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[54] **WARP TENSION CONTROL MECHANISM**

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[51] **Int. Cl.** **D03d 49/06,** D03d 49/08
[58] **Field of Search** .... 139/109, 110, 100, 103; 66/80 A

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[57] **ABSTRACT**

To maintain constant the tensions in warp yarns fed from a yarn beam of the negative let-off motion type of a loom, an improved warp tension control mechanism is herein proposed which consists of a brake unit adapted to exert a substantially constant braking torque on the yarn beam and a brake control unit which is responsive to variation in the tensions in the warp yarns being fed from the yarn beam and which is operative to lessen the braking torque on the yarn beam in response to an increase in the tensions in the warp yarns as caused by the stepwise reduction of the outside diameter of the roll of the yarns on the yarn beam and by any unforeseen operational conditions of the loom during weaving operation.

8 Claims, 3 Drawing Figures

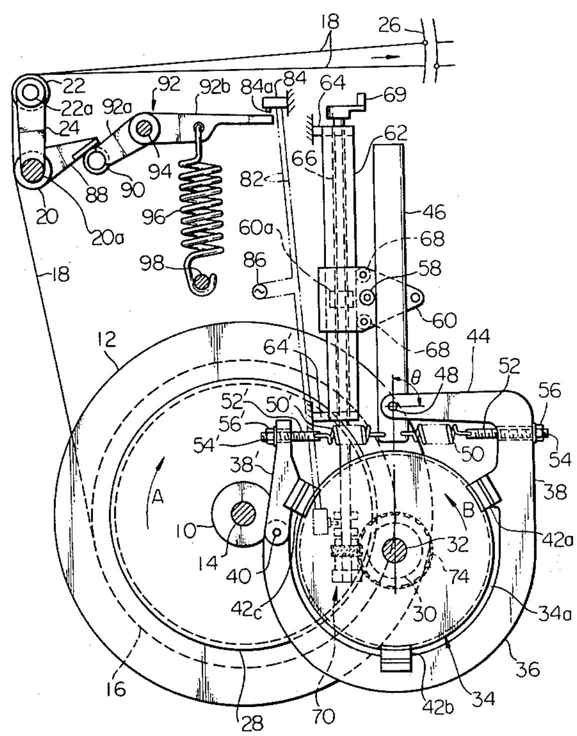

Fig. 1

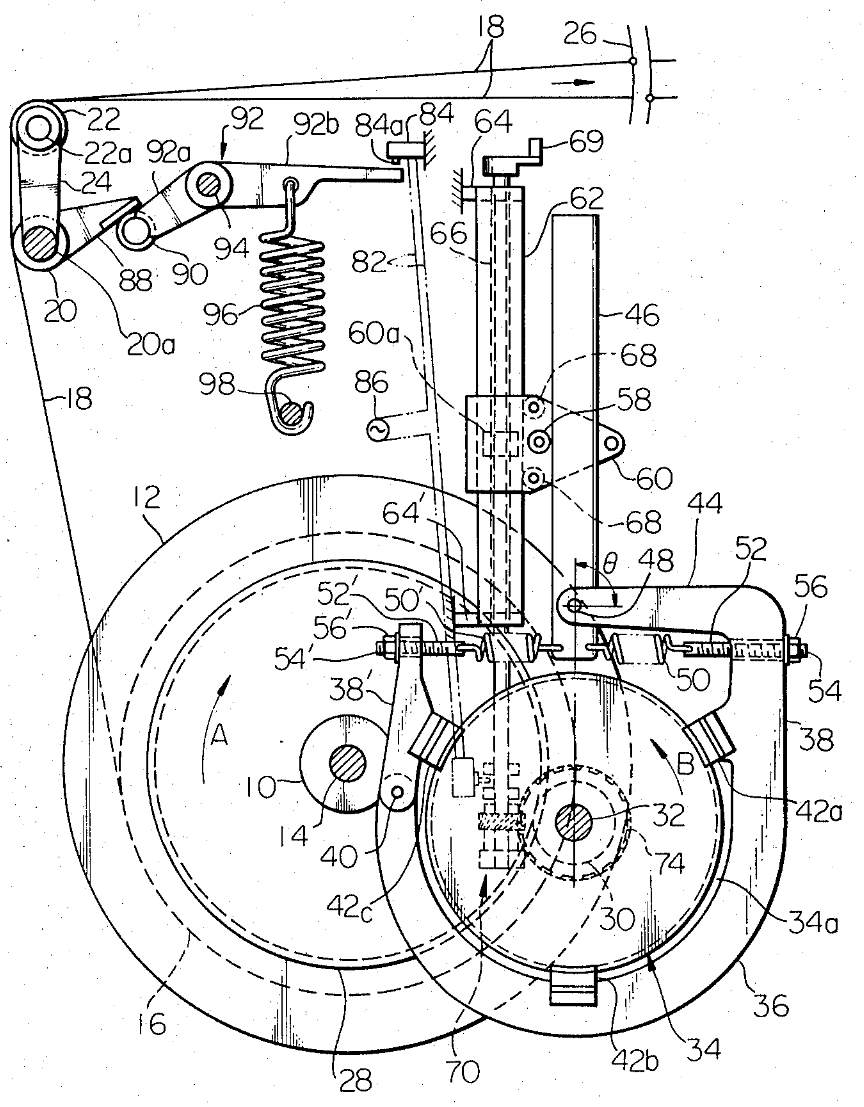
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Fig. 2

