Hybrid, microprocessor-upgraded Servo detector installation on the Seaboard System at Goose Creek, S.C. scanning journals on a passing freight. Current railroad wayside defect detection programs include such enhancements as updated scanner monitoring and electronics, on-site heat-signature processing on the basis of refined alarm criteria, data digitization for transmission, and direct radio "talker" identification to train crew members of multiple types and locations of detected defects. Photo: Roy Blanchard

Detectors get smarter

With several thousand hotbox, dragging equipment and other detectors now in place, attention is turning to upgrading and refining their already extensive monitoring capabilities.

By JOHN ARMSTRONG,
Associate Editor

On the basis of a *Railway Age* survey, it appears that sometime late in 1982 the number of hotbox detector installations on U.S. and Canadian railroads passed the 3,000 mark. In 1983, quite possibly for the first time in at least a century, the number of train accidents on U.S. railroads attributed to heat-broken journal bearings dipped below 100.

There's a gratifying connection between these two facts, of course, though the relationship is neither simple nor direct when such factors as shifts in bearing types, car capacity, train speeds and car mileage are cranked in. As AAR hotbox detection and bearing failure statistics over the last decade indicate, year-by-year curves are frequently lumpy despite the large numbers involved. Overall, real improvement has been achieved, even though performance of both plain (solid) and roller bearings has remained about the same and today's smarter wayside detection systems are hard put to do much more than stay even with increasingly stringent needs for sensing and interpreting incipient journal heating indications as the active car fleet creeps toward 100% roller-bearing status.

• **Filling in the gaps.** With the survey showing some 3,100 wayside hotbox detector locations in service, most main lines are approaching the 15- to 25-mile-per-scanner installation density most roads believe justifiable; the 700 or so installations projected for this and the next few years are primarily those needed to provide coverage of new or upgraded sections of main line, to bring up to snuff routes whose installations were deferred or delayed for financial reasons, or to fill the occasional gap left due to a variety of reasons now past.

Roads buying scanners will find no dearth of competition. Of the four scanners described in a previous review (*RA*, Nov. 10, 1980, p. 29), only Marine Electric's HB-76 has with its supplier fallen by the wayside.

—Harmon has acquired and continues to provide spares and service support for the pyroelectric-sensor unit previously built by General Electric; with a new cantilever mounting adaptable to any customer-preferred target of scan (wheel hub, inside- or outside-journal surface) and all-new microprocessor-based electronics, the basic scanner lives on in the Harmon WCO-32 hotbox detector system now in production.

—Servo's current 8909 sensor attaches interchangeably to either rail with its new ISO-CLAMP mounting which also effectively attenuates the most severe levels of rail shock and vibration as well as lightning-induced voltages; as a pioneer in the scanner business and therefore having the largest number of elderly units in the field, Servo is also busy providing kits for upgrading existing 7700-series units with new solid-state preamplifier, micropositioner, and pulse-processor vacuum tube and relay replacements for improved performance over an additional decade or so of service life.

—General Railway Signal's scanner was recently physically and electronically brought up to date; today's possibilities for enhancing data processing and interfacing capabilities with a microprocessor are such that GRS has several complete detector, processor and reporting systems in field test and is now pre-

