SAFE LOAD INDICATOR FOR CRANE HOISTS

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My invention relates to a safe load indicator for crane hoists, the object being to provide a crane operator with means which will enable him to avoid so loading his crane as to tip the crane from its track or support due to the leverage action of the loaded boom taking into consideration both the actual load being raised and the boom angle.

The features of my invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. For a better understanding of my invention, reference is made in the following description to the accompanying drawing in which Fig. 1 represents a hoist crane of the general character to which my invention is applicable; Fig. 2 represents a preferred electric measuring circuit for carrying out the invention, and Fig. 3 a simplified electric circuit for this purpose.

In Fig. 1 I have represented a crane hoist which will serve to represent the general type of crane to which my invention may be applied. In such illustration 16 may represent a stationary or movable support having a circular track 11 thereon. A crane 12 is rotatively mounted on the circular track by flanged wheels 14. The crane is shown provided with a boom 14 hinged at 18. A cable 16 connected between a motor operated drum 15 and the boom 14 is provided for raising and lowering the boom. Another cable 18 has one end secured in fixed relation to the outer end of the boom, runs through the hoisting hook pulley 19 back over a pulley 20 at the outer end of the boom and to a motor operated hoist drum 21. The rotation of the crane about track 11 and the raising and lowering of the boom 14 and the hoisting hook 22 is under the control of the operator indicated at 23. The crane is assumed to be electrically operated but this is immaterial to my invention.

It is possible for an operator to so load a crane of this general type as to tip the crane from its track and cause damage, loss of time, etc.

In general, we may say that the stability of the crane is determined by the moment of crane load at P times horizontal boom radius D. Thus, if the boom makes an angle X to the vertical, a given load P will produce a tip moment:

\[ M = P(D \sin X) \]

For any particular crane there is an optimum moment which, if exceeded, will tip the crane over. This optimum moment we may designate K. Hence, in any situation P(D \sin X) must not exceed K. K may be readily determined by calculation or measurement. It is desirable for the operator to have before him an instrument or signal or both at which he may look at or be warned by in any case where the loading of the crane approached an unsafe or tipping condition. In accordance with my invention I provide the operator with an instrument 24 and an alarm 25 conveniently located which indicates the measurement of the tip moment M and gives an alarm in case M approaches dangerously close to the value K.

For the measurement of the load P, I provide an electro-responsive gauging device 26 in the dead end of the load hoisting cable 16 and for measuring the value \( \sin X \) I provide an electric device at 27 having a part rotated with and responsive to the turning of the boom 14 about its pivot 15.

Electric currents proportional to these measurements P and \( \sin X \) are conveyed to the electrical instrument at 24, in the form of a wattmeter, where the products of the currents are measured in terms of M. The meter is provided with alarm contacts which close to actuate the alarm 25 in case the measurement approaches dangerously close to the value K.

A preferred measuring system for this purpose is shown in Fig. 2. The load measuring device 26 comprises a known form of electric strain gauge. It comprises a piece of metal 28 of suitable dimensions and material which is placed under tension by the load or pull on cable 16 and which is elongated within its elastic limit in proportion to such tension. Fastened near the opposite ends of the tension member 28 are the two magnetic core parts 29 and 30 of a variable reactance. These parts are, therefore, moved towards and away from each other with decrease and increase of the load P. Such variation changes the air gap in the magnetic circuit and the current in the coil 31 which is energized by alternating current and produces a flux across the air gap between the magnetic core parts 28 and 30. The variable reactance just described is contained in a bridge circuit containing branch impedance elements 32, 33 and 34. Impedance element 34 is a reactance substantially similar to the one included in the strain gauge but is manually adjustable for circuit calibration purposes.