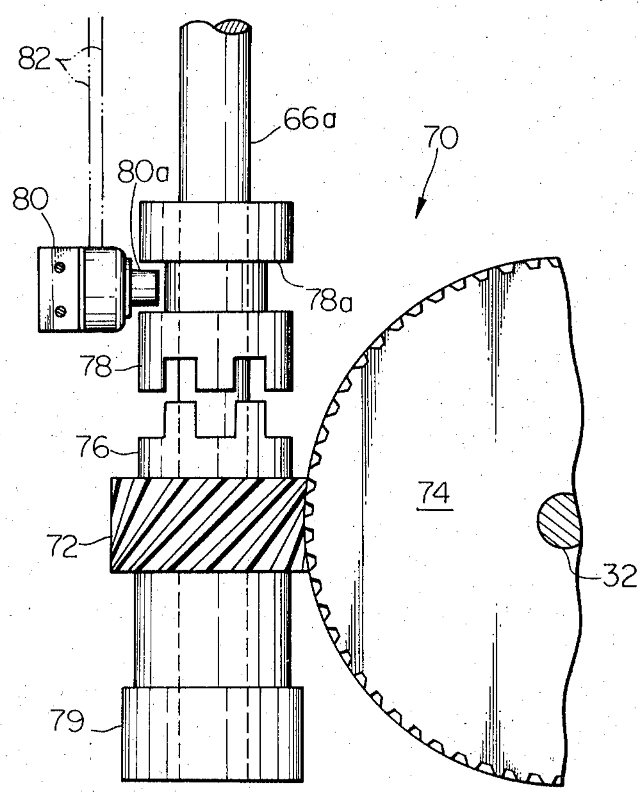

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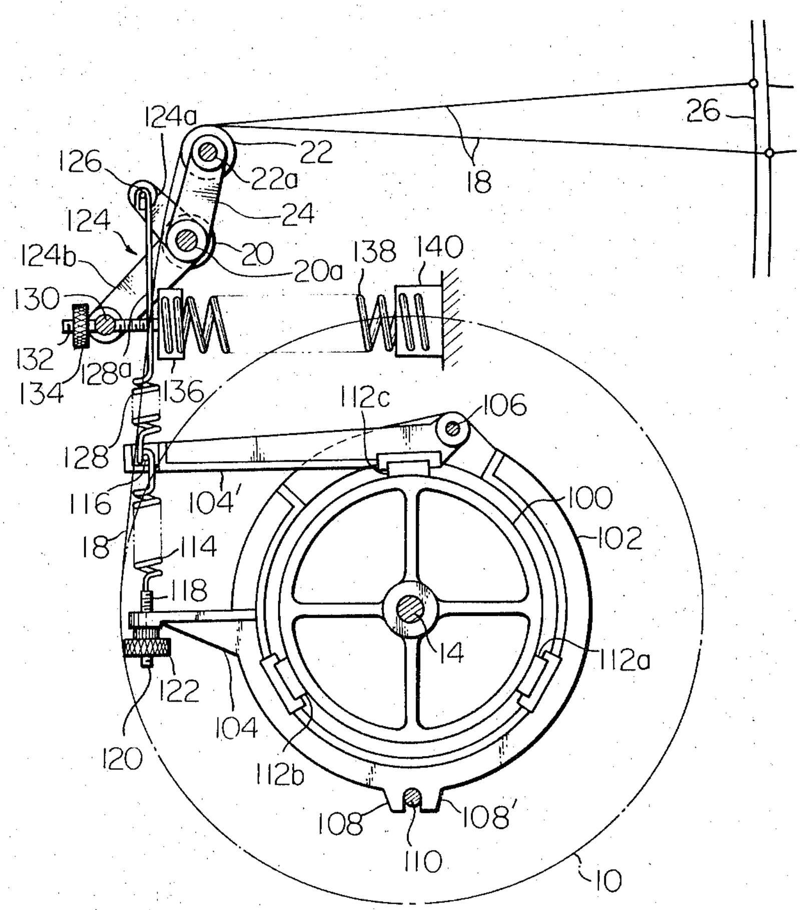
Fig. 3



WARP TENSION CONTROL MECHANISM

The present invention relates to looms and, more paritcularly, to a warp tension control mechanism for use in a loom of a specific character having a warp yarn supply means of the negative let-off motion type.

In the loom using the warp yarn supply means of the negative let-off motion type, warp yarns are continuously unwound and fed from a yarn supply package of a roll form by means of tensions in the warp yarns, viz., without aid of any positive drive means. The yarn supply package of the roll form is carried on a rotary structure which is usually called the yarn beam. The yarn beam has a shaft which is journaled on a stationary frame of the loom so as to be rotated about the shaft as the warp yarns carried thereon are unwound by a drawing effort which is imparted to the yarns from a weaving mechanism (usually including healds and reed as is well known in the art) of the loom. To provide positive control over the tensions in the yarns thus fed from the yarn beam, some looms are equipped with frictional braking units which are operatively associated with the yarn beams through the shafts of the yarn beams or through shafts which are driven for rotation from the shafts of the yarn beams. Typical of the braking units of this nature is such that the braking unit is selectively coupled to and uncoupled from the shaft of the yarn beam or the shaft rotatable with the shaft for the yarn beam in response to increases in the tensions in the warp yarns during weaving operation. Such selective actuation of the braking unit frequently invites sticking of the brake shoes or band to the brake disc or drum when they engage each other and it has therefore been difficult to achieve a prescribed frictional force between the braking elements, failing to provide a proper braking torque on the yarn beam and accordingly to enable the yarn beam to follow the variation in the tensions in the warp yarns.

A major cause of the variation in the tensions in the warp yarns fed from the yarn beam is the variation in an outside diameter of the roll of the yarns wound on the yarn beam although the tensions in the yarns vary due to various operating conditions of the loom during the weaving operation. As the warp yarns are unwound from the yarn beam, the outside diameter of the yarn supply package in the roll form on the yarn beam decreases from one layer of the yarns to another so that the length of the yarns unwound from the yarn beam per turn of the beam decreases to cause the tensions in the yarns to stepwise increase as the weaving operation proceeds. Thus, even though the braking torque imparted to the yarn beam may be successfully maintained constant through improvement of the braking elements to be used, control means should be provided so as to compensate for the increases in the tensions in the warp yarns preferably in close relation to increments of the tensions. Braking arrangements have been proposed and put into practice to achieve this end, using springs and/or weights the actions of which are controlled through sensing of the changes in the outside diameters of the yarn supply packages on the yarn beams. The changes in the outside diameters of the yarn supply packages will be to some extent representative of the changes in the tensions of the yarns being fed from the yarn beams when the looms are operating under normal conditions. When, however, the weaving cycles are varied as at the start or stop of the looms, such variations can not be followed by the braking arrangements so that the tensions in the warp yarns can not be properly adjusted when the weaving cycles of the looms increase or decrease temporarily. In the braking arrangements using the springs and/or weights, furthermore, the braking torques imparted to the yarn beams are subject to undue variations resulting from changes in ambient temperatures or any other weather conditions and to the deposits of duct and moisture on the working surfaces of the brake discs or drums, providing another important cause which is responsible for the inability of properly controlling the tensions in the warp yarns. All these problems have been reflected by deterioration of the quality of the cloth produced in the looms using the warp yarn supply means of the negative let-off motion type. The present invention contemplates provision of a successful solution to these problems in a simple and economical construction.

It is, thus, an important object of the present invention to provide an improved yarn tension control mechanism for use in a loom having a warp yarn supply means of the negative let-off motion type.

It is another important object of the invention to provide an improved warp tension control mechanism which is adapted to achieve optimum tensions in the warp yarns fed from a warp yarn supply means of the negative let-off motion type.

It is still another important object of the invention to provide an improved warp tension control mechanism incorporating a braking unit which is capable of applying an optimum braking torque on a warp yarn supply means of the netative let-off motion type throughout weaving operation of the loom.

It is still another important object of the present invention to provide an improved warp tension control mechanism having a brake unit which is controlled in relation to the tensions in the warp yarns being fed from the yarn supply means of the negative let-off motion type so that the yarn supply means is continuously braked to provide optimum tensions in the warp yarns in spite of the stepwise decrease in an outside diameter of the roll of the yarns on the supply means.

It is still another important object of the present invention to provide an improved warp tension control mechanism which is adapted to substantially continuously control to proper levels the tensions in the warp yarns from the yarn supply means in response to change in the outside diameter of the roll of the yarns on the supply means and to any unforseen condition resulting in change in the tensions in the warp yarns during weaving operation of the loom.

