United States Patent [19]

Armstrong et al.

[11] **3,929,308**

[45] **Dec. 30, 1975**

[54] **LOCAL DERAILMENT SENSOR AND BRAKE ACTUATOR SYSTEM**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy,** Washington, D.C.

[22] Filed: **Aug. 7, 1974**

[21] Appl. No.: **495,480**

[52] **U.S. Cl.** ..... **246/169 A;** 246/170; 340/57

[51] **Int. Cl.²** **B61K 9/04**

[58] **Field of Search** ..... 246/169 R, 169 A, 170, 246/172, 182 A, 182 B, 188; 116/114 AM, 114 S, 114 AE, 114 Y, 101, 106, DIG. 38; 200/61.08; 340/57; 102/70.2 GA; 180/103

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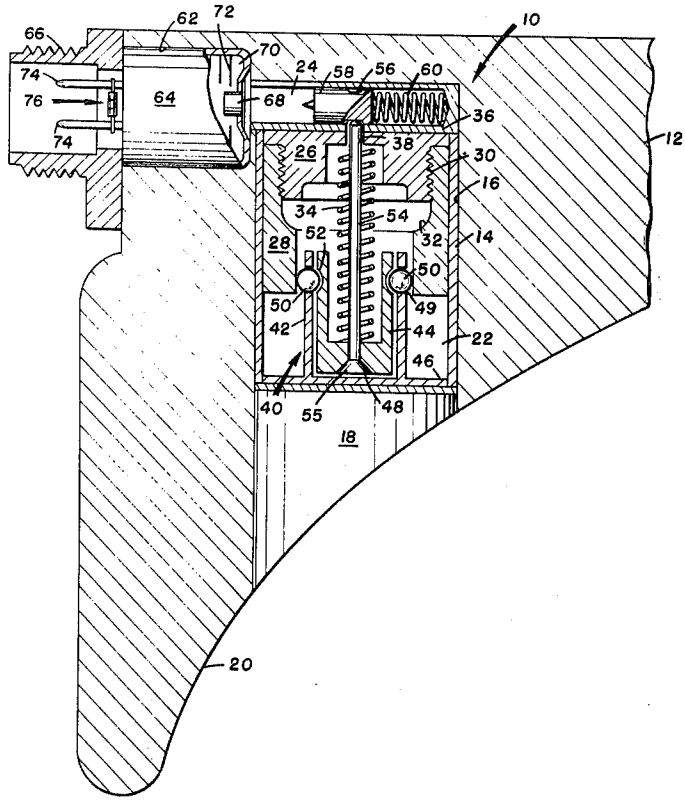
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Attorney, Agent, or Firm—R. S. Sciascia; J. A. Cooke; F. K. Yee

[57] **ABSTRACT**

A motion sensor combined with a journal bearing thermal detector produces an output signal utilized to activate a train's brake system upon detection of a local wheel derailment or excessive bearing temperatures. Wheel impact with the roadbed and/or bearing temperatures exceeding a predetermined value causes the sensor to activate a percussion-initiated power source. The output signal triggers an electroexplosive brake venting mechanism, puncturing and venting the brake line for a full service brake application to stop the train.

