# PENNSY'S T1 *reassessed*

In a setting that valued simplicity, and with diesels on the way, America's final 100-mph steam locomotive was a good machine that was "too much, too late"

BY **DAVID R. STEPHENSON**

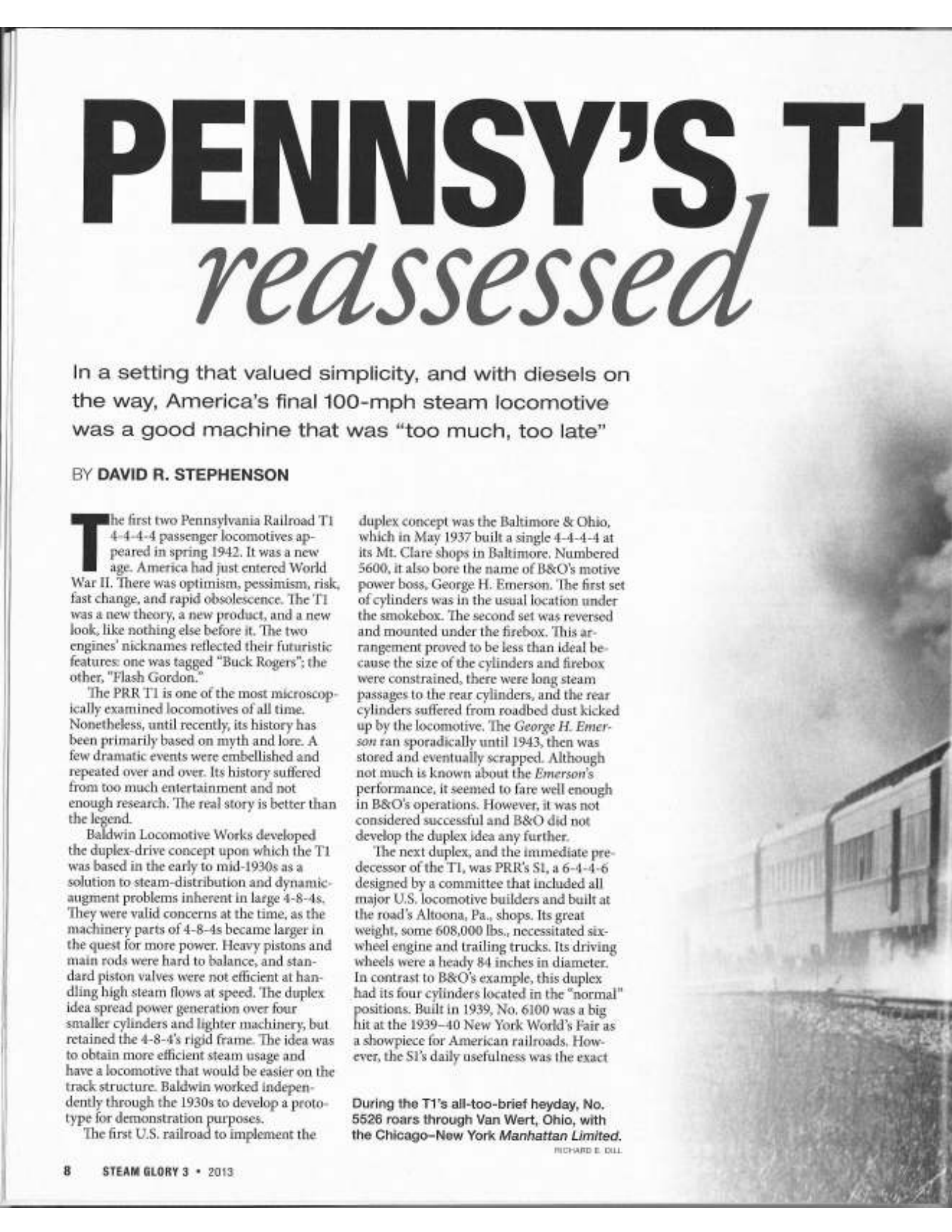
The first two Pennsylvania Railroad T1 4-4-4-4 passenger locomotives appeared in spring 1942. It was a new age. America had just entered World War II. There was optimism, pessimism, risk, fast change, and rapid obsolescence. The T1 was a new theory, a new product, and a new look, like nothing else before it. The two engines' nicknames reflected their futuristic features: one was tagged "Buck Rogers"; the other, "Flash Gordon."

The PRR T1 is one of the most microscopically examined locomotives of all time. Nonetheless, until recently, its history has been primarily based on myth and lore. A few dramatic events were embellished and repeated over and over. Its history suffered from too much entertainment and not enough research. The real story is better than the legend.

