US 20050230449A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2005/0230449 A1

Meyer et al. (43) Pub. Date: Oct. 20, 2005

(54) APPARATUS AND METHOD OF INCREASING WEB STORAGE IN A DANCER

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(21) Appl. No.: **11/110,616**

(22) Filed: **Apr. 20, 2005**

Related U.S. Application Data

(60) Provisional application No. 60/563,840, filed on Apr. 20, 2004.

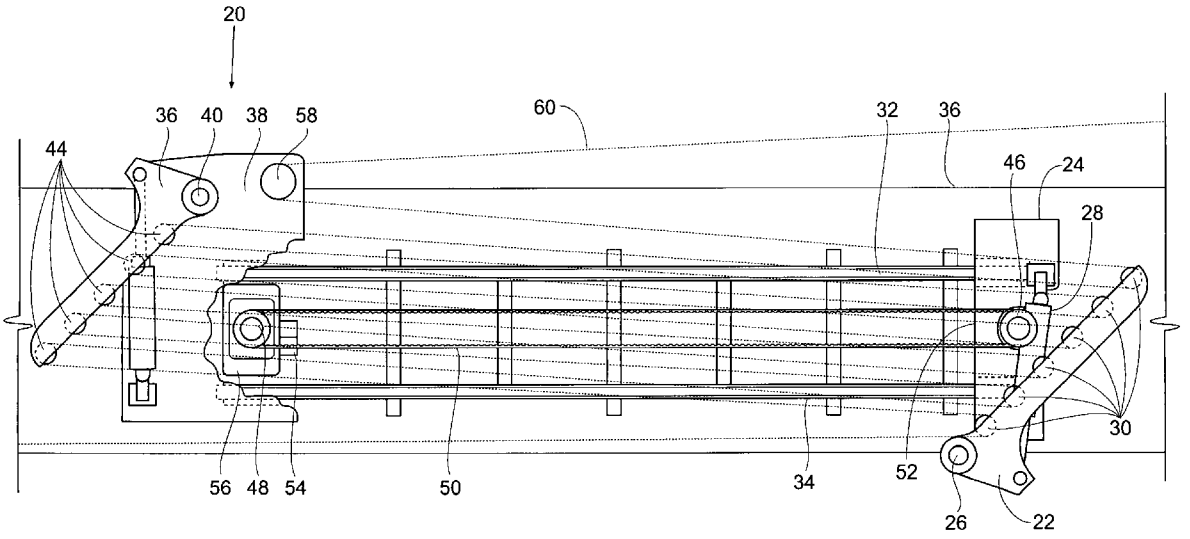
Publication Classification

(51) **Int. Cl.**[7] **B65H 20/34**

(52) **U.S. Cl.** **226/118.2**

(57) **ABSTRACT**

An improved web accumulator with two arms where at least one arm is a swinging dancer arm and at least one arm is attached to a sliding carriage. Each arm has a set of rollers attached. A web is threaded alternately between the two sets of rollers. The arms are mechanically connected to move simultaneously towards or away from each other. The arms are initially position at their maximum separation to accumulate a maximum length of web. When web infeed is interrupted while web outfeed or draw persists, the arms are first rotated in towards each other to pay out the stored length of web. As the demand persists and the dancer arm is rotated beyond some predefined position, the sliding carriage begins to slide to a least storage position. As web infeed returns to normal operational speeds, the dancer arm and the sliding carriage are returned to their original position to again accumulate a maximum amount of web.



