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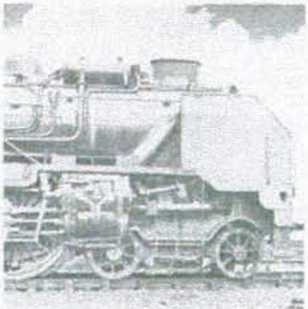
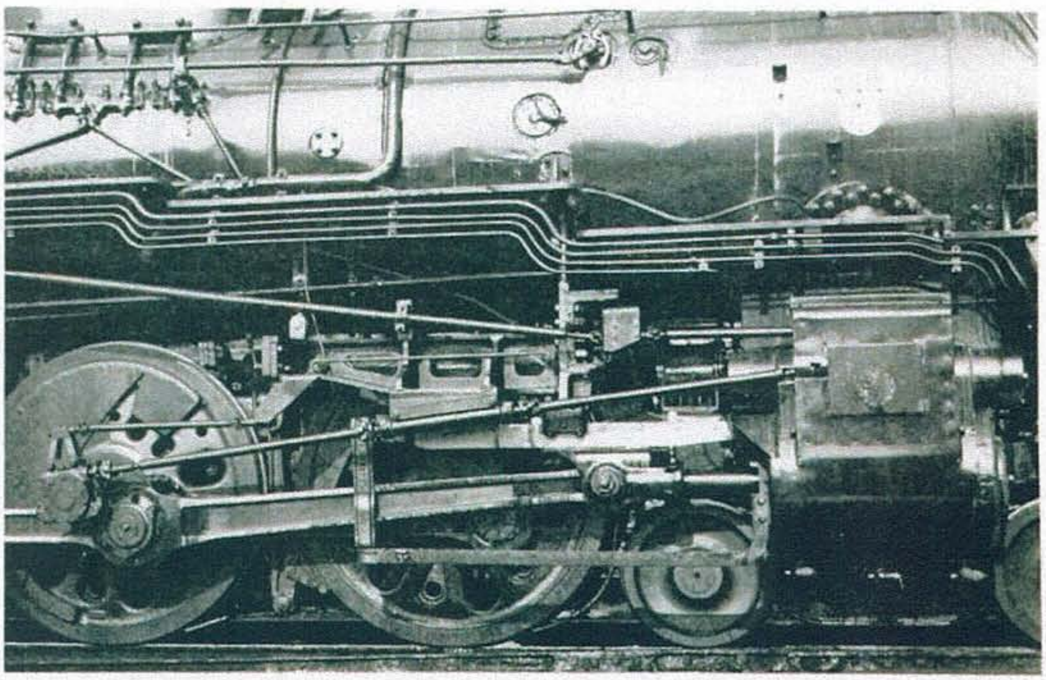


THE CASE FOR THE FRENCH STEAM LOCOMOTIVE

Remember this article in December 1966 TRAINS? Now an expert comes forth with . . .

The case for the AMERICAN steam locomotive



Ken Casford.

VERNON L. SMITH

illustration / AUTHOR'S COLLECTION OR AS NOTED

IN his "The Case for the French Steam Locomotive" in December 1966 TRAINS, author R. K. Evans stated, ". . . The fact remains unquestioned that nowhere in the world was the art of steam locomotive design developed as far and as close to perfection as in France."

I question the claim put forth by Mr. Evans, because it is not supported by data and performance records gathered during the high tide of American locomotive design.

Comparing locomotives used in different countries and under different conditions is not always easy. Therefore, to avoid any possibility of unfairness, I will try to explore carefully the factors which controlled the design or method of operation of steam locomotives in the two countries.

Since Pennsylvania's T1 4-4-4-4 was singled out for criticism on page 30 of Mr. Evans' article (the power output figures quoted are incorrect, incidentally), I have selected this particular class of engine, along with Pennsy's rebuilt K4s 4-6-2 No. 5399, and Santa Fe's 4-8-4 2900 class built new and the road's 4-8-4 No. 3752 as rebuilt, to illustrate the position of locomotive engineering in the United States near the end of the steam era.

Using these examples for comparison is quite suitable. The two new locomotives, PRR's T1 and Santa Fe's 2900 class, were of the same tractive effort and were roughly in the same horsepower category, yet one represents the divided-drive planning and the other the concept of straight coupling of eight drive wheels through tandem rods. The two rebuilt locomotives, PRR No. 5399 and Santa Fe No. 3752, clearly illustrate that the French had no exclusive talent in the improving of old locomotives. And finally, I knew these four engines well.

SOME of the elements which mold the arrangement and construction of locomotives for different parts of the world are:

(1) Nature — the terrain to be crossed, the distances to be run, the rigors of climate, and the quantity and quality of fuel and water available.

(2) The demands of the Traffic Department for speeds and tonnages of trains to be handled — in America these are high and harsh.

(3) Miscellaneous conditions — the labor market, the working clearances (loading gauge), the maintenance practices, and the locomotive availability and utilization required.

