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[54] **METHOD FOR TESTING WIRE ROPE**

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[51] **Int. Cl.^{2}** **G01L 5/04**
[58] **Field of Search** .... 73/158, 88 R, 95, 15.6

[56] **References Cited**

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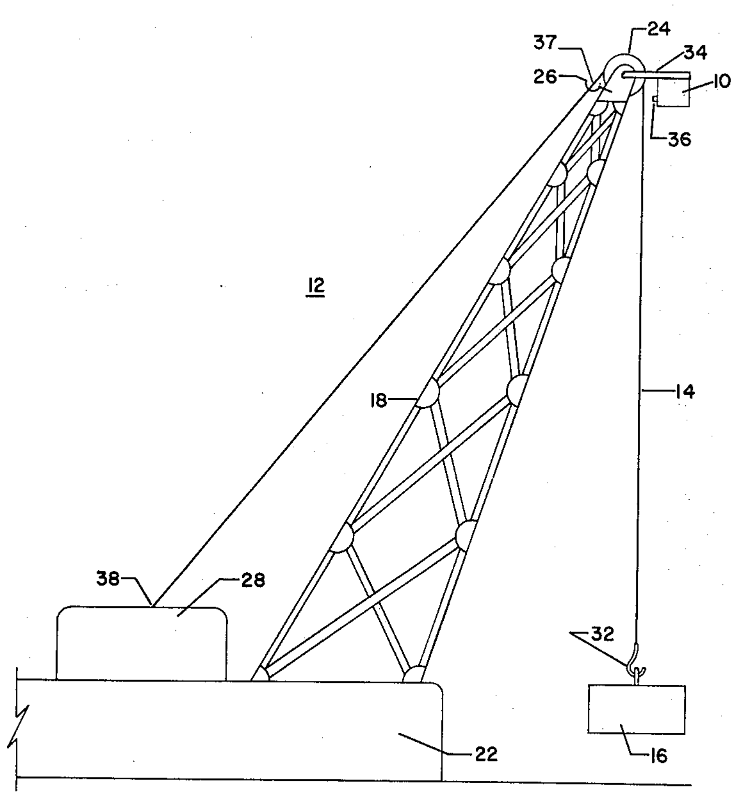
[57] **ABSTRACT**

A system for determining the quality of wire rope or cable. The thermal increase in a rope when it is performing work is utilized to determine its quality, a poorer quality rope displaying a larger temperature rise than a higher quality rope.