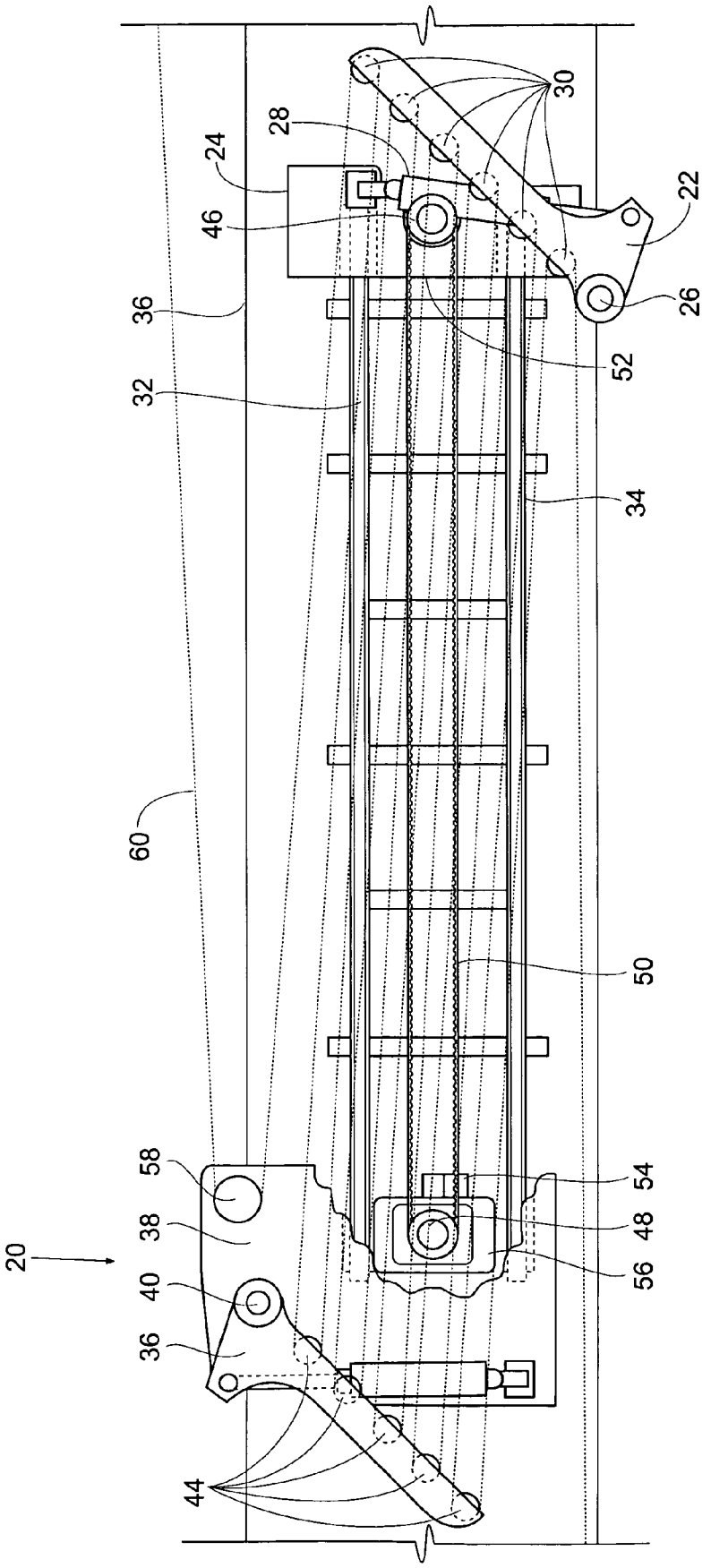


Fig. 1

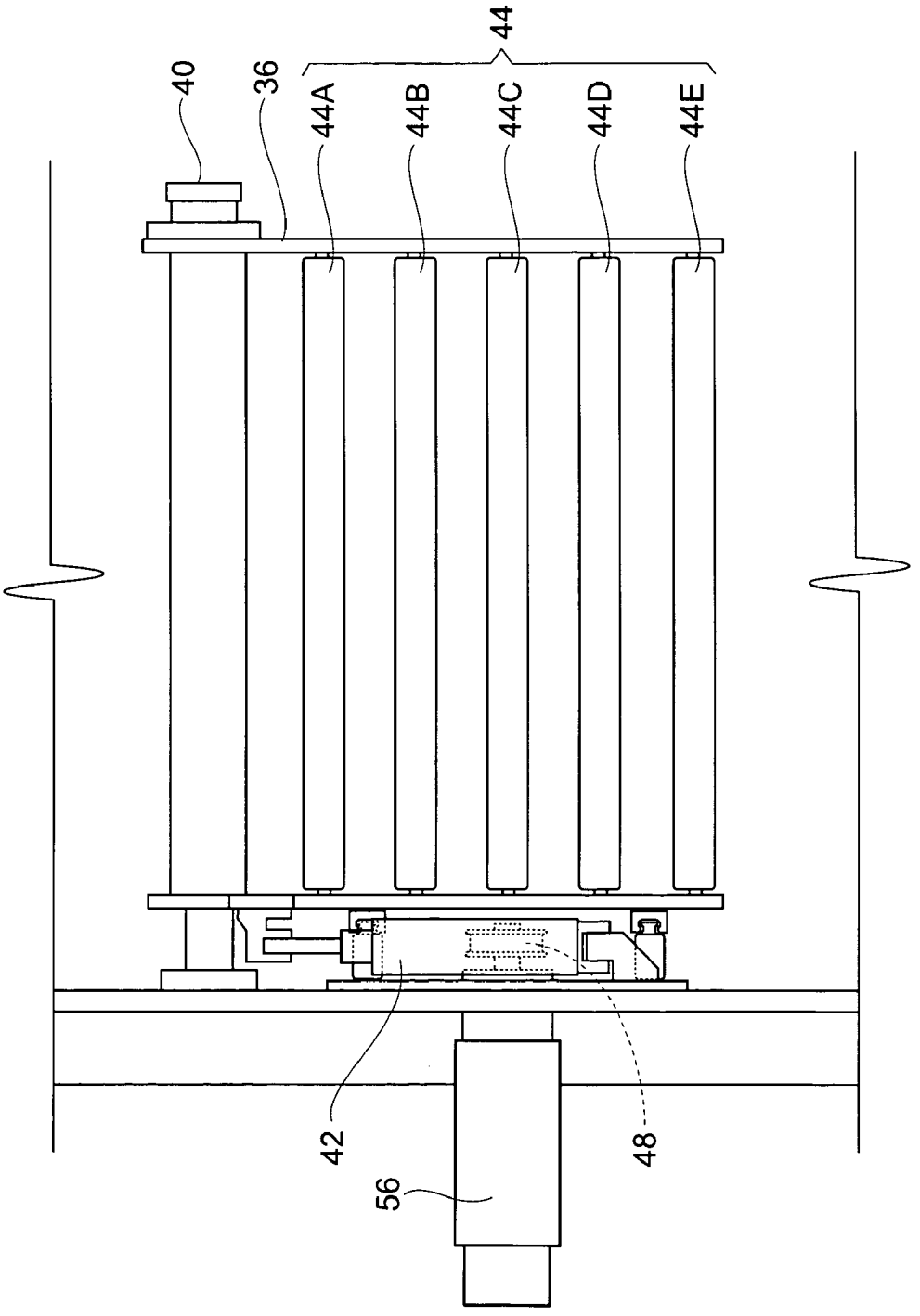
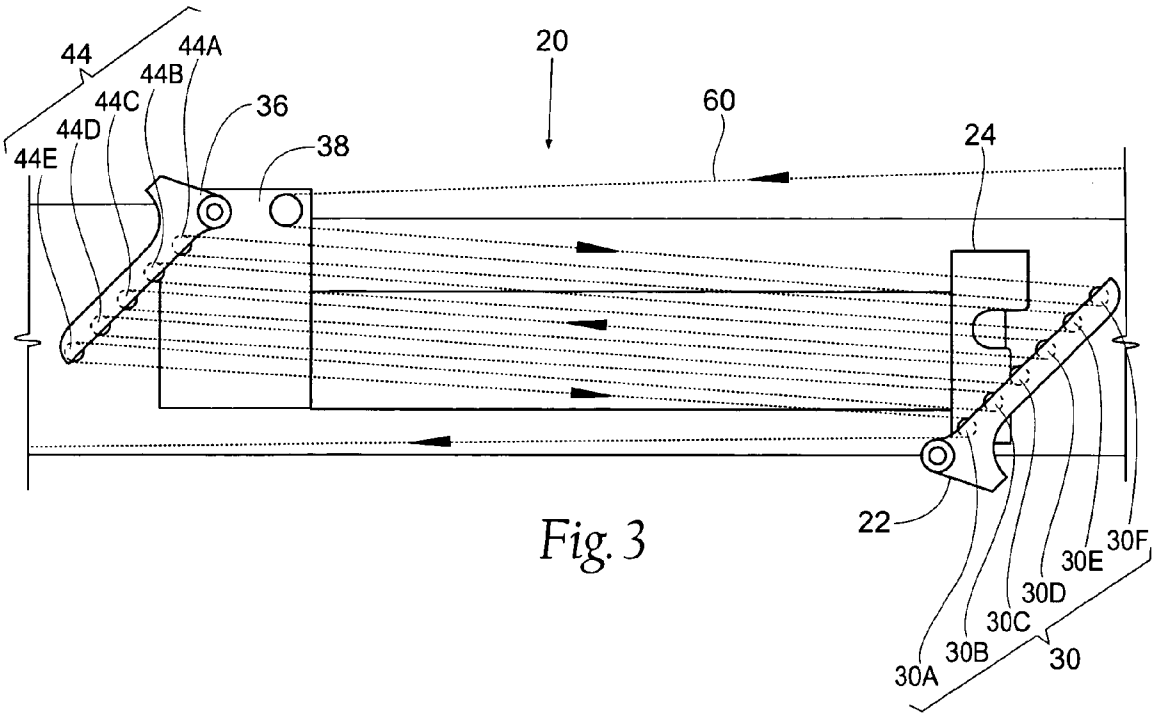


Fig. 2


44
44A
44B
44C
44D
44E
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38
20
60
24
22
30F
30E
30D
30C
30B
30A
30

