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Eiler

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[54] **CRANE OVERLOAD SAFETY DEVICE WITH TEMPERATURE COMPENSATION**

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[51] **Int. Cl.** **B66c 13/48**

[58] **Field of Search** .... 33/147 D, 148 D, 125 T; 73/88 R, 141 A; 212/39; 340/267 C

[56] **References Cited**

UNITED STATES PATENTS

3,754,665 8/1973 Eiler .... 212/39 MS

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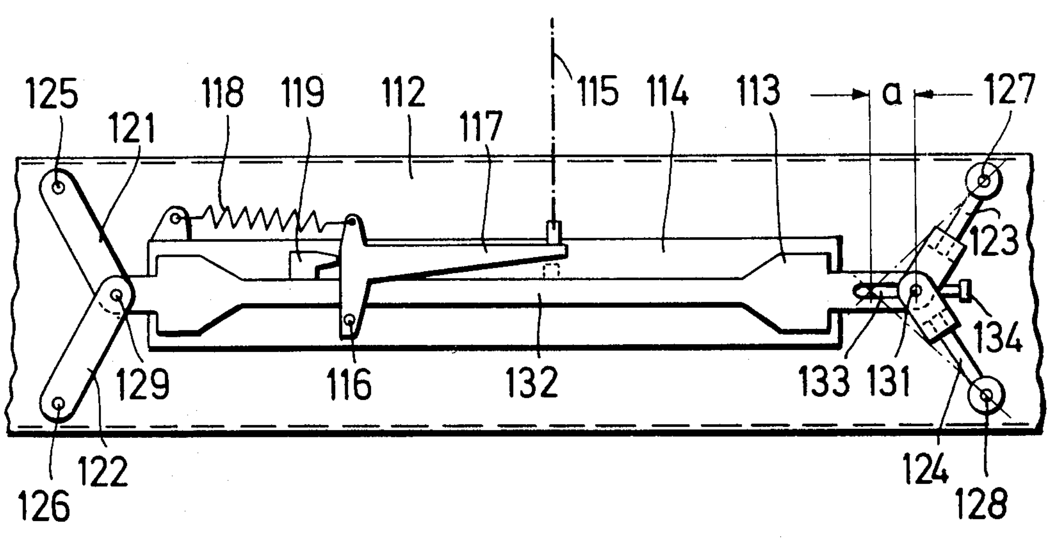
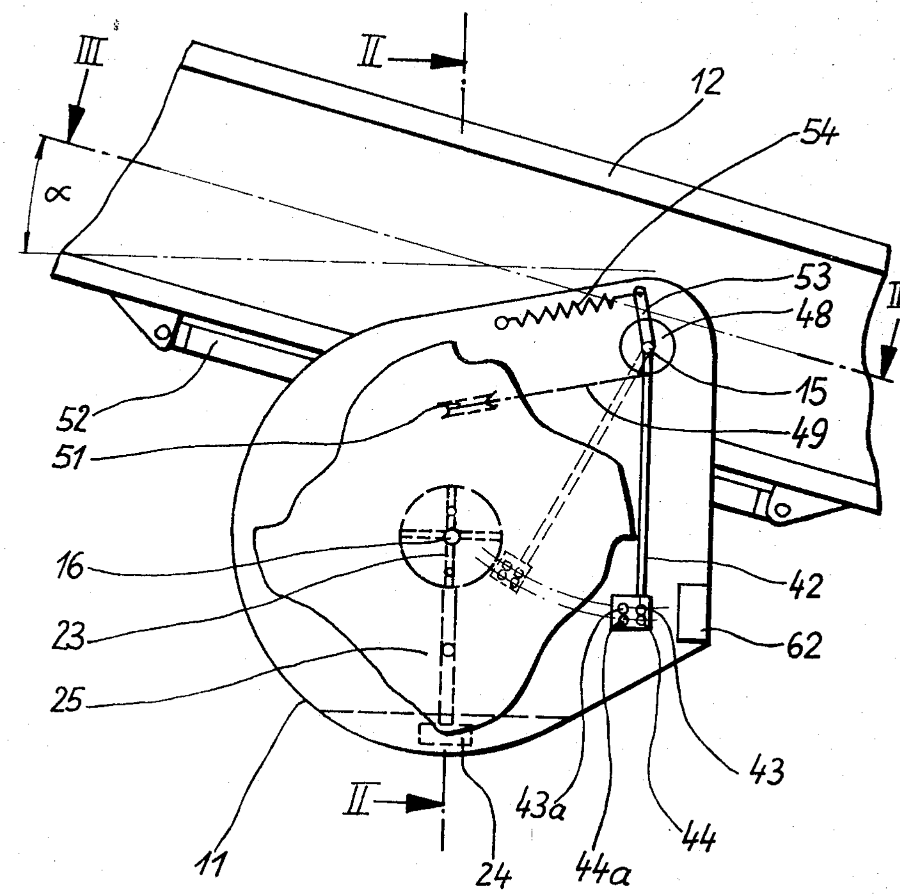
[57] **ABSTRACT**

