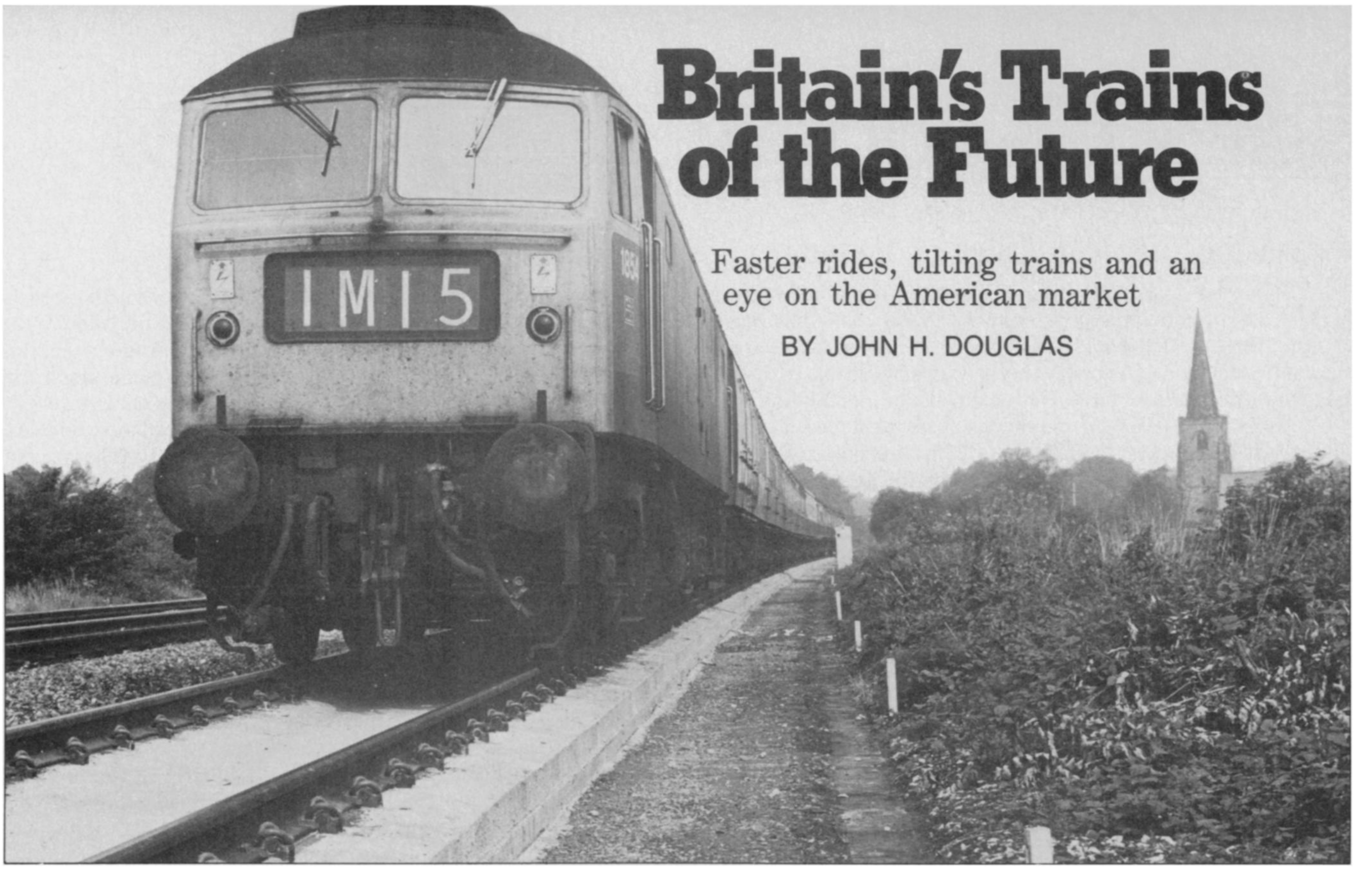


Britain's Trains of the Future

Faster rides, tilting trains and an eye on the American market

BY JOHN H. DOUGLAS

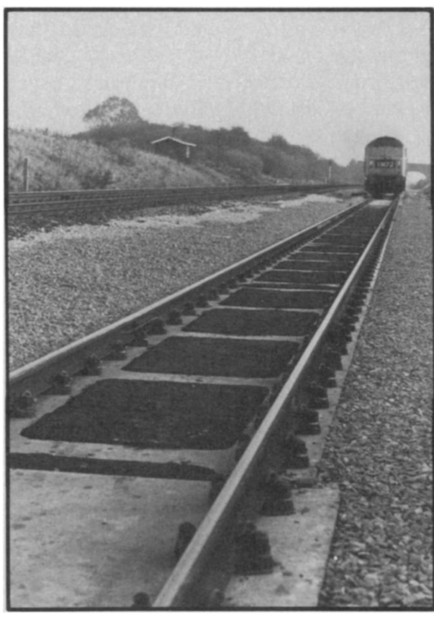
Accurate, maintenance-free tracks, like these supported on a concrete bed, will help future trains achieve their full potential.

SN's John H. Douglas recently toured the British Rail research center at Derby, claimed to be the largest facility of its kind in the world.

Anyone who has banged along the Metroliner route from Washington to New York can appreciate the truth of a Briton's recent remark: "You've kept down your track maintenance costs by simply not maintaining them." One can also begin to appreciate why British rail officials are so hopeful that as Americans begin to rediscover the train there may be a good market for advanced rail technology imported from countries that have not only maintained, but constantly improved, their rail passenger systems. The engineers at Derby are optimistic that as such competition arises, their innovations will be applicable to the American system.

One reason for such optimism is the similarity between the United Kingdom and the northeast industrial corridor of the United States, both in size and population. Already, rail service has begun to improve and compete with airlines along this corridor, through the high-speed, electric Metroliner service between Washington and New York and turbine-driven trains between New York and Boston. The potential for service increase along this stretch can be judged, in part, on recent British experience. When the 180-mile trip between London and Manchester was cut from four hours to two and a half, patronage doubled over a five-year period, largely because of passengers switching back from plane to train. One British Rail official told SCIENCE NEWS that trains can now compete with planes in that country up to distances of 300 miles.

Other countries, too, have greatly improved rail service and shortened travel times, but usually with a different philosophy in mind. On the continent, for example, Europeans have often concentrated their efforts on improving the performance of a few crack trains, such as the Trans-European Express, which has a regular price above even the first-class service of other trains. In Japan, the New Tokaido Line required laying a new, carefully graded track to carry the 57 trains that run daily each direction between Tokyo and Osaka, averaging 101.1 miles per hour (including stops). The British philosophy, on the other hand, is to improve the *regular* service between major centers, using existing tracks.