Detectors: Installed or on the way

	Hotbox			Dragging equipment			Other**		
	In operation Dec. 1983	To be installed 1984	To be installed 1984-89	In operation Dec. 1983	To be installed 1984	To be installed 1984-89	In operation Dec. 1983	To be installed 1984	To be installed 1984-89
Alaska RR				3					
Algoma Central					2	4			
Amtrak	264* + 29	202*	174*	182			2		
Atchison, Topeka & Santa Fe	160	10		193	10		22		
Bangor & Aroostook		2							
Bessemer & Lake Erie	7			11			2		
Boston & Maine	7		9	3		9	3		3
British Columbia			5			5			5
Burlington Northern	248	28	90	120					
Canadian National	256	23	50	255	23	50	1	10	
Canadian Pacific	232	23		232	23		195	23	
Chessie System	116	72	117	84	79	117	1		
Chicago & North Western	55	23	41	2	23	41		22	35
Chicago, Milwaukee, St. Paul & Pacific	19	6	15	7			3		
Conrail	282	25	85	746	25	85	51	8	14
Delaware & Hudson	8		10	8		10	1		4
Denver & Rio Grande Western	33	5	10	381	24	35	15		
Duluth, Missabe & Iron Range	7			19	2		1		2
Elgin, Joliet & Eastern	1			2			1		
Florida East Coast	20			20			22		
Grand Trunk Western	24		2	24		2			
Illinois Central Gulf	93			84			91		
Kansas City Southern	75			82	8	8	37	5	19
Maine Central			7			7			3
Missouri-Kansas-Texas	30	1	5	30	1	5		1	6
Missouri Pacific	161	13	50	169	13	50	2		
Norfolk Southern (NW)	172	1		173	1		172	1	
Norfolk Southern (SOU)	187			256			37		
Quebec, North Shore & Labrador	11			7		17			
Richmond, Fredericksburg & Potomac	10		2	24			1		
Seaboard System	376	12	30	369	76	30	10	1	
Soo	21	2	10	18	2	10	22	2	10
Southern Pacific	287	2		697	2		71	4	
Union Pacific (incl. WP)	173	9	10	154	37	58	3		
Total	264*+3,100	202* + 257	174* + 548	4,355	351	543	766	77	101

*On-board hotbox detectors in service on various Amfleet equipment
**Includes hot wheel, loose wheel, flat wheel, and outsized load detectors

Conrail hot box detector installation at Harmersville, Pa. with display board readouts. Following highly favorable train crew reactions to its first 11 "talker" installations in 1980-81, Conrail began large-scale applications and currently has more than 450 hot box, hot wheel and dragging equipment detectors with voice readouts, generally providing more complete information on multiple detectors than practical with the limited number of auxiliary indication lights used along with the axle-count display board. Photo: John S. Murray

pared to supply a complete multi-sensor wayside detection, analysis and reporting package.

• **Another microprocessor revolution.** If there was ever a ready-made application crying for the ministrations of a microprocessor, the hotbox scanner is it. At best, only subtle distinctions exist between the heat signature of a bearing that's good for another million miles and one that may be ready to heat up and burn off within the next few miles; analysis going far beyond simply comparing indicated journal temperatures at the ends of the same axle is necessary if the best possible "to alarm or not to alarm" decision, taking into account all available known effects of air temperature, solar heating, wind and so on, is to be made and acted upon in real time while the train is thundering by at speed.

If still not exactly duck soup for the microprocessor, such on-site analyses have rather suddenly become both conceivable and, in comparison to the cost of the scanner optics, quite affordable.

Some fairly high-powered thinking is going into the selection and implementation of alarm criteria, and trade-offs remain: How does discrimination capability which might be derived from a triple analysis of bearing data from the entire side of a 150-car train—which a micro can make in less than second—compare with the benefit of sending an alarm the instant a possible emergency-level signal is established on the basis of a sophisticated one-car/eight-bearing algorithm? At this point, there's room for argument—and the already-exploited capability of today's processors to generate and transmit more than a single level of alarm sometimes may make it possible to have things both ways.

A premise behind establishment of the FRA's Wayside Detection Research Facility at Pueblo Transportation Test Center in 1978 was that microprocessor integration of the analysis and reporting of multiple sensors could be a good thing if only it were demonstrated to the industry. Funding to complete the planned program ran out, and the WDRF is now inactive; the microprocessor revolution in this area, having generated its own steam, is in effect coming to pass anyway.

