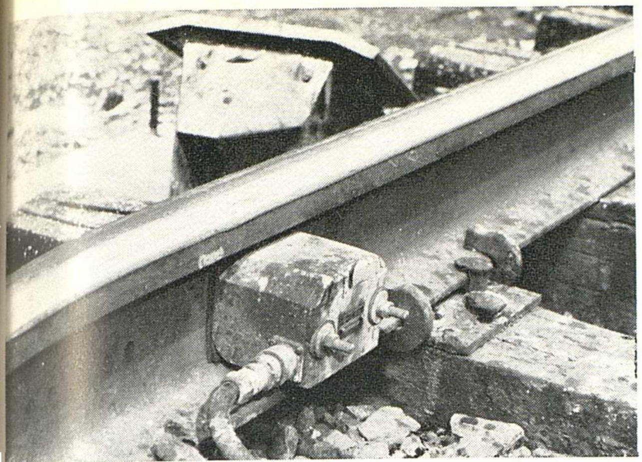
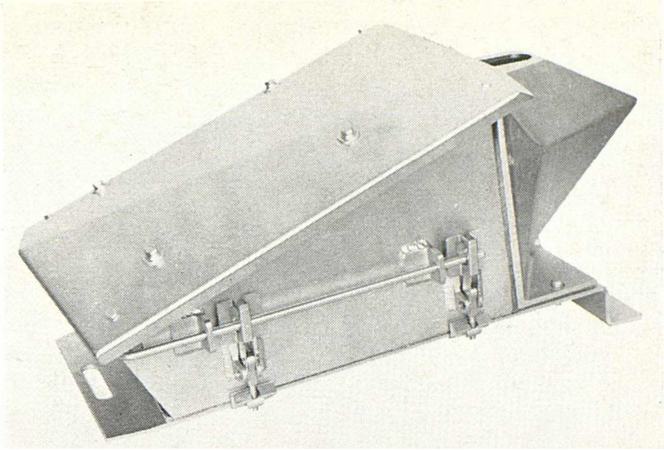


Magnetic wheel pickup is bolted to the rail web.



Trackside scanner for shutter-type hotbox detector.

GE approach to hotbox detection

By Earl Taylor
Application Engineer
General Electric Co.

Even though the number of reported hotboxes has been gradually decreasing over the past five years, the railroads have a continuing problem with hot journals or roller bearings. This problem might be likened to the flat tire problem of your automobile. It does not happen often, but it could be catastrophic when it does.

Hotboxes occur when inadequate bearing lubrication or mechanical flaws cause a significant increase in wheel bearing friction which in turn results in an increase of wheel bearing temperature. As the bearing temperature rises to an abnormally high level, a bearing failure may result. Such bearing failures constitute a major cause of car derailment endangering life, destroying property, and resulting in costly delays and maintenance.

Some of the questions asked by people who are concerned now about hotbox systems are:

(1) What part is the best place to scan?

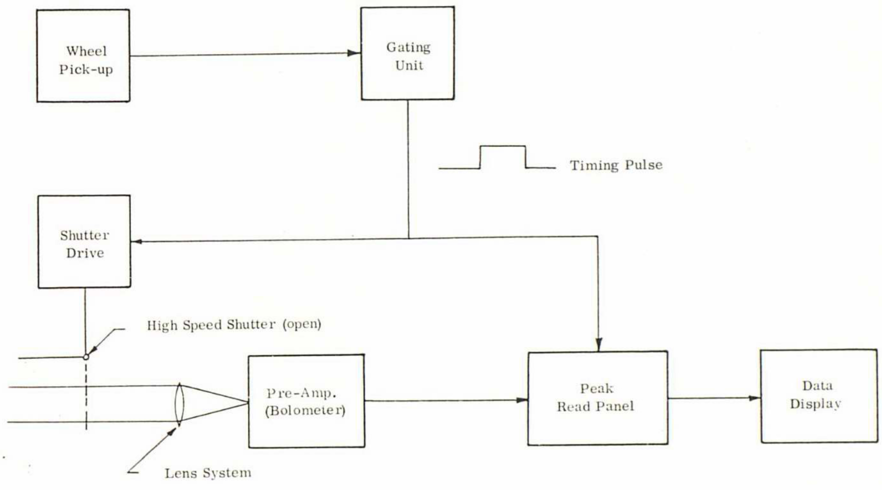
(2) Why do some use one kind of a sensing and optical system and some another?

