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(54) Fabric take-up mechanism for circular knitting machines.

(57) A fabric take-up apparatus for a circular knitting machine (320) includes a set of delivery rolls for flattening and delivering the flattened fabric (327) to a take-up mechanism (330) which winds the flattened fabric into a roll, a plurality of sensors are provided for sensing the vertical tension in the fabric as reflected in at least one of the delivery rolls while minimizing lateral tension and for generating electrical signals indicative of fluctuations in tension from a predetermined desired tension in the fabric. A variable speed drive motor is provided for driving the delivery rolls, and a control mechanism is provided for controlling the variable speed drive motor responsive to the electrical signals generated by the tension sensors.

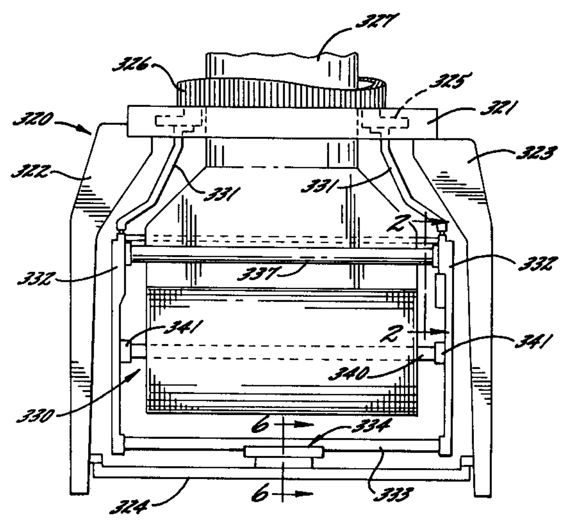

Fig. 1.

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Field Of The Invention

This invention relates to circular knitting machines and more particularly to a fabric take-up mechanism for such circular knitting machines.

Background Of The Invention

Circular knitting machines have rotating cylinders and knitting instrumentalities which produce a tubular fabric which rotates with the cylinder. It is known to withdraw the fabric being formed downwardly through the rotating cylinder by a fabric take-up mechanism including a plurality of delivery rolls which flatten the tubular fabric and wind the flattened fabric around a take-up roll. In such circular knitting machines, the take-up mechanism rotates synchronously with the cylinder to avoid twisting of the fabric as it rotates with the needle cylinder.

Conventionally, the take-up speed of the take-up mechanism of the circular knitting machine is adjusted while the machine is not in operation to a preset value calculated to maintain the fabric under tension when the knitting machine knits the maximum length of fabric it is capable of producing for that type of fabric. However, if the length of fabric being knitted varies from this maximum length because of different stitch construction, different types of yarn, or variation in the stitch lengths being formed, tension in the fabric as reflected in at least one of the delivery rolls will gradually increase during knitting to the point that the fabric is torn or knitting needles are placed under sufficient stress that breakage occurs. Previous attempts to solve this problem have either failed or have been only partially successful.

One such prior attempt provides a detector for detecting substantial increases in tension in the fabric and a stop motion to stop the knitting machine when such tension exceeds a predetermined maximum allowable value. While avoiding torn fabric or breakage of needles, such an attempt resulted in substantial downtime for knitting machines and reduced production, as well as substantial operator time in making manual adjustments of the take-up speed of the knitting machines.

Another suggested solution to the problem is disclosed in the United States Patent No. 4,671,083, owned by the same assignee as is this application. In this patent, a variable speed drive is disclosed involving a belt and variable pulleys which respond somewhat to the tension in the fabric to vary the speed of the take-up mechanism to reduce the tension in the fabric due to belt slippage in the pulleys. The drive mechanism for the take-up unit disclosed in United States Patent No. 4,671,083 has been partially successful in addressing the problem but still requires substantial operator adjustment of the drive mechanism and only partially responds to increases and decreases in tension in the knitted fabric.

Summary Of The Invention

This invention provides improved take-up mechanisms for circular knitting machines that are preferably based on the applicant's prior take-up system disclosed in European Patent Application No. 93116325.7, filed October 8, 1993. The latter measures tension of a circular knit fabric during knitting of the fabric and adjusts, in response to changes in fabric tension, the speed of fabric delivery rolls which receive knit fabric from the circular knitting machine and the speed of a take-up roll which receives the fabric from the delivery rolls. In practice it has been found that although this take-up mechanism substantially improves knit fabric tension uniformity, the adjustment of take-up speed can be influenced by various factors other than changes in fabric tension resulting from variations in knitting.

With the foregoing in mind, it is an object of the present invention to provide a take-up mechanism for a circular knitting machine which more accurately adjusts windup speed in response to variations in tension in the fabric being received from the circular knitting machine. Another object of the invention is to more accurately and reliably sense circular knit fabric tension changes during manufacture thereof. Yet another object of the invention is to provide windup speed adjustment in a take-up mechanism for a circular knit fabric which adjusts windup speed in response to fabric tension variations attributable to knitting, while minimizing adjustment of windup speed in response to variations in fabric tension resulting from other causes.

The present invention provides a take-up mechanism including a plurality of delivery rolls which receive fabric from the circular knitting machine cylinder, flattens the fabric and delivers the fabric to a take-up roll which winds the flattened fabric thereabout to form a roll of fabric. The take-up mechanism of this invention includes tension sensing means for selectively sensing fabric tension variations in a predetermined direction, preferably the direction of fabric travel from the knitting machine to the take-up mechanism. When the tension in the predetermined direction varies above or below a predetermined value, a variable speed motor drive means that is connected to the sensing means and includes a control means varies the speed of the motor drive for the delivery rolls and/or the take-up roll, to maintain a substantially uniform desired tension in the fabric. Advantageously, selective fabric tension sensing is accomplished by selectively sensing transverse movement of at least one delivery roll in the predetermined direction. More preferably, selective fabric tension sensing is accomplished by selectively sensing tension of at least one delivery roll in a predetermined direction transverse to its axis of rotation, preferably in the direction of fabric travel from the knitting machine to the delivery rolls.

In accordance with another embodiment of the invention, fabric tension sensing by the tension sensing mechanism is improved by minimizing or eliminating the effects of fabric tension changes occurring in the delivery rolls and/or between the delivery rolls and the fabric windup roll. Advantageously, this is accomplished by directing the knit fabric along a path of travel between the delivery rolls and the windup roll, in a direction substantially transverse to the path of fabric travel between the knitting machine cylinder and the delivery rolls. As a result, any changes in fabric tension between the delivery rolls and the windup roll, which can be caused, for example, by changing winder speed, result in the application of tension to the delivery rolls in a direction substantially transverse to the direction of fabric travel between the knitting machine cylinder and the delivery rolls. This allows for more accurate sensing of the fabric tension between the knitting machine and the delivery rolls without undue interference by tension changes resulting solely from tension changes within or downstream of the delivery rolls. In an advantageous embodiment according to this aspect of the invention, the take-up mechanism includes delivery rolls positioned substantially vertically below the knitting cylinder of a circular knitting machine, and a guide roll positioned between the delivery rolls and the winder at a location defining a substantially horizontal path of fabric travel.

Brief Description Of The Drawings

Some of the objects and advantages of the present invention having been stated, others will appear as the description proceeds when considered in conjunction with the accompanying schematic drawings, in which:

Figure 1 is a fragmentary front elevational view of a circular knitting machine incorporating the features of the present invention;

Figure 2 is a fragmentary sectional view taken substantially along line 2-2 in Figure 1;

Figure 3 is a fragmentary enlarged sectional view taken substantially along line 3-3 in Figure 2;

Figure 4 is an enlarged fragmentary elevational view looking in the direction of the arrows 4-4 in Figure 2;

Figure 5 is a view similar to Figure 4 looking in the direction of the arrows 5-5 in Figure 2;

Figure 6 is a fragmentary enlarged sectional view taken substantially along line 6-6 in Figure 1;

Figure 7 is a circuit diagram illustrating the control circuit for the take-up mechanism of the present invention;

Figure 8 is a top plane view of the take-up mechanism of the present invention;

Figure 9 is a side view of the first and second bracket of the present invention illustrating the effect of transverse movement in the first direction on the second bracket and how it affects the strain gauges;

Figure 10 is a view similar to that shown in Figure 9 showing the affect of transverse motion in both the first and second direction;

Figure 11 is a side view similar to that shown in Figure 2, of an alternative embodiment of the present invention showing various winding paths for the fabric;

Figure 12 is a side view similar to that shown in Figure 2 of an alternative embodiment of the present invention;

Figure 13 is a side of an alternative embodiment of the first bracket of the present invention; and

Figure 14 is a side view similar to that shown in Figure 11, of an alternative embodiment of the present invention.

Detailed Description Of The Preferred Embodiments

In the following detailed description, there are set forth preferred embodiments of the invention in order to enable a full understanding and practice of the invention. It will be apparent that although specific terms are employed in describing the invention, they are used for purposes of description and not for purposes of limitation.

Referring now more specifically to the drawings and particularly to Figures 1 and 2, there is illustrated a circular knitting machine, generally indicated at **320**, which includes a bed **321** supported by a plurality of legs **322** and **323** connected near their lower ends by a base frame member **324**. The bed **321** supports a ring gear **325** for drivingly rotating a needle cylinder **326** rotatably mounted on bed **321**. Knitting machine **320** includes knitting instrumentalities (not shown) which produce a seamless tubular knit fabric **327** which depends downwardly through the cylinder **326**.

A fabric take-up mechanism is generally indicated at **330** and includes a supporting framework which mounts the take-up mechanism **330** from ring gear **325** and base member **324** for rotation synchronously with the cylinder **326**. This framework includes brackets **331** suspended from ring gear **325** and depending downwardly and outwardly therefrom. A pair of side frame members **332** are mounted at their upper ends on brackets **331** and depend downwardly therefrom and are connected together at their lower ends by a bottom frame member **333**. Bottom frame member **333** is rotatably mounted on base member **324** by a bearing box **334**. The supporting structure for the take-up mechanism **330** is more particularly shown and described in United States Patent No. 4,671,083 issued June 9, 1987, which disclosure is incorporated herein by reference.