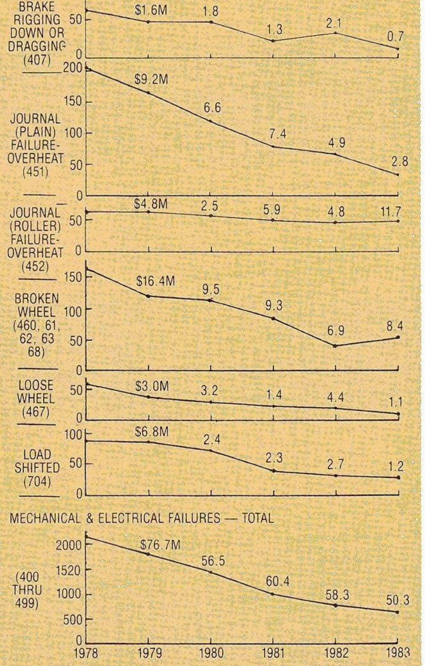
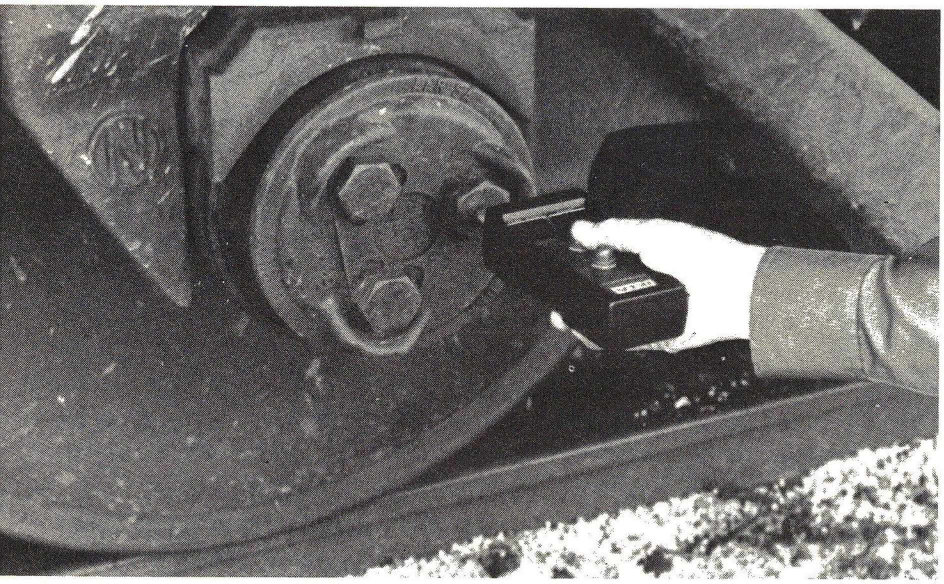


Fig. 1: Number (left axis) and total reportable cost ($ million) of selected categories of train accidents attributed to classes of defect susceptible to some degree of preventive monitoring or detection. Data from FRA annual Accident-Incident Bulletins, 1978 through 1983; accident-category line numbers in parenthesis.

• **The instant buggywhip.** When it comes to a sudden shift in technology and the resulting reduction of a substantial product line to buggywhip status, however, the effect of the caboose-off agreement and microprocessor adjuncts on the preferred detector readout really stands out.

As an alternative to the scoreboard display alerting the rear-end crew to the general nature of any defects picked up by the sensors and giving a single axle-count location of the first one detected, the "talker" with its music-box radio playback was first installed by Seaboard in the late 1970's. It not only eliminated a bulky wayside installation but presaged the ultimate cabooseless consist by allowing its message to be picked up by a crew member regardless of his location on the train.

At first based on the somewhat clumsy technology of picking out appropriate messages from a pre-recorded tape, the talker was considerably reduced in size, complexity and cost as soon as microprocessor voice units became available; now that the eventual concentration of crew members on the head end of the train has become a solid bet, choosing a detector read-out method has typically become a matter of deciding whether the radio message to the crew should come via a central analysis and recording office or be generated and transmitted automatically at the detector site; or perhaps—given the message generating, digitizing, classifying and routing capability inherent in the wayside micro-



After a detector senses a problem, the trouble spot must be pinpointed. One device made for that task is the Servoprobe, a hand-held train inspection verifier that counts axles and digitally displays wheel or journal temperatures.

processor—both ways. *Hot* bearing alarms, for example, may be transmitted directly and immediately to the crew; *warm* indications go to central for further analysis.

