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.

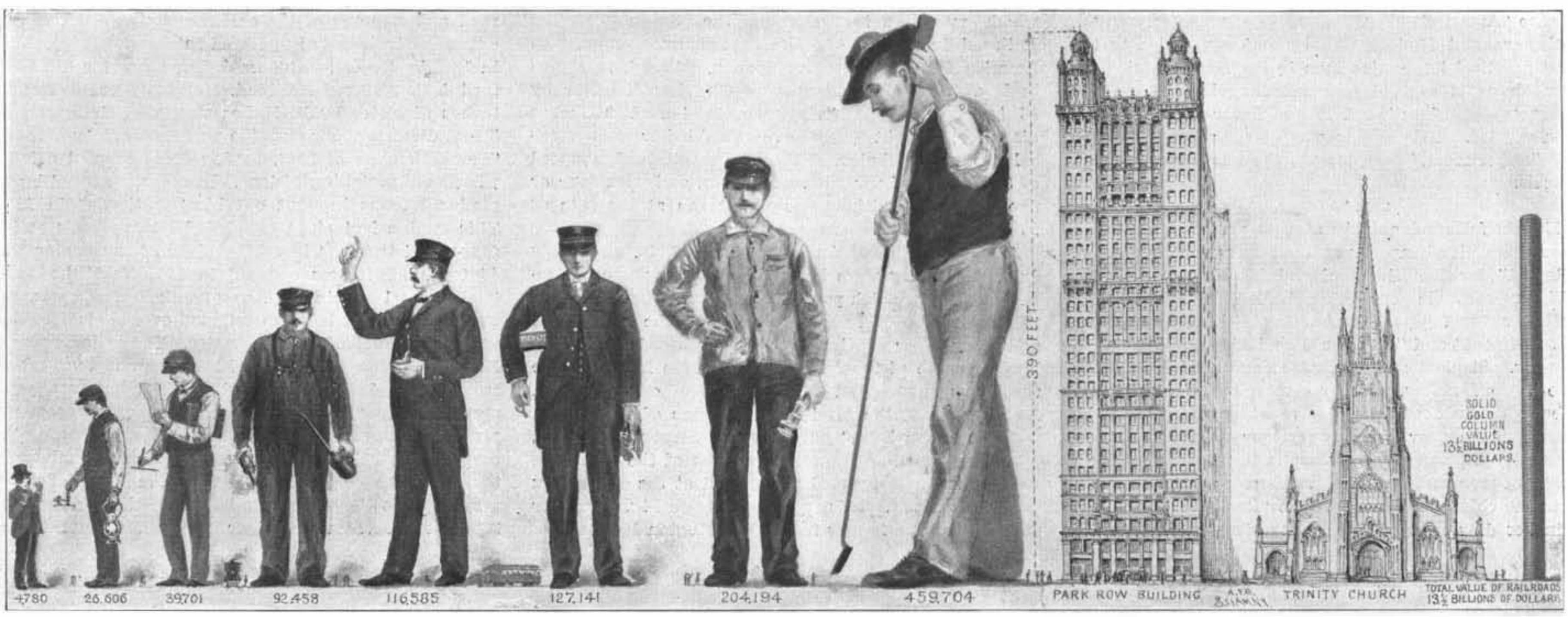
In attempting to impress upon the mind the magnitude of the properties and the operations represented by the statistics of such huge interests as the railroads of the United States, where the figures run into the millions and billions, it is necessary to translate these figures into concrete terms and 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.

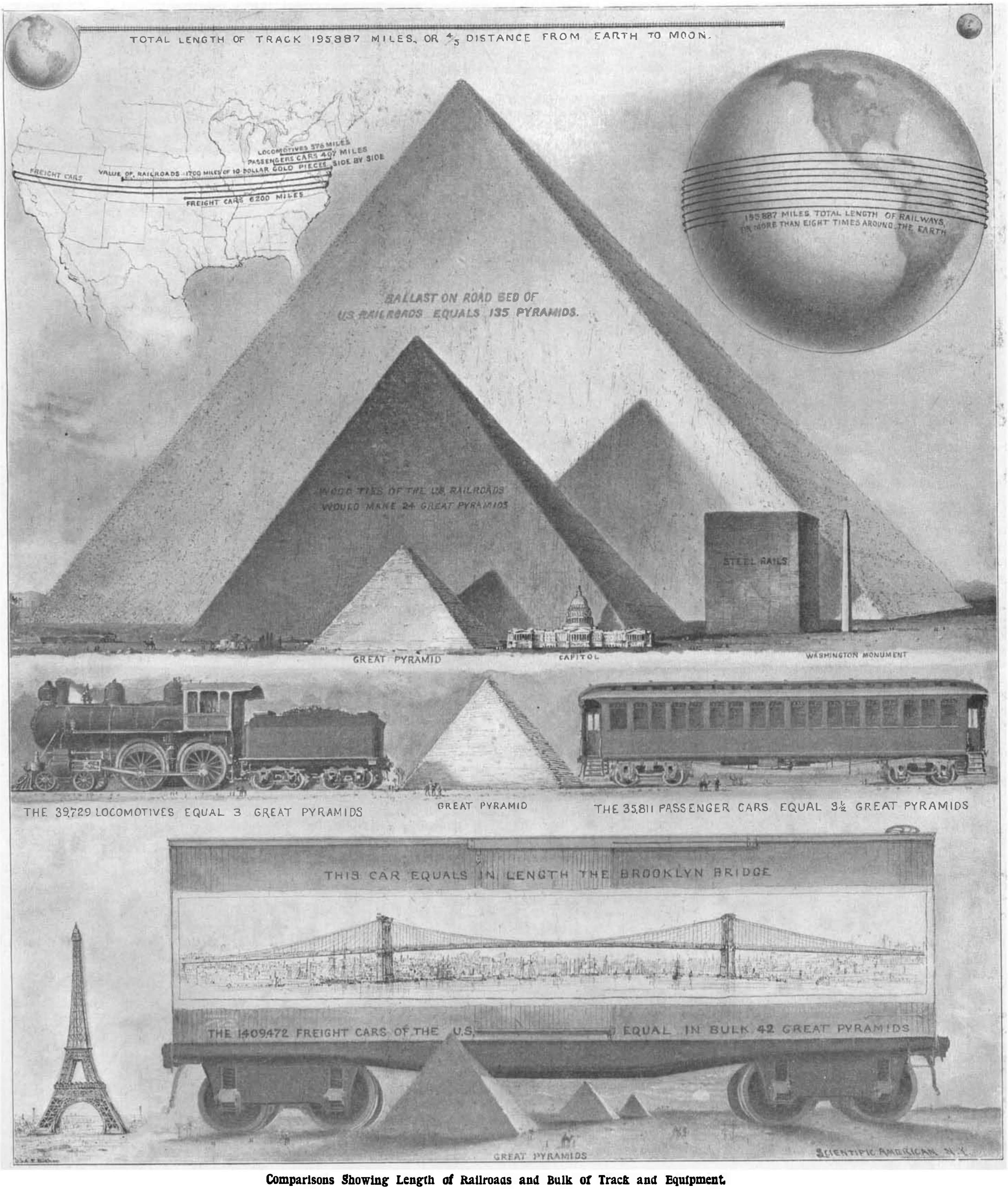
of a mile. So much for the roadbed and the track. Now let us turn our attention to the equipment.