It is still another important object of the invention to provide an improved warp tension control mechanism including a brake control unit which is sensitive to any slight changes in the tensions of the warp yarns being fed from the yarn supply means of the negative let-off motion type during varying operational conditions of the loom.

In accordance with the present invention, these objects will be accomplished in a warp tension control mechanism which comprises in combination a brake wheel having a circumferential working surface and rotatable with the yarn supply means which is usually in the form of a yarn beam, the brake wheel being driven for rotation about its axis by the yarn supply means when the yarn is fed from the supply means, a brake frame positioned around part of the circumferential working surface of the brake wheel, a first brake arm which is fast on one end portion of the brake frame, a second brake arm which is pivotally connected to the other end portion of the brake and which extends substantially in parallel to and at a spacing from the first brake arm, the spacing between the first and second brake arms being variable by means of the pivotal connection between the brake frame and the second brake arm, at least two brake shoes one of which is carried on the brake frame and the other of which is carried by the second brake arm, biasing means for mechanically biasing the second brake arm toward the first brake arm for urging the brake shoes against the working surface of the brake wheel, the brake frame being urged to rotate about the axis of rotation of the brake wheel when a rotational force is imparted from the brake wheel to the brake frame through the brake shoes, and restraint means for restricting rotation of the brake frame relative to the brake wheel while permitting the brake wheel to rotate about its axis against a braking torque applied to the brake wheel from the brake shoes when the brake wheel is driven from the yarn supply means.

In one preferred embodiment of the present invention, the warp tension control mechanism may comprise, in combination, a brake wheel having a circumferential working surface and rotatable with the warp yarn supply means, the brake wheel being driven for rotation about its axis by the warp yarn supply means, a brake frame which is positioned around part of the circumferential working surface of the brake wheel, a first brake arm which is fast on one end portion of the brake frame, a second brake arm which is pivotally connected to the other end portion of the brake frame and which extends substantially in parallel to and at a spacing from the first brake arm, the spacing between the first and second brake arms being variable through the pivotal connection between the brake frame and the second brake arm, at least two brake shoes one of which is carried by the brake frame and the other of which is carried by the second brake arm, biasing means for mechanically biasing the second brake arm toward the first brake arm for urging the brake shoes against the working surface of the brake wheel, the brake frame being urged to rotate about the axis of rotation of the brake wheel when a rotational force is imparted from the brake wheel to the brake frame through the brake shoes, restraint means for restricting the rotation of the brake frame relative to the brake wheel, the restraint means being associated with the biasing means for urging the brake frame to a rest position permitting the brake wheel to rotate relative to the brake frame against a braking torque applied to the brake wheel from the brake shoes when the brake wheel is driven for rotation from the warp yarn supply means, and brake torque varying means responsive to the tension in the warp yarn being unwound and fed from the yarn supply means and associated with the restraint means for decreasing the biasing force imparted from the biasing means to the second brake arm and accordingly reducing the braking torque applied to the brake wheel from the brake shoes in response to an increase in the tension in the warp yarn from the yarn supply means.

In another preferred embodiment of the present invention, the warp tension control mechanism may comprise in combination a brake wheel which has a circumferential working surface and which is rotatable with the warp yarn supply means, the brake wheel being driven for rotation about its axis by the warp yarn supply means when the yarn supply means is rotated by the yarn being unwound therefrom, a brake wheel positioned around part of the circumferential working surface of the brake wheel, a first brake arm which is fast on one end portion of the brake frame, a second brake arm which is pivotally connected to the other end portion of the brake frame and which extends substantially in parallel to and at a spacing from the first brake arm, the spacing between the first and second brake arms being variable through the pivotal connection between the brake frame and the second brake arm, at least two brake shoes one of which is carried by the brake frame and the other of which is carried by the second brake arm, first biasing means for applying a first biasing force to the second brake arm for urging the second brake arm toward the first brake arm so that the brake shoes on the brake frame and second brake arm are urged against the working surface of the brake wheel, the brake frame being urged to rotate about its axis when a rotational force is imparted from the brake wheel to the brake frame through the brake shoes, restraint means for restraining the brake frame from rotating around the brake wheel while permitting the brake wheel to rotate about its axis against a braking torque which is applied to the brake wheel from the brake shoes when the brake wheel is driven from the yarn supply means, and second biasing means responsive to the tension in the warp yarn being unwound and fed from the yarn supply means for applying a second biasing force to the second brake arm to urge the second brake arm away from the first brake arm so that the first biasing force and accordingly the braking torque applied to the brake wheel from the brake shoes are reduced in response to an increase in the tension in the warp yarn being fed from the warp yarn supply means.

The features and advantages of the warp tension control mechanism according to the present invention will become more apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic side elevational view showing a preferred embodiment of the warp tension control mechanism according to the present invention;

FIG. 2 is a side elevational view showing a clutch and gear arrangement forming part of the brake torque varying means of the tension control mechanism depicted in FIG. 1; and

FIG. 3 is also a schematic side elevational view showing another preferred embodiment of the warp tension control mechanism according to the present invention.

Reference will now be made to the drawings, first to FIG. 1. As previously noted, the tension control mechanism herein disclosed in intended for use in a loom having a warp yarn supply means of the negative let-off motion type in which warp yarns are unwound and fed from the supply means by the tensions in the warp yarns and without aid of any positive or external drive means. The warp yarn supply means such a character is usually in the form of a yarn beam **10** having flanges **12** at both ends. The yarn beam **10** has a shaft **14** extending from both the flanges **12** and journaled on a stationary frame structure (not shown) of the loom. The yarn beam **10** is thus adapted to carry thereon a warp yarn supply package **16** of yarns **18** which are wound on the beam **10** in a roll form as indicated by a broken line. Substantially above the yarn beam **10** is positioned a guide roller **20** which is rotatably supported on a shaft **20***a* journaled on the stationary frame structure of the loom. A back-rest roller **22** is positioned posterior to this guide roller **20** and is rotatably supported on a shaft **22***a*. The shaft **22***a* of the back-rest roller **22** is fixedly connected to the shaft **20***a* of the guide roller **20** through a connecting member **24** so that the back-rest roller **22** is rotatable not only about the shaft **22***a* but the shaft **20***a* of the guide roller **20** through the connecting member **22**. The warp yarns **18** from the yarn beam **10** are passed through these guide roller **20** and back-rest roller **22** over to healds **26** so as to be shed to received a weft yarn as customary. The warp yarns **18** are drawn by means (not shown) which are positioned posterior to the healds **26** so that the yarns **18** are unwound and fed from the yarn beam **10** by the tensions in the warp yarns being passed through the guide roller **20** and back-rest roller **22** without application of any positive driving effort to the yarn beam **10** during weaving operation. The present invention is directed to the mechanism for controlling the tensions in the warp yarns **18** being fed from the yarn beam **10** and, as such, no further detailed description will be herein incorporated as to the construction of the weaving and drawing mechanism forming part of the loom.