So, scoreboard-readout sales have dropped essentially to zero. The big end of the detector stick for many railroads for the next few years will be an orderly conversion program to achieve all-talker status, and talker suppliers are—at least proportionally to the number of units involved—as numerous as purveyors of IBM-compatible personal computers.

Typical is Southern Pacific's 1984 program: New installations include two hotbox, four hot wheel and two dragging equipment detectors (all with voice readouts); 140 of its 287 existing HBD's and 368 of 697 DED's are to be converted to talkers.

• **Finding the rascal.** Every railroad with a network of detectors in service has experienced the frustration of stopping a train on the detector's indication of a hotbox or dragger, finding nothing from on-the-ground inspection, and letting the train resume its journey only to have it demonstrate the power of modern technology and Murphy's law by piling up a few miles down the road from the effects of the very trouble that was sensed but not pinpointed. Estimates of what the effectiveness of the inspection process *should* be differ if made at a desk in the office rather than at trackside in the dark in rotten weather; in any case, developing changes in train crew consist and deployment are bound to affect the real-world answer.

Is some sophistication in order? Servo has ready its "Servoprobe" hand-held train inspection verifier which will count axles and read out wheel or journal temperatures on its digital displays. An item that would have to be spread around in quantity to be used effectively over a major railroad, and one that will remain fairly expensive unless commitments justifying large scale production are made, it has already found favor on some overseas heavy-haul railroads where one unit per train-set can really speed up the process of run-by inspection of a cabooseless unit train halted by a defect indication.

• **On-board detection.** With the best of wayside detectors, some hotbox accidents will still occur when bearing heating starts soon after passing the scanner and progresses to burn-off before the next check point; the remedy is a full-time, on-board detector. While FRA-supported projects to develop and prove such systems for freight service have petered out for lack of funding, routine continuous monitoring of a significant number of passenger train bearings has now become an accomplished fact.

Amtrak's 640 Amfleet I and II cars, many now in service at 120 mph on the Northeast Corridor, have Pioneer III trucks whose inside, rubber-doughnut-enclosed bearings cannot be surveyed by wayside scanners. Following up on a program (*RA*, Nov. 10, 1980, p. 31) to develop a nonproprietary monitoring system, Amtrak has already equipped 264 cars and its AEM-7 electric and F-40PH diesel locomotives hauling them with Safetran-supplied monitoring hardware and has the remaining 376 inside-bearing cars programmed for retrofit.

A green light in the locomotive cab, in communication via a wire in the trainline jumpers with any equipped cars in the consist, verifies sensor circuit integrity and safe bearing temperatures. Any trouble indication extinguishes the green light, activates a beeper in the affected car, and indicates on a local panel the truck in question for temperature-stick (200 deg. F) investigation after the train has been stopped.

• **Beyond the hotbox.** As if to re-emphasize the fact that *any* burned-off-journal accident *can* turn out to be *very* expensive, the reportable damage total for 1983's record low number of such happenings was $14.5 million dollars—higher than for the considerably larger number of them occuring during any one of the five previous years, as shown in Fig. 1, and close to the $15.1 million reportable cost for the 409 such accidents racked up a decade earlier in 1970. Overcoming a 292% price index increase over the 13 years to stay below that dollar-damage total in a bad year remains a feat which any detector salesman or railroad C&S officer might like to mention.

Also included in Fig. 1 are numbers and reportable-damage totals for those other major accident causes for which at least the possibility of cost-effective defect detection exists.

As it happens, detectors for at least some aspects of all these causes are in service; dragging equipment detectors (which of course catch other misplaced items besides those brake rigging components that are their main fodder) will continue to lead the field, in numbers if not in cost or sophistication, with over 300 to be installed or upgraded in 1984. An attractive upgrade in this microprocessor era is tying the DED into the hotbox talker's processor so that the crew also gets the axle count of any dragging equipment indication and can check out the situation with less walking and delay.