The take-up mechanism **330** further includes a set of fabric delivery rolls, which as illustrated in Figures 1, 2, 8 and 11-13, is a set of three rolls **335**, **336** and **337**. The delivery rolls are each mounted for rotation about an axis of rotation, shown as shaft **339** for roll **335**. The delivery rolls co-act together to form nips therebetween through which the fabric **327** is threaded. In the embodiment of Figures 2-6 the fabric **327** passes first through the nip between rolls **336** and **337**, then around the bottom of roll **336** and upwardly through the nip between rolls **335** and **336**, and then around roll **335** to a take-up roll **340**. This is shown in Figure 11 as path **a**. The take-up roll **340** is journaled for free rotation on bearings **341**, located at opposite ends thereof and mounted on the side frame members **332**.

As illustrated in Figures 2-5, 8 and 11-13, the delivery rolls **336** and **337** are journaled for rotation at their opposite ends on pivotal mounting members **301**, **302** which are pivotally mounted at their lower ends to the side frame members **332** by bolts **352** and **353**. The delivery roll **335** is mounted in the center of the three delivery roll arrangement with the driven delivery rolls **336** and **337** mounted in horizontal alignment on opposite sides thereof.

Because of the arrangement of the delivery rolls **335-337**, in relation to the path of travel of the fabric **327** and the take-up roll **340**, changes in fabric tension, which occur during the knitting process, also result in the application of tension to the delivery rolls **335-337** in a direction substantially transverse to their axes of rotation, i.e., shaft **339** in the case of roll **335**. Typically this direction is generally in the same direction as the direction of fabric travel between the knitting cylinder and the delivery rolls, or substantially vertically upward in the apparatus shown in the drawings. In turn, this tension can cause the delivery rolls to move in the same direction, i.e., in the case of the delivery roll **335**, in a direction substantially transverse (may also be slightly oblique) to its axis of rotation **339**, that is vertically upward.

However, it has also been determined that during the operation of the take-up mechanism, other factors which do not result directly from changing fabric tension, can also cause the application of tension to the delivery rolls and/or cause movement thereof. In general, those factors result in changing tension and/or roll movement in a second direction, also substantially transverse to its axis of rotation, that is different than the primary or first direction of tension and/or roll movement which results directly from changes in fabric tension. The first direction of tension and/or roll movement is normally parallel to the path of the fabric **327** as it enters into the delivery rolls **335** and **337**, i.e., vertically upwardly in the case of the apparatus shown in the drawings. The second or different direction of tension can be in any of various directions which are generally perpendicular or oblique with respect to the path of the fabric as described immediately above.

For example, it has been found in practice, that in a system which allows the delivery rolls **336** and **337** to move laterally, either away from or toward the delivery roll **335**, substantial lateral tension can be applied to the delivery rolls as a result of such movement. In turn the subject invention provides for the sensing of transverse movement and or tension changes of at least one delivery roll, preferably delivery roll **335**, in the first or vertical direction in order to more accurately reflect changes in the fabric tension. Advantageously, this is accomplished by employing a sensing mechanism that senses the transverse movement of the delivery roll **335** in the first or vertical direction, while also substantially ignoring the effect of movement and tension changes on the delivery roll **335** in the second or lateral direction. Thus the present invention can substantially improve circular knitting because it is vertical movement which, when adjusted through increasing or decreasing the rotation of the delivery rolls **335**, **336**, and **337**, and possibly take-up roll **340**, allows tension in the fabric, as reflected in the delivery roll **335**, to remain substantially constant, thereby avoiding undesirable damage to the fabric and possibly the needles within the needle cylinder **326**.

As best seen in Figure 2, the three delivery rolls are connected by a pair of tension springs **307** which bias the delivery rolls **336** and **337** against the center delivery roll **335**. The springs are connected to the pivotal mounting members **301** and **302** by horizontally mounted studs **305** and **306**, respectively. The delivery rolls **335**, **336** and **337** are able to move laterally away from each other, against the force of the springs **307** as a result of various lateral forces applied thereto during operation. Such lateral forces may result from a change in fabric tension, changes in the speed of the variable speed motor **360**, differences in the relative speed of the delivery rolls, etc. As indicated previously the subject invention provides an arrangement where increased lateral tension, no matter the cause, as reflected in the delivery roll **335**, will result in substantially no, or only minimal adjustment of the speed of fabric take-up. As discussed below, in one embodiment of the invention, the sensor mechanism is adapted to minimizes the possibility that such lateral movements of the delivery rolls will interfere with accurate measurement of changes in fabric tension.

Referring again to Figure 2-5 and 8-10, the delivery roll **335** is journaled for rotation at its opposite ends on a first bracket **397** which is fixedly mounted on side frame members **332** by bolts **352** and **353** at one end thereof. The first bracket **397** has a generally rectangular configuration which is positioned between the pivotal mounting members **301,302** and the side frame members **332**. The upper surface of the first bracket defines a pair of openings **403** adapted to receive the pair of second fasteners **402**. The first bracket also defines an aperture **405** for receiving the delivery roll **335**.

A second bracket **398** is mounted in contact with the end of the first bracket **397**, opposite the bolts **352** and **353**, such that a mounting surface **401** of the second bracket contacts the first bracket. Unlike the second bracket which is pivotal about bolts **352** and **353**, the first bracket is fixed at the bottom portion thereof by these bolts and at the top by the pair of second fasteners **402**. In the present embodiment, the bolts **352**, **353** are mounted at the bottom of the first bracket and the second bracket is mounted on top of the first bracket, as shown in Figures 2, 4 and 5. It is to be understood however, that the arrangement of the bolts **352**, **353** and the second bracket may be reversed while remaining within the spirit of the invention.

The second bracket **398** has a generally rectangular configuration and is attached to the side frame members **332** by a pair of first fasteners **399** located at opposed ends of the second bracket. Adjacent the opposed ends of the second bracket are a pair of cutouts **400** which have a generally hour-glass shape such that the longitudinal axis of the hour-glass shape runs along the longitudinal axis of the second bracket. Each hour-glass shape defines a pair of a neck portions **407** which define the locations at which each cutout can flex. The pair of cutouts **400** are oriented so that they allow the second bracket **398** to flex in response to movement by the delivery roll **335**. Located adjacent the pair of cutouts **400**, toward the center of the second bracket, are a pair of second fasteners **402** which secure the second bracket to the top of the first bracket **397**.

In Figures 2 and 8-10, above each of the cutouts **400** in the second bracket, are positioned a pair of sensors **404a-d**. The sensors are each positioned adjacent a neck portion **407** of a cutout. In this embodiment, each of the sensors are strain gauges which are connected via Wheatstone bridge to provide a single signal representative of the vertical tension. In such an arrangement, each of the strain gauges will detect any flexion of the second bracket **398** in response to movement of at least one of the delivery rolls (in this embodiment delivery roll **335**). In other words, any tension applied to the delivery roll results in flexing of the second bracket **398** at each of the cutouts **400**.

In response to such flexing, each strain gauge **404a-d** emits a signal representative, in part, of the amount of vertical tension being applied to the cutout **400** in the second bracket. Such vertical tension in turn reflects the amount of vertical tension being applied to the delivery roll **335**, and in turn this tension is representative of the amount of vertical tension being applied to the fabric. The Wheatstone bridge configuration of the strain gauges acts to minimize or eliminate the undesirable force component of the tension (in this embodiment lateral tension) applied to the delivery roll **335** to thereby provide a signal selectively representative of substantially vertical tension applied to the fabric as a result of the knitting process. Because of the arrangement of the strain gauges at plural locations for sensing tension in the delivery roll, the lateral forces applied to the second bracket work in opposition to and cancel each other out so that the resultant signal is representative of the vertical tension.

Operation of the strain gauges responsive to various forces is illustrated in Figures 9 and 10. In Figures 9 and 10, the strain gauges **404a-d** are shown in position on top of the second bracket **398** and also individually below the second bracket to illustrate how they are affected by the transverse movement of the first bracket **397** against the second bracket **398** as a result of corresponding transverse movement of the delivery roll **335** against the first bracket relative to its axis of rotation **339**. Figure 9 represents a purely vertical transverse movement of the delivery roll **335**. As may be seen, the first bracket moves vertically against the second bracket causing the second bracket to flex at neck portions **407** of cutouts **400**.

As a result of the flexion of the second bracket, the strain gauges **404a-d** will each sense the a portion of the vertical tension applied as reflected in the flexing of the second bracket. The magnitude of the individual strain gauge readings obtained are reflected by the blocks which appear below the second bracket in Figure 9. As illustrated the strain gauges **404a** and **404d** obtain substantially identical readings of decreased magnitude reflecting compression. On the other hand, strain gauges **404b** and **404c** each provide substantially identical readings reflecting a great deal of strain increase because the flexion is almost purely vertical.

The four signals from the four strain gauges are then combined in the Wheatstone bridge to provide a single value which will be compared to a predetermined tension value. If the value is greater or less than the predetermined value, a signal will be sent to the control circuit **383** which will send a signal to the motor control **381** to either speed up the motor driving the delivery rolls (in this embodiment **335**) to adjust the tension in the fabric back to the desired level.

Figure 10 illustrates the result of transverse movement in both the vertical and lateral directions. In such an event, the strain gauges **404a-d** not only measure the magnitude and direction of the tension in the same fashion as previously described, but they also minimize the lateral portion of the tension applied. Thus, although the strain at sensor **404a** is decreased due to compression resulting from lateral movement of bracket **397** laterally, the strain at sensor **404d** is increased due to extension resulting from lateral movement. Similarly the strain at sensor **404b** reflects increased strain due both to vertical and lateral movement while the strain at sensor **404c** reflects both increased strain resulting from vertical movement along with decreased strain caused by lateral movement. When the resultant signals from the strain gauges are combined via the Wheatstone bridge, the resultant signal is selectively representative of substantially vertical tension.

As best shown in Figures 3 and 8, delivery rolls **335**, **336** and **337** are driven by a drive means which includes a variable speed, out-rotor type DC motor **360**, such as, a motor made by Itoh Electric, K.K. Motor **360** drives reduction gearing **361** which, in turn, drives delivery roll **335**. Motor **360** and gearing **361** are housed within the hollow delivery roll **335** and are mounted on a stub shaft **362** which also mounts roll **335** for rotation.

Control means, generally indicated at **380** in Figure 7, is provided for controlling the speed of the motor **360** that drives delivery rolls **335**, **336** and **337** in accordance with the signals generated by the tension sensing means of the present invention. The control means **380** includes a motor control **381** which is connected to a suitable power source **382**, such as a DC power source. Motor control **381** is connected to motor **360** and receives a feedback signal from motor **360** concerning the state of operation of motor **360** at any given time. If the signal from the strain gauges **404a-d** indicates a decrease in fabric tension from the desired preset value, as reflected in the delivery roll **335**, the control means **380** will cause motor **360** to drive delivery roll **335**, **336** and **337** faster until the fabric tension equals the desired predetermined value. If the signal from the strain gauges **404a-d** indicates an increase in tension above the preset value, the control means **380** will cause the motor **360** to drive the delivery rolls at a slower speed until the tension in the fabric is reduced to the desired predetermined value.

