United States Patent

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[54] THERMAL PROTECTION SYSTEM FOR HIGH SPEED ROTATING PARTS

11 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **192/116.5,** 116/114.5; 184/1; 318/460; 340/270; 415/9
[51] **Int. Cl.** **H02p 3/00**
[50] **Field of Search** ..... 192/116.5, 129(.2); 116/114.5; 318/460; 184/1(C), 6(D); 415/9

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ABSTRACT: A rotating machine part subject to possible overheating during high-speed operation is in mechanical vibration-transmitting relation to apparatus having vibration-sensing means for causing emergency shutdown. The rotating part includes an eccentrically mounted displaceable mass that in normal position maintains dynamic balance of the part. Upon overheating of the part, the mass is released in response to temperature rise and displaced by centrifugal force, thereby causing sensible vibration and emergency shutdown of the apparatus.

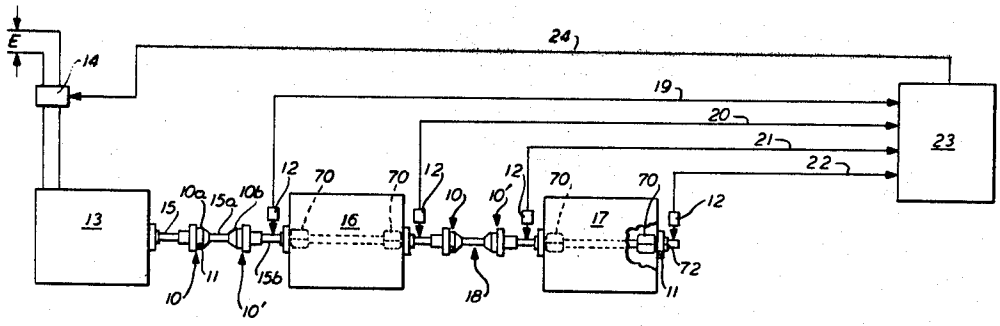


FIG. 1

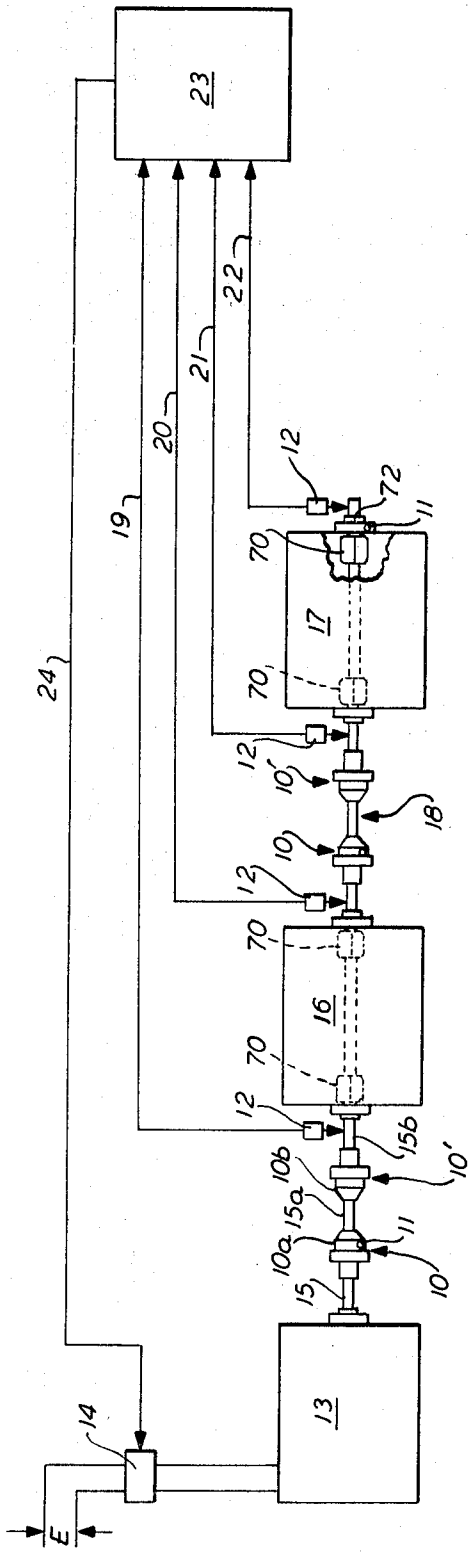
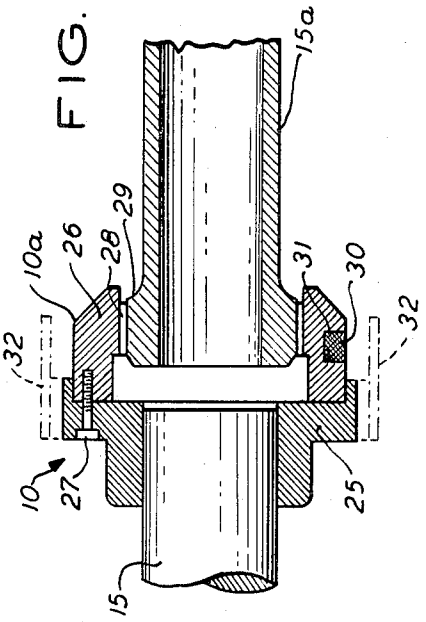


