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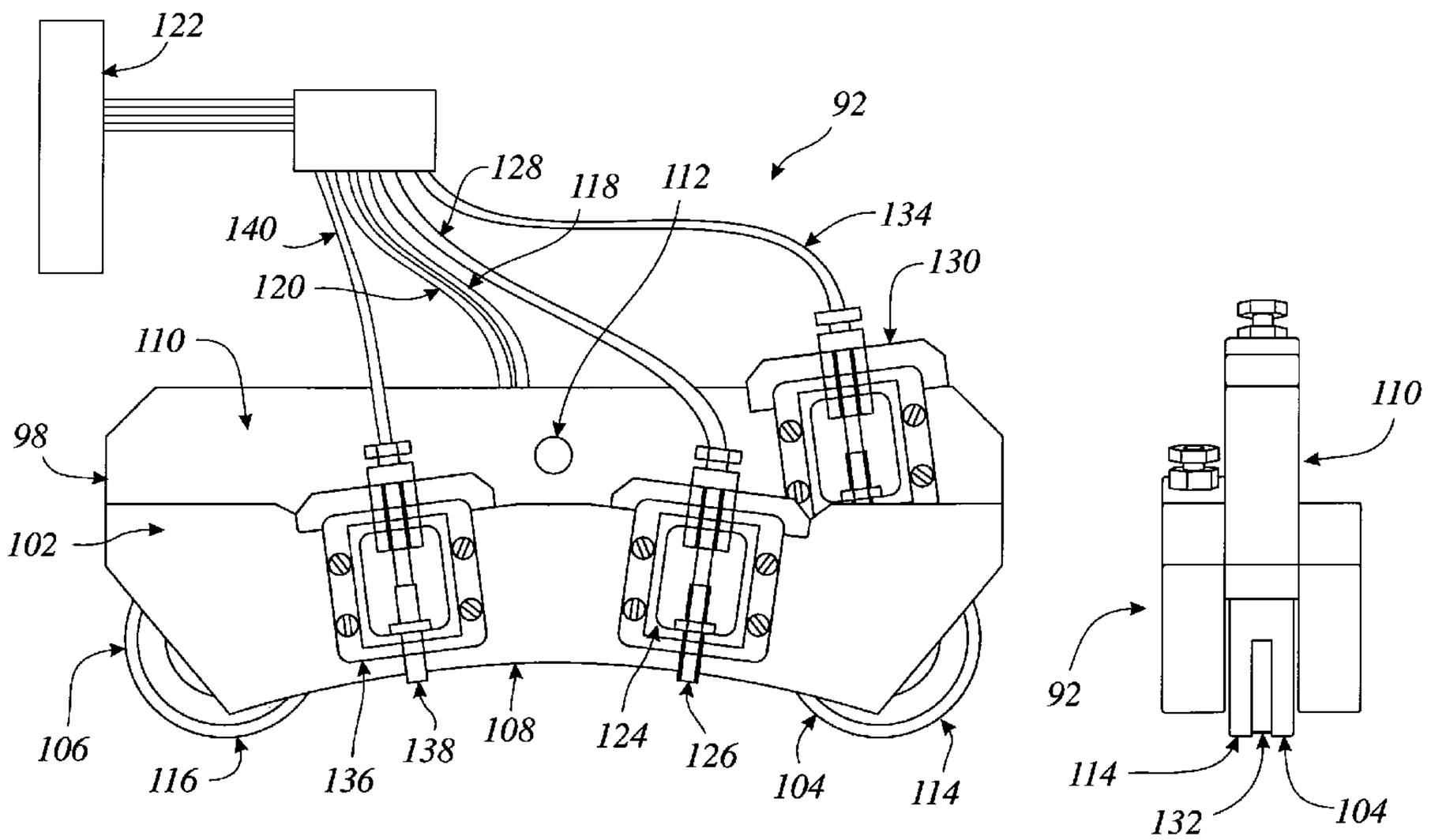
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(54) **METHODE D'ENROULEMENT D'UNE BANDE, ET APPAREIL CONNEXE**

(54) **APPARATUS AND METHOD FOR REELING A WEB**



(57) Le retournement d'une bande continue depuis un enrouleur principal vers une nouvelle bobine s'effectue au moyen d'un appareil permettant la détection de la présence d'une bande récemment coupée près de la nouvelle bobine et l'acheminement de la nouvelle bobine près du tambour de l'enrouleuse à entraînement périphérique lorsque la bande commence à s'enrouler sur la nouvelle bobine. Un système de traitement des

(57) The turn-up of a continuous web from a parent reel to a new spool is made using an apparatus for sensing the presence of the newly cut web about the new spool and moving the new spool about a pope reel drum once the web has begun to wind on the new spool. A signal processing system is provided to monitor the speed of the web, defects in the web, the position of primary and secondary arms, and whether a turn-up has failed. The

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signaux permet de surveiller la vitesse de la bande, de détecter ses défauts, d'établir la position des bras primaires et secondaires, ainsi que de vérifier si le retournement s'est effectué. Le système transmet des signaux de sortie pour établir le moment du retournement de la bande ainsi que le mouvement des bras primaires et secondaires. Cet appareil peut comprendre plusieurs détecteurs permettant de déterminer la présence de la bande, sa vitesse et le nombre de tours effectués par la bobine. Il peut comporter divers types de détecteurs pouvant être utilisés avec différents types de matériaux de bobine.

system provides output signals to control the timing of the turn-up and the motion of the primary and secondary arms. The apparatus may have several sensors for measuring the presence of the web, the speed and elapsed number of turns of the spool, and may have different types of sensors for use with different types of spool materials.

Apparatus & Method for Reeling a Web

Abstract of the Disclosure

The turn-up of a continuous web from a parent reel to a new spool is made using an apparatus for sensing the presence of the newly cut web about the new spool and moving the new spool about a pope reel drum once the web has begun to wind on the new spool. A signal processing system is provided to monitor the speed of the web, defects in the web, the position of primary and secondary arms, and whether a turn-up has failed. The system provides output signals to control the timing of the turn-up and the motion of the primary and secondary arms. The apparatus may have several sensors for measuring the presence of the web, the speed and elapsed number of turns of the spool, and may have different types of sensors for use with different types of spool materials.

Apparatus and Method for Reeling a Web

Field of Invention

This invention relates generally to devices for reeling a web onto a cylinder, and more particularly for detecting the presence of a web about a cylinder for determining timing and motion of reeling equipment. Most specifically, the invention concerns the process of terminating accumulation of a web on a first spool, and commencing accumulation of a web on a second spool while the web continues to be delivered to the reel forming apparatus at a constant rate, and a device for detecting when the web has engaged the second spool.

Background of the Invention

A recurrent problem in the paper making industry, and other industries having similar processes, has concerned the reeling of paper onto spools as the paper leaves the paper making machine. As it is difficult and expensive to stop the paper making machine merely to change a take up spool, a system is required to terminate the accumulation of paper on one spool and to commence accumulation on another spool while newly made paper continues to be delivered from the paper making machine at a relatively constant speed. This process of cutting and transferring a web to a new reel is called a turn-up.

Once a web has been cut, the cut end is not necessarily prone to feed onto the new spool without wrinkles. The wrinkled portion of the web collected on the spool is generally unusable, and so becomes waste. One way to reduce the amount of wrinkling is to bend the web about a drum and to move the new reel away from the twelve o'clock position as quickly as possible.

Since the web of paper will continue to stream out of the paper machine at high speed it is important to determine as quickly as possible whether the web has failed to engage the new spool properly. If so, the new spool must be moved out of the way as quickly as possible and another effort at starting a new spool must be made.

It is also advantageous in the operation of paper reeling machinery to make sure that a spool moved about a drum to a better position for reeling without wrinkles will find appropriate machinery waiting to receive it.

At present an operator watches to determine when each spool is full, that is, when it has reached a specific diameter, when to lower the next spool against the top of the drum, and when enough of the web has collected on the new spool that it can safely be moved about the drum. Notwithstanding experience, an operator's eye is a relatively imprecise measuring instrument, and the timing and accuracy of the operation varies from operator to operator. It would be preferable to have a device and method for ascertaining when the web has engaged the spool sufficiently, and for controlling the movement of the various elements of the process.

It is not uncommon for patches of unusable web to be delivered to the output reel. An operator may, again, have difficulty estimating the amount by which the diameter of a parent reel should be increased to allow for defective portions of the web, since too little allowance will yield insufficient good web to yield the amount desired, and too great an allowance will yield a wasteful amount beyond the amount of good web desired on the reel.

There is therefore a need for an improved system for controlling the turn-up of a continuous web onto a spool.

Disclosure of Invention

The present invention relates to a means for determining whether a web is present about a spool. In a first aspect of the invention there is an apparatus for sensing the presence of a web about a spool, that apparatus comprising a structural member for mounting to a support structure for deployment of the apparatus adjacent the spool; a sensing means mounted to the structural member having sensing means alterable from a first output state when sensing a bare spool to a second output state when sensing a web on the spool; and means for communicating the output states to a signal processing device.

In a further aspect of the invention , the apparatus includes distance measuring means for measuring the circumferential distance turned by the spool. In still another aspect of the invention the sensing means is of a type chosen from at least one of the group consisting of: a) an electrical resistance measurement circuit; b) a proximity sensor; c) a photoelectric sensor; and d) a digital camera. In still yet another aspect of the invention the apparatus has first and second followers mounted to the structural member for riding upon the surface of one of (a) the spool; and (b) a web covering the spool.

In another aspect of the invention there is a system for controlling the turn-up of a paper reeling machine, that paper reeling machine having a) a drum against which to turn a continuous moving web; b) first means for urging a first reeling spool toward the drum to squeeze the web therebetween; c) second means for moving the spool about the drum from a first position to a second position; d) third means for receiving the spool from the second means and for retaining the spool during reeling of the web thereupon; and e) fourth means for cutting the web upstream of a spool in said first position, and for encouraging the leading edge of the cut web to wind about the spool; that system having a structural member for mounting to a support structure adjacent to the spool; a sensing means mounted to the structural member having sensing means alterable from a first output state when sensing a bare spool to a second output state when sensing a web on the spool; and means for communicating the output states to a signal processing device.

