimed in claim **20**,

said respective one of the switches being fixed relative to one of the gauges of the corresponding pair, and including a contact which serves to activate the switch when engaged,

said signal including a switch activating member fixed relative to the other of the gauges of the corresponding pair for engaging the contact as the gauges shift relative to one another when the bale diameter at the corresponding end location is less than the diameter at the intermediate location.

22. A bale shape monitor for attachment to a round baler including a plurality of laterally spaced endless elements disposed between a pair of sidewalls for cooperatively defining an expandable baling chamber which increases in size as a cylindrical bale is formed therein, said monitor comprising:

a pair of end diameter sensors and an intermediate diameter sensor;

support structure for mounting the diameter sensors on the baler so that the end diameter sensors sense the diameter of the bale at end locations adjacent opposite ends of the bale and the intermediate diameter sensor senses the diameter of the bale at an intermediate location spaced between the end locations; and

a signal responsive to the diameter sensors to indicate when the diameter of the bale at one of the end locations is less than the diameter at the intermediate location.

23. A bale shape monitor as claimed in claim **22**,

each of said diameter sensors including a bale diameter gauge associated with a respective one of the elements,

said support structure serving to shiftably mount the gauge on the baler so that the gauge shifts as the bale diameter changes at the respective one of the elements.

24. A bale shape monitor as claimed in claim **23**,

said gauge comprising a swingable arm and a roller rotatably supported adjacent one end of the arm,

said roller being engageable with the respective one of the elements.

25. A bale shape monitor as claimed in claim **24**,

said gauge including biasing mechanism coupled with the arm for yieldably biasing the roller against the respective one of the elements.

26. A bale shape monitor as claimed in claim **23**,

said signal including a pair of indicators, each of which is associated with one of the end diameter sensors for signaling when the diameter of the bale at a corresponding one of the end locations is less than the diameter at the intermediate location.

27. A bale shape monitor as claimed in claim **26**,

said indicators being operable independently of one another.

28. A bale shape monitor as claimed in claim **27**,

said signal being electrically powered and including an electrical circuit having a pair of switches,

each of said switches being associated with one of the end diameter sensors to operate a respective one of the indicators when the diameter of the bale at the corresponding end location is less than the diameter at the intermediate location.

29. A bale shape monitor as claimed in claim **28**,

each of said indicators comprising a light.

30. A bale shape monitor as claimed in claim **28**,

said gauge of each of the end diameter sensors cooperating with the gauge of the intermediate diameter sensor to present a pair of corresponding gauges which are operably coupled with a respective one of the switches for activating said respective one of the switches as the gauges shift relative to one another when the bale diameter at the corresponding end location is less than the diameter at the intermediate location.

31. A bale shape monitor as claimed in claim **30**,

said respective one of the switches being fixed relative to one of the gauges of the corresponding pair, and including a contact which serves to activate the switch when engaged,

said signal including a switch activating member fixed relative to the other of the gauges of the corresponding pair for engaging the contact as the gauges shift relative to one another when the bale diameter at the corresponding end location is less than the diameter at the intermediate location.

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