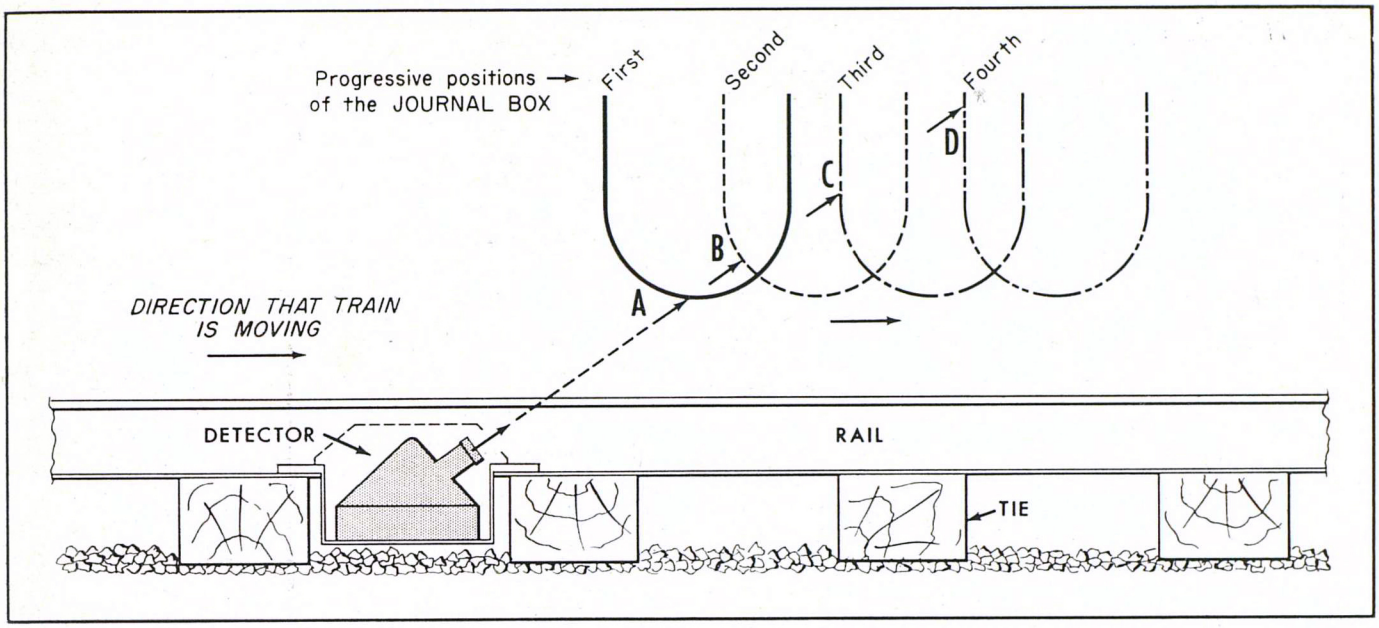


As journal box moves from left to right, the "view line" of detector first encounters the bottom of the box at "A", then, as box moves on to the right the "view line" progresses up the side of the box, as at "B", "C" and "D".

Electronics Pin-Point Hot Boxes

When a westbound fast freight on the Reading was stopped by a CTC signal recently, the conductor phoned the leverman at "WX" tower, two miles to his rear, and said, "Why did you stop me here?" The leverman answered, "You have a hot box on 14th car from head end, rear box, front truck, north side." The conductor replied, "Is that so, how do you know all that?" The leverman answered, "Here at 'WX' we now have an electronic automatic system that detects and records hot boxes on passing freight trains at any speed up to 60 mph."

This installation, and another on the Chesapeake & Ohio, as well as tests on the Norfolk & Western and Pennsylvania, have proved that this system has attained the important objective of detecting hot boxes in a reliable and practicable manner. The equipment used in this detector system was developed by and manufactured by the Servo Corporation of America, New Hyde Park, N.Y., which is a well-known designer and manufacturer of infrared control systems for industry and infrared weapon systems for the Armed Forces.