The pivotal mounting members **301** and **302**, as illustrated in Figure 2, cooperate with a cam member **310** and an operating lever **311**. The pivotal mounting members **310** and **302** each have an extension **301a** and **302a**, respectively which are located at the end opposite the end mounted by bolts **352** and **353**. In this embodiment, the pivotal mounting members **301** and **302** each have cam portions or surfaces **336a** and **337a**, respectively, located at extensions **301a** and **302a**, in between which the cam member **310** is mounted. The cam member **310** cooperates with the operating lever **311** connected thereto for manual pivotal movement of the cam member against the cam surfaces **336a** and **337a** of the pivotal members **301** and **302**, respectively to pivot the pivotal members **301** and **302** away from each other and to thereby laterally move the delivery rolls **336** and **337** away from the center mounted delivery roll 335, to manually release tension between the delivery rolls and the fabric to allow the take-up roll **340** to be removed from the circular knitting machine **320**.

Figure 13 illustrates an alternative embodiment of a first bracket **497**. In this embodiment, rather than a first and second bracket as previously discussed, a single bracket **497** is utilized. The first bracket has a generally rectangular body portion **581** which has a shape similar to the first bracket **397** previously described. Located above the body portion **581** is a head portion **598** which has a similar shape to previously described second bracket **398**. However, in this embodiment, the head portion **598** only has first fasteners **502** for mounting the bracket **497** onto the side frame members **332**.

Joining the body portion **581** to the head portion **598** is a neck portion **507**. The neck portion is generally rectangular and is in longitudinal alignment with the body portion **581**. The neck portion defines a generally rectangular cutout **500** which in turn defines two thin vertical flexible necks **508a** and **508b** located on opposed sides of the cutout **500**. These separate flexible vertical necks in this embodiment function in the same manner as the horizontal necks in the previously described embodiment to provide a plurality of flex points allowing selective measurement of vertical tension or movement of the delivery roll **335**.

As in the previous embodiment, a plurality of strain gauges **504a-d** are positioned adjacent the flexible necks **508a** and **508b**. In this case two strain gauges are positioned adjacent each neck, each being placed on one opposed side thereof. When the bracket moves only in the upward direction, all four strain gauges sense compression. However, lateral forces result in the lateral bending of one or both necks. In such event one side of the neck is elongated, while the opposed side thereof is compressed. Thus when the strain readings are combined, for example in a Wheatstone bridge, transverse movement of the delivery roll **335** provides strain readings that cancel out one another, while vertical movement thereof provides additive strain readings. In all other respects, this embodiment functions in the same manner as the embodiment previously described in detail.

Figures 11 and 14 illustrate another embodiment of the invention in which fabric tension sensing by the tension sensing mechanism is improved by minimizing or eliminating the effects of fabric tension changes occurring in the delivery rolls and/or between the delivery rolls and the fabric windup roll. In accordance with this aspect of the invention the path of fabric travel is changed in order to change the direction of tension applied to delivery rolls due to fabric tension changes within or downstream of the delivery rolls. This can be accomplished according to the invention by employing any one of several alternative paths for winding the fabric **327** onto the take-up roll **340**.

Preferred alternative paths in accordance with this aspect of the invention are shown as paths **b**, and **c-d**, in Figure 11. In addition Figures 11, 12 and 14 also illustrate alternative embodiments of the take-up mechanism **330** modified for achieving these fabric paths. In Figures 12 and 14 a guide roll **410** which is mounted in horizontal lateral alignment with the delivery rolls **335**, **336** and **337**, downstream thereof, i.e., between the delivery rolls and the take-up roll. The guide roll **410** can be mounted in a fixed location or mounted to allow a desired amount of pivoting about a spring biased mounting lever (not shown) so as to be flexible. In Figure 11, a second guide roll **411** is positioned in horizontal alignment with the delivery rolls **335**, **336** and **337**, upstream thereof, opposite from the first guide roll **410**. The guide roll **410** or rolls **410** and **411**, function to direct the knit fabric exiting and/or entering the delivery rolls, along a path of travel in a direction substantially transverse to the path of fabric travel between the knitting machine cylinder and the delivery rolls. As a result, changes in fabric tension during travel of the fabric **327** within the delivery rolls and/or between the delivery rolls and the take-up roll **340** result in the application of tension to the delivery rolls in a direction substantially transverse to the direction of fabric travel between the knitting machine cylinder and the delivery rolls. Such tension changes can result from various causes such as, for example, by changing winder speed and the like, and in some instances can interfere with accurate sensing of the fabric tension between the knitting machine and the delivery rolls.

Referring again to Figures 11 and 14, path **a**, which has previously been described in connection with Figures 2-6 directs the fabric between delivery roll **335** and **337**, then around delivery roll **335** onto delivery roll **336** and then to take-up roll **340**. In path **a**, it can be seen that any changes in fabric tension downstream of the last delivery roll **336** can result in the application of vertical force on the delivery roll **336**. Similarly, lateral movement of roll **336** in the direction away from the center delivery roll **335** can increase the tension the fabric applies vertically to roll **335**, as it travels beneath this roll.

Path **b** of Figure 11 and the corresponding apparatus illustrated in Figure 12 illustrate one preferred method and apparatus for substantially decreasing the effects of varying fabric tension occurring within or downstream of the carrier rolls **335**, **336**, and **337**. In this embodiment the take-up mechanism includes delivery rolls **335**, **336**, and **337** positioned substantially vertically below the knitting cylinder of the circular knitting machine, and a guide roll **410** positioned between the delivery rolls and the winder at a location defining a substantially horizontal path of fabric travel. Path **b** employed in this embodiment is similar to path **a**, described above, except that the fabric **327** travels from the delivery roll **336** in a horizontal direction onto the guide roll **410** before travelling vertically downwardly to take-up roll **340**.

Path **c-d** of Figure 11 employs a guide roll **411** upstream of the delivery rolls **335**, **336**, and **337**. In this case the fabric **327** initially follows path **a** or **b** but rather than being wound into a roll following passage across guide roll **410**, the fabric travels along path **c** back up to and over the second guide roll **411** and is then directed back between the nip of delivery rolls **335** and **337** then follows path **d** onto the take-up roll **340**. In the case of path **c-d**, changes in the speed of the take-up roll **340** simultaneously provide an increased or decreased rate of fabric feed to the take-up roll (along path **c**) to accommodate any increase or decrease in the rate of fabric withdrawal by the take-up roll (along path **d**). Accordingly, when the speed of the take-up roll **340** is changed, any vertical change in fabric tension immediately upstream of the take-up roll is minimized or eliminated.

Moreover as shown in Figure 14 when the path **c-d** is employed, fabric take-up on roll **340** can be accomplished using the force supplied to the fabric

327 by the driven delivery rolls **336** and **337** without requiring use of a separate driven roll **412** - (shown in Figure 11) for rotation of the take-up roll **340**. This can further improve sensing of fabric tension by eliminating fabric tension changes that might result from possible temporary inconsistencies between the speed of the take-up roll **340** and the speeds of the driven delivery rolls **336** and **337** which might occur during changes in the speed of the separate drive mechanism for the take-up roll **340**.

Figure 14 illustrates an embodiment which is has a mounting arrangement for the first delivery roll **337** that is different than that previously described. Specifically, in the embodiment shown, a lever arm **513** supporting delivery roll **337** is not pivotally mounted on the first bracket **397** at an angle relative to the center delivery roll **335**. Rather, this lever arm **513** which provides pivoting of the roll **337** is pivotally mounted directly to the side frame members **332** and is biased in a substantially vertical position so that fabric tension from the fabric on path **c** does not cause pivoting of the lever arm.

In its various embodiments the invention is susceptible to numerous variations not specifically discussed herein. For example, although not shown, it to be understood that it is possible to replace the strain gauges with optical sensors or the like to selectively sense variations is fabric and/or delivery roll position and tension and still remain within the spirit of the invention. Similarly, it will be apparent that various control mechanisms, including electronic or computer based controls, can be substituted for the mechanical control discussed herein; that separate signals representative of varying fabric and/or roll tension can be combined in apparatus other than the Wheatstone bridge discussed previously in order to provide a single signal that is substantially selectively representative of fabric tension in a predetermined direction; that a signal selectively representative of roll and/or fabric tension in a predetermined direction can also be obtained without requiring use of plural sensors; and that numerous other such changes can be accomplished.

Thus, the invention has been described in considerable detail with reference to its preferred embodiments. However, numerous changes and variations can be made without departure from the spirit and scope of the invention as described in the foregoing detailed description and defined in the appended claims.

Claims

1. A fabric take-up apparatus for a circular knitting machine including a needle cylinder for forming a tubular knit fabric, said fabric take-up mechanism being adapted for flattening the fabric and winding the flattened fabric under tension into a roll, comprising:

   a delivery roll system for delivering fabric to said take-up mechanism and comprising at least one delivery roll being rotatably mounted about an axis;

   mounting means for mounting said delivery roll for transverse movement responsive to changes in the fabric tension;

   sensing means adapted for selectively sensing transverse movement of said delivery roll in a predetermined first direction; and

   adjustment means for adjusting tension in the fabric delivered to said take-up mechanism in response to said sensing means.

2. A fabric take-up apparatus according to Claim 1 wherein said adjustment means comprises a control means operatively associated with said delivery roll system for varying the speed of rotation of said delivery roll in response to said sensing means.

3. A fabric take-up apparatus according to Claims 1 or 2 wherein said sensing means comprises a tension sensing means for selectively sensing tension in said delivery rolling a predetermined first direction.

4. A fabric take-up apparatus according to any of Claims 2 or 3 wherein said control means comprises:

   adjustable means for adjusting a predetermined value corresponding to a desired fabric tension to be maintained;

   comparative means for comparing the electrical signals received from said sensing means with said predetermined value; and

   generating means for generating a control signal indicative of any deviation of the signals from said sensing means from said reference value.

5. A fabric take-up apparatus according to any of Claims 1-4 wherein said mounting means comprises:

   a support frame attached to the circular knitting machine; and

   bracket means attached to the support frame for movably mounting said delivery roll axis and for cooperating with said sensing means.