Fig. 3

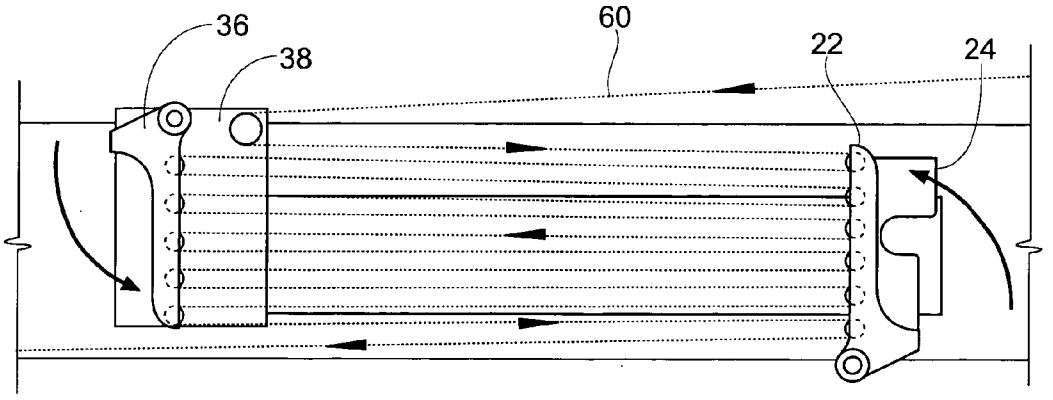

36
38
60
22
24

Fig. 4

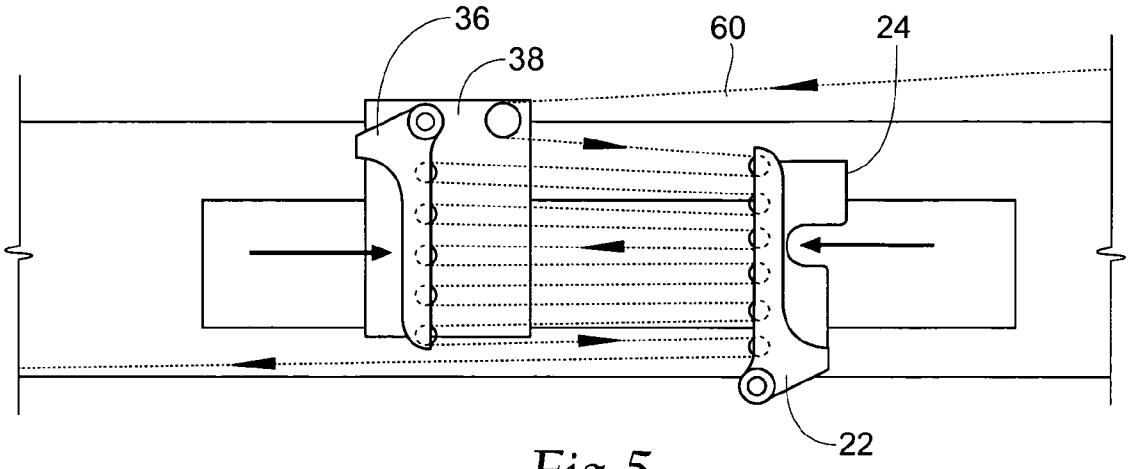


Fig. 5

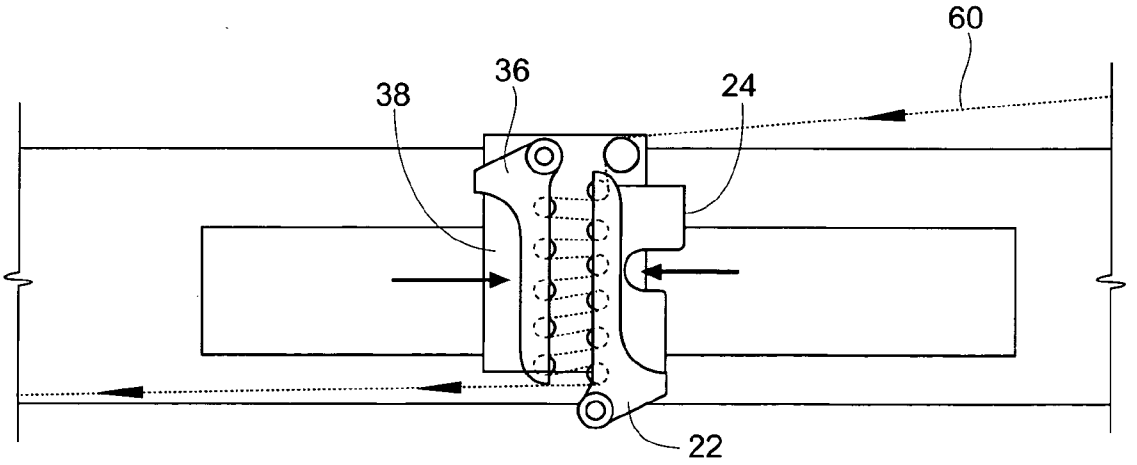
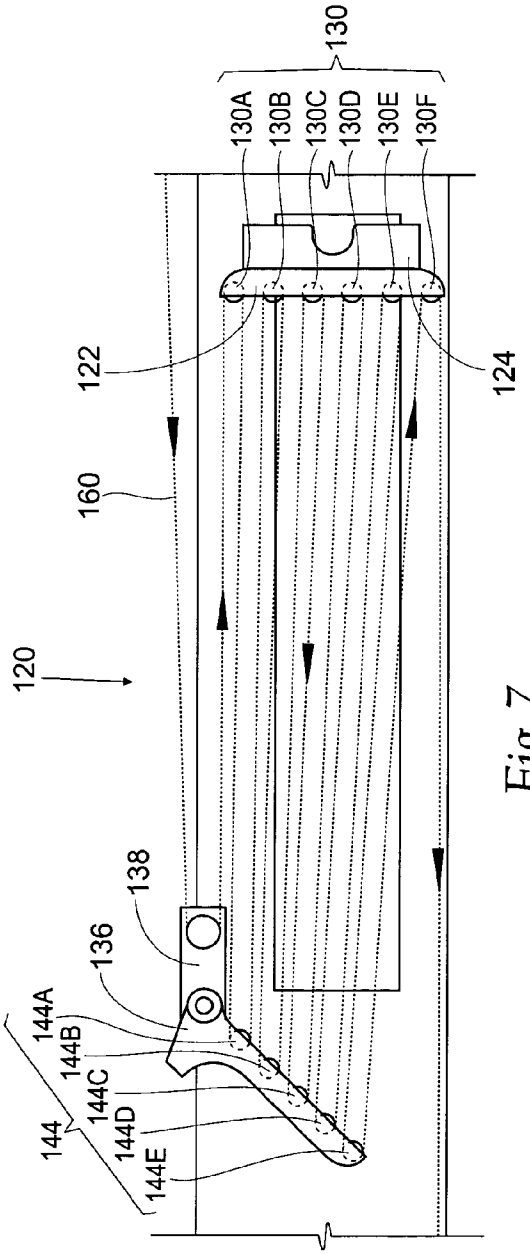