Baldwin Locomotive Works developed the duplex-drive concept upon which the T1 was based in the early to mid-1930s as a solution to steam-distribution and dynamic-augment problems inherent in large 4-8-4s. They were valid concerns at the time, as the machinery parts of 4-8-4s became larger in the quest for more power. Heavy pistons and main rods were hard to balance, and standard piston valves were not efficient at handling high steam flows at speed. The duplex idea spread power generation over four smaller cylinders and lighter machinery, but retained the 4-8-4's rigid frame. The idea was to obtain more efficient steam usage and have a locomotive that would be easier on the track structure. Baldwin worked independently through the 1930s to develop a prototype for demonstration purposes.

The first U.S. railroad to implement the duplex concept was the Baltimore & Ohio, which in May 1937 built a single 4-4-4-4 at its Mt. Clare shops in Baltimore. Numbered 5600, it also bore the name of B&O's motive power boss, George H. Emerson. The first set of cylinders was in the usual location under the smokebox. The second set was reversed and mounted under the firebox. This arrangement proved to be less than ideal because the size of the cylinders and firebox were constrained, there were long steam passages to the rear cylinders, and the rear cylinders suffered from roadbed dust kicked up by the locomotive. The *George H. Emerson* ran sporadically until 1943, then was stored and eventually scrapped. Although not much is known about the *Emerson's* performance, it seemed to fare well enough in B&O's operations. However, it was not considered successful and B&O did not develop the duplex idea any further.

The next duplex, and the immediate predecessor of the T1, was PRR's S1, a 6-4-4-6 designed by a committee that included all major U.S. locomotive builders and built at the road's Altoona, Pa., shops. Its great weight, some 608,000 lbs., necessitated six-wheel engine and trailing trucks. Its driving wheels were a heady 84 inches in diameter. In contrast to B&O's example, this duplex had its four cylinders located in the "normal" positions. Built in 1939, No. 6100 was a big hit at the 1939–40 New York World's Fair as a showpiece for American railroads. However, the S1's daily usefulness was the exact



**During the T1's all-too-brief heyday, No. 5526 roars through Van Wert, Ohio, with the Chicago–New York *Manhattan Limited*.**

RICHARD E. DILL

Two K4s Pacifics accelerate a mail and express train, brought in from the east by a GG1 electric, out of Harrisburg in March 1946. The T1 was intended to end doubleheading on PRR's "Blue Ribbon Fleet" of east-west passenger trains, and to be the equal of a GG1.

CHARLES A. BROWN

opposite. Most of what was learned from it was negative. It was immense, slippery, and impractical. However, it could easily haul 15- and 16-car trains at 100 mph, which indicated that the four-cylinder, rigid-frame idea worked.

## TWO PROTOTYPES

B&O's *Emerson* and PRR's S1 showed that the duplex concept was valid from an engineering standpoint, but it had consequences that may not have been considered in the initial stages of development. A pair of two-axle engines would be sensitive to rail conditions. As result, particular attention had to be given to locomotive components (*e.g.*, suspension, sanding), the railroad's physical plant, and proper handling methods. PRR decided to try Baldwin's idea, which was more realistic than the oversized S1.

The T1 was designed to power PRR's fleet of heavy, limited-stop trains between the East Coast and the Midwest. East of Harrisburg, Pa., these were hauled by single 4,620 h.p. GG1 electrics; to the west, doubleheaded K4s Pacifics were usually required. The T1 was not intended to be Pennsy's next general-service locomotive. Its most notable specification was that it should be capable of hauling 880 tons at 100 mph. Built by Baldwin, the first two, Nos. 6110 and 6111, were completed on April 22 and May 21, 1942. As he had for the S1, Raymond Loewy designed the external shrouding, whose "yacht nose" prow was like no other locomotive's.

The T1's were about the same size and weight as the largest 4-8-4s. However, their boilers were relatively small, comparable to a large 4-6-4 or a medium-size 4-8-4. This was a compromise dictated by PRR weight restrictions. Poppet valves were intended to make up for this difference by using available steam more efficiently than conventional piston valves.

There is considerable evidence that suggests the initial two T1's suffered from both design flaws and manufacturing defects. The former should be viewed in light of the fact that the T1's were radically new machines incorporating many new ideas. The design flaws found in 6110 and 6111 included poor drafting, inadequate suspension equalization, erratic adhesion, inaccessible valve-gear boxes, and faulty tender coupling.

The manufacturing problems are less defensible. Baldwin was an experienced locomotive builder, and should have had better quality control. The defects included poor bearing tolerances, leaking joints, ineffective sanders, and loose piping.

Plenty of attention has been given to the T1's early troubles, and PRR did have its hands full sorting things out. What has not been adequately noted is that the two prototypes were improved during three years of modifications. PRR did not sit around wondering what happened. In spite of the enormous amount of wartime traffic the railroad had to move, development continued and changes were made. In addition, the two T1's were thoroughly tested over the road and on the Altoona test plant.

No. 6110 was subjected to a total of 59 test-plant sessions between April 25 and July 3, 1944. These included full-throttle and part-throttle tests at various speeds and cut-off settings. Performance was evaluated at speeds from 38 to 100 mph, with cut-off varying from 50 percent to as low as 10 percent. Test duration ranged from 18 minutes to 170 minutes. Technicians tried some 14 different front-end arrangements to improve drafting.

