had got his nerves quite to the sticking point, the fireman shouted that we were on the downgrade. The acceleration was rapid, and our stop-watch timing (the fireman calling off the mileposts) soon showed that we were making eighty-three miles an hour. That six-mile run by night was certainly the most thrilling experience in high-speed travel of a lifetime. We have stood at night on the bridge of the "Deutschland" when, with the "Kaiser Wilhelm" at her heels she was rushing at 27 miles an hour through a fog that shut the forecastle deck from view; and again when, to test her rough-weather ability, she was making twenty-four miles an hour against a full southwesterly gale; but from the standpoint of pure sensationalism those experiences were tame compared to this wild ride by night through the Mohawk Valley. To the writer, who was not by any means a stranger to locomotive riding, the experience was simply terrific—impossible of adequate description to the traveler whose gage of greater speed is the slightly increased swaying of a Pullman car. The sensations of such a ride strike at every avenue to the emotions; ear, eye, and touch are violently assailed. For the ear there is a "clang and clash and roar," so loud that one has to shout into the ear to be heard—there is the concussion of the moving parts of the engine—the jangling of metal against metal—the crashing impact of the driving wheels and trailers upon the track—while above all this strident orchestra, like some great organ note, is heard the deep, sustained roar of the exhaust from the smokestack. For the sense of touch there is the amazingly rough riding of the engine which, compared with a nicely-poised Pullman car, is as the movement of a springless farm wagon to a rubber-tired carriage. The unevenness of the track, slight as it is, is but little absorbed by the stiff locomotive springs, and when the driving wheels and the massive reciprocating parts—side rods, connecting rods, crossheads, pistons, weighing tons in the aggregate—are threshing round and darting to and fro to the tune of over 300 revolutions a minute, the great mass of the engine vibrates and lurches and rolls, until one feels that the only logical outcome would be for the structure to rend itself into a thousand fragments! Then, for the eye, there is the sense—at eightly miles an hour by night—of incredible speed. By day, objects approach slowly out of a far perspective; but by night they rush at you out of the near darkness in one mad whirl of ghostly shapes, punctuated by horizontal, rocket-like streaks of fire—the signals and station lights.

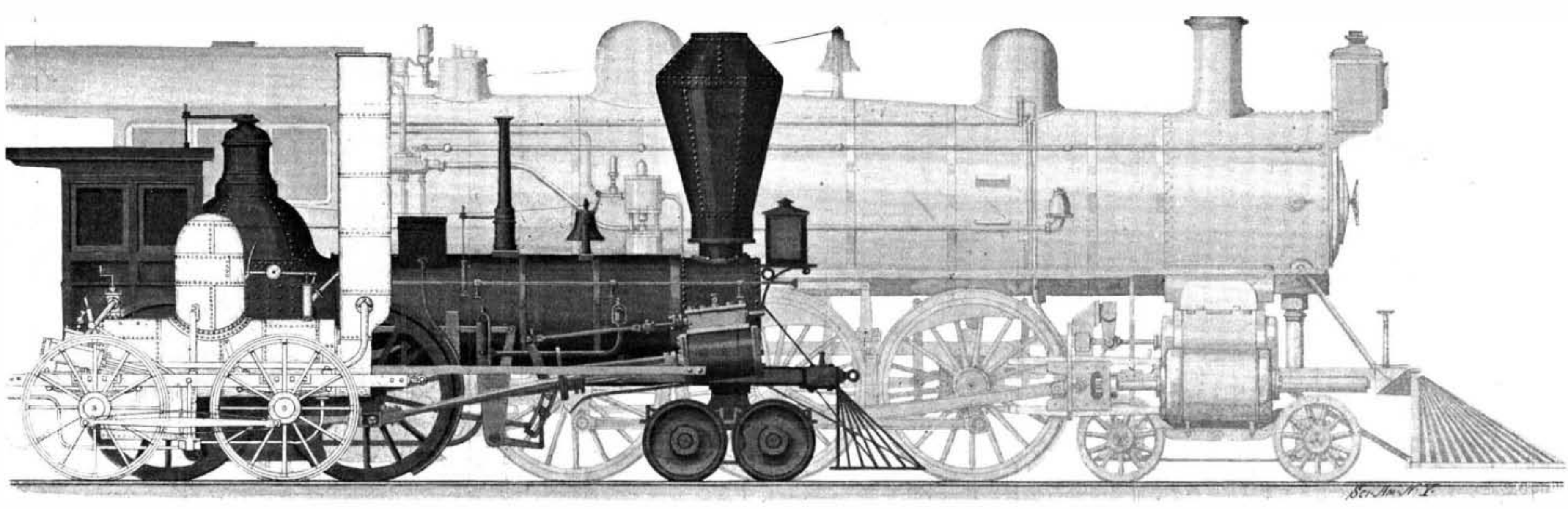
To the novice, the most thrilling moments come with the headlong dash through a station yard, where the tail-lights of a side-tracked freight train glare with their evil red eyes at you from the distance—surely they are on your own track—and you sweep down upon a mass of white lights, red lights, headlights, whirling hand lamps, dwarf signal lights below, and arc lights above, with two or three switching locomotives to heighten the crowded effect! Clear track? Absurdly impossible! I tell you, gentle passenger, lounging back there in the cushioned security and comfort of a Pullman, that should you sit here just now with me at the very front end of this roaring cataract of steel and fire, and realize that it is hurling you into that bewildering yard at over one hundred feet a second, with a stored-up energy back of you equal to that of a shell from a 13-inch gun—if you realized, as I did, that to develop that energy requires only a misplaced switch, a careless signalman, a broken rail or axle, you would understand how sublime [illegible] t be the faith of that quiet man at the throttle [illegible] e clean-cut profile you can just see silhouetted against the window of his cab) in the material, the men, and the management of that most wonderful of modern creations, a first-class trunk railroad.

The perfect faith of the engineer in the system was strikingly brought home on the return trip from Chicago. A delay in Cleveland had put the train twenty-five minutes late, and time was being made up with a powerful, Prairie-type, six-coupled, ten-wheeled engine with 20 x 28-inch cylinders and boiler to match. The engineer had congratulated us on the fact that because of the delay we should see some fast running, and we had just snapped the stop-watch on a two-mile run at seventy-eight miles an hour, when "Red" shouted the fireman, and with brakes hard down, we pulled up at a wayside station signal for orders. As we were starting again, the fireman courteously showed us the order, which read that from So-and-so to So-and-so the east-bound track was closed, and east-bound trains would use the west-bound track; No. 26 (our train) to have right-of-way over all trains. "What! Does this mean that we shall run against the traffic?" "It does." "But, surely, not at this speed." "Indeed, we shall." And indeed we did; for full out came the throttle, and soon we were sweeping into darkness (on the other fellow's track, mind you) with nothing between us and Heaven-knows-what but the faithful watchfulness of a train dispatcher, sitting in his office a hundred miles or more away. Sublime faith in a marvelous system, we thought, as we settled down for the only uncomfortable quarter of an hour of the whole trip. Twelve miles further on we passed the obstruction—a disabled freight train—and switched back to our own track.