The warp tension control mechanism for use in the yarn beam **10** of the negative let-off motion type in accordance with the present invention consists essentially of a brake unit which is adapted to apply a braking force to the yarn beam in response to a rotational force imparted thereto from the yarn beam **10** and a brake control unit which is adapted to control the braking torque of the brake unit in accordance with the tensions in the warp yarns.

The brake unit comprises a drive gear **28** which is securely carried on the shaft **14** of the yarn beam **10** and a driven gear **30** which is in constant mesh with the drive gear **28** and which is supported on a shaft **32** journaled on the stationary frame structure (not shown) of the loom. The shaft **32** further carries thereon a brake disc or wheel **34** which is thus rotatable with the driven gear **30** and which has a circumferential working surface **34***a*. An approximately semi-circular brake frame **36** is positioned around part of the circumferential working surface **34***a* of the brake disc or wheel **34**. The brake frame **36** is integral at one end thereof with a first brake arm **38** and is pivotally connected at the other end thereof to a second brake arm **38'** through a pivotal pin **40**. The first and second brake arms **38** and **38'**, respectively, extend substantially in parallel to and at a spacing from each other so that the brake frame **36** and the brake arms **38** and **38'** are arranged in a generally U-shaped configuration. The spacing between the brake arms **38** and **38'** is variable by reason of the pivotal connection between the brake frame **36** and the second brake arm **38'**. The brake frame **36** carries at its inner peripheral end two brake shoes **42***a* and **42***b* while the second brake arm **38'** carries at its inner end a brake shoe **42***c*. The brake shoes **42***a*, **42***b* and **42***c* are substantially equiangularly spaced apart from each other around the axis of the brake wheel **34**, viz., spaced apart 120° from each other and are adapted to engages at their inner faces the working surface **34***a* of the brake wheel **34**.

The first brake arm **38** is provided with an extension **44** which is directed substantially in parallel to the spacing between the brake arms **38** and **38'**, viz., approximately transverse to the arms. The extension **44** terminates approximately halfway of the spacing between the brake arms **38** and **38'** so as to be substantially aligned with the axis of rotation of the brake wheel **34** as will be seen in FIG. **1.** The extension **44** pivotally carries at its leading end a guide lever **46** through a pivotal pin **48.** The guide lever **46** has an end portion appreciably extending beyond the extension **44** toward the brake wheel **34** and extends away from the brake wheel. A first tension spring **50** is anchored at one end to the end portion of the guide member **46** close to the brake wheel **34** and connected at the other end to the first brake arm **38** through a fitting **52** which is fastened to the brake arm **38** by an adjustable bolt **54** and nut **56.** Likewise, a second tension spring **50'** is anchored at one end to the end portion of the guide member **46** and connected at the other to the second brake arm **38'** through a fitting **52'** which is fastened to the brake arm **38'** by an adjustable bolt **54'** and nut **56'**. The first and second tension springs **50** and **50'**, respectively, usually have a common spring contant so that the second brake arm **38'** is urged toward the first brake arm **38**, thereby holding the guide lever **46** substantially perpendicular to the extension **44.** With the second brake arm **38'** thus urged to turn toward the first brake arm **38** about the pivotal pin **40**, the brake shoe **42***c* on the second brake arm **38'** is forced against the working surface **34***a* of the brake wheel **34** with the result that the other brake shoes **42***a* and **42***b* are forced against the working surface **34***a* of the brake wheel **34.** The brake wheel **34** is thus pressed upon by the three equiangularly spaced brake shoes **42***a*, **42***b* and **42***c* in such a manner that the vector forces exerted from the brake shoes become zero when combined. The brake frame **36,** brake arms **38** and **38'** and extension **44** are, therefore, supported on the brake wheel solely by means of the pressing engagement of the brake shoes **42***a*, **42***b* and **42***c* with the working surface **34***a* of the brake wheel **34** and are not subject to restraint by any other mechanical means.

Although, in the above description, the brake shoes have been assumed to be three in number, such is merly by way of example and, therefore, only two or even more than three brake shoes may be used where desired. It is, in this instance, preferable to have the brake shoes located substantially equiangularly from each other so as to enable them to impart a uniform braking torque to the brake wheel. However, the intent of the present invention will be maintained even in an arrangement in which the brake shoes carried on the brake frame are located in symmetry with respect to a line joining the center of the brake shoe carried on the second brake arm and the axis of rotation of the brake wheel.

The guide lever **46** is in constant engagement at its lengthwise edge with a stop or fulcrum member **58** which is herein assumed to be held stationary providing restraint on the angular movement of the guide lever **46** about the pivotal pin **48.** As will be described later, however, the stop or fulcrum member **58** is movable in a direction substantially parallel to the guide lever **46** assuming a neutral position which is shown in FIG. **1.** This direction will be referred to as a vertical direction for the simplicity of description although the brake unit of the construction thus far described may assume any relative position other than that illustrated in FIG. 1.

Similarly, the terms "upward" and "downward" and "clockwise" and "counter clockwise" as will be used hereinafter should be interpreted merely as indicating the directions of motions relative to the drawings and not as limitative of the actual or practically possible directions of motions in the mechanism implementing the present invention.

When, now, the loom is inoperative with the yarn beam **10** held at rest, the tension springs **50** and **50'** coact with each other for maintaining the guide lever **46** in the neutral position illustrated and forcing the brake shoes **42a**, **42b** and **42c** tightly against the working surface **34a** of the brake wheel **34** with equal braking forces. The braking forces thus exerted on the brake wheel **34** can be adjusted by varying the spring constants of the tension springs **50** and **50'** through adjustment of the bolts **54** and **54'** and nuts **56** and **56'**, respectively. The guide lever **46** thus held in the neutral position extends in a vertical direction which is substantially in alignment with the center of the brake wheel **34** so that an angle θ of the guide lever **46** from the extension **44** (which is assumed to extend substantially horizontally in the drawing) is approximately 90°.