Mr. Evans in his article spoke of compounding and maintenance, drawbar horsepower, fuel economy, valve gears, improved front ends, enlarged steam and exhaust passages, riding qualities and speed, and boiler blowdown practices. All of these will be considered — in the light of the factors previously mentioned and with direct reference to the four American locomotives mentioned — with the exception of compounding. Multiple expansion will be touched upon only briefly, since except for Mallet pushers and the Delaware & Hudson experimentals, compounds have been obsolete in America for many years.

Compounding in the U. S. can be best expressed by saying that it was the most important and economic link for producing fuel savings in the period between the single-expansion saturated steam locomotive of 1880 and the superheater locomotive of, say, 1910. Norfolk & Western and Chesapeake & Ohio Mallets used in the slow-speed coal traffic were modest exceptions to the general practice.

The Santa Fe Railway had extensive experience with nearly all forms of compounds, including the cross-compound, tandem, Mallet, Vauclain, and the four-cylinder balanced types. The end came when the compounds could no longer meet the traffic demands or justify the high maintenance costs.

It is true, as Mr. Evans pointed out, that the French have diligently developed the three- and four-cylinder compounds. Many of these locomotives, as he noted, were arranged with separate reach rods and reverse mechanisms for the high-pressure and the low-pressure engines to permit the driver to adjust the cutoff on each engine independently of the other for optimum performance. It should be repeated that the French engineman from the turn of the century to the 1930's was highly trained after serving a thorough shop apprenticeship before going out on the road. This technical background resulted in fine, economical handling of compound engines.

Many of the later four-cylinder engines have the two reach rods connected or pinned together to avoid improper division of the work by the engineman between the high- and low-pressure systems. This suggests that the labor market may be changing in France and that less refined locomotive driving is taking place. And it means that some of the original economies are not being obtained. To secure an acceptable standard of performance with any driver, and to reduce excessive maintenance costs on the machinery, the mechanical officer selects the best point to combine the work of both sets by sacrificing some of the performance within the power ranges.

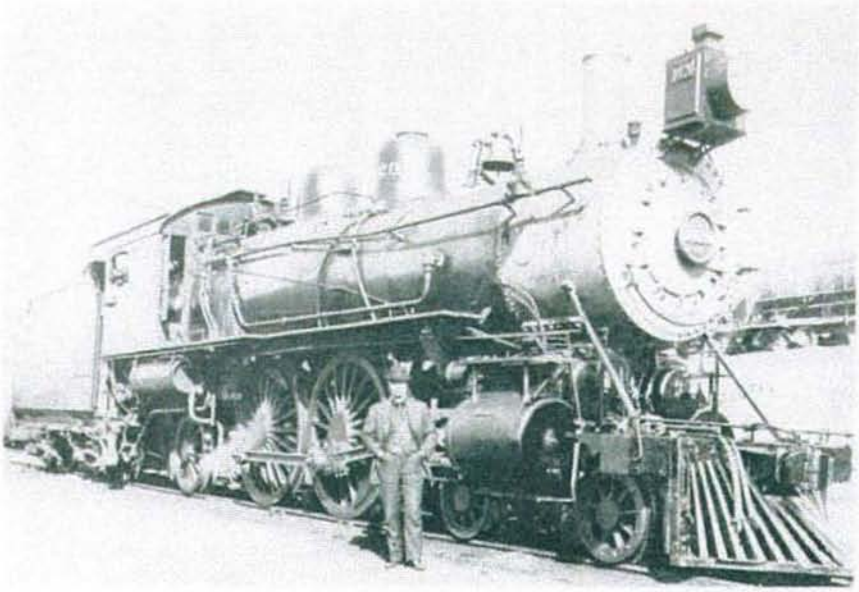
Some of the European compounds spent considerable time in the shed for work after relatively short trips. This situation would not be tolerated in the United States in view of the wage scales paid and the capital tied up.

One reason the French might be moving toward our methods as their costs increase is the fact that the American-built single-expansion Class 141R's, which "thrive on hard work and poor fuel," are still in service in quantity, whereas the equivalent or more complicated French classes are largely stored or retired.

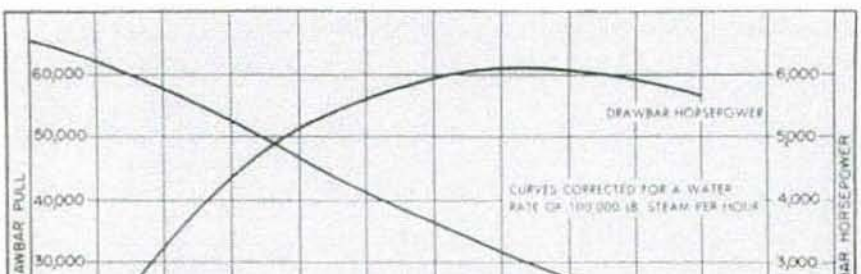
AND NOW on to the other matters to be discussed.