Several unusual things were noted during the tests, among them power output, steam rate per unit of output, and steam temperature. The 6110 developed 6,666 indicated horsepower at 100 mph and 6,100 locomotive drawbar horsepower at 76 mph. At 76 mph and 20 percent cut-off, a water rate of 13.6 lbs. per indicated horsepower was posted, which has been credited as the lowest ever recorded. Several other runs showed similar results, indicating that the poppet valves did their job well. The steam temperature for the T1 as it was initially configured for the tests was higher than desirable from a maintenance standpoint. However, high superheat temperature was one of the factors enabling the T1's high performance. The hotter the steam, the more work is available. The T1 may have set a record there as well, with a maximum superheat of 381 degrees.

The Altoona tests indicated that the T1 had great performance potential and would deliver this performance at low fuel and water cost. What they didn't show was that the T1 would be a demanding locomotive to operate and that business as usual would not be good enough.

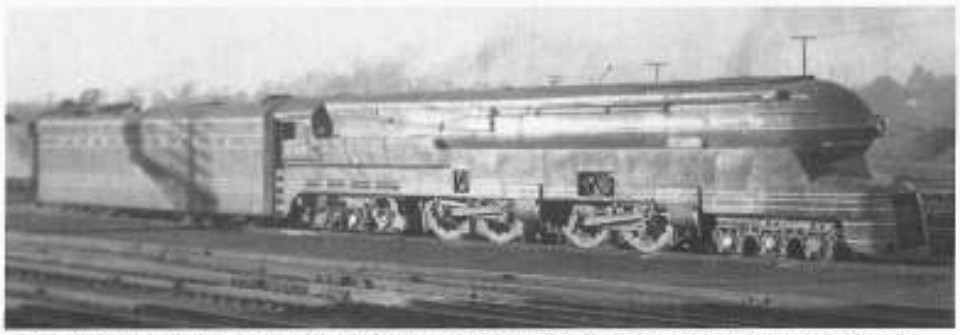
## WHAT ABOUT A 4-8-4?

As the T1 evaluation progressed, PRR President Martin Clement asked whether Norfolk & Western's class J 4-8-4 would be suitable for PRR service. James W. Symes, then vice-president of PRR's Western Region, arranged to borrow N&W No. 610 from December 5, 1944, through January 3, 1945. Running out of Chicago on the fast Fort Wayne Division, the J acquitted itself very well, earning high praise from all those involved in its operation. It made or bettered the schedule with PRR's heaviest and fastest trains, accelerated the trains quickly, rode smoothly at all speeds, steamed well with a clear stack at high steam rates, was easy to inspect and maintain, and operated at up to 111 mph.

However, the T1 program had momentum. A few weeks after the class J tests, PRR retrofitted the 6110 and 6111 with modifications that were also scheduled for the upcoming production lot. In March 1945, the War Production Board allowed PRR to order 50 T1's, 25 from Altoona and 25 from Baldwin. The order was split to get the locomotives on the road as soon as possible. PRR and Baldwin began to accumulate material and started work on the production T1's in June. Nonetheless, Symes resumed his search for an alternative.

PRR continued to evaluate the two prototypes on a daily basis. They were given difficult assignments in regular passenger service between Harrisburg and Pittsburgh from September through November 1945. Average train size for all runs was 15.2 cars, with about 40 percent of the runs at 17 cars or more, and a maximum train size of 21 cars. The two T1's made up considerable running time, some under adverse rail conditions, with these large trains.

These tests confirm that PRR was not viewing the T1's performance through rose-colored glasses. The engines could move the trains, and the tests proved that they were



**B&O 5600 of 1937 (top, at Washington in 1940) was the first U.S. duplex; it shared a 4-4-4-4 wheel arrangement with the T1, but its rear engine was "backwards." Two years later came PRR's "Big Engine," class S1 No. 6100 (at Fort Wayne in 1941); the colossal 6-4-4-6 was too large for general use, but it sold PRR on the duplex-drive concept.**

TOP, R. V. NIXON; ABOVE, R. W. CARSON

**PRR and Baldwin drew on what they learned from the S1 when designing the two prototype T1's of 1942, the first of which, No. 6110, pauses at Englewood, Ill., on June 8, 1945.**

V. O. HARKNESS

As it was working out the bugs in the T1 prototypes, PRR borrowed an N&W J for tests. The 4-8-4 (at Englewood), performed well, but PRR sent it home and ordered more T1's.

PAUL ELENBERGER

No. 5526, one of the 50 production T1's, still lacks some sheet-metal streamlining as its front-end throttle gets some attention at the Baldwin plant on November 30, 1945.