Fig. 6


130
130A
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144B
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144D
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144

Fig. 7

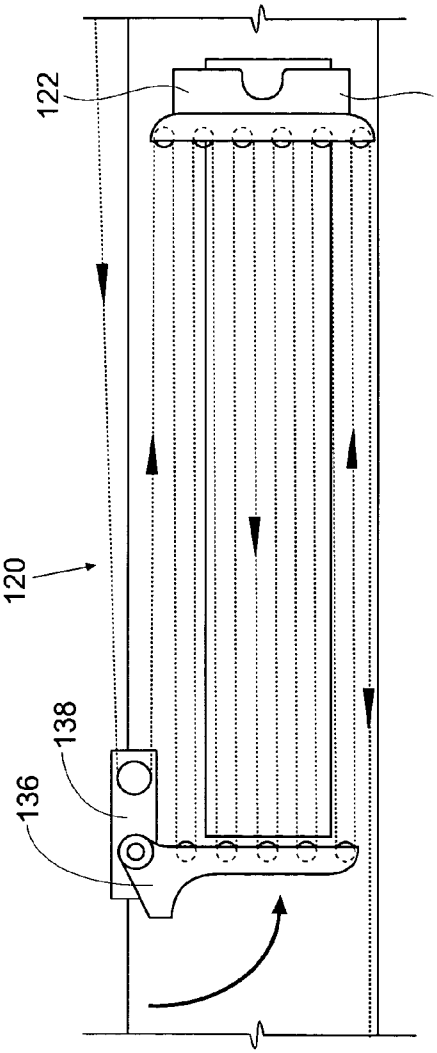
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Fig. 8

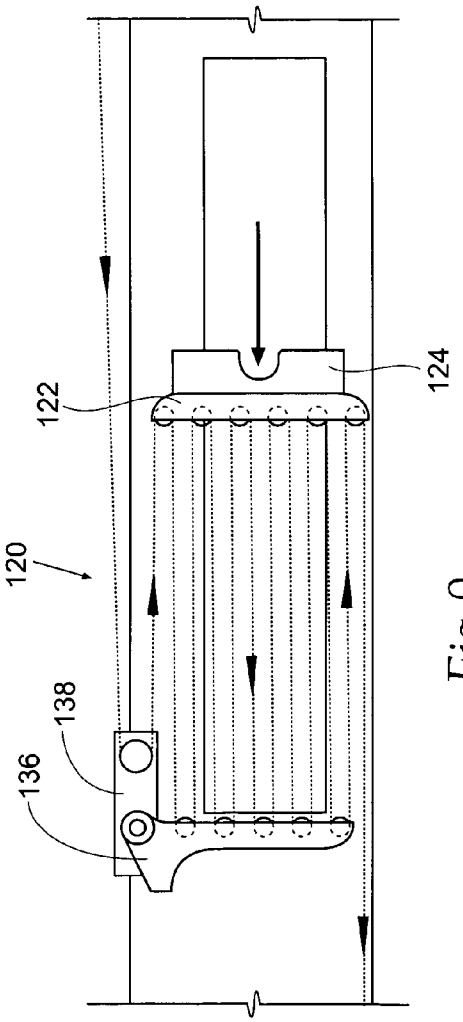

Fig. 9

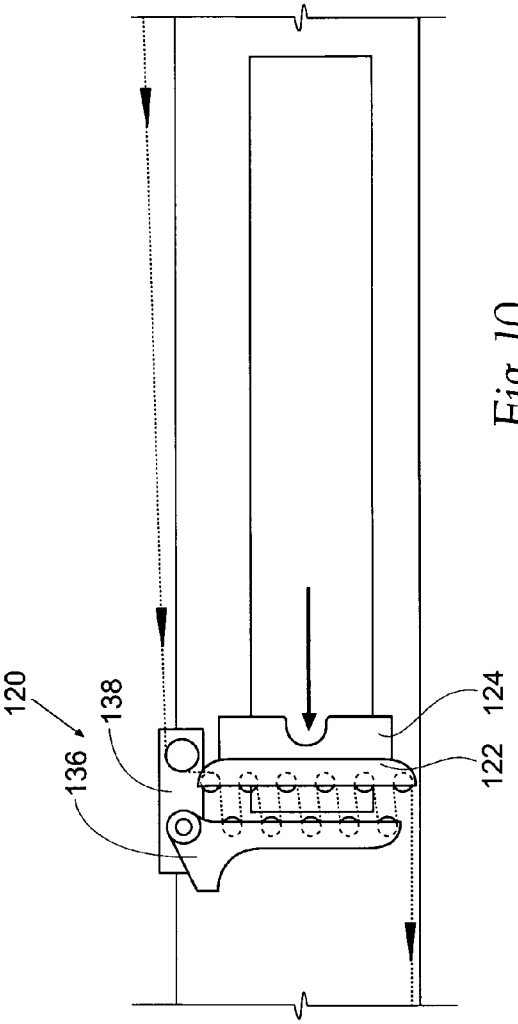

Fig. 10

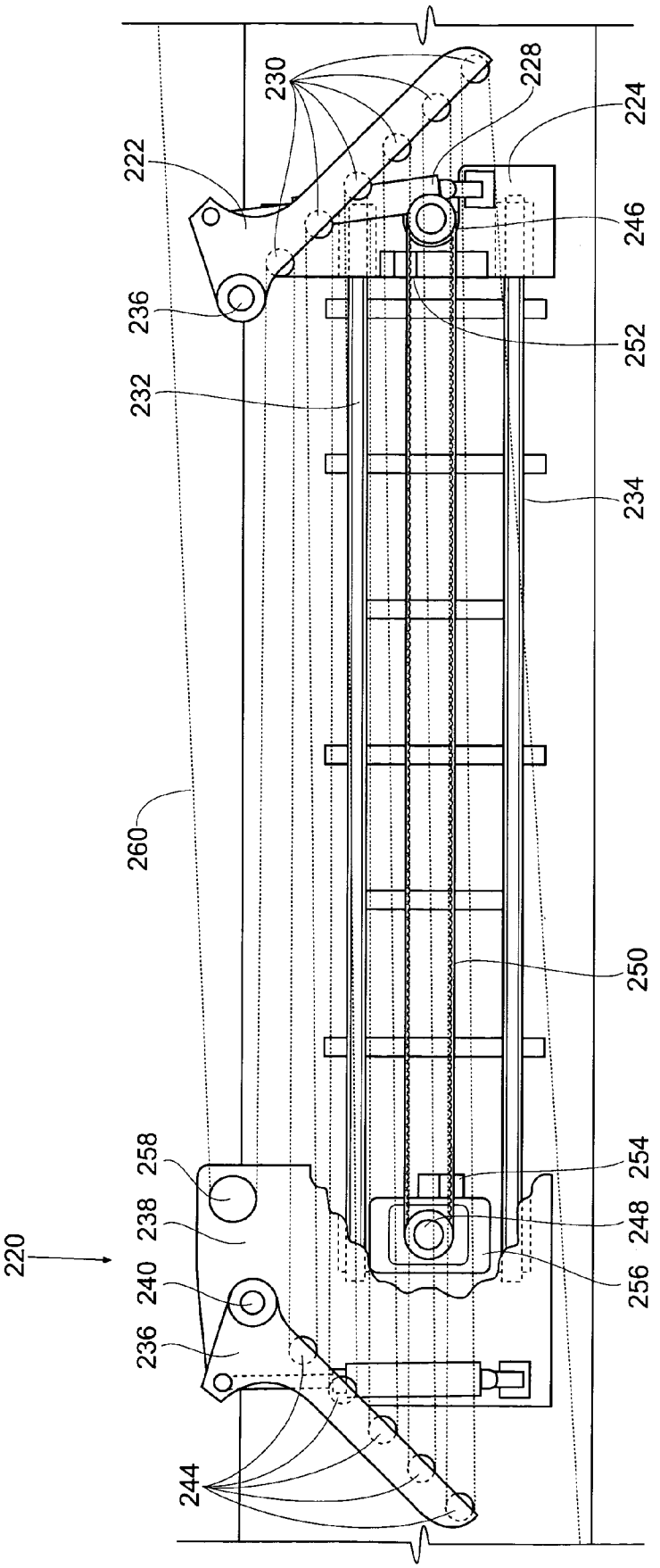
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Fig. 11

