additional fault indicator systems that would make maintenance simpler. One should also design automatic diagnostic equipment for these trains. Since the demonstration schedule calls for a 1-hour turnaround, some such equipment is mandatory.

It is recommended that a task force be established immediately to (*a*) determine which failures should and can be displayed; (*b*) determine which failures should and can be diagnosed rapidly with repairs effected at the New York, Philadelphia, and Washington terminals; (*c*) identify which failures can be repaired only at depots; (*d*) design trainborne and stationary equipment to aid this diagnosis; (*e*) list the spares to be stored at terminals and depots; (*f*) identify the electronic failure mechanisms that are most deleterious to schedule probability; (*g*) recommend quick fixes, if any are required, that may be implemented within a 6-month period; (*h*) recalculate the schedule probability; and (*i*) report back within 45 days.

The major equipment suppliers should be involved in train maintenance, at least for a period of time, which we understand is the railroad's intention.

Wheel thermal capabilities

At 120 miles per hour (110+10 percent safety factor) the maximum deceleration available based on maximum dry rail adhesion is about 2 miles per hour/second. This will produce a peak heat load of approximately 400,000 ft. lbs./second if the braking is accomplished by air alone. According to Schrader,[2] this is a hazardous heat rate input, leading to thermal cracks even in class A wheels. The number of applications of this heat rate necessary to develop a thermal crack is a function of the metallurgical composition of the wheel and its quenching.

The railroad has already directed a change from class C to class A wheels before revenue service commences. The railroad has further indicated that a change order will be issued to add dynamic brake to the controller emergency brake position so that the maximum thermal rate input to a wheel would be 280,000 ft. lbs./second in a Westinghouse propelled car and 220,000 ft. lbs./second in a GE-propelled car, which may be reasonable for the limited number of times an emergency brake application is expected.

These rates could be exceeded only if there was a penalty or alertor brake application, or if there was a major power circuit failure disabling the dynamic brakes, an air brake pipe failure, or deliberate dumping of the air brake pipe by the engineer or conductor at a train speed of 120 miles per hour.

In the case of penalty or alertor brake application, we recommend that dynamic braking be included with air for the same reasons that the railroad has added dynamic braking to the controller emergency brake position. The remaining cases would seem to be sufficiently rare so that operational procedures might be used to record their occurrences and perform appropriate inspection during regular maintenance periods.

These thermal rate inputs under emergency braking could be reduced further if the deceleration rates could be reduced, which would seem possible since, even at 120 miles per hour, the stopping distance is approximately 1 mile, which seems well within railroad practice. It might also be possible to alter signal spacing to accommodate lower deceleration rates. Actually, the specified braking rates are not obtained in practice (due, presumably, to brake fade).

We recommend that the railroad, with Government support (if the railroad so desires), review the metallurgical aspects of thermal cracking, the retardation characteristics of friction brakes, and braking criteria with a view toward specifying among class A wheels those with minimum cracking susceptibility. We recommend that the railroad review procedures to determine if it is feasible to reduce deceleration rates. We further recommend that, until these reviews are completed, it would be prudent to limit speed in revenue service to 120 miles per hour.

Pantograph-catenary current collection

Simulations and experience indicate that, winter or summer, light or heavy wire, up to speeds of 120 miles per hour, a physical separation of the pantograph from the catenary will not occur for periods of more than one-third of a second. The electrical interruption will be less than this because of arc conduction. The

[2] "The Effect of Brake Shoe Action on Thermal Cracking and on Failure of Wrought Steel Railway Car Wheels," Wetenkamp, Sidebottom, Schrader. University of Illinois Bulletin, June 1950.