CHARLES A. BROWN

## HOW THE DUPLEXES STACKED UP

| Wheel Arrangement | 4-4-4-4 | 6-4-4-6 | 4-4-4-4 | 4-4-4-4 | 4-4-4-4 |
|---|---|---|---|---|---|
| Railroad | B&O | PRR | PRR | PRR | PRR |
| Class | N1 | S1 | T1 | T1 | T1 |
| Road numbers | 5600 | 6100 | 6110 | 6111 | 5500-5549 |
| Date built | 1937 | 1939 | 1942 | 1942 | 1945-1946 |
| Cylinders (bore x stroke in inches) | 18x26 1/2 | 22x26 | 19 3/4x26 | 19 3/4x26 | 19 3/4x26 |
| Boiler pressure (psi) | 350 | 300 | 300 | 300 | 300 |
| Driver diameter (inches) | 76 | 84 | 80 | 80 | 80 |
| Tractive effort, rated (lbs.) | 65,000 | 72,000 | 64,640 | 64,640 | 64,640 |
| Tractive effort, booster (lbs.) | none | none | none | 13,500 | none |
| Tractive effort, total (lbs.) | 65,000 | 72,000 | 64,640 | 78,140 | 64,640 |
| Factor of adhesion, rated | 3.70 | 3.91 | 4.15 | 4.14 | 4.33 |
| Total direct htg. surf. (sq. ft.) | 677 | 660 | 490 | 490 | 490 |
| Indirect heating surface (sq. ft.) | 4,220 | 5,001 | 3,719 | 3,719 | 3,719 |
| Evaporative heating surface (sq. ft.) | 4,897 | 5,661 | 4,209 | 4,209 | 4,209 |
| Superheating surface (sq. ft.) | 1,312 | 2,085 | 1,430 | 1,430 | 1,430 |
| Total heating surface (sq. ft.) | 6,209 | 7,746 | 5,639 | 5,639 | 5,639 |
| Grate area (sq. ft.) | 80.5 | 132.0 | 92.0 | 92.0 | 92.0 |
| Weight on drivers (lbs.) | 240,350 | 281,440 | 268,200 | 267,840 | 279,910 |
| Weight on engine truck (lbs.) | 61,200 | 135,100 | 100,200 | 102,360 | 99,570 |
| Weight on trailing truck (lbs.) | 90,000 | 191,630 | 128,800 | 138,200 | 122,720 |
| Total engine weight (lbs.) | 391,550 | 608,170 | 497,200 | 508,400 | 502,200 |
| Tender capacity, coal (tons) | 23.0 | 26.5 | 41.0 | 41.0 | 42.6 |
| Tender capacity, water (gallons) | 22,000 | 24,230 | 19,500 | 19,500 | 19,200 |
| Total weight, engine and tender (lbs.) | 741,550 | 1,059,920 | 930,200 | 941,400 | 944,700 |

not nearly as skittish as their reputation suggested. Given decent preparation and a competent crew, there were very few problems over the road. It was another story if neglected and dispatched with reportable defects or operated in an inappropriate manner. This happened more frequently than one would expect, particularly considering the microscope they were under.

Tempering this, it is likely that many contemporary 4-8-4s could have performed in a similar manner, albeit without the caveats of thorough preparation and crew ability. But PRR seemed to focus on performance potential, not on reliability or possible staffing problems. The road also seemed to overlook maintenance, preparation, and operation standards that would have to be considerably higher than those required by its hundreds of K4's.

As the prototype tests went on, Symes requested diesels for his Western Region in September 1945, and suggested canceling some of the T1's. However, it was felt that too much material had already been ordered, and that the need for new passenger locomotives was too urgent. In spite of Symes' efforts to change direction, the 50 T1's remained in production.