A still further aspect of the invention includes a method of controlling the turn-up of a continuous web onto a spool, that method comprising the steps of: positioning a new spool above a continuously moving web at a location where that web is being bent about a partial arc of a drum; positioning an apparatus for sensing the presence of a web about a spool in a position for sensing the presence of a web about the spool, that apparatus having a sensing means alterable from a first output state when sensing a bare spool to a second output state when sensing a web on the spool; and means for communicating said output states to a signal processing device; cutting the web and causing the leading edge of the cut web to wrap around the spool; sensing with said apparatus for the presence of web about the spool monitoring the output states of the sensing means with the signal processing device; and moving the spool about the drum on interpretation by the processing device that the web is present about the spool.

Brief Description of Drawings

Figure **1** shows a general arrangement side view of an embodiment of web reeling machinery according to the present invention.

Figure **2,** being Figures **2a** and **2b**, shows side and front views of an apparatus for sensing the presence of a web about a spool for use in the web reeling apparatus of Figure 1.

Figure **3**, having first and second sheets, shows an algorithm for operating the web reeling machine of Figure **1** with the apparatus shown in Figure **2**.

Figure **4,** being Figures **4a, 4b**, **4c**, **4d**, **4e** and **4f** shows a series of views according to the cyclic operation of the machine of Figure 1 according to the algorithm of Figure **3**.

Best Mode for Carrying Out the Invention

In the description which follows, like parts are marked throughout the specification and the drawings with the same respective reference numerals. The drawings are not necessarily to scale and in some instances proportions may have been exaggerated in order more clearly to depict certain features of the invention.

The output end of a paper machine is shown generally in Figure 1 as **20**. A nearly full spool, or parent reel, is indicated as **22**, a waiting empty spool is illustrated as **24**, and a driven drum is indicated as **26**. A continuous web **28** leaves paper machine **20** at a constant speed, several hundreds of feet per minute, in the direction of arrow '**A**'. Initially empty spool **24** waits clear of web **28**. Most commonly, spools such as item **24** are 20 inch diameter steel cylinders weighing roughly 1800 lb., having a central shaft extending axially from both ends thereof, each shaft end having a bearing mounted thereto suitable to be grasped by a spool holding device such that the bearing is held and the cylinder is free to revolve about the axis of the shaft. Spools need not always be made of steel, and may have, for example, a rubber or other elastomeric surface in some cases. A spool starter drive apparatus, shown generally as **30**, is used to cause spool **24** to spin at a speed approximating the speed at which web **28** is moving. Once the previous, or parent reel, has reached the calculated desired reel size, measured by length of web (SPEC LENGTH) or reel diameter (SPEC DIAMETER), spool **24** is lowered to contact web **28**, in what, although not precisely vertical, may for convenience nonetheless be termed the twelve o'clock position, or α_{12} . Very soon thereafter web **28** is cut by any of several known means, between the last roll, a paper spreading roll **32** of paper machine **20** and drum **26**. That portion of web **28** downstream of the cut runs along drum **26** to collect on full spool **22**, which

is then moved away for subsequent processing or use. That portion of web **28** upstream from the cut begins to wind onto spool **24**, encouraged by any one of several known means. Once spool **24** has begun to accumulate web **28**, it becomes the new parent reel, and is rotated about drum **26** to the position formerly occupied by spool **22**, which, although not precisely horizontal, may for convenience nonetheless be referred to as the three o'clock position, or α_3 , and a new spool **34** is brought into position, ready to recommence the cycle when spool **24** has been filled.

The embodiment illustrated in Figure 1 will now be described in greater detail with reference also to Figures 2, 3, and 4. A spool holding apparatus in the nature of a pope reel is shown generally as **36**. It includes drum **26**, and a pair of primary arms **38**, one of the pair being the visible side illustrated, the other, not visible in the illustrations, being a matching arm of opposite hand at the far end of drum **26**, which pivot about an axis of rotation **40** common to drum **26**, and, as shown in Figure 4f, a driven gear **42**. As shown in Figure 4a, primary arms **38** have an arcuate seat **44** for receiving the bearing surface of a spool, be it **24**, **34** or some other. As shown in Figure 4a, seat **44** is disposed between a grasping mechanism in the form of a slidingly retractable tongue **46** , the sliding direction being vertical in Figure 4a, and a co-operable opposed claw **48** pivotally movable about a pivot **50** from an open position in which a new spool may be introduced into seat **44**; and a closed position in which a finger **52** urges a spool, such as spool **24**, to remain within the grasp of primary arms **38**. The movement of claw **48** to the open position described also causes a movable stop **54** to move about pivot **50** to a position in which a spool located between tongue **46** and claw **48** at α_{12} is compelled to sit clear of web **28** and drum **26**. A clearance of 3/8 inches has been found satisfactory.

Primary arms **38** are movable about axis **40** from a first position for receiving a spool, at α_{12}, to a second position, or α_3 for delivering that spool to a pair of secondary arms **56** which co-operate with a pair of ways **58** along which a filled roll is removed, as will be described below. As with primary arms **38**, only one of secondary arms **56** is shown, the other being of opposite hand and not visible in the illustrations. The motion of primary arms **38** about axis **40** is controlled by an electric motor and gear drive system of conventional construction not visible in the illustrations. The sliding motion of tongue **46** and the pivoting motion of claw **48** are driven by pneumatic cylinders of conventional construction and operation, also not visible in the illustrations. A feature of such a pneumatic system during movement from α_{12} to α_3 that as web **28** accumulates about spool **24** pneumatic pressure, acting through the medium of finger **52** of claw **48**, constantly urges spool **24** toward drum **26**. Also, as the number of layers of web **28** about spool **24** increases, that increase in diameter of the reel forces spool **24** outwardly from seat **44**. This motion compels finger **52** to deflect incrementally counter-clockwise about pivot

50. Despite this deflection, pneumatic pressure continues to act through finger **52** to urge against spool **24** against drum **26**.

As indicated in Figure 4b et seq., secondary arms **56** each have the form of a yoke **60** mounted on a shaft **62** extending radially outward from an axle **64** about which secondary arms **56** may pivot. A double acting pneumatic cylinder **66** is used to urge secondary arms **56** forward, or clockwise, about axle **64** to an extended position, and backward, or counter-clockwise, thereabout to a home, or return, position. Cylinder **66** is connected to a pressurized air supply and valve system permitting supply of 90 p.s.i.g. in the forward directions, and 30 or 90 p.s.i.g. in the rearward direction. Each leg **68** or **70** of yoke **60** terminates in a toe **72** or **74** respectively, each having a roller **76** or **78** mounted thereto. Yoke **60** is of a radius of curvature to allow generous entry of spool **24** therein between rollers **76** and **78**, and of such a size that the weight of each full parent reel is carried by ways **58**.

In operation, secondary arms **56** are positioned in the first, or home position, to receive a spool, such as spool **24** as it moves to α_3 in the grasp of primary arms **38**. The thickness of web **28** collected on spool **24** as it arrives at α_3 is not, in general, constant from spool to spool, but varies according to the thickness of stock produced by paper machine **20**, and the number of turns accumulated before reaching α_3. Yoke **60** accommodates this variation. As web **28** builds about spool **24**, finger **52** deflects, and eventually spool **24** engages roller **78**. At this point backward pressure in cylinder **66** works to urge spool **24** against drum **26** and claw **48** can be released and returned to its open position. Similarly, tongue **46** may be retracted to facilitate return of primary arms **38** to α_{12} to await a succeeding spool.

The position of secondary arms **56** may be measured in many ways, whether by angular position about axle **64** or by linear measurement on ways **58**. In the embodiment illustrated the position of secondary arms **56** is determined by linear measurement using a Magnerule *Plus* (T.M.) a magnetic induction sensitive position sensor indicated as **80**. A discrete measuring system, or a system of mechanical stops and relays could also be used, as could other forms of continuous distance measurement.

Spool starter drive apparatus **30**, includes a motor of conventional nature, not visible in the illustrations, connected to driven wheel **82** mounted at the depending extremity of an arm **84**, itself pivotally mounted to a support structure **86**. Double acting pneumatic cylinder **88** extends from structure **86** to arm **84** such that provision of pressurized air to one side or the other of cylinder **88** will bias driven wheel **82** against or away from spool **24**. A motor control

(not shown) is used to adjust the speed of the motor, and hence driven wheel **82** to cause a spool to revolve at a rate for matching the linear speed of web **28**.

A web cutting device is indicated as **90**. In the illustrated embodiment this device is a Sandar Industries Inc., TUSA IV (T.M.) web cutter using a cutting tape in the manner set forth in laid open Canadian Patent Application 2,046,605. Other web cutters are known in the art.

Finally, an apparatus for sensing the presence of the web about the new reel is indicated generally as **92**. In the embodiment illustrated it includes an arm **94** movably extending from a support **96**, and a sensor carriage **98** loosely mounted to the distal end of arm **94**. As before, a pneumatic cylinder **100** is provided to urge carriage **98** against or away from spool **24** as may be desired. Apparatus **92** is shown in Figure 1 contacting spool **24** on a slant, for ease of illustration. In the preferred embodiment it swings downwardly and outwardly from support **96** to ride on top of spool **24** at roughly the 12 o'clock position.

Carriage **98** is shown most fully in Figures **2a** and **2b**. Carriage **98** includes a frame or body **102** to which are mounted a leading spool follower in the nature of a steel roller bearing indicated as a first roller **104** and a trailing spool follower in the nature of another steel roller bearing indicated as second roller **106**. Body **102** has a relieved arcuate face **108**, the better to accommodate the curvature of a spool, such as spool **24**, and an outwardly extending dorsal member, or spine **110** having a through hole **112** located more or less centrally therein to permit attachment to arm **94**. Rollers **104** and **106** are mounted within body **102** such that their rolling surfaces **114** and **116** stand proud of arcuate face **108** for contacting a spool, and are each in electrical contact with a lead wire, **118** or **120** respectively, in turn suitable for connection to an electrical resistance sensing device and signal processing apparatus of a conventional nature, indicated schematically as **122**. When placed in contact with a bare steel spool the electrical resistance registered between rollers **104** and **106** will be negligible. However, when a web of paper or other less conductive material is present electrical resistance therebetween will be significantly increased. It will be appreciated that other devices, such as brushes or sliding electrical contact shoes or similar devices could be substituted for rollers **104** and **106** without altering this function.