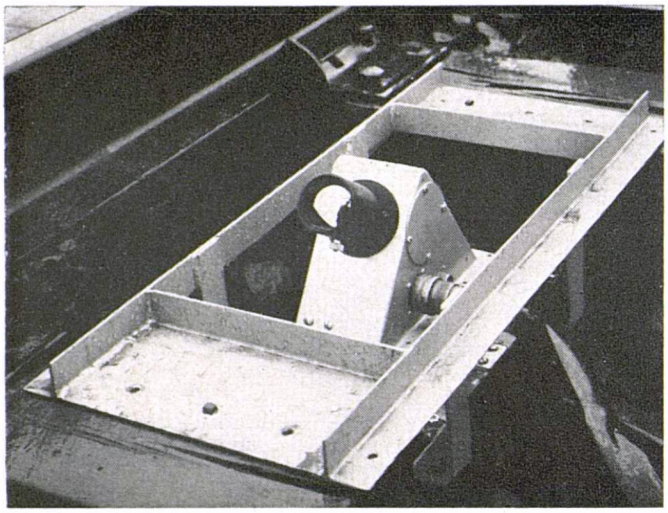
PROBLEM—For several years, other industries, such as steel mills, have used electronic devices, known as infrared pyrometers, to detect infrared rays being emitted from heated metal and thus measure the temperature, although the pyrometer may be 10 to 15 ft or more from the metal. Tests on railroads proved that the temperatures of journal bearings on freight cars—from normal to "hot"—are within a range that can be detected by an infrared sensitive device located 3 ft to 5 ft from the journal boxes.

In order to adapt these infrared pyrometers for detecting hot boxes on passing freight trains, some of the first problems were: (1) what part of the box can be and should be "viewed," and (2) where should the pyrometer be located on the wayside to "view" the box.

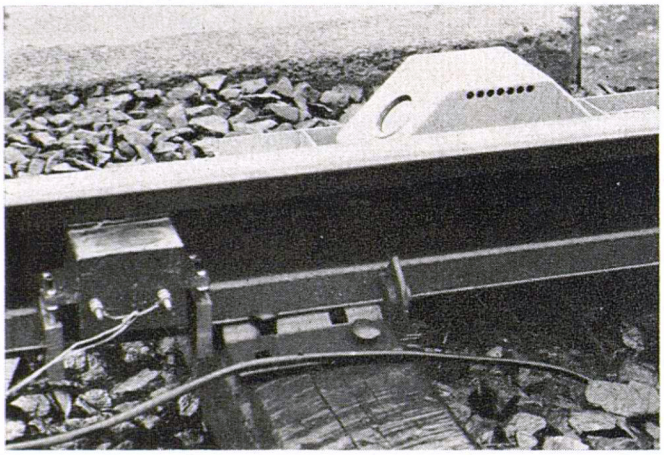
SOLUTION—The top of the journal box, itself has the most metallic contact with the journal bearing, thus the top side of the box would give a better indication of the temperature of the journal than would the lid. However, the top of the box is inaccessible to view from any angle. Accordingly, engineers of Servo Corporation decided that a wayside pyrometer should be mounted between the ends of two adjacent cross-ties about 16 in. from the gauge line to the center line of the pyrometer lens. The second pyrometer of the pair is placed at a corresponding position between the same two ties on the far side of the other rail.

The "view" center line of each pyrometer is pointed in the direction of the train movement, and at an angle of 30 to 40 deg above horizontal. Thus, as a journal box recedes beyond the detector, the pyrometer "views" first the bottom of the box, and then up along the rear side to the top. The pyrometer has a meniscus lens which views an area on the box of approximately 1 sq in. Thus it limits the width of "view" to a 2-in. strip up the side of the box. This allows for lateral movement within the truck as well as between wheels and rails.

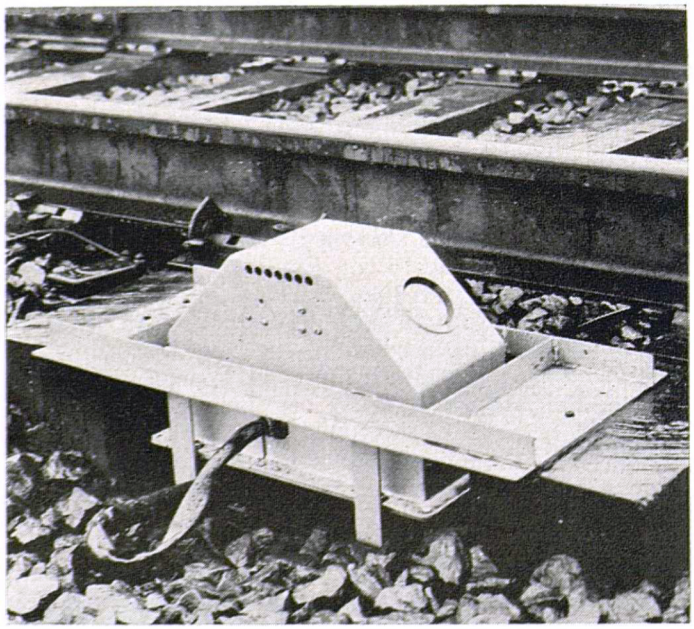
ELECTRONIC CONTROL FOR SPLIT-SECOND VIEWING—The thermistor bolometer, or sensitive element, in each pyrometer receives infrared rays from any and all heat sources, within its range of vision, all of the time a freight train is passing. The "trick" is to confine the final recording of the indications to only the split-second periods when each box is being viewed, thereby excluding all other heat sources such as hot brake shoes, hot wheel rims, etc. This result is accomplished by automatically controlling the circuit to the graphic recorder, so that it indicates only while each box is in range of its respective detector. These