FIG. 2



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FIG. 3

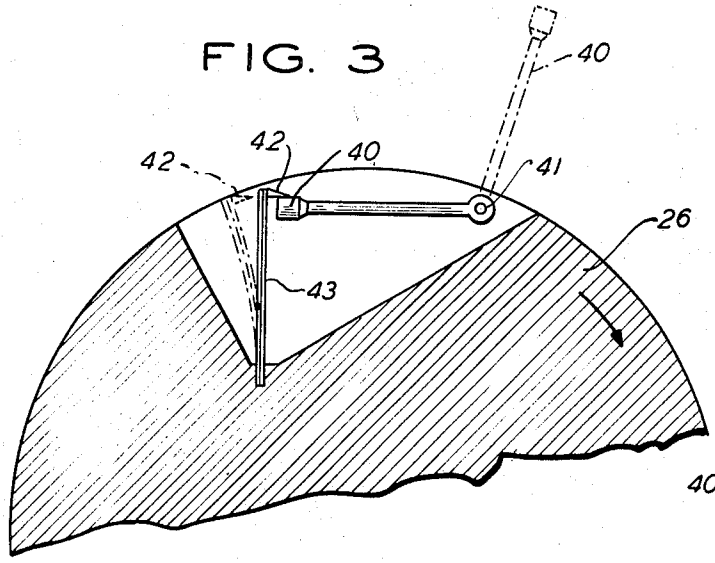


FIG. 4

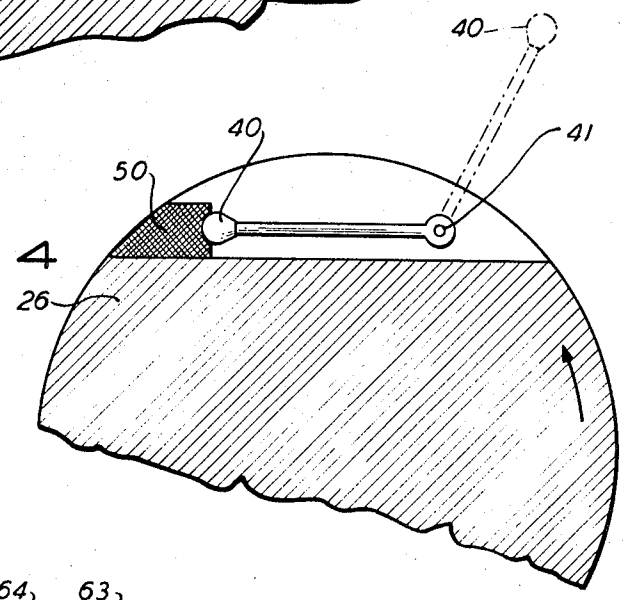
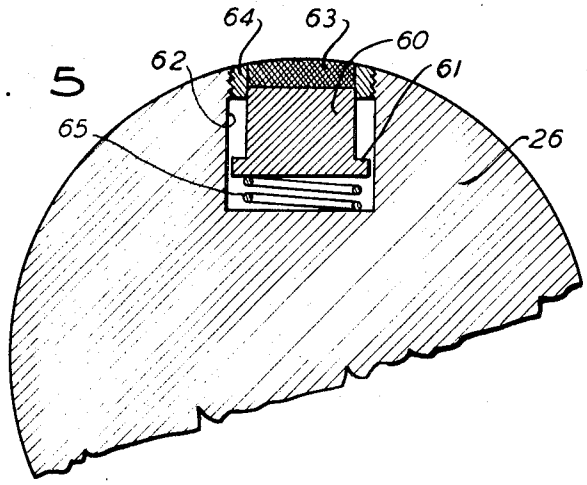