In the version of TUSA IV (T.M.) web cutter employed, the tear begins at one side and works in a spiral to the other side. In another type of web cutter a tear is initiated near the centre line of web **28** which eventually works its way on a curve to the outer edges of the web. In either case apparatus **92** is preferably placed at a location near the edge of web **28** where the last part

of the tear will occur. thus it will also be at the last location at which the new web will begin to turn up.

It may be noted that a non-contacting sensor, such as a suitably positioned, rigidly mounted digital camera capable of differentiating between a bare metal, or bare rubber, surface and a paper or textile web surface may also be suitable for the present purposes, and could be augmented by optical timing marks or other similar means for determining the cumulative angular displacement of spool **24**. Such a camera need not ride on spool **24** but could be positioned in fixed spaced relationship therefrom at a desired orientation and distance for observing spool **24** while not obstructing the spool changing process.

A second device for sensing the presence of a web, in the nature of a proximity sensor is shown as **124**, mounted within body **102** and having a probe **126** extending therefrom proud of arcuate face **108** for suspension in close proximity to the surface of a spool when rollers **104** and **106** are riding thereupon. It will be noted that sensor **124** whether it is a reluctance or capacitance or similarly based electrical properties sensor, is sensitive to the distance of separation between probe **126** and the more or less monolithic steel structure of spool **24** and the reading obtained therefrom will vary significantly as each successive layer of web **28** is introduced therebetween. In the prefered embodiment a reluctance sensor is used. As above, the output signal from sensor **124** is communicated by wire **128** to signal processing device **122**.

A third sensing device in the nature of a counter is shown as **130**. Roller **104** is provided with a partial rebate or groove **132** extending through a partial arc of the circumference, that partial arc being 180 degrees. Each revolution of roller **104** will generate an alternating signal in counter **130**, communicated via wire **134** to signal processing device **122**, such that the distance traveled along a contact surface may be computed, the rate of alternation also providing a measure of the speed spool **24**, and subsequently of web **28**.

A fourth sensor in the nature of an optical sensor **136** is shown mounted to body **102** and has an objective **138** extending proud of face **108** for observing spool **24**. An output signal is communicated to signal processing device **122** by means of wire **140**.

Also shown in Figure 1 are a reel calendar web speed measuring device **142** and a web OFF SPEC defect indicating device **144**, each providing an output signal to signal processing device **122**.

The operational sequence for achieving a web turn-up onto a new spool will now be described with reference to the sequence of illustrations of Figures 4b through 4f, following the logical sequence set out in Figure **3**. In Figure 4b parent reel **22** is nearing its full size. New spool **24** has just been lowered into primary arms **38** at the twelve o'clock position and claw **48** is in its open position such that spool **24** is held on stop **54**, clear of web **28** and drum **26**. Spool **24** is not revolving. Apparatus **92** and driven wheel **82** are both held clear of spool **24**. Cylinder **66** is provided with sufficient pressure to urge secondary arms **56** in the backward direction, in a position in which the signal from position locating device **80** to signal processing device **122** is interpreted as δ_X. An operator has selected automatic operation, or AUTO mode.

Signal processing device **122** continuously monitors δ_X to compare it with a set point turn-up value δ_F (i.e., parent reel full). δ_F is not necessarily a constant value, but is calculated for each successive reel on the basis of a desired quantity of good web plus an adjustment for any amount of web containing defects detected by OFF SPEC defect indicating device **144** at the web speed υ_W indicated by web speed measuring device **142**. A value for either ON SPEC LENGTH or ON SPEC DIAMETER parameters is calculated, and updated at real time, whence a current value for δ_F is determined according to the specific geometry of the machine.

At a time T1, $(\delta_F - \delta_X)/\upsilon_W$ equals a preset value of X1 seconds for the time remaining before a turn-up is due. At time T1 apparatus **92** and driven wheel **82** are brought into engagement with spool **24**. At time T2, similarly determined, signal processing device **122** provides a signal to bring driven wheel **82** into engagement with spool **24** and, while monitoring the output from counter **130**, provides an ON/OFF output signal to the motor of spool starter apparatus **30** to cause driven wheel **82** to drive spool **24** at a circumferential speed between υ_W and υ_W plus a pre-selected dead-band value, ε, by a time X2 seconds before a turn-up is due. At time T3, X3 seconds before a turn-up is due, the pressure in cylinder **66** is reduced to LOADING pressure, a reduced pressure, such as 30 p.s.i.g., in the backward direction. This is the state illustrated in Figure 4b.

At time T4 the turn-up is initiated as driven wheel **82** is disengaged from spool **24**, claw **48** is moved to its closed position thus lowering stop **52** and permitting spool **24** to engage drum **26** at $\delta_F = \delta_X$. After a 750 ms wait the web cutting device is energized, in the specific embodiment illustrated the TUSA IV (T.M.) cutter advances the sticky end of its tape into the nip between spool **24** and drum **26**. As soon as the tape is pinched between web **28** and spool **24** it begins to wind in a spiral thereabout, cutting web **28** as it does so, and compelling that portion of web **28** upstream from the cut location also to wrap around spool **24**. The remainder of web **28** downstream from the cut location continues along drum **26** to accumulated on parent reel **22**.

Signal processing device **122** monitors the resistance between rollers **104** and **106** and the proximity of sensor **124**, and the photoelectric output of sensor **136**, to determine whether there has been a change in electrical conductivity or a change in proximity or detection which would indicate the presence of web **28** about spool **24**. From the time that such a signal is received processing device **122** monitors the signal from counter **130** while continuing to test for the presence of web **28**. In the preferred embodiment the test for a successful turn-up is whether web **28** is present after two full revolutions of spool **24**. Not all of the sensors need be provided, but additional sensors permit more versatile use of a single apparatus for more than one type of spool, and may also provide a measure of verification for each other.

If the test for the presence of web **28** fails after two full revolutions then signal processing device **122** provides a signal to cause claw **48** to return to the open position, in which stop **54** once again raises spool **24** clear of drum **26,** causes a warning signal to alert an operator, and terminates automatic operation by transferring the entire system to manual control.

If the test is successful, then signal processing device **122** initiates operation of the primary arm motor to cause the primary arms **38** to leave the twelve o'clock position and move toward the three o'clock position. It is advantageous to do this at an early opportunity since forcing web **28** to traverse a greater distance along an arc of drum **26** before winding on spool **24** will tend to discourage, if not rapidly eliminate, wrinkling. During this movement pneumatic pressure acting through finger **52** urges spool **24** toward drum **26**, encouraging formation of a taut reel. Once a successful turn-up has been achieved apparatus **98** is also withdrawn to an inactive position.

As primary arms **38** rotate about axis **40** carrying spool **24** they soon approach a critical angle, $\alpha_{Critical}$ which defines the angle beyond which the motor driving the motion of primary arms **38** is incapable of stopping and returning spool **24** to the twelve o'clock position. Before primary arms **38** move past $\alpha_{Critical}$ and complete the motion to α_3 it is necessary to determine whether secondary arms **56** will be in an appropriate position for receiving the new reel, spool **24**, when it arrives. A number of steps must have occurred to satisfy that condition.

When web **28** is cut at $\delta_X = \delta_F$ the reduced, loading pressure, such as 30 p.s.i.g., is released from the backward direction of cylinder **66** and an high ejecting pressure, such as 90 p.s.i.g. in the forward direction is applied to urge secondary arms **56** to move in a clockwise direction, that is, away from pope drum **26**. This pressure will force parent reel **22** outwardly in the direction of arrow 'B' along ways **58** to a position from which it may be moved elsewhere

for further processing. During this motion signal processing device **122** monitors the Magnerule *Plus* (T.M.) output to ensure that both arms of secondary arms **56** move synchronously, it being advantageous to avoid ejecting a full reel, weighing perhaps 15 tons, at a skewed angle.

Figure 4c shows uppermost roller **76** at the point at which it no can longer exert a force against parent reel **22**. Roller **78** is shy of the uppermost surface of ways **58**. and cannot impede the ejection of parent reel **22** which is thus released from yoke **60**. In this position measuring sensor **80** indicates δ_E, that is, full extension of secondary arms **56**. Parent reel **22** has enough momentum to continue rolling along ways **58** to reach a stop.

When signal processing device **120** finds that $\delta_X = \delta_E$, it produces an output signal to vent the pressure from the forward side of cylinder **66** and to apply high pressure, such as 90 p.s.i.g , to the rearward side of cylinder **66** to cause secondary arms **56** to return toward drum **26**. Having done this processing device **122** continues to monitor the output signal from measuring sensor **80** and to test it against δ_R , that is, a chosen location along ways **58** closer to drum **26** than δ_E. When $\delta_X = \delta_R$ one may infer that secondary arms are returning toward δ_H, a home, or return position close to drum **26**, and it is permissible to allow primary arms **38** to pass $\alpha_{Critical}$ since it may also be inferred that the time required for the secondary arms **56** to travel from δ_R to δ_H is less than the time for primary arms **38** to move from $\alpha_{Critical}$ to α_3.

When $\delta_X = \delta_H$ secondary arms **56** cease motion and await the arrival of spool **24**. When $\alpha = \alpha_3$, that is, when spool **24** enters yoke **60** and encounters ways **58**, signal processing device **122** causes the primary arm motor to stop. Web **28** continues to build on spool **24**, causing it further to deflect finger **52**. In due course spool **24** also begins to cause motion of secondary arms **56** clockwise about axle **64**. When $\delta_X = \delta_A$ the force required to maintain spool **24** against drum **26** is provided by cylinder **66** and the pneumatic force on finger **52** may be released. Thus signal processing device **122** causes claw **48** to move to its open position, releasing spool **24**. To facilitate early return of primary arms **38** to α_{12} signal processing device **122** further causes slidable retraction of tongue **46** such that primary arms **38** may rotate counter clockwise without lifting spool **24**.

