OVERLOAD WARNING APPARATUS

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ABSTRACT

An overload warning apparatus for cranes having a vertically angularly movable boom includes a boom radius cam coupled to the boom to be moved with changes in the angular elevation of the boom, an allowable load cam, and adjustable linkages connecting the two cams and connecting the allowable load cam to a pointer. One linkage can be manually adjusted to reflect different actual boom lengths, and another linkage can be manually adjusted to reflect different hoist tackle ratios, so that the pointer will give an indication of the maximum allowable or safe load on the hoist cable. A second pointer is responsive to a load cell which measures the actual load on the hoist cable. Coincidence of the pointers indicates that the maximum allowable or safe load on the hoist cable has been reached.

5 Claims, 6 Drawing Figures
Fig. 3

TO INDICATING SCALE

Fig. 4

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BACKGROUND OF THE INVENTION

This invention relates to boom equipped hoisting machines, and more particularly to an improved overload warning apparatus for such machines.

The hazards attending the operation of boom equipped cranes, and similar machinery, are well known. The problems of overloading the cranes so as to cause overturning or collapse of the boom supporting structure are real hazards. Many overload warning devices and maximum safe load indicators have been proposed to alert the operator of the approach of an unsafe condition or, in some cases, to directly affect the operation of the equipment so that an unsafe load cannot be lifted.

It is known that the safe load for any particular crane or similar machine is a function of the weight of the load being lifted, including the weight of the boom, and of the working radius at which the load is being lifted, and that the working radius in turn is a function of the angle of elevation of the boom and the length of the boom. Accordingly, warning systems have been proposed in which the boom angle is measured and a maximum safe load is determined based upon the boom angle, which maximum safe load is then compared with the actual load on the boom. The conversion of boom angle to maximum allowable load on the boom is often accomplished by means of a cam. A single cam can provide the proper conversion for a boom of a fixed length. However, if the boom length is changeable, it may be necessary to have several cams which can be alternately employed, with each cam being correct for a particular length of boom. Thus, when the boom length is changed by adding or removing sections, the safe load indicating apparatus must likewise be changed by bringing a different cam into operation. Alternatively, a single cam may be used with an adjustment either to the input or output of the cam to reflect the actual boom length being used. An example of this latter approach in which the input to the cam is adjusted is found in U.S. Pat. No. 2,978,925, issued Oct. 11, 1966, to Saunders et al. Whichever approach is adopted, ideally the adjustment should be capable of being accomplished readily by the crane operator without requiring excessive overhaul of the safe load indicating apparatus as the boom length is changed.

The measurement of actual load on the boom can effectively be made in cable operated hoisting equipment by measuring the tension in the hoist cable which runs from a hoist drum over the boom point. Such tension would be theoretically equal to the load being lifted on the boom if there were a single line leading from the boom point to the load. If, as commonly occurs, a multi-part hoist tackle is employed to provide a mechanical advantage, then the tension in the hoist cable is only a fixed fraction of the load being lifted, and when hoist tackle having a different number of parts is substituted then the fraction changes. Accordingly, when the hoist tackle ratio is changed, such change affects the ratio of the measured cable tension to loads lifted, and it must be compensated for in the warning apparatus. The necessity of compensating for changes in hoist tackle ratio was also recognized in said U.S. Pat. No. 2,978,925. Again, adjustment for changes in hoist tackle ratios should be capable of easy accomplishment by the crane operator.

The overload warning apparatus of this invention provides a simple, mechanical apparatus for producing a maximum allowable hoist load indication which can be compared with an indication of the actual load on the boom, and with provision for easy adjustment of the apparatus to compensate for changes in the length of the boom and for changes in the hoist tackle ratio.

