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W. HADAM ET AL

3,719,061

SAFETY DEVICE FOR FLAT KNITTING MACHINE

Filed Nov. 17, 1971

3 Sheets-Sheet 1

Fig. 7

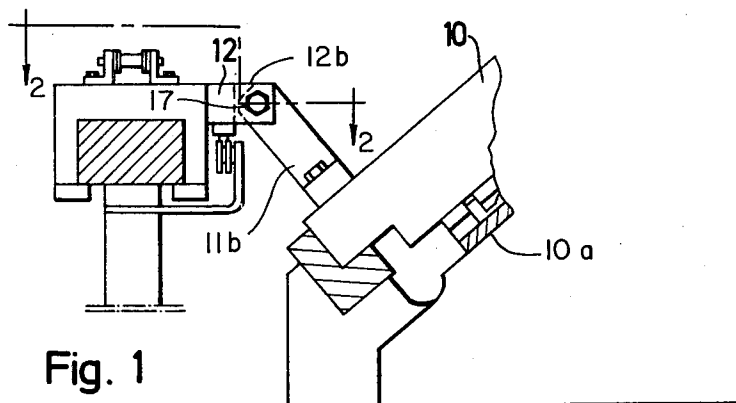
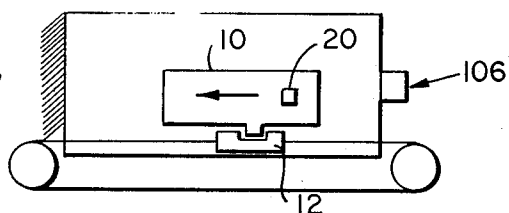
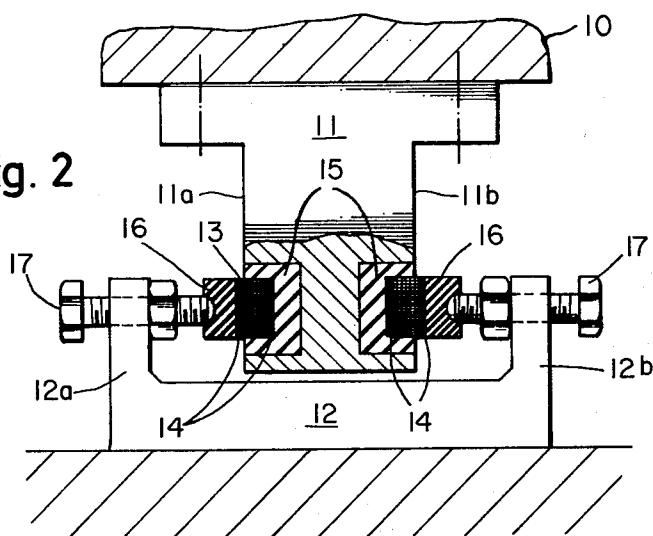