Photos: British Railways Board

Asphalt railbeds harden quickly.

The challenge is great. Along some British lines, trains must slow down every dozen miles or so to round corners at 40 to 50 miles per hour, because some powerful 19th-century landowner didn't want some great smoky machine rumbling through *his* orchard. Also, when faster engines are used to pull older cars, the sideways oscillation called "hunting" can become annoying. Finally, how does a country strapped with the worst inflation in the industrialized world raise the capital to lay new tracks or even hang the wires needed for extending electrification of the system?

To meet these challenges, British Rail (wholly Government-owned) has embarked on a three-phase program that emphasizes improving existing technology and minimizes the need for large-scale overhaul of the system. The first stage, now basically fulfilled, involved electrification of the main north-south rail artery between London and Glasgow and introduction of diesel engines capable of 100 mile-per-hour top speeds on key non-electric lines. Patronage of the 400-mile London-Glasgow run has already risen 50 percent after the journey time was cut from six to five hours, a little over a year ago. Stage two began last year with introduction of a prototype High Speed Train (HST), which the British claim pushes conventional locomotion about as far as it can go. The HST set a world speed record for diesel traction of 143 miles per hour in June 1973, and is now operating over existing tracks at up to 125 mph.

To go faster than this, a new concept had to be developed, if completely rerouting the nation's tracks was to be avoided. The main problem was how to whip around tight curves without slinging passengers to one side of the train. If new tracks were laid, curves could be straightened or banked, but the stage three Advanced Passenger Train (APT), developed at Derby, solves the problem hydraulically by banking the train instead of the tracks. As each car rounds a bend, a servo-mechanism automatically tilts it to provide equilibrium of forces on the passengers—just as an airline pilot banks his plane going into a curve. This suspension system allows the APT to negotiate curves some 40 percent faster than conventional trains, and an aerodynamically shaped, lightweight body of extruded aluminum gives it even more advantages on the straight-away.