If tongue **46** does not retract then signal processing device **122** monitors the position of secondary arms **56**. When $\delta_X = \delta_B$ spool **24** is clear of the furthest possible extent of tongue **46** and signal processing device **122** activates the primary arm motor to return primary arms **38** to α_{12} position if it has not already been done, without regard to the position of tongue **46**. When primary arms **38** reach the twelve o'clock position the turn-up sequence is complete. Tongue **46** may be extended once again awaiting commencement of the next turn-up cycle.

Various embodiments of the invention have now been described in detail. Since changes in and or additions to the above-described best mode may be made without departing from the nature, spirit or scope of the invention, the invention is not to be limited to those details, but only by the appended claims and their equivalents.

CLAIMS

1. Apparatus for sensing the presence of a web on a spool, said apparatus comprising:

a structural member mountable on a support structure for positioning the apparatus adjacent a spool,

sensing means carried out by the structural member and operable to directly sense the presence or otherwise of a web on the spool, said sensing means having a first output state when a bare spool is directly sensed and a second output state when a web on the spool is directly sensed, and

means for communicating the output state of the sensing means to a signal processing device.

2. Apparatus according to claim 1 wherein first and second followers are carried by the structural member for riding on the surface of a bare spool or on a web on the spool.

3. Apparatus according to claim 2 wherein the sensing means includes an electrical resistance measuring circuit with which the first and second followers are in electrical communication whereby the electrical resistance of the surface on which the followers ride can be measured to distinguish between a bare spool and a web on the spool.

4. Apparatus according to claim 2 wherein the sensing means has a sensing end between the first and second followers and positionable adjacent to the spool.

5. Apparatus according to claim 2 wherein the sensing means includes distance measuring means associated with one of the followers.

6. Apparatus according to claim 1 wherein the sensing means is selected from the group consisting of:

a) an electrical resistance measurement circuit;

b) a proximity sensor;

c) a photoelectric sensor; and

d) a digital camera.

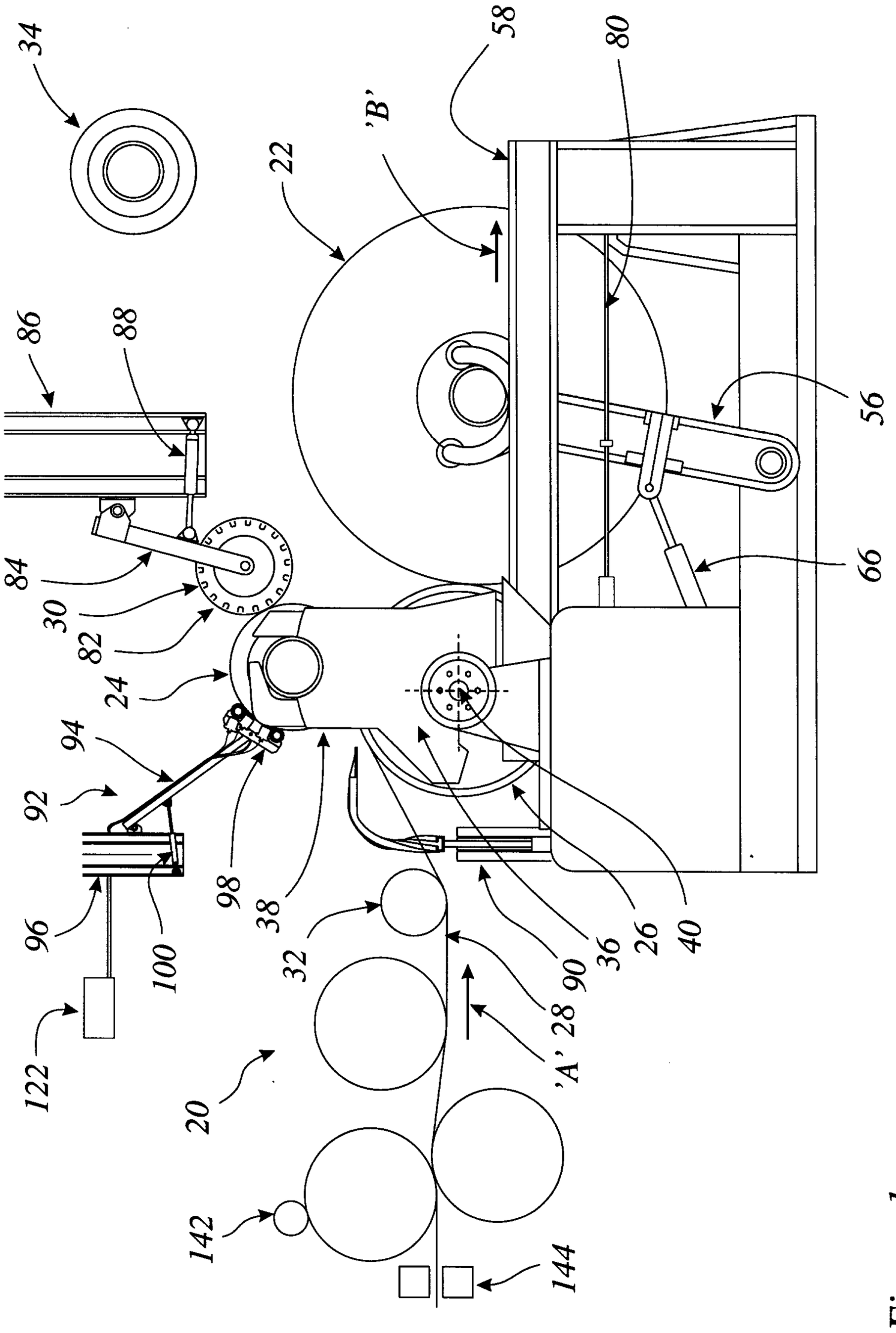

34
58
80
'B'
22
86
88
56
84
30
82
66
24
94
92
98
38
96
100
32
90
36
26
40
122
'A'
28
20
142
144

Figure 1.

Figure 2.

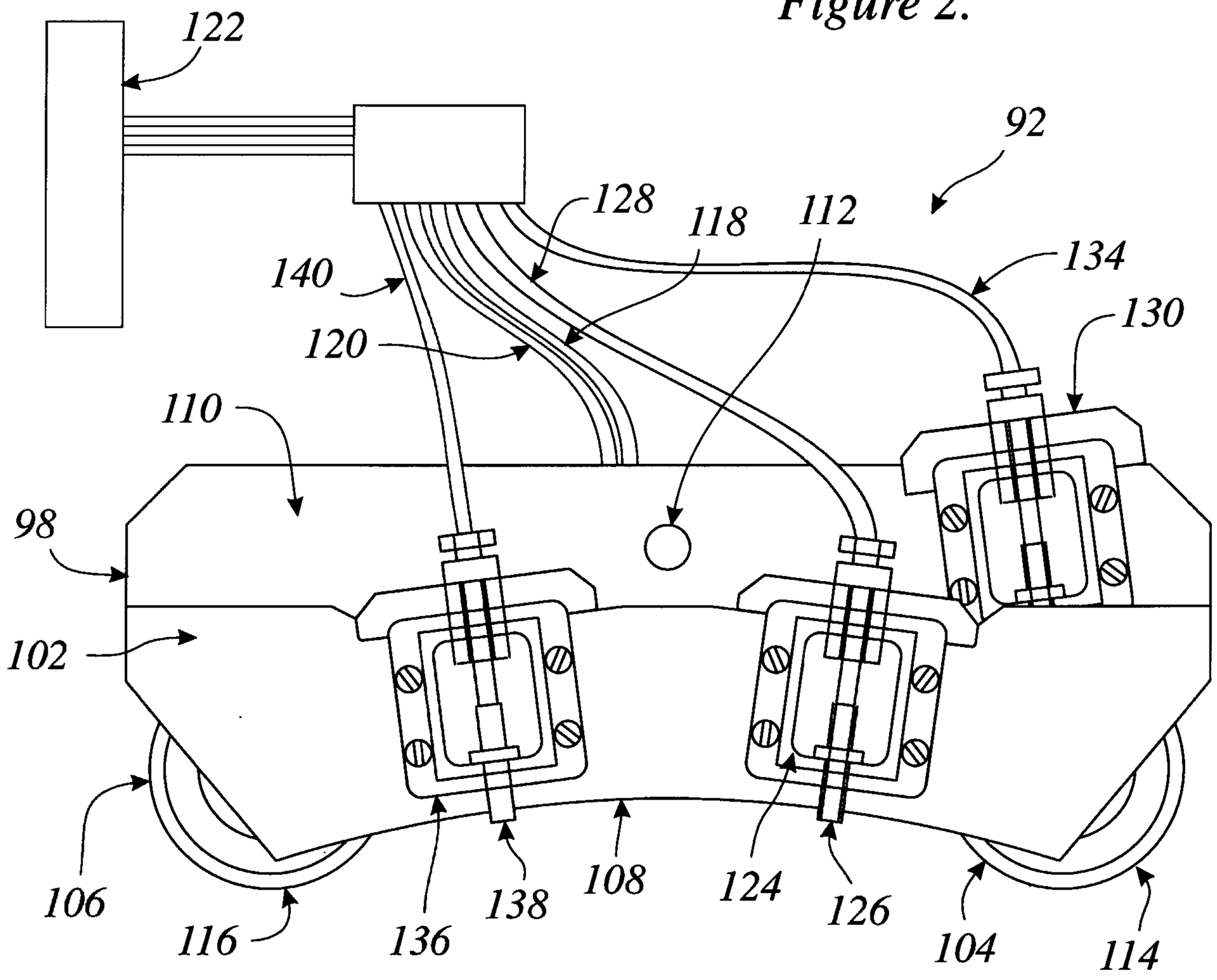


Figure 2a.