When, then, the loom starts the weaving operation, the warp yarns **18** are drawn toward the weaving station including the healds **26** through the guide roller **20** and back-rest roller **22**. The warp yarns **18** are thus continuously unwound and fed in a row from the yarn supply package **16** on the yarn beam **10** by means of the tensions produced therein by the drawing force imparted to the yarns from the weaving station. The yarn beam **10** is accordingly rotated about the shaft **14** in clockwise direction as indicated by an arrow A with a circumferential velocity which is substantially equal to the velocity at which the yarns **18** advance through the guide roller **20** and back-rest roller **22**. This causes the drive gear **28** to rotate about the shaft **14** for causing, in turn, the driven gear **30** to rotate about the shaft **32** so that the brake wheel **34** carried on the shaft **32** is driven to rotate about its axis in counter clockwise direction as indicated by an arrow B. Under this condition, the brake shoes **42a**, **42b** and **42c** are tightly forced against the working surface **34a** of the brake wheel **34** by the actions of the tension springs **50** and **50'** so that the brake frame **36** together with the brake arms **38** and **38'** and extension **44** is tugged by the brake wheel **34** rotating about the shaft **32** and is accordingly rotated in the counter clockwise direction through a certain angle. The rotation of the brake frame **36** about the shaft **32** is followed by pivotal movement in clockwise direction of the guide lever **46** about the pivotal pin **48** on the extension **44** and about the fulcrum member **58** which is in engagement with the lengthwise edge of the guide lever **46**. As a consequence, the first tension spring **50** is elongated from the initial length providing an increased spring action while the second tension spring **50'** is compressed from the initial length providing a reduced spring action. The second brake arm **38'** loaded by the second tension spring **50'** is pivotally connected to the brake frame **36** as previously described so that the decrease in the spring action of the tension spring **50'** is followed by reduction in the compressive force of the brake shoe **42c** on the working surface **34a** of the brake wheel **34** and accordingly by decreases in the braking forces of the other brake shoes **42a** and **42b** on the brake wheel **34** by reason of the action and reaction. The brake wheel **34** thus overcomes the braking torque applied thereto from the brake shoes **42a**, **42b** and **42c** and is allowed to rotate about the shaft **32** in unison with the yarn beam **10**, maintaining the brake frame **36** in a rest position by means of the restraint from the guide member **46** and by the increased spring action of the first tension spring **50**. The frictional forces exerted between the working surface **34a** of the brake wheel **34** and the individual brake shoes **42a**, **42b** and **42c** can thus be maintained substantially constant because the braking action of each of the brake shoes decreases as the brake frame **36** is urged to turn together with the brake wheel **34**. The yarn beam **10** is therefore, subject to a substantially constant braking torque insofar as the yarn beam **10** is driven by the warp yarns **18** with a fixed torque.

As will be understood from the foregoing description, the braking torque imparted to the yarn beam **10** varies depending upon the angle θ of the guide lever **46** to the extension **44**, viz., upon the relative angular positions of the guide lever **46** and the brake frame **36**. If, for example, the angle θ decreases as in the condition in which the brake frame **36** is tugged by the brake wheel **34** and brought into the rest position as described above, the tension springs **50** and **50'** exert differential spring actions so that the guide lever **46** is urged in counter clockwise direction and accordingly the brake frame **36** urged in clockwise direction which is opposite to the direction of arrow B. If, therefore, the yarn beam **10** is driven by the yarns **18** with a constant torque, then the brake frame **36** will be held in the rest position with the angle θ maintained substantially constant so that the tensions in the yarns **18** being fed from the yarn beam **10** will be also maintained constant. The fact is, however, that the yarn beam **10** is driven by the yarns **18** with a stepwise increasing torque because the outside diameter of the roll **16** of the yarns on the yarn beam **10** decreases from one layer of the yarns to another as the weaving operation proceeds and, for this reason, it is necessary for maintaining constant the tensions in the warp yarns **18** to have the angle θ reduced as the diameter of the roll **16** of the yarns decreases. This purpose will be accomplished in the warp tension control mechanism according to the present invention through provision of a brake control unit which is combined with the brake unit of the construction previously described.

When the brake frame **36** is turned a certain central angle around the brake wheel **34** as a result of the rotation of the brake wheel about the axis thereof, the guide lever **46** will be moved in unison with the extension **44** with the consequent decrease in the angle θ between the guide lever **46** and the extension **44** as already explained. The decrement of the angle θ is dictated by a distance between the pivotal pin **48** and the engaging point of the guide lever **46** with the fulcrum member **58** which has been assumed as being held stationary for convenience's sake. Thus, the greater the distance between the pivotal pin **48** and the fulcrum member **58**, the smaller the angle θ and accordingly the smaller the braking turque imparted from the brake shoes **42a**, **42b** and **42c** to the brake wheel **34**, and vice versa. The brake control unit forming part of the warp tension control mechanism according to the present invention is adapted to move the fulcrum member **58** away from the pivotal pin **48** as the weaving operation proceeds and accordingly the outside diameter of the roll **16** of the yarns on the yarn beam decreases.

For this purpose, the fulcrum member **58** is carried on a slider **60** which is slidably mounted on a guide rail **62** extending in a vertical direction which is substantially parallel to the direction in which the guide lever **46** extends when it is held in the neutral position as previously mentioned. The guide rail **62** is secured in position on the stationary frame structure of the loom through brackets **64** and **64'** which are connected to both ends of the guide rail. The slider **60** has a portion **60***a* which is internally screw-threaded and engages through this internally screw-threaded portion **60***a* with an externally screw-threaded guide rod **66** which extends along the entire length of the guide rail **62** and which is journaled at both ends on the brackets **64** and **64'**. The guide rod **66** is rotatable about its axis so that the slider **60** carried thereon is driven to move axially of the guide rod by means of the engagement between the screw-threaded portion **60***a* of the slider **60** and the guide rod. To facilitate the sliding movement of the slider **60** on the guide rail **62**, the slider **60** may be provided with roller **68** which is in rolling contact with the guide rain **62.** Designated by reference numeral **68** is a handle for permitting manual adjustment of the realtive position of the slider **60** on the guide rod **66.**

The guide rod **66** has an axial extension **66***a* which terminates in close proximity to the driven gear **30** on the shaft **32** for carrying thereon a clutch and gear arrangement which is adapted to be driven substantially in synchronism with the brake wheel **34** and accordingly with the yarn beam **10.** The clutch and gear arrangment, indicated by broken lines and designated as a whole by reference **70** in FIG. **1,** is illustrated in detail in FIG. **2.**

Referring to FIG. **2,** the extension **66***a* carries at its leading end portion of a spiral gear **72** which is rotatable on the extension **66***a*. The spiral gear **72** is in constant mesh with a spiral gear **74** which is fixedly carried on the shaft **32** supporting the brake wheel **34** so that the rotation of the shaft **32** is carried over to the spiral gear **72** through the spiral gear **74.** The spiral gear **72** is integral on one face thereof with a clutch half **76** which is engagable with a clutch half **78.** The clutch half **76** is rotatable on the extension **66***a* of the guide rod **66** similarly to the spiral gear and is prevented by suitable means for moving axially of the extension **66***a*. The clutch half **78,** on the other hand, is fixedly mounted on and accordingly rotatable with the extension **66***a* of the guide rod **66** and is keyed or splined or otherwise axially movably carried on the extension **66***a*. The clutch half **78** is thus adapted to be coupled to and uncoupled from the clutch half **76** as it is moved axially of the extension **66***a* of the guide rod **66.** The extension **66***a* of the guide rod **66** is rotatably received at its end in a mount **79** which is fast on a stationary frame structure (not shown) of the loom.

The clutch half **78** secured on the extension **66***a* of the guide rod **66** is formed with an annular groove **78***a* for receiving therein an appropriate member which is adapted to drive the clutch half **78** to move axially of the extension **66***a* of the guide rod **66** responsive to variation in the tensions in the warp yarns being fed from the yarn beam **10** (FIG. **1**).