Leaving the engine at Buffalo we crept at midnight, from the dirt and din of the cab, very tired, into the comfort and sweet linen of a lower berth, for a six-hour sleep to Albany. Here our letter made us known to Mr. Ryan, another New York Central veteran, who started in 1865 as a fireman, and for thirty-three consecutive years as engineman, has run heavy express trains through the Hudson Valley. The engine, another of the splendid Atlantics, was to make the record run of the whole round trip. With six cars of 352 tons total weight and a handicap of twenty-nine minutes, we set out to make up time. It was an ideal morning as we pulled out at 7.04, with a slightly favoring wind, and a dry rail. Two or three minutes were lost in going slow over the bridges and through the yard, and then we straightened out to what we judged to be fifty, sixty, and seventy miles an hour. Out came the stop-watch, and the next mile was made in forty-eight seconds. It did not seem like it, so as there were no slowdowns ahead, we timed for a complete five-mile stretch, which was done in exactly four minutes; and for the next five, which were also covered in exactly another four minutes, making eight minutes for the ten miles, or seventy-five miles an hour. Then came a slowdown to twenty-five miles through Hudson, then two slowdowns in succession for water, another for a sharp curve through Poughkeepsie; a slow to 12 miles an hour through a rock cut in the Highlands, another at Croton for water, and at Peekskill for signals. Each of these from a seventy to seventy-five mile speed meant a loss of one-half to two minutes before the high average was reached again; and yet we passed through Spuyten Duyvil, 131.73 miles from Albany, at 9:15, having covered the distance in 131 minutes.

To appreciate this performance we must remember that though the line is level, it is full of curvature, forty-eight miles, or over one-third, consisting of curves that vary from one degree to eight degrees. It is estimated that every degree of curvature is equal to 3-100 of a foot of rise in every 100 feet. Therefore, the resistance of dragging a train round a six-degree curve is equal to a rise of about ten feet to the mile. The estimate, however, is made for the fifteen-mile speed of freight trains, and for an express at seventy-five miles an hour it will be vastly greater. Exactly what it amounts to can only be conjectured; but its equivalent in grades would represent a track with decided gradients and with no downgrade to compensate. The engine was handled with the consummate judgment born of long experience. For the most part the throttle was three-quarters open, and the cut-off at one-third stroke. At the running speed, which finished with a burst from Yonkers to Spuyten Duyvil of 14.13 miles in 11:5 minutes (73.72 miles an hour over heavy curvature), the engine, under 203 to 204 pounds of steam, which she carried steadily, must have been indicating her maximum of 1,450 to 1,500 horse power.

It is a popular delusion that the engineers who run such trains soon break down under the strain; yet the two partners on the New York-Albany run of this train are to-day fine-looking men in the best of health. The work calls for nerve, of course, but as more than one of them told us they kept their nerves right by right living. A more temperate, intelligent and courteous body of men than these trainmen one must travel far to find; and it was with his usual insight into character that President Roosevelt went among their trusted representatives to select one of the arbitrators in a notable industrial controversy of the day.



DEWITT CLINTON. 1831.		ENGINE OF 1850.		ENGINE OF 1902.	
Cylinders, 5½x16 inches.	Boiler pressure, 80 pounds.	Cylinders, 16 x 20 inches.	Pressure, 100 pounds.	Cylinders, 22x28 inches.	Boiler pressure, 200 pounds.
Drivers, 54 inches.	Tractive effort = 919 pounds.	Drivers. 66 inches.	Tractive effort = 7758 pounds.	Wheels, 72 inches.	Tractive effort = 32,000 pounds.

SEVENTY ONE YEARS' GROWTH OF THE AMERICAN LOCOMOTIVE.

NOTES ON THE HISTORY OF THE AMERICAN LOCOMOTIVE.

BY HERBERT T. WALKER.

In the following notes on the History of the American Locomotive, we will pass over the various attempts to produce self-moving road carriages, and begin with the year 1802-3 when Richard Trevithick, of Cornwall, England, who is known as "the father of the locomotive," laid down the plans for an engine to run on the Merthyr Tydvil tramway in Wales. This, the first railroad engine in the world, embodied some of the salient features of the modern locomotive, namely, high pressure steam and a horizontal cylinder, the exhaust steam being turned into the chimney. This engine, which is illustrated in Fig. 1, hauled passengers and freight weighing about 10 tons at a speed of 5 miles an hour, and is said to have once attained a speed of 16 miles an hour, when running without a train. Its weight, 5 tons, was found too heavy for the cast-iron rails or "plates," and this objection, coupled with the fact that it was more expensive than horse traction, condemned it for commercial purposes. Like other great men, Trevithick was in advance of his time, and the world was not ready for him. He was, moreover, too easily discouraged by partially successful experiments, and, although he subsequently built improved locomotives—some of them having such familiar features of our modern engineering practice as a fusible plug in the crown sheet of the fire-box, and means for superheating the steam—he was unfortunate, and failed to command the capital necessary for developing his ideas. The antagonism of Watt also told heavily against him, and after a series of reverses he died in obscurity, and was laid to rest in a pauper's grave. It was only recently that the Institution of Civil Engineers reminded the nation of his true position among engineering heroes by erecting to his memory a memorial window in Westminster Abbey.

Passing over Blenkinsop's and Hedley's engines, which were but little more than continuations of Trevithick's designs, we come to the advent of George Stephenson, who built his first locomotive in 1813. Stephenson did not show the originality of Trevithick, and

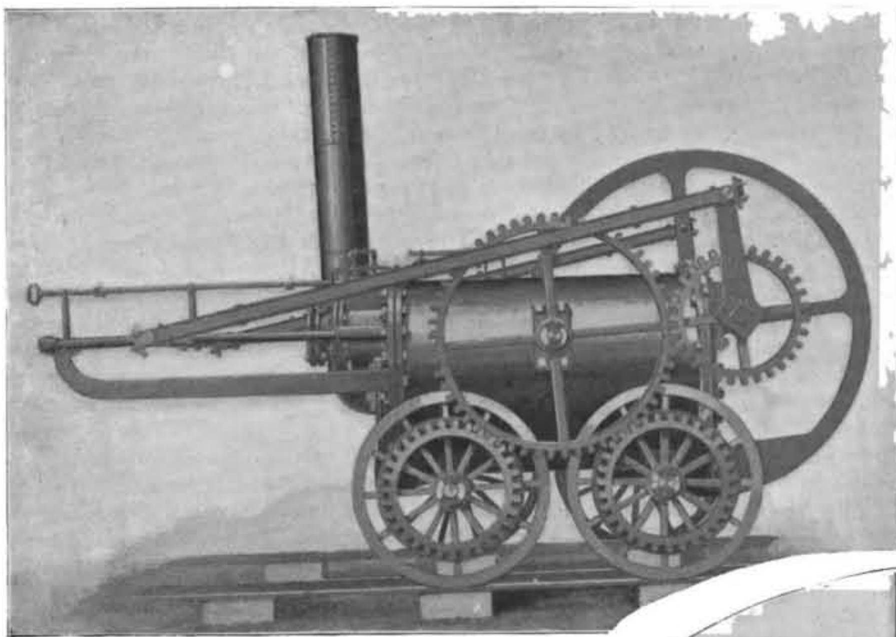


Fig. 1.—Trevithick's Engine. 1803. First Locomotive to Run on Rails.

