May 11, 1965 R. B. BARNES ETAL 3,183,349

HOT BOX DETECTOR

Filed Oct. 30, 1959 3 Sheets-Sheet 1

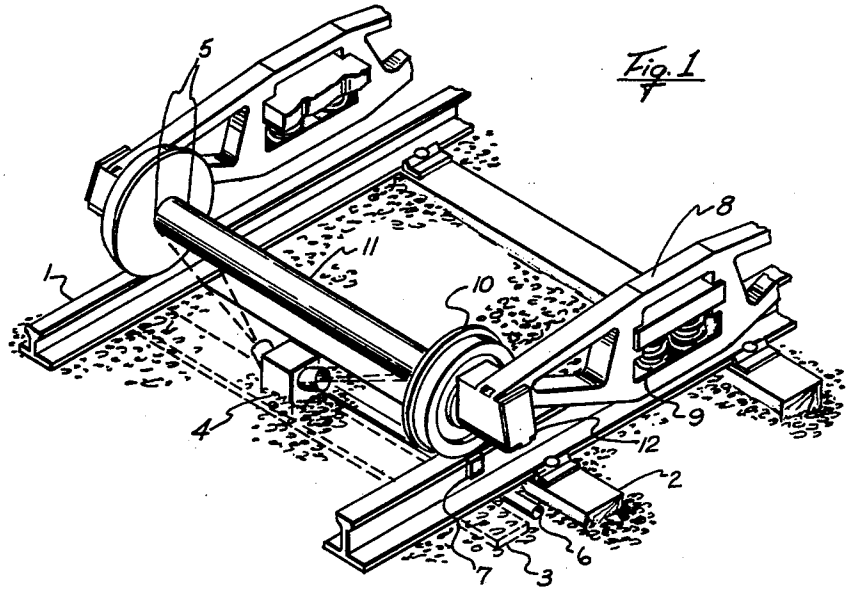


Fig. 1

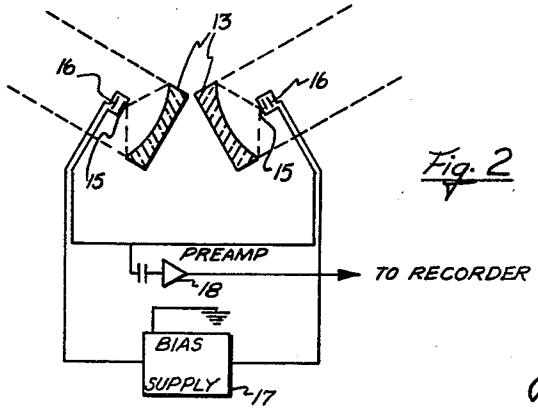


Fig. 2

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HOT BOX DETECTOR

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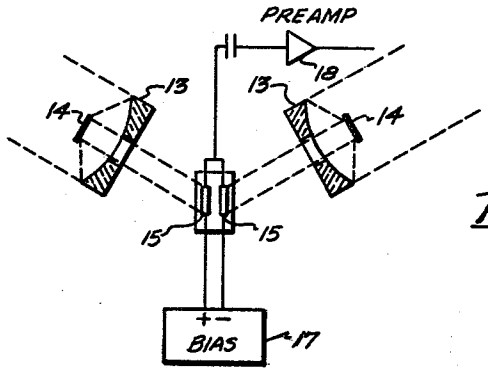