SUMMARY OF THE INVENTION

In the present invention there is provided an overload warning apparatus for a boom equipped crane or similar machine having a hoist cable operating on the boom through a hoist tackle for lifting loads on the boom, together with measuring means responsive to the load on the hoist cable, a first cam movable in response to changes in the angular elevation of the boom and having a cam surface each point of which represents the working radius of a given boom length at a particular boom angle, a second cam having a cam surface each point of which represents the maximum allowable or safe load on the hoist cable corresponding to a given hoist tackle ratio at a particular actual working radius of the boom, a first cam follower riding the cam surface of the first cam and being moved in an amount proportional to changes in the working radius of the given length of boom as the boom angle changes, means for modifying the motion of the first cam follower to reflect differences between the actual boom length and the given boom length and for transmitting to the second cam the modified motion of the first cam follower, a second cam follower riding the cam surface of the second cam and being moved in an amount proportional to changes in the maximum allowable or safe load on the hoist cable corresponding to the given hoist tackle ratio at a particular actual working radius of the boom, means for modifying the motion of the second cam follower to reflect differences between the actual hoist tackle ratio and the given hoist tackle ratio, and means for comparing the output of the measuring means with the output of the means for modifying the motion of the second cam follower.

The invention further resides in the use of a link having an adjustable pivot point in the modifying means for adjusting for differences in the hoist tackle ratio. Specifically, the means for modifying and transmitting the motion of the second cam follower may include a linearly movable transmission member speed from the second cam follower, which is also linearly movable, and a link pivotally connecting the transmission member and the second cam follower. Means are provided for pivotally mounting the link at different points between the second cam follower and the transmission member corresponding to different particular hoist tackle ratios. The transmission member is thereby moved in an amount proportional to changes in the maximum allowable or safe hoist cable load corresponding to the actual hoist tackle ratio being used at a particular actual working radius of the boom.

Advantageously, with the foregoing arrangement, it is not necessary to change the cams every time the length of the crane boom is altered, or every time the mechanical advantage of the load hoist system is altered. Means are provided in the present invention to make simple manual adjustments so as to modify the output of such cams. Furthermore, the warning apparatus of the invention can be applied without change to all simi-
lar pieces of boom equipped machines of a particular type and size.

Accordingly, objects of this invention are: to provide improvements in overload warning apparatus constructions; to provide an overload warning apparatus having a mechanical arrangement which includes two cams, one for generating the working radius of a given length of the boom and the other for generating the maximum allowable load on the hoist cable corresponding to a given hoist tackle ratio, both of whose outputs can be modified without the necessity of changing the cams when the boom length is altered or the hoist tackle ratio is changed; to provide an overload warning apparatus which incorporates a cam for determining the maximum allowable hoist cable load corresponding to a given hoist tackle ratio at a particular actual working radius of the boom, and an easily adjustable pivotal linkage actuated by said cam for modifying the output thereof to reflect the actual hoist tackle ratio being used; and, in general, to provide an overload warning apparatus which is accurate, reliable and readily adaptable to various boom equipped hoisting machines while still being relatively simple and inexpensive to manufacture, assemble and use. Other objects and advantages will become apparent from the following description in which there is shown, by way of illustration and not of limitation, a preferred embodiment of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view in elevation of a crawler mounted crane to which the overload warning apparatus of the invention can be applied.

FIG. 2 is a side view in elevation of a hoist cable load transducer for measuring the actual load on the hoist cable.

FIG. 3 is a top plan view of a safe load indicator apparatus for indicating the maximum allowable load on the hoist cable.

FIG. 4 is a view in vertical section of the safe load indicator apparatus taken in the plane of the line 4—4 of FIG. 3.

FIG. 5 is a view in vertical section of the safe load indicator apparatus taken in the plane of the line 5—5 of FIG. 3.