(3) Should I use an automatic evaluation device to stop trains with bearings in distress or rely upon human judgement?

(4) What is the most desirable location for the scanner?

(5) What are the aspects of performance in assessing the use of hotbox detectors?

(6) What are the factors affecting performance?



Block diagram of shutter system (protective shutter not shown).

The exact place to scan and orientation of the scanner relative to the target has consumed many hours to trackside testing, evaluation, and discussion. This work has lead the majority of people concerned with hotbox systems to the belief that the best way to check the bearings is to scan the journal box.

Scanning the hub of the wheel is another way to look for bearings in trouble. Detectors scanning wheel hubs, which have their line-of-sight at right angles to the track must do their scanning as close as possible to the wheel hub for the temperature decreases rapidly with increasing radius. This could give an indication which would not be indicative of what really is happening to the bearing because of the distance from the source of trouble.

The question of the proper criterion for the existence of a hotbox has become the subject of debate. A number of the railroad mechanical departments feel that the journal box temperature is the proper criterion because the first sympton of a bearing in real trouble is the melting of the babbit at 370° F. It has been suggested that the bearing is always 100° F. hotter than the journal box, and that this assumption can serve to establish a box temperature which is the threshold for a hotbox. Data taken on bearings in railroad service in which lubrication failures were in-

Editor's Note: The article is an abstract of a paper presented at a recent C&S Section, AAR, sectional meeting.

duced show that once the heat generated in the bearing becomes abnormally high, it is probable that a runaway condition will result and failure is imminent. The rate at which this process takes place may vary considerably from one occurrence to the next, but there have been cases where bearings rose more than 100° F. in 5 minutes. The closer to the source of trouble, the quicker the problem is detected. Therefore, sensing temperature rise of the journal box seems to be the best indication of the presence of a hotbox.

An infrared hotbox detector is a device which is concerned with infrared energy emitted by the journal box or roller bearing. Since hot brake shoes, steam lines, reflected light, and direct sunlight are radiation sources, they all can cause false signals if viewed by the detector. Such false signals will stop trains unnecessarily.

Careful steps must be taken in detector design to exclude the other radiation sources. It is essential that the detector be responsive to the particular wave length of radiation which the journal box emits. The design of the detectors optical and sensing elements should take into consideration these important facts.

One way to eliminate extraneous heat sources from the detector is to block the view of the scanner with a shutter and open it long enough to see the target. As added insurance the sensor and optical material should be chosen which responds greatest to the specific type of radiation given off by the target.

The target temperatures which are of interest are those between -10° F. and 180° F. Reference sources on infrared radiation indicate that these temperatures correspond to 11 and 8 microns respectively. The form of electromagnetic energy which we call heat consists of electric waves similar to radio or light waves having a wave length of approximately 7 to 15 microns.

Some of the commercially available optical materials are germanium, arsenic trisulfide, and silver chloride. Arsenic trisulfide, and silver chloride allow the short wave length energy to pass through. This energy from sunlight and reflected light can result in false indications and poor detector performance.

The use of germanium for the optical system will reject or filter out the short wave lengths (sun and reflected light) and pass the longer wave lengths which is the spectral region we are concerned about.

For sensing the infrared energy there are two types of sensors or detection devices; the photon and thermal detector. The photon detectors are similar to photocells in that they respond when they are hit by particles of light energy (photons). The thermal dectector or bolometer detector reacts to being hit by radiation. We use the bolometer sensor because it is responsive in the spectral region of eight to eleven microns. Even though the bolometer is considered a slower device compared to the photon detector it is fast enough to detect trains going at 90 mph while eliminating false signals.

The GE shutter-type hotbox detector functionally consists of a gating or timing section, a heat measuring section, and a data display section. The gating elements of the system essentially control the sequencing of the several operations performed in the heat measuring section.

The magnetic wheel pickup provides a signal to start the system when the first wheel of the train passes and provides successive signals actuating the scanner for each wheel. This unit is sealed in an epoxy resin and is usually bolted to the rail web.

Two trackside scanners are required, each containing a heat sensitive bolometer, a precision germanium optical system, a high speed shutter, a preamplifier and a protective shutter all mounted in a rugged metal enclosure. These scanners receive the journal box infrared radiation, amplify the information received and transmit it ultimately to the recorder.