Fig. 3

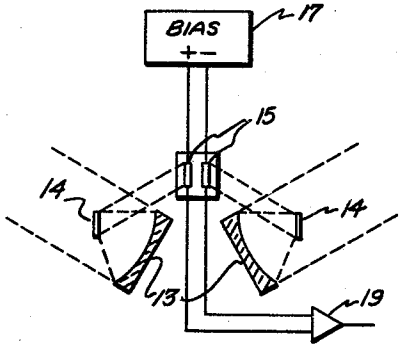


Fig. 4

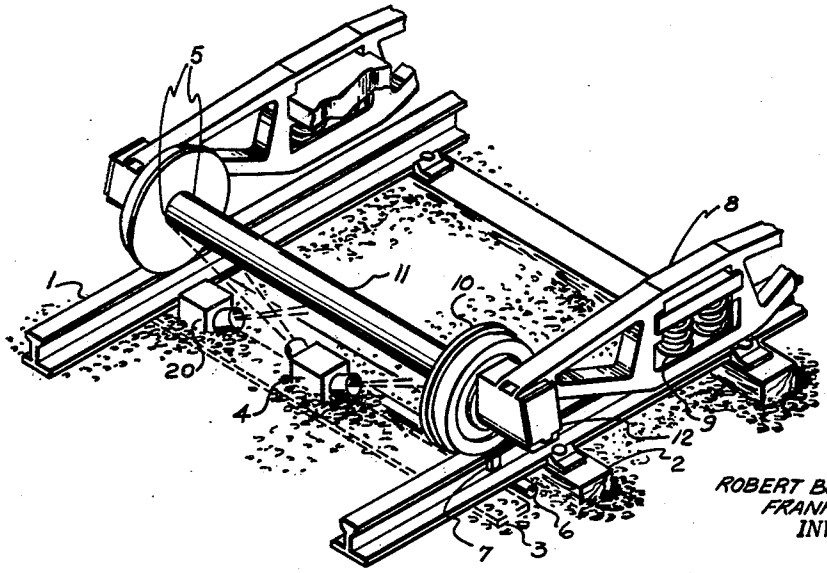


Fig. 5

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Filed Oct. 30, 1959 3 Sheets-Sheet 3

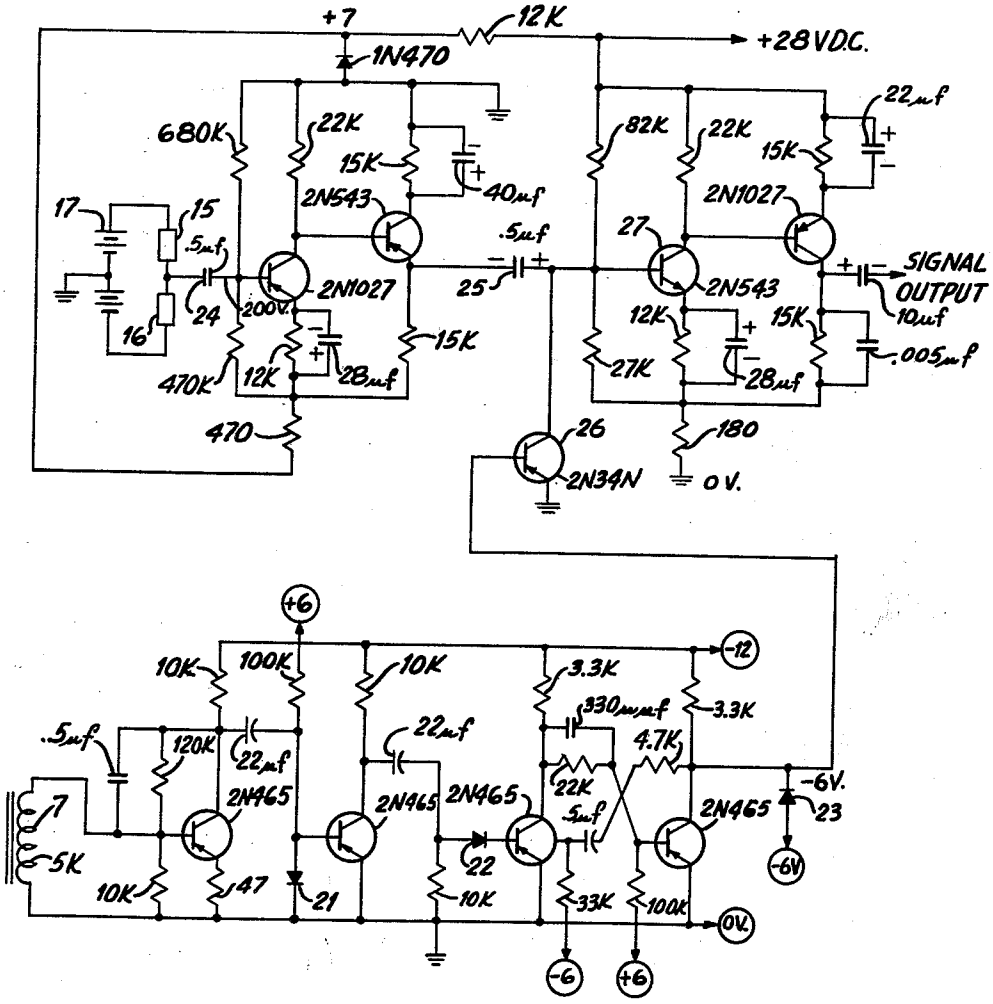


FIG. 6

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3,183,349

HOT BOX DETECTOR

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8 Claims. (Cl. 246—169)

This invention relates to a hot box detector system.