Receiving spottier acceptance so far are hot-wheel detectors. Some roads such as Canadian Pacific are attacking the problem of thermal wheel abuse and its possibilities for later catastrophic failure by routinely locating one at every HBD/DED site. Partisans of the separately-aimed hot-wheel scanner can cite extensive experience indicating that it typically catches (particularly if located near a yard exit) at least twice as many problems as the HBD—struck brakes, mis-set retainers, unreleased hand brakes and the like—at an add-on cost of less than 20% that of a modern HBD.

Others remain less convinced, suggesting that the augmentation of a hub-scanning hotbox sensor with sophisticated processing which can properly interpret slightly warm readings on four or eight wheels of a car as a brake problem may accomplish much the same purpose less expensively.

Also fairly widespread, with over 200 installations reported in service now and a few more expected each year, are outsize-load ("high-wide") detectors. Intercepting both misrouted—statistically a very minor problem—and shifted loads before they impact overhead or wayside obstructions with at least embarrassing and assuredly expensive consequences, detector configurations tend to be specific to the particular site. As a result, the total number of installations has sometimes seemed to be little larger than the number of suppliers (a majority of them railroad signal departments rolling their own), and some "commercial" systems have gone off the market for lack of volume.

Simple in principle and operation, loose-wheel detectors in which electrical contact between a wheel which has slipped into narrow gauge completes an electrical circuit with a spring-loaded sensor bar (Safetran continues to supply the veteran "Rails" device) are primarily effective at yard speeds or slightly above. Some 300 installations are in service, but on only 9 railroads—notably, FEC, ICG and NW. With the practicability of combining their output with other sensors at a site, however, several additional roads expect to install some within the next few years.

- **Train-dynamics monitoring.** In the face of diminished R&D funding, FRA has continued limited support for a task exploring the use of track/wheel force measurements to detect such potentially critical items as unreleased handbrakes and L/V force ratios approaching derailment levels. Several possibilities are at least theoretically promising, although reliably measuring and analyzing these second-order forces day in and day out, outdoors, in the face of the railroad mechanical and electrical environment remains technically challenging with or without a microprocessor.

Meanwhile, a significant milestone in putting such instrumentation-type technology to work has been passed with the installation of Amtrak's "Kips Machine" at Edgewood, Md. Officially labeled a wheel impact load detector, the installation has four strain gauges on the rail web measuring forces generated by 10-inch segments of the circumference of passing wheels. Microprocessors digitize the resulting signals and transmit calculated wheel input forces exceeding a threshold (currently 60,000 pounds—60 kips) by phone circuits to printers in Washington and Philadelphia. Indentifiable to the specific axle responsible, excessive loads are cause for shopping of an offending car.

Specific cause for the investigation (with Battelle Columbus Labs, which also developed the detector system) leading to this installation was extensive rail-seat cracking—troublesome though not life-threatening—occurring in concrete ties under the Corridor's mixed heavy freight and high speed passenger traffic. Primary culprit? The combination of high speed and a peculiar type of out-of-round wheel developing on some Amfleet I and Heritage Fleet (rebuilt pre-Amtrak) cars. Not "flats" in the usual sense, these wheel defects are not readily visible to a car inspector but can generate rail-seat forces greater than more heavily loaded flat wheels on freights at their speeds. With the KIPS machine and its successors in service, such dogs will get no more than one bite at the right-of-way.

- **Identifying broken wheels.** Broken wheels—failures in flange, rim, plate or hub or thermal cracking—remain a costly problem, in some years exceeding heat-broken journals in aggregate reportable damage, as a look at Fig. 1 will show. A cooperative FRA-AAR program, its $3.2 million of Federal funding this year representing the agency's principal R&D commitment, continues to seek better ways for identifying the wounded wheels before it's too late.