A crane overload safety device including at least one pivoted arm connected to a strain measuring device adapted to be fixed to a loaded part of the crane. The pivoted arm is provided with one or more photocell devices or the like and cooperates with at least one cam disc. The strain measuring device is in the form of a tension rod dynamometer both ends of which are adapted to be attached to the loaded part of the crane by multipoint suspension devices.

9 Claims, 5 Drawing Figures

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α
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48
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FIG. 1

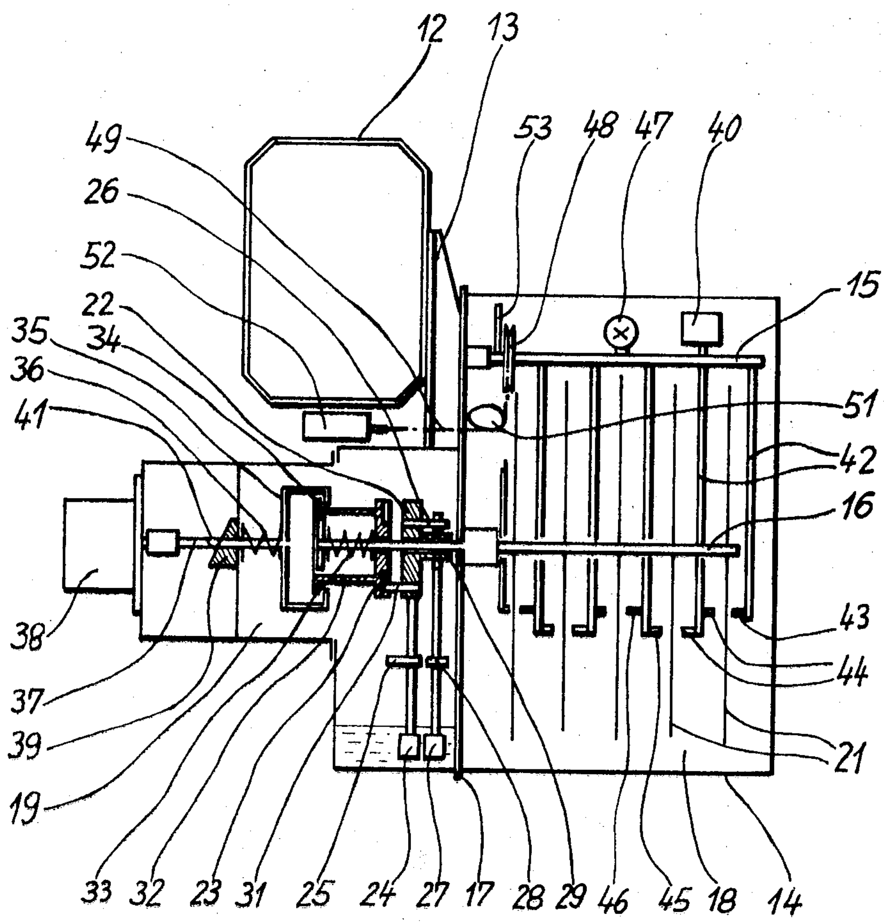
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FIG. 2