21 Claims, 6 Drawing Figures



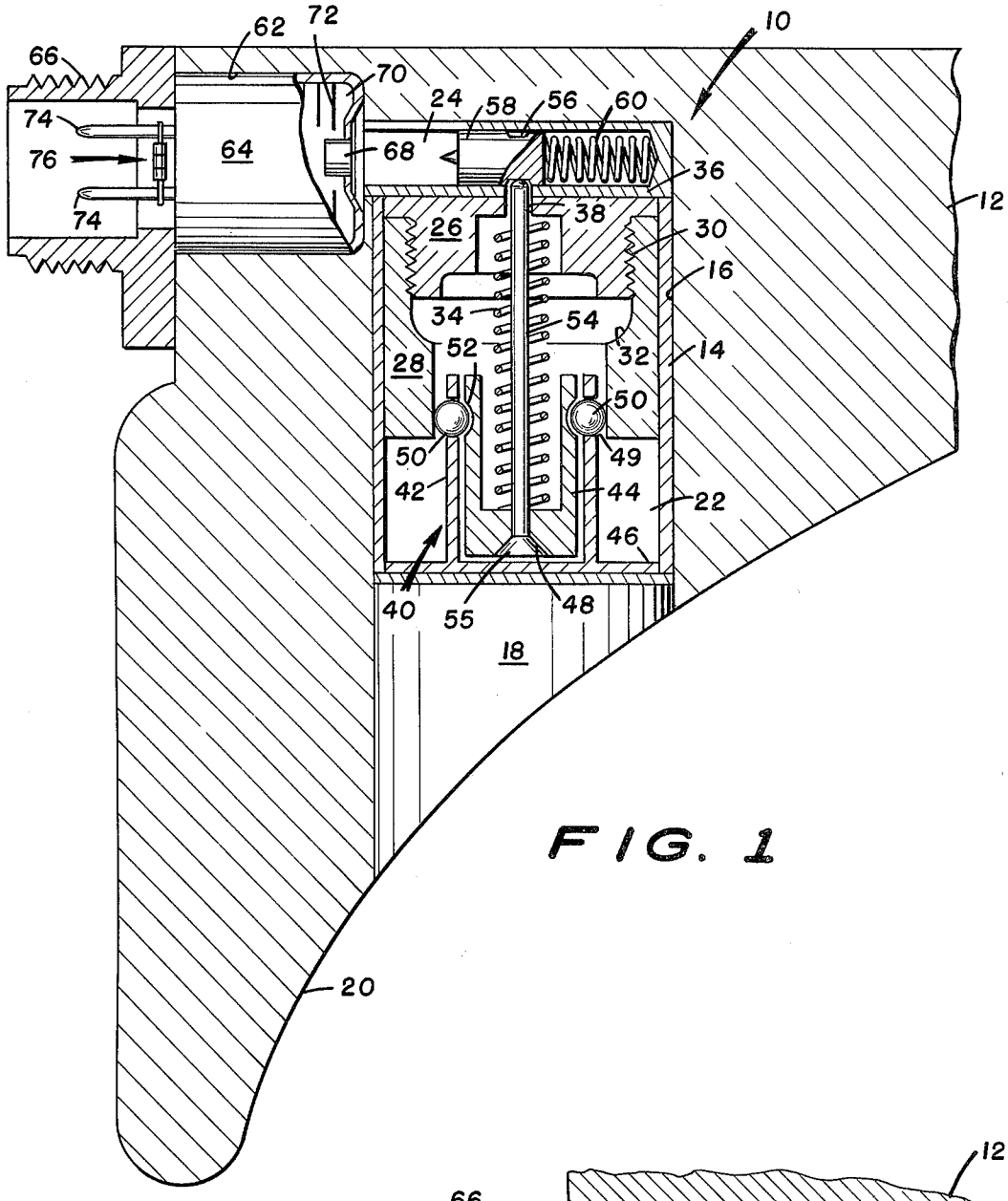

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FIG. 1

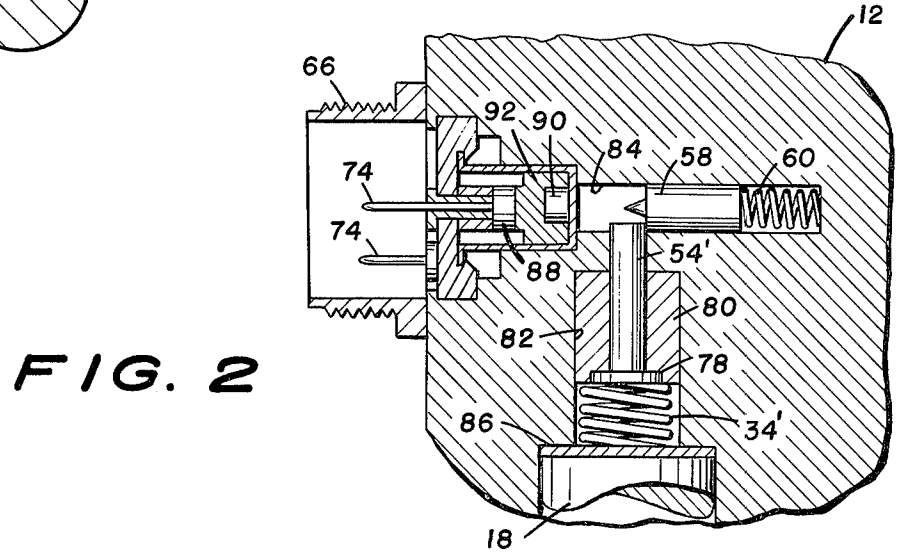

12
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34'
54'
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60
66
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74
78
80
82
84
86
88
90
92