Fig. 1

Fig. 2



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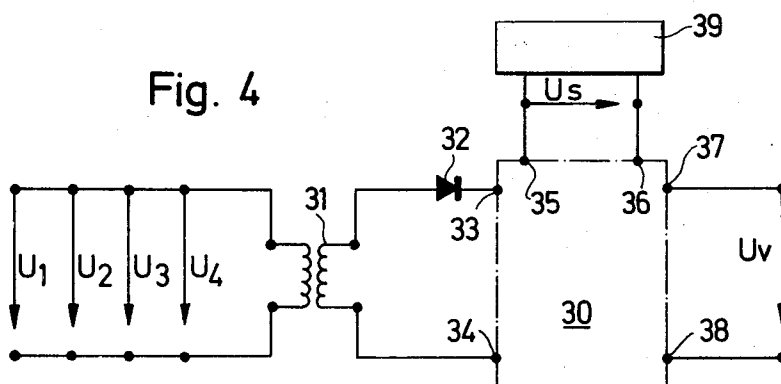
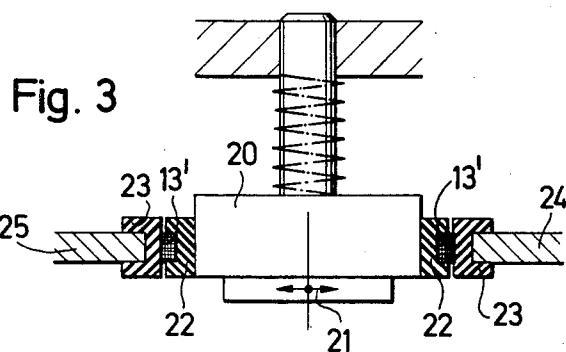
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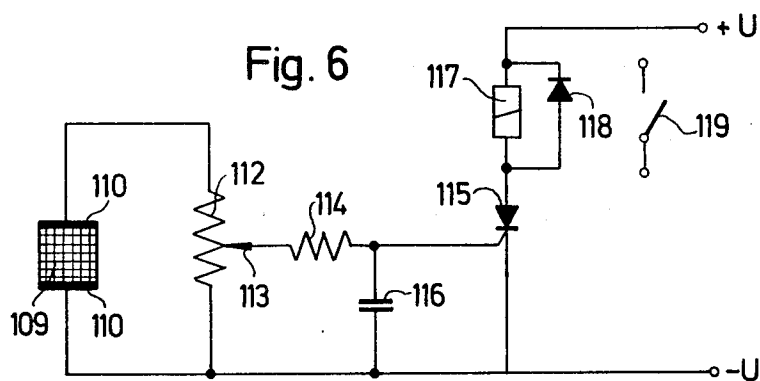
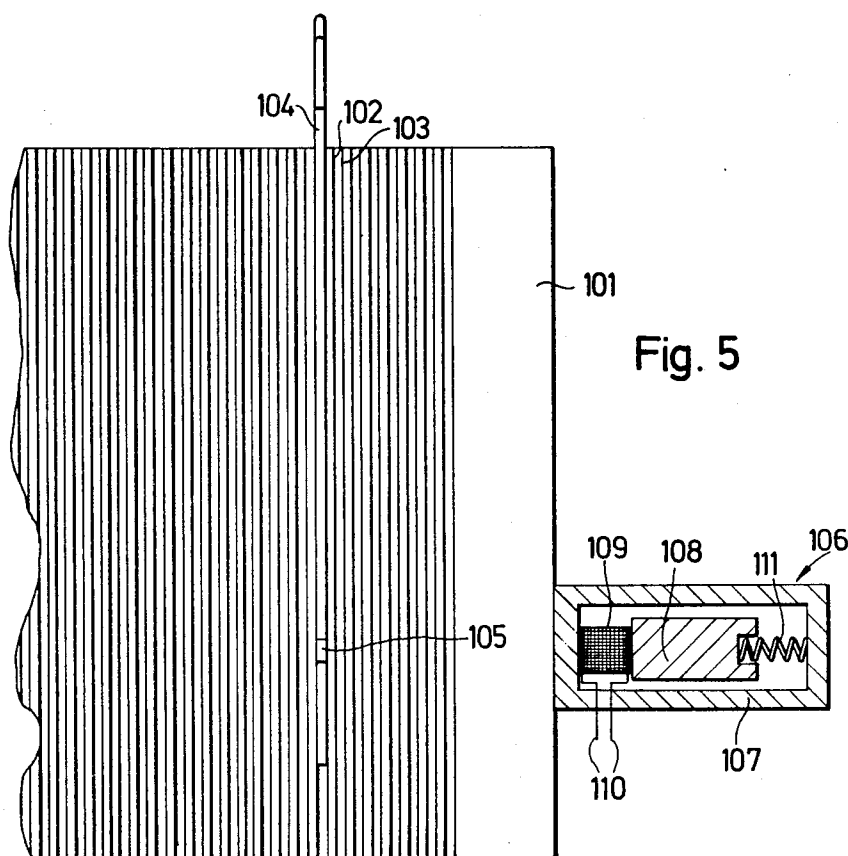
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3,719,061

SAFETY DEVICE FOR FLAT KNITTING MACHINE
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Int. Cl. D04b 35/10

U.S. Cl. 66—157

23 Claims

ABSTRACT OF THE DISCLOSURE

In a flat knitting machine, a safety device for sensing large disturbances or reaction forces to cut off the machine and hence prevent damage thereto. The safety device includes piezoelectric pressure bodies strategically located to convert pressure forces into electrical signals. An electrical circuit senses the electrical signals and, if the signals are of sufficient magnitude, causes the machine to cut off. The electrical circuit may include a comparator to compare signals from the piezoelectric body or bodies or a semi-conductor which transmits a current to a relay to cut off the knitting machine drive only when it is triggered by a peak voltage from the piezoelectric body.