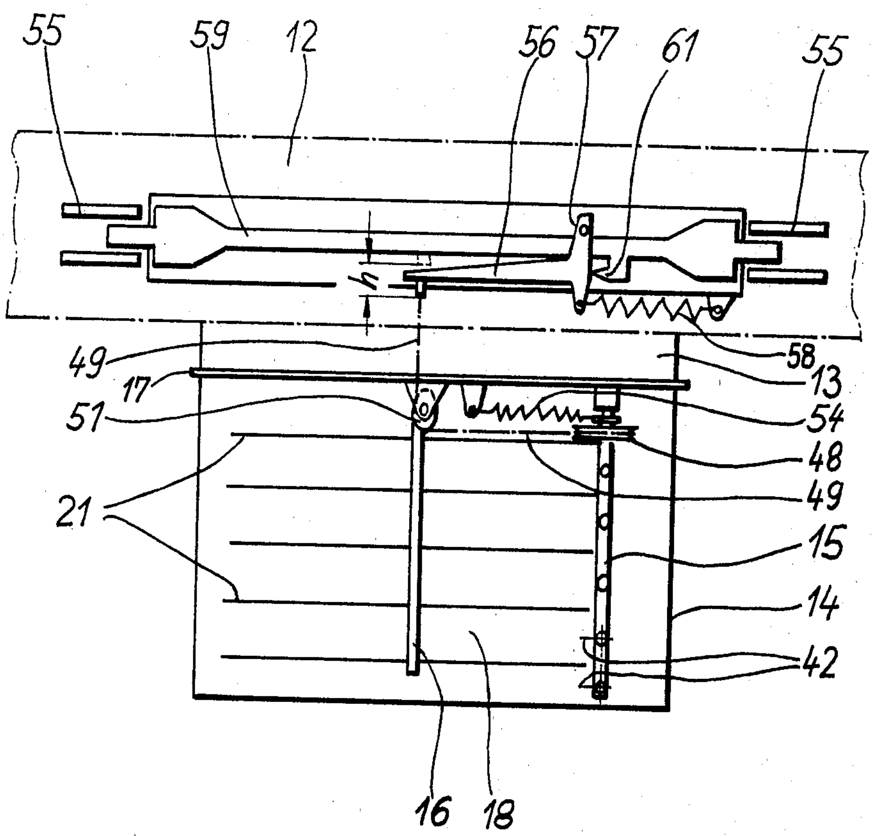
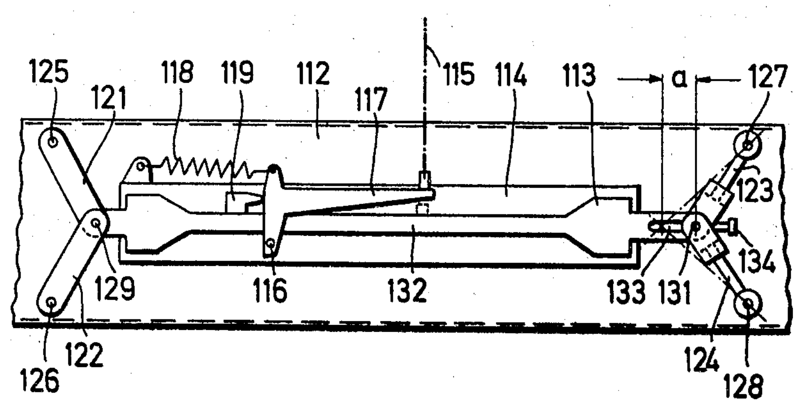


FIG. 3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121
118
119
112
117
115
114
113
a
127
123
134
129
116
132
133
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124
128

FIG.4

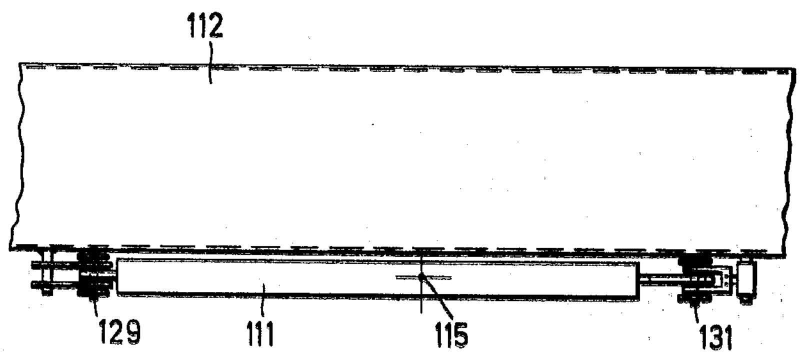
112
129
111
115
131

FIG. 5

CRANE OVERLOAD SAFETY DEVICE WITH TEMPERATURE COMPENSATION

This invention relates to overload safety devices for cranes, particularly for mobile cranes mounted on motor driven vehicles.

