# United States Patent [19]

**Kita**

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[54] **WORN BRAKE LINING ALARM CIRCUIT**


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[73] Assignee: **Sumitomo Electric Industries Ltd.,** Osaka, Japan



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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **340/52 A,** 200/61.44

[51] **Int. Cl.** ..... **B60t 17/22**

[58] **Field of Search** ..... 340/52 A, 52 B, 69; 200/61.4, 61.44, 61.42



[56] **References Cited**

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*Primary Examiner*—Alvin H. Waring

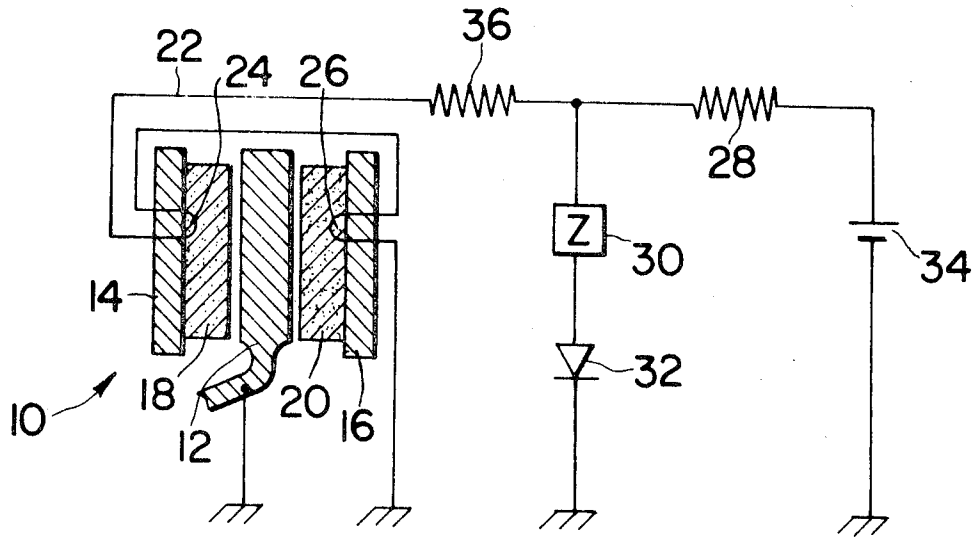
*Attorney, Agent, or Firm*—Sughrue, Rothwell, Mion, Zinn & Macpeak



[57] **ABSTRACT**

A negative resistance diode and an alarm device are connected in a series circuit with a battery whose terminal potential is higher than the threshold switching voltage of the diode. A worn brake lining detector circuit is connected in shunt with the series circuit. Normally, the shunt circuit draws current from the battery so that the voltage applied across the diode is below its switching voltage but above its holding voltage, and the alarm is not actuated. If even a momentary interruption of the shunt circuit occurs, the full battery potential is applied to the diode, thereby switching the diode into a conducting state to actuate the alarm. Even if the shunt circuit is subsequently closed by electrical contact with the rotating brake disc, the holding current through the diode is maintained, so that the diode remains conducting and the alarm remains actuated.