FIG. 2

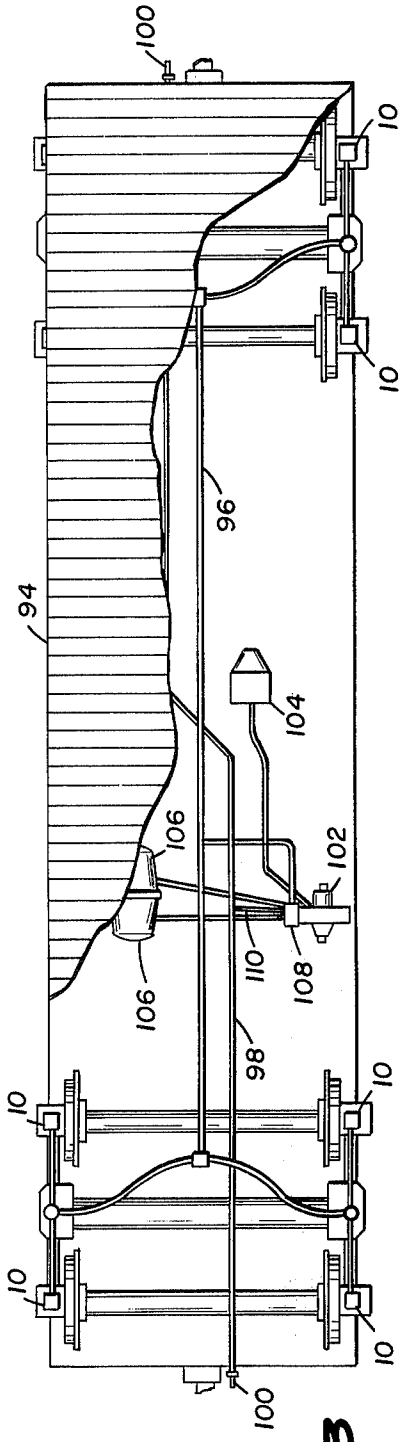

100
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96
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108
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10
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FIG. 3

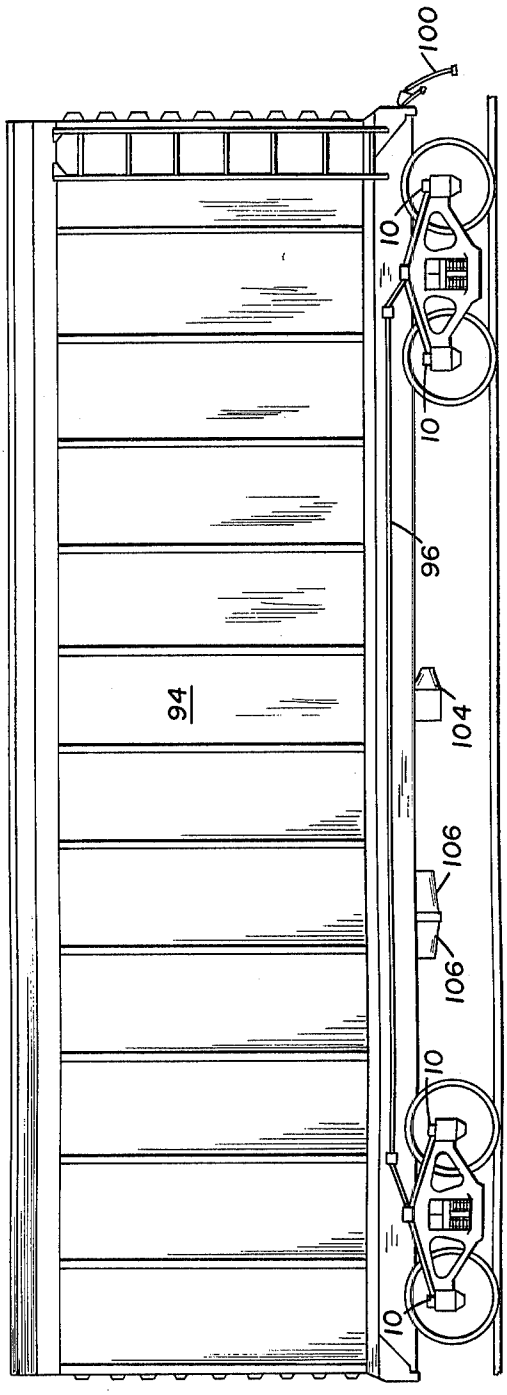

100
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94
104
106
106
10
10

FIG. 4

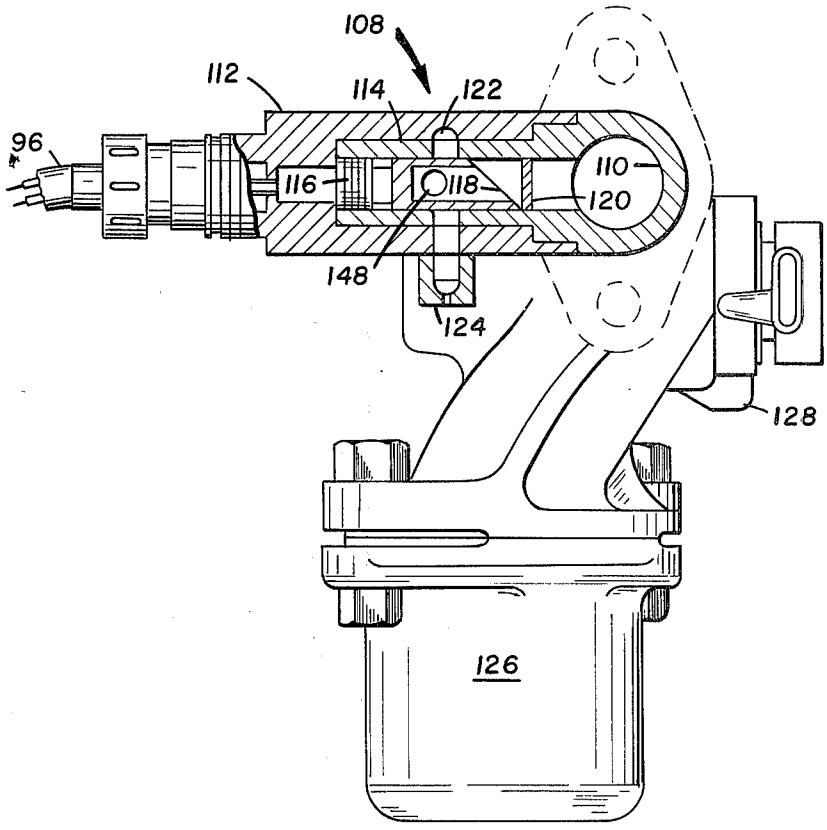

108
112
114
122
96
116
118
110
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148
124
128
126