In accordance with the present invention, the reciprocating movement of the clutch **78** is brought about by means of a solenoid-operated rotary motion device **80.** The solenoid-operated rotary motion device **80** has a plunger **80**a which is rotatable about its axis as the solenoid incooporated in the rotary motion device **80** is energized in a manner to be described. The plunger **80***a* is in constant engagement with the clutch half **78** through the annular groove **78***a* so as to move the clutch half **78** to a position coupled with the clutch half **76** when the plunger **80***a* is turned in response to actuation of the rotary motion device **80.**

An arrangement for actuating the solenoid-operated rotary motion device is illustrated in FIG. **1.** Turning back to FIG. **1,** the solenoid in the rotary motion device **80** has a coil (not shown) which are connected by lines **82** to a limit switch **84** through a power source **86.** To actuate this limit switch **84** in response to increases in the tensions in the warp yarns **18** being fed from the yarn beam **10,** a lever **88** is secured to the shaft **20***a* carrying the guide roller **20.** The lever **88** is angularly spaced apart from the connecting member **24** interconnecting the shafts **20***a* and **22***a* of the guide and backrest rollers **20** and **22,** respectively, and is thus pivotally movable about the shaft **20***a* as the back-rest roller **22** is turned about the shaft **20***a*. The lever **88** is in engagement at its leading end with a roller **90** which is rotatably carried on a rocking lever **92.** The rocking lever **92** is pivotally mounted on a shaft **94** and has approximately diametrically opposed arms **92***a* and **92***b*, the roller **90** being carried on the arm **92***a*. The other arm **92***b* has its end portion in close proximity to and accordingly engageable with an actuating element **84***a* of the limit switch **84.** With the levers **88** and **92** arranged in the relative positions illustrated in FIG. **1,** the lever **88** is turned clockwise as the back-rest roller **22** turns clockwise and such clockwise rotation of the lever **88** causes the rocking lever **92** to turn counter clockwise about the shaft **94** through the roller **90.** The counter clockwise rotation of the rocking lever **92,** in turn, causes tha actuating element **84***a* of the limit switch **84** to be depressed by the leading end of the arm **92***b* so that the limit switch **84** closes to energize the solenoid coil in the solenoid-operated rotary motion device **80.** To normally maintain the limit switch **84,** the rocking lever **92** is urged by suitable mechanical biasing means to turn clockwise about the shaft **94** so that the arm **92***b* thereof is biased to be disengaged from the actuating element **84***a* of the limit switch **84.** The mechanical biasing means is herein assumed to be a coiled tension spring **96** which is anchored at one end to the arm **92***b* and at the other end to a pin **98** which is fast on a stationary frame structure (not shown) of the loom.

As previously described, the brake unit of the warp tension control mechanism according to the present invention is adapted to produce a substantially constant braking torque without respect of the variation in the tensions in the warp yarns fed from the yarn beam **10.** The brake control unit having the construction above described is intended to control the brake unit for regulating the braking torque in response to the variation in the warp yarns from the yarn beam throughout the weaving operation of the loom.

When, thus, the tensions in the warp yarns **18** being fed from the yarn beam **10** to the healds **26** through the guide roller **20** and back-rest roller **22,** then the backrest roller **22** will be urged in the forward direction of the warp yarns **18** which are being passed therethrough. The back-rest roller **22** is consequently forced to turn clockwise about the shaft **20***a* carrying the guide roller **20** so that the lever **88** is also turned clockwise of the shaft **20***a* through the connecting member **24.** The lever **88** then depresses the roller **90** on the arm **92***a* of the rocking lever **92** which is consequently turned about the shaft **94** against the action of the tension spring **96,** thereby raising the arm **92***b* until the arm **92***b* abuts against and presses upon the actuating element **84***a* of the limit switch **84.** The limit switch **84** now closes so as to energize the coil in the solenoid-operated rotary motion device **80.** The plunger **82***a* of the rotary motion device **80** then commences to turn about its axis so that the clutch half **78** engaged thereby is driven to move into engagement with the clutch half **76.** The spiral gear **72** is constantly driven to rotate on the extension **66***a* of the guide rod **66** from the shaft **32** through the spiral gear **74** so that, when the clutch halves **76** and **78** are coupled with each other, the rotational force from the shaft **32** is carried over to the guide rod **66** through the spiral gears **74** and **72,** clutch halves **76** and **78** and extension **66***a* of the guide rod **66.** The shaft **32** being rotated in unison with the yarn beam **10** through the gears **28** and **30** as previously discussed, the guide rod **66** is rotated about its axis as the yarn beam **10** is driven to rotate about the shaft **14** by means of the tensions in the warp yarns **18** being unwound therefrom. When the guide rod **66** is driven to rotate in this manner, the slider **60** is moved upwardly, viz., away from the extension **66***a* through engagement between the internally screw-threaded portion **60***a* of the slider **60** and the externally screw-threaded guide rod **66.** This upward movement of the slider **60** is guided by the guide rail **62** and the rollers **68** which roll on the guide rail.

The stop or fulcrum member **58** which is fast on the slider **60** is in this manner moved away from the brake wheel **34** as the outside diameter of the roll **16** of the yarns on the yarn beam **10** decreases and accordingly the tensions in the yarns **18** passing through the back-rest roller **22** increase. This will result in reduction of the angle θ between the guide lever **46** and the extension **44** from the first brake arm **38** on the brake frame **36** and consequently in continuous reduction of the braking torque applied from the brake shoes **42***a*, **42***b* and **42***c* to the brake wheel **34.** The braking action of the yarn beam **10** is thus reduced so that the tensions in the yarns **18** being fed from the yarn beam decrease to a proper level. When the proper level is reached by the tensions in the yarns, then the back-rest roller **22** will restore its initial position so that the rocking lever **92** is allowed to turn counter clockwise about the shaft **94** by the action of the tension spring **96.** The limit switch **84** then opens and accordingly the solenoid-operated rotary motion device **80** is de-energized to permit the plunger **80***a* to turn to its initial position for moving the clutch half **78** out of engagement with the clutch half **76.** the clutch half **78** and accordingly the guide rod **66** thus cease to rotate while the clutch half **76** integral with the spiral gear **72** continues to rotate driven constantly by the spiral gear **74.** The clutch halves **76** and **78** are in this manner coupled and uncoupled repeatedly as the tensions in the warp yarns **18** passing through the back-rest roller **22** are about to increase beyond the proper level whereby the tensions of the yarns are maintained substantially at a constant optimum value which is dictated by the geometry of the levers **88** and **92** and the spring constant of the tension spring **96.**

The slider **60** will be moved to the upper end of the guide rod **66** remote from the brake wheel **34** at a final stage of the weaving operation when the yarn beam **10** is empty. For the succeeding weaving operation with the yarn beam **10** replaced with a full one, the slider **60** should be driven to move to the lower end of the guide rod **66** close to the brake wheel **34** by rotating the guide rod at the handle **69** in opposite direction.

FIG. **3** illustrates another preferred embodiment of the warp tension control mechanism according to the present invention. The tension control mechanism herein shown is also made up of a brake unit adapted to produce a substantially constant braking torque and a brake control unit which is adapted to control the brake unit for substantially continuously adjusting the braking torque so as to maintain the tensions in the warp yarns from the yarn beam to a proper level throughout the varying operational conditions of the loom. The mechanism shown in FIG. **3** features an increased sensitivity to the variation of the tensions in the yarns resulting from the stepwise decrease of the outside diameter of the yarn supply package in a roll form of the yarns on the yarn beam and from unforeseen causes which may be invited in the weaving station of the loom.