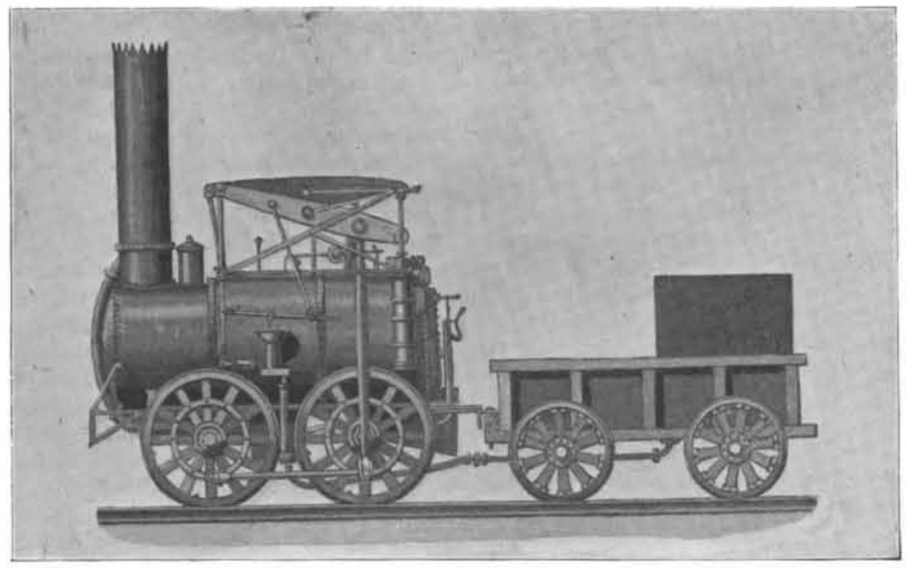


Fig. 2.—"Stourbridge Lion." 1828. First Locomotive to Turn a Wheel in the U. S.

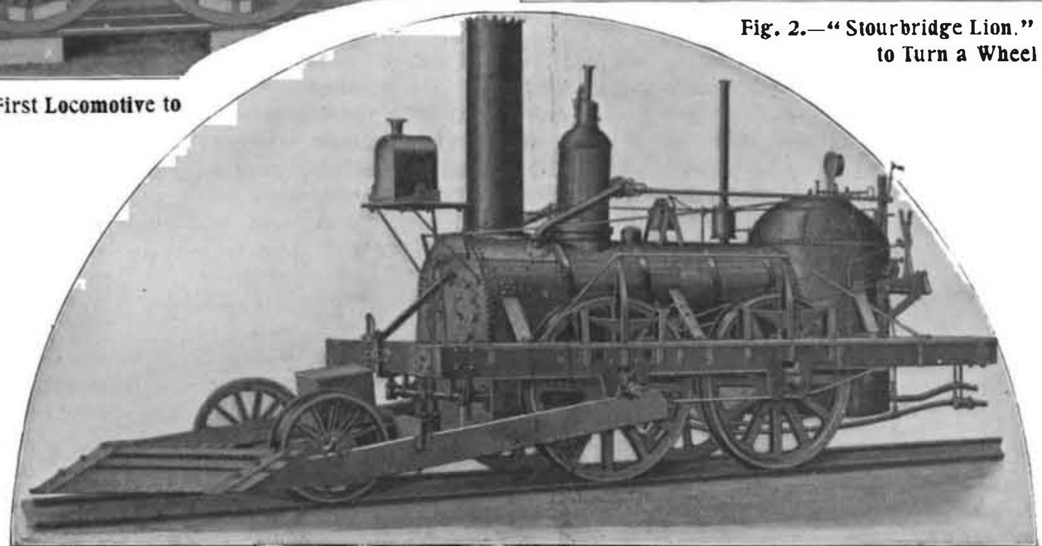


Fig. 5.—The "John Bull." 1831. Camden & Amboy R.R.

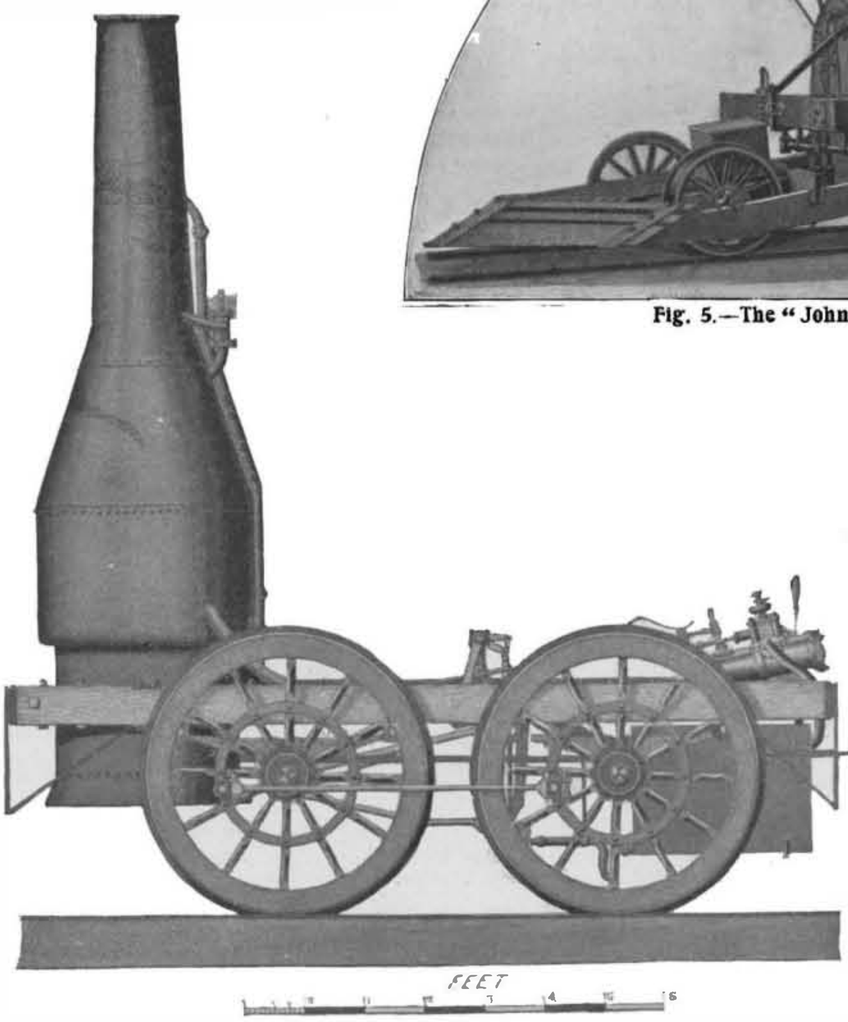


Fig. 4.—"The Best Friend" First Locomotive in Actual Service in U. S. 1830.