6. A fabric take-up apparatus according to any of Claims 1-5 wherein said bracket means comprises:

an aperture for receiving said delivery roll;

a pair of cutouts, each of said cutouts defining a flex point enabling said bracket means to flex in response to transverse movement of said delivery roll; and

fastening means for fastening said bracket to said support frame.

7. A fabric take-up apparatus according to any of the previous claims wherein said sensing means comprises a plurality of sensors for sensing deviation of said delivery roll from its desired predetermined position.

8. A fabric take-up apparatus according to Claim 7 wherein said plurality of sensors comprises at least one strain gauge operatively associated with said bracket means and activated in response to flexion thereof.

9. A fabric take-up apparatus according to any of Claims 5-8 wherein said bracket means includes a flexible neck portion enabling said bracket means to flex in response to transverse movement of said delivery roll.

10. A fabric take-up apparatus according to any of the previous claims further comprising:

a guide roll mounted on the circular knitting machine and cooperating with said delivery roll for minimizing the effect of fabric tension substantially transverse to said predetermined first direction.

11. A fabric take-up apparatus according to any of the previous claims wherein said take-up apparatus further comprises

a support frame and wherein said bracket means is attached to said support frame for movably mounting said axis of said at least one of said delivery rolls.

12. A fabric take-up apparatus according to any of Claims 5-11 wherein said bracket comprises:

a generally rectangular body portion defining an aperture for receiving said delivery roll axis, allowing transverse movement thereof;

a generally rectangular head portion located generally transverse to the longitudinal axis of said body portion;

a neck portion located between said body portion and said head portion, said neck portion defining a generally rectangular cutout so as to allow said neck portion to flex in response to transverse movement of said delivery roll axis;

a plurality of sensors located in said neck portion for selectively sensing transverse motion of said body portion relative to said neck portion in response to transverse motion of said delivery roll axis; and

fastening means for fastening said bracket means to said take-up apparatus.

13. A fabric take-up apparatus according to Claim 12 wherein said plurality of sensors are arranged within said neck portion such that one of said plurality of sensors is located on opposed sides of said cutout and one of said plurality of sensors is located on opposed sides of said neck portion opposite a respective one of said plurality of sensors located within said cutout.

14. A fabric take-up apparatus according to Claim 1 wherein said predetermined first direction comprises a vertical direction toward the direction the fabric is being fed into said delivery roll system.

15. A fabric take-up apparatus according to any of the previous claims wherein said sensing means further comprises means for selectively minimizing sensing of a transverse movement of said delivery roll axis in a predetermined second direction.

16. A fabric take-up apparatus according to Claim 15 wherein said predetermined second direction comprises a lateral direction generally transverse to the direction the fabric is being fed into said delivery roll system.

17. A fabric take-up apparatus according to any of the previous claims further comprising a second delivery roll and a third delivery roll mounted in horizontal alignment with and on opposed sides of said delivery roll.

18. A fabric take-up apparatus according to Claim 17 wherein said second and third delivery rolls are pivotally mounted to on said take-up apparatus enabling lateral movement thereof relative to said delivery roll.

19. A fabric take-up apparatus according to Claims 17 or 18 wherein at least one of said delivery rolls is passively driven and the remainder of said delivery rolls are mounted in general horizontal alignment therewith and rotatably movable relative thereto.

20. The fabric take-up apparatus of any of the previous claims, said fabric take-up apparatus being operatively associated with a circular knitting machine and positioned below the circular needle cylinder thereof.

21. A circular knitting machine including a needle cylinder for forming a tubular knit fabric and a fabric take-up mechanism for flattening the fabric and winding the flattened fabric into a roll, said take-up mechanism including fabric delivery rolls rotatable about an axis for fictionally gripping the fabric formed in the needle cylinder for flattening and feeding the fabric downwardly from the needle cylinder, and a fabric take-up means beneath said fabric delivery rolls for winding the flattened fabric delivered by said fabric delivery rolls into a roll, said circular knitting machine comprising:

sensing means for selectively sensing tension in at least one of said delivery rolls substantially in a predetermined first direction;

variable speed drive means for driving said fabric delivery rolls; and

control means operatively connected to said sensing means and said variable speed drive means for varying the rotational speed of said at least one of said delivery rolls responsive to said sensing means to maintain a substantially uniform tension.

22. A circular knitting machine according to Claim 21 wherein said sensing means comprises:

mounting means for mounting at least one of said delivery rolls for transverse movement of said axis of said at least one of said delivery rolls in response to changes in the fabric tension;

a sensor for selectively sensing movement of at least one of said delivery rolls in a predetermined first direction; and

signaling means for signaling said control means responsive to transverse movement sensed by said sensor.

23. A circular knitting machine according to Claims 21 or 22 wherein said predetermined first direction comprises a vertical direction toward the direction the fabric is being fed into said one of said delivery rolls.

24. A circular knitting machine according to any of claims 21-23 wherein said mounting means comprises:

a bracket defining an aperture for receiving a shaft of at least one of said delivery rolls and a flex portion enabling said bracket means to flex in response to transverse movement of said delivery roll.

25. A circular knitting machine according to any of Claims 21-24 further comprising:

a guide roll mounted on the circular knitting machine and cooperating with said delivery roll to define a fabric path adapted for minimizing the effect of fabric tension substantially transverse to said predetermined first direction.

26. A circular knitting machine according to any of Claims 21-25 wherein said take up apparatus comprises:

a support frame; and

a first bracket attached to said support frame for movably mounting said axis of said at least one of said delivery rolls.

27. A circular knitting machine according to any of claims 21-26 wherein said sensing means further comprises means for selectively minimizing sensing of a transverse movement of said axis of said at least one of said delivery rolls in a predetermined second direction.

28. A circular knitting machine according to Claim 27 wherein said predetermined second direction comprises a lateral direction generally transverse to the direction the fabric is being fed into said one of said delivery rolls.

29. A circular knitting machine according to any of claims 21-28 wherein said sensing means is adapted for sensing tension selectively substantially in said predetermined first direction.

30. A circular knitting machine including a needle cylinder for forming a tubular knit fabric and a fabric take-up mechanism for flattening the fabric and winding the flattened fabric under tension into a roll, said circular knitting machine comprising:

a plurality of delivery rolls for delivering fabric to said take-up mechanism, each of said delivery rolls being rotatably mounted about a respective axis;

sensing means for sensing transverse movement of said at least one of said delivery rolls;

a guide roll cooperating with said at least one of said delivery rolls for directing fabric withdrawn from or supplied to said delivery rolls along a path substantially transverse to the direction of fabric travel between said knitting cylinder and said delivery rolls; and

adjustment means for adjusting tension in the fabric delivered to said take-up mechanism in response to said sensing means.

31. A circular knitting machine according to Claim 30 wherein said adjustment means comprises a variable speed drive motor for varying the speed of rotation of said at least one of said delivery rolls in response to said sensing means.

32. A circular knitting machine according to Claim 31 wherein said sensing means is adapted for sensing tension on said at least one delivery roll.

33. A circular knitting machine according to Claim 32 further comprises:

control means connected to said sensing means for receiving electrical signals therefrom and connected to said adjustment means for controlling the rotation of one or more of said delivery rolls in response to said electrical signal.

34. A circular knitting machine according to Claim any of Claims 31-33 wherein said control means comprises:

adjustable means for adjusting a predetermined value corresponding to a desired fabric tension to be maintained;

comparative means for comparing the electrical signals received from said sensing means with said predetermined value; and

generating means for generating a control signal indicative of any deviation of the signals from said sensing means from said reference value.

35. A circular knitting machine according to any of Claims 30-34 wherein said mounting means comprise bracket means attached to said take-up apparatus and cooperating with said sensing means for movably mounting said respective axis of said at least one of said delivery rolls.

36. A circular knitting machine according to Claim 35 wherein said bracket means comprises:

a an aperture for receiving a shaft of said at least one of said delivery rolls and a pair of cutouts each of said cutouts defining a flex point enabling said bracket to flex in response to transverse movement of said at least one of said delivery rolls.

37. A circular knitting machine according to any of Claims 30-36 wherein said sensing means comprises a plurality of sensors for sensing deviation of said at least one of said delivery rolls from its desired predetermined position.

38. A circular knitting machine according to Claim 37 wherein said plurality of sensors comprises at least one strain gauge operatively associated with said bracket means and activated in response to flexion thereof.

39. A circular knitting machine according to Claim any of Claims 30-38 further comprising:

a second guide roll adapted for minimizing the effect of tension changes on said sensing means.

40. A circular knitting machine according to any of Claims 30-39 wherein said sensing means comprises means for selectively sensing transverse movement of said at least one of said delivery rolls in a predetermined direction.

41. A circular knitting machine according to Claims 40 wherein said predetermined direction comprises a direction generally in the direction the fabric is being fed into said one of said delivery rolls.