FIG. 5

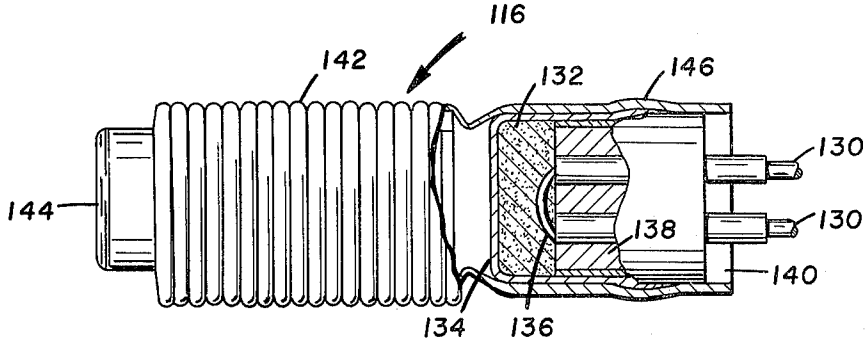

116
142
132
146
130
144
130
138
140
134
136

FIG. 6

LOCAL DERAILMENT SENSOR AND BRAKE ACTUATOR SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates generally to motion sensor systems and, more particularly, to a motion sensor system which can detect the derailment of wheels of railroad cars and generate a signal to apply the trains brake system.

In a certain proportion of train derailments, initial local derailment, in which one or more wheels drop off the rail head, will occur and the train will proceed some distance with little further disturbance and with no awareness of the derailment until some obstruction or further damage to the derailed equipment leads to a general derailment, the magnitude of which is most directly related to train speed at the time.

The most likely obstructions triggering the general derailment are turnouts or highway grade crossings. Since both of these are more common in villages or other developed areas, there appears to be a disproportionate tendency for pile-ups to occur in populated areas. Such pile-ups often involve, in addition to costly property damage and expensive loss time, explosions, fires or release of hazardous materials. While the actual number of such two-stage major derailments is not readily determined, even if as few as 2 to 5% of the train derailments should be in this category, the total potential for savings would be in the $2 to $10 million-per-year range. In view of such potential savings and the concomitant safety improvements, the desirability and requirement for a reliable and economical means to detect local derailment and initiate corrective procedures are clearly evident.

Local derailments could occur in connection with almost any of the classifications of equipment and roadway failures or defects causing derailments. They could also arise from such forms of negligence as improperly secured loads or highway vehicles running into side of train and from a variety of causes classed as miscellaneous, including track obstructions. In these derailments, the wheels and axle drop off the rail head, once the flange on one side has passed beyond its outer edge, and accelerate downward until the flange strikes the roadbed. Dynamically, three different situations may occur. One wheel may drop from the rail head and hit the tie plates while its mate and the other axle of the truck remain on the rail. This type of local derailment results in the highest impact velocity. In most derailments, the second wheel on the axle must leave the rail head at about the same time as its mate because the typical overlap is less than ⅝ inch. This case results in lower impact velocities. For two-axle derailments both wheels on one side of the truck derail at the same instant. For this to occur, both flanges on one side must travel some distance atop the rail head, crossing it at a rather small angle, so that both go "over the brink" at the same time. Once a wheel drops from the rail head, it hits the tie plates in approximately 30 to 60 milliseconds (3½ to 7 feet travel distance at 60 mph). This situation is relatively rare in occurrence, and since the completely derailed truck which results is not stable in yaw, it is therefore not likely to represent one of the delayed pile-ups characteristic of two-stage derailments.

Upon local derailment, the truck and suspension geometry gives the springs, backed by the inertia of the car body, a very significant leverage, driving the wheel, axle and journal downward with an initial acceleration of approximately 5g in the case of an empty car and 19g for a fully-loaded car. Vertical velocity of the wheel prior to impact upon the roadbed will be about 19ft/sec for a single-axle drop on a loaded car or 8 ft/sec on an empty car, which would be equivalent to free-fall drops of 66 and 13 inches, respectively.

It is theoretically possible for an integrating accelerometer to sense the velocity change involved in these downward accelerations during actual derailment and probably to differentiate them from low joints, frogs, flat wheels and other "normal" accelerations and impacts that involve higher accelerations but smaller velocity change. In practice, however, this approach would involve such sensitive devices that acceptable life in the face of the severe vibration environment is not likely, and direct readout in a simple device with the limited operating force available would be a problem. A much more practical event for detecting derailment is impact with the roadbed. In essentially all cases in a drop onto typical mainline roadbed (21-inch tie spacing), the wheel flange or tread will first hit on one or two tie-plates. This is a reasonably reproducible "target" in hardness and location for analytic studies from which impact parameter estimates may be made to identify and separate the derailment impact "signal" from the "noise" of normal impacts. The local derailment signals are of approximately half-sine wave shape and of 3 to 5-millisecond duration.