BACKGROUND OF THE INVENTION

This invention relates to a safety device for a flat knitting machine designed for use in stopping the machine in the event of overloads or disturbing forces acting at a monitored part of the machine.

It is known to incorporate in a flat knitting machine between the carriage and the means driving the same, a so-called resistance stop adapted to act as a safety device, thus stopping the machine should a resistance which exceeds a predetermined tolerance occur in the carriage. In this case the safety device consists of a lever or slide which is held loaded by one or two springs—depending on whether the safety device is to be stressed in one or in both directions of travel of the carriage—the loading determining the permissible stress limits. Such a known safety device, however, has the drawback that to trigger it the lever or slide must undergo a specific displacement against the force of the spring, or the appropriate spring, as the case may be. The movement of the spring must be relatively large to prevent the machine responding inadvertently to fluctuating circumstances which will normally and naturally occur on the carriage. The sensitivity of the known form of safety device is accordingly limited. A consequential, and very substantial, disadvantage of this prior safety device lies in the fact that it can only be set to a specific maximum output value and this maximum value must be outside the relatively wide tolerance range in which the reaction forces effective on the carriage will normally fluctuate in the manufacture of a knitted product. When a cam part strikes a needle butt, the conventional resistance stop motion for the carriage only responds when the kinetic energy of the carriage resulting from the impact has been expended. In this event the needle beds can be considerably damaged in the case of a carriage of large mass. For this reason further resistance stop motions should ideally be applied to every cam or to each part participating in a forward or a reverse traverse of the carriage. If, however, a cam is provided with a resistance stop motion this cannot operate on the conventional spring principle because during the shifting of a cam the drawing would not be in conformity as between the leading and the rear cam, and in the case of an electronic needle selection system faults would be likely to develop in the needle selection during a traverse of the carriage.

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Thus, there exists a need for a new and improved safety device of the type described for a flat knitting machine.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a safety device of the kind set forth which is not only capable of versatile use not limited merely to the monitoring of the machine carriage, but which also responds more rapidly than previous safety devices, and, if desired, can be made so sensitive that the breakage of a single needle or jack butt can be recorded and trigger stoppage of the machine drive.

In accordance with the invention these requirements are met by the fact that at least one force-detecting piezoelectric pressure body is coupled to the monitored machine part and connected in an electrical circuit controlling the machine drive. The piezoelectric pressure body, hereinafter referred to as "a piezobody" for short, may be connected to one input of a signal comparator stage, the output signal of which controls the machine drive. In accordance with a feature of the invention the signal comparator stage may be connected to a reference value emitter which gives a reference value signal dependent on an operative condition of the machine, for example on the carriage setting, and the output signal of the signal comparator stage may be proportional to the difference between the actual value signal and the reference value signal.

The piezobody may be polarized in the force transmitting direction under a mechanical bias at one force transmission area of the monitored machine part.

Thus, the incident mechanical force will produce proportional electrical voltages in the piezobodies, and these can be compared in the signal comparator stage with standard electrical reference voltage signals, the machine being stopped when the reference value is exceeded. In addition to the advantage of the continuous adaption of the reference value signal to the prevailing operating conditions and to the natural fluctuations of the reaction forces effecting the supervised machine part, during the operation of the machine, the safety device according to the invention has the attribute that it will respond partially without any relative displacement of the monitored part relatively either to the body of the machine or to some other datum part. With no such displacement, the rate of response of this safety device is much higher than is the case with known forms of safety devices; this is in addition to the substantially increased sensitivity secured by the continuous adaption of the reference value signal.

The piezoelectric force detector can be made small and relatively sensitive so that it can also be used for the supervision of relatively light parts of the flat knitting machine, for example individual cams or even individual parts of a cam.

In one advantageous embodiment of the safety device a driving part of the carriage is equipped at each of its two ends, as seen in the direction of stroke of the carriage, with a piezobody serving as a force detector, and these two piezobodies are indirectly operated by screw bolts which are adjustable and fixably mounted in a driving member having arms which enfold the aforesaid driving part of the carriage at two sides and coupled with a driving component such, for instance, as a chain, spindle or the like.

In another embodiment at least one piezobody may be clamped as the force detector between a cam part mounted in the cam box and the cam plate or between the cam plate and the carriage, in which event two piezobodies will be used and arranged at each end of the cam part as related to the direction of carriage travel.