10 Claims, 2 Drawing Figures



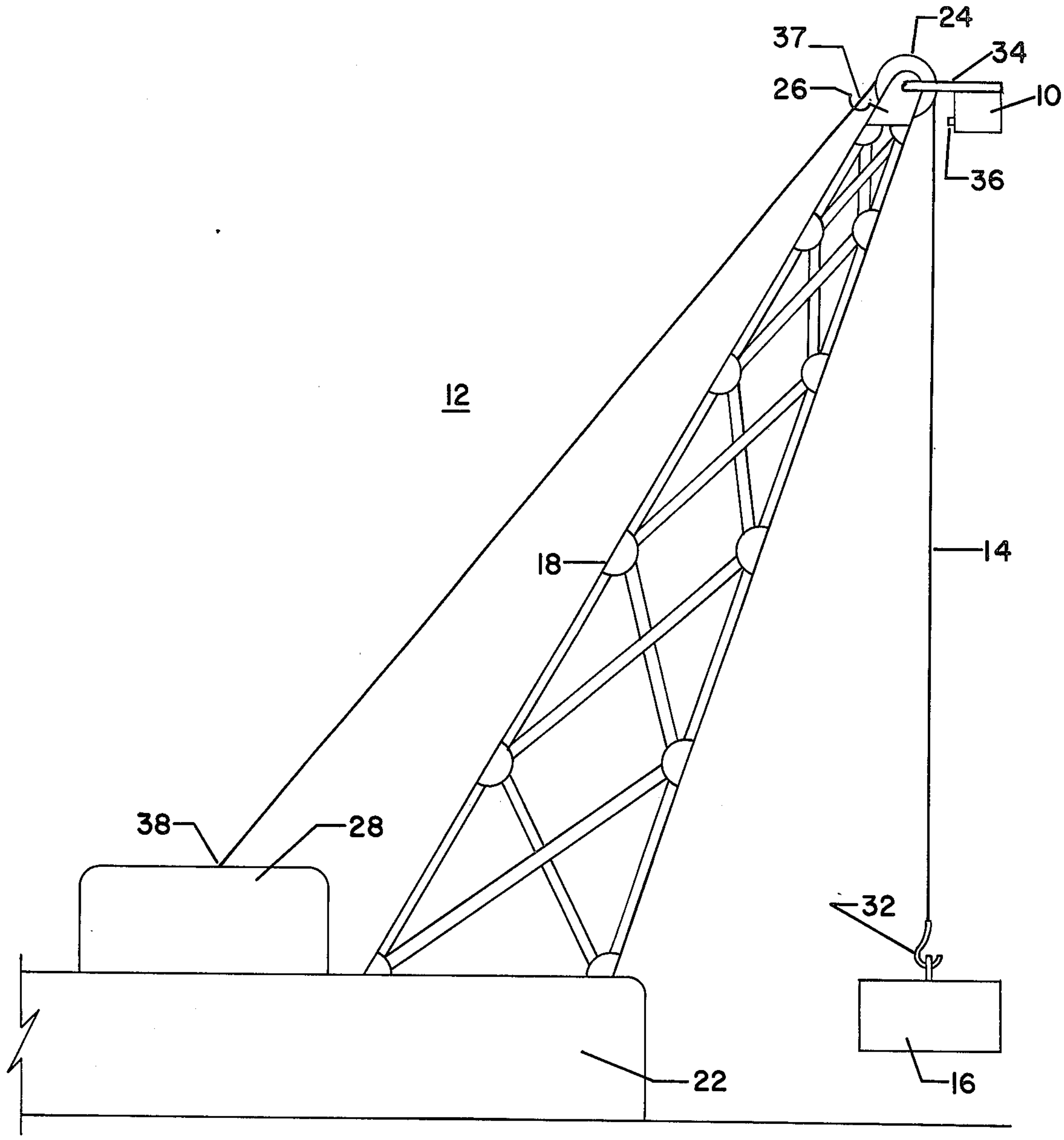


FIGURE 1.

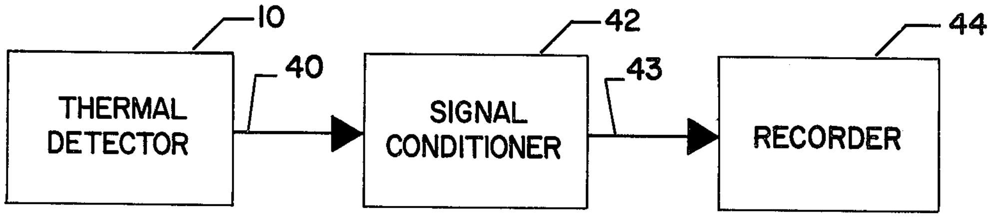


FIGURE 2.

METHOD FOR TESTING WIRE ROPE

The invention described herein was made in the course of or under Contract No. AT(29-1)-1183 with the U.S. Atomic Energy Commission.

BACKGROUND OF THE INVENTION

This invention relates to wire rope, or cable, and more particularly to a method of determining the quality of such wire rope by nondestructive means.

The wire rope, or cable, to which this invention relates is of the type which is usually manufactured by twisting together a plurality of strands of wire, each strand being composed of a plurality of twisted together individual wires. The number of uses of wire rope in our present day industrial society is truly legion. Uses of wire rope in cranes, hoists, elevators, ski lifts, etc., to suspend, raise, lower, shift or otherwise manipulate heavy loads come readily to mind. The failure of a rope in any of these applications could result in substantial property damage, injury, or even loss of life. It is apparent that the quality of a rope with respect to its ability to perform without failing can be degraded by the subjection of the rope to wear or damage through use. With the possible results of a failure of such ropes being so severe and in view of the long history of their widespread use, it may be assumed by those unfamiliar with this art that reliable, objective tests for determining whether or not a particular rope can be safely continued in use in a particular application had been developed long ago and were presently in regular use. However, such is not the case.