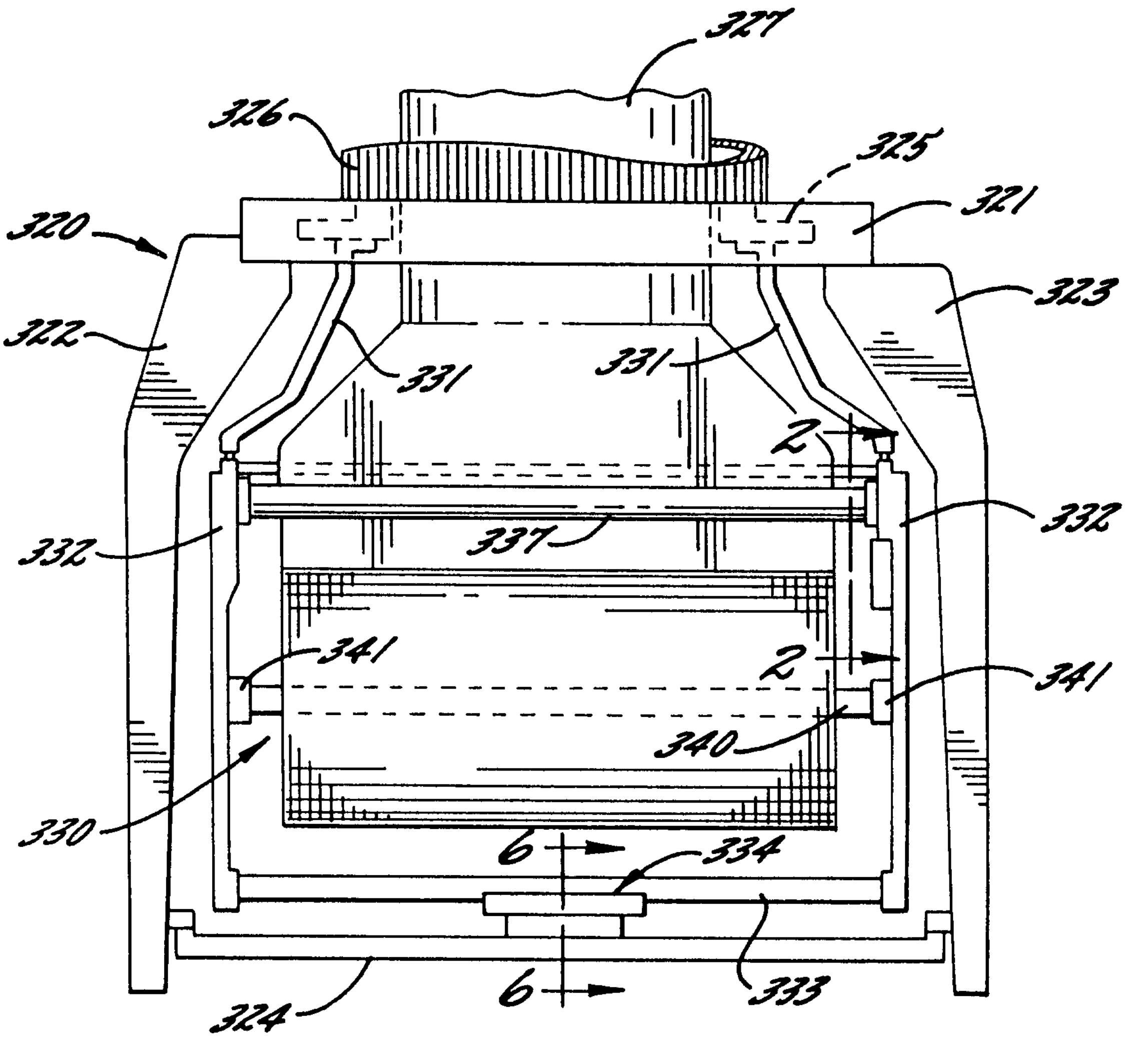
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Fig. 1.

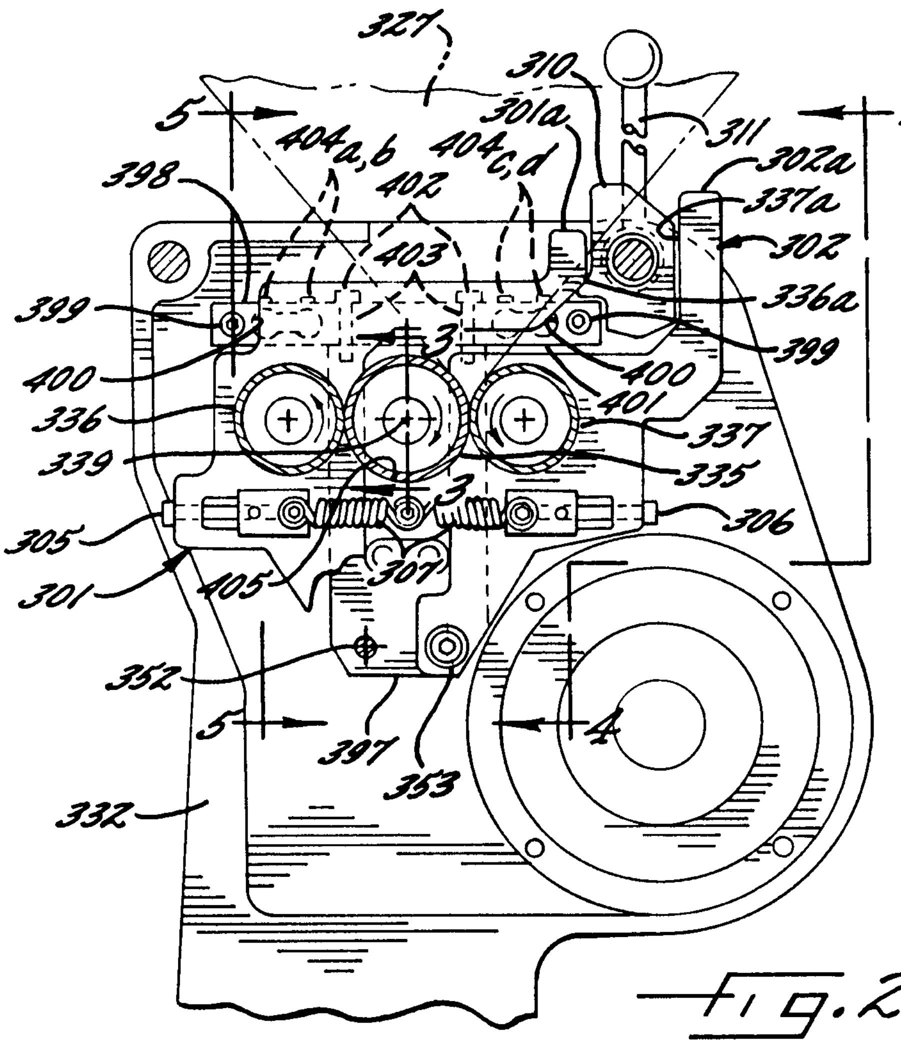
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Fig. 2.

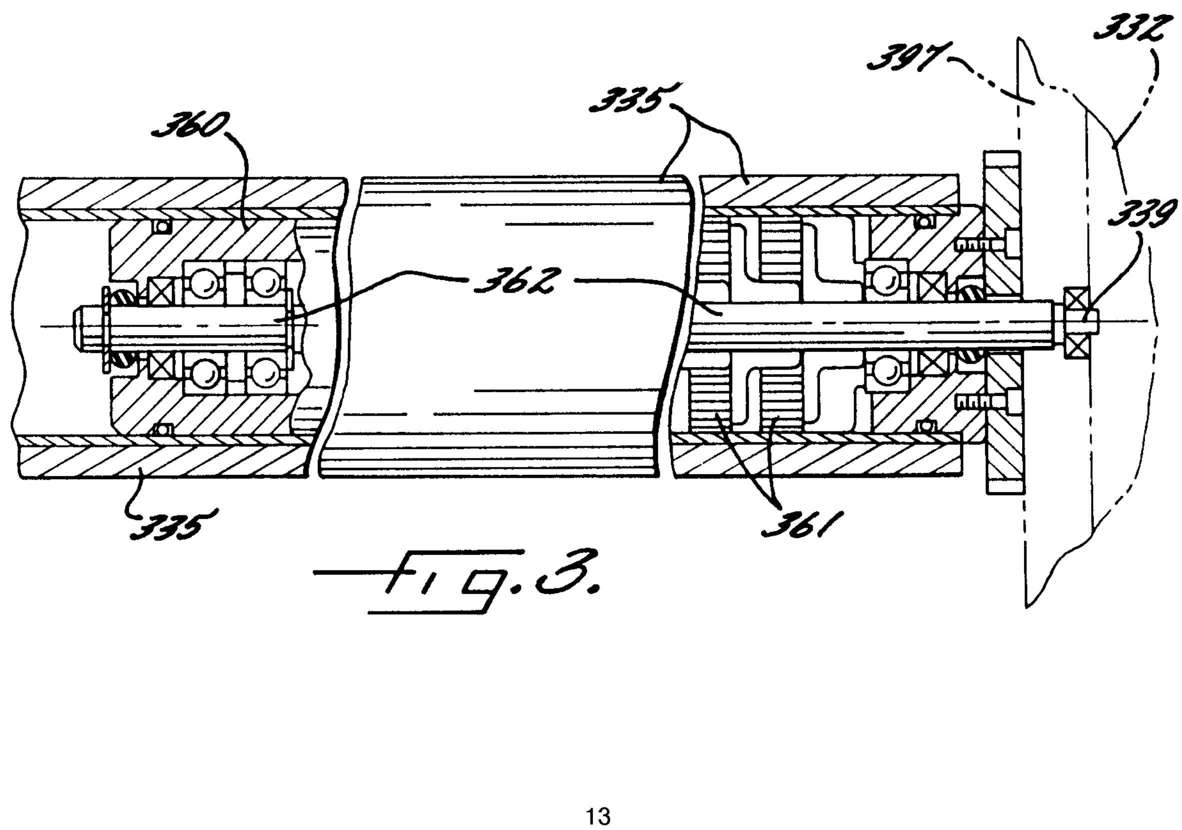
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Fig. 3.

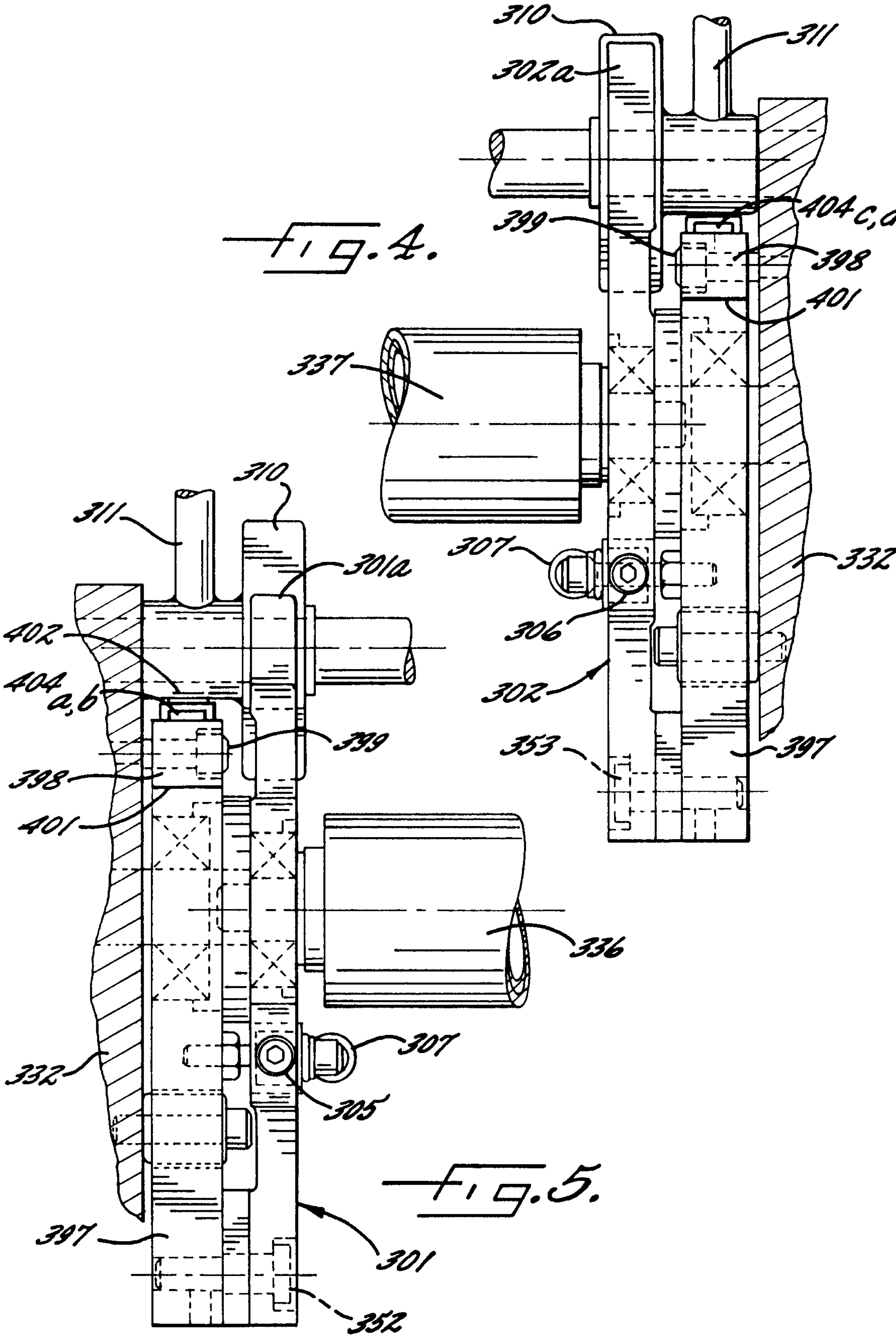
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Fig. 4.