Cranes, particularly those mounted on motor driven vehicles, need to be equipped with overload safety devices for preventing accidents. This is necessary not only from practical experience but also to comply with relevant legal regulations. Several forms of overload safety devices have already been proposed. Existing overload safety devices are intended in particular to ensure that the crane, mounted on its motor driven vehicle, cannot topple over in operation. This ensurance is of particular importance in the operation of cranes mounted on turntable. In cranes of this kind the highest permissible crane load is limited by the stability of the crane, particularly when the jib extends sideways from the longitudinal axis of the vehicle. To ensure safety the load lifted by the crane must never be as high as 100 percent of the ultimate load determined by the stability of the vehicle on the ground.

All the safety devices which have hitherto been proposed for giving warning signals and for actuating systems for preventing further operation of the crane, when the permissible load limit is approached, involve the use of electronic devices, in particular transmitters which deliver signals representing stresses, moments and geometric quantities, for example jib angles, jib extension lengths and the like. The transmitters operate on known comparison principles in which the measured value of a current or voltage is compared with a specified value. The measured values are processed by a central computing device which continuously compares them with stored specified values. As soon as the permissible load is reached signals are automatically delivered which prevent operation of all the crane functions which could increase the load still further. The advantage of this is that the crane operator does not need to observe signals representing stresses and geometric quantities, during operation of the crane and compare the indicated values with the permissible values, which has to read from tables, so that he can adapt the further operation of the crane to the prevailing conditions and safety regulations.

However, although existing overload safety devices do relieve the operator from the need to read signals and consult tables, nevertheless they have considerable disadvantages in that they are not well adapted to the conditions which prevail in the operation of cranes mounted on motor driven vehicles. In the first place, the highly sensitive electronic transmitters and computing devices are too fragile to withstand the rough working conditions of a crane, or they have an insufficiently long working life. Furthermore, devices of this kind are costly and when they develop faults repairs can be effected, if at all, only at considerable cost in time and money. Repairs usually involve a dismantling of the entire device by specialists who have to be brought in for the purpose.

I have previously proposed an overload safety device for a crane, the device being less costly to manufacture, of more robust and reliable construction, and having greater ease of installation on a crane without repairing specialized technical knowledge. Such prior device included at least one pivoted arm connected to a strain measuring device which is adapted to be fixed to a loaded part of the crane, the pivoted arm being provided with one or more photocell devices or the like and cooperating with at least one cam disc.

Thus this prior device avoids the use of delicate electronic devices and enables an overload safety device to be constructed using mechanical parts shaped to represent operational parameters, the mechanical parts themselves in the form of the cam disc or discs performing evaluation and comparision functions in such a way that when the permissible load limits are reached signals are delivered which prevent the operation of further load-increasing crane functions.

During operation of the crane the position of the pivoted arm is determined at any instant by the strain measuring device in dependence on the forces acting on the crane at that instant. The pivoted arm or each pivoted arm cooperates, by means of its photocell device or the like, with the edge of the cam disc, which has a shape representing the permissible values of the relevant parameters, for example the jib angle, the length of the jib extension, the direction of the jib plane relative to the vehicle in the case of a mobile crane, and the nature of the support of the vehicle on the ground. The edge of the cam disc interrupts a beam such as a light beam of the photocell device or the like when the permissible load is reached.

However, although this prior overload safety device operates entirely satisfactorily, nevertheless it has been found that the indications given by the device and the controlling action of the device are subjected, under certain circumstances, to temperature influences which can have disadvantageous effects. For example, if the dynamometer is in the shade while the stressed constructional part of the crane is being warmed by the sun, different thermal expansions occur which are superposed on the changes in length produced by the crane loads. Consequently, the overload safety device responds either too early or too late.

The object of the present invention is to improve the overload safety device so as to allow it to function independently of temperature changes. The invention starts out with the idea of utilizing the stress effects in the loaded structural part of the crane for the temperature compensation by suitably attaching the dynamometer to the loaded structural part, using a compensating attachment. The problem is solved according to the invention in that both ends of the strain measuring device, which is in the form of a tension rod dynamometer, are arranged to be attached to the loaded structural part of the crane by multipoint suspension devices. What is essential in the invention is therefore that the tension rod dynamometer is attached to the loaded structural part at geometrically separate points.

Each multipoint suspension device preferably consists of two links pivoted to the end of the tension rod dynamometer preferably on a common axis, the other ends of the links being arranged to be attached to the loaded structural part. It has been found that by this method of attachment the different thermal expansions between the dynamometer and the loaded part are compensated as though the two structures are both at the same temperature.