At present, a decision to remove a wire rope from service is made on a very subjective appraisal of its quality. Tests presently used to assist in formulating such a decision are highly nonquantitative in nature. The most commonly used test consists of laying the rope on the ground and counting the number of individual wires that are broken and converting this to a breaks per foot figure. To increase the likelihood of finding the breaks in the individual wires, it is common practice for the individual conducting the test to place loose cotton in his hand and rub the cotton along the rope. The loose cotton is caught by broken ends of the individual wires thereby making them more visible to the person conducting the test. The breaks per foot figure is utilized as an indication as to whether the quality of the cable has deteriorated to the point where the cable should be removed from service.

The only other test commonly applied to wire rope is to determine how well the cable is lubricated. Since individual wires and strands of wires are subjected to relative movement when the rope is in use, abrasion between strands or wires of unlubricated rope can increase the effective stress applied to them. Although X-ray examination and examination through the use of magnetized particles such as by the process marketed under the trademark Magna-Flux have been used to study wire rope, they are not widely used due to the relatively high cost.

In view of the lack, heretofore, of any practical definitive test for determining the quality of a wire rope, it has been common practice to specify very large safety factors in applications where failure of the rope could produce serious consequences. It follows that in such applications safety considerations would dictate that the rope be removed from service at the first signs of deterioration as may be determined by a visual inspection or a visual inspection augmented by a breaks per foot test. Following such practice raises a great deal of uncertainty since there is no assurance that all failure modes involve defects that will be found upon a visual inspection of the outside of the rope and it undoubtedly will result in the removal of rope from service which actually is of sufficiently good quality for the particular application.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a test system for nondestructively determining the quality of wire rope or cable. It is an additional object of the invention to provide a system for testing wire rope or cable which provides an objective, quantitative indication of the quality thereof through the use of relatively simple procedures and apparatus.

Briefly summarized, these and additional objectives are accomplished by a test system which utilizes the increase in thermal content of wire rope as it performs work as a measure of its quality. It has been found that wire rope, being a mechanical system, generates heat as it works and that a greater quantity of heat is generated in a degraded rope than in a rope of higher quality. Indicia of the rise in heat content of increments of a wire rope which is subjected to work can be discerned and the thermal differential exhibited by a degraded rope, or a degraded increment of rope, is measurably higher than the thermal differential exhibited by increments of a high quality rope subjected to the same work.

Accordingly, a wire rope, the quality of which is to be determined, is used to perform a predetermined quantity of work in a predetermined manner such as by lifting or lowering a specified load at a specified rate, while an indicia of the thermal content of the rope is observed. The thermal rise, Δt, of the rope while performing the work is then compared against that obtained for a high quality or standard rope and correlated with relative quality of the rope. The ropes, or increments of a rope, that exhibit larger Δt's than the standard are of poorer quality than the standard and the degree of degredation of the quality of the rope, or increment thereof, is an inverse function of its Δt.

The optimum placement of the heat sensor is at that location of the mechanical system where the rope is subjected to the maximum stress since the increase in heat content will be greatest at that point. Since the individual strands and individual wires within the strands are subjected to relative movement and flexure as the rope passes over the sheaves, or pulleys, of the system, the stress is increased at the sheaves.

Generally speaking, in applications such as cranes, hoists, drill rigs and the like the stress on the rope is maximum as the rope passes over the main sheave, usually referred to as the crown or head sheave. Accordingly, in many systems employing wire rope a particularly advantageous location for sensing the thermal rise in the rope is immediately after the rope passes over the head sheave. In systems employing multiple lines and multiple sheaves an analysis of the line and sheave system will readily indicate whether a sheave or sheaves other than the head sheave would provide better Δt information. In this regard, since flexing of the wires will be greater at smaller sheaves, the stress would be greater at smaller sheaves, other factors remaining constant.