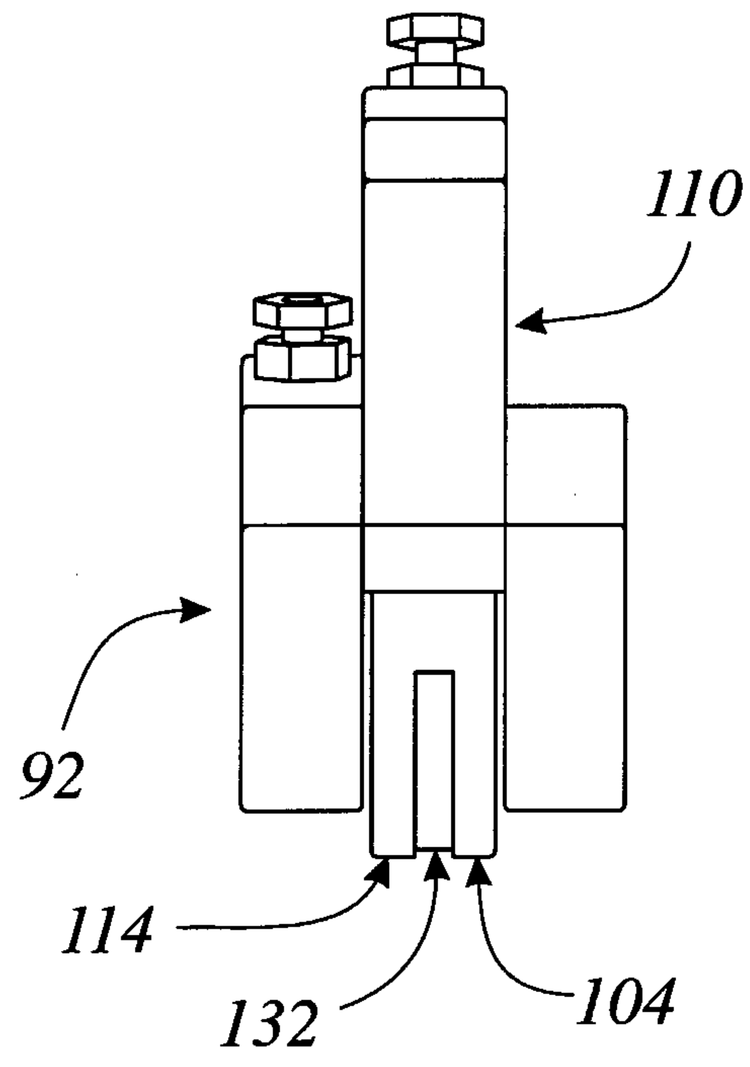


Figure 2b.

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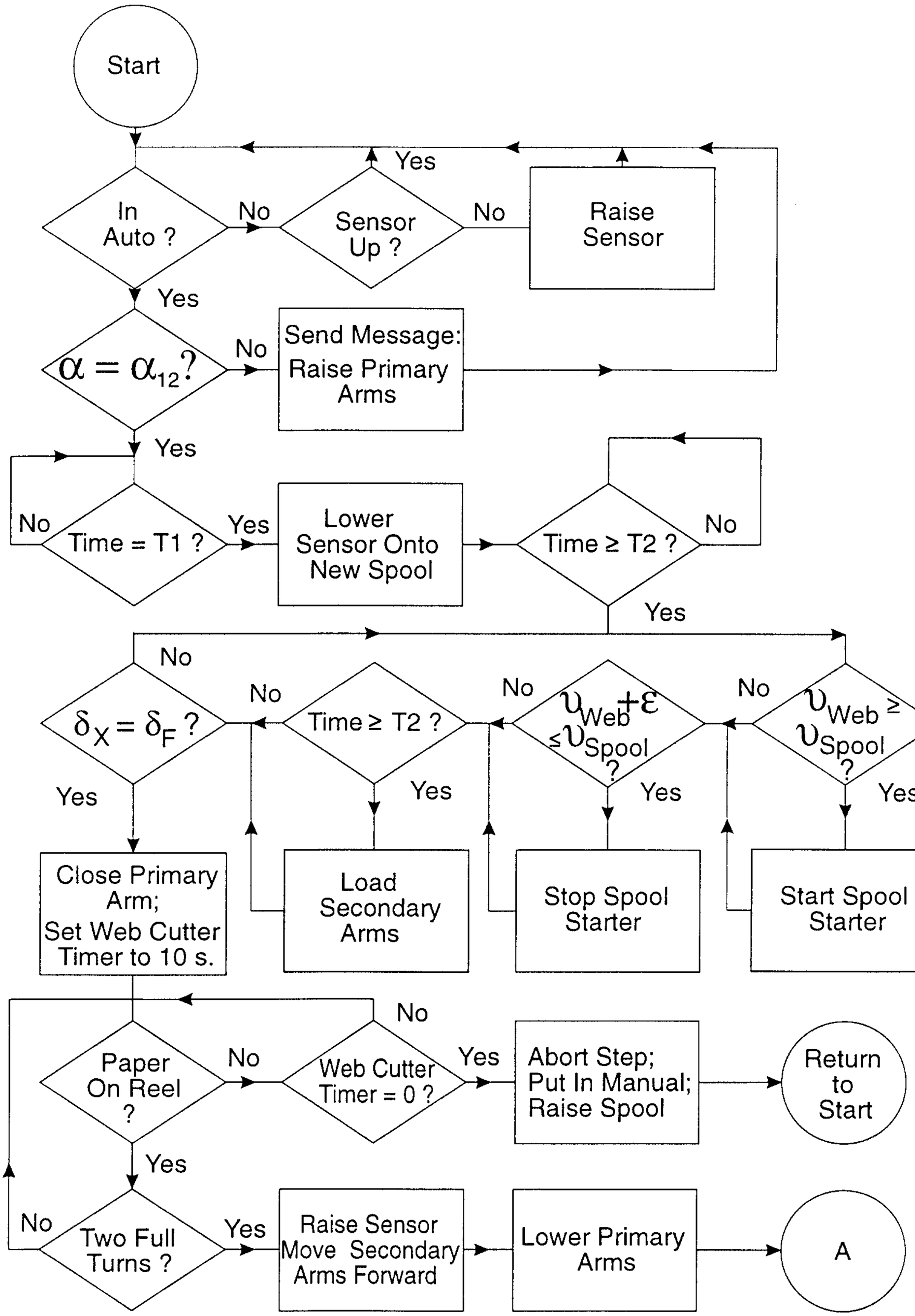

Start
In Auto ?
No
Sensor Up ?
Yes
No
Raise Sensor
Yes
$\alpha = \alpha_{12}$?
No
Send Message: Raise Primary Arms
Yes
No
Time = T1 ?
Yes
Lower Sensor Onto New Spool
Time ≥ T2 ?
No
Yes
No
$\delta_X = \delta_F$?
No
Time ≥ T2 ?
No
$\upsilon_{Web} + \varepsilon \leq \upsilon_{Spool}$?
No
$\upsilon_{Web} \geq \upsilon_{Spool}$?
Yes
Yes
Yes
Yes
Close Primary Arm; Set Web Cutter Timer to 10 s.
Load Secondary Arms
Stop Spool Starter
Start Spool Starter
No
Paper On Reel ?
No
Web Cutter Timer = 0 ?
Yes
Abort Step; Put In Manual; Raise Spool
Return to Start
Yes
No
Two Full Turns ?
Yes
Raise Sensor Move Secondary Arms Forward
Lower Primary Arms
A

Figure 3a.