From these data and estimates, the derailment roadbed impact in either a loaded car or an empty can be distinguished fairly reliably from normal service conditions by a sensor which actuates when appropriate threshold acceleration and velocity-change criteria are both met.

Presently there are no existing sensors that can distinguish the impact signal of local derailment from normal vibratory "noise" and produce a usable output to activate a general train anti-derailment system only when local derailment occurs.

SUMMARY OF THE INVENTION

Accordingly it is an object of the present invention to provide a new and improved sensor system which can detect the derailment of train wheels.

Another object of the present invention is to provide a new and improved sensor system which can detect train wheel derailment by distinguishing the particular shock signature associated with wheel derailment from normal shock and vibratory motions.

Another object of the present invention is to provide a new and improved sensor system capable of detecting the derailment of train wheels and generating a signal to automatically stop the train.

Yet another object of the invention is the provision of a new and improved sensor system capable of detecting the derailment of train wheels and generate a signal to automatically activate the train's air brake system.

Still another object of the invention is to provide a new and improved sensor system for detecting train wheel derailment that is reliable, economical and without an excessive false-alarm rate.

Yet still another object of the present invention is the provision of a new and improved sensor system for detecting train wheel derailment using only inexpensive components which are rugged and able to withstand the severe mechanical abuse and adverse environment

encountered at the axle journal location in railroad service.

Briefly, these and other objects of the present invention are attained in a combined wheel roadbed impact and journal bearing thermal sensor positioned adjacent the wheels of each train axle. Excessive bearing temperatures and/or wheel impact with th attendant prerequisite acceleration forces and velocity changes triggers the sensor which in turn activates an electrical power source. Bearing temperatures higher than a predetermined value causes a heat-responsive release pin to foreshorten, releasing a cocked firing pin to impact upon a percussion-initiated electrical generator. Wheel impact with the road bed displaces an accelerometer mass, causing a ball retainer to free the spring-loaded release pin to separate from the cocked firing pin and activate the electrical generator. The resultant electric signal activates an electroexplosive brake venting mechanism, puncturing and venting the brake line for a full service brake application to stop the train.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention and many of the attendant advantages thereof will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a partial view of the sideframe, partly in section, showing the installation of the motion sensor subsystem of the present invention;

FIG. 2 is an alternative embodiment of the sensor of FIG. 1;

FIG. 3 is a partially-sectioned plan view of a train car embodying the anti-derailment system of the present invention;

FIG. 4 is an elevation view of the train car of FIG. 3;

FIG. 5 is a partially-sectioned view of the brake line venting mechanism; and

FIG. 6 shows the bellows actuator of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and more particularly to FIG. 1 thereof, there is shown generally a combined roadbed impact and bearing thermal sensor **10** positioned within a bore **16** provided in a standard roller bearing adapter **12.** A filler plug **18** of a suitable heat-transmitting material, such as aluminum, fills the remaining portion of bore **16** after sensor installation, helps to position the sensor securely and serves to seal out dirt and moisture. Adapter **12** has the customary arcuate surface **20** to conform to the roller bearing. Sensor housing **14** is separated by partition **36** into a lower, larger chamber **22** to receive the impact sensing portion of sensor **10** and a smaller, upper chamber **24** to receive a spring loaded impact member.

The impact-sensing portion of sensor **10** is essentially an integrating accelerometer which requies a combination of a threshold acceleration and the prerequisite velocity change for actuation and is capable of detecting the impact of the wheel on its axle with the roadbed in a local derailment while ignoring normal shock and vibration conditions in service. For these particular conditions, a simple preloaded-spring, seismic-mass system arranged to sense both acceleration threshold and velocity change before actuation is of reasonable size. Escapements, clutter mechanisms or flywheels, needed in mechanisms required to integrate over longer periods of time, can be eliminated by simply requiring a certain amount of spring compression by the mass, for example, ¼-inch, prior to actuation. The energy thus absorbed is made equal to that represented by the mass of the seismic element and its change in velocity.