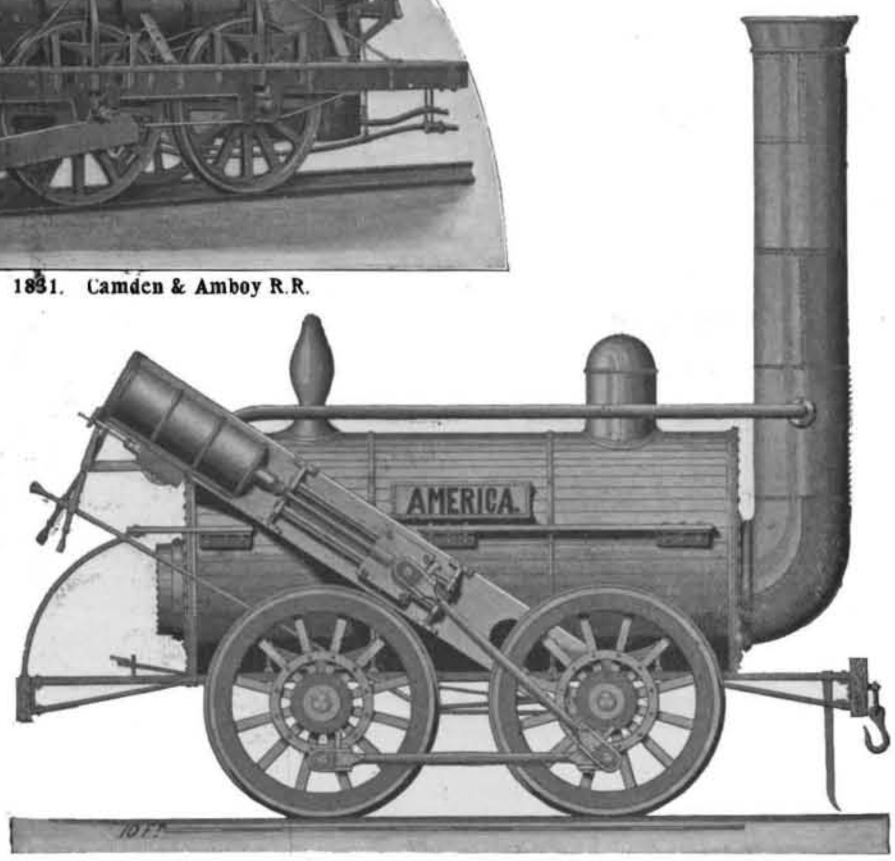


Fig. 3.—Stephenson's Engine. 1828. First Locomotive Seen in America.

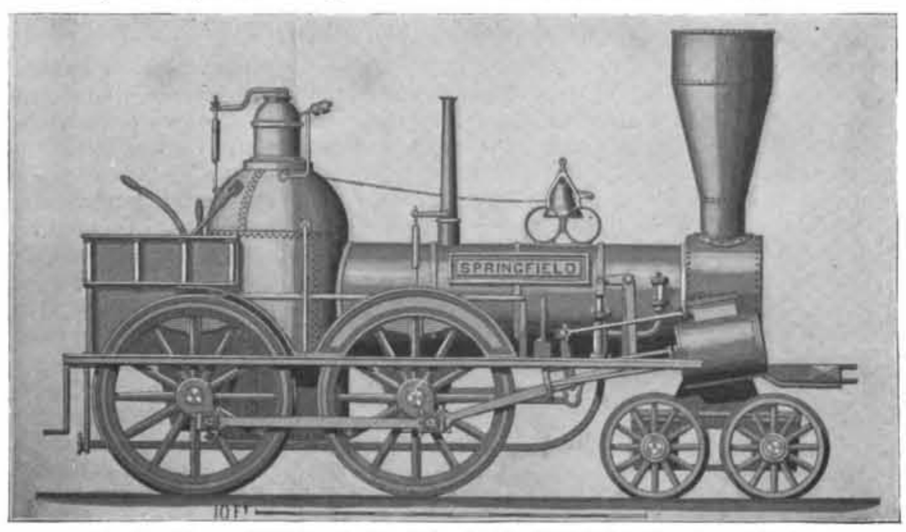


Fig. 7.—Rogers' Passenger Engine. 1845. Hartford & New Haven R.R.