FIG. 6 is a schematic view of a mechanism for comparing the output of the load transducer of FIG. 2 with the indicated maximum allowable load.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, in FIG. 1 there is shown a crane 1 to which the apparatus of this invention may be applied. The crane 1 includes a crawler type carrier vehicle 2 having a revolving machinery platform 3 mounted thereon. A cab 4 encloses the machinery on the platform 3 as well as the crane operator's station. A boom 5 is pivoted at its foot on the platform 3 for movement in a vertical plane and is supported at selected angular positions by a boom hoist cable 6 connected to a plural part boom hoist tackle, designated generally by the numeral 7. The free end of the boom hoist tackle cable is drawn about a driven boom hoist cable drum 8. The boom hoist tackle 7 is supported at the lower end on an A-frame 9 and at the upper end by a mast 10 pivotally connected to the machinery platform 3. A hoist cable 11 is drawn about a driven hoist cable drum 12 on the platform 3 and extends over a boom point sheave 13 at the upper end of the boom 5 to support a hook block 14.

A load transducer assembly 15 is mounted on the hoist cable 11 and is supported at a position adjacent to the hoist cable drum 12. The load transducer assembly 15 is of a known type in which a pair of spaced, fixed sheaves 16 are rotatably mounted on a frame 17 to engage the hoist cable 11 at longitudinally spaced points on one side of the cable 11. Disposed between the fixed sheaves 16 and to the opposite side of the hoist cable 11 is a movable sheave 18. The movable sheave 18 is supported in a cage structure 19 which encircles the frame 17 and has a top plate 20 which bears on one side of a hydraulic load cell 21. The other side of the load cell 21 is mounted against the frame 17. The transducer assembly 15 may be restrained and supported upon the hoist cable 11 in any suitable manner, as by lines 22 connected between the frame and anchorages on the machinery platform 3.

The hoist cable 11 is deflected as it threads its way through the fixed and movable sheaves 16 and 18, respectively. As the load on the hoist cable 11 increases, such increase will be reflected in increased tension in the cable 11 with the result that the cable 11 will tend to straighten its path through the sheaves 16 and 18 and will tend to move the movable sheave 18 away from the fixed sheaves 16. This force against the sheaves 16 and 18 is transmitted to the load cell 21 where it is transformed into an increase in hydraulic fluid pressure in the cell 21. Reduction in the load on the hoist cable is similarly transformed into reductions in the hydraulic fluid pressure in the load cell 21. The hydraulic fluid pressure in the load cell 21, and any changes therein is transmitted by a hose 23 to operate a suitable signaling or indicating device to be later described.

Accordingly, the load transducer assembly 15 will produce a signal, in the form of hydraulic fluid pressure, which is directly proportional to the load on the hoist cable 11. The load on the hoist cable 11 will not, however, be the same as the load on the hook unless the hook is directly connected to the hoist cable 11. More commonly, a plural part hoist tackle is employed, as in FIG. 1 wherein a two-part tackle is shown. In such cases, the load on the hoist cable 11 is a fixed fraction of the actual load being lifted (theoretically one-half in the two-part tackle of FIG. 1). Also, that fixed fraction will change as hoist tackles of different ratios are substituted. The warning device of the present invention includes provision for compensating for changes in the hoist tackle ratio.

Referring to FIGS. 3–5, a safe load indicator assembly 26 includes a base 27 and two spaced, parallel supporting plates 28 and 29 rising therefrom. A horizontal shaft 30 is journaled in the support plate 28. The exterior end of the shaft 30 is directly coupled to the crane boom 5 by suitable means (not shown) so that it rotates with the boom 5 as the boom is elevated or lowered. Thus, the angular position of the shaft 30 will correspond directly to the angle of elevation of the boom 5.

A boom radius cam 31 is secured to the inner end of the shaft 30 for rotation therewith. The cam 31 includes a slot 32 defining a cam surface and a linearly movable radius cam follower 33 mounts a follower pin 34 which rides in the slot 32. The radius cam follower 33 is guided for vertical movement by spaced guide blocks 35 mounted on the support plate 28. The slot 32
is so formed that each point thereof represents the working radius for a boom of a given assumed length at a boom elevation corresponding to the angular position of cam 31. Thus, the cam 31 converts the boom elevation to working radius for a given length of boom and the vertical position of the cam follower 33 is directly proportional to the working radius for the given length of boom. The given assumed length of boom would normally be taken as the standard length of boom supplied with the crane. The actual working radius of the boom is, of course, dependent on the length of the boom as well as the elevation of the boom. Since the length of the boom may be changed by adding or removing incremental lengths of boom as conditions warrant, provision is made to adjust the indicator 26 to reflect differences between the actual length of boom being used and the given boom length assumed for the cam 31. This adjustment is accomplished in a linkage between the cam follower 33 and a vertically movable transmission member 36.