The seismic element shown in FIG. **1** includes an upper impact sensor mass **26** and a lower impact sensor mass **28,** suitably joined to be displaceable as a unit, such as by screw threads **30.** The lower impact mass **28** is substantially a cylindrical shell, open at both ends with the lower portion having a greater thickness than the upper portion. The intermediate area joining the different-thickness portions forms an arcuate step **32,** the purpose of which will be considered more fully below. The upper impact mass **26** is of substantially disc shape provided with a central aperture **38,** attached to the upper edge of lower mass **28** by means of the screw threads **30,** and under the force of accelerometer spring **34** abuts against the partition **36.** Impact masses **26** and **28** are able to displace downwardly within chamber **22** under acceleration forces, and to this end a space is provided between the lower impact mass **28** and the base of chamber **22.**

A ball release **40** extends through the lower, open end of the impact mass **28** to restrain movement of the accelerometer prior to the wheels undergoing the required acceleration forces necessary to activate the impact sensor **10.** The ball release **40** includes an outer, cylindrical support sleeve **42** with a base **46** resting on the lower chamber **22** and an inner, concentric, cylindrical thermal pin collar **44,** the bottom of which is closed and provided with a flared through bore **48.** Near the upper open end of support sleeve **42** are a plurality of holes **49** which receive balls **50.** An annular recess **52** on the upper portion of collar **44** provides a receiving space for the balls **50.**

A thermal release pin **54** having an enlarged, flared head **55** extends through the flared bore **48** in collar **44,** spring **34,** aperture **38** in the upper impact mass **26,** and engages an annular groove **56** in the firing pin **58.** The lower, flared head **55** on release pin **54** fits with the flared opening of bore **48** so that the downward force of the compressed spring **34** translates into an upward force on the collar **44** which in turn tends to force the balls **50** outwardly against the lower impact mass **28** to immobilize the accelerometer.

The firing pin **58** is slidably positioned within the upper chamber **24** and is restrained against the force of spring **60** by the engagement of pin **54** with groove **56.** Positioned in a bore **62** aligned with the axis of the firing pin **58** is a pulse-type thermal battery **64,** secured in place by a threaded connector fitting **66.** A stab-type percussion primer **68** is positioned in battery **64** directly in line with the firing pin **58.** The battery includes alternating layers of a pyrotechnic material contained within the wafer-type cells of the heat pads **70** and an electrolyte, a salt such as lithium/potassium chloride, contained within a disk-shaped electrochemical cell **72.** Terminals **74** provide the proper connection with the battery **64** and a resistor **76** joins the terminals **74** to facilitate electrical continuity check during testing of the system.

In the configuration shown in FIG. **1,** the size and weight of the impact masses **26** and **28** may be suitably varied according to train car size and cargo loads. Similarly, the length of spring **34** may be varied according

to the anticipated acceleration loads. Tests have indicated the adjustment range, as determined by existing car length and loads, to be between 100 to 150g for the preload on the accelerometer spring **34** and a mass travel equivalent to 10 to 15 ft/sec velocity change for the impact masses **26** and **28**.

Thermal release pin **54** may be made from 55-nitinol, the generic name for a series of nickel-titanium intermetallic compound alloy having a unique "memory" property developed by the Naval Ordnance Laboratory. Nitinol alloys have chemical composition in the range from about 53 to 57 weight percent nickel and the balance titanium. The "memory" properties are such that, given the proper conditions, Nitinol objects can be restored to their original shape even after being "permanently" deformed out of that shape. The return to the original shape is triggered by heating the alloy to a moderate temperature. The use of Nitinol in a thermal release pin for a temperature detector is disclosed more fully in the copending application of J. H. Armstrong and F. C. Kluge, Ser. No. 495,478, filed Aug. 7, 1974. The composition and properties of Nitinol are described more fully in U.S. Pat. No. 3,174,851, issued March 23, 1965.

Briefly, the steps in imparting a shape "memory" to a Nitinol article include: forming the alloy into the shape that it will be called upon to "remember", i.e., its "memory configuration"; heat treating the Nitinol shape while it is constrained in a fixture and subsequently cooling it below the transformation temperature range; and then straining the part to an "intermediate shape", which is the shape that the part is to retain until it is heated to restore it to the memory configurations. The temperature to which the part must be heated in order to return it to the memory configuration depends upon the chemical composition of the alloy. This is described more fully in U.S. Pat. No. 3,558,369, issued Jan. 26, 1971. Thus the Nitinol release pin **54** would have a heat-initiated, "shrunken" memory length sufficient to release the firing pin **58**, and from this length the pin would be strained longitudinally to be just long enough to restrain the firing pin in the cocked position of FIG. **1**.

In operation, the combined thermal detector and wheel impact sensor **10** of FIG. **1** is actuated either when the journal bearing overheats and the temperature detected exceeds that determined by the characteristics of the Nitinol thermal release pin **54** or when the acceleration threshold and velocity change of the accelerometer are exceeded by a wheel striking the roadbed. If the journal bearing temperature exceeds the limit of the Nitinol pin **54**, it physically shrinks, disengaging itself from groove **56** in the firing pin **58**. The cocked firing pin **58** impacts upon the stab primer **68** in the thermal pulse battery **64** to produce a flame which ignites the heat pads **70**. Burning of this material produces sufficient heat to melt the electrolyte within the electrochemical cells **72**. Once the electrolyte is melted and its ions released, normal electro-chemical action generates a voltage until the active materials are depleted or cooling resolidifies the electrolyte.