In yet another safety device according to the invention for stopping the flat knitting machine in the event of

needle breakage, the piezobody is arranged in a vibration pick-up which is attached to the needle bed in such a way that the direction in which the grip is applied to piezobody coincides with the longitudinal direction of the said bed. Such a safety device responds to longitudinal vibrations occurring in the needle bed, and the vibration pick-up may advantageously comprise, in combination, a housing which is applied firmly against the needle bed, a mass within the housing, a piezobody which is provided with two electrodes and is gripped between the wall of the housing and one end of the mass, and a compression spring which is arranged between an opposite end of the mass and housing and urges the mass towards the piezobody.

Should the machine carriage strike a needle butt or jack butt this will produce an impulse which will be propagated to the part where the piezoelectric vibration pick-up is disposed. When the vibration reaches the housing of the vibration pick-up, the piezobody will be subject to mechanical stress because of the inertia of the mass to which it is applied. There will then be an electrical voltage set up at the electrodes of the piezobody, which may be connected, via a by-pass and a voltage distributor, with a thyristor in a relay circuit, to stop the machine drive.

In the case of a two-bed flat knitting machine the needle beds would each be provided with a piezoelectric vibration pick-up and the two pick-ups would be electrically connected in parallel.

Thus, it is an object of this invention to provide a new and improved safety device for a flat knitting machine.

It is another object of this invention to provide a new and improved safety device for a flat knitting machine in which piezoelectric pressure bodies are utilized as the force sensing mechanism.

It is another object of this invention to provide a safety device for a flat knitting machine of sufficient sensitivity such that even forces applied to individual cam parts may be sensed.

It is another object of this invention to provide a safety device for a flat knitting machine in which piezoelectric bodies are mounted between the movable carriage and a part associated with the machine drive for sensing reaction forces therebetween.

It is another object of this invention to provide a safety device for a flat knitting machine in which piezoelectric bodies are positioned between an individual cam part and the adjacent cam plates for sensing reaction forces therebetween.

It is another object of this invention to provide a vibration pick-up device for sensing longitudinal vibrations of the needle bed caused, for example, by needle breakage.

It is another object of this invention to provide a safety device for a flat knitting machine in which piezoelectric bodies are used as the force sensing means and in which electrical circuit means receive electrical signals from the piezoelectric body and, if the signals exceed a predetermined level, cause the drive of the knitting machine to cut off.

Other objects and the advantages of the present invention will become apparent from the detailed description to follow together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

There follows a detailed description of preferred embodiments of the invention to be read together with the accompanying drawings.

FIG. 1 is a diagrammatic partial sectional view through a carriage of a flat knitting machine provided with one form of the improved safety device.

FIG. 2 is a partial plan and partial horizontal sectional view of FIG. 1, taken along line 2—2 of FIG. 1.

FIG. 3 is a diagrammatic section view through a cam part mounted in a cam plate of the carriage and showing another embodiment of the invention.

FIG. 4 is a schematic drawing of an electrical circuit portion of the safety device which is usable with the

embodiment of FIGS. 1 and 2 and/or the embodiment of FIG. 3.

FIG. 5 is a partial plan view of a needle bed of a flat knitting machine and showing another embodiment of the invention.

FIG. 6 illustrates schematically an electrical circuit for use with the embodiment of FIG. 5.

FIG. 7 is a diagrammatic view showing the general position of the three illustrated embodiments of the invention in a knitting machine.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, like numerals represent like elements throughout the several views.

Referring to FIGS. 1 and 2 it will be seen that a driving element 11 is connected both to a machine carriage 10 (not fully shown) which moves longitudinally relative to a needle bed 10a and also to a U-shaped driving part 12. This driving part is in turn connected to a driving spindle (not shown) and has arms 12a and 12b which project out around the driving element 11. A piezoelectric pressure body (piezobody for short) 13 is located at each of the two opposite sides 11a and 11b of the driving element 11 and is polarized in the direction of travel of the carriage 10. Each of these two bodies 13, which is effective in one of the directions of travel of the carriage, is provided at both sides thereof in the polarization direction, with electrodes 14. Each inner electrode is insulated relatively to the driving element 11 by an insert 15 of sintered ceramic material, and each piezobody 13, together with its inner electrode, is inserted into a recess in this material. Moreover, each of the two piezobodies 13 is contacted in the vicinity of its outer electrode 14 by a thrust plate 16 which is also made of an electrically-insulating sintered ceramic material. These thrust plates 16 are applied against the piezobodies 13 by screws 17 which are mounted in the arms 12a and 12b of the driving part 12 in such a way that these bodies are pre-stressed and are fixed, free of play between the driving parts 11 and 12.