A suspension device which is particularly simple to install on the crane is provided if the attachment points of the links on the loaded part of the crane are situated on either side of the longitudinal axis of the dynamometer, symmetrically with respect to this axis.

The method of attachment of the overload safety device has the further advantage that a particularly simple means of adjustment can be arranged for adjusting the movement ratio between the movement of the pivoted arm and the movement of the pivoted lever of the dynamometer. The pivoted arm is connected to the pivoted lever of the dynamometer by a cable. It is necessary to adjust the movement ratio because the thicknesses of the structural parts of cranes vary from crane to crane, within the manufacturing tolerances. Consequently, for a given crane load, and assuming given crane load conditions, the change in length of the dynamometer tension rod varies from crane to crane. This can falsify the measured values and the switching off action of the overload safety device. Before putting a crane equipped with an overload safety device into operation it is therefore necessary to calibrate the overload safety device, in order to ensure that under given load conditions the pivoted arm takes up the correct position relative to the disc cam. Hitherto the calibration has been effected by selecting a roller or segment disc of suitable diameter. This roller or segment disc is mounted on the axle of the pivoted arm and supports the cable connecting the pivoted arm to the pivoted lever on the dynamometer. The suspension device according to the invention allows the calibration to be effected without any necessity to exchange a part of the overload safety device, or at least allows a coarse calibration to be obtained. For this purpose at least one end of the dynamometer may have a slot in which the pivot pin for the ends of the links connected to the dynamometer is adjustable in position by means of an adjustment screw. The two links are preferably made adjustable in length.

An example of an overload safety device in accordance with the invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic side view of part of a crane jib incorporating an overload safety device;

FIG. 2 is a section taken along the line II—II in FIG. 1;

FIG. 3 is a section taken along the line III—III in FIG. 1;

FIG. 4 is a diagrammatic plan view of the tension rod dynamometer according to the invention attached to a crane jib; and,

FIG. 5 is a side view corresponding to FIG. 4.

As shown in the drawings an overload safety device **11** is attached by means of a bracket **13** to a crane jib **12**, of which the drawings show only a part. The overload safety device **11** has a housing **14** which is subdivided into two compartments **18** and **19** by a wall **17** which supports two shafts **15** and **16**. The shaft **16** rotates in a bearing fixed to the wall **17** and extends into both compartments. The part of the shaft **16** in the compartment **18** supports a number of cam discs **21**. The rim of each cam disc **21** has a complex curved shape representing permissible jib loads for varying jib luffing angles α. Each cam disc **21** is divided into four quadrants, each of which represents a particular crane operating condition, that is to say with the crane vehicle supported, for example, by outriggers; the crane vehicle unsupported; the jib in the plane of vehicle's longitudinal axis; and the jib in a plane perpendicular to vehicle's longitudinal axis. Furthermore, each individual cam disc **21** represents a particular amount of jib extension, for example when the jib is telescoped.

The part of the shaft **16** in the compartment **19** supports a pendulum plate **22** which is free to rotate on the shaft **16.** To the lower part of the pendulum plate **22** a pendulum **24** is attached by an arm to which a photocell or a light source **25** is mounted. A coupling pin **31** projects from the side of the pendulum plate **22.** Projecting from the other side of the pendulum plate **22** in a position above the shaft **16** there is a pivot pin **26** from which a control pendulum **27** is suspended. A photocell or light source **28** is mounted on the arm of the control pendulum **27** and this photocell or light source **28** cooperates with the photocell or light source **25** of the main pendulum **24.** The arm of the controller pendulum **27** is interrupted by a clearance ring **29** which surrounds the shaft **16.**

The free ends of the two pendulums **24** and **27** are immersed in a highly viscous liquid contained in the lower part of the compartment **19.** The viscous liquid has a damping effect on the two pendulums for the purpose of damping out oscillations when the jib angle is changed. It should be observed that the overload safety device is fixed to the jib by the bracket **13** and therefore follows the jib movements.