The bridge circuit is energized from an A.C. source 35. Its output is rectified by a rectifier 36 and fed to one coil of the direct current wattmeter 24. Elongation of member 28 due to load P unbalances the bridge and a current is supplied to the wattmeter proportional to P.
The device 27 for measuring \( \sin X \) may comprise a rotary type alternating current voltage regulating transformer having a stationary primary winding 37 and a rotary secondary winding 38. The rotary winding 38 will be rotated by the rotation of boom 14 about its axis 15. The winding 37 has opposite points energized from the A.C. source 35 and the secondary winding 38 has diametrically opposite terminals and feeds through a rectifier 36 to the remaining coil of the D.C. wattmeter 24.

If the boom 14 were straight up and the angle X zero, rotor 38 would be so positioned with respect to stator 37 that the leads to the respective windings would be 90 degrees displaced from each other. Under these conditions no voltage would be induced into the secondary winding 38. With the boom 14 lowered to the horizontal, the rotor 38 would be rotated to have its leads in line with the primary connections and a maximum voltage would be induced into the secondary. Thus the device 27 produces a voltage proportional to \( \sin X \), as intended.

For calibration purposes and to meet the conditions of different cranes the circuits are provided with calibration adjustment features. For example, the reactance 34 may be adjusted so that a small D.C. voltage appears across the rectifier 36 when there is no load on the hook 22 to represent the load of the weight of the boom assembly itself. One of the leads to the stator winding 37 may be adjustable to introduce a small plus or minus voltage on the rectifier 36 to adjust for cranes where the pivot of the boom is not directly over the tipping point which in this case is the right-hand wheel 13. A variable resistance 40 may be provided in the leads to the rectifier 36 to obtain the desired relation between the currents supplied from the two rectifiers to the wattmeter.

Exacting calibration of the wattmeter is not important except for values of \( X \) close to the critical tipping moment \( K \). Calibration may be had by trial for example with the boom horizontal and with \( P \) hooked to an excessive load on the ground, tighten cable 18 until the left-hand wheel 13 is raised slightly from the track. The reading of the meter 24 then corresponds to \( K \) and the alarm contacts at 41 should be set to ring the alarm and the scale of the meter at this pointer position and above may be painted, red for example as indicated at 42.

Another trial should be made with the boom 14 nearly vertical. Trials may also be made in lifting loads with maximum acceleration, etc. During such calibration trials a safety cable such as represented at 43 may be used to prevent dangerous tipping. The meter 24 is marked and its alarm contacts adjusted to indicate a dangerous condition before it is actually reached but close enough to the danger point so that the operator will utilize the full safe capacity of his crane.

A less elaborate measuring circuit for rough work is represented in Fig. 3. A reactance bridge similar to the one of Fig. 2 is provided but is energized through the device 27, and an A.C. voltmeter 42 is connected across the bridge. The voltmeter serves the purpose of wattmeter 24 of Fig. 2. The components \( X \) and \( P \) are combined in the bridge instead of in the wattmeter of Fig. 2.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for indicating the safe loading of boom cranes comprising electrical means for producing a current substantially proportional to the boom loading, electrical means for producing a current substantially proportional to the sine of the boom angle from the vertical and a wattmeter for measuring the product of such currents and producing an indication in terms of the degree of safety of crane boom loading.

2. Apparatus for indicating the safe loading of boom cranes comprising an electrical measuring instrument, a pair of electric controllers jointly influencing the energization of said instrument, one of said controllers causing the energization of said instrument to be substantially proportional to the boom loading and the other of said controllers causing the energization of said instrument to be substantially proportional to the sine of the angle of the boom from a vertical position, said instrument having a measurement response proportional to the product of the boom loading and the sine of the angle of the boom from a vertical position.

3. Apparatus for indicating the safe loading of boom cranes comprising an electrical measuring instrument, a strain gauge associated with an energizing circuit of said instrument, said gauge being controlled by the loading of the crane boom and causing the energization of said instrument to be substantially proportional to the boom loading, and a voltage regulator associated with an energizing circuit of said instrument, said regulator having relatively rotatable primary and secondary windings, one of which is rotated by the raising and lowering of the boom to cause the energization of said instrument to be substantially proportional to the angle of said boom from a vertical position, said instrument having a measurement response proportional to the product of the boom loading and the sine of the angle of the boom from a vertical position.