**4 Claims, 4 Drawing Figures**



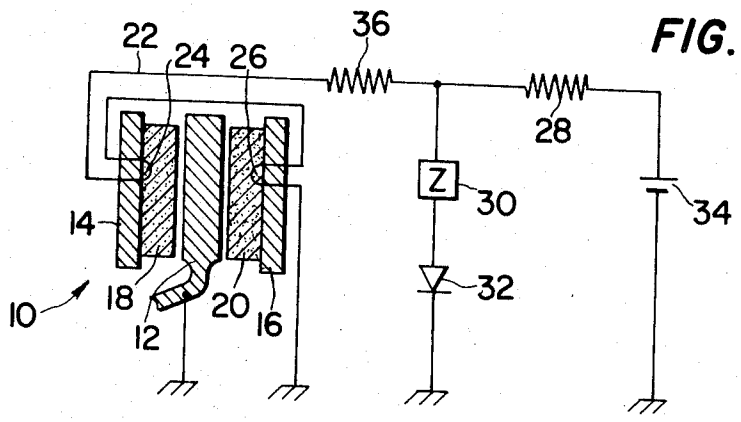



FIG. 1

FIG. 2

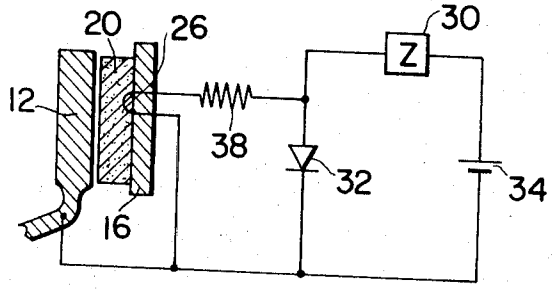



FIG. 3

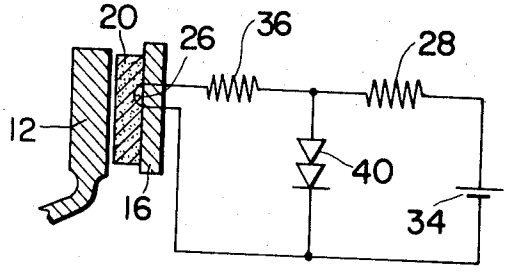
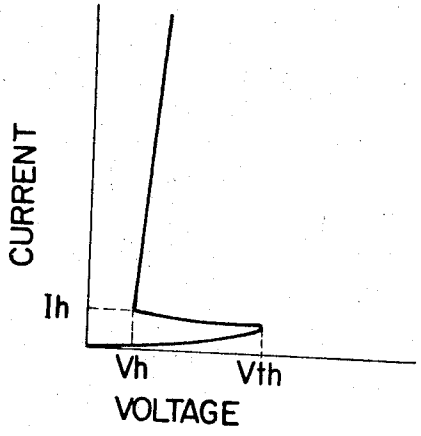



FIG. 4



# WORN BRAKE LINING ALARM CIRCUIT

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of electrical alarm circuits for detecting a worn condition of friction brake linings, and, more particularly, to such a circuit which is fail-safe in operation.

2. Description of the Prior Art

A prior art worn brake lining alarm circuit of the type in which a warning is issued when an electric detecting circuit is interrupted when the lining wears down beyond a predetermined working limit is disclosed in Japanese Publication No. 8,499/1972, filed Feb. 13, 1968. Such a prior art circuit is superior to other prior art circuits in that any interruption in any portion of the detection circuit, including the lead wire to an alarm device is indicated as an alarm condition. Such fail-safe operation is important since the detection circuit may be interrupted by causes, such as vibration, etc., other than a wearing down of a brake lining beyond its working limit.

However, in the past a considerable amount of hardware was required to achieve this fail-safe function with a loop working limit detection circuit of the type disclosed in German Patent Publication Serial No. 1,045,259, filed July 12, 1957 when, after an initial interruption of the detection circuit, the detection circuit is subsequently closed by the lining's wearing down to its working limit so that the loop circuit is short-circuited to the grounded rotating disc of the brake assembly.

## SUMMARY OF THE INVENTION

The object of this invention is to provide an improved worn brake lining alarm circuit, employing the principle of the interruption of a conductor loop detector circuit for detecting that a lining has worn down beyond its working limit, and which issues a continuous warning once the detector circuit is even only momentarily interrupted, even when subsequent wearing of the lining to its working limit causes a loop to electrically contact the grounded brake assembly to reclose the detector circuit.

Another object is to provide such an improved circuit including a negative resistance diode to accomplish the result stated in the foregoing object.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1–3** are schematic circuit diagrams of preferred embodiments of the invention.

FIG. **4** is a current and voltage characteristic curve diagram of a negative resistance diode employed in this invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates one preferred embodiment of the present invention for actuating an alarm when the working limit of a friction lining of a disc brake assembly has been exceeded. In FIG. **1,** a disc brake assembly **10** includes a rotating brake disc **12** and a pair of brake pads **14** and **16** having mounted thereon friction linings **18** and **20** respectively. An insulated electrical conductor **22** has formed therein two fixed loops **24** and **26.** Loop **24** projects through the pad **14** and into the back of the lining **18** to a point corresponding to the working limit of the lining **18.** That is, the point at which the loop **24** is embedded in the back of the lining **18** is the point beyond which the brake lining should not wear, and it is at this point that it is desired to actuate an alarm to indicate that the lining has worn down to its working limit. In like manner, loop **26** is embedded in the lining **20** at a point corresponding to the working limit of that lining.



The circuit formed by conductor **22** and loops **24, 26** functions as a detector circuit for detecting that at least one of the brake linings has worn down to its working limit. As described in West German Publication Ser. No. 1,045,259, for example, each loop is adapted to be abraded by the rotating brake disc **12** when the working limit is reached, thereby causing an interruption of the detector circuit.