DRAWBAR HORSEPOWER

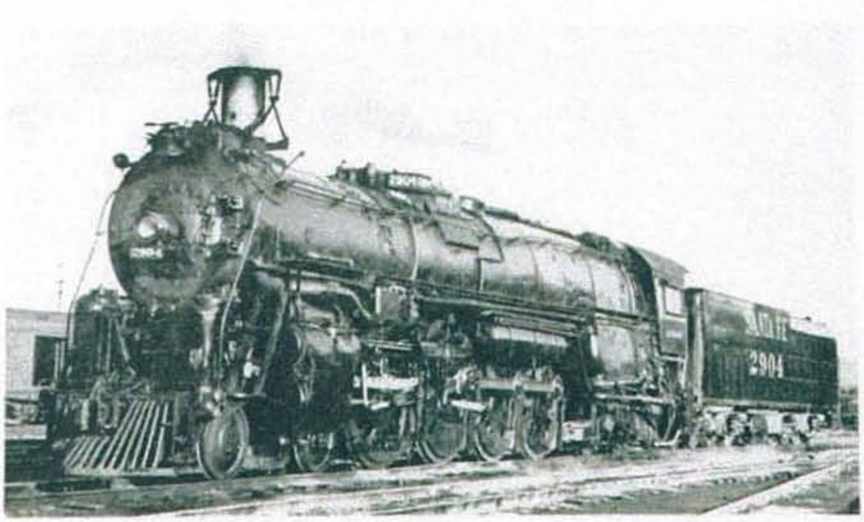
First of all, it is time to set right the record on the drawbar horsepower output of a T1. The graph on page 24 shows a curve prepared from the Altoona Test Plant data showing the high drawbar horsepowers this duplex would produce. It is plain that the T1's drawbar horsepower of 6000 at the speed of 62 mph greatly exceeded the 4000-drawbar-horsepower capacity quoted by Mr. Evans. French 4-8-4 No. 242 A 1 developed a maximum of 4200 h.p. (not 5000, as stated by Mr. Evans) at 56 mph while running on a grade of 11 in 1000, according to a report furnished by André Chapelon and published in 1948. The report does not state whether this is indi-



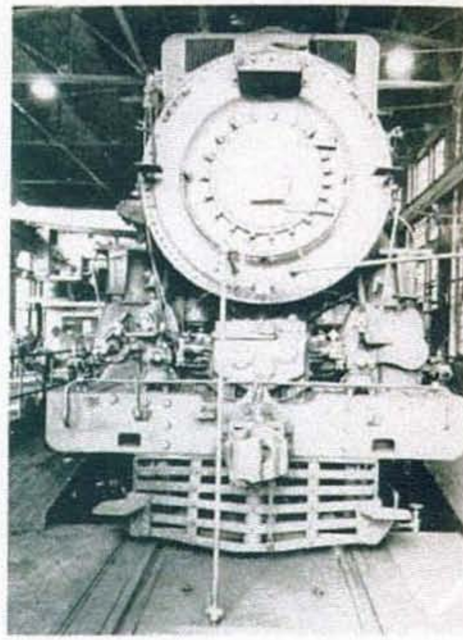
"ONE-engine, one-man" concept of operation in U. S. was in its twilight when this shot of a high-mileage-between-shoppings AT&SF four-cylinder balanced compound was made.



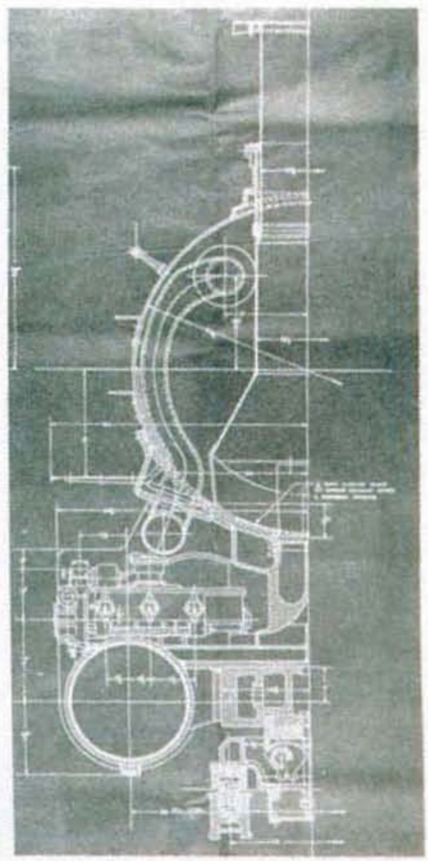
DRAWBAR HORSEPOWER curve for Pennsy's duplex-drive T1-class 4-4-4-4 shows a flatness at top of curve over the wide range of speed at which high horsepower prevailed.