The standard Δt against which the observed Δt is compared may be obtained through subjecting one or more ropes of known quality to the prescribed test procedure. However, individual increments of a rope which have defects which lower their quality can be readily identified by testing procedures according to the invention. Individual portions of a rope that have degraded in quality due to broken individual wires, kinks or other defect will exhibit a Δt which is higher than the portions of the rope that are free from defects by a factor which is related to the severity of the defect. Factors as high as 6 have been obtained for increments having severe defects such as cut strands. Accordingly, a rope can be tested for uniformity of quality in accordance with the invention in which case the standard Δt to which a comparison is made will be the thermal rise which is observed for high quality portions of the rope.

Satisfactory thermal measurements have been obtained through a relatively simple, readily available, infrared sensing instrument, the Barnes Engineering Company non-contact thermometer Model IT–4A. Any of a number of commercially available thermal sensing instruments or thermometers would undoubtedly be satisfactory. Arranging the IT–4A sensing instrument so that the cable filled up the detector field and conditioning the detector output signal to suppress contributions extraneous to that resulting from performance of the work, such as from ambient, were each found to be important in obtaining reliable data since only a few degrees F separate the ΔtXs for good and defective ropes. While an EG&G, Inc. signal conditioner model DP–11 has been used, other suitable instruments are commercially available.

The conditioned voltage output of the IT–4A sensor was utilized directly as the indicia of Δt in one series of tests involving four ¾ inch diameter independent center wire ropes, one of which was a new rope and the other three of which had defects of increasing severity. The average maximum reading for the new rope over five trials utilizing a load of **22,900** lbs. was **4.8** mv with the extremes being **7** mv and **3** mv. The average maximum reading was **19** mv for a used cable with a relatively small kink, **25.5** mv for a used cable with a more severe kink and minimal lubrication and **30** mv for a used cable some of the individual wires of which were cut.

The above-mentioned and additional objects and advantages of the invention and a further understanding of the invention will be apparent after consideration of the following description of a preferred embodiment described in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a side elevation of a representative mechanical system showing the use of a preferred embodiment of the invention therewith, and

FIG. **2** is a block diagram of the main electronic components used in connection with a preferred embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

FIG. **1** illustrates the placement of heat or thermal sensing device **10** for practicing the invention in connection with a conceptualized typical lifting mechanism **12** which uses wire rope, or cable, **14** to manipulate a load **16.** Mechanism **12** has a truss framework **18,** mounted on a suitable platform **22,** which supports a rotatably mounted head sheave, or crown sheave, **24** at its head **26.** Wire rope **14** is run through sheave **24** and wound and unwound on a drum, not shown, of draw works **28** by operation of a typical winding mechanism in order to raise or lower loads attached to lifting hook **32** secured to the terminal end of rope **14.**

As indicated earlier, it would be preferable to mount the thermal sensing device in a position where the increase in the thermal content of the rope can be observed at the point where the cable is subjected to the greatest stress. In the case of the simple hoist shown in FIG. **1,** thermal sensing device **10** would preferably be mounted, such as by support **34** to head **26,** in a manner whereby lens or window **36** of sensing device **10** would view rope **14** just as it leaves head sheave **24** upon the lowering of load **16.**

Speaking generally with respect to lifting or other manipulating mechanisms utilizing wire rope, the stress on a rope is increased at a sheave or pulley due to the relative movement and flexing of the strands and individual wires of the rope caused by the change in direction of the rope. Since the mass of the sheave itself somewhat masks the increase in temperature, sensing the temperature of the rope just after it leaves the sheave as shown in FIG. **1** would be the preferred location for the system portrayed therein when the test procedure calls for lowering load **16.** Positioning sensor **10** to view rope **14** on the opposite side of sheave **24** at position **37** would be preferred for procedures involving the lifting of load **16.**

Increased stress would also be experienced at sheaves other than the crown sheave in multiple sheave systems and at the draw works. In the arrangement of FIG. **1,** placement of a sensor to view the cable at **38** as it leaves draw works **28** would provide Δt information for portions of the rope which could not be conveniently observed by the indicated positions of sensor **10** at head **26.** In cranes and other rigs employing multiple line systems it may be necessary to view the rope at several locations in order to obtain Δt information over the entire length of the rope used.