Electrical voltages are produced, in known fashion, by resilient deformations of the piezobodies 13 which are in the nature of piezo-oxide transformer bodies. This is because the fluctuating reaction forces which are effective during a carriage stroke cause changes in the mechanical stresses in the said bodies 13, from the rest condition, and these changes produce in the bodies a proportional electrical alternating voltage of a frequency in the kHz. range. The actual signals emitted from the piezobodies 13 are transmitted to a signal comparator stage such as that presently to be described in conjunction with FIG. 4.

FIG. 3 diagrammatically illustrates an arrangement of piezobodies 13' at opposed sides of a cam part 20 which is to be monitored as regards the strength of the forces which are active in the directions of the double arrow 21. The two piezobodies 13' are again provided with electrodes and are mounted in a playfree manner between electrical insulating bearings 22 and pressure bodies 23. Each bearing 22 is connected to the relevant end face of the cam part 20 while the corresponding pressure body 23 is connected to the adjacent wall of a cambox plate 24 or 25. Here again, forces acting on the cam part 20 in the direction of the double arrow 21 are manifest as a consequence of deformation of the piezobodies 13' and the resulting signal voltages are conducted to a signal comparator stage for exploitation.

FIG. 4 illustrates an electrical circuit usable with the embodiments of FIGS. 1, 2 and/or FIG. 3. A plurality of piezobodies having their electrodes connected in parallel, and indicated by the voltage arrows U_1 to U_n , are transmitted through an input transformer 31 and a diode 32 to the actual value input terminals 33 and 34 of a signal comparator stage 30. Instead of employing a transformer use may be made of a threshold value switch which responds when a specific voltage peak is exceeded.

In addition, the signal comparator stage 30 has two reference value input terminals 35 and 36 to which is applied a reference signal indicated by the voltage U_s . This reference signal is emitted by a reference value transmitter (not shown) into which a reference value signal corresponding to an assumed or detected tensile force pattern on the carriage (or other appropriate part) is fed during a stroke of the carriage and is transmitted synchronously with the development of the carriage movement.

The signal comparator stage 30 delivers to the two output terminals 37 and 38 thereof control signal or fault signal U_v which is equal or proportional to the difference between the instantaneous value of the actual signal and the reference value signal. If, by reason of a sudden and rapidly increasing mechanical pressure an actual value signal amplitude is produced at one of the two piezobodies connected in parallel, which amplitude exceeds the reference value signal at that moment applied to the comparator stage 30, an appropriately strong control signal U_v is produced to stop the flat knitting machine.

FIGS. 5 and 6 show a further example of the improved safety device. FIG. 5 illustrates the end section of a needle bed 101. The needle tricks formed in this bed are indicated at 102 and the intervening ribs at 103. A needle 104 is shown inserted in one of the tricks 102, and the butt of this needle is shown at 105. Arranged at an end of the needle bed 101 is a piezoelectric vibration pick-up 106 comprising the adjacent wall of the housing 107 applied against the needle bed 101. The piezobody 109 has two electrodes 110. The loading of piezobody 109 is performed by a compression spring 111 which is stressed between the other end of mass 108 and the opposing wall of housing 107. Mass 108 is therefore out of direct communication with the housing 107 of the vibration pick-up 106.

When the carriage strikes a needle butt 105 an impulse is transmitted to the needle bed 101—as has already been explained—and this becomes manifest as a longitudinal vibration of the vibration pick-up 106. The transmission of the vibration to housing 107 is not communicated to mass 108 which, in fact, remains stationary within this housing. As a consequence there is a mechanical variation of stress on the piezobody 109 which is clamped between mass 108 and housing 107, and this transmits an electrical voltage to electrodes 110.

As can be seen from FIG. 6, the electrodes 110 of piezobody 109 are connected to the two ends of a potentiometer 112 acting as a voltage distributor and a tapping 113 of which leads to the control input of a thyristor semiconductor 115 via a protective resistance 114. A condenser 116 is coupled between the control input of thyristor 115 and electrode 110 of the piezobody 109 and this shields the control input of the thyristor from disturbing voltage peaks. The thyristor 115 is connected to a control voltage source $\pm U$ in series with the energizing winding of a relay 117. The relay winding is by-passed in one direction by a diode 118. Relay 117 operates a switch 119 in the current supply circuit (not shown) of the flat knitting machine.