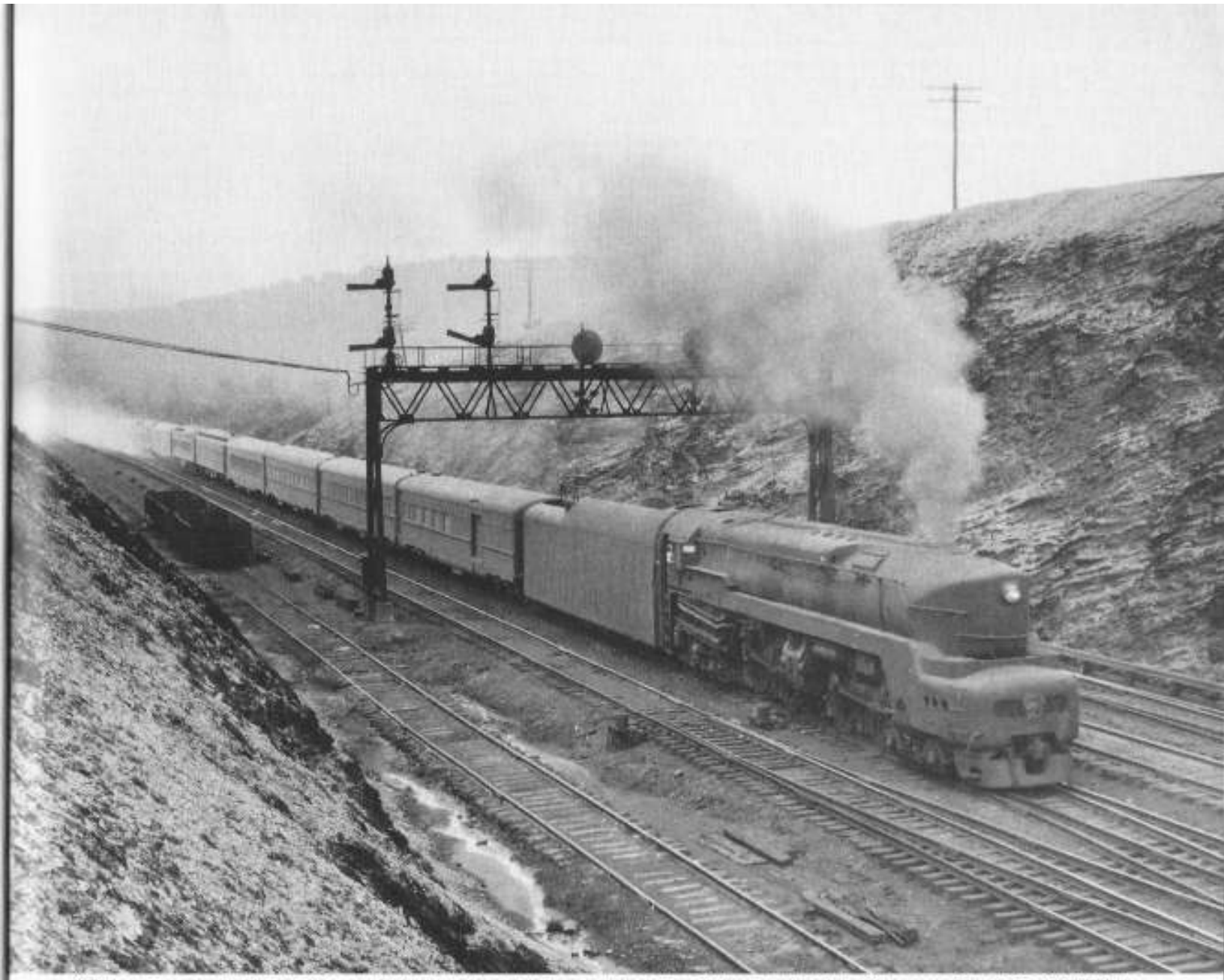
The 50 production T1's, Nos. 5500–5549, were built between November 16, 1945, and August 27, 1946. They included modifications to improve their performance and reliability, *e.g.*, improved suspension equalization, reduced streamlined shrouding, and better sanders. However, PRR chose not to use Type B poppets, which were available by that time. These would have eliminated the inaccessibility problems of the Type A's.

### T1 VS. K4

Inevitably, the T1 was compared with the renowned K4, PRR's standard passenger engine since about 1920. The K4 was as simple as you can get and reliable as an anvil. Its performance was achieved by matching an excellent boiler with properly proportioned running gear. It had piston valves, a stoker, one air pump, two sanders, and two mechanical lubricators. It did not have "frills" such as a feedwater heater, aftercooler, extra air pumps, or multiple sanders.

The K4 had a dome throttle, a single three-axle engine set, and a relatively high factor of adhesion. It was not fussy about handling or maintenance. It was forgiving of crude operation and would rise to almost any occasion if treated well. Servicing was straightforward.

In contrast, the T1 had all the accessories: four to eight sanders, a Hancock exhaust steam injector, two air pumps, an aftercooler, a front-end throttle, and four sets of poppet valves. It was a mechanic's wonderland of moving parts. It had large steam passages, insignificant steam-circuit losses, and low back pressure. These qualities gave the T1 its



A T1 leaves a cloud of brakeshoe smoke in its wake at it brings a train down off the mountain into Altoona on March 15, 1947. This is the as-built condition of the 50 production T1's, before the addition of steps and number-board/marker-light boxes to the front end.

CARL M. JOHNSON

performance potential, but also set the stage for trouble.

Given decent handing, a T1 could work wonders over the road. Its front-end throttle made it much more responsive than a K4. However, despite a factor of adhesion comparable to a 4-8-4, if handled poorly, a T1 could slip, stall, and do other things to remind the crew who was in charge. Servicing had to be thorough to get a T1's available power to the rail. Compared to a K4, a T1 had up to four times the number of sanders to check, many new appliances, hidden accessories, and hard-to-access poppet valve gear cases.

## TALES FROM THE ROAD

Two runs involving the same locomotive several days apart illustrate how performance could vary.

In the first example, No. 6110 was given one of the best crews. They took a 21-car passenger train over the Middle Division, rain and fog the whole way, with just two slips recorded. They left Harrisburg 6 minutes late and arrived 2 minutes early at Altoona. There were at least three intermediate stops and no difficulties were encountered at any of them.