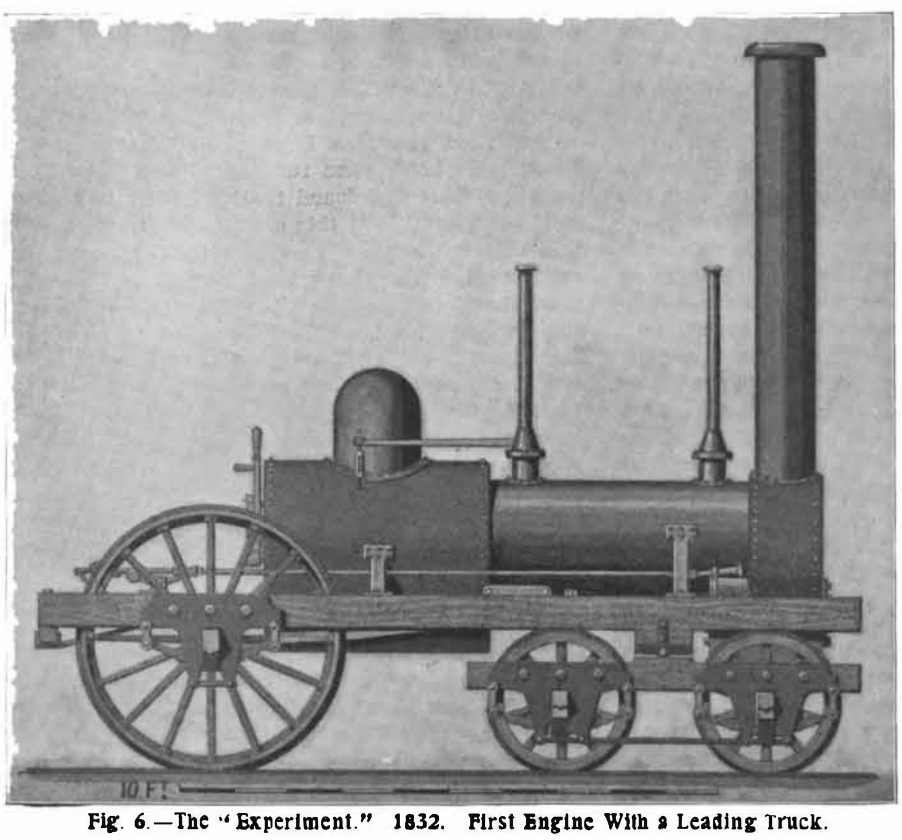


Fig. 6.—The "Experiment." 1832. First Engine With a Leading Truck.

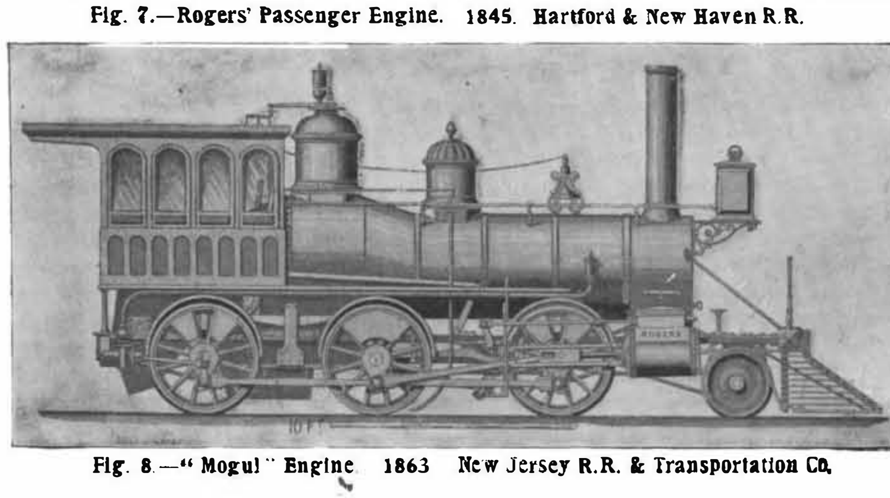


Fig. 8.—"Mogul" Engine. 1863. New Jersey R.R. & Transportation Co.

SOME TYPES ILLUSTRATING THE DEVELOPMENT OF THE LOCOMOTIVE.

cannot be said to have been a great inventor, but he was a man of indomitable energy and perseverance, possessing the rare combination of the engineer and the man of business. He also had the faculty of selecting the crude ideas of other inventors, putting them into practical shape and combining them with his own designs. This not only placed him at the head of his profession but enabled him to command the capital to build his own shops, which he opened at Newcastle-upon-Tyne in 1824. This factory is running to-day, and is the oldest locomotive works in the world.

SIX COUPLED WHEELS.

Here Stephenson developed some historical engines, among them being the "Experiment" for the Stockton and Darlington Railway, having six-coupled wheels and directly-connected inclined cylinders, the piston rods giving motion to the cranks by connecting rods, without any intermediate gearing. This engine was built in 1826 and was a landmark in locomotive history, introducing as it did one of the essential features of the modern locomotive; for up to this time Stephenson's designs showed no practical improvement over those of Trevithick and other makers. A fair example of the locomotive of this period was the "Stourbridge Lion," illustrated by Fig. 2. It was built by Foster Rastrick & Co., and was sent to the United States in the year 1828 for the Delaware and Hudson Canal Company's railroad. As it was too heavy (7 tons) for the rails it was soon withdrawn from traction service; but it was the first practical locomotive to turn a wheel in this country. In the same year Stephenson built the engine "America" (Fig. 3), which was also sent to the Delaware and Hudson Canal Company, and was the first practical locomotive seen in the United States, inasmuch as it arrived four months earlier than the "Stourbridge Lion;" but it was never used for traction service. This engine was of the same design as the "Experiment," except as to the number of coupled wheels.

THE "ROCKET."

Events followed quickly at this period, and in the year 1829 Stephenson produced his world-renowned "Rocket" for the Liverpool and Manchester Railway. This remarkable engine embodied a multitubular boiler, a blast pipe, direct-acting pistons (as in the "Experiment" and "America") and a water-surrounded fire-box. Stephenson appears to have originated these two latter features, and, by combining them with the others, he produced a locomotive which, aside from improved valve gear and some minor details, was substantially the same engine that is in use to-day. As a basis of comparison with modern engines we will note the chief dimensions of the "Rocket": Cylinders 8 inches diameter by 16½ inches stroke; diameter of driving wheels, 4 feet 8½ inches; boiler, 3 feet 4 inches diameter by 6 feet long; heating surface of tubes 117.75 square feet; fire-box heating surface, 20 square feet; total 137.75 square feet. Area of fire-grate, 6 square feet; working pressure, 50 pounds per square inch. Weight of engine in working order 4 tons 5 hundredweight. Weight of tender loaded, 3 tons 4 hundredweight; total, 7 tons 9 hundredweight. At the celebrated Rainhill trials this engine hauled a coach filled with passengers at a speed of 24 miles an hour, and its average speed with a load of 13 tons was 15 miles an hour. On a later occasion it is said to have covered a mile in 60 seconds when running without a train.

Turning again to the United States it appears that the design of Stephenson's "Rocket," which established for all time the elements of the practical locomotive, had either not reached or had failed to impress American engineers, for we find in the years 1830-31 a variety of experimental locomotives having but little historical value. The most noteworthy engine of this group was that built by Peter Cooper, having an upright boiler with gun barrels for tubes; the cylinder was vertical and the exhaust was into the atmosphere. This engine was tried on the Baltimore & Ohio Railroad in 1830 and was the first locomotive built in America; but it was only run experimentally.

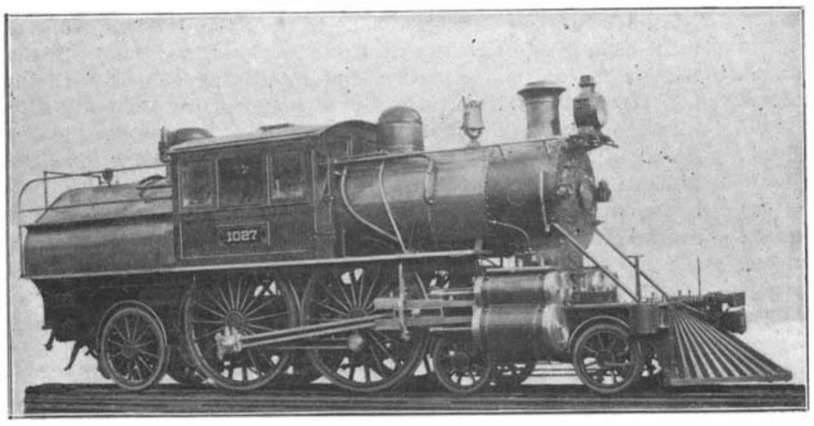


Fig. 9.—Vauclain Compound Engine. 1895. Atlantic City Railroad.