Sensor **10** is arranged so that its field of view is filled by rope **14.** Pickup of noncable background by sensor **10** would, of course, add an extraneous factor into the data obtained and could adversely affect the determination of the actual Δt experienced by the cable. However, the exclusion of noncable background could be accomplished, for instance, by the use of a suitable arrangement of optical lenses, in which event a portable detector **10** could be positioned on the ground in the embodiment of FIG. **1.**

The electronics for processing the thermal information obtained from a rope can be quite simple. In the embodiment of FIG. **2** the thermal information received by thermal detector **10** is converted to an electrical signal **40.** The contributions from ambient are suppressed from signal **40** by signal conditioner **42** to produce a signal **43** which represents the Δt experienced by rope **14.** Signal **43** is recorded by recorder **44** and correlated against a standard Δt representative of rope of known quality in order to determine the relative quality of rope vis-a-vis that standard.

Many embellishments on the processing of the electrical signals will come readily to mind to those familiar with such processing. For instance, the automatic comparison of the observed Δt against a standard Δt can be effected with other signal conditioning functions. Recorder **44** can provide a strip chart and/or magnetic tape, for instance for review, further processing and/or storage.

Standard Δt information can be developed empirically by the performance of a prescribed quantity of work by a wire rope of known quality under prescribed conditions. The Δt information for wire ropes of unknown quality can then be obtained through the performance of work under those prescribed conditions. Comparison of the Δt information against the standard will reveal the relative quality of the length of rope tested.

Since only a relatively modest capital outlay would be required to obtain the necessary electronic equipment, it may be desirable in some applications to permanently mount detector **10** in the desired position for viewing the rope and continually, or periodically, obtain Δt information. The standard could be developed for the cable when it is installed in the new condition and the degradation of its quality subsequently monitored. However, temporary clamping arrangements such as magnetic clamps, or remote placement of the thermal detector as previously discussed, can be used to set up the equipment each time a test is desired in applications where less frequent monitoring of the quality of a rope is sufficient.

The continuity of the quality of a wire rope over a particular length thereof can be obtained at any time without the necessity of creating a preexisting standard. As long as the work is performed by the cable in a uniform manner over the length of the cable tested, any deviation in the Δt from the normal, or average, will indicate an increment of rope of differing quality.

While the fundamental novel features of the invention have been shown and described and pointed out as applied to particular embodiments by way of example, it will be appreciated by those skilled in the art that various omissions, substitutions and changes may be made within the principle and scope of the invention as expressed in the appended claims.

What we claim is:

1. A method of nondestructively determining quality of a wire rope comprising performing a predetermined quantity of work with said rope under predetermined conditions, obtaining an indicia of the increase in heat content of said rope resulting from said work and correlating said increase with quality of said rope.

2. The method of claim **1** wherein said indicia is obtained for a plurality of increments of the length of said rope for which said determination of quality is desired.

3. The method of claim **2** wherein said increments of wire rope are moved past stationary means for observing said indicia.

4. The method of claim **1** wherein a relative movement of at least some of the strands of said rope is effected prior to obtaining said indicia.

5. The method of claim **4** wherein said relative movement of strands of said rope is obtained by movement of said rope over a sheave.

6. The method of claim **5** wherein said correlating step includes the comparison of said indicia against a like indicia obtained for a like cable of known quality when performing said quantity of work in a like manner.

7. The method of claim **5** wherein said correlating step includes comparing the indicia obtained for individual increments against the indicia obtained for other increments of the same rope whereby increments of lower quality are identified.

8. The method of claim **1** wherein said obtaining an indicia of the increase in heat content includes observing the rope with a thermal sensing device which produces an electrical output signal representative of the heat content of the rope and conditioning said output signal to suppress contributions extraneous to that resulting from performance of said work.

9. The method of claim **8** wherein a relative movement of at least some of the strands of said rope is effected prior to obtaining each indicia by movement of said rope over a sheave.

10. The method of claim **9** wherein said correlating step includes the comparison of said indicia against a like indicia obtained for a like cable of known quality when performing said quantity of work in a like manner.

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