Three days later things were different. PRR memos describe an engineman's improper handling of the 6110 during poor rail conditions ascending the west slope of the Alleghenies. "After we had taken sand at Conemaugh," the report states, referencing a point 2.5 miles east of Johnstown, "the engineman had the train moving and if he had left the throttle in its position, the locomotive would have hauled the train away, but he jerked it open, the locomotive slipped, the train stalled and we had to put a pusher on to get the train away."

The engineer also allowed 6110 to slip so badly that the PRR official in the cab stated that "... I was afraid we would do some damage to the locomotive before the engineman noticed the slip and closed the throttle."

How crews operated the T1's had a major impact on performance. Improper handling was the major contributor to the slipping legend. Flogging a T1 would get you nothing but trouble.

Australian railroad historian Neil Burnell interviewed many T1 crewmen at length and a consistent story line emerged. Although

No. 5527 sweeps under a signal bridge at Whiting, Ind., in the afternoon of March 29, 1947. In 17 miles, the duplex will nose up to a bumping post at Chicago Union Station.
DAVE WALLACE

A 1948 or '49 equipment display at Harrisburg featured two E7's and, appropriately in the background of this photo, T1 5548. Diesels eclipsed the duplexes almost immediately.
JAY WILLIAMS COLLECTION

some of the crews preferred the K4 for ease of handing, they all liked the T1 for its ability to make up time. The men stated that once you learned to handle them, they were fine locomotives. They steamed easily, rode well, and could make up time with any train. As far as slipping goes, they said the T1's were no worse than any other locomotive as long as you handled them properly. PRR's training policy could be hit-or-miss, so most of the crews said they learned by doing. Some engineers learned faster than others; some never got the hang of it. The crews summarized things this way: The T1's weren't nearly as bad as their reputation; they were just different from the K4.

Lore has it that the T1's never made decent monthly mileages. However, the T1's posted the highest systemwide monthly mileage of *any* PRR steam locomotive. Official mileage reports for April 1946 show that No. 5504 was the highest-mileage T1 at the time, posting 40,642 miles since its in-service date of September 5, 1945, an average of 8,294 miles per month. During April, 5504 posted 10,793 miles; 5512 tallied 11,442 miles; and 5508 racked up 10,942 miles. By comparison, PRR's first E7 passenger diesels, which arrived in September 1945, were averaging about 11,500 miles per month. T1's could make competitive mileages when given a chance.

Offsetting this, the fleet average for the 30 T1's in service in April 1946 was about 7,244 miles a month, substantially less than the E7's. More telling than that, diesel mileage increased as time went by, so that by October 1947 the fleet average was about 19,620 miles per month. By this time, with all 52 T1's in service, fleet mileage had slowly declined to about 6,738 miles per month, with the K4's even lower.

There are indications that PRR's dispatching policy adversely affected the monthly mileage. In order to cut costs, T1's were being favored for runs where they could replace doubleheaded K4's. If a T1 was ready for service, but not assigned immediately, its opportunity to accumulate miles would be compromised.

However, one significant event occurred that would make the T1's performance irrelevant: PRR lost money for the first time in 1946. This got the corporation's attention. In addition, competitor New York Central, like virtually all other railroads, was dieselizing its passenger trains. About the same time as the last production T1 was delivered, PRR made its decision to dieselize all first-line passenger trains, exactly the ones the T1's were supposed to handle. They were out of a job by the time they were built.

## C&O, N&W: WANT TO BUY A T1?

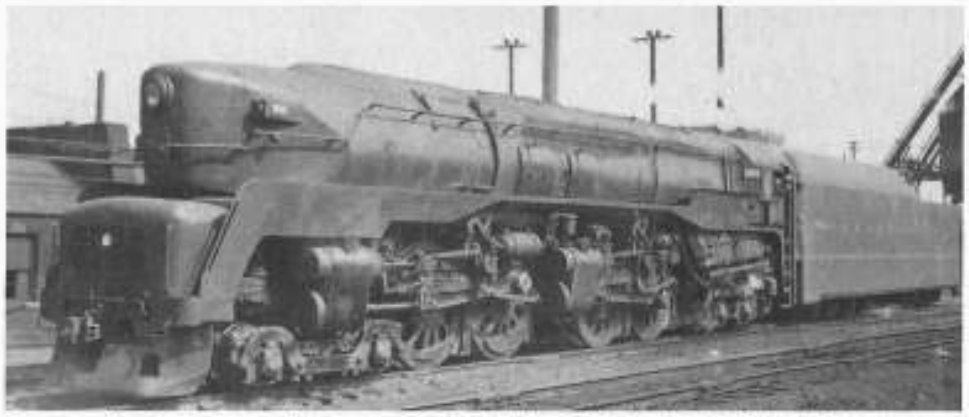
Once PRR made the commitment to dieselize, it tried to find an application for the T1 on railroads still committed to coal-burning steam locomotives such as N&W and Chesapeake & Ohio. PRR approached C&O first.