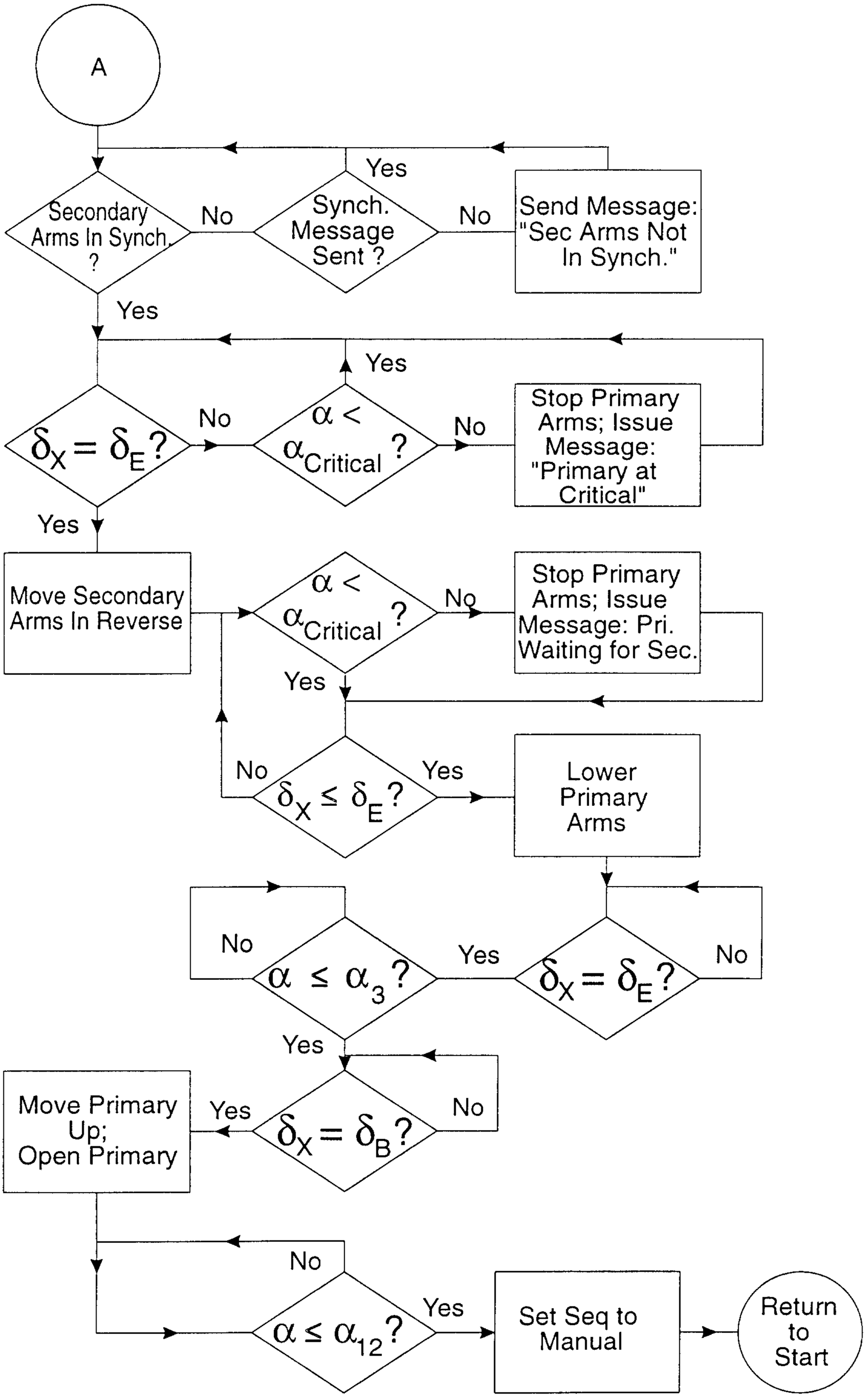

A
Secondary Arms In Synch. ?
No
Synch. Message Sent ?
Yes
No
Send Message: "Sec Arms Not In Synch."
Yes
$\delta_X = \delta_E$?
No
$\alpha < \alpha_{Critical}$?
Yes
No
Stop Primary Arms; Issue Message: "Primary at Critical"
Yes
Move Secondary Arms In Reverse
$\alpha < \alpha_{Critical}$?
No
Stop Primary Arms; Issue Message: Pri. Waiting for Sec.
Yes
No
$\delta_X \leq \delta_E$?
Yes
Lower Primary Arms
No
$\alpha \leq \alpha_3$?
Yes
$\delta_X = \delta_E$?
No
Yes
Move Primary Up; Open Primary
Yes
$\delta_X = \delta_B$?
No
No
$\alpha \leq \alpha_{12}$?
Yes
Set Seq to Manual
Return to Start

Figure 3b.

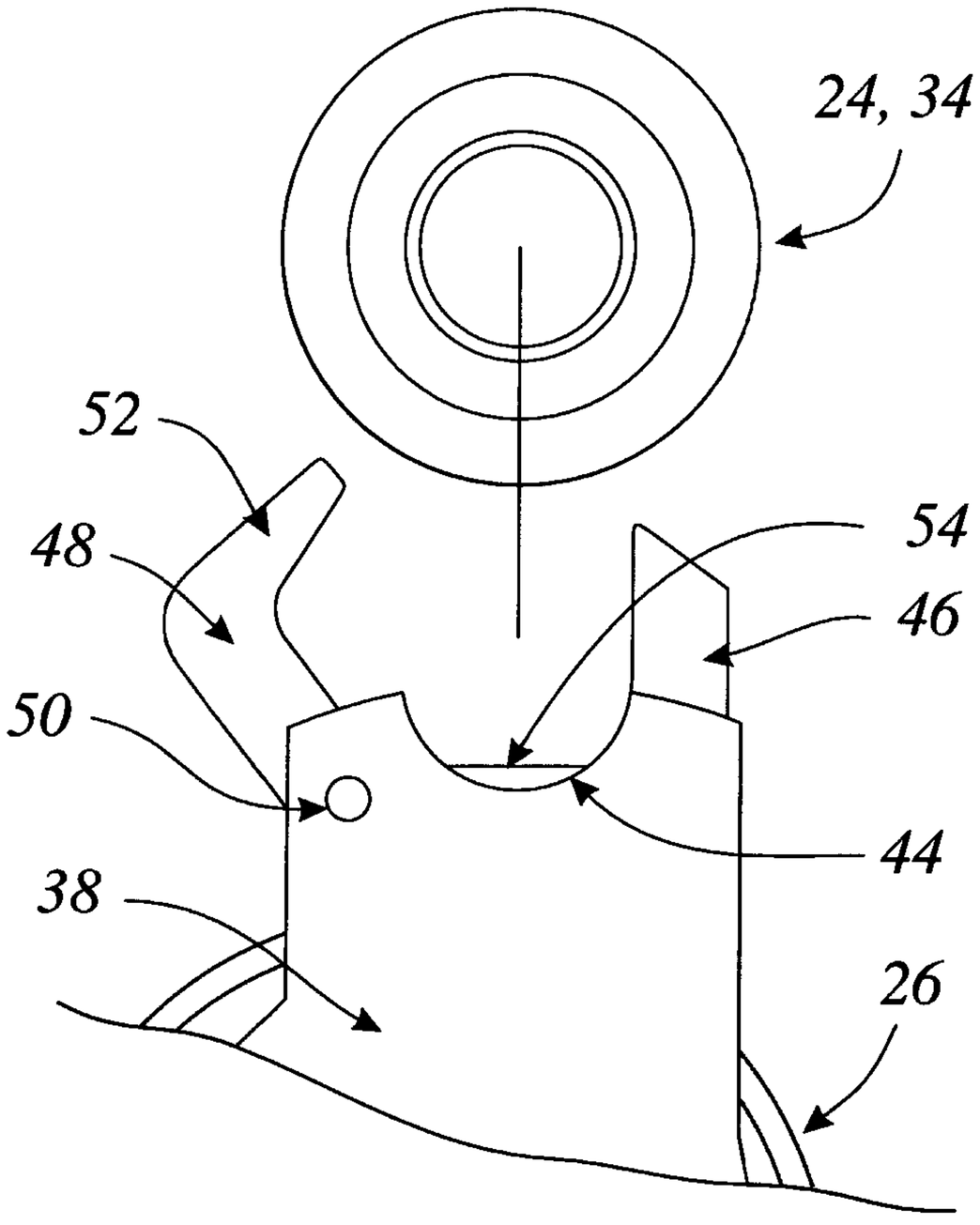


Figure 4a.

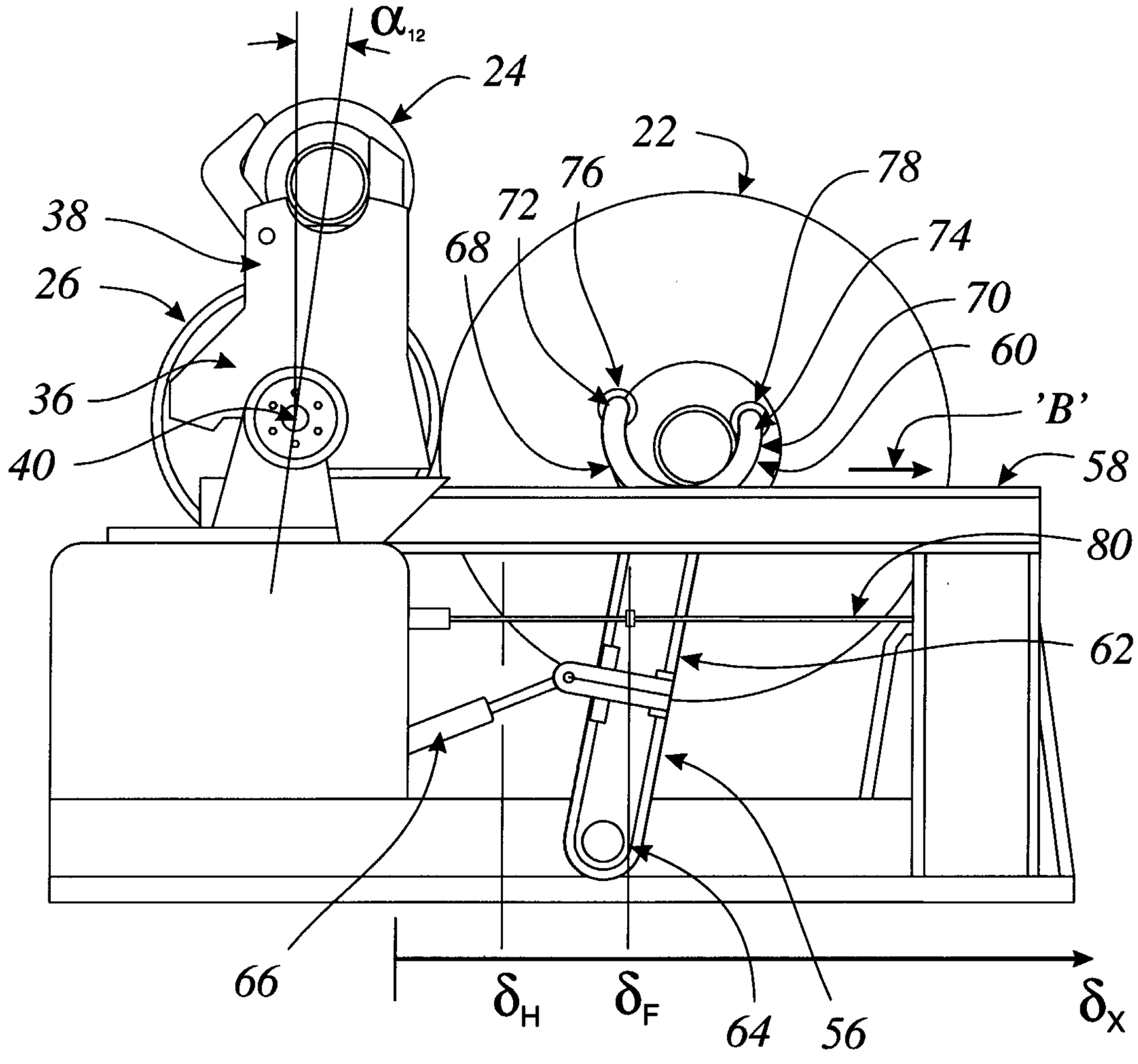


Figure 4b.