Upon impact with the roadbed of a derailed wheel, upward acceleration of the sensor **10** above a value corresponding to the preload of the accelerometer spring **34**, results in movement of the upper and lower impact sensor masses **26**, **28** as a unit downward with respect to the balls **50** which are locking the thermal pin collar **44** in position. After travel corresponding to the threshold velocity change, the step **32** inside the lower mass frees the balls to move outwardly, releasing the thermal pin collar **44**. The accelerometer spring **34** than pushes the thermal pin **54** and its collar downward, releasing the firing pin **58** and initiating the same action as the thermal sensor function of the thermal pin **54**.

The arrangement shown in FIG. **1** is as it might be built for experimental service to determine the proper settings for detecting the largest practical proportion of local derailments without encountering an excessive false-alarm rate. The two-piece sensor mass allows adjustment of the velocity change (ΔV) threshold independently of the acceleration threshold. For mass production, a one-piece mass as shown in FIG. **2** might be used.

The embodiment of FIG. **2** uses a Nitinol thermal release pin **54'** having a flat, enlarged head **78** received in a recess provided in the one-piece impact mass **80**. A spring **34'** biases upwardly both the release pin **54'** and the impact mass **80**, with the mass **80** being received in a bore **82** provided in the adaptor **12** and the release pin **54'** extending into a firing pin-receiving-bore **84** to restrain the firing pin **58** against spring **60**. The open end of bore **82** is closed by a cover **86** and a filler plug **18** seals the bore. The operation of the release pin **54'** and the one-piece mass **80** is identical to the corresponding elements of FIG. **1**.

An alternative power source is also shown in FIG. **2** wherein a piezoelectric crystal **88** replaces the thermal pulse battery **64**. It should be noted that both the thermal battery and the piezo-electric crystal are known to those skilled in the art and are briefly summarized for completeness of description. Crystal materials, such as lead zirconate/lead titanate sintered elements, electrically polarized to obtain the proper stress-output axis, are crushed by the explosive force of a detonator **90** to produce a relatively high voltage of short duration. In a typical low-resistance output circuit the current is approximately 35 amperes. Since there is a "race" between generation of a large electrical output from the extremely high explosive-generated pressures on the crystal and its termination by destruction of the electrical continuity of the output, the aluminum "wave-shaper" **92** is used to strike a balance between these opposed events.

The power source shown in FIGS. **1** and **2** may be used interchangeably with the accelerometer/thermal sensor combination of these figures. Additionally, if the thermal sensor function is not desired, the Nitinol thermal release pin may be replaced with an ordinary release pin insensitive to temperature.

FIGS. **3** and **4** show the plan view and elevation view, respectively, of a train car **94** provided with the brake actuation subsystem of the present invention. The impact/thermal sensors **10**, each with the associated power source **64**, are electrically connected by a shielded conductor system **96**, such as sheathed or armored cable, to the brake line venting mechanism **108**. The train's brake line **98** extend the length of car **94** and terminate in end couplings **100**. Connected to the train line **98** are the brake valve **102**, brake cylinder **104** and brake reservoirs **106**, elements common to a train's brake system and known in the art.

Positioned on the brake pipe **110** joining the brake valve **102** to the train line **98** is the brake line venting mechanism **108**, shown more fully in FIG. **5**. The venting mechanism includes shield **112** surrounding a dia-

phragm cutter having a cylindrical housing **114**; an explosively-driven bellows motor actuator **116** connected to the electrical conductors **96** positioned at one end of housing **114**; a slidably-mounted cutter **118** disposed adjacent the actuator **116**; a shearable diaphragm **120** positioned adjacent the other end of housing **114** to separate the housing from the internal passage of brake pipe **110**; an annular passage **122** provided in the housing **114** to permit passage of air from the brake pipe **110** after diaphragm rupture; and a calibrated venting orifice structure **124** to vent the released air. Also visible in FIG. **5** is the dirt chamber **126** and the cut-out cock **128,** elements common to train brake systems. The shield **112** around the diaphragm cutter, as well as the shielding around conductor **96,** serves to prevent interference from stray electromagnetic radiation and to provide mechanical protection against the severe environment existing beneath the train car. The diaphragm cutter may be similar to that disclosed in copending application Ser. No. 465,400, filed Apr. 29, 1974, and the explosive-type cutter actuator described therein may be used in place of the bellows motor actuator **116.**

Details of the bridge-wire bellows motor actuator **116** may be seen in FIG. **6,** wherein the wires **130** of the shielded conductor **96** are positioned against a propellant **132** contained in cup **134,** the ends of wires **130** being joined by a fine bridge wire **136** embedded in the propellant. Wires **130** are suitably insulated with insulating material **138,** and cup **134** is sealed with a plug **140** of glass, plastic or other suitable material. Bellows **142** is pleated from suitable malleable, ductile metal, such as copper, with the forward end formed into a blunt nose **144** and the edge of the aft, open end crimped over the seal plug **140.** Approximate this open edge, the bellows **142** is provided with an outwardly-extending ridge **146,** which receives a similarly-shaped ridge formed on the propellant cup **134** to properly position the cup.