FIG. 5



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THERMAL PROTECTION SYSTEM FOR HIGH SPEED ROTATING PARTS

BACKGROUND OF THE INVENTION

Shaft bearings and the like, subject to overheating have been provided with thermal indicators, such as fusible means for protecting the bearing or other part, against overheating in various ways. For example, fusible capsules positioned on a bearing, or on an overhanging end of the journal, have been proposed for producing sight and small sense warning signals, such as smoke and pervasive odors upon overheating of the part, for alerting personnel in the vicinity. Thermal telltales positioned in the lubricant of a bearing housing and operated in response to melting of a fusible element are also used for giving visual indication of overheating. In another proposed system a fused latch carried by a connecting rod bearing is tripped and engages the crankcase housing for operating a circuit breaker and stopping the machine, such as by shorting an ignition circuit.

Warning and control systems of this character involve practical disadvantages, the latter for example, depending on the reliability of a latch-switch combination, sliprings, etc., subject to fouling by contaminants etc., and the odor and smoke warnings and telltales being useful in high-speed machinery only when operating personnel are in the immediate vicinity of the overheated machine, and can take prompt protective action.

Vibration sensing control is in many cases, conventional for shutting down high-speed machines in response to excessive vibration indicative of malfunction. However, damage that may be caused by overheating often precedes any sensed vibration due thereto, so that protection from overheating damage is not necessarily obtained by vibration sensing, per se.

The present invention is concerned with ensuring more positive thermal protection of high-speed rotating parts of machines having vibration sensors, from damage due to overheating.

SUMMARY OF THE INVENTION

In accordance with the invention, a rotating part or component of machinery such as a shaft coupling, bearing journal, or the like subject to accidental overheating during high-speed operation, is mechanically connected to a machine, power transmission drive, etc., that is equipped with standard vibration-sensing means capable of causing emergency shutdown of the machine when vibration exceeds a tolerable limit. To this end, in a preferred embodiment of the invention a fusible mass is eccentrically mounted on the rotating part in good heat transfer relation therewith; the part is designed for dynamic balance when the fusible mass is in normal position. Upon overheating of the part, the mass is melted and displaced by centrifugal force, thereby dynamically unbalancing the part and causing excessive vibration that in turn, is sensed as indicated above for producing machine shutdown.

In other forms the invention may assume, the mass (not necessarily fusible) is released in response to excessive temperature rise in the part, and displaced primarily by centrifugal force for dynamically unbalancing the part.

A principal object of the invention therefore is to provide an improved thermal protection system for high-speedrotating machinery equipped with vibration sensitive shutdown means.

A further and related object is to provide in machinery having vibration-sensitive shutdown means, an improved thermal protection system for a high-speed rotating part, utilizing centrifugal force for dynamically unbalancing the part in response to excessive temperature rise therein, and arbitrarily setting up machine vibration for causing shutdown.

A further object is to provide an improved thermal protection system for high-speed rotating parts that is simple and inexpensive in its application to machinery having vibration-sensing control.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a partly schematic illustration of a thermal protection system for high-speed machinery embodying the present invention;

FIG. 2 is an enlarged view in longitudinal section of the shaft coupling of FIG. 1 specifically adapted for use in the present invention; and

FIGS. 3, 4 and 5 are partly schematic illustrations generally in transverse section, of a rotatable part having respectively, alternative forms of overheat temperature sensing for causing dynamic unbalance of the part.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a preferred form of the invention as applied to the compensating end **10***a* of a shaft alignment-compensating coupling **10** rotating with the shaft at high speed. In the shaft arrangement shown, a similar shaft coupling **10'** has its compensating end **10***b* in facing and spaced relation to that of the coupling **10** on the shaft. Each coupling embodies the invention concept wherein radial displacement of a normally balancing mass **11** in a part of the rotating coupling occurs in response to predetermined temperature rise in the part for arbitrarily dynamically unbalancing the coupling in question. The resulting mechanical vibration is transmitted to standard vibration sensing means generally indicated at **12** for shutting down in conventional manner a driving means **13** connected to the coupling.