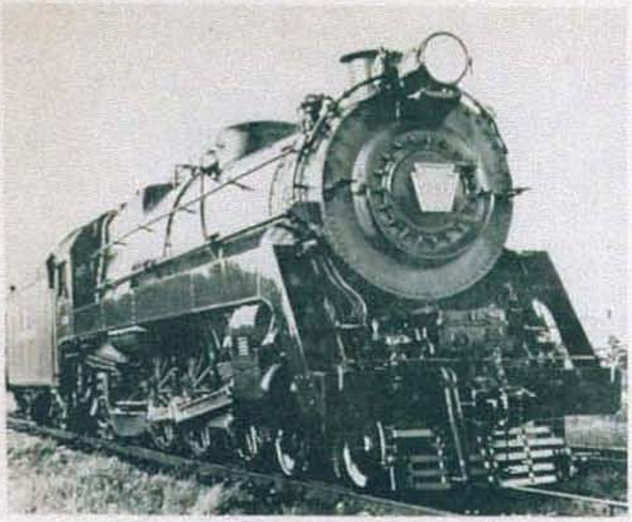
VERY free-running Santa Fe 4-8-4 2904 produced nearly 6000 indicated horsepower and could — and did — furnish competition for 5400 h.p. diesels out of Argentine, Kans.



PENNSY K4 5399 in final modified form with front-end throttle, improved drafting, and ASW superheater units stands on the Altoona Test Plant in 1940. Small pipes extending out of smokebox sampled CO_2 content of the locomotive's exhaust gases.



HALF-SECTION through smokebox of Santa Fe poppet-valve 4-8-4 3752 reveals great length of stack obtained by low flare and sliding stack extension. With stack extended, 3752 stood 18 feet 5½ inches high.



PENNSY K4 5399 is shown as originally refitted at Lima in September 1939 with oscillating-cam poppet valve gear. Frames were extended about 10 inches to accommodate gearbox atop pilot.

ABOUT THE AUTHOR

VERNON L. SMITH contracted locomotive fever early in his life. He was born in the iron range country in Virginia, Minn., in 1911. At age 16 he was graduated from high school and went firing coal-burning steam locomotives; at 19 he went on the extra board as an engineer. On the recommendation of his master mechanic and through the kindness of an M. A. Hanna Company vice-president, Smith was able to combine a mechanical engineering education with drawing-room employment at the Differential Steel Car Company and the Lima Locomotive Works, working under such notables as F. Flowers, A. J. Townsend, W. E. Woodard, and J. Kirchhof. Thereafter he was loaned out to Franklin Railway Supply Company to help develop its poppet valve gear.

"I maintained a keen interest in diesel traction," Smith says, "and at the close of World War II I left Lima to join the Santa Fe as Assistant Engineer of Test (Locomotive)." There he combined steam, diesel, and electric work. He joined the Belt Railway of Chicago in 1953 and has been its Superintendent of Motive Power since 1954. I

cated horsepower or drawbar horsepower, but from the size of the engine, it appears to be indicated horsepower. In fact, PRR 4-6-2 No. 5399 came very close to equaling the French 4-8-4 in drawbar horsepower. The maximum drawbar horsepower from the converted K4s was 3934; the indicated horsepower reached 4267. Again, this was recorded on the Altoona Test Plant.

A much greater firing rate and heat release was possible with the Pennsy T1 (with a 92 sq. ft. grate area and a firebox heating surface of 499 sq. ft.) than with SNCF 242 A 1 (with a 53.8 sq. ft. grate area and a firebox heating surface of 273 sq. ft.); and remember, heat and work output are convertible.

The Westmoreland County coal burned in the two PRR engines produced 13,130 Btu's and 11 per cent ash. This is comparable generally to the heat content of coal employed at that time in France — about 14,000 Btu's and 8 per cent ash.

ECONOMY

Indications of maximum economy and maximum power do not usually coincide on the performance curve of a locomotive. In some countries fuel supplies are limited or must be imported, and the operating choice often stresses economy and lower speed in handling the train. In America, though, power has always been the first requirement, since the railway management usually regards the locomotive as only a traffic machine. All of the American engines considered here were good revenue-earners. In addition to high power outputs, excellent economies were also secured with these locomotives; and these performances could be sustained over long distances — another requisite of the American scene. Steam rates as evolved from test data are as follows:

BEST STEAM RATE PER INDICATED HORSEPOWER HOUR

PRR K4s 4-6-2 5399	15.0 lbs.
PRR T1 4-4-4-4	13.6 lbs.
AT&SF 4-8-4 No. 3752	13.5 lbs.

[The AT&SF 4-8-4 2900-class engines are believed never to have been tested on measured steam rates because they were placed in service immediately upon receipt.]

Santa Fe No. 3752 produced this low rate of steam consumption over an extremely wide speed range of 25 to 55 mph. This record is probably unsurpassed anywhere for such a spread of speeds.

The Chapelon Pacifics are reported to have achieved as low as 12.5 pounds of steam per indicated horsepower at their most favorable speed. This is indeed a fine efficiency, although it was not sustained over long time periods.