The operation of the bellows motor actuator and the venting mechanism **108** can be readily seen from the foregoing description. Briefly, the propellant **132** is ignited by the signal generated by the thermal battery **64** or the piezoelectric element **88,** as set forth above, the expanding gases forcibly extending the bellows **142,** causing the blunt nose **144** to contact and displace cutter **118,** which in turn severs diaphragm **120** to release the air from brake pipe **110,** this slowing and eventually stopping the train. The escaping air flows out through passage **122** and the venting orifice **124.** As the air flows through orifice **124,** a distinct, audible sound is produced to help the train crew locate the car which has been braked and to determine what possible derailment condition has actuated the system. This permits remedial action prior to any actual derailment. Additionally, the actuation of the brake system can be monitored from a central location, such as the engine cab.

Bellows **142** a sufficiently rigid after expansion to prevent cutter **118** from being forced by air pressure back through the ruptured diaphragm and possibly obstructing the flow. To further assure free air flow, cutter **118** may be hollow with an opening **148** therein to permit unobstructed flow between brake pipe **110** and annular passage **122.**

Obviously, numerous modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A motion and temperature sensor system for detecting train wheel local derailment and actuating the brake system comprising:
- a motion sensor activated by wheel impact with the roadbed;
- a thermal sensor responsive to journal bearing temperature exceeding a predetermined value;
- an output signal generator operatively coupled with and activated by said motion sensor and said thermal sensor; and
- an electroexplosive means coupled to said signal generator for venting the brake system,
- whereby the train brake system is applied to stop the train upon detection of wheel impact with the roadbed or journal bearing temperature exceeding a predetermined value.

2. The sensor system of claim **1** further comprising an impact member and a biasing spring, said impact member being released by said motion sensor and said thermal sensor to activate said signal generator.

3. The sensor system of claim **2** wherein said thermal sensor comprises a heat responsive element which physically deforms at temperatures above a predetermined value.

4. The sensor system of claim **3** wherein said heat-responsive element comprises an intermetallic alloy of nickel and titanium.

5. The sensor system of claim **4** wherein said heat-responsive element comprises an elongated member extending adjacent said impact member to restrain said impact member against said biasing spring.

6. The sensor system of claim **5** wherein said motion sensor comprises:
- a displaceable mass; and
- a spring for maintaining said displaceable mass in a first position, said displaceable mass being moveable from said first position for wheel motions above a predetermined acceleration threshold and velocity change.

7. The sensor system of claim **6** wherein said displaceable mass is provided with an opening, said elongated heat-responsive member extends through said opening, and said spring maintains said displaceable mass in said first position and said heat-responsive member against said impact member.

8. The sensor system of claim **7** wherein said electroexplosive means comprises an explosively-actuated diaphragm cutter to puncture and vent the train brake line.

9. The sensor system of claim **8** wherein said diaphragm cutter is actuated by an explosively-extended bellows motor.

10. The sensor system of claim **9** further comprising a calibrated venting means connected to said diaphragm cutter capable of producing an audible signal upon brake line venting.

11. The sensor system of claim **8** wherein said output signal generator comprises a thermal battery activated by said impact member.

12. The sensor system of claim **11** wherein said thermal battery comprises:
- a pyrotechnic reactant;
- an electrochemical reactant; and

a percussion primer triggered by said impact member to initiate an electric current producing reaction between said pyrotechnic reactant and said electrochemical reactant.

13. The sensor system of claim **8** wherein said output signal generator comprises a piezoelectric element initiated by said impact member.

14. The sensor system of claim **13** wherein said piezoelectric element comprises a detonator initiated by said impact member and piezoelectric crystals crushed by pressure from said detonator to produce an electric current.

15. The sensor system of claim **8** further comprising releasable restraining means for maintaining said displaceable mass in said first position.

16. The sensor system of claim **15** wherein said releasable restraining means comprises a ball release whereby a plurality of balls are movable between a restraining position and a release position.

17. The sensor system of claim **16** where said ball release comprises:

a first cylindrical sleeve;

a plurality of apertures provided in said first sleeve;

a plurality of balls positioned in said apertures and contacting said displaceable mass;

a concentric, inner cylindrical sleeve in contact with said plurality of balls and supporting said spring to exert an outward force on said balls; and

a receiving recess in said displaceable mass located adjacent said plurality of balls,

whereby said displaceable mass is maintained in said first position by the force of said plurality of balls, and upon acceleration of said displaceable mass by wheel impact with the roadbed, said mass is displaced downwardly to align said receiving recess with said balls, releasing said balls from the restraining position and permitting said heat-responsive member to release said impact member.

18. The sensor system of claim **17** wherein said output signal generator comprises a thermal battery activated by said impact member.

19. The sensor system of claim **18** wherein said thermal battery comprises

a pyrotechnic reactant;

an electrochemical reactants; and

a percussion primer triggered by said impact member to initiate an electric current producing reaction between said pyrotechnic reactant and said electrochemical reactant.

20. The sensor system of claim **17** wherein said output signal generator comprises a piezoelectric element initiated by said impact member.

21. The sensor system of claim **20** wherein said piezoelectric element comprises a detonator initiated by said impact member and piezoelectric crystals crushed by pressure from said detonator to produce an electric current.

* * * * *