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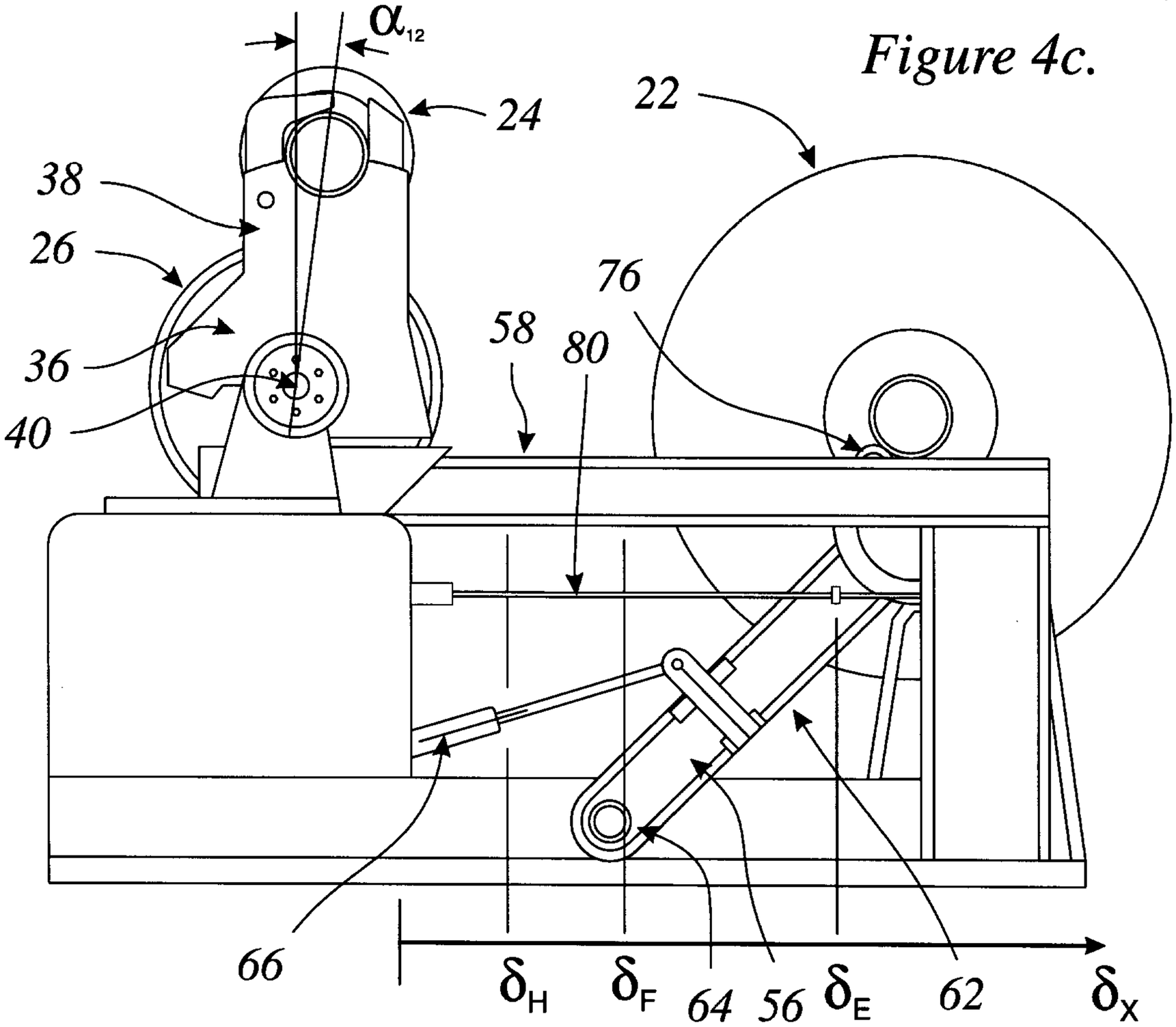


Figure 4c.

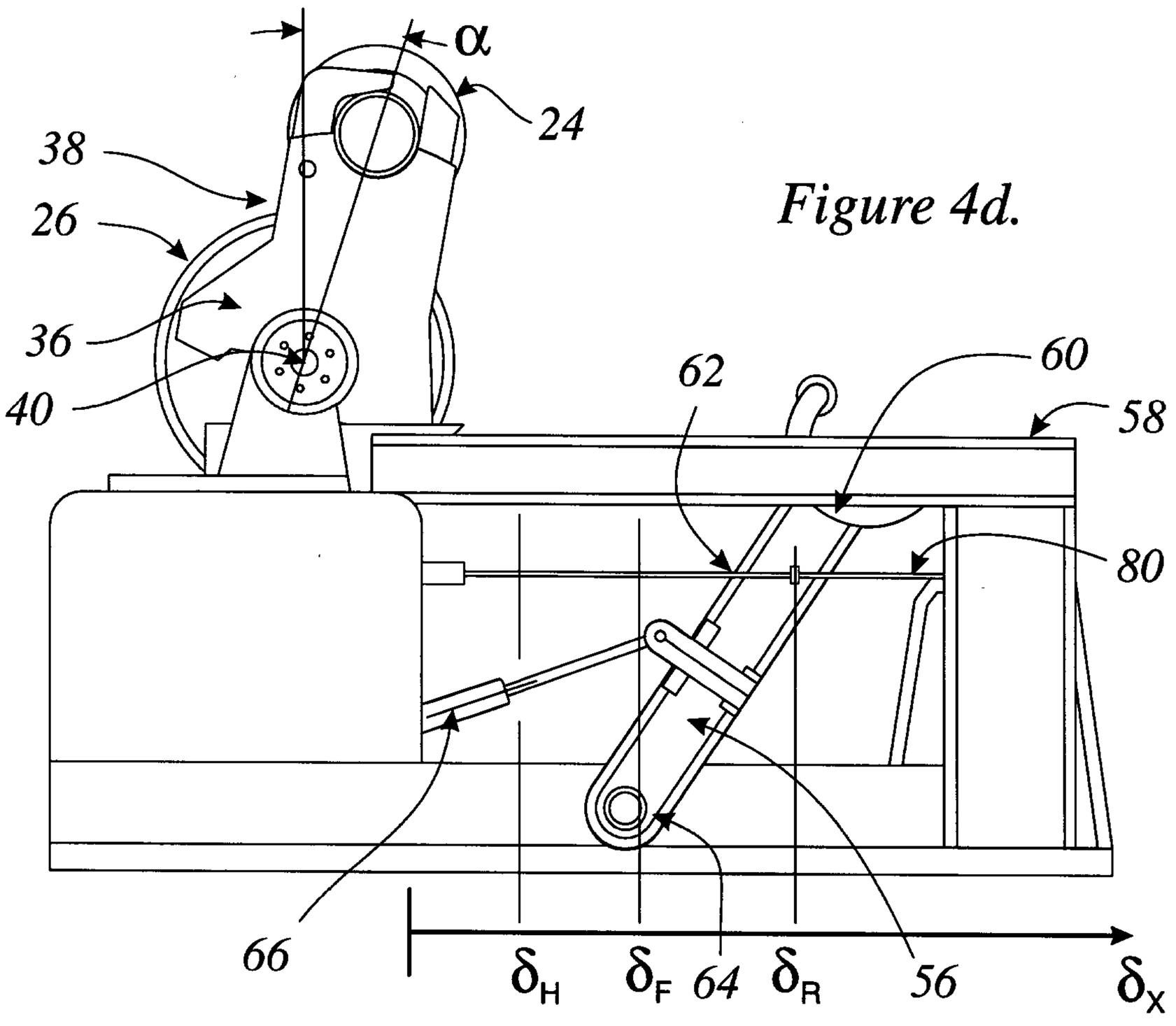


Figure 4d.

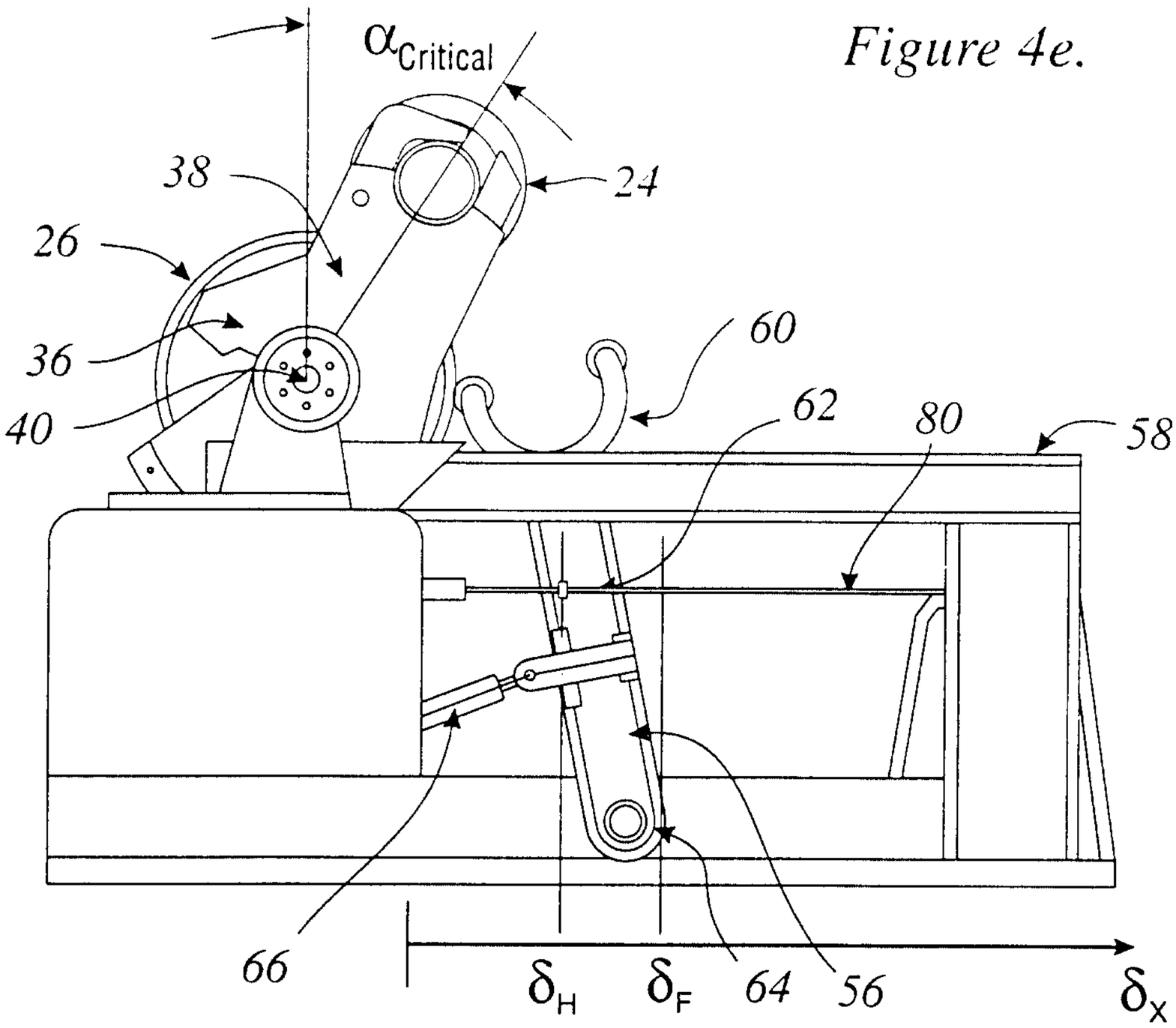


Figure 4e.