The problem of detecting hot boxes on railroad cars and particularly freight cars is a very serious one. Not only is there danger involved if a neglected hot box seizes, which sometimes has been known to cause derailment, but even where there are no such dire results the train may be stopped between stations or yards and the cutting out of the car consumes much time and results in a very substantial additional operating expense. Any means of detecting hot boxes should, therefore, be sufficiently sensitive and reliable so that it gives warning for some time before the box seizes, permitting cutting out the car in question at the next yard or station and avoiding the tying up of tracks and other expensive delays which occur when a hot box actually seizes.

At first blush the solution of the problem is fairly obvious. All that might be expected to be required would be an infrared radiometer directed toward the correct boxes. In practice there are some serious operational problems which must be solved for an ideally reliable device. An approach to the solution is described and claimed in U.S. Patent 2,880,309 to Gallagher and Pelino. Essentially the patent describes double infrared radiometers alongside the rails, either outside the tracks or inside, which sight along the track at a suitable angle so that they strike the sides of successive journal boxes as a train moves along. The output of the radiometers is sent to a central location or to the next station or yard and can be recorded. When a hot box passes, the recorder will show a response which can be distinguished from other normal journal boxes and from external conditions such as circuit noise and the like. The modification shown in FIGS. 1, 2 and 11 of the patent in which the radiometers are outside the tracks, while theoretically operative are practically not usable except in fair weather. Infrared radiation is absorbed by solid water and a rainstorm may be so heavy as to render the device of such low and erratic sensitivity as to be impractical. Even in less extreme storms the water from the whole car top may cascade off one side a sheet of water.

The modification shown in FIGS. 8, 9 and 10 of the Gallagher patent, in which the radiometers are located just inside the rails, is more practical as the passing cars serve as umbrellas and prevent heavy sheets of rain from falling between the radiometer and the wheel journal or other portion, the temperature of which is to be measured. This permits operation on many rainy days but still does not take care of the situation presented when heavy rain and high wind occur at the same time on open stretches of track. The rain then blows in sideways and again the devices becomes unsatisfactory. Days of this nature are somewhat less frequent than days with heavy rain, with or without wind, but they are sufficiently frequent so that the instrument is not reliable the year around.

An essential and fundamental disadvantage of the Gallagher device is that it requires four radiometers in order to be useful for the measurement of the temperature of journal boxes and adjacent metal parts. This is an essential limitation because, as the patentees correctly realized, the front edge of an approaching journal box may not be at the same temperature as the rear edge because the front edge is subjected to a blast of cooling air whereas the air adjacent to the rear edge is relatively stagnant. As a result it is necessary to have separate radiometers facing in opposite directions for each track. These are associated with switches or other devices actuated by the wheels so that the proper radiometer is cut into circuit depending on the direction in which the car is traveling on the track. Even when the correct radiometer is cut in so that it views receding cars, there are differences between the journals of a single bogie because of intervening members which obscure one journal more than the other when viewed along a path nearly parallel to the rails. Other disadvantages of the device of the Gallagher patent will be referred to below in connection with the description of the present invention which eliminates all of the disadvantages.

Essentially the present invention comprises two radiometers, or in a more specific aspect two optical systems, with a single detector mounted more or less centrally between the tracks and receiving radiation from an upwardly inclined direction substantially at right angles to the rails instead of predominantly from a direction along the rails as is specified as an essential requirement of the device of the Gallagher patent. The radiometers of the present invention receive radiation from portions of the inner part of the wheel as is the case with the device of the Gallagher et al. patent shown in FIGS. 8 and 9. However, they receive this radiation in a direction substantially at right angles to the rails instead of essentially along them as in FIG. 8 of Gallagher or parallel to the plane thereof and straight up as in FIG. 9 which Gallagher et al. themselves agree is not satisfactory as it exposes the optics to dirt and weather.