C&O had its own reasons to be interested in new locomotives. There were two groups of 4-8-4s on the property in late 1946, all showing signs of extensive use during the war. In addition, the older 4-6-2s and 4-8-2s were almost completely worn out by this time. Although passenger traffic was declining, C&O decided to increase its passenger fleet, and agreed to host a T1.

The tests ran September 4–14, 1946, and involved two T1's, 5511 and 5539. All tests were conducted in regular passenger service. No. 5511 was tested from Huntington, W.Va., to Clifton Forge, Va.; Clifton Forge to Toledo, Ohio; and Toledo to Hinton, W.Va. No. 5539 was tested from Huntington to Charlottesville, Va., and Charlottesville to Cincinnati.

C&O's test report and correspondence showed that overall performance was good to commendable. Both T1's steamed well, rode well, and showed no excessive tendency to slip. Interestingly, information in PRR files indicated that the engines' performance was not quite as glossy. However, there was no argument that they could perform well even when given low quality coal, or pushed to the limit in heavy grade territory. They were operated at wide-open throttle most of the time and no complaints were recorded about slipping. They were given no quarter in attempts to maintain schedules.

When 5511 arrived, there were signs that PRR's preparation and maintenance were inadequate, and C&O had to make some adjustments. It should have done very well on the more level parts of the system where it was tested. However, 5511's performance was not as good as expected and the valves were thought to be out of calibration.



Even as diesels were coming on strong, PRR tinkered with the T1's. No. 5500 (top, at Cincinnati with two K4's) was re-equipped with Franklin rotary cam valve gear, while 5547 (at Pittsburgh in '48) got Walschaerts, prompting a change in classification to T1a.

TOP, DONALD P. CAMPBELL; ABOVE, BERT PENNYPACKER

In June 1948, while on the N&W for evaluation, PRR 5515 backs toward its test train at the station in Roanoke, Va. Instead of buying T1's, N&W built three more J-class 4-8-4s.

O. H. BORSUM

The second T1, 5539, was also poorly prepared. On C&O's Mountain Subdivision, it had to start trains under conditions that were beyond its capacity, but contrary to all anecdotes, did not slip during the attempts.

Worse, C&O evaluated the two T1's using inconsistent standards. Their performance was criticized because uncorrected road test data was compared to Altoona test plant measurements, and as a result, the locomotives appeared deficient when they actually weren't.

The C&O tests were a case of "almost, but not quite." The performance potential was there, and could be impressive, but it was offset by problems that wouldn't go away. As a

In its final months of operation, T1 5527 on a 27-car eastbound mail and express train creeps up to a stop signal at Huntingdon, Pa., on June 21, 1951. By this time diesels were on all top passenger trains, leaving locals and mail trains for the dwindling T1 fleet.
EDWARD TREDINGER

result, neither of the two T1's gave a clear account of itself.

Regardless of the test results, the T1 was not what C&O needed. Boosters would have been required to run them successfully on the Mountain Subdivision, which would have added cost. For the rest of the railroad, the T1's high-speed capability was not useful because existing 4-6-4s were adequate.

From this point forward, the T1's settled into their place in Pennsy's passenger fleet and did what was expected of them. They performed well if dispatched with working sanders, proper lubrication, and a competent crew. Too often they got none of those. At least 10 were equipped with smaller cylinders. Rotary cam poppet valves were retrofitted on No. 5500 in 1948, and Walschaerts valve gear on the 5547 in 1949. The T1's spent their lives in an atmosphere of continuing development.

In 1948, PRR made one last effort to find a home for the T1's. It suggested that N&W, majority owned by the PRR but with a proud tradition of homegrown steam, might be interested in testing a T1. N&W proposed a series of tests to develop comparative performance and operating economies of the T1 and its own class J. N&W's finest met PRR's newest in one of the more obscure events in late steam history.

PRR loaned No. 5511, a veteran of the 1946 C&O tests, to N&W from June 9 to 26, 1948. N&W ran the T1 on test trains between Roanoke and Christiansburg, Va., and compared the results to similar tests made in 1945 with class J 604. Additional tests took place between Poe and Suffolk, Va.

The test report shows that the J had the performance advantage in heavy grade territory. At most commonly found passenger-train speeds, the J used less coal and water for the same unit of output. The T1 fared better during the high-speed tests. As speed increased into the 75 and 85 mph ranges, the T1 used less coal and water than the J for the same unit of output. The T1 also covered more distance at these higher speeds in comparative acceleration tests. Adhesion was not an issue at any time.

The N&W tests indicated that the duplex was not economically superior to a highly refined conventional 4-8-4 at normally encountered operating speeds. This is significant because the J was designed for conditions on N&W, which were considerably different from those on most railroads. Overall, N&W coaxed good performance out of 5511, but it wasn't enough to persuade the railroad to buy.