The coupling pin **31** is capable of fitting into any one of four recesses **23** distributed at 90° intervals around the face of a cam disc adjustment plate **32** which is mounted on the shaft **16** so that it cannot rotate relative to the shaft **16** but can slide axially along the shaft **16,** against the action of a spring **33.** An extension sleeve of the cam disc adjustment plate **32,** extending away from the pendulum plate **22,** has a radially projecting rim **34** which cooperates with the rim of a surrounding housing **35.** The housing **35** is mounted on a shaft **37** of a windscreen wiper motor **38** fixed to the housing **14** of the overload safety device. The housing **35** cannot rotate relative to the shaft **37** but can slide axially along the shaft **37** against the action of a spring **36.** Fixed to the shaft **37** is a face cam **39** which cooperates with a pin **41** in such a way that when the windscreen wiper motor **38** is set in motion the housing **35** is moved axially along the shaft **37,** towards the left as seen in FIG. **2.** The rim of the housing **35** then engages frictionally with the radially projecting rim **34** of the cam disc adjustment plate **32,** pulling it away from the pendulum plate **22** until the coupling pin **31** comes out of engagement with the recess **23.**

Fixed to the other shaft **15** there are a number of arms **42.** As shown in FIGS. **2** and **3** the arms **42** are spaced along the shaft **15,** relative to the cam discs **21,** in such a way that each arm **42** swings inwards between two cam discs. The arms **42** are counterbalanced by a counterweight **40.** The shaft **15** is positioned to one side of the shaft **16** so that when the arms **42** are vertical they occupy a plane beyond the ends of the radii of the cam discs **21.** The free ends of the arms **42** carry photocells or light sources or the like. In the example shown the arms **42** at the extreme right in FIG. **2,** furthest away from the windscreen wiper motor, has a light source **43.** The arm next towards the left carries two photocells **44,** one of which is in line with the light source **43,** the other photocell being displaced in position relative to the first and facing in the opposite direction. This photocell cooperates with a light source **45** on the next arm towards the left, this arm having a second light source **46** facing towards the left. The arrangement is repeated all the way to the arm furthest to the left. This manner of arranging the light sources and photocells reduces the amount of electrical wiring to the minimum and also keeps the photocells away from stray beams of light. The wiring can if desired be reduced still further by mounting a lamp bulb **47** centrally on the shaft **15**, the light from the bulb **47** being conducted to the locations **43, 45, 46** and any remaining light source locations by light conductors such as optical fibre bundles.

As shown in FIG. **1,** each arm **42** can be equipped with auxiliary photocells **43***a*, **44***a* situated next to the photocells **43, 44,** to provide an early warning system.

A pulley wheel **48** is fixed on the left hand end of the shaft **15** as seen in FIG. **2,** that is to say the end nearest to the jib **12.** One end of a tension cable **49** is fixed to the pulley wheel **48.** The cable **49** runs over a second pulley wheel **51,** the other end of the cable being attached to a tension rod strain gauge **52** which is fixed to the surface of the lower web, that is to say the compression web, of the crane jib **12.** A return tension spring **54** acts on a lever **53** fixed to the shaft **15,** the return spring **54** pulling against the tension of the cable **49.**

In the example illustrated, the tension rod strain gauge **52** is arranged as follows: The tension rod **59** is installed with a tensile prestress corresponding to the highest permissible compressive stress which can be applied to the web of the crane jib. When the crane is in operation, if the jib stress reaches the highest permissible value the tension rod **59** is no longer stressed in tension. As soon as the jib load increases beyond this point the tension rod releases itself from its two anchorages **55.** This is to ensure that if the operator disconnects the overload safety device, for example willfully, the device nevertheless suffers no damage.

The free end of the cable **49** is attached to a lever **56** pivoted at **57** to a frame of the gauge. In FIG. **3** the jib is assumed to be unloaded. Under these circumstances the free end of the lever **56** is at a distance *h* from its other limiting position, corresponding to the highest permissible jib load. A return tension spring **58** holds the lever **56** in contact with an actuating finger **61** on the tension rod **59.**

This example of the overload safety device operates as follows: Let it be assumed that the jib is initially in the working position shown in FIG. **1.** The pendulum **24,** acting through the cam disc adjustment plate **32,** which cannot rotate relative to the shaft **16,** rotates all the cam discs **21** into positions corresponding to a vertical position of the pendulum. This automatically compensates for any slope of the vehicle on which the crane jib is mounted. A load lifted by the crane and applied to the jib swings the arms **42** inwards by means of the strain gauge and the cable **49.** If the jib load reaches the permissible limit the light beam of the photocell device **43, 44** is interrupted by the edge of the cam disc.