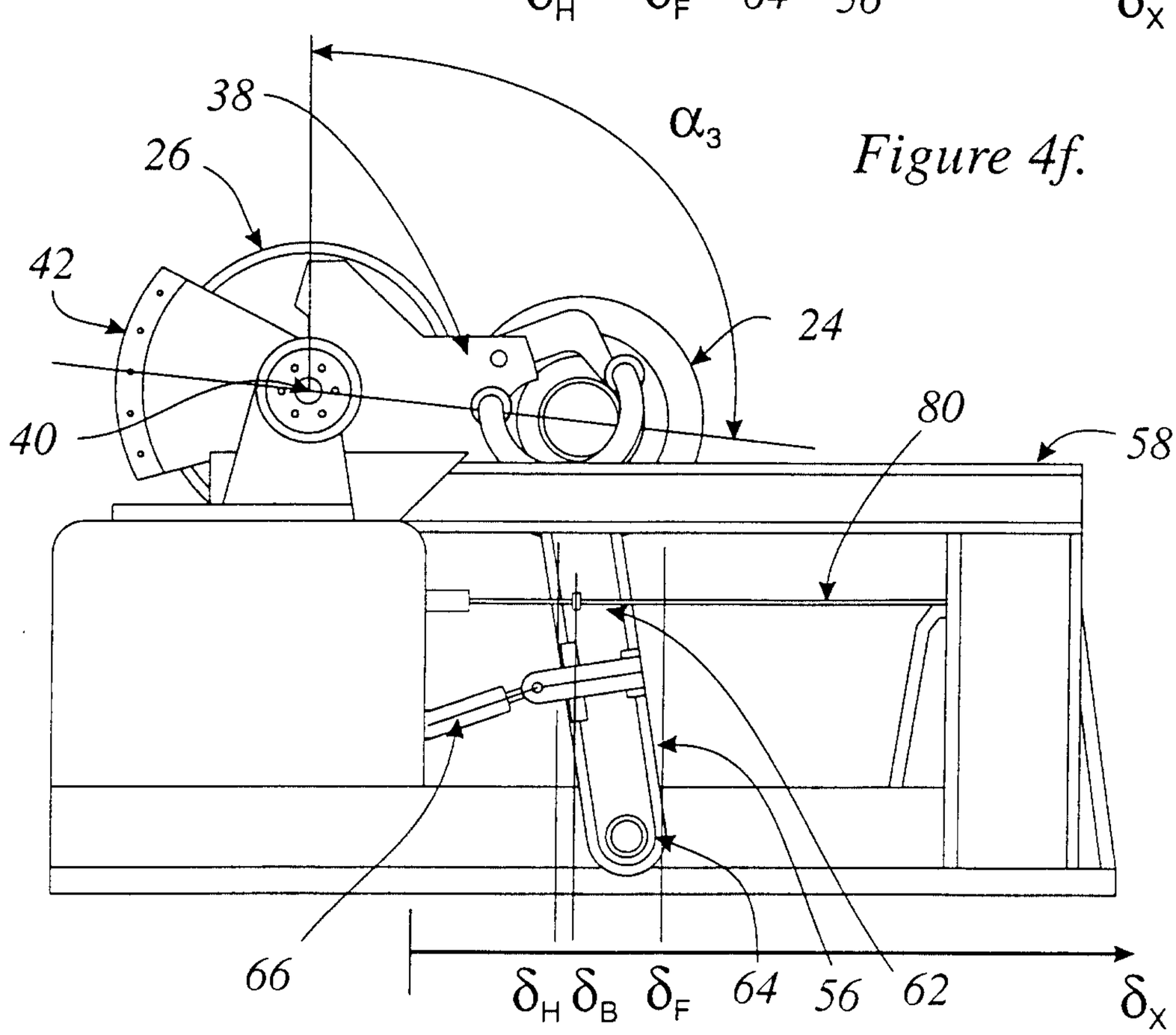
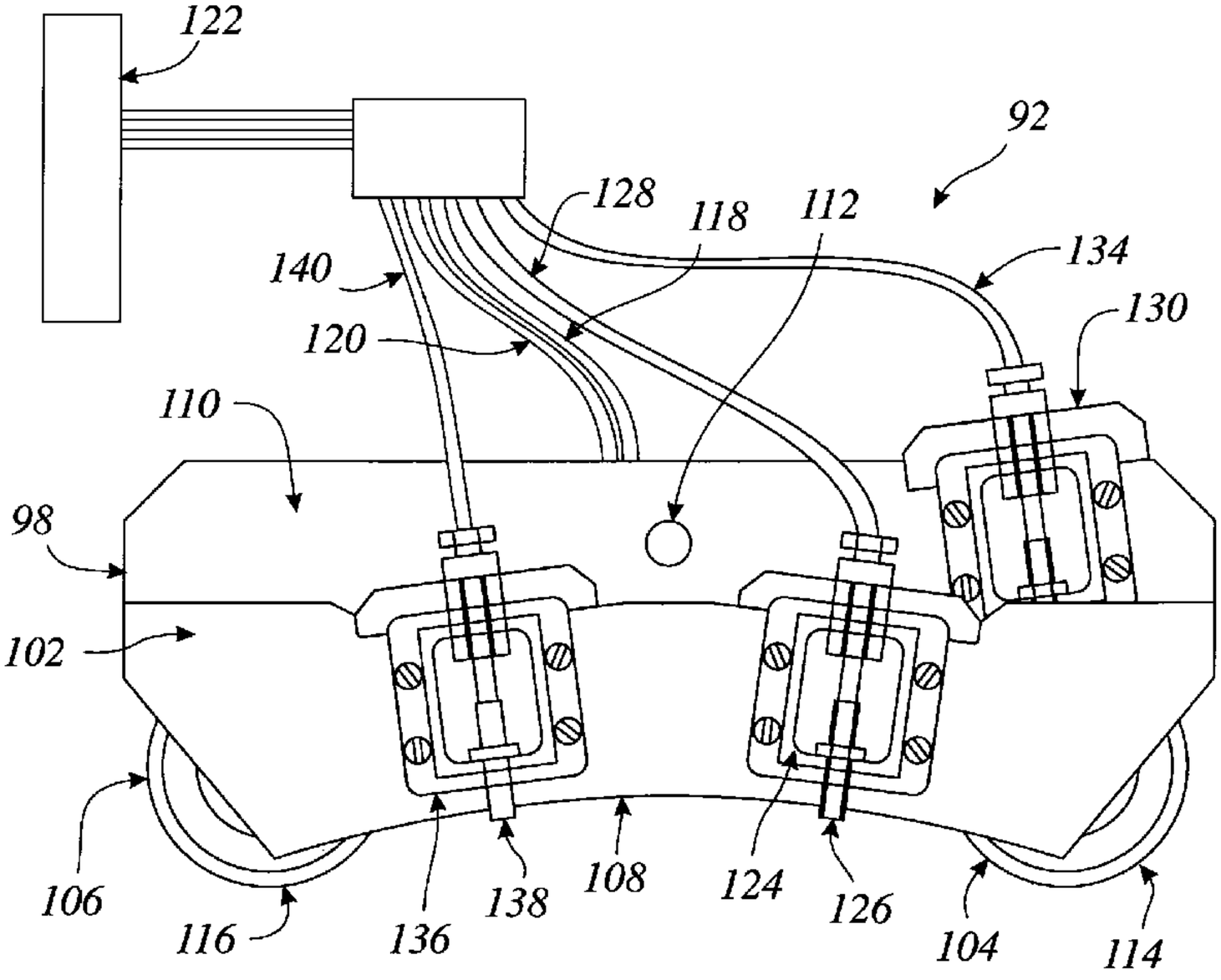
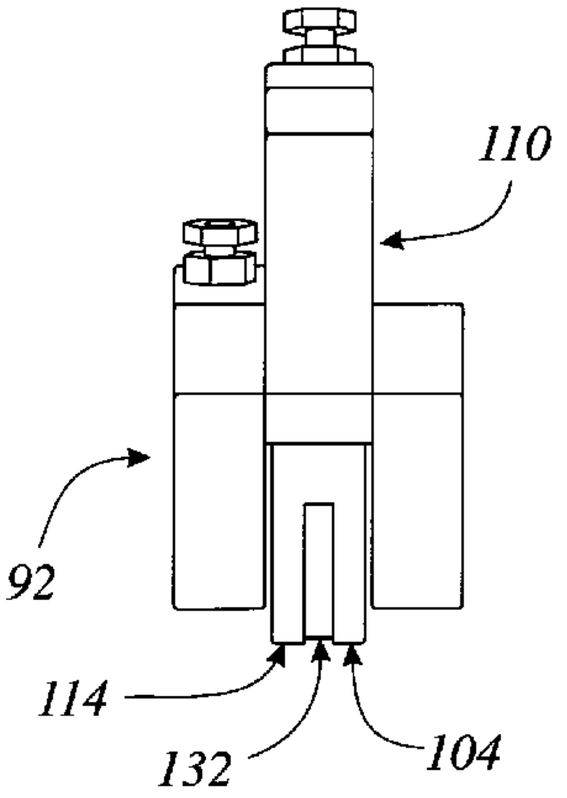


Figure 4f.


122
92
128
118
112
140
134
120
130
110
98
102
106
116
136
138
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124
126
104
114


110
92
114
132
104