FIRST AMERICAN LOCOMOTIVE.

An important engine, historically considered, was the "Best Friend," designed by Adam Hall and constructed at the West Point Foundry, N. Y., which was put to work on the South Carolina Railroad in 1830. This, the first locomotive built in America for actual service upon a railroad, is shown in Fig. 4. The cylinders were 6 inches diameter by 16 inches stroke; driving wheels 4 feet 9 inches diameter; weight 4½ tons. The boiler was vertical and multitubular. This engine attained a speed of 35 miles an hour without a train, and with four or five cars filled with passengers it ran at the rate of 20 miles an hour.

All the engines of American design built up to this date, while they were bold and original, possessed inherent defects which prevented their adoption for practical railroad work, so that engines of the Stephenson and Bury types continued to be purchased from England, in spite of the fact that they were ill-adapted to the sharp curves and rough tracks of our railroads. An example of the foreign-built engine of this period was the "John Bull," purchased of Stephenson & Co., which embodied an improved position of the cylinders, namely, inside connected and placed at the smoke box end of the boiler. This engine, shown in Fig. 5, ran for many years and is now in the Washington Museum.

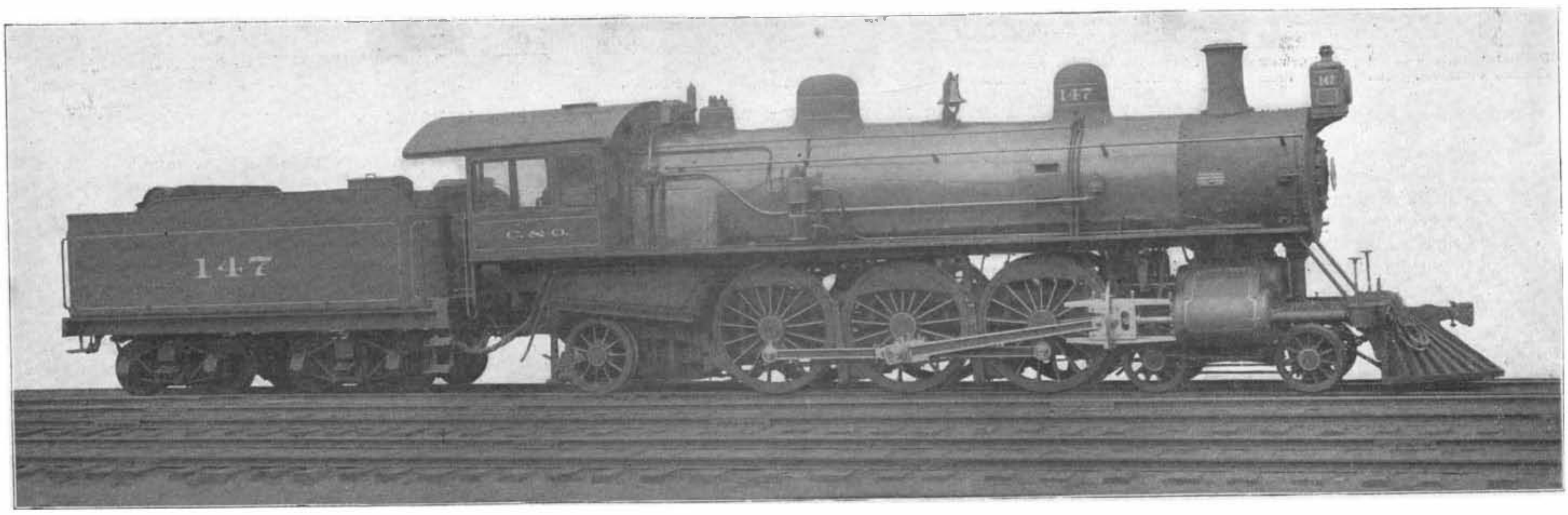


Fig. 10.—Largest Passenger Locomotive in the World. 1902. Chesapeake and Ohio Railroad.

SOME TYPES ILLUSTRATING THE DEVELOPMENT OF THE LOCOMOTIVE.

THE LEADING TRUCK.

As before stated, the English engines were not adapted to American conditions, their rigid wheel bases causing constant derailments. Ross Winans and John B. Jervis experimented with swiveling, four-wheel trucks in 1831-32, and although trucks or "bogies" were used in England for many years prior to the period under notice, it appears that John B. Jervis is entitled to the honor of having first applied a leading truck to a locomotive. This engine, named "Experiment," is illustrated in Fig. 6. It was built in 1832 and did satisfactory duty on the Mohawk & Hudson Railroad, frequently attaining a speed of a mile a minute.

In this same year William T. James, of New York, invented a very important improvement in the locomotive engine, namely, the link motion. This valve gear is now used the world over and is the standard form of reversing and expansion gear. James's engine was totally destroyed by explosion of the boiler, and the link motion was lost sight of until ten years later, when it was reinvented in Stephenson's shops and applied to several English engines with complete success. The advent of the "Experiment" marked a period in American locomotive practice at which a departure from English designs commenced, and a process of adaptation to the peculiar conditions of the railroads in this country quickly followed. Among these changes we note the adoption of the bar frame in preference to the plate frame, although the bar frame was used in many early English engines.

EQUALIZING LEVERS.

The next step with a view to increased flexibility and more even distribution of weight, was the introduction in 1837-38 of equalizing levers in Eastwick & Harrison's "Hercules." With the bar frame, the leading truck and equalizing levers, the American locomotive became the best machine in the world for heavy loads and high speeds on a track that caused nearly every imported engine to come to grief sooner or later.