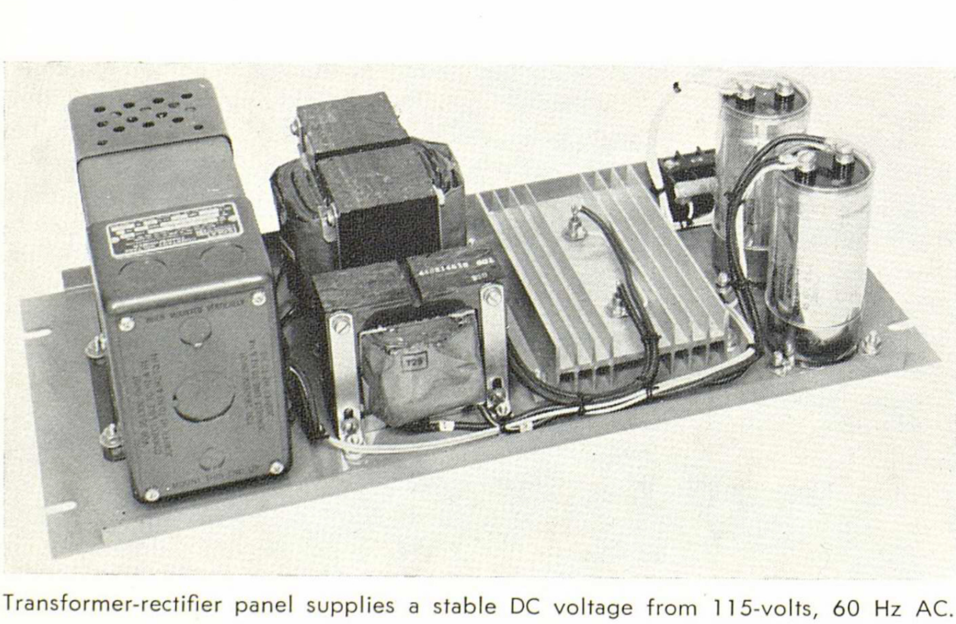
HIGH SPEED SHUTTER

The high speed shutter used in the scanner opens just briefly for each axle only while the journal box is in the line of sight of the scanner. The shutter has two important functions: (1) It allows the sensor to see only the journal box (2) It is also used as a reference in comparing the temperature of the journal. This system is greatly improved over previous systems in that it is not subject to false readings from stray sunlight, steam lines, and other heated objects beneath a railroad car.

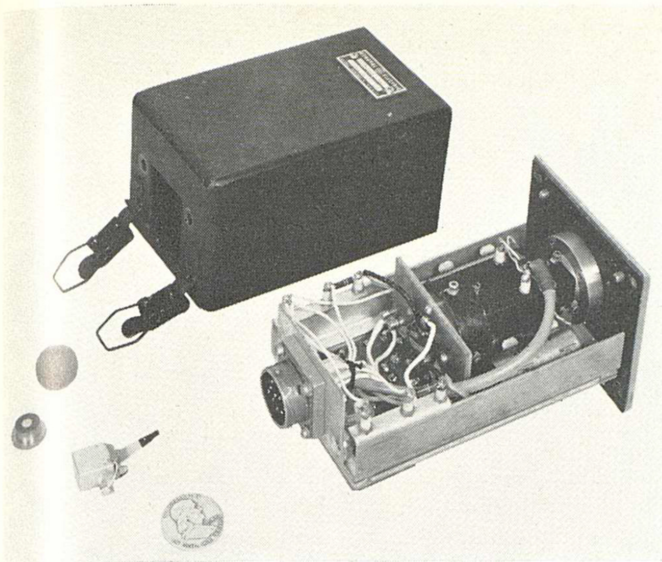
A transformer-rectifier panel supplies a stable source of 24 volts DC from a 115-volt, 60 cycle line. For applications requiring battery operation the control functions can operate directly from a standard 24-volt battery.

The control panel operates from 24 volts DC and houses the plug-in circuit boards for the peak read function, shutter drive junction, and power supply function.