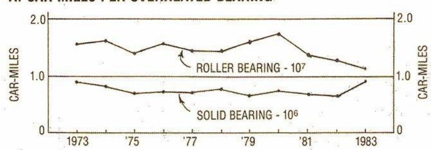
One facet of the program monitors progress of the numerous parties searching worldwide for that particular Holy Grail that has been attracting metallurgists, physicists and mechanical engineers for many, many decades: a nondestructive procedure capable of determining the state of residual stress.

The other major prong of the offensive is a brute-force approach toward identifying those particular forms and degrees of thermal abuse which do and do not result in hazardously weakened wheels. A monster dynamometer formerly located in U.S. Steel's laboratories has been acquired and moved to the AAR Technical Center in Chicago. Now situated so that wheel-abuse tests can be routinely carried to destruction, it is hoped that this machine may represent the key but previously-unexploited weapon permitting a more realistic, extensive and ultimately fruitful assault on the problem. ■

The hotbox story: 1973-1983

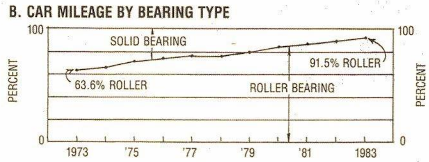
As a continuing major source of damage, delays and expense despite the phasing in of roller bearings and the ten-fold improvement in solid-bearing performance achieved by the elimination of loose waste packing in favor of journal pad lubricators in the late 1950's, overheated journals are tracked by special report to the AAR's Operations and Maintenance Department. Results go quarterly to chief mechanical officers of the member U.S. and Canadian roads; historical summaries for all years from 1973 on are comparable with data currently being collected.

A. CAR MILES PER OVERHEATED BEARING



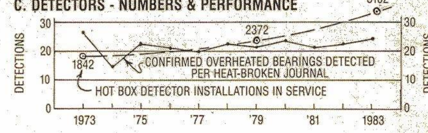
Fleetwide performance levels for both roller and solid bearings have remained generally static during the period. Mileage per hotbox for roller bearings has fluctuated between 12 and 24 times that for solid bearings; for 1983, it was near the bottom end of that range as performance of the remaining solid-bearing cars improved considerably.

B. CAR MILEAGE BY BEARING TYPE



The percentage of total miles run by roller-bearing cars has increased steadily, introduction of roller bearings via new-car installations in heavier-traffic periods being matched to some degree by increased rates of retirement or storage of older solid-bearing cars when traffic is lower.

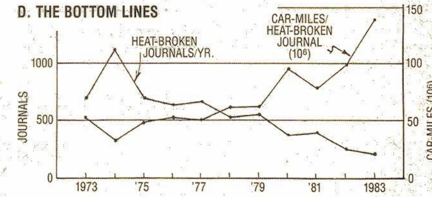
C. DETECTORS - NUMBERS & PERFORMANCE



Since the introduction of infra-red journal bearing scanning in 1956 there has been an accelerating rate of detector development and installation which, with the concentration of traffic on fewer miles of main track, has resulted in better scanning of train bearings at increasingly frequent intervals. However, probably primarily because a roller bearing that does run hot tends to progress to axle failure more rapidly, the *overall* ratio of detected hotboxes to heat-broken journals has improved only marginally as the percentage of solid bearings has decreased in recent years. Twenty-four hot bearings were detected in 1983 for every heat-broken (undetected) journal.

Detectors-in-service data for 1972 and 1980 are from surveys by Committee F of the AAR Communication & Signal Division; 1983 data were collected by *Railway Age*.

D. THE BOTTOM LINES



Net result has been a fairly steady decrease in the number of failures in service as solid-bearing car-miles have decreased by 75%; overall, car-miles per heat-broken journal reached a new high of 140 million in 1983, more than double that of the early 1970's.

AAR journal bearing performance statistics are not directly comparable with U.S. FRA figures for corresponding failures because they represent a somewhat different car fleet (including Canadian roads) and failures reported are not subject to the reportable-damage threshold applicable to accident data.