In accordance with this invention, a resistance **28,** an electrically operated warning device **30,** such as an electric lamp, a luminous diode, a buzzer, etc., and a negative resistance diode **32** are series-connected with a power source **34,** such as a battery, which generates a terminal voltage equal to or greater than the threshold switching voltage Vth of the negative resistance diode **32.**

A resistance **36,** conductor **22,** and loops **24, 26** are series-connected and are shunt-connected with respect to the series circuit formed by the alarm device **30** and the negative resistance diode **32.**

In the operation of the circuit shown in FIG. **1,** the voltage of the source **34** is divided by the resistances **28** and **36** so as to apply to diode **32** a voltage lower than its switching voltage *Vth*, but higher than its holding voltage *Vh*. The diode **32** is a known negative resistance diode having current-voltage characteristics as shown in FIG. **4.** Consequently, under normal conditions, the diode is non-conducting so that the warning device **30** is not activated.

However, if any interruption occurs in any part of the detector circuit connected in shunt with the series-connected alarm **30** and diode **32,** the full, undivided source voltage is applied to the diode **32** so that a voltage higher than the switching voltage *Vth* is applied thereto, with the result that the diode conducts and the alarm device **30** is activated. Even if the shunt-circuit which has been interrupted by the breaking of a loop through abrasion is reclosed by electrical contact of the loop with the grounded disc upon subsequent application of the brake, a current larger than the holding current Ih of the diode continues to flow through the alarm device **30** to maintain it activated. This result occurs since the divided voltage is always greater than the diode holding voltage *Vh*, even though it is lower than the switching voltage *Vth*. That is, the momentary interruption of the shunt circuit is memorized by diode **32.** Furthermore, the alarm is fail-safe, since it is activated in the above manner even when the conductor **22,** which is a part of the shunt-circuit, is broken by any cause.

FIG. **2** is a further preferred embodiment wherein the internal resistance of the alarm device **30** is used, instead of the resistance **28,** to form the voltage divider. In this case, a resistance **38** is required, and its value is selected so that the divided voltage applied to diode **32** is greater than *Vh*, but less than *Vth*. In this embodiment, the loop detector circuit is connected directly in shunt with the diode **32.**

FIG. 3 is a still further simplified preferred embodiment wherein a recently developed negative resistance luminous diode **40** which operates as a luminous of light-emitting diode having negative resistance is used to provide both the switching function of diode **32** and the alarm function of device **30,** as shown in FIG. **1.**

As described in detail above, the present invention provides a working limit warning apparatus for brake friction lining, which apparatus is highly improved in safety and wherein the suspension of a warning is prevented when an interruption-type detector circuit is used.

Even though the above embodiments include an embedded loop type detector, the invention covers a fail-safe alarm circuit for use with any detector circuit of the type in which an electrical interruption within the detector circuit indicates a worn brake lining; e.g. the type in which the grounded back plate is disconnected from the conductor **22** when the lining wears beyond its working limit.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

I claim:

**1.** In combination with a worn brake-lining detector circuit of the type which is electrically interrupted when the lining wears down to a predetermined working limit, an improved alarm circuit for indicating the interruption comprising:

a. a D.C. power source,

b. voltage divider means connected to said power source,

c. a normally non-conducting two-terminal negative resistance diode coupled to said voltage divider means,

d. means connecting said detector circuit in shunt with said diode; whereby when said shunt-connected detector circuit is normally uninterrupted, the divided voltage applied to said diode by said voltage divider means is less than the threshold switching voltage, but greater than the holding voltage, of said diode; and

e. said D.C. power source having a terminal potential greater than or equal to the threshold switching voltage of said diode so that, when said detector circuit is interrupted even only momentarily, said terminal voltage is applied to said diode to render said diode conducting as an indication of the interruption, said diode remaining continuously conducting even if said detector circuit is subsequently closed.

**2.** The improved alarm circuit as defined in claim **1,** further comprising a current-actuated alarm means connected in series with said diode, and wherein said detector circuit is connected in shunt with the series combination of said diode and said alarm means.

**3.** The improved alarm circuit as defined in claim **1,** wherein said diode is a light-emitting diode which emits light when said diode becomes conducting.

**4.** The improved alarm circuit as defined in claim **1,** wherein said voltage divider comprises a resistor and the internal resistance of an electrical alarm means connected in series between said detector circuit and one terminal of said power source; and further comprising means connecting said diode between the other terminal of said power source and the function of said resistor and said alarm means, whereby said alarm means is current-activated only when said diode is conducting.

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