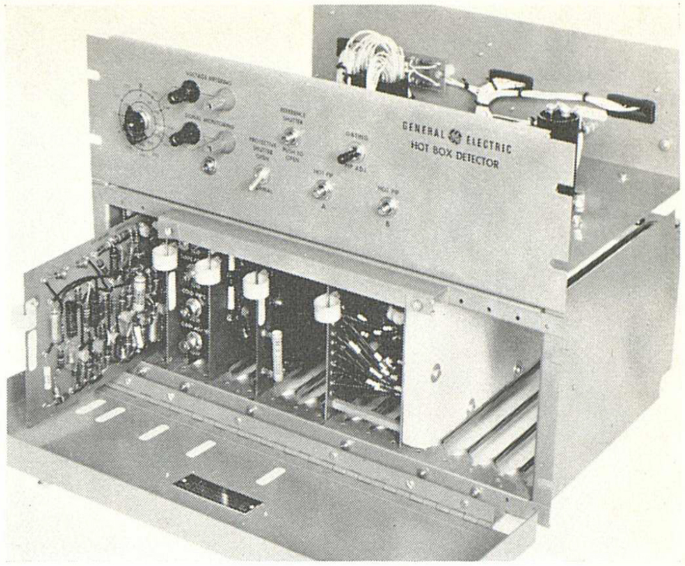
The peak read function using fully transistorized circuitry synchronizes the high speed shutter, stores the peak heat signal received from the scanner during the time the bearing is in view and reads out the maximum temperature signal for each wheel. This panel operates when the wheel pickup senses an approaching train wheel and triggers the shutter



Transformer-rectifier panel supplies a stable DC voltage from 115-volts, 60 Hz AC.



Preamplifier, lens, bolometer and reference shutter.



Control panel has plug-in circuit boards.

drive so that the high speed shutter opens and the bolometer "looks" at the journal box.

The shutter drive function controls the high speed shutter in the optical system and also controls the protective shutter.

The control panel has a built-in test function which consists of test jacks for plugging in meters or other instruments. A selector switch is included for the purpose of connecting these jacks to all important signal and voltage points. Switches are provided for opening the protective and reference shutter and for applying a series of simulated wheel pickup pulses to open the shutter repeatedly and operate the peak read circuits synchronously. This built-in test function offers ease during the checkout and maintenance of the system.

The signal from the control panel (after being tansmitted by carrier, cable, or open wire) is amplified by a transistorized galvanometer drive panel to a power level sufficient to drive the pens in a strip chart recorder. This panel is located near the recorder.

DATA RECORDED

The data picked up at trackside is recorded on a two channel, electric or ink writing strip chart recorder. Each channel records temperature indications from one side of the train as a series of pips, each representing one bearing.

Two general types of information display are used, depending on whether the temperature data has been evaluated by the equipment or not. Where the automatic equipment has made the normal or abnormal evaluation, only information on abnormal bearings need be displayed. One of the simplest displays is the lighting of a light or the sounding of an audible alarm to indicate that a given train has produced at least one abnormal indication. The equipment widely used in automatic systems today is one which compares the temperature at the ends of the same axle. The selection of the proper temperature difference to serve as an indication of trouble is left to the using railroad. There is not an automatic indication which is 100% reliable.

DIFFERENT BEARINGS

One of the problems with such an automatic evaluation system is the number of different bearings that are scanned which give different indications—roller bearings vs. friction bearings. The variations in roller bearing indications have seriously hampered the adoption and performance of such automatic equipment. The heart of the problem is that different temperature criteria must be used for solid and roller bearings, and there is nothing which can reliably tell the automatic equipment which bearing is of which type. This makes it quite difficult to establish the proper threshold voltage to trigger the display. The use of an automatic comparison system makes it very important that the detector have an output which is linear over a wide ambient temperature range. Also both channels of the system must be calibrated alike and maintain their respective gains stably over long periods.

The other method of displaying data is a strip chart recorder which displays directly the scanner outputs. Manual interpretation of the tapes with trained men seems to be best way to evaluate the data. This method leaves the decision whether to stop the train or not up to the chart reader based upon limits set up at his railroad. One large railroad has chosen to transmit all data to a central location where a single observer can monitor the entire system. This simplifies the task of maintaining uniform standards of decision-making.