There is a choice of what portion of the wheel is viewed by the radiometers. It can be any part of the inner surface but is preferably the junction of the axle and the wheel. It has been found that here there is the greatest rise in temperature with development of hot boxes and the effect of heating of the periphery of the wheels by brake shoes is minimized. However, there is sufficient rise in temperature adjacent to the junction of axle and inner wheel surface so that the invention is not absolutely limited to viewing precisely the junction of wheel and axle. In general, however, the greater efficiency of this viewing location renders it the preferred embodiment of the invention. It will be seen that two radiometers, both fully protected from the weather by the viewing angle, which is not too far removed from the horizontal plane, perform the same function as four radiometers in the modifications of the Gallagher patent which are practically useful and in which protected radiometers are used, viewing in general, along the tracks. In other words, the same effect of measuring the temperature developed by the journals of wheels in cars going in either direction along the rails is effected with half the number of parts. In a more specific modification of the device still further saving of parts is made possible.

The invention will be described in greater detail in conjunction with the drawings in which:

FIG. 1 is a perspective of a freight car bogie on the track;

FIG. 2 is a schematic detail in section of optics using separate detectors;

FIG. 3 is a schematic in section of reflective optics using half the number of detectors;

FIG. 4 is a schematic in section of different reflecting optics using half the number of detectors;

FIG. 5 is a perspective similar to FIG. 1 showing an additional comparison radiometer, and

FIG. 6 is a schematic diagram of a typical transistor amplifying and gating circuit.

In FIG. 1 the rails are shown at 1 with conventional cross ties at 2 and a separate mounting tie 3 between the regular ties and having mounted thereon a twin radiometer 4 shown as receiving rays from the junctions 5 of

axle and wheel. The wheels and axles are shown in the conventional bogie which comprises frame 8, springs 9, wheels 10, axles 11 and journal boxes 12. It will be noted that a twin radiometer, instead of two twin radiometers, performs the same function as is performed by the only, at least partially practical, modification of the Gallagher patent in FIG. 8. There is a further preferred element of design, namely, that the radiometer is mounted on a separate tie which is not connected to the rails instead of on the regular ties as in the Gallagher patent. This avoids the major portion of the low frequency vibration caused by the passage of the railroad cars. In the Gallagher device the mounting is on the tie which receives this vibration without any diminution. That this problem is a serious one was realized by Gallagher who suggests using a shock mounting in his FIG. 4.

Shock mounting is helpful even in the devices of the present invention if vacuum tube amplifiers are used in the radiometer itself. It is less necessary when separate mounting ties or bases are used as in the present invention and when transistorized amplifiers are used which are preferred in the devices of the invention, no shock mounting need be provided where there is a separate mounting base. It should be noted that when the mounting is on the tie itself the vibration may be so intense that even parts of the radiometer other than tube amplifiers may be adversely affected. It should be noted that the central mounting of the radiometers of the present invention minimize the effect of vibration as their location is about as far from both rails as possible.

FIG. 1 illustrates one further desirable feature though it is not absolutely essential. This feature employs drainage pipes to keep the area between the ties where the double radiometer is mounted from filling with water in the vent of severe rain or melting snow. There is fairly good drainage in well ballasted track using rock ballast and so in most locations it is possible to operate without special drainage means. However, they are desirable and so in preferred aspects of the present invention are included.