Specifically, the transmission member 36 is laterally spaced from the radius cam follower 33 and is guided for vertical movement in guide blocks 37 mounted on the support plate 28. A floating radius link 38 connects the transmission member 36 and the radius cam follower 33. A pin 39 extends at a right angle from the upper end of the cam follower 33, and pivotally carries a slide block 40. The slide block 40 engages a slot 41 in the link 38 located near one end thereof. Similarly, a pin 42 extends at a right angle from the upper end of the transmission member 36, and pivotally carries a slide block 43. The slide block 43 engages a second slot 44 in the link 38 located near the opposite end thereof.

The link 38 is pivotally mounted on a removable pin 45 which can be inserted in any one of a series of pairs of apertures in the link 38 and the support plate 28. The link 38 is provided with a bank of spaced apertures 46 intermediate its ends. A horizontal bank of spaced apertures 47 is likewise formed in the support plate 28 intermediate the locations of the transmission member 36 and cam follower 33. Each aperture 47 in the support plate bank is associated with an aperture 46 in the floating link 38 to form a number of operative pairs, each such pair corresponding to a different part of the length of the boom 5. The pair of apertures 46 and 47 disposed closest to the connection between the link 38 and the transmission member 36 would represent the shortest length of boom, while the pair of such apertures closest to the connection between the cam follower 33 and the link 38 would represent the longest boom. Thus, by adjusting the pivot point of the floating link 38, the linear motion of the cam follower 33 is translated into linear motion of the transmission member 36 and is modified to reflect any difference between the actual length of the boom and the given length of boom. As can be appreciated, the linear movement of the transmission member 36 is thereby directly proportional to changes in the actual working radius of the boom 5; that is, the working radius for the actual length of boom being used.

The transmission member 36 carries a rack 48 which meshes with a pinion 49, the pinion being secured to a rotatable shaft 50 journaled in the support plates 28 and 29. As shown in FIGS. 3 and 5, a machine load capability cam 51 is mounted on the shaft 50 for rotary movement therewith and is located adjacent the support plate 29. The load cam 51 rotates through an arc proportional to changes in the actual working radius of the boom 5. The load cam 51 has a slot 52 forming its cam surface.

A linearly movable load cam follower 53 has a projecting follower pin 54 at its lower end that engages the slot 52 to ride the cam surface. The load cam follower 53 is guided for vertical movement in guide blocks 55 mounted on the support plate 29. The slot 52 is so formed that each point thereof represents the maximum allowable load for the crane at the actual working radius of the boom. This maximum allowable load is determined in terms of the hoist cable load for an assumed hoist cable tackle ratio and reflects consideration of the structural capability of the boom as well as the stability of the crane against overturning, whichever factor is critical at a particular working radius. Rotary movement of the shaft 50 will, therefore, be translated into linear movement of the load cam follower 53 in an amount directly proportional to the maximum allowable hoist cable load for the changing actual working radius of the boom for an assumed given hoist tackle ratio.

The hoist cable tackle can be and often is changed to adjust the hoist cable tension. Since the hoist cable tension for a given maximum allowable boom load will vary depending upon the tackle ratio, it is necessary to provide an adjustment for changes in the hoist cable tackle ratio. This adjustment is accomplished by translating the linear movement of the load cam follower 53 into a linear movement of another linearly movable transmission member 56 and at the same time modifying the translated vertical motion to reflect changes in the tackle ratio. The transmission member 56 is horizontally spaced from the load cam follower 53 near the opposite end of the support plate 29 and is guided for vertical movement in guide blocks 57 mounted on such support plate. A floating load link 58 connects the load cam follower 53 and the transmission member 56. A pin 59 extends at right angles to the upper end of the cam follower 53 and pivotally carries a slide block 60 which engages a slot 61 in the link 58. Similarly, a pin 62 extends at a right angle from the upper end of the second transmission member 56 and pivotally carries a slide block 63 which engages a second slot 64 in the link 58 at the opposite end thereof.