At about the same period the ever-increasing loads demanded an increase of adhesive weight, and the so-called "American eight-wheeler" appeared in 1837 built by Campbell and used on the Philadelphia, Germantown & Norristown Railroad. This engine had inside cylinders, but one of this type, with outside cylinders, was built by Norris in 1838 for the Baltimore & Ohio Railroad and was one of the earliest of that class, a good example of which is illustrated in Fig. 7. It was built in 1845 by Rogers, Ketchum & Grosvenor for the Hartford & New Haven Railroad. The cylinders were 11½ inches diameter by 18 inches stroke. Driving wheels 5 feet diameter. This engine was followed by Winans' "Camel" engine of 1848, having eight coupled driving wheels and weighing 25 tons. In order to ascend heavy grades Winans brought out his "Centipede" in 1852. This engine had eight coupled driving wheels and a four-wheel truck. The total weight of the engine was 45 tons, but it was eclipsed in 1857 by Milholland's twelve-wheel engine "Pennsylvania," its enormous weight of 50 tons being distributed over twelve coupled wheels of 3 feet 7 inches diameter. The cylinders were 20 inches diameter by 26 inches troke, and the heating surface was 1328 square feet. These, however, were special designs and were in advance of the common practice, the average weight of passenger engines in the early fifties being 20 tons, and of freight engines 30 tons. At the close of this period the domed fire-box gave place to the wagon top boiler, so that by the year 1853 the American passenger engine had assumed the form which it has to-day, the only difference being in matters of dimensions and weight.

The increasing weight of trains now demanded a tractive power beyond the capacity of the eight-wheeler, and additional coupled wheels came into use, the year 1846 marking the appearance of Norris's 10-wheeler "Chesapeake," the six coupled driving wheels of which were 3 feet 10 inches diameter and the cylinders 14½ inches diameter by 22 inches stroke; weight 20 tons.

At the beginning of the sixties the rapid increase in train loads called for heavier locomotives, and the "Mogul" engine (Fig. 8) built at the Rogers Works, with six coupled driving wheels and a two-wheel truck was adopted for freight purposes. The weight of this engine was about 35 tons When it was found that the

Moguls would haul more cars than the average freight engine, additional cars were soon forthcoming—the transportation department always keeping ahead of the motive power—and a fourth pair of driving wheels was embodied in the engine "Consolidation," built by Baldwin in 1866. This engine weighed about 45 tons, but in 1881 the "Mastodon," an engine with the same number of coupled wheels as the "Consolidation" but with a four-wheel truck made its appearance. This engine weighed about 50 tons and did some remarkable hauling at that time, its tractive effort being about 14 tons.

THE LOCOMOTIVE'S GROWTH.

It is of interest thus to note the enormous growth of the locomotive engine, for by referring to the dimensions of Stephenson's "Rocket," previously recorded, we find that the tractive effort of that engine was about 785 pounds, and compared with one of the latest powerful freight engines (No. 940), built at the Baldwin Works for the Atchison, Topeka & Santa Fe Railroad, not only Stephenson's locomotive, but all the others herein noticed are as pigmies to a giant, for "940" weighs 133½ tons; the diameter of the boiler is 6 feet 6¾ inches. The total heating surface is 5,390 square feet; grate area 58.5 square feet. Working pressure 225 pounds per square inch. The compound cylinders, four in number, are 19 inches and 32 inches diameter, with a common stroke of 32 inches. The drawbar pull is no less than 31 tons, sufficient to lift as a dead weight a passenger engine of thirty years ago.

Since the days of Watt, the question of the economical use of steam has been one of the most important, and much has been done by expanding the steam in a plurality of cylinders; but in the case of the locomotive it is a problem of peculiar difficulty by reason of the small compass within which the extra parts must be inclosed. Within recent years, however, many well designed compound engines have been built, a notable example being illustrated in Fig. 9, which shows an engine of the "Atlantic" type built at the Baldwin Works under the Vauclain patents. It will be seen that the cylinders are arranged in pairs, the high pressure above the low pressure, the piston rods engaging a common crosshead. The cylinders are 13 inches and 22 inches in diameter by 26 inches stroke. Piston valves are used, being placed on the inner sides of the high pressure cylinders. The driving wheels are 84 inches diameter, and the engine and tender together weigh 227,000 pounds. An average speed of 71 miles an hour has been maintained by this engine on a run of over fifty miles with a train of five or six coaches weighing 200 tons.

The latest of the "Atlantic" type are some fine engines built for the fast passenger service of the Pennsylvania and New York Central lines between New York and Chicago. Illustrations and particulars of the performance of the latter are given elsewhere in this issue.

As in 1836 it was found necessary to build four-coupled engines for "heavy" freight service, so about twenty years ago six-coupled engines for heavy passenger service came into the field, and it is noteworthy that some of the fastest speeds recorded have been attained by engines of this class, and in order to maintain high speeds with the heavy modern passenger coaches some remarkably fine engines have been placed in service, a striking example being illustrated in Fig. 10, which shows the largest passenger locomotive in the world. This engine was built for the Chesapeake & Ohio Railroad by the American Locomotive Company at their Schenectady works, and certainly does great credit to her designers. The cylinders are 22 inches diameter with a stroke of no less than 28 inches, so that with the 72-inch driving wheels and a steam pressure of 200 pounds on the square inch, the tractive power of this magnificent locomotive is 16 tons. The total heating surface is 3533.28 square feet, and the weight of the engine and tender in working trim is 154½ tons.

This class of engine is known as the "Mountain" type, and is coming rapidly to the front for hauling the fastest trains over exceptionally heavy grades.

On page 399 we give a graphic illustration of the growth of the American locomotive from 1831 to 1902, which, with the data given below the cut, needs no further explanation.

An attempt has thus been made to trace the development of the American locomotive in bare outline; but the history of this important and interesting subject has yet to be written. If it ever appears, we shall incline to share the opinion of John Bright expressed in one of his speeches in the House of Commons, when he said: "Who are the greatest men of the present age? Not your warriors, not your statesmen; they are your engineers."

THE RAILROAD SYSTEM OF THE UNITED STATES.

If one were called upon to name the field of engineering in which the vast scale upon which things are done in this country is most strikingly shown, he would be safe in pointing to the colossal railroad system of the United States. In respect of the total length of track, the total number of locomotives and cars, the veritable army of employes, and the gross value of capital invested, our railway system is so huge that it stands absolutely in a class by itself among the railroad systems of the world. It is equally true that in respect of the character of its track, rolling stock, its general equipment, and methods of operation, it is marked by national characteristics which distinguish it far more sharply from the great European and Asiatic roads, than they are distinguished from each other.