This view, with cover removed, shows the 2-in. lense with its barrel pointed up at an angle so that line of view encounters journal boxes



Two electro-magnetic track devices are mounted on the gauge side of the web of one rail. When wheel passes, inductive kick operates relay to close circuit to recorder. Second track device opens circuit



This view shows how detector is located in brackets between the ends of two ties. Also this view shows the sheet-metal cover in place. The 2½ in. circular door on the sloping surface is opened automatically when a train approaches, and stays open until this train has passed

controls are initiated by two wheel-actuated electromagnetic transducers, developed by the Servo Corporation, each of which has an outward appearance of a metal case about 4 in. by 4 in. by 8 in. Bolts hold them against the web of the rail on the gauge side, with the top of the transducer at a level of about 1¾ in. below the top of the rail where it will not be touched by the flange of a wheel, even with maximum permissible standard tread wear. As the rim of a wheel passes through the magnetic field of the transducer, an inductive "kick" is generated which indirectly energizes a relay in the circuits to the recorder. When this journal box has receded beyond the "view" of the wayside pyrometer, the corresponding wheel passes over a second transducer that causes a second inductive "kick," which indirectly releases the relay. Thus two transducers, on one rail, control the circuits to the recorder for two pyrometers, the one on the north side of the track and the other on the south. The timing is as close to being instantaneous as is required. These relays operate in about 3 milli-seconds. If one foot of forward motion is allotted for viewing of a box, the time to do this, at 30 mph, is approximately 0.023 seconds duration. The detector system operates for any freight train speed up to 60 mph or higher.

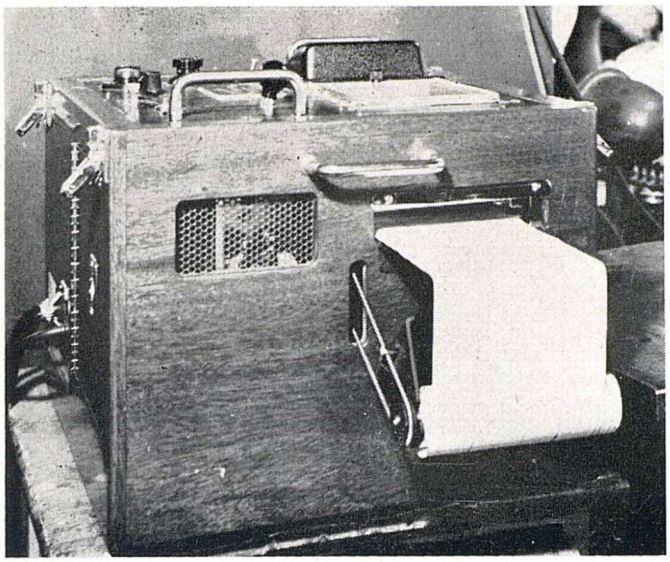
WHAT KEEPS RAIN AND DIRT OUT—The infrared rays from a journal box enter the wayside device through a 2-in. lense made of special material, called Servofrax,* that will transmit infrared rays. Too much dirt and moisture on this lense might interfere with proper operation. Therefore the pyrometer is enclosed in a protective metal case, with a circular opening, about 2½ in. in diameter, which is normally closed by a movable metal disc. Therefore rain and dirt are prevented from falling into the case during inactive periods. When a train approaches, this disc is opened automatically by a solenoid magnet device, controlled by impulses from the same magnetic transducers mentioned previously; and it stays open until after the rear of the train has passed.

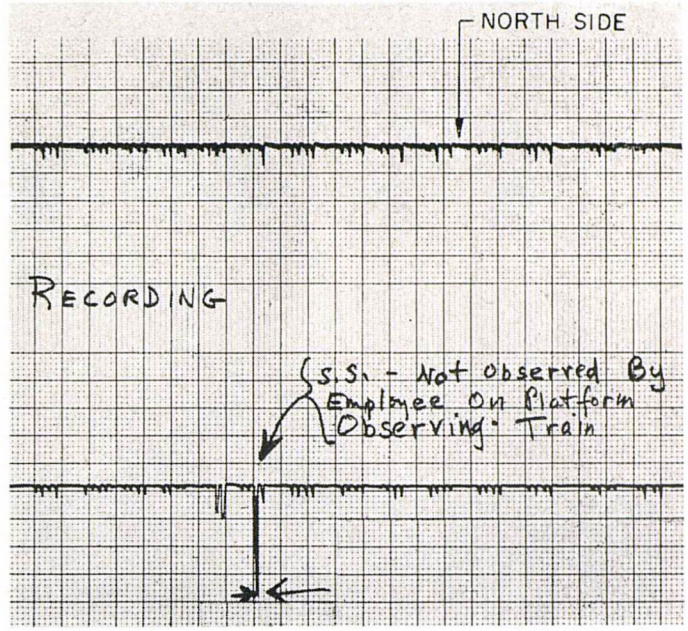
Dirt which falls from a passing train is swept along in the train's direction. Therefore this dirt is not likely to enter the 2½-in. opening of the detector units, because these openings are in the direction opposite to the approaching train. This is one of the reasons for "viewing" the boxes as they recede, rather than as they approach.