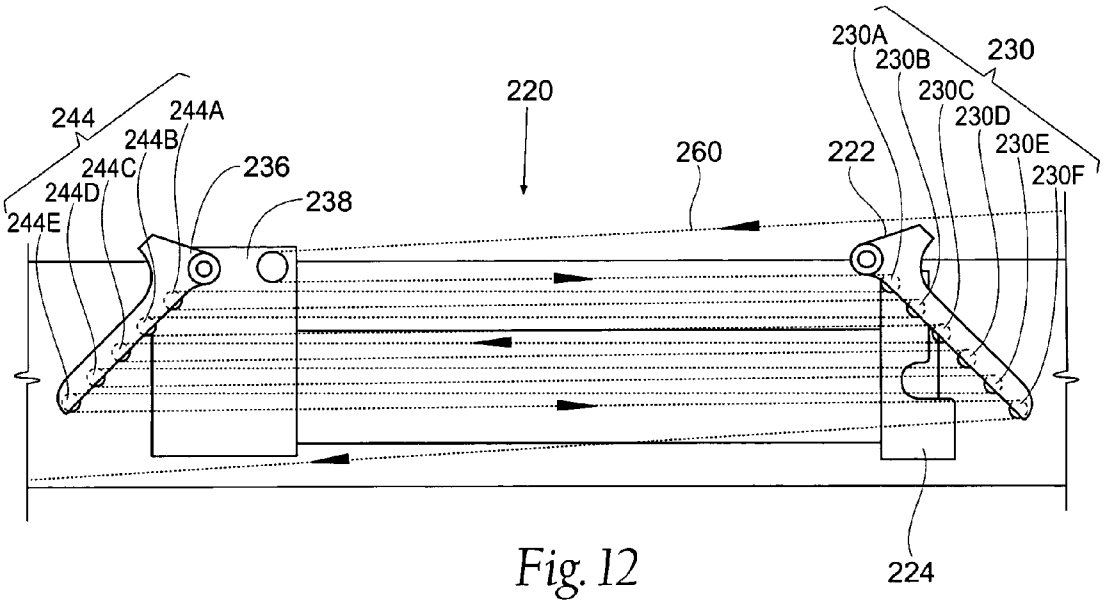
230A
230B
230
220
244
244A
244B
244C
244D
244E
236
238
260
222
230C
230D
230E
230F
224