The load link 58 is also pivotally mounted on a removable pin 65 which can be inserted in any one of the series of pairs of apertures in the link 58 and the support plate 29. The link 58 is provided with a bank of spaced apertures 66 intermediate its ends and a horizontal bank of spaced apertures 67 is provided on the support plate 29 intermediate the locations of the transmission member 56 and cam follower 53. Each aperture 67 in the support plate bank is associated with an aperture 66 in the second link 58 to form a number of operative pairs, each such pair corresponding to a different particular number hoist tackle ratio. The pair of apertures 66 and 67 disposed closest to the connection between the cam follower 53 and the link 58 represents the lowest hoist tackle ratio, while the pair of such apertures closest to the connection between the transmission member 56 and the link 58 represents the highest hoist tackle ratio. By adjusting the pivot point of the load link 58, the linear motion of the cam follower 53 can then be modified to reflect any difference between the actual ratio and the assumed ratio. The linear movement of the transmission member 56 is thereby
made directly proportional to changes in the maximum allowable load as reflected by the maximum allowable safe pull in the hoist cable 11.

Since the output of the transmission member 56 is in direct proportion to the maximum allowable load it may be compared with the output of the load cell 21 which is directly proportional to the actual load on the hoist cable 1. The output of the transmission member 56 may be compared either in its linear form or by converting the motion to a rotary motion of a shaft 68 which mounts a pinion 69 in mesh with a rack 70 on the transmission member 56. The shaft 68 is journaled in a suitable opening in the support plate 29.

It is contemplated that those skilled in the art will be able to devise any number of suitable means for comparing the output of the hydraulic load cell 21 with the output of the transmission member 56 to initiate the operation of visual, or audible warning signal means, or both (not shown), signifying to the crane operator that the actual load on the boom and the corresponding hoist cable load is approaching, has reached, or is in excess of the maximum allowable or safe load for which the crane has been designed; or to initiate the operation of means for stopping or initiating the stoppage of the hoisting gear, or the like.

In FIG. 6, there is provided a suitable comparison means such as an indicating scale 71 which is mounted in the cab 4. The scale 71 is calibrated in terms of the load on the hoist cable 11. The output of the hydraulic load cell 21 operates a pointer 72 which is mounted for rotation on shaft 73; changes in hydraulic pressure in the load cell 21 being converted into angular motion of the pointer 72. A second pointer 74 is rotatably coupled to the output shaft 68 on the support plate 29. The pointer 74 is mounted for rotation (in a different plane than pointer 72) on shaft 75 which shaft fits concentrically about a portion of shaft 73 and rotates independently thereof. Thus, the output of the transmission member 56 is converted into angular motion of the pointer 74, which pointer indicates the maximum allowable or safe pull in the hoist cable 11 properly adjusted for actual boom length and actual hoist tackle ratio. Suitable means (not shown) can then be provided, for example, to produce a warning signal when the pointers 72, 74 come into coincidence, such coincidence of the pointers indicating that the maximum safe load is being lifted by the crane 1; or to stop or initiate stoppage of the hoisting gear upon coincidence of the pointers 72, 74. Various other modifications known to those skilled in the art are also possible.

The location of the apertures 47 in the support plate 28 and the cooperating apertures 46 in the radius link 38 can be selected not only to reflect change in working radius in accordance with change in boom length, but also to compensate for the additional boom weight resulting from increase in boom length. By taking increased boom weight into consideration in fixing the location of such apertures, such correction will be reflected in the output of the transmission member 56 and will result in a more accurate indication of maximum allowable load.