VALVE GEARS

Without going into the historical aspects of valve gears, I would like to mention that the Santa Fe was a pioneer in long-travel, long-steam-lap valve gears. In my opinion, the piston valve engine with long-travel Walschaerts gear reached its highest state of excellence in the AT&SF 2900 class built in 1943. This locomotive had Wagner bypass valves above the piston valve chamber to ensure proper drifting down the long grades on the Santa Fe. The roller-bearing boxes were equipped with automatic compensation. This feature, together with roller-bearing rods and Timken crossheads, provided a locomotive with low maintenance cost and one which moved almost silently when steam was shut off.

Pennsylvania T1 class and No. 5399 were equipped with Franklin oscillating-cam poppet valve gears developed in America. Each pair of cylinders had its valves driven by four sets of Walschaerts gear running inverted in an oil-tight casing. The casing, or gearbox, with the valve gear was on the front deck of No. 5399. The input motion was taken from the crossheads, and the two output arms on either side of the gearbox operated the admission and exhaust valves independently.

AT&SF No. 3752 was fitted with Franklin rotary-cam poppet valve gear, a design by Franklin Railway Supply which was a U. S. licensee of the Société D' Exploitation des Procédés Dabeg of Paris. This locomotive had the largest fabricated steel cylinders ever built — 30-inch bore x 30-inch stroke — and the complete weldment weighed over 26,000 pounds.

Obviously American engineers did not neglect the study of valve gear arrangements at home or abroad. Locomotive designers were always interested in one another's work, and U. S. engineers examined with interest whatever French drawings and data became available to them. I still remember the lettering on the French screw reverse gear frames: MARCHE AVANT and MARCHE ARRIÈRE. In the exchange of ideas, André Chapelon came to the U. S. in 1938 and paid a visit to our shops to see what we were doing with valve gears and cylinders.

IMPROVED FRONT ENDS

We had excellent smokebox arrangements in the United States, for it was here at Purdue in 1902 that Prof. W. F. M. Goss determined the basic proportions on his little 4-4-0, and it was in the U. S. that the self-cleaning front end was developed. Unlike the French Kylchap or Lemaître arrangements, the various American smokebox and exhaust constructions were not usually publicized or sold off the railway commercially.

The cross-section through the smokebox of Santa Fe No. 3752 at the lower right of page 24 shows the Lanning front end with the Layden exhaust nozzle and some minor refinements by the writer (removing the top flange from the Layden nozzle improved it).

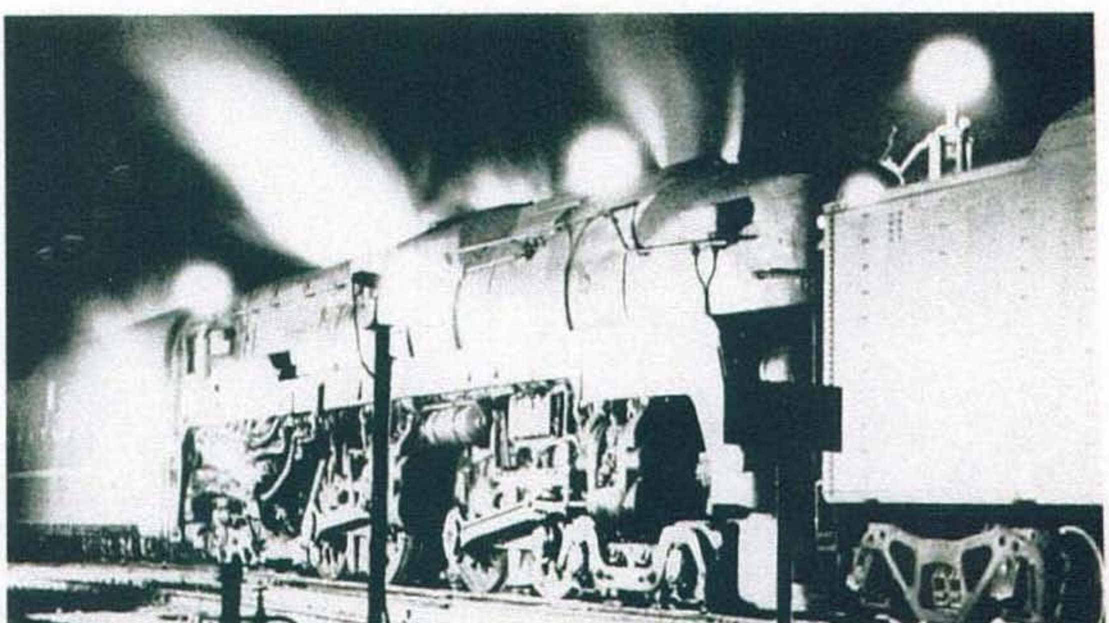
The distance from the lower edge on the flare of the inside extension to the top of the extended stack was 10 feet 4¾ inches; but since ample clearances were available on AT&SF, the extended stack need not be lowered, except in enginehouses, all the way from Kansas City to the Pacific Coast. My old notebook shows that when the 4-8-4 was handling a train of 16 cars, 1140 tons, at 80 mph and 18 per cent cutoff, the back pressure was only 3 pounds. The other engines mentioned here were also good steamers.