Fig. 12

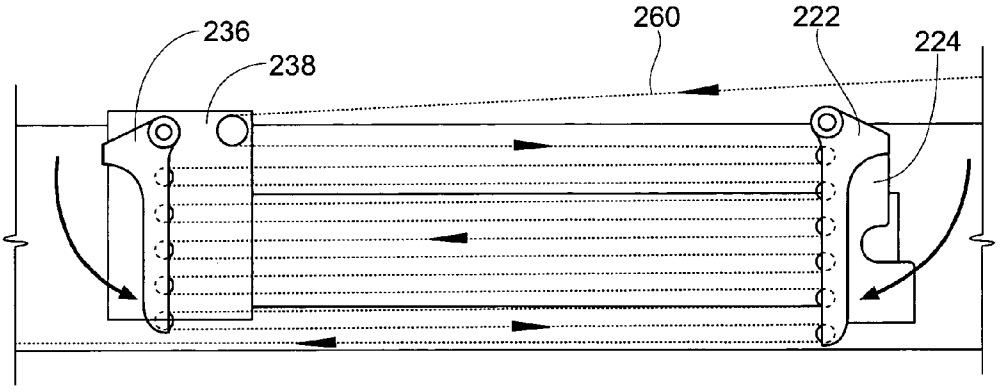
236
238
260
222
224

Fig. 13

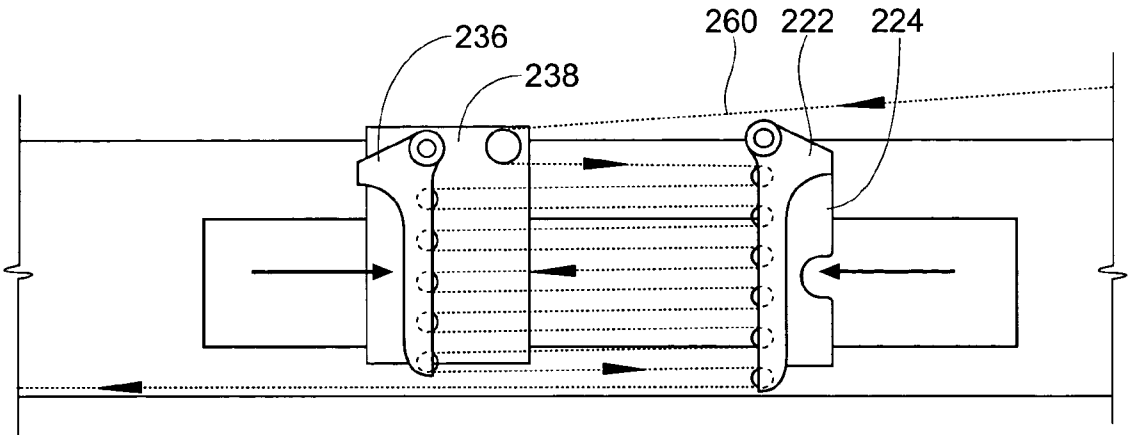

Fig. 14

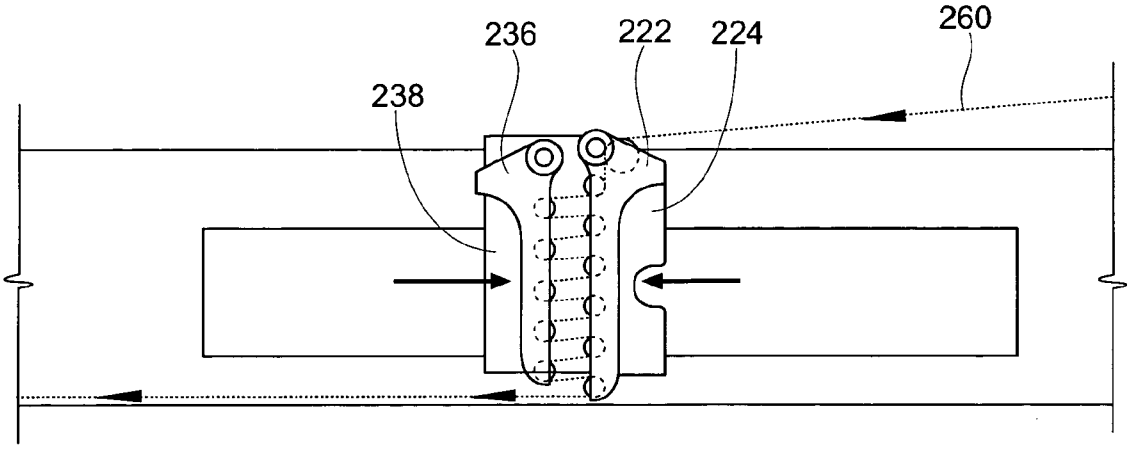

Fig. 15

APPARATUS AND METHOD OF INCREASING WEB STORAGE IN A DANCER

RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application Ser. No. 60/563,840, filed 20 Apr. 2004, and entitled "Method of Increasing Web Storage in a Dancer."

BACKGROUND OF THE INVENTION

[0002] The invention disclosed herein relates to a method for increasing the amount of web storage available from a web accumulation dancer system. The invention pertains to an accumulator for accumulating a substantial length of a running web such that if the infeed to the accumulator is stopped or slowed for a short interval the web in storage is paid out continuously to a web-utilizing device so that the device has a constant web supply and thus need not be slowed or stopped. Increased storage is an imperative for successful operation of zero speed splicing at very high machine speeds.

[0003] A common use of a web accumulator is where a web is fed from a primary supply wheel and it is necessary to splice the leading edge of the web from a standby supply wheel to the trailing edge of the web from the primary supply wheel in a manner that will not cause interruption of the web supply to a web consuming or utilizing device.

[0004] In one known type of accumulator, the swinging dancer arm type, there is a set of spaced apart rollers on a swingable dancer arm cooperating with another set of rollers on an arm that may be stationary or swingable. A web is looped back and forth between the sets of rollers on opposed arms in a serpentine fashion. When the swingable arm is swung away from the other arm a substantial length of web is accumulated. During normal running of the web the arms will be urged to their maximum practical separation from each other to accumulate the maximum length of web. If the infeed web is slowed or stopped for a short time the tension in the web urges the arms to the minimum separation position in order to make the accumulated web available to the machine. After infeed to the accumulator is resumed the arms separate again and return to their original position to accumulate and store another length of web.

[0005] In another known type of accumulator, the linear sliding carriage type, there is a set of rollers mounted on a movable carriage which can run linearly toward or away from a set of corresponding rollers which may either be stationary or similarly slidably mounted. During normal operation of the accumulator, the two sets of rollers will be slid to their maximum practical separation to accumulate the maximum amount of web. If the infeed supply to the web accumulator is slowed or stopped, the rollers will be slid toward each other to allow the stored web to be paid out. As the web infeed is returned to regular operational speed the movable rollers slide back toward the original position to accumulate another length of web.

[0006] It is well known in the art that the swinging arm dancer type of web accumulator first discussed is efficient in that the friction losses to the web are low. However, the dancer type of accumulator does not store a sufficient length of web. Alternatively, the linear sliding carriage type of accumulator allows more web to be accumulated; however, more frictional losses occur.

[0007] The consequences of friction and inertia may be appreciated when it is realized that the web may be running at a very high speed when suddenly, for some reason, such as when making a splice, the infeeding web is stopped or decelerated. This change in web motion will result in a reaction by the components of the accumulator. Most notable of these reactions is the motion imparted to the movable assembly of the accumulator. After the web is slowed or stopped, the web at the infeed can only accelerate as fast as the rollers can accelerate. The force to accelerate the rollers is provided by tension in the web. Minimizing the number of rollers and minimizing the inertia of each roller minimizes the necessary web tension.

[0008] Minimization and control of the inertia and friction associated with this reaction is therefore an important desired attribute of such accumulators. There is an important need for a web accumulator which provides the benefits of low friction and minimized inertia, allowing it to handle the most delicate of webs at high speeds without breakage or loss of control.

[0009] The invention disclosed herein combines a swinging arm dancer with a linear slide. Thus the invention disclosed herein has the advantage of web storage capability substantially equal to that of a linear accumulation system but with minimized frictional losses.

SUMMARY OF THE INVENTION

[0010] The new arrangement combines the best features of both previously known accumulators to gain the advantages of both systems while eliminating the disadvantages of each. The new web accumulator achieves a large amount of web storage for the amount of rollers it utilizes.

[0011] In general terms, the preferred new web accumulator includes arms, each arm has a set of rollers attached. A web is threaded alternately between the two sets of rollers. The arms are mechanically connected to move simultaneously towards or away from each other. The arms are initially position at their maximum separation to accumulate a maximum length of web. When web infeed is interrupted while web outfeed or draw persists, the arms are first rotated in towards each other to pay out the stored length of web. As the demand persists and the dancer arm is rotated beyond some predefined position, the sliding carriage begins to slide to a least storage position. As web infeed returns to normal operational speeds, the dancer arm and the sliding carriage are returned to their original position to again accumulate a maximum amount of web.

[0012] There are several possible variations to this system, such as vertical or horizontal orientation, one or more swinging dancer arms, and either the dancer arm or the linear arm can be sliding.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a front elevational view of the preferred embodiment of the web accumulator.

[0014] **FIG. 2** is a side elevational view of the accumulator of **FIG. 1**.

[0015] **FIG. 3** is a simplified front elevational view of the preferred embodiment of the accumulator of the present

invention with its roller carrying arms in the position in which the maximum length of web is accumulated.

[0016] **FIG. 4** is a similar to **FIG. 3** except that the dancer arms of the accumulator are rotating toward each other as would be the case when infeed of the web is stopped and the length of web that is stored in the accumulator is being paid out.