Fig. 5.

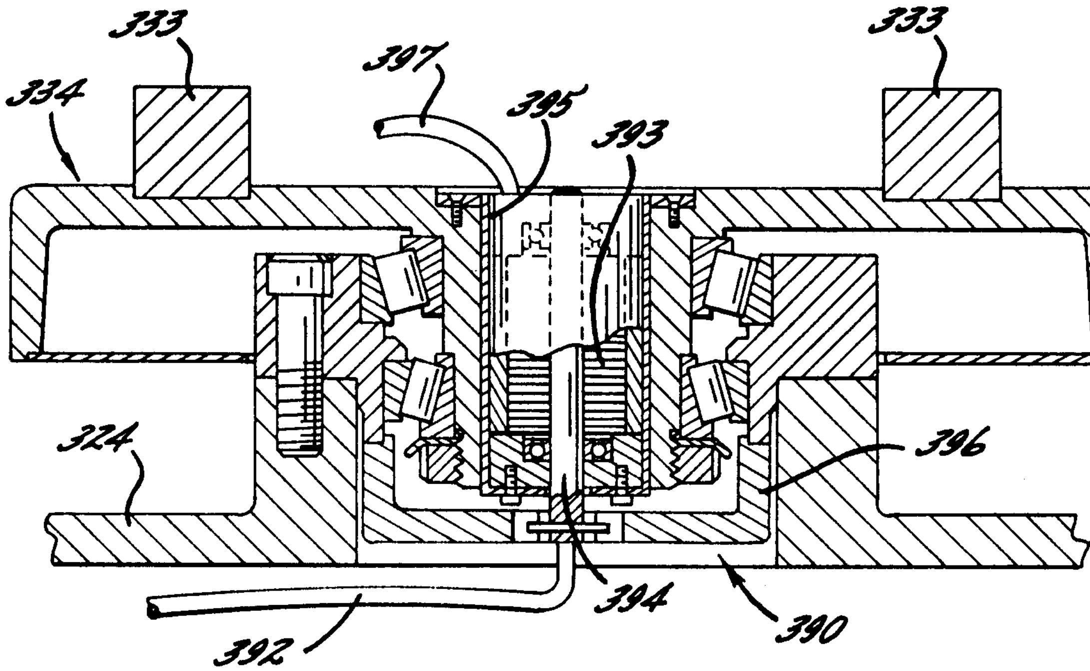
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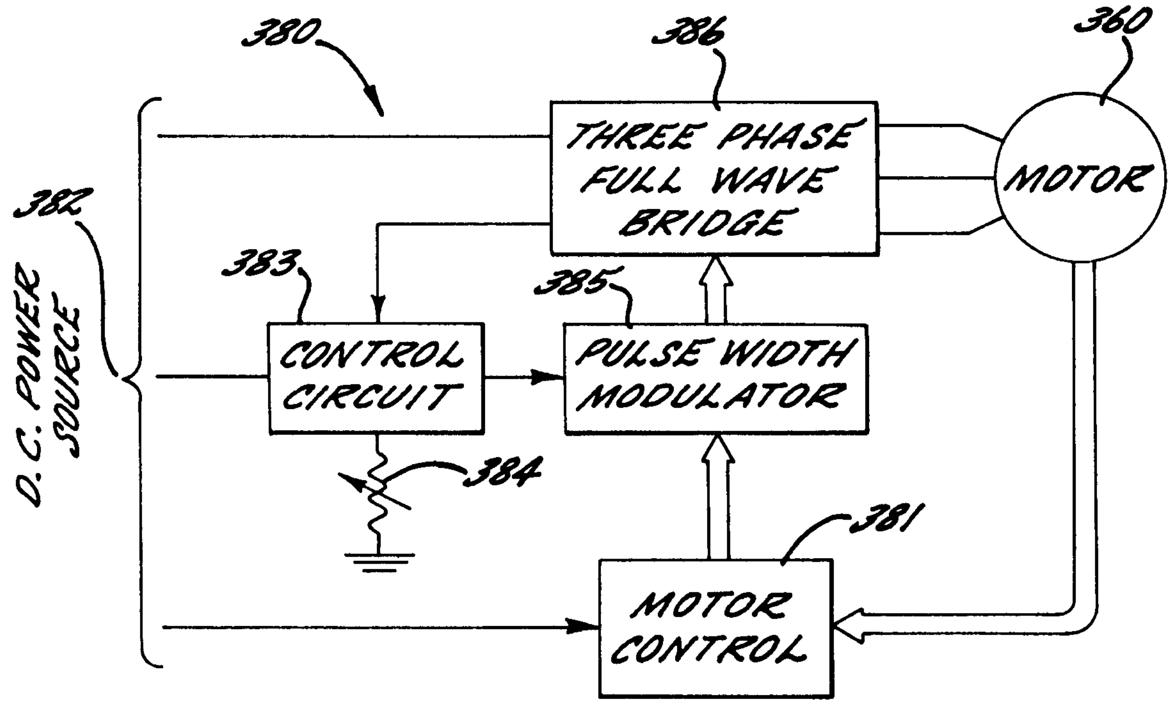
Fig. 6.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THREE PHASE FULL WAVE BRIDGE
MOTOR
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D.C. POWER SOURCE
CONTROL CIRCUIT
PULSE WIDTH MODULATOR
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MOTOR CONTROL

Fig. 7.

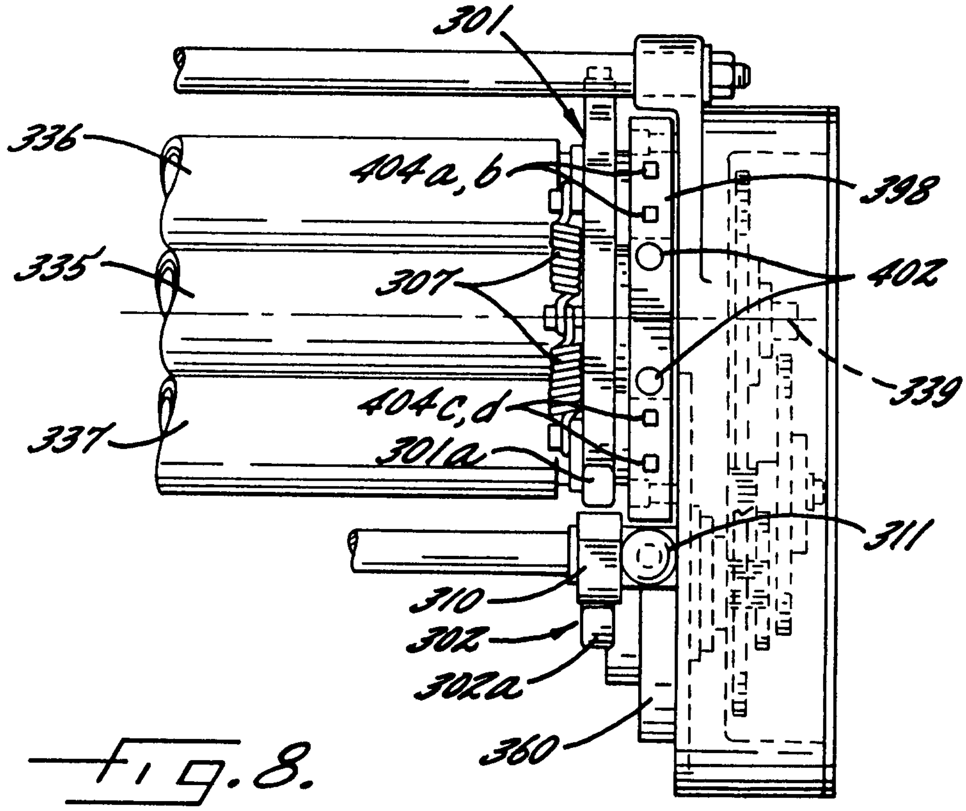
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Fig. 8.