HOW IS HOT BOX REGISTERED—In this installation on the Reading, the relative heat emitted of each and every journal box on every freight car in each train is registered on graph paper, on a Twin-Viso automatic recorder made by the Sanborn Company, Cambridge, Mass., and modified by Servo Corporation. This recorder starts automatically when a train approaches, and is stopped after the rear of the train has passed the detector. The speed at which the graph paper moves can be adjusted.

The recorder has two pens, one controlled by the detector for the south side of cars, and the other controlled by the detector for the north side. The pens are operated by galvanometer action, and therefore are very fast. As the graph paper moves, each pen records on a rectilinear chart. Then, as each and every journal passes its wayside pyrometer a "pip" is made by the recorder. A journal at normal temperature makes a small "pip," about 2 to 3 millimeters high. A solid bearing journal that is hot enough to cause trouble, will make a "pip" 15 to 20 millimeters high. An adjustment can be made to increase or decrease the rela-

*Registered trademark of Servo Corporation of America





tive height of all "pips." Thus this device indicates hot boxes that could not be detected by an employee watching the train.

The boxes on freight cars equipped with roller bearings normally run at higher temperatures than are normal for solid bearings, the differences being readily identified on the graph. The recorder also indicates the passing of locomotive journals, which also can readily be recognized.

This automatic graphic recorder is in the operating room in "WX" tower, near Manville, N.J. When a train is passing, or has passed, an employee on duty checks the graph. If he notes a "pip" that indicates a hot box he can control a wayside signal to stop the train within the territory controlled by the machine in this tower, which extends about 25 miles.

Looking to the future, thought is being given to means for transmitting hot box alarms from outlying locations to the dispatcher's office, from which place directions can be issued to stop trains. A further idea is to arrange equipment and circuit so that the indications now registered on the hot box recorders can be used indirectly to automatically control a wayside signal to stop a train, in the same manner as now in practice with dragging equipment detectors on several railroads.

In order that such controls will apply only with respect to solid bearing journals on freight cars, selective devices are in development to omit indications caused by roller bearings. A consideration in this is that in all instances, roller bearings are installed on both ends of an axle. Thus, if the "pips" are high for both the north and south indicators, such a reading could be omitted from further consideration. A conclusion in this respect is that having accomplished the primary objective of developing the electronic hot-box detector to operate satisfactorily, the controls may be carried into the wayside signal system easily.

This installation of electronic hot-box detectors was made under the direction of George B. Blatt, Chief Signal, Electrical and Communications Engineer of the Reading. Those phases of the project having to do with cars and locomotives are under the direction of W. A. W. Fister, Superintendent of Motive Power and Rolling Equipment.

WHAT IS A THERMISTOR BOLOMETER— The devices which detect infrared rays from hot journal boxes, on this project, are the Thermistor type bolometers. Each such device includes two electrical resistance units in the form of flakes, made of special material, a characteristic of which is that heat decreases its electrical resistance. The incoming infrared rays from the journal boxes are directed onto the "A" flake and thereby decreases its resistance. The "B" flake is shielded from the effects of the infrared rays, and therefore its electrical resistance is controlled primarily by ambient temperature, i.e., the temperature of the surrounding air.

Thus this equipment does not actually measure temperature in degrees, but it gives an electrical signal proportional to the amount of heat energy falling on the "A" flake. In all instances the value of the differences between a normal box and hot box is amplified in the electronic equipment. The ratio of hot box signals to normal box signals is in the order of 15 to 1.

In each detector the "A" and "B" bolometer flakes are connected in a bridge circuit. When the infrared rays fall on the "A" unit its resistance decreases, thus throwing the bridge out of balance. This unbalanced signal is fed through electronic amplifier equipment with a gain of more than 100,000 times. The output signal of the amplifier is fed to the corresponding galvanometer pen in the recording machine. The amplifier equipment utilizes conventional amplifier circuitry.