[0017] **FIG. 5** is similar to **FIG. 4** except that the dancer arms of the accumulator have begun to slide toward each other to further pay out the stored web material.

[0018] **FIG. 6** is similar to **FIG. 5** except that the dancer arms of the accumulator have slid to the least storage position.

[0019] **FIG. 7** is a simplified front elevational view of an alternate embodiment of the accumulator of the present invention with its roller carrying arms in the position in which the maximum length of web is accumulated.

[0020] **FIG. 8** is similar to **FIG. 7** except that the swinging dancer arm of the accumulator is rotating toward the non-rotating linear arm as would be the case when infeed of the web is stopped and the length of web which is stored in the accumulator is being paid out.

[0021] **FIG. 9** is similar to **FIG. 8** except that the nonrotating linear arm has begun to slide toward the rotating arm to further pay out the stored web material.

[0022] **FIG. 10** is similar to **FIG. 9** except that the arms of the accumulator are in the least storage position.

[0023] **FIG. 11** is a front elevational view of an alternate embodiment of the web accumulator.

[0024] **FIG. 12** is simplified front elevational view of the accumulator of **FIG. 11** with its roller carrying dancer arms in the position in which the maximum length of web is accumulated.

[0025] **FIG. 13** is a similar to **FIG. 12** except that the dancer arms of the accumulator are rotating toward each other as would be the case when infeed of the web is stopped and the length of web that is stored in the accumulator is being paid out.

[0026] **FIG. 14** is similar to **FIG. 13** except that the dancer arms of the accumulator have begun to slide toward each other to further pay out the stored web material.

[0027] **FIG. 15** is similar to **FIG. 14** except that the dancer arms of the accumulator have slid to the least storage position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0028] Although the disclosure hereof is detailed and exact to enable those skilled in the art to practice the invention, the physical embodiments herein disclosed merely exemplify the invention which may be embodied in other specific structure. While the preferred embodiment has been described, the details may be changed without departing from the invention.

[0029] **FIG. 1** illustrates the preferred embodiment of the new web accumulator **20**. The accumulator **20** consists of a first swinging dancer arm **22** rotatably mounted to a first carriage **24**. First dancer arm **22** rotates about axle shaft **26**. A first pneumatic actuator **28** is attached to both first carriage **24** and first dancer arm **22** such that the actuator **28** will function to rotate the dancer arm **22** about axle shaft **26**. Dancer arm **22** supports a first set of web accumulator rollers **30** which are individually numbered **30**A-**30**F, inclusive (see, e.g., **FIG. 3**.) The web accumulation rollers **30**A-**30**F, inclusive, are rotatably mounted on the dancer arm **22**. The carriage **24** is slidably mounted on an upper track **32** and a lower track **34**.

[0030] On the opposite end of the tracks **32** and **34** is a second swinging dancer arm **36** which is preferably identical to first swinging dancer arm **22**, but rotated 180 degrees from the first swinging dancer arm **22**. Second dancer arm **36** is rotatably mounted to a second carriage **38** for rotation about second axle shaft **40**. A second pneumatic actuator is attached to the second dancer arm **36** and the second carriage **38** to facilitate rotation of the second dancer arm **36** about the second axle shaft **40**. The second carriage **38** is slidably mounted to the upper track **32** and the lower track **34**. A second set of web accumulator rollers **44** which are individually numbered as **44**A-**44**E (see **FIG. 2**), inclusive are rotatably mounted on the second dancer arm **36**.

[0031] The drive system includes two idler arms **46** and **48** with flexible mechanical linkage **50**. In the preferred embodiment of this invention, the flexible mechanical linkage is a toothed belt. Slidable carriages **24** and **38** are affixed to the belt such that they will not move independently of each other and can only move simultaneously in opposite directions. Carriages **24** and **38** are attached to the toothed belt by clamps **52** and **54**, respectively. The drive system is driven by servomotor **56**.

[0032] It will be noted that in the illustrated embodiment the roller set **30** includes six (6) individual rollers and the roller set **44** includes five (5) rollers. This number can be varied using either a lesser or greater number of rollers as selected for a particular application. However, it will be obvious to one of skill in the art that in order to loop the web between the arms and practice the invention as described herein, the first roller set **30** should include at least two individual rollers and the second roller set **44** should include at least one individual roller. The sets of rollers **30** and **44** are common in the art and therefore are of known configuration.

[0033] In **FIG. 1** the accumulator **20** is in its maximum storage position as would be the case when the web **60** is being drawn out of the accumulator **20** and is being fed into the accumulator **20** at the same rate. The dancer arms **22** and **36** are swung apart as far as is practical to store the maximum amount of web **60** in the form of loops running back and forth between the dancer arms **22** and **36**.

[0034] The web **60** is fed into the web accumulator **20**. The web **60** first passes around an idler roll assembly **58** which is mounted on the second carriage **38**. The web **60** then passes around the first roller **30**A of roller set **30** mounted on first dancer arm **22** and next around the first roller **44**A of the roller set **44** mounted on second dancer arm **36**. The web **60** continues to alternate between the consecutive rollers of roller set **30** and roller set **44** until the web **60** has passed over all the rollers. The web **60** then exits the accumulator **20** and is fed to a web utilization device (not shown).

[0035] **FIG. 2** is a side elevation view of the accumulator **20** of **FIG. 1**. This view shows how the individual rollers

44A-44E of roller set **44** are rotationally mounted to dancer arm **36**. This view also shows how the dancer arm **36** is attached to the second axle shaft **40** and to the second actuator **42**. Servomotor **56** is shown with idler arm **48** shown in phantom lines.

[**0036**] Referring now to **FIGS. 3, 4, 5**, and **6**, the dancer arms **22** and **36** are shown rotating and driven towards each other to pay out accumulated web **60** to the outfeed when infeed of web **60** is stopped for a short interval. **FIG. 3** shows the web accumulator **20** in the maximum storage position. **FIG. 4** shows the dancer arms **22** and **26** as they are swinging towards each other. The dancer arms **22** and **36** swing towards each other until some specified point when, as shown in **FIG. 5**, the carriages **24** and **38** on which the dancer arms **22** and **36** are mounted begin to slide toward each other to further continue pay out. **FIG. 6** shows the web accumulator **20** in its least storage position, which is the position at which the dancer arms **22** and **26** are the closest.

[**0037**] More specifically, the control of the sliding carriages **24** and **38** is dependent on the displacement of the dancer arms **22** and **36**. As the web infeed is slowed or stopped, the tension due to drawing the web **60** from the outfeed end of the web accumulator **20** causes the dancer arms **22** and **36** to move towards the less storage position while the length of web **60** in storage is paid out. The web tension causes the dancer arms **22** and **36** to begin to move. However, the actuators **28** and **42** help drive the swinging dancer arms **22** and **36** to overcome the inertia and friction losses of the roller sets **30** and **44** and dancer arms **22** and **36**. If the dancer arms **22** and **36** and roller sets **30** and **44** had no inertia or frictional losses, the force applied to the dancer arms **22** and **36** by the web tension forces would be sufficient to rotate the dancer arms **22** and **36** to the appropriate positions to pay out the stored web. However, because friction and inertia are a factor, the actuators **28** and **42** must drive the rotating dancer arms **22** and **36** to overcome the losses from friction and inertia.