Hotbox detector systems are being used in two types of locations: line-of-road and at entrance to yard. There are more detectors used on line-of-road than at yards. Detectors at line of road locations are intended to spot bearings which are so seriously in trouble that they would cause a derailment before the next scheduled stop. At the same time for operating economy, the railroad does not wish to stop any trains which could make their way to the next regular stop without an accident. With all the variables associated with bearing performance it is impossible to predict with accuracy from detector indications whether a particular bearing will or will not make it. Good judgement dictates that the line be drawn on the conservative side so that the railroad pays the price of also stopping questionable trains in order to avoid what might be extremely expensive wrecks.

Spacing of line-of-road detectors

must be carefully considered to insure maximum efficiency. The basic requirement is that detectors be close enough together so that a bearing which does not cause an alarm when it passes one detector will not have caused a wreck before it passes the next. Studies of the location of hotbox set-outs have shown that a substantial number occur about 30 miles after leaving a yard where the car has been inspected and found normal. It is assumed then, that dangerous hotboxes can be created in a 30 mile distance.

The purpose of locating detectors at the entrance to yards is so that defects may be corrected when the train makes its scheduled stop in the yard. Detectors for yard inspection should be located far enough ahead of the yard so that the train will not have started braking before passing the detector. The most common source of heat other than bearings is brakes. A detector may sense the heat in smoke or sparks given off by applied brakes passing in front of the journal while it is being scanned.

There are essentially three aspects of performance which are of major importance in assessing the use of hot box detectors. The one aspect which is frequencly discussed because it can be readily measured has been commonly called efficiency. Whatever you wish to call it, it is calculated as the ratio of actual hotboxes found to the number of trains stopped because of an indicated hotbox by the detector. Obviously the more set-outs caused by false indications from such things as sticking brakes, steam leaks, the sun, and reflected light energy would lower the efficiency of that particular detector system.

A second aspect of performance which is of real significance, is the reliability of detectors from the maintenance standpoint. This should be fundamental to any economic evaluation of the use of hotbox detectors, even though it might be a little difficult to measure in quantitative terms. It is possible to establish such ratios as:

(1) Maintenance man-hours per detector per month.

(2) Percent of trains for which detector was operating satisfactorily.

The third aspect should be the very essence of any evaluation of hotbox detector performance. This could be expressed as the ratio of hotboxes detected to hotboxes passing the detector. There are, however, some difficulties with the evaluation. Since hotboxes can develop rapidly, there is always some uncertainty whether a hotbox found some distance beyond the detector did or did not exist when the train passed the detector. Another difficulty is that criteria for defining a hotbox is not always clearly established.

FIGURE OF MERIT

It might be possible to derive some figure of merit for a hotbox detector which takes into consideration all three aspects already discussed. A dollar cost or saving might be determined for a detector over a given period of operation by assigning realistic cost values to (1) the investigation of a false indication (2) maintenance of a detector and (3) the cost of an undetected hotbox.

In addition to the nature of the bearing (roller bearing or friction) plus the characteristics of the hotbox detector itself, there are other factors which affect the performance of a hotbox detector.

Sunlight, snow, electrical noise and other heat sources are some of the ambient conditions which may modifiy the performance of a hotbox detector if not considered in the design of the hotbox detector system.

Falling snow, or swirling snow caught up by a high-speed train, may if thick enough partially cut off infrared radiation from the train resulting in indications lower than normal.

Another factor affecting the performance and the effective utilization of hotbox equipment is the amount of cooperation between departments in the railroad organization. The various aspect of work associated with hotbox detectors does not fall within the scope of any one department's responsiblility. Car inspectors must check bearings which have been tabbed as overheated, signalmen must provide maintenance of detectors, men from the communications group must plan and maintain data transmission equipment. The criteria for normal and abnormal bearings must be established by the mechanical department but the detector performance to meet these criteria must be reached and maintained by electronics people. Close cooperation and communication between the proper people are essential from the planning stage and performance measurements for the first installation through the continuing day-to-day operation after the units are in use.

Hotbox detectors have more than proven their economic worth on the railroads that have used them. In some instances, railroad management has estimated the time required to pay off the investment has been as short as two weeks. One major railroad has stated that the indication of a bearing in serious trouble by one hotbox detector would pay for all the detectors purchased in 1965. Wherever they are in use, hotbox detectors have become as vital to railroad operations as the signal or communication systems. Intelligent application, installation, maintenance and interpretation can make hotbox detector systems one of the most valuable tools in the signal and communication department.

RS&C

Galvanometer drive panel has test and adjustment points.