The location of the cooperating pairs of apertures 66 and 67 should likewise be fixed to compensate for the increased frictional losses in sheaves and elsewhere resulting from increasing the number of parts of line in the hoist tackle. While hoisting, the load on the hoist cable 11 will be greater than theoretical because of the inefficiencies of the sheaves, and this condition may be taken into account in fixing the location of the apertures 66 and 67.

The overload warning apparatus of this invention provides a simple and accurate means of indicating the approach or existence of dangerous hoisting conditions. Compensation for varying hoist tackle ratio as well as for varying boom lengths is readily made with minor adjustments in order to arrive at the maximum allowable hoist cable pull. The indicator 26 can be located in the operator's cab so that the adjustments can be easily made. An overload warning apparatus is provided which can be applied to virtually all types of cable operated, boom equipped hoisting equipment.

I claim:

1. An overload warning apparatus for a crane having a boom that is pivoted for angular movement in a vertical plane, a hoist cable working on said boom through a hoist tackle for hoisting loads, and measuring means responsive to the load on said hoist cable, said warning apparatus comprising:
   a first cam coupled to the boom for movement in response to changes in the angular elevation of said boom, said first cam having a cam surface each point of which represents the working radius of a given boom length at a particular angular elevation of the boom;
   a second cam having a cam surface each point of which represents the maximum allowable load on said hoist cable corresponding to a given hoist tackle ratio at a particular actual working radius of the boom;
   a first cam follower riding the cam surface of said first cam and being moved in an amount proportional to changes in the working radius of said given boom length as the elevation of said boom changes;
   means for modifying the motion of said first cam follower to reflect differences between the actual boom length and said given boom length, and for transmitting the modified motion of said first cam follower to said second cam;
   a linearly movable second cam follower riding said cam surface of said second cam and being moved in an amount proportional to changes in the maximum allowable load on said hoist cable corresponding to said given tackle ratio at a particular actual working radius of the boom;
   a linearly movable transmission member spaced from said second cam follower;
   a link pivotally connecting said second cam follower and said transmission member;
   means for pivotally mounting said link at different points between said second cam follower and said transmission member corresponding to different hoist tackle ratios;
   said transmission member being moved in an amount proportional to changes in the maximum allowable hoist cable load corresponding to the actual hoist tackle ratio at a particular actual working radius of the boom; and
   means for comparing the output of said measuring means with the output of said transmission member.

2. The warning apparatus of claim 1 wherein said first cam follower is linearly movable and wherein said
means for modifying and transmitting the motion of said first cam follower comprises:

a linearly movable second transmission member spaced from said first cam follower and operatively connected to said second cam;
a second link pivotally connecting said second transmission member and said first cam follower;

and means for pivotally mounting said second link at different points between said second transmission member and said first cam follower corresponding to different particular lengths of the boom;
said second transmission member being thereby moved in an amount proportional to changes in the particular actual working radius of the boom corresponding to the actual length thereof.

3. The warning apparatus of claim 1 wherein said comparing means includes a first pointer the movement of which is controlled by said measuring means, and a second pointer the movement of which is controlled by said transmission member, the movement of the two pointers into coincidence indicating that the maximum allowable hoist cable load has been reached.

4. The warning apparatus of claim 1 wherein said link is formed with a number of spaced apertures and said mounting means includes a removable pivot pin and a supporting plate having a horizontal bank of spaced apertures, each aperture in said supporting plate bank cooperating with an aperture in said link to form a number of operative pairs, and said pivot pin being engageable with a selected one of said operative pairs of apertures.

5. The warning apparatus of claim 2 wherein said second link is formed with a bank of spaced apertures, and said mounting means includes a removable pivot pin and a supporting plate having a horizontal bank of spaced apertures, each aperture in said supporting plate bank cooperating with an aperture in said second link to form a number of operative pairs, said pivot pin being engageable with a selected one of said operative pairs of apertures, and wherein the spacing of the apertures in each bank compensates for changes in actual boom length from the given boom length as well as for changes in boom weight corresponding to said boom length changes, thereby resulting in modified motion of said first cam follower.

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