While the APT will initially be restricted to the same top speed as the HST, 125 miles per hour, the *average* speed will be increased from 90 to 100 miles per hour on existing track, because of the better performance on curves. The APT is scheduled to enter the London-Glasgow line in 1978. The HST will then be shifted to lines that do not lend themselves to sustained high speed but can still have their running time improved by superior acceleration and braking. Derby engineers say that if new tracks are laid, the APT can eventually reach speeds of 250 miles per hour while still remaining compatible with existing railway access to city centers (a severe problem facing proposed alternative trains that require special guideways).

To support the three-stage plan for revamping Britain's railways, engineers at Derby are also experimenting with several new concepts for improving communication, track life and basic drive systems:

- Communication between train and station may prove to be an ideal application for optical fibers, which adapt well to rough environments where corrosion and static hinder wire-based telephony (SN: 7/19/75, p. 44 and 7/26/75, p. 60). Derby engineers are examining fiber costs to see if an optical system might not be cheaper to install when present cables need replacing, since shielding wires against the elements is one of the most expensive parts of the operation. A more immediately useful device is a new transponder developed at the laboratories. Looking somewhat like a baseball home plate nailed to the crossties, the transponder contains a sophisticated transmitter and receiver that exchange bursts of data with trains overhead.
- Recent advances in electronics have also made possible a new type of train motor that will be much less subject to wear. The problem with most heavy-duty motors is that the commutator and brush assembly that conduct electricity to the moving parts quickly wear out and need frequent maintenance. So-called "induction" motors—which do not require such vulnerable assemblies—have long been known, but changing their speed depends on varying the frequency of the driving current, so their use has been limited mainly to small units such as clocks. Now, development of special transistors, called thyristors, promises to allow the necessary control over large currents, and four prototype induction motors for trains are under construction at Derby for testing this year. The new motors have an added advantage—they provide effective braking while slowing down and may thus offer additional savings from wearing parts.
- As trains go faster and faster, the damage to tracks and overhead wires becomes increasingly serious. As a wheel approaches the junction between two tracks, it depresses the one it is on and bangs against the edge of the next. Similarly, as overhead wires droop between supports, the train's metal contact (called a pantograph) tends to drag the drooping parts. Both these effects are exaggerated by speed. To correct the problem one could either revamp the whole system—laying welded track on concrete base and installing specially strung overhead wires—or try to modify the new trains to minimize the damage. Again, British Rail has chosen clever ways to take the easier course, for the present. (For all the talk about a British penchant for "muddling through," too little credit has been given to the special genius it requires.) On the APT, a special suspension system is used to share weight between cars so wheel impact is minimized. Studies of suspension have also reduced the "hunting" motion on present freight and passenger trains. Wear on overhead wires is reduced by moving the pantograph automatically up and down to compensate for slack.
- Looking toward the time that money for investment is again available, rail engineers are testing several new track-laying systems at Derby. The advantages of welded rail on a concrete base are obvious: smoother ride, capacity to carry heavier loads and faster trains, extreme stability against heat distortion and very low maintenance costs. The disadvantages are that service would be disrupted for long periods before such tracks could be installed on existing routes, and of course, there is the problem of money. To lower costs, a "paving train" has been designed that will be able to lay track at a rate of 40 meters per hour with a surface accuracy of one millimeter. But concrete takes a long time to harden, so where existing track needs replacing, a compromise system of quick-setting asphalt-based track has been developed. Strips of both new tracks have been laid on heavily traveled lines to test their performance.