If a sufficiently powerful blow is exerted on the piezobody a positive voltage peak is applied, through potentiometer 112, resistance 114 and condenser 116 to the control input of thyristor 115, and this latter is triggered. Relay 117 closes switch 119 and thus stops the drive of the machine. The fact that every vibration has wave crests and valleys ensures that a positive voltage peak is emitted by the piezobody for every impulsive effect on the needle bed 101, irrespective of whether the impulse is produced on the needle bed 101 with the machine carriage moving in one direction or in the opposite direction.

The anti-needle breakage system only requires a small outlay in terms of manufacture and electrical equipment and operates in the required way very rapidly and positively.

FIG. 7 is a diagrammatic view of an overall needle bed carriage and drive therefor showing the relative locations of the three embodiments of the safety device described in detail above. While only a single cam part 20 is shown in FIG. 7, of course a suitable safety device may be provided for each cam part. Also, in a two-bed knitting machine, these safety devices could be duplicated on the opposite bed and carriage. It will be apparent that any one or any combination of these safety devices may be employed on a single knitting machine.

Although the invention has been described in considerable detail with respect to a preferred embodiment thereof, it will be apparent that the invention is capable of numerous modifications and variations apparent to those skilled in the art without departing from the spirit and scope of the invention.

We claim:

1. In a flat knitting machine, a safety means for stopping the machine in response to forces above a predetermined level acting on a monitored part of the machine, said safety means comprising at least one force-detecting piezoelectric pressure body operatively coupled to said monitored part such that in response to the application of a force from the monitored part to the piezoelectric body a first electrical signal is transmitted, and means responsive to said first electrical signal for controlling the drive of the knitting machine.

2. The invention of claim 1 including a signal comparator, means for developing a reference electrical signal, said comparator including means for receiving and comparing the reference signal and the said first signal and transmitting an output signal proportional to the difference between the said first signal and the said output signal for controlling the drive of the knitting machine.

3. The invention of claim 2, wherein the said comparator has a pair of input means and an output means, said piezoelectric body being connected to one of said input means, means for emitting a reference electrical signal, said reference electrical signal being connected to the second input means of the comparator, and said comparator transmitting an output signal through said output means, which output signal is proportional to the difference between the said first electrical signal and the said reference electrical signal.

4. The invention of claim 1, wherein the piezoelectric body is polarized in the force transmitting direction under a mechanical bias at one force-transmission area of the monitored machine part.

5. The invention of claim 1, wherein said machine includes a movable carriage and said safety means is positioned to sense reaction forces set up by the carriage.

6. The invention of claim 5, including a driving member movable with the drive of the knitting machine, said monitored part of the machine being a driven part of the carriage, a force detecting piezoelectric body located on each end of the said driven part of the carriage, as seen in the direction of travel of the carriage, and said driving member having arms positioned on opposite sides of each piezoelectric body, as seen in the direction of travel of the carriage, whereby forces tending to create relative movement between the driving member and the driven parts are sensed by the piezoelectric bodies.

7. The invention of claim 6 including electrically insulated members located on the driven part and said piezoelectric bodies being fixed thereagainst, electrically insulated pressure plates located on the sides of each piezoelectric body opposite from its electrically insulated members, said driving member having an elongated part, out from which the two said arms of the driving member project on opposite sides of the said carriage driven part, and means attached to said arms for adjustably forcing the pressure plates against the said piezoelectric bodies.

8. The invention of claim 6, wherein the two piezoelectric bodies are connected in parallel, a comparator stage having first and second inputs, a reference signal emitter,

said comparator receiving a signal from said piezoelectric bodies at the first input and the reference signal at the second input, said comparator including means for delivering an output signal proportional to the difference between the said first signal received from the piezoelectric bodies and the reference signals, and means electrically connecting the said output signal to the machine drive to stop the same and hence also stop the driving member and the carriage when the signal from the piezoelectric bodies exceeds the reference signal by a predetermined amount.

9. The invention of claim 1, said machine having a movable carriage and cam parts mounted therein in cam plates fixed to the carriage, and wherein said safety means is positioned to sense reaction forces to which the cam part is subjected.