The load on the jib allows the tension rod **59** to contract, the finger **61** pivoting the lever **56** clockwise towards the tension rod. The cable **49** consequently rotates the pulley wheel **48** clockwise, as seen in FIG. **1.** This swings the arms **42** towards the shaft **16.** If the jib load approaches the permissible limit, the light beams of the early-warning photocells **43***a*, **44***a* are first interrupted by the edge of the cam disc **21.** This produces an early-warning signal. With further increase of the jib load the light beam of the photocell device **43, 44** is interrupted by the edge of the cam disc, the interruption automatically prevents any crane movements which could increase the jib load still further.

A fail-safe effect is obtained as follows. Should the connection between the swinging arms **42** and the rod **59** be interrupted, for example by rupture of the cable **49,** potentially dangerous crane movements are prevented by the fact that the return spring **54** immediately swings the arms **42** back into a safety light trap **62,** interrupting all the relevant circuits.

As already mentioned, each individual cam disc represents a particular jib extension, or range of extensions, whereas each of the four quadrants of each cam disc represents a particular crane operating condition. When the operator changes from one operating condition to another, for example when he swings the jib around from a longitudinal position to a transverse position relative to the longitudinal axis of the crane vehicle the overload safety device is re-set to the new condition as follows. The windscreen wiper motor **38** is started and rotates the face cam **39** relative to the pin **41.** This pulls the housing **35** and the cam disc adjustment plate **32** away from the pendulum plate **22,** disengaging the coupling pin **31** from the recess **23.** The cam disc adjustment plate **32** is then rotated through **90°** until the coupling pin **31** engages in the next recess **23.** During this movement the shaft **16** rotates, rotating all the cam discs **21** through 90°. The movements leaves the overload safety device re-set for the new operating condition.

The resetting of the overload safety device to a different jib extension is a simple matter. All that is necessary is to switch over electrically so as to connect the photocell of the relevant cam disc. Electric connection is made between the photocell device and the safety switch system for preventing the crane operations. It should be observed that only one photocell device is connected at a given instant with the safety switch system. Consequently even though all the swinging arms **42** move simultaneously, only the particular photocell device which is connected in the control circuit can deliver a signal to indicate that its light beam has been interrupted by the edge of the relevant cam disc. In principle it would be possible to re-set the system for a different jib extension by switching on the relevant photocell light source. Considerable advantages are however obtained by using optical fibre light conductors. All the light conductors are fed with light from a central light source. This arrangement has the advantage of greater reliability and considerably less electric wiring is required.

FIGS. **4** and **5** illustrate a preferred strain-measuring device in the form of a tension rod dynamometer **111** attached to a crane jib **112,** which acts as the stressed structural part. Only a portion of the crane jib is shown in the Figures. The tension rod dynamometer **111** is attached to the crane jib by two suspension devices which will be described in greater detail further below. For the reasons already mentioned the tension rod dynamometer **111** is installed prestressed. Moreover the two rods **113** and **114** forming the dynamometer are also prestressed against each other, that is to say the inner rod **113** is prestressed against the outer rod **114,** the two rods being fixed to each other at one end. This is to prevent damage, particularly to the pivoted arm by collision with the cam disc axle if the prestressing is entirely cancelled by overloading, for example if the crane operator unintentionally by-passes the overload safety device.

A cable **115** has one end attached to the pivoted arm mentioned above, the other end of the cable being attached to the end of a pivoted lever **117** which pivots on a pivot pin **116.** The pivoted lever **117** is held back by a tension spring **118** so that the pivoted lever rests in contact with an actuating finger **119** fixed to the inner rod **113.**

The tension rod dynamometer is supported at each end by a multipoint suspension device attached to the stressed structural part **112.** At each end of the tension rod dynamometer the multipoint suspension device consists of two links **121, 122** or **123, 124.** One end of each link is pivoted to the structural part **112** by a pivot pin **125, 126, 127, 128.** The other end of each link is pivoted to one end of the tension rod dynamometer, the links being pivoted to the ends of the tension rod dynamometer in pairs on common pivot pins, that is to say the two links **121, 122** are pivoted to one end of the tension rod dynamometer on the common pivot pin **129,** the other two links **123, 124** being pivoted to the other end of the tension rod dynamometer on a common pivot pin **131.** The two common pivot pins **129** and **131** are fixed to the two ends of the tension rod dynamometer **111.**