Each of these technologies has consid-
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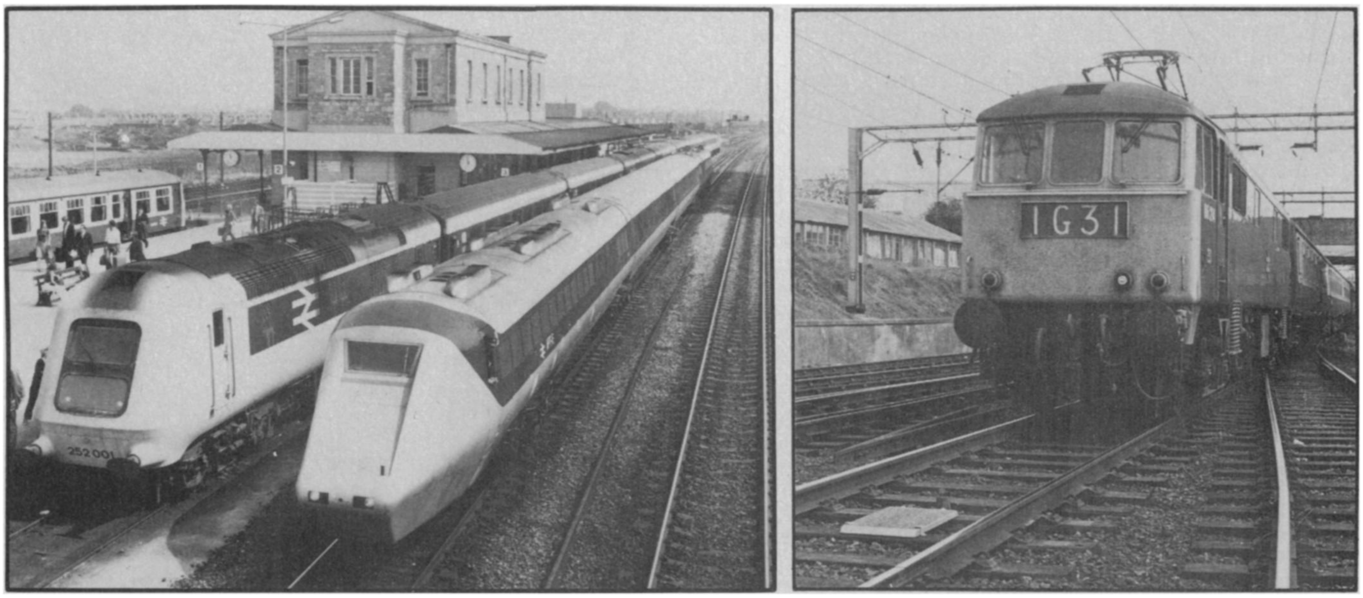

The HST and APT stand side by side at a station (left). Lying on the trackbed, a transponder communicates with passing train.

have learned, by preventing the normal inhibition of nerve synapses. The toxin probably enters the central nervous system by way of peripheral motor nerves. Once the toxin binds to nerve synapses, it can no longer be reversed therapeutically.

Diphtheria toxin is not nerve-specific as are the botulinus and tetanus toxins. It can damage many organs, notably the heart, leading to sudden heart failure and death. One of the reasons that cells are susceptible to the toxin, Frank Ruddle and his team at Yale University have found, is due to the presence of chromosome number five. They suspected that there may be a gene on this chromosome that codes for a diphtheria toxin membrane receptor. Or the gene may make an enzyme that modifies the cell's membrane in such a way that it will bind to the toxin. After diphtheria toxin gets into the cell, it then interferes with protein synthesis. The toxin specifically inactivates one of the elongation factors involved in the growth of the polypeptide chain.

Pseudomonas toxin, investigators have found, goes for liver, kidney and spleen cells, then inhibits their protein synthesis. How the toxin inhibits protein synthesis was not known until recently. Then Barbara H. Iglewski and David Kabat of the University of Oregon Medical School found that the toxin results in a block at an elongation step of polypeptide assembly, just as diphtheria toxin does. "Although pseudomonas and diphtheria toxins have different cellular specificities and molecular properties and produce different clinical symptoms, their intracellular mechanisms appear to be identical," they conclude.

If pseudomonas toxin or any other gram-negative bacterial toxin gets into the bloodstream, it decreases the number of platelets. The reason is that platelets, traitorously, have specific receptors for the toxins on their membranes, Jacek J. Hawiger, and his colleagues at Vanderbilt University School of Medicine recently found. Such a discovery, they stress, is important because "platelets are intimately involved in activation of blood coagulation, and their interaction with toxin may help us to understand better toxin-induced intravascular coagulation and shock."

As for cholera toxin, it triggers extensive diarrhea, vomiting, muscle cramps and collapse and will lead to death if not treated. Complications such as pneumonia and serious skin infections can delay recovery. The action of cholera toxin in the body has been extensively explored. Scientists now know that many types of cells are sensitive to cholera toxin, and that the toxin first interacts with a limited number of receptors on their membranes. The toxin then provokes the activation of the intracellular messenger cyclic AMP.