In particular, the system in general is shown as including a high-speed electric drive motor **13** energized from a source of potential E through circuit control means **14** including standard relay and circuit breaker equipment. In other applications, the drive means may constitute a high-speed turbine or the like, that is controlled in analogous manner. The drive means where required, is connected to a gear box or equivalent speed conversion unit (not shown) for rotating the drive shaft **15** and flexible coupling **10**, **10'** at high speed, such as 10,000 r.m.p. or more, for driving one or more load units or machines such as indicated at **16** and **17** respectively. The drive shaft **15** is connected by the couplings **10** and **10'** through an intermediate shaft or coupling sleeve **15***a* to a driven shaft **15***b* for the load units. A similar coupling arrangement is shown between the load units **16** and **17**.

In practice, the sensed vibration signal at one or more of the sensing units **12**, where its magnitude exceeds a predetermined minimum representing normal operation, is transmitted through channels indicated at **19** to **22** respectively, to standard control equipment **23**. The signal is amplified for producing a control signal on line **24** that in turn causes in conventional manner actuation of the shutdown control at **14**. The coupling is thereby protected from damage due to extended overheating by the automatic shutdown of the drive motor.

Referring to FIG. 2 the illustrated coupling **10** comprises a pair of complementary flanged portions **25** and **26** for interconnecting the respective ends of the drive shaft **15** and the coupling sleeve shaft **15***a*. The portion **25** is rigidly secured to the end of shaft **15** and also connected as by securing bolts at **27** to the complementary abutting portion **26**. The inner periphery of the portion **26** is connected by a conventional gear-teeth spline **28** to the outer surface of a shoulder **29** at the corresponding end of the coupling sleeve shaft **15***a* for compensating in known manner minor misalignment of the drive shaft **15** and the driven coupling sleeve shaft **15***a* during rotation of the drive assembly.

The gear-teeth spline is normally lubricated for preventing overheating at the spline during high-speed rotation of the shaft and coupling, etc. However, depending upon the magnitude of the load, speed of rotation, etc., overheating at the spline may occur within a short time upon failure or loss of lubrication. If this should occur, continued high-speed operation of the coupling could cause excessive overheating and failure of the part.

For protecting the coupling from such damage, a fusible mass 30 is mounted within a bore 31 at the outer periphery of the coupling portion 26 as indicated, so that the fusible mass is in good heat-transfer relation with the metal adjacent to the spline 28. The fusible mass is composed of a suitable alloy that is designed to melt at a temperature above which operation of the coupling is inadvisable. The coupling with the fusible mass 30 in normal position as illustrated in FIG. 2, is dynamically balanced by known technique so that the coupling operates without sensible vibration, that is, within the prescribed tolerance limit for shaft vibration. Accordingly, when the spline starts to overheat for any reason, and the temperature rise in the coupling portion 26 reaches the known fusing point of the mass alloy, that is, the temperature beyond the upper limit of tolerable coupling temperature, the mass rapidly softens and melts thereby destroying any restraining bond between it and the surrounding metal wall of the bore 31. Practically simultaneously, the now-released mass is forcibly ejected by centrifugal action of the rapidly rotating coupling, thereby dynamically unbalancing the coupling and setting up sensible vibrations therein that are transmitted as described above to one or more vibration sensors at 12. Where the coupling is so located that ejection of the fused mass may cause injury to an operative, a protecting shroud such as indicated at 32 may be suitably mounted on the coupling.

In instances of very high rates of rotation where comparatively large centrifugal forces are involved, the bore may be under-cut or dovetailed somewhat for locking the solid mass in position under normal operating conditions.

It will be apparent from the foregoing description that the inventive concept of displacing a mass with respect to a high-speed rotating part in response to predetermined temperature rise thereof for dynamically unbalancing the part and arbitrarily setting up sensible vibrations therein can be embodied in various modifications. By way of example but without limitation thereto, FIGS. 3 to 5 illustrate several alternative forms of the invention.

Referring first to FIG. 3 there is schematically shown an arrangement that may be incorporated in a high-speed rotating element such as the coupling part 26 for causing displacement of an unbalancing mass 40 in response to sensed temperature rise in the part. The mass is indicated as pivotally mounted at 41 on the coupling part, and is latched in the normal dynamically balanced condition by a detent 42 carried by a bimetal element 43 that is suitably anchored on the part 26. Upon predetermined temperature rise the bimetal element flexes toward the dotted line position and causes unlatching and release of the mass 40. The existing centrifugal force thereupon swings the mass outwardly to the dotted line position shown for dynamically unbalancing the coupling In this arrangement, the mass is readily reset after the part 26 has cooled by moving the mass beneath the latching detent 42.