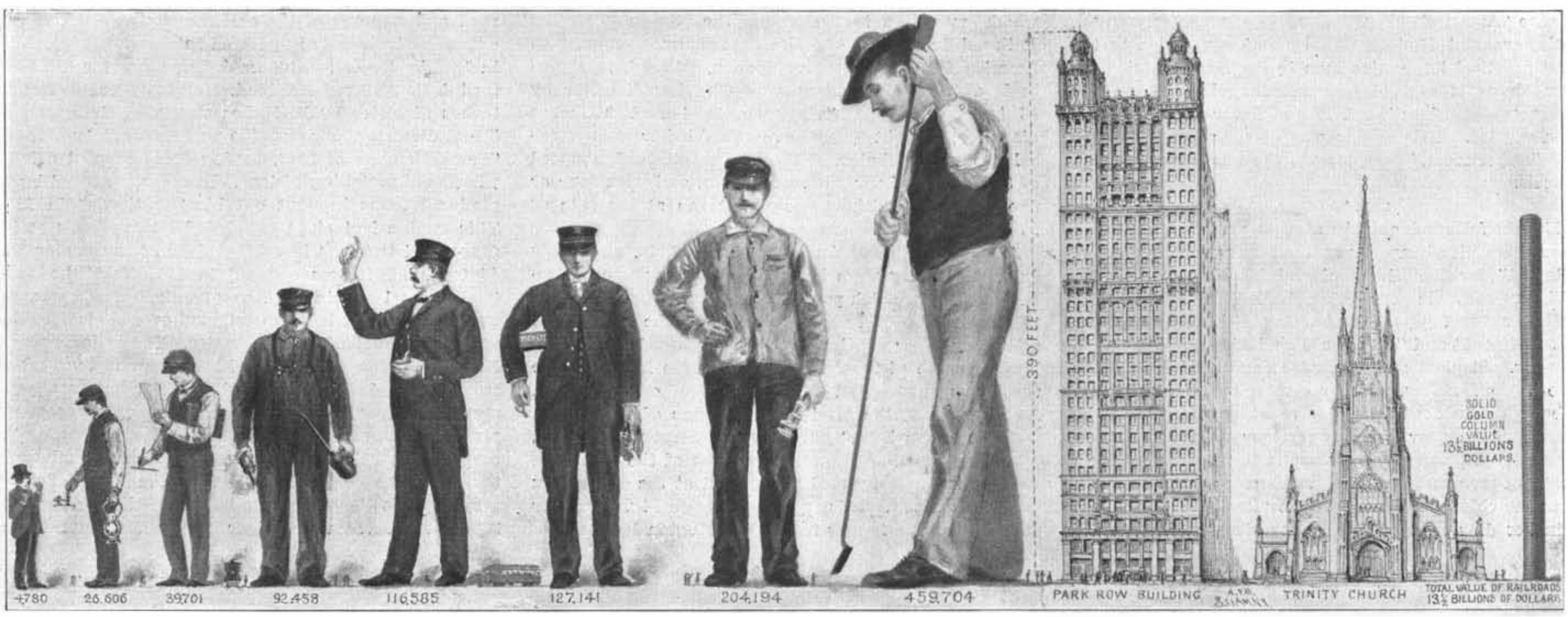
In attempting to impress upon the mind the magnitude of the properties and the operations represented by the statistics of such huge interests as the railroads of the United States, where the figures run into the millions and billions, it is necessary to translate these figures into concrete terms and refer them to some widely-known standard of measurement, whether of distance, weight, or bulk. In the present instance, our artist has endeavored—and we think very successfully—to transform the statistics of our railroads into concrete form by taking as a unit of measurement the greatest single constructive work of man, the great Pyramid of Egypt, with whose dimensions every voting American citizen is perfectly familiar, or if he is not, ought to be. From time immemorial the great Pyramid, being one of the original seven wonders of the world, has been a favorite standard of comparison with other great constructive works. It measures some 756 feet on the base by 481 feet in height, and contains about 91½ million cubic feet. Now, before we can use even this well-known standard and be sure that it will convey its full impression to the average reader, we must compare the Pyramid itself with some big and well-known structure, and for this purpose our artist has drawn the Capitol of Washington at the side of the Pyramid, both on the same scale. If it were possible to take a shell of the Pyramid, composed merely of the outer layer of stone, and place it over the Capitol, it would practically shut it out from view, and the apex of the Pyramid would extend 200 feet above the highest point of the Capitol's dome.

The total length of the railroads in operation in the United States at the close of the fiscal year 1901 was 195,887 miles, this total not including track in sidings, etc. If these railroads could be stretched out in one continuous line, they would be sufficient to girdle the earth at the equator more than eight times; or, if started from the earth and stretched outward into space, they would reach four-fifths of the distance from the earth to the moon.

STEEL RAILS.—Now, to arrive at an estimate of what it has taken in material to build this length of railroad, let us assume that a fair average size of rail is one weighing 75 pounds to the yard. Much of the track in the Eastern States weighs 80, 90 and 100 pounds to the yard, while most of the track west of the Mississippi weighs 70, 60 and in some instances as low as 56 pounds to the yard. On this basis it is an easy calculation to determine that the total weight of these rails is over 25,000,000 tons; and if the mass were melted and cast in solid pyramidal form it would contain 105,540,000 cubic feet, and would be over fifteen per cent larger than the great Pyramid itself. If the rails were cast in one rectangular block, it would form a mass 436 feet square on the base and equal in height to the Washington Monument, which towers 550 feet above its base.

RAILROAD TIES.—The railroad ties used in this country vary in size from a tie 8 inches wide, 6 inches deep and 9 feet long to ties as much as 12 inches in width and 8 inches in depth. A fair average would be a tie 10 inches in width and 7 inches in depth and 9 feet long, and a good average spacing would be 24 inches, center to center of the ties, or say 2,600 to the mile. On this basis we find that, could all these ties be gathered together on the Nile desert and piled one upon another into a pyramid of the same proportions as that at Gizeh, it would form a mass twenty-four times as great as the Pyramid of the Pharaohs, measuring 2,200 feet on its base and reaching 1,390 feet into the air.

ROCK AND GRAVEL BALLAST.—After the ties and rails have been laid in the construction of a railroad the ballast cars pass over it and unload their broken rock or gravel, which is tamped beneath and filled around the ties to form a solid but well-drained foundation. On some of our eastern roads the depth of the ballast will exceed 18 or 20 inches; on the other hand, some of the western roads have none at all, although of late years a vast advance has been made in the ballasting of the more cheaply constructed systems. Assuming an average depth of 12 inches of ballast, we find that if the railroad builders of the United States had concentrated their efforts, as did the Egyptians of old, on a single structure on the banks of the Nile, they would, in a period of years not much greater than that required to build the Pyramid, have raised a pyramid of their own 135 times greater in bulk than the tomb of Cheops. This vast pile would measure 3,900 feet on each side at the base, and would lift its head nearly half a mile into the air, or to be exact just 2,500 feet. Were the spirit of the great Cheops to return to earth, and attempt to pace off the distance around the base, it would have to step out some 5,000 paces, or say three miles, to make the circuit; and should it climb to the summit, it would have to make a journey of about three-quarters



General officers. Telegraph operators. Clerks, etc. Enginemen and firemen. Conductors and brakemen. Station agents and stationmen. Machinists and shopmen. Trackmen and laborers.

THE EMPLOYES AND THE MONEY VALUE OF THE UNITED STATES RAILROADS.