In order to determine where a hot box is located as a train moves past, some axle counting device is desirable. A typical such wheel actuated device is shown in the Gallagher patent and it is an advantage of the present invention that any suitable counting device may be used. At the same time the wheel actuated switch, which is shown at 7 as of the magnetic type, can perform an additional function. That is to say it can be used as a gate or more precisely to trigger a gating transistor for the electrical systems receiving signals from the radiometers thus causing the circuits to be open only when the radiometers view a predetermined portion of the wheel, for example, the junction of axle and wheel. The gating in the electronic circuits may be of standard design and it is an advantage of the present invention that no special or complicated circuitry is needed. The electronic circuits are, therefore, not shown, only the wheel actuated device 7 being illustrated in diagrammatic form. The only difference of significance lies in the desirability of using transistorized amplifiers to eliminate microphonic problems and for minimum power consumption and maximum life. The radiometers, or more correctly the twin radiometer of the present invention, views the passing wheel axle junction for only a few inches and the time during which the detector receives radiation is, therefore, dependent on the speed of the train. This constitutes no practical problem although it is a necessary limitation of the present invention. In general, with maximum freight train speeds of about 70 miles an hour, the viewing time is of the order of 5 milliseconds. The calculation is as follows: 70 m.p.h.= 103 ft./sec. As the area observed on the wheel is about 6" this corresponds to 4.9 milliseconds. Infrared detectors of a shorter response time, for example, of the order of 1 or 2 milliseconds, are standard articles of commerce and, therefore, while the present invention requires detectors of fast response this is not a practical limitation since it merely determines the choice of known conventional types of detectors. These high speed detectors are ordinarily of small dimensions and this in turn may affect the choice of a particular type of optics, namely, those which are substantially achromatic over the infrared energy band to be received. Theoretically lenses or lense filter systems which are achromatic over a wide band of infrared radiation could be used. However, ordinary lens materials show considerable chromatic aberration and therefore, in general, the optics shown in the Gallagher patent, which employ ordinary conventional infrared lenses, are not suitable for the present invention because the chromatic aberration results in the focusing of different wavelengths of the infrared radiation in different planes of the small fast detectors. However, the most serious loss with most infrared lenses lies in the fact that most materials cut off a considerable portion of the far infrared, for example, beyond 15 microns. With the fairly low temperatures that are being measured a considerable portion of the energy is radiated in this region. Therefore, most lenses utilize only a portion of the infrared energy radiated. The present invention, therefore, prefers infrared optics, particularly reflective optics, which utilize the energy more efficiently and, therefore, may be considered more efficient.

Another method for handling the problem of detector time constant is to use electronic amplifiers which amplify more strongly the changes in detector output rather than solely the amount of voltage generated. To a considerable extent such amplifiers can compensate for somewhat slower detectors. These amplifiers normally operate by boosting the high frequency response.

Three representative types of reflective optics are shown in FIGS. 2 to 4, the same elements bearing the same reference numerals. In all three figures there are present two converging mirrors 13. Three types of mirrors are shown in the different figures, ordinary condensing mirrors in FIG. 2, Cassegrain mirrors with reflecting mirrors 14 in FIG. 3 and Newtonian condensing mirrors with reflecting mirrors in FIG. 4. In FIG. 2 there are two separate detectors of conventional design, that is to say, having a detecting element 15 receiving the radiation and a similar element 16 connected in opposition to balance out changes in ambient conditions. The detectors, which are illustrated as preferably of the thermistor type, but may be other types of infrared sensitive detectors, are energized by a bias supply 17 and the differential output is fed to a conventional preamplifier 18, the output of which can be led to the telemetering systems, recorders, alarms, etc.

In FIG. 3 there is illustrated a twin radiometer with only half as many detector elements. Here each detector receives radiation from the wheels but the two detectors are connected in opposition so that only a difference voltage is applied to the preamplifier. This requires reasonably matched detectors but has the advantage that the number of elements is halved; in other words, in this modification two detector flakes take the place of the eight flakes which are needed in the practical modifications of the Gallagher patent.

FIG. 4 illustrates a different use of two detectors by feeding their output into a differential preamplifier 19. While this is a different type of amplifier than that shown in FIG. 3 it is also conventional and so is shown only diagrammatically.

FIG. 6 illustrates a typical transistor amplifying and gating circuit. The values of the components are given but only some of the components are designated by reference numbers. The diagram shows the two thermistors 15 and 16 and their bias source 17 in schematic form. The differential signal from the thermistors enters the amplifying circuit through the large capacitor 24 which,

with the associated circuit constants, results in a time constant of suitable length so that the response of the instrument does not change significantly with the speed of the railroad train up to a maximum of about 70 miles per hour.

Essentially the first part of the amplifier is a standard A.C. amplifier with a fairly long time constant so that there is no continuing signal beyond the approximately 5 millisecond interval. The output which is in the form of a broad pulse determined by the time constant of the preamplifier, passes on through the capacitor 25 which blocks direct current signals. Capacitor 25 connects to the base of the gating transistor 27, which is normally biased to cutoff and so does not amplify any signal.