In FIG. 4, the mass 40 pivoted at 41 as in FIG. 3, is released for unbalancing the part 26 in response to predetermined temperature rise therein by melting of a fusible retainer 50, such as a metal alloy plug that is conveniently mounted in the part 26. Upon melting of the fusible retainer 50 the mass 40 is displaced outwardly as indicated, generally, in the manner of FIG. 3 for dynamically unbalancing the part.

In FIG. 5, the mass 60 is formed as a cylindrical plug having an annular retaining shoulder 61 at its lower edge. The plug is guided as shown within a bore 62 and is normally held therein by a fusible retainer cap 63. Upon melting of the fusible retainer 63 in response to predetermined temperature rise in the coupling portion 26, the mass 60 is displaced radially outward, principally by centrifugal force, for dynamically unbalancing the coupling and causing shutdown of the drive means as described above. Retention of the mass for subsequent resetting is provided by the retaining shoulder 61 that engages a guiding and restraining shoulder 64 at the outer end of the bore 62. For convenience in resetting, the guide 64 and fusible retainer 63 may constitute an integral replaceable unit that can be screwed into the upper part of the bore for holding the mass in normal position against the bias of a positioning spring 65.

From the foregoing description it will be seen that the invention achieves positive and efficient thermal protection of a high-speed rotating part that is embodied in machinery having vibration-sensing and shutdown control. An advantageous feature of the invention is that it lends itself to the same general type of precisely designed high-speed equipment ordinarily having vibration-sensing protective control for causing shutdown in response to unusual sensed vibrations indicative of mechanical malfunction and/or failure.

Although the invention as shown is for thermal protection of a high-speed alignment-compensating coupling, it will be apparent that it is equally applicable to thermal protection of other rotating parts subject to overheating, such as the bearings generally indicated at 70 in the driven machines. In this instance the unbalancing mass could be incorporated in a rotating part, such as a collar 72 secured to the bearing journal and located outside and closely alongside the bearing housing for functioning without interfering with the bearing function.

Having set forth the invention in what is considered to be the best embodiment thereof, it will be understood that changes may be made in the system and apparatus as above set forth without departing from the spirit of the invention or exceeding the scope thereof as defined in the following claims.

I claim:

1. In a thermal protection system for a rotating part that is operated at high speed, the rotatable part including a displaceable mass that normally ensures dynamic balance of the part, the method which comprises:
   a. causing displacement of the mass upon predetermined rise of temperature of the part for dynamically unbalancing the part and setting up sensible vibrations therein;
   b. sensing the vibration, and
   c. shutting down operation of the part when the sensed vibration exceeds a predetermined value for stopping rotation of the part.

2. The method as specified in claim 1 wherein the mass is displaced in a generally radial direction principally by centrifugal force.

3. The method as specified in claim 1 wherein sensible vibration of the part is transmitted to a sensing control, and the control is operable to cause deenergization of drive means for stopping rotation of the part.

4. A thermal protection system for a part of machinery including drive means for rotating the part at high speed, comprising a displaceable mass normally positioned with respect to the axis of rotation of the part and restrained therein so that the part is in dynamic balance during high-speed rotation, the mass upon predetermined temperature rise of the part being released for outward radial displacement thereby dynamically unbalancing the part, and vibration sensing means for detecting the unbalance and causing deenergization of the drive means.

5. A thermal protection system as specified in claim 4 wherein release of the mass is caused by melting of fusible means upon the predetermined temperature rise.

6. A thermal protection system as specified in claim 4 wherein the part is a shaft coupling having splines of the gear-teeth type, and the mass consists of a fusible plug normally positioned at a peripheral portion of the coupling for displacement by centrifugal force upon fusing, the plug being in good heat-transfer relation with the gear-teeth splines of the coupling.

7. A thermal protection system as specified in claim 4 wherein the mass is released for displacement by a temperature responsive latch.

8. A thermal protection system as specified in claim 5 wherein the mass is composed of fusible material mounted at a peripheral position on the part and is displaced upon melting by centrifugal force.

9. A thermal protection system as specified in claim 5 wherein the mass is mounted for limited outward movement

with respect to the part, and a fusible element responsive to temperature rise of the part releases the mass for outward displacement upon melting of the fusible element.

10. A thermal protection system as specified in claim 8 wherein the mass is a fusible plug normally mounted within a cavity on the part in good heat transfer relation therewith.

11. A thermal protection system as specified in claim 9 wherein the mass is guided for outward radial movement and is retained in normal position by fusible means in good heat transfer relation with the part.