Incidentally, PRR T1 No. 6110 evaporated 105,475 pounds of water per hour on the Altoona plant. No. 5399 evaporated 77,480 pounds of water — nearly 40 tons of water converted into steam per hour. This was a fine performance from a magnificent boiler originally designed in 1914. The skillful stoker firing of No. 5399 was the work of Norman Suhrie, then road foreman of engines, who had hand-fired the Pennsylvania engines on the original test plant exhibited at the Louisiana Purchase Exposition at St. Louis in 1904.

ENLARGED STEAM AND EXHAUST PASSAGES

Extensive work on steam and exhaust passages was done at Lima Locomotive Works using full-size plaster models of passages and ports to check colored smoke or dust flows. The measurement of steam flows in actual locomotives was also in progress. The photo of Pennsy 5399 on page 25 shows her as originally converted with poppet gear. After she was placed in service and tested, the throttle valve and superheater units were found to be restricting the potential of the boiler. The engine was further modified with

. . . And the case for the T1



William N. Clark.

I TO CLEAR UP some of the misconceptions surrounding the Pennsylvania's T1's, as well as to place this large class of locomotives in proper perspective on the American railroad scene, let us trace the background of the design, performance, shortcomings, and merits of these 4-4-4-4's.

On the Pennsylvania Railroad in the 1930's, nearly all through mainline passenger trains west of Harrisburg, Pa., required two K4s engines, plus another helper at Altoona, to maintain the schedules. West of Crestline, O., all name trains over 12 cars required a doubleheader. This was costly in terms of machines, manpower, and money.

About 1936 the Pennsylvania invited the three locomotive builders, American, Baldwin, and Lima, to join with the PRR Mechanical Department in designing a fast passenger engine to handle the service unassisted. Out of several designs submitted came the S1 6-4-4-6, the New York World's Fair engine of 1939. The S1 immediately demonstrated her ability to haul heavy trains swiftly, but she was found to be inordinately awkward to turn and service because of her great length. A special wye was built at Crestline to turn this engine, and on the Chicago end of the run the Burlington connection was used.

The experience gained from the S1 indicated that a somewhat more compact duplex engine would be the locomotive to power the "steel fleet," and the builders were requested to furnish proposals for such an engine.

The Alco proposal was the most conventional in appearance, and Baldwin's was next. Lima, always in the forefront, at one stage had laid out the design with 80-inch-diameter drive wheels on the front engine set and 76-inch-diameter wheels on the rear set. This arrangement had two advantages: first, the two engine sets could never get into phase because their rpm's would always be different; second, the rear boiler courses could be enlarged over the smaller wheels to provide better circulation of water at the firebox connection and still have adequate spring rigging clearances. This scheme was shelved, however, in favor of one tire size on both engine sets.

Several interesting proposals were made on the streamenlarged front-end throttle and new superheater, and the smokestack and nozzle were angled forward slightly.

The half-section of No. 3752 shows the free and sweeping exhaust passages and the steam branch pipe passing over the cam box. This branch pipe contained 10 per cent of the cylinder volume and helped ensure high mean effective pressure on the pistons.

RIDING QUALITIES AND SPEED

All of the locomotives described rode well, although the smallest, No. 5399, would become a little choppy on the vertical motion as the speed approached 100 mph. She could go, however — on at least five recorded occasions she reached 105 mph. The fastest of all, of course, were the T1's.

No. 3752 was the last steam locomotive tested at over 100 mph on the Santa Fe. Shortly after those bright spring days in May 1948, the I.C.C. edict of June 17, 1947, became effective, limiting train speed in non-cab-signal or non-train-stop territory to 79 mph.

Counterbalancing of steam locomotives was of a very high order on the Santa Fe. Cross-balancing of the main and intermediate drivers in conjunction with tandem rods was the practice instituted by Mechanical Engineer H. Lanning in 1937. The drive wheels had three balances — a primary, an auxiliary, and a wheel check balance block. This arrangement ensured absolute correction of wheel castings and accurate counterbalancing.

Modern Santa Fe power was extremely easy on the track structure. Furthermore, the weight distribution on drivers of Santa Fe 4-8-4's was held close to specification. The leading pair was designed to carry 24.5 per cent of the weight, the main drivers 26.5 per cent, the intermediate pair 24.5 per cent, and the back drivers 24.5 per cent. The working weight on drivers of the 2900 class, which was 295,000 pounds, distributed as follows:

	Designed	Actual
Lead Pair	72,275 lbs.	73,000 lbs.
Main	78,175 lbs.	77,600 lbs.
Intermediate	72,275 lbs.	72,000 lbs.
Back	72,275 lbs.	72,400 lbs.

Continued on page 28

lining. One of these envisaged transparent plastic smoke lifters on each side of the smokebox. A large-size illuminated engine number was obtained by projecting light rays on the clear plastic. Ultimately, the dynamic chisel-shaped nose streamlining by Mr. Loewy was adopted.