In the present example the dynamometer is suspended as though by toggle joints by the two pairs of links **121, 122** and **123, 124** at the four support points **125, 126, 127, 128** of the stressed structural part **112.** As a result a surprisingly effective temperature compensation is obtained in that unequal thermal expansions resulting from temperature differences, which could falsify the stress measurements, are compensated so effectively that the overload safety device functions correctly, responding only to the load conditions of the crane. It has been found advantageous to make the distances between the support points, measured longitudinally, that is to say the distance between the support point **125** and the support point **127,** and the distance between the support point **126** and the support point **128** greater than the length of the dynamometer **111.** In other words, the distances between each two support points on the same side of the symmetry axis **132** are in each case greater than the length of the dynamometer **111.** The arrangement shown in FIG. **4** is thus obtained, the two links of each pair, that is to say the links **121** and **122** and the links **123** and **124,** spreading outwards away from the dynamometer.

The overload safety device is particularly well suited, due to its special construction, to facilitate the necessary adjustment, mentioned earlier, of the movement ratio between the movement of the pivoted lever **117** and the resulting movement of the pivoted arm. This adjustment is necessary for calibrating the overload safety device to compensate for differences in the thickness of the stressed structural part **112** in different cranes. To allow this adjustment to be made one end of the dynamometer **111** has a longitudinal slot **133** allowing the pivot pin **131** to be adjusted in position by means of an adjustment screw **134.** The lengths of the links **123, 124** are also adjustable. In the present example each link **123, 124** consists of an externally threaded rod pivoted at one end of the pivot pin **127** or **128.** Each externally threaded rod cooperates with an internally threaded part pivoted on the common pivot pin **131.** This arrangement makes it unnecessary to interfere with the interior of the measurement or switch-off apparatus. The angle between the links **123** and **124** can be changed continuously, that is to say steplessly, to allow for differences in the thickness of the structural part **112,** which of course influences the changes in the length of the tension rod, and therefore in the angular position of the pivoted lever **117,** produced by changes in the load conditions of the crane.

The overload safety device in accordance with the invention is outstanding in the simplicity of its construction. A further considerable advantage is that the construction is particularly resistant to the impact shocks which occur during the operation of a crane. The device is therefore suitable for application to a wide variety of hoisting machines and related devices in which the highest permissible working load is limited by a number of different factors.

I claim:

1. An overload safety device for a crane comprising a strain measuring device arranged to be mounted on the crane boom, a pivotally mounted arm operatively connected to said strain measuring device, at least one photocell device positioned on said arm, at least one cam device arranged to cooperate with said photocell device to signal overload on the crane boom, wherein the improvement comprises that said strain measuring device is a tension rod dynamometer, and multipoint suspension means for each end of said tension rod dynamometer for separately connecting a common point on each end of said tension rod dynamometer to spaced attachment points on the boom.

2. A device according to claim **1,** wherein each of said multipoint suspension means consists of two links each pivoted to the common point on the end of said tension rod dynamometer, and the opposite ends of said links being arranged for attachment to the spaced attachment points on the boom.

3. A device according to claim **2,** wherein said dynamometer has a longitudinal axis extending through the common points at its opposite ends, and the attachments points of said links to said boom are situated on opposite sides of the longitudinal axis of said dynamometer and are symmetrical with respect to the longitudinal axis.

4. A device according to claim **3,** wherein the distance between each pair of said attachment points located on one side of said longitudinal axis and at the opposite ends of said dynamometer is greater than the length of said dynamometer.

5. A device according to claim **3,** wherein the distance between each pair of attachment points located on one side of said longitudinal axis and at the opposite ends of said dynamometer is less than the length of said dynamometer.

6. A device according to claim **2,** wherein at least one end of said dynamometer has a slot extending in the longitudinal direction thereof, a pivot pin forming the common point at one end of said dynamometer and extending through said slot and being adjustably positionable in the longitudinal direction of the slot, and an adjustable screw operatively connected to said pivot pin for positioning it within the slot in the longitudinal direction thereof.

7. A device according to claim **6,** wherein said two links connected to said pivot pin are each extensible in length.

8. A device according to claim **7,** wherein each of said extensible links consists of an externally threaded rod and an internally threaded cylinder in threaded engagement with said rod.

9. A device according to claim **1,** wherein said dynamometer comprises an inner rod and an outer rod coextensive with said inner rod and said inner rod and outer rod being pre-stressed against each other.

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