[**0038**] When the dancer arms **22** and **36** reach some predetermined position, the carriage slide drive **56** is commanded to move the carriages **24** and **38** towards each other. Under normal circumstances the carriages **24** and **38** maintain their preset position. In this manner nominal changes in dancer arm **22** and **36** positions are ignored.

[**0039**] As discussed above, the carriages **24** and **38** are mechanically coupled to each other through the drive belt **50** such that they move away from or towards each other synchronously. The velocity of the carriages **24** and **38** is proportional to the rate of displacement of the dancer arms **22** and **36**. This allows the system to pay out web **60** such that the web utilizing device is not slowed or stopped. The servomotor **56** is given the command to move the sliding carriages **24** and **38** to the least storage position at a velocity proportional to the displacement error of the dancer arm **22** and **36** position.

[**0040**] As the displacement error is nullified, the carriage slide drive **56** is slowed to a stop even if it has not reached its final commanded position. If the error goes negative, the carriage slide drive **56** is commanded to return the sliding carriages **24** and **38** to the preset position at a velocity proportional to the dancer arm **22** and **36** error.

[**0041**] **FIGS. 7, 8, 9**, and **10** depict the operation of an alternate embodiment of the web accumulator of the present invention. The alternate embodiment shown in **FIG. 7** consists of a first linear arm **122** with a set of rollers **130** rotatably mounted thereon. The linear arm **122** is nonrotatably attached to a carriage **124**. The carriage **124** is slidably mounted on a set of tracks (not shown). The carriage **124** is mounted in a known fashion, as described regarding the preferred embodiment above. At the other side of the web accumulator **120** of **FIG. 7** is a swinging dancer arm **136** mounted to a plate **138**. The dancer arm **136** has a set of rollers **144** rotatably attached thereon.

[**0042**] **FIG. 7** shows this alternate embodiment of the accumulator **120** in its maximum web storage position. When the infeed to the accumulator stops or slows, the dancer arm **136** swings toward the linear arm as shown in **FIG. 8**. When the dancer arm **136** rotates past some predetermined point, the carriage **124** upon which linear arm **122** is mounted begins to slide toward dancer arm **136** as can be seen in **FIG. 9**. **FIG. 10** shows this alternate embodiment of the accumulator **120** in its least storage position.

[**0043**] Another alternate embodiment of the invention (not shown) has one swinging dancer arm and one linear arm, as described above in **FIG. 7**. However, in this embodiment the swinging dancer arm is slidably mounted on tracks while the linear arm is stationary. When the web infeed slows or stops, the web will pull the swinging dancer arm toward the stationary linear arm. At some predetermined point the dancer arm will be slid toward the stationary linear arm to pay out the remaining accumulated web.

[**0044**] **FIGS. 11-15** illustrate yet another alternate embodiment of the web accumulator **220** of the present invention. This embodiment is similar to the preferred embodiment of the invention, however in this embodiment the first swinging dancer arm **222** and the second swinging dancer arm **236** are mirror images of each other. As shown in **FIG. 11**, the web accumulator **220** consists of a first swinging dancer arm **222** rotatably mounted to a first carriage **224** and a second swinging dancer arm **236** rotatably mounted to a second carriage **238**. The first and second carriages **224,238** are slidably attached to an upper track **232** and a lower track **234**. The swinging dancer arms **222,236** and carriages **224,238** operate in the manner as described above regarding the preferred embodiment above.

[**0045**] **FIG. 12** shows this alternate embodiment of the web accumulator **220** in its maximum web storage position. When the infeed to the accumulator **220** slows or stops, the dancer arms **222,236** swing toward each other as shown in **FIG. 13**. When the dancer arms **222,236** rotate past some predetermined point, the first and second carriages **224,238** begin to slide towards each other as seen in **FIG. 14**. **FIG. 15** shows this alternate embodiment of the web accumulator **220** in its least storage position.

[**0046**] The embodiments described above, and depicted in the **FIGS. 1-15** disclose a web accumulator with a horizontal orientation. That is, the carriages slide on tracks in a horizontal direction. However, it is within the purview of the invention to utilize the web accumulator, as disclosed above, with a vertical orientation.

[**0047**] The foregoing is considered as illustrative only of the principles of the invention. Furthermore, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact

construction and operation shown and described. While the preferred embodiment has been described, the details may be changed without departing from the invention.

We claim:

1. A web accumulator for accumulating and paying out a portion of a continuous moving web passing through the accumulator comprising:

a first rotating dancer arm carrying a first plurality of rollers for engaging a moving web;

a second dancer arm carrying a second plurality of rollers for engaging said web;

at least one of said arms being slidably mounted to a body;

a drive mechanism associated with said slidably mounted arm, wherein said slidably mounted arm can be driven in a first substantially linear direction toward the other arm, and a second substantially linear direction away from the other arm;

whereby the length of travel of the web can be varied by radial movement of the first rotating dancer arm and linear movement of at least one of the dancer arms.

2. A web accumulator according to claim 1, said first rotating dancer arm carried by a first carriage.

3. A web accumulator according to claim 2, said second dancer arm carried by a second carriage.

4. A web accumulator according to claim 3, said first and second carriages coupled to each other, wherein said both said first and second carriages are slidably mounted to a body.

5. A web accumulator according to claim 4, said first and second carriages coupled by a toothed belt, wherein movement of said belt cause movement of said first and second carriages.

6. In combination, a linear accumulator and a rotating arm dancer, wherein said rotating arm dancer and said linear accumulator operate in conjunction to first accumulate and second pay out a portion of a continuous moving web passing through the accumulator.

7. A web accumulator for accumulating and paying out a portion of a continuous moving web passing through the accumulator comprising:

a first rotating dancer arm carrying a first plurality of rollers for engaging a moving web;

a second rotating dancer arm carrying a second plurality of rollers for engaging said web;

at least one of said arms being slidably mounted to a body;

a drive mechanism associated with said slidably mounted arm, wherein said slidably mounted arm can be driven in a first substantially linear direction toward the other arm, and a second substantially linear direction away from the other arm;

whereby the length of travel of the web can be varied by linear movement of at least one of the dancer arms and radial movement of the first rotating dancer arm.

8. A web accumulator according to claim 7 wherein the second arm is identical to the first arm.

9. A web accumulator according to claim 8, said second arm rotated approximately 180 degrees from from said first arm when said arms are in a maximum storage position.

10. A web accumulator according to claim 7 wherein the second arm is a mirror image of the first arm and the arms are configured such that an angle of approximately 90 degrees is formed between the arms when the arms are in a maximum storage position.

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