Referring to FIG. **3,** the yarn beam, yarns fed from the yarn beam, guide and back-rest rollers positioned in the paths of the warp yarns, and healds forming part of the weaving station are designated by reference numerals **10, 18, 20, 22** and **26,** respectively, and the yarn beam **10,** guide roller **20** and back-rest **20** have shafts **14, 20***a* and **22***a*, respectively, similarly to the mechanism illustrated in FIG. **1.** The shafts **14** and **22***a* of the yarn beam **10** and guide roller **20** are journaled on stationary frame structure of the loom while the shaft **22***a* of the back-rest roller **22** is fixedly connected to the shaft **20***a* of the guide roller **20** through the connecting member **24.**

While the brake wheel **34** are driven for rotation from the yarn beam **10** through the gears **28** and **30** and the shaft **32** carrying the gear **30** and brake wheel **34** in the mechanism shown in FIG. **1,** the warp tension control mechanism illustrated in FIG. **3** has a brake wheel **100** which is directly carried on the shaft **14** so as to be rotatable with the yarn beam **10** as the yarns **18** are unwound and fed from the yarn beam by means of the tensions in the yarns. Around part of the circumferential working surface of the brake wheel **100** is positioned a substantially semi-circular brake frame **102.** The brake frame **102** is integral at one end portion there of a first brake arm **104** extending substantially outwardly radially of the brake frame and is pivotally connected at the other end portion thereof to a second brake arm **104'** through a pivotal pin **106.** The second brake arm **104'** extends approximately in parallel to and at a spacing from the first brake arm **104,** the arms **104** and **104'** being shown as extending substantially horizontally in FIG. **3.** The brake frame **102** has formed on its outer peripheral edge spaced parallel projections **108** and **108'** which closely receive therebetween a stop pin **110** which is fast on a stationary frame structure (not shown) of the loom so that the brake frame **102** is restrained from rotating about its center. The brake frame **102** carries on its inner peripheral edge first and second brake shoes **112***a* and **112***b* while the second brake arm **104'** carries on its inner edge a third brake shoe **112***c*. The brake shoes **112***a*, **112***b* and **112***c* are in contact with the brake wheel **100** and are preferably substantially equiangularly spaced apart from each other around the center of the brake wheel **100** as seen in FIG. **3.** As previously discussed in connection with the brake shoes incorporated in the tension control mechanism illustrated in FIG. **1,** the number of the brake shoes may be increased or decreased as desired and it is permissible that the brake shoes are not in symmetrical with each other with respect to the center of the brake wheel **100** insofar as the brake shoes on the brake frame **102** are in symmetry with each other with respect to the line joining the center of the brake shoe on the second brake arm **104'** and the center of the brake wheel **100.**

Suitable mechanical biasing means is provided so as to urge the second brake arm **104'** toward the first brake arm **104.** The biasing means is herein exemplified as a coiled tension spring **114** which is anchored at one end to the second brake arm **104'** through a pin **116** fixed on the arm **104'** and connected to the other end to the first brake arm **104** through an adjustable bolt **120** which is adjustably fastened to the brake arm **104** by means of a nut **122.** The second brake arm **104'** is consequently urged toward the second brake arm **104** so that the third brake shoe **112***c* is forced against the working surface **100***a* of the brake wheel **100** whereby the other brake shoes **112***a* and **112***b* are also pressed upon the working surface of the brake wheel **100** by reason of Newton's third law of motion.

While the mechanical biasing means operative to urge the second brake arm **104'** to turn counter clockwise of the drawing has been assumed to be the coiled tension spring **114** in the above discussion, such is merely by way of example so that a weight and pulley arrangement may be utilized where desired. In this instance, a rope or any other flexible line may be anchored at one end to the first brake arm **104,** passed on a pulley mounted on the second brake arm **104'** and connected to the other end to a weight which is thus suspended from the pulley on the second brake arm **104,** though not shown in FIG. **3.**

The mechanical biasing means, which may thus be in any desired form, forms essential part of the brake unit of the tension control mechanism shown in FIG. **3,** causing the brake shoes **112***a*, **112***b* and **112***c* to apply a substantially uniform and constant braking torque to the brake wheel **100** as the brake wheel is driven by the yarn beam **10** to rotate about the shaft **14** essentially similarly to the brake unit of the mechanism shown in FIG. **1.**

The braking torque thus exerted by the described brake unit is controlled by the brake control unit which is responsive to the variation in the tensions in the warp yarns **18** fed from the yarn beam **10.**

To sense the tensions in the warp yarns **18** being fed from the yarn beam **10** to the healds **26,** the brake control unit comprises a bell-crank lever **124** which is fast on and rotatable with the shaft **20***a* of the guide roller **20.** The bell-crank lever **124** has angularly spaced arms **124***a* and **124***b* which are rotatable about the shaft **20***a* as the connecting member **24** interconnecting the shafts **20***a* and **22***a* of the guide and back-rest rollers **20** and **22.** One arm **124***a* of the bell-crank lever **124** carries at its free end a pin **126.** Suitable mechanical biasing means such as a coiled tension spring **128** is connected at one end to this pin **126** through a substantially straight rod portion **128***a* and at the other end to the pin **116** on the second brake arm **104'** of the brake unit. This tension spring **128** is adapted to provide a varying load on the second brake arm **104'** opposing the action of the tension spring **114,** and may be replaced with a weight and pulley arrangement which was discussed previously with regard to the tension spring **114.** Or otherwise desired, the arm **124***a* may be connected to the second brake arm **104'** by a substantially rigid member if the second brake arm **104'** is formed with a pliable material such as a spring steel.

When, now, the outside diameter of the roll (not seen in FIG. 3) of the yarns on the yarn beam **10** stepwise decrease from one layer of the yarns to another as the weaving operation proceeds in the loom, then the tensions in the warp yarns **18** being passed from the back-rest roller **22** tend to increase. The back-rest roller **22** is therefore caused to turn clockwise of the drawing about the shaft **20***a* of the guide roller **20** through the connecting member **24,** causing the bell-crank lever **124** to accordingly turn clockwise about the shaft **20***a*. The arm **124***a* of the bell-crank lever **124** is consequently turned upwardly so that the rod portion **128***a* of the tension spring **128** is raised from its initial position, viz., away from the second brake arm **104'** with a consequent increase in the spring force of the tension spring **128.** This causes the second brake arm **104'** to be urged toward the first brake arm **104** with a lesser force due to an increased opposing effort applied from the tension spring **128** with the result that the compressive forces exerted on the working surface of the brake wheel **100** decrease. The brake wheel **100** is accordingly subjected to a braking torque which is so lessened as to be appropriate for rendering the tensions in the warp yarns **18** to a proper level. The spring action of the tension spring **128** is thus substantially continuously increased as the outside diameter of the roll of the yarns on the yarn beam **10** decreases so that the tensions in the warp yarns **18** fed from the yarn beam are at all times maintained at the proper level.