But how does the toxin do this? The toxin first acts on the membrane enzyme, adenylate cyclase. A component in the cell's cytoplasm, nicotinamide adenine dinucleotide (NAD) then serves as an abettor, Gill and some other researchers have found. However, Naji Sahyoun and Pedro Cuagrecasas of Johns Hopkins University School of Medicine report just the opposite—that components in the cytoplasm do not seem to be necessary for cyclic AMP activation.

In any event, stimulation of cyclic AMP appears to be the key to the toxin's cellular action. What's more, cyclic AMP activation can help explain why the toxin leads to such extensive diarrhea, Jan Holmgren and his team at the University of Goteborg, Sweden, and other toxin researchers concur. Overproduction of cyclic AMP could lead to the oversecretion of chloride from cells, and the chloride could trigger diarrhea.

Even though toxin investigators now know a lot about bacterial toxin chemistry and actions, they are not about to lock up their labs. They want to learn more about the compositions of these toxins and the parts that are responsible for toxicity. Regarding gram-negative bacterial toxins, for instance, one current notion is that the lipid portion is the culprit. Researchers also want to learn more about the actions of bacterial toxins in the human body. Schantz, for example, is intrigued by the discovery that the botulinus molecule starts off as a protein with a molecular weight of 900,000, then splits into a 150,000-weight toxin and a 750,000-weight nontoxic protein. "It seems as if the big molecule stabilizes the toxic part," he speculates. "If you didn't have the whole molecule, you would probably not get poisoned, because it would not be stable enough to survive the digestive tract and be carried into the blood and on to the site of action."

Bacterial toxin behavior at the molecular level is still another area that researchers want to plumb further. As Iglewski and Kabat point out, substantial information at this level is known for only three of the toxins—diphtheria, pseudomonas and cholera. And even with these three, scientists are eager to probe the miasma further. Gill, for instance, wants to understand NAD's precise role in helping cholera toxin activate cyclic AMP. "Only then," he insists, "will we have a full understanding of cholera."

Researchers would also like to know exactly how much the bacterial toxins resemble each other in their actions and why. As Iglewski and Kabat point out, "We were surprised to find that both diphtheria and pseudomonas toxins have the same intracellular mechanism of action. The probability of this happening by chance or convergent evolution is obviously remote. Accordingly, we suggest that these two toxins may have had a common evolutionary origin and that some other bacterial toxins will be found to act similarly."

Probably the question that still nettles toxin researchers the most is why bacterial toxins are the world's most virulent biological substances. "We don't know the answer, and we'd sure like to," Schantz admits. The answer will undoubtedly only come to light as researchers unravel the two- and three-dimensional structures of these molecules and thoroughly unmask their baleful actions both inside and outside various cells. □

. . . Trains

erable export potential. Newly rich countries of the developing world are already entering the market for advanced rail equipment. Iran has just become the third country in the world to schedule trains over 100 miles per hour, by placing two French Turbotrains on the line from Teheran to Mashhad. But the largest potential market must still be considered the United States. Amtrak's timetable is about one quarter the size of the Scottish regional timetable of British Rail. Though the total length of track used for its passenger service is only one quarter that of the United States, British Rail Intercity Line logs twice as many passenger miles per year as Amtrak, and more than six times the passenger journeys (neither figure includes commuters). Already the U.S. Department of Transportation has given contracts to the British Rail Research and Development Division for consultation (including contributions to a research vehicle that set a 234-mile-per-hour world record in Colorado). If President Ford's commitment to revitalizing America's railways as a part of energy conservation begins to bear fruit (SN: 1/24/76, p. 52), some of the innovations pioneered at Derby may find a ready market here.

A final note of caution, however, must be added. Even as this article was in preparation, the British Government was preparing a position paper that some press accounts predict will close nearly a third of Britain's 11,500-mile passenger rail system. Rail officials will welcome some of the closures (one of them told SCIENCE NEWS it would be cheaper to buy cars for some remote villagers than maintain train service), but any shift of emphasis to trucks as a freight medium would come as a shock. As in this country, the intrinsic economies of railways versus roadways are obscured by complex labor and social issues, and whether a nation as deeply into recession as the United Kingdom will provide the tens of millions of pounds needed to complete the APT remains to be seen.

Technologically, however, that venerable old British invention, the Iron Horse, is still up there with the best of them. □