The power requirements of the Pennsylvania were such that these locomotives must handle the same passenger trains out of Harrisburg west that the GG1 electrics brought in from the east. The specifications required that the duplex be able to move a trailing load of 880 tons at 100 mph on level track. The new steam locomotives were intended to go through to Chicago, 713 miles, with only one stop for coal en route. The ash pans were as large as possible, and the coal capacity of the tender was brought to 41 tons by sacrificing water capacity. Water could be replenished from the track pans. After many engineering conferences an order for two prototype locomotives was placed with Baldwin in July 1940, with the valve gear and cylinder design coming from Lima.

I recall that on Sunday, December 7, 1941, at Franklin Railway Supply we were bench-testing the valve gear for the first engine. In April 1942 No. 6110, in her yellow chromate primer, backed out of the erecting shop onto the test track along the Chester Pike. Steaming back and forth, she was a fine sight, not easily forgotten. The following month No. 6111 was completed and the two were deadheaded to Harrisburg where, because of their futuristic appearance, they were promptly dubbed "Buck Rogers" and "Flash Gordon" by local forces.

Nos. 6110 and 6111 were placed in the passenger pool and immediately started turning in some spectacular performances. The 6110's first through trip west was with 14 cars weighing 1000 tons, and the engine bettered the schedule by 20 minutes between Crestline and Fort Wayne in a distance of only 132 miles. It is a matter of record that 6111 with 16 cars averaged 102 mph over 69 miles on the Fort Wayne Division.

The T1's were probably the swiftest locomotives ever built — they could go like the wind when under way. What do you think of a locomotive against which a complaint was registered that "the spring rigging does not respond well at 125 mph." I wonder if anyone *really* knew how fast the T1's would go with, say, 14 cars when the 4-4-4-4's were in top condition. Here was a single unit of over 6550 indicated horsepower.

In 1945 50 additional T1's with somewhat pug noses and reduced streamlining were placed in service. Altoona works constructed 25 and Baldwin built 25.

Why, then, did such a promising locomotive have such a short life and small standing in motive power history? The two prototypes were introduced in a wartime period and were followed by 50 more units which could receive but little refinement before being pressed into service and into competition with the more efficient diesel-electrics already in operation and proven on the Pennsy.

The T1's were basically a sound design but they were saddled with a few troublesome factors which detracted from their availability and added to maintenance costs:

1. The grate area of 92 sq. ft. was a substantial reduction from the 132 sq. ft. of the S1. The T1's should have had about 108 sq. ft. to reduce the firing rate. The same boiler-forming dies could have been used and the firebox and frame cradle merely lengthened.

2. Poppet valve gear was a must for these high performance engines; however, the valve gear should have been of the rotary-cam type as recommended by the mechanical engineers. This would have been very accessible from the outside; and with the small cylinder volumes involved, single-deck cam boxes could have been employed with only one intake and one exhaust valve per cylinder port. Instead, these engines were equipped with oscillating-cam gears driving double-deck cam boxes with eight valves per cylinder. The arrangement was quite inaccessible. The front valve gear could be examined only by removing covers in the bottom of the smokebox and the top of the gearbox, and the back valve gear by lowering the valve gearbox into a shop pit below the engine after first removing the spring rigging equalizers. All this work took time and held the locomotive out of service. Much later No. 5500 was rebuilt with rotary-cam gear and did well working out of St. Louis.

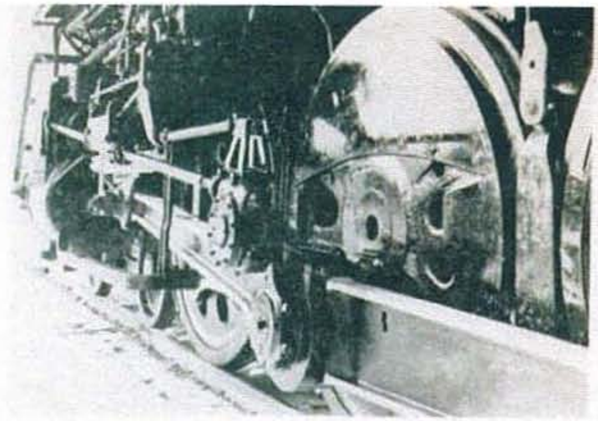
3. The spring rigging and its ability to distribute weight was faulty. The rear engine set tended to become unloaded, resulting in excessive slippage and difficulty in starting trains.

4. The turbopump-type boiler feed arrangement was less satisfactory than the well-proven open-type feedwater heater.

5. The engines could be dirty in operation, with the air flow over the streamlining causing coal dust from a partially empty tender to swirl about the back of the cab.

This is about all that needed change; had these few details been suitably modified in the beginning, the following 50 T1's would have been truly great engines and established the ultimate in performance. The T1's were caught between the rush of a wartime economy, the diesels, and the younger generation of design and maintenance men who could see that the future did not lie with steam. I, too, joined the diesel revolution. I

AFTER running 105 mph, Santa Fe poppet-valve 4-8-4 3752, dynamometer car 29, and Second 7, the Fast Mail, take siding just east of Dodge City, Kans., in May 1948 to clear the eastbound El Capitan. The performance delighted a North German Lloyd Steamship Lines engineering officer who was an observer on the dynamometer car during test.