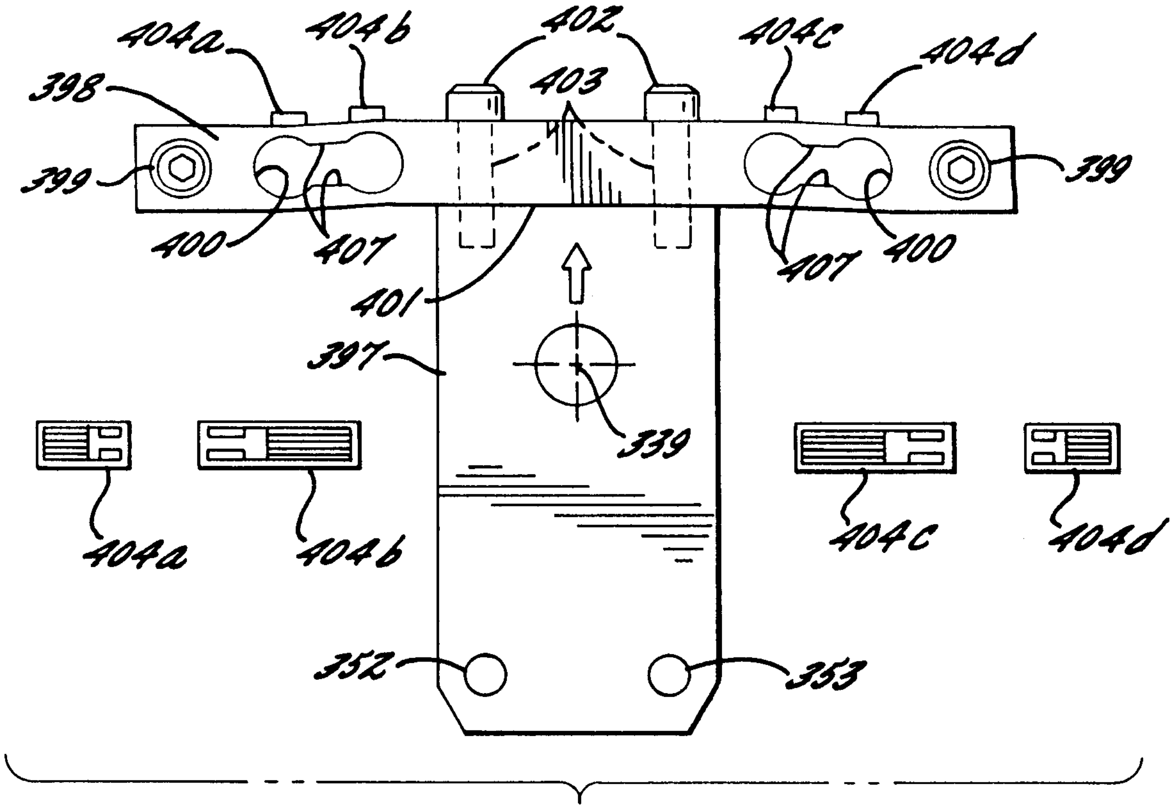
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Fig. 9.

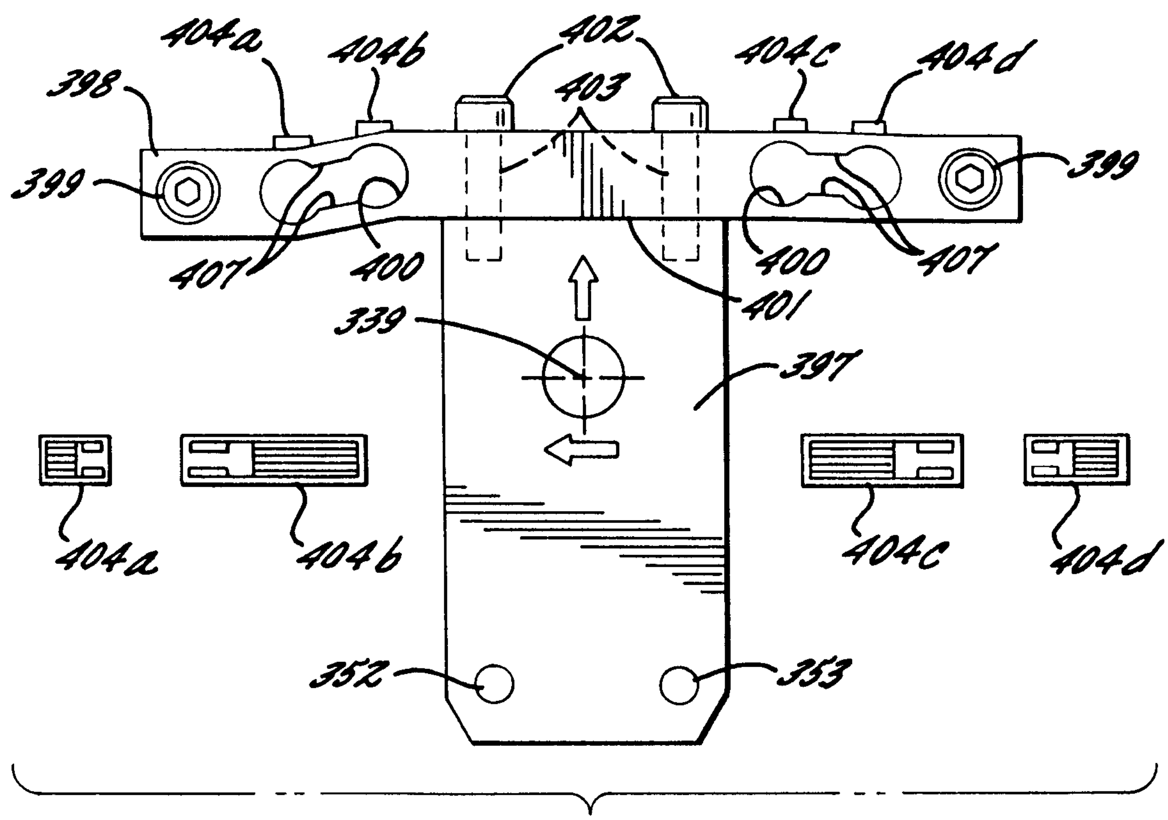
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Fig. 10.

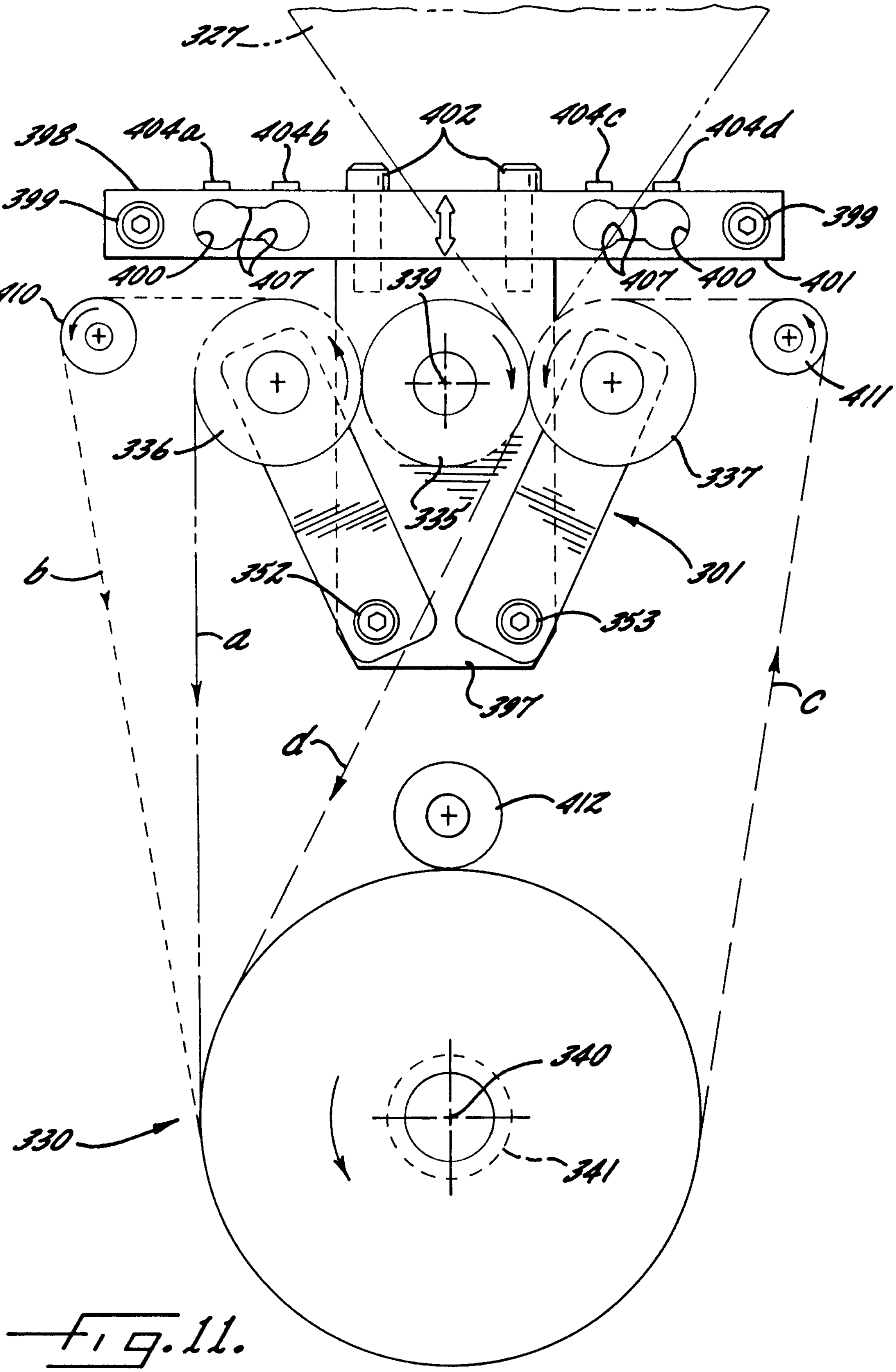
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Fig.11.