When a train wheel passes the magnetic switch 7 (represented schematically on FIG. 6 as an inductance), a pulse results which is clamped to a certain voltage by the diode 21 and is amplified and passed by the diode 22 to the transistors forming a conventional flip flop circuit. The output of this circuit, clamped by the diode 23, is applied to the base of the transistor 26. This transistor is normally biased to cutoff and hence does not affect the voltage on the base of the gating transistor 27. When, however, the amplified pulse from the magnetic switch actuates the flip flop circuit, a positive voltage is applied to the base of transistor 26, causing the latter to conduct. As a result the transistor 26 presents very low resistance and for practical purposes brings the base of the gating transistor to ground potential. This causes the transistor to be biased in operating condition, i.e., the gate is opened and any amplified signals from the thermistors 15 and 16 are amplified by the gating transistor 27 and its succeeding transistor, and a signal output in the form of a pulse results.

When the train is moving at 70 miles an hour or more the next pulse from the magnetic switch 7, caused by the partial collapse of its magnetic field, is amplified and resets the flip flop circuit to its original state. The transistor 26 ceases to conduct, the gating transistor 27 is biased to cutoff, and the gate is closed. If, however, the train is moving very slowly, signals from the thermistors 15 and 16 will cease to be amplified after a short period of time determined by the time constant of the input circuit to the preamplifier of which capacitor 24 is one element. The duration of the pulse is, therefore, determined either by the opening and closing of the gate due to signals from the magnetic switch 7, or by the effect of the time constant of the preamplifier, whichever is shorter. In the unlikely event of speeds above 70 miles per hour the magnetic switch will close the gate after a period somewhat shorter than 5 milliseconds. This will result in a narrower pulse with a little less energy, but the occurrence is rare and the shortening of the pulse duration is too small to affect seriously the signal from the gated amplifier circuit.

Theoretically it might be argued that the record of two hot boxes on the same axle would cancel out and so would not record the presence of a hot box. It should be noted that they would have to be exactly the same temperature at both ends of the axle which makes the likelihood of two incipient hot boxes on the same axle having the same temperature too small to be considered, as the probability of such an occurrence is extremely remote. It is, however, possible, particularly with a differential preamplifier, as shown in FIG. 4, to prevent even such an extremely improbable occurrence from causing the machine to fail to give an indication of an incipient hot box. This can be simply taken care of by taking off a portion of each detector signal before they are combined to produce a differential output and using these signals to actuate an alarm system. If either or both show excessive outputs, this can be fed into the recorder, if desired through suitable threshold circuits, so that if the signal is large enough from either detector a record will appear. It is an advantage of the present invention that in many installations it is not necessary to provide for the unlikely occurrence of two incipient hot boxes of the same temperature on the same axle, if it is desired this additional protection may be obtained.

FIG. 5 illustrates in perspective a somewhat more elaborate device. The corresponding parts bear the same reference numerals as in FIG. 1. It has been found that the part of the axle and wheel assembly which is most nearly constant in its temperature, once it has adjusted itself to ambient conditions, is the middle of the axle. This can, therefore, be used as a reference point and in FIG. 5 a third radiometer 20 is positioned with its beam pointing substantially at right angles to the track and upward so that the center of the axle is imaged at the time when the other radiometers are receiving their infrared radiation from the wheels or as in the preferred modification from the point where the axle joins the wheel. A comparison is thus possible which under certain circumstances gives a more reliable indication than do the two radiometers alone. For example, if a differential signal or a differential signal amplifier is used, as in FIGS. 3 and 4, the output signal is determined by the relative temperatures of the two wheels. Under certain extreme climatic conditions a difference may be caused by something other than a hot box. For example, in the case of a sleet storm blowing across the track, one side of a freight car, including its wheels and bogie frame work, may be coated with ice. This may result in a lower temperature for the corresponding wheel, particularly if brakes have been applied which would warm up the wheel not coated with ice, while the ice coating to a large extent absorbed the braking heat as latent heat of fusion. A similar situation might result if a freight car had been standing with an intense summer sun beating on one side. Again the wheels on the different side of the car may be at different temperatures. In each case the center of the axle would be least affected and can be used as a reference point. For example, the radiometer 20 may feed a signal which is compared with the signals from the other two radiometers and an alarm only registered if there is a temperature difference of significance between the center of the axle and the wheel which is getting heated by an inadequately lubricated bearing.