The arm **124***b* of the bell-crank lever **124** and parts associated therewith are intended to apply tensions to the warp yarns **18** fed to the healds **26** at an incipient stage of the weaving operation and to substantially compensate for unexpected changes in the tensions in the warp yarns **18** as would be caused by the shedding and beating of the yarns at the weaving station of the loom during operation. Thus, the arm **124***b* is pivotally connected at its free end to a pivotal member **130** which is in turn connected through an adjustable bolt **132** and nut **134** to a spring seat member **136.** A coiled tension spring **138** is anchored at one end to this spring seat member **136** and at the other end to a spring seat member **140** which is secured to a stationary frame structure of the loom. The tension spring **138** thus urges the bell-crank lever **124** and accordingly the back-rest roller **22** to turn counter clockwise and may be replaced with mechanical biasing means of any form other than the coiled tension spring. The arrangement including the arm **124***b* of the bell-crank lever **124** and the tension spring **138** is provided merely by preference so that it may be dispensed with where desired.

What is claimed is:

1. A warp tension control mechanism for a loom having warp yarn supply means driven for rotation by a tension in a warp yarn fed from a yarn supply package of a roll form on said warp yarn supply means comprising, in combination, a brake wheel having a circumferential working susrface and rotatable with said warp yarn supply means, the brake wheel being driven to rotate about its axis by said yarn supply means, a brake frame which is positioned around part of said working surface of said brake wheel, a first brake arm which is fast on one end portion of said brake frame, a second brake arm which is pivotally connected to the other end portion of said brake frame and which extends substantially in parallel to and at a spacing from said first brake arm, said spacing between the first and second brake arms being variable by means of the pivotal connection between said brake frame and said second brake arm, at least three brake shoes one of which is carried on said second brake arm and the others of which are carried on said brake frame, the brake shoes on the brake frame being equidistantly spaced apart from the brake shoe on the second brake arm, said first brake arm having an extension having a leading end portion which is located substantially halfway of said spacing between the first and second brake arms, a guide lever which is connected through a pivot to said leading end portion of said extension and which extends away from said brake wheel, first and second mechanical biasing means associated respectively with said first and second brake arms and urging said guide lever to a neutral position which is substantially in alignment with the axis of rotation of said brake wheel, a movable fulcrum member which is in sliding engagement with said guide lever for allowing the guide lever to turn about the fulcrum member and about the pivotal connection between the guide lever and said leading end portion of said extension, said brake frame being urged to turn about the axis of rotation of said brake wheel to a rest position with said first mechanical biasing means caused to have its biasing force increased and said second mechanical biasing means caused to have its biasing force reduced as a rotation force is imparted from said brake wheel to the brake frame through said brake shoes for moving said guide lever to a position which is angularly spaced apart from said extension at a reduced angle and for permitting the brake wheel to rotate about its axis by a rotational force imparted thereto from said yarn supply means, and brake torque varying means responsive to variation in the tension of the warp yarn being unwound and fed from said yarn supply means and associated with said fulcrum member for decreasing said angle between said guide lever and said extension in response to an increase in the tension in the yarn so that the biasing force of said second mechanical biasing means is reduced and said brake shoes are urged against said brake wheel with a reduced biasing force.

2. A warp tension control mechanism as claimed in claim **1**, in which said brake torque varying means comprises a slider which carries thereon said fulcrum member, guide means for guiding said slider in a path which is substantially parallel to a direction in which said guide lever assumes when it is in said neutral position aligned with the axis of rotation of said brake wheel, and drive means responsive to variation in the tension in the warp yarn being fed from said yarn supply means and operative to be driven from the yarn supply means, said drive means being disconnected from said guide means when the tension in the warp yarn fed from the yarn supply means is maintained under a predetermined level and drivingly connected thereto in response to an increase in the tension in the yarn.

3. A warp tension control mechanism as claimed in claim **2**, in which said guide means comprises an internally screw-threaded portion forming part of said slider and an externally screw-threaded guide rod engaging with said internally screw-threaded portion and extending along said path, said drive means being drivingly connected to said guide rod in response to the increase in the warp yarn from the yarn supply means for rotating the guide rod about its axis so that said internally screw-threaded portion of the slider is moved along the guide rod.

4. A warp tension control mechanism as claimed in claim **2**, in which said drive means comprises clutch means having a first clutch half rotatable with said yarn supply means and constantly driven therefrom and a second clutch half engageable with said first clutch half and drivingly connected to said guide means, electromagnetic actuating means in mechanical engagement with said second clutch half and having an inoperative position holding the second clutch half uncoupled from said first clutch half and an inoperative position moving said second clutch half into engagement with said first clutch half for driving said guide means, electric switch means electrically connected to said actuating means, a control lever which is mechanically engageable with said switch means and which is operative to be moved responsive to an increase in the tension in the warp yarn being fed from said yarn supply means for thereby actuating said switch means to close and energize said electromagnetic actuating means, and mechanical biasing means uring said control lever to a position disengaged from said switch means.

5. A warp tension control mechanism as claimed in claim **1**, in which said brake torque varying means comprises a slider which carries thereon said fulcrum member, an internally screw-threaded portion forming part of said slider, an externally screw-threaded guide rod engaging said internally screw-threaded portion and engaging substantially in parallel to a direction in which said guide lever assumes when it is in said neutral position aligned with the axis of rotation of said brake wheel, clutch means having a first clutch half which is rotatable with and constantly driven from said yarn supply means and a second clutch half engageable with said clutch half and drivingly connected to said guide rod, said guide rod and said second clutch half being driven to rotate about their axes when the clutch halves are coupled together, electromagnetic actuating means in mechanical engagement with said second clutch half and having an operative position holding said second clutch half uncoupled from said first clutch half and an inoperative position moving the second clutch half into engagement with said first clutch half for driving said guide rod from said yarn supply means through said first clutch half, electric switch means electrically connected to said actuating means, a control lever which is mechanically engageable with said switch means and which is operative to be moved responsive to an increase in the tension in the warp yarn being fed from said yarn supply means for thereby actuating said switch means to close and energize said electromagnetic actuating means, and mechanical biasing means urging said control lever toward a position disengaged from said switch means.

6. A warp tension control mechanism as claimed in claim 5, in which said first and second mechanical biasing means comprise first and second tension springs, the first tension spring being anchored at one end to an end portion of said guide lever close to said brake wheel and at the other end to said first brake arm and the second tension spring being anchored at one end to said end portion of the guide lever and at the other to said second brake arm.

7. A warp tension control mechanism as claimed in claim 1, in which said brake shoes carried on said brake frames are located substantially in symmetry with respect to a line joining a center of said brake shoe carried on said second brake arm and the axis of rotation of said brake wheel.

8. A warp tension control mechanism as claimed in claim 7, in which said at least three brake shoes are located substantially equiangularly around said axis of rotation of said brake wheel.

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