10. The invention of claim 9, including a piezoelectric body on each end of the cam part, as seen in the direction of carriage travel, a part of said cam plate positioned on the opposite side and in force-engaging contact with each piezoelectric body.

11. The invention of claim 10, including a pair of electrically insulated members located on the cam part and said piezoelectric bodies being fixed thereto, electrically insulated pressure plates located on the sides of the piezoelectric bodies opposite from the electrically insulated members and connected to the said parts of the cam plate.

12. The invention of claim 10, wherein the two piezoelectric bodies are connected in parallel, a comparator stage having first and second inputs and a reference signal emitter, said comparator receiving a signal from said piezoelectric bodies at the first input and the reference signal at the second input, said comparator including means for delivering an output signal proportional to the difference between the said first signal received from the piezoelectric bodies and the reference signals, and means electrically connecting the said output signal to the machine drive to stop the same and hence also stop the driving member and the carriage when the signal from the piezoelectric bodies exceeds the reference signal by a predetermined amount.

13. The invention of claim 1, said knitting machine including a needled bed, and said safety means being a vibration pick-up positioned to sense vibrations of the needle bed.

14. The invention of claim 13, wherein the vibration pick-up comprises, in combination, a housing which is applied firmly against the needle bed, a mass within the said housing, a piezoelectric body which is provided with two electrodes and is gripped between a wall of the housing and one end of the mass, and a compression spring which is arranged between the opposite end of the mass and the opposed part of the housing to urge the mass towards the piezoelectric body.

15. The invention of claim 13, said means responsive to the first signal being a semi-conductor, a relay means in series with the semi-conductor for controlling operation of the knitting machine, and wherein when the said first signal is of sufficient magnitude it triggers the semi-conductor to permit passage therethrough of electrical current to operate the relay means.

16. The invention of claim 15, said semi-conductor being a thyristor, said piezoelectric body electrodes being connected through a voltage distributor and a filter to the thyristor.

17. The invention of claim 13, wherein the machine is a two-bed flat knitting machine, and wherein each needle

bed includes a piezoelectric vibration pick-up and the two said pick-ups are electrically connected in parallel.

18. The invention of claim 1, said machine having a movable carriage and cam parts mounted therein in cam plates fixed to the carriage, and wherein said safety means includes means for sensing reaction forces set up by the carriage and also means for sensing reaction forces to which the cam parts are subjected.

19. The invention of claim 18, wherein said means sensing reaction forces of the carriage comprises a driving member movable with the drive of the knitting machine, said monitored part of the machine being a driven part of the carriage, a force detecting piezoelectric body located on each end of the said driven part of the carriage, as seen in the direction of travel of the carriage, and said driving member having arms positioned on opposite sides of each piezoelectric body, as seen in the direction of travel of the carriage, whereby forces tending to create relative movement between the driving member and the driven parts are sensed by the piezoelectric bodies, and wherein the means responsive to reaction forces on the cam parts includes a piezoelectric body on each end of the cam part, as seen in the direction of travel, and a part of the said cam plate being positioned on the opposite side of each piezoelectric body.

20. The invention of claim 19, wherein all said piezoelectric bodies are connected in parallel, a comparator stage having first and second inputs, a reference signal emitter, said comparator receiving a signal from said piezoelectric bodies at the first input and the reference signal at the second input, said comparator including means for delivering an output signal proportional to the difference between the said first signal received from the piezoelectric bodies and the reference signal, and means electrically connecting the said output signal to the machine drive to stop the same and hence also stop the driving member and the carriage when the signal from the piezoelectric bodies exceeds the reference signal by a predetermined amount.

21. The invention of claim 20, said knitting machine including a needle bed, said safety means further including a vibration pick-up device positioned to sense vibration of the needle bed.

22. The invention of claim 21, wherein the vibration pick-up device comprises, in combination, a housing which is applied firmly against the needle bed, a mass within the said housing, a piezoelectric body which is provided with two electrodes and is gripped between the wall of the housing and one end of the mass, and a compression spring which is arranged between the opposite end of the mass and the opposed part of the housing to urge the mass towards the piezoelectric body.

23. The invention of claim 22, said means responsive to the piezoelectric bodies of the vibration pick-up device being a semi-conductor, a relay means in series with the semi-conductor for controlling operation of the knitting machine, and wherein the vibration pick-up force signal is of sufficient magnitude it triggers the semi-conductor to permit passage therethrough of an electrical current to the relay means to open the circuit delivering current to the machine driving means.

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