The decision as to whether a device similar to FIG. 5 is to be used or the simpler device of FIG. 1 would be largely dictated by economic and geographical considerations. The additional radiometer, of course, adds to the cost of the device and so the more elaborate device would normally be used only where climatic conditions are such that the additional reliability is worthwhile. Since the most serious climatic condition is a heavy sleet storm the simpler device will frequently be preferable in the south where such conditions do not occur. However, it is an advantage of the present invention that it is quite flexible and that devices of differing degrees of complexity and function are available to suit every condition.

It has been proposed to use a plurality of hot box detectors at reasonably close intervals, for example, two or three miles so that three readings could be consulted for, of course, the most reliable indication is a rapid rise in temperature. The idea of multiple installations to achieve the above desired result is not our invention. Reference thereto, however, is made here because the devices of the present invention are very suitable in such a system. Also, when there are several detectors which will be considered in series, the risk of a false indication by reason of laterally asymmetric temperature conditions is minimized for a differential temperature reading between wheels on the same axle would not be as significant if there were no change through successive hot box detectors. Therefore, when the multiple hot box detector is used it will often be considered economically possible or desirable to use the simpler device of FIG. 1 whereas under the same geographic conditions if only

a single detector was being provided the more accurate reading of the device of FIG. 5 might be found preferable.

FIGS. 2 to 4 show different achromatic optics associated with different detector designs. It will be understood that any one of the achromatic optics can be used with any one type of detector.

While the largely horizontal direction of the infrared path furnishes considerable protection of the mirrors from the elements it is desirable to use a suitable infrared window such as a thin sheet of polyethylene in order to keep out dust. The sheet can be backed up with a perforated metal plate for greater strength.

We claim:

1. A hot box detector comprising in combination a length of railroad track, an infrared detection device mounted between the rails of said track, said detection device comprising infrared detectors and optical means with substantially uniform transmission through a predetermined wavelength band imaging each infrared detector along an axis inclined upwardly with respect to the track elevation and substantially at right angles to the track, the inclination of the axis being such as to image a portion of the central part of railroad car wheels passing over the said infrared detection device whereby infrared energy radiated from said central portion of the railroad car wheels along said axis is shielded from rain from both top and sides as an axle passes over the detecting device.

2. A hot box detector according to claim 1 in which the infrared detectors comprise a single detector each connected in opposition whereby the detectors produce a differential output signal.

3. A hot box detector according to claim 1 including wheel responsive means for actuating the infrared detecting device for a predetermined time interval as each pair of railroad car wheels pass over the detector.

4. A hot box detector according to claim 3 in which the infrared detectors have a response time not exceeding 5 milliseconds.

5. A hot box detector according to claim 3 in which

the infrared detectors each consist of a single detector bridge circuit, the outputs thereof being connected in opposition whereby a differential output signal is produced.

6. A hot box detector according to claim 1 in which the imaging means image the infrared detectors on the junction of the railroad car axle with the wheel.

7. A hot box detector according to claim 3 in which the imaging means image the infrared detectors on the junction of the railroad car axle with the wheel.

8. A hot box detector according to claim 1 in which the output of the infrared detectors are energized and their output amplified by fully transistorized equipment.

References Cited by the Examiner

UNITED STATES PATENTS

1,901,192	3/33	Reinhardt et al.	73—355
2,376,311	5/45	Hood.	
2,565,249	8/51	Machler	73—355
2,710,559	6/55	Heitmuller et al.	
2,818,508	12/57	Johanson et al.	246—169 X
2,829,267	4/58	Howell	246—169
2,856,539	10/58	Orthuber et al.	246—169
2,880,309	3/59	Gallagher et al.	246—169
2,920,485	1/60	Derganc	73—355
2,963,575	12/60	Pelino et al.	246—169
3,065,347	11/62	Bossart	246—169 X

FOREIGN PATENTS

1,199,244	6/59	France.
940,785	3/56	Germany.
1,031,338	6/58	Germany.
705,327	3/54	Great Britain.
328,951	3/58	Switzerland.

OTHER REFERENCES

S.H.A. (1), German application 1,002,381, printed Feb. 14, 1957 (KL 20h).

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