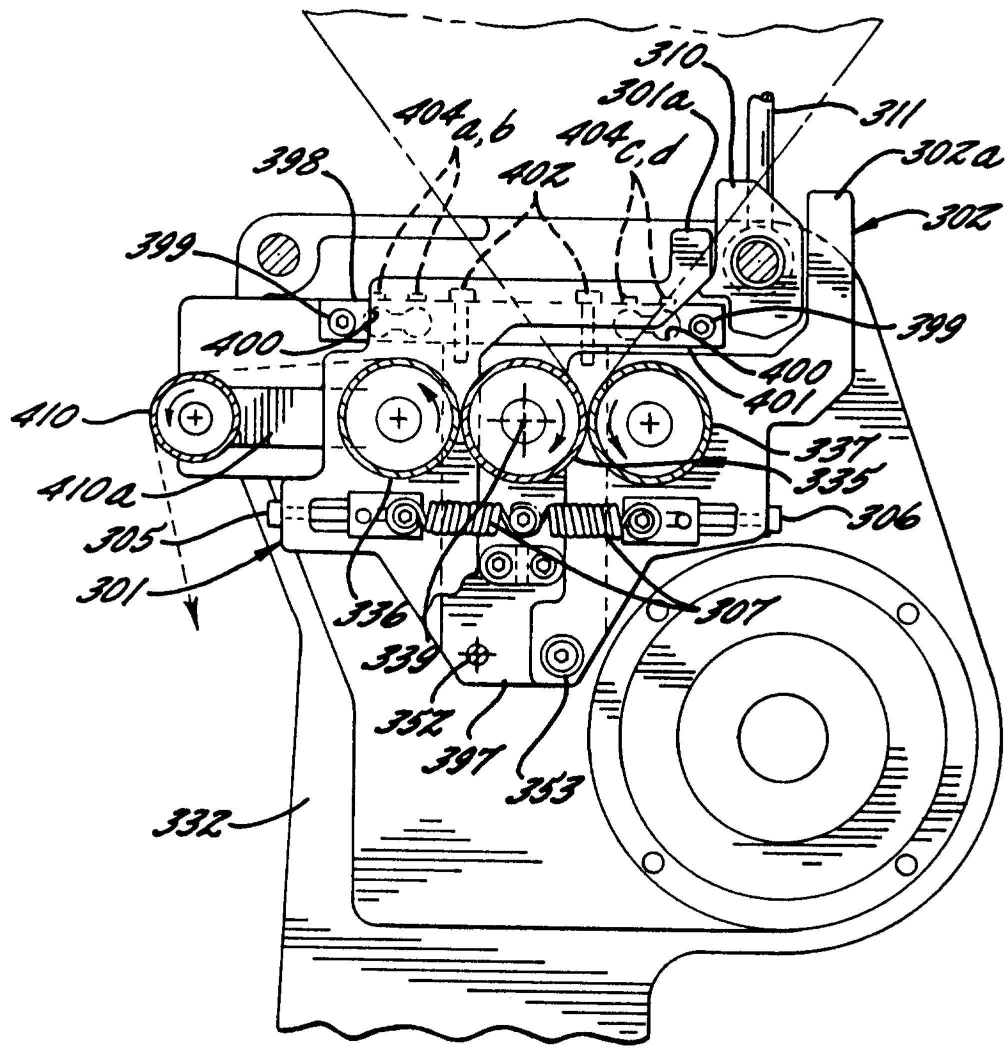
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Fig. 12.

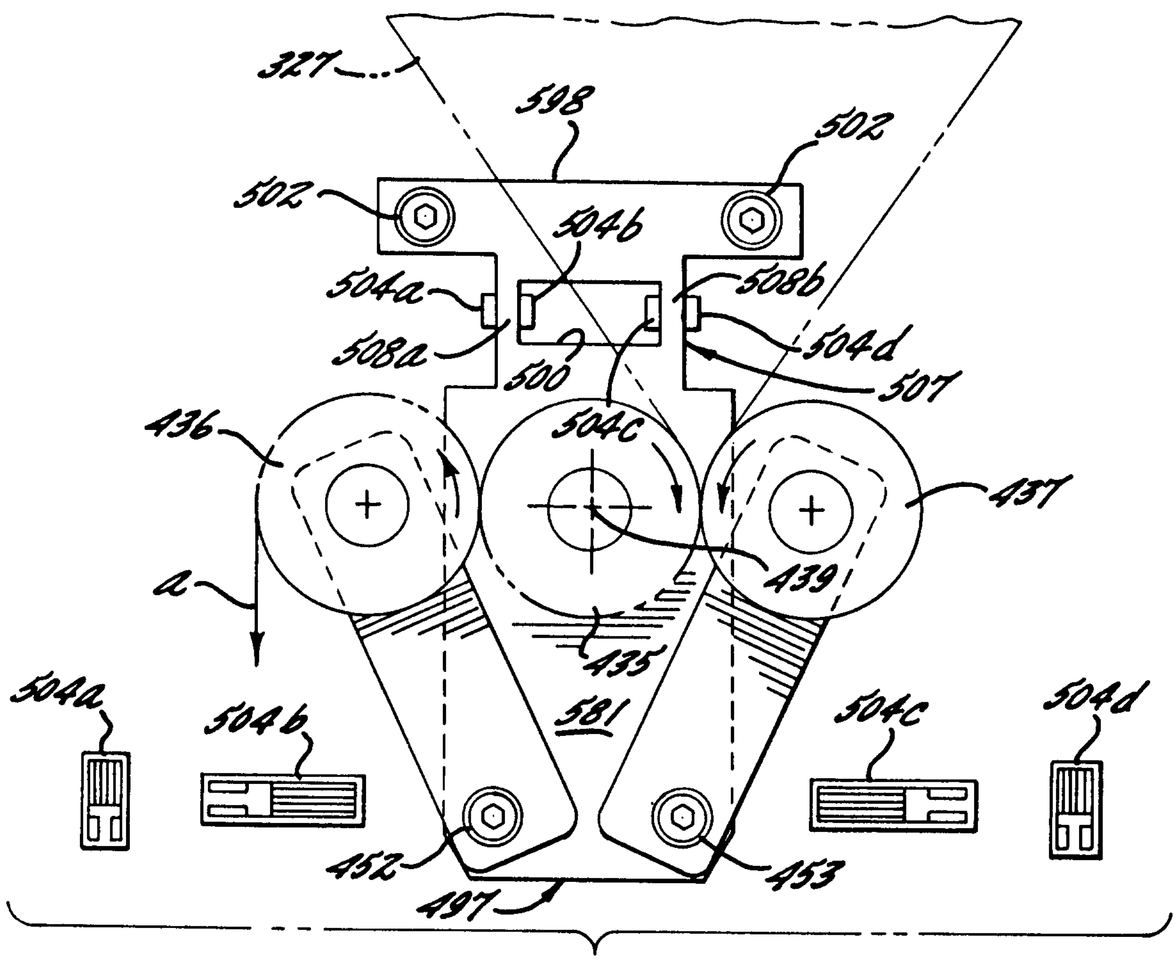
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Fig. 13.

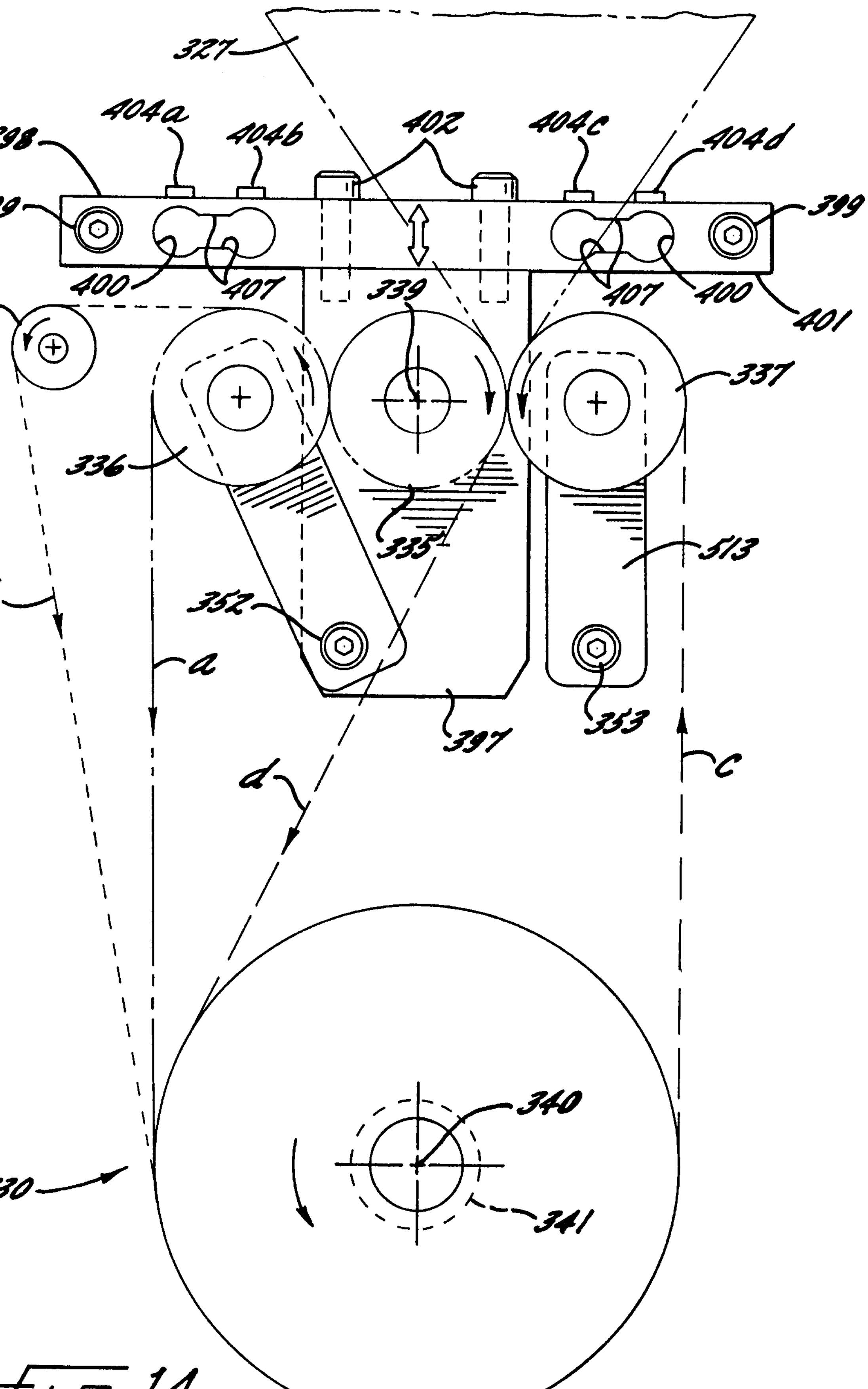
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Fig. 14.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 11 9684

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	EP-A-0 148 727 (BATTELLE MEMORIAL INSTITUTE)	1-5,14, 20-23, 29-35, 40,41	D04B15/88
	* page 3, line 9 - page 5, line 30; figures 1-5 *		
A		7,11,26	
A	US-A-3 031 152 (COHEN ET AL)	1,3,6-9, 12,13	
	* column 2, line 65 - column 5, line 46; figures 1-6 *		
D,A	US-A-4 671 083 (SAWAZAKI ET AL)		
A	EP-A-0 237 493 (E.M.M.)		
A	US-A-3 842 627 (BASSIST)		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

D04B
B65H
D03D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 July 1994	Van Gelder, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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