THE 3752 possessed a simple, excellent valve gear. Return crank of rotary-cam valve gear had a worm wheel in an oil-tight box located in line with the center of the axle, and for each rotation of the driving wheel the drive shaft revolved 4-1/7 times. Cam box on the cylinder had the same pitch worm and worm wheel to open and close the valves.

BOILER BLOWDOWN PRACTICE

How fortunate were the French, for Mr. Evans states, "They were required to do 30 seconds of blowing-down every 31 miles."

On the Santa Fe all possible water problems seem to have existed. A locomotive started westward out of the Chicago enginehouse with Zeolite treated water. On a fast train such as the *Chief*, this tended to cause priming that did not settle down until about Streator, Ill., 89 miles from Chicago. Farther westward, the water of Dodge City, Kans., was not compatible with that of the water station at Lamar, Colo. The next water at La Junta, Colo., was the hardest of the hard. In Arizona there was no locomotive water at all. If my recollection is correct, about 3 million gallons of water was hauled daily into Hackberry, Ariz., in 1942 to support the steam locomotive operation across the desert.

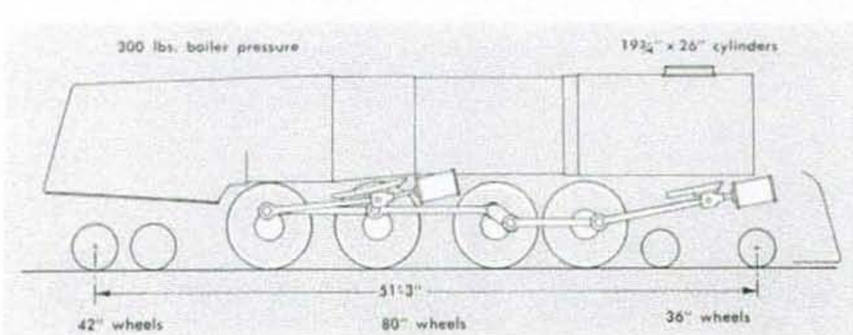
Nearly all the mainline power was equipped with continuous blowdown devices (in addition, a few of the 4-6-4's had automatic blowoff equipment on the "dry" pipe going to the throttle), and in some districts 10 per cent of the water being evaporated in the boiler had to be blown away — with consequent heat loss — to keep the level of boiler water impurities within acceptable limits.

In 1946 trains 19 and 20, the *Chief*, and 7 and 8, the *Fast Mail* (the latter usually in two sections) were powered with steam. These trains were normally run with one 4-6-4 (a 3460 class) from Chicago to La Junta, a distance of 992 miles. At La Junta a 4-8-4 with 80-inch-diameter wheels took over for California and did not come off the train until Los Angeles was reached, 1255 miles away.

This steam locomotive performance and utilization was unexcelled anywhere.

For more than a decade the builders and the railroad had been carrying out some progressive designing which was destined never to reach fulfillment because the diesel age was coming into its own.

There were divided drives. In the U. S. we had them in variety, especially on the drawing board; but some of these were built, of course — particularly on the Pennsylvania. About 1940 Baltimore & Ohio had planned a 4-2-2-2-2-4 with independently driven axles, but only one of the independent engine units for a single axle was made and tested.



PROPOSED connected duplex-drive was aimed at providing a better turning movement for a four-cylinder engine. This was one of many ideas pondered in the twilight of steam.

At Lima a 4-6-6 passenger locomotive was designed for a Midwestern railroad. It was to have an enormous firebox and would burn coal slowly (somewhat akin to stationary power plant practice), with resultant fuel economies.

On the Santa Fe one of the last projects for the steam locomotive was dynamic braking. By an improvement of the LeChatelier principle of introducing wet steam into the cylinders, it would be possible for a heavy train descending a mountain grade to be held with the cylinders. The heat of braking (energy destroyed by compression in the cylinders) would be taken up by the wet steam. What a strange and compelling sight it would have been to see great billows of steam exhausting from a pipe behind the smokestack while the engine held her train in check down Cajon or Glorieta.

The application of the factors which control locomotive design is very different in France and in the U. S., but I thank Mr. Evans for reviving thoughts of the past with steam. Once again I was a young designer with the 5399 on a fast night train, ofttimes weary, and sometimes mesmerized by the monkey wrench (the only tool furnished an engine by the PRR) swinging back and forth from a stud on the boiler head. . . . Or I was with the 3752. She was a splendid starter, and I can still feel the stretching of the draft gears of a heavy train, the momentary hesitation when all the slack was taken up; and then the firm motion forward, with the exhausts coming sharp and square, as 120 cars of merchandise advanced toward Wellington.

No, France did not develop the steam locomotive further and closer to perfection than anyone else. The American locomotive was second to none. I