## WHAT KILLED THE T1?

The T1's did what they were designed to do and more. They could easily pull 1,000-ton trains at 100 mph, and do it on less steam than a conventional 4-8-4. But they were a complicated bag of tricks, with many new features sprung on a conservative railroad at an inopportune time. In hindsight, if PRR wished to stick with steam, it needed a straightforward 4-8-4—simple, reliable and tolerant, much like the K4. Instead, it specified (and got) a highly specialized, completely different, and very demanding locomotive.

PRR retired the T1's early and rapidly. To many observers, this confirms that they were a defective design and couldn't perform. This wasn't the case. Dieselization was occurring because of competitive pressures and PRR's financial distress. The existence of the T1 had nothing to do with it. Time, money, and corporate will ran out for the T1 in the face of PRR's postwar economic problems and the diesel's superior features.

When their primary assignments went to diesels, the duplexes were ill-suited for secondary jobs. This wasn't unusual with modern steam power. As more capability was packed into a single locomotive, it became less flexible with respect to lower-grade assignments. PRR had literally hundreds of simpler, cheaper, go-anywhere K4's to handle its remaining secondary passenger operations. Toward the end of steam, available assignments decreased and neglect increased. The T1 required too much attention to be useful in this environment.

The only other alternative use for the T1's would have been freight service. PRR had begun to rebuild 40 of its M1a 4-8-2s into M1b's in 1945 with higher boiler pressure and increased capacity in the medium-speed range. As a result, it had a supply of virtually new, yet still familiar, simple, and reliable locomotives for freight operations as dieselization progressed. PRR had no incentive to bother with the T1 because it offered no advantage over the M1b.

Economics ruled from 1946 on, and no steam locomotive could come close to the EMD E7. PRR realized what it had to do. Technological change and economic factors overwhelmed the T1 just as surely as they engulfed the best and worst and all the rest

End of the duplex dream: No. 5531 is among 39 T1's awaiting the cutting torch at Sharpsburg, Pa., in 1952. Pennsy steam lasted another five years, during which time the remaining passenger engines were 4-4-2s, 4-6-0s, and 4-6-2s designed in the 1910s and '20s.

J. J. YOUNG JR.

of steam. The entire process was cost-driven.

Save money where you can; cut your losses where you must—that's how corporations work. The T1 may have been different; ultimately, PRR wasn't. The last T1's were set aside by 1952 and scrapped in the mid-'50s.

Other contemporary modern passenger locomotives fared no better. C&O's newest 4-8-4s and 4-6-4s were built in 1948, the last and most modern conventional steam passenger locomotives from Lima and Baldwin; they were retired by 1956. NYC's Niagaras were built in 1945 and by any standard were highly successful, yet they were cold by 1956. N&W built its final J's in 1950; they didn't make it to 1960.

## DUPLEX DEAD-END

The duplex idea never caught on and the Pennsylvania remained its only U.S. proponent. In addition to the T1's, PRR tried duplexes for freight, building one class Q1 4-6-4-4 in 1942, an improved Q2 4-4-6-4 in 1944, and 25 more Q2's in 1945. The Q2's carry the same mixed legacy as the T1's: immensely powerful at speed, but complex and temperamental. They worked the west end of the PRR, which in the road's generally west-to-east dieselization program dropped steam relatively early.

In one way, the duplexes were a solution to an anticipated problem that did not materialize. During the late 1930s and early '40s, conventional locomotive design changed. New materials were developed, lighter reciprocating and rotating parts were incorporated, and counterbalancing was improved. As things turned out, large 4-8-4s did not have the problems that were predicted. Consequently, the duplex solution no longer had a problem to solve.

For example, Union Pacific's 80-inch-drivered 4-8-4s, built during 1939–44, had no problems with sustained high-speed operation. N&W's class J's rode on drivers of just 70 inches, but were unmatched for acceleration and getting heavy trains over mountain grades. NYC's Niagara indicated that performance similar to that of the T1 could be obtained from a compact conventional 4-8-4. Most important, none of these examples deviated from one of the basic tenets of locomotive design: simplicity.

The T1's were too much, too late, but they deserve better than being painted with the broad, black brush of failure. They were a significant development in steam locomotive technology. When placed side by side with a GG1, they presented a striking picture of the Pennsylvania Railroad's progressiveness coming into the postwar period. Unfortunately, the T1's were designed and built to a performance specification that focused on the unrealistic. The specialization and complexity incorporated to achieve the performance worked against them in day-to-day operations. Who gets the blame: those who proposed the questionable performance standard, those who developed the overly complex design, or the locomotive that met the specification in spite of itself?

In the end, the T1 appeals to the imagination more than anything else. As David P. Morgan noted in the November 1959 issue of TRAINS, it was the last steam locomotive specifically designed and built to run at the century mark. And that's where a T1 could not be denied—going really, really fast with almost any train that could be tied to its tender. Once past about 70 mph, very few locomotives could stay with it or operate as economically. But that's not where the bread-and-butter operation was. Real life was more mundane, and a harsh judge of the T1. ■