LOCOMOTIVES.—At the close of the fiscal year 1901, there were in service on the United States railroads 39,729 locomotives. Assuming that the average locomotive fills a block 10 feet wide by 15 feet high by 50 feet long, and that all these locomotives could be brought into review at Gizeh and there piled up into one great block, a locomotive that would fill that block would be 510 feet in height and 1,700 feet, or say a third of a mile in length, its smokestack towering 29 feet above the summit of the Pyramid.

PASSENGER CARS.—There are 35,800 passenger, mail and baggage cars on our railroads, and a typical car representing the space occupied by these would be 500 feet high and 1,950 feet in length, and it would take 3½ great Pyramids to equal it in bulk.

FREIGHT CARS.—As far as the equipment is concerned, it is in the extraordinary number of the freight cars employed that we get the best idea of the great scale upon which our railroads are operated. The total number of cars is 1,409,472. They vary, of course, considerably in size, capacity and type, there being in addition to the familiar box car, the coal cars of various sizes and type, the freight cars, and a small number of miscellaneous cars for railroad construction and other purposes. A single box car representing the space occupied by all these freight cars would be two-thirds of a mile in length and one-quarter of a mile in height. The Pyramid of Cheops would reach about to the floor of the car. Were the Eiffel Tower set alongside of it, it would reach only two-thirds of the distance to its roof, while the whole Brooklyn Bridge, with its anchorages, could be placed bodily inside the car, and if the foundations of its piers rested upon the car floor, the summit of its towers would still reach only half way to the roof of the car.

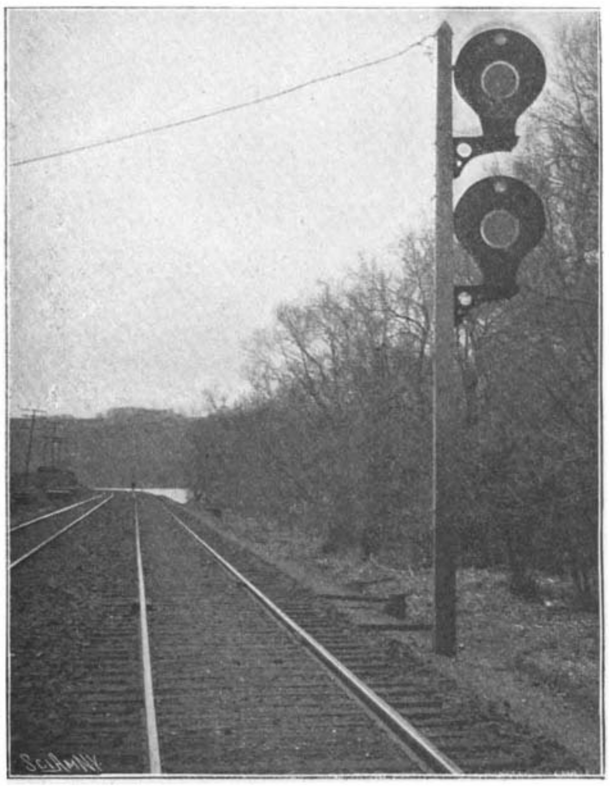
EMPLOYES.—It requires over one million employes for the maintenance and operation of our railroads. Of these nearly one-half are engaged upon the track and roadbed, in proportions made up as follows: There are 33,817 section foremen, each of whom has a stretch of a few miles of track under his charge, and a gang of from five to eight or ten section men, his duties being those of maintaining the track in proper level and line, seeing that the track bolts are kept tight, the joints in good order, and that the roadbed is properly trimmed, graded, and drained. The total number of trackmen employed in the section gangs, as they are called, is 239,166. There are also 47,576 switchmen, flagmen, and watchmen, who are engaged in switching work at the yards, in guarding the level crossings, and in patrolling the track. There are also over 7,423 men employed on work trains and other work incidental to track maintenance. In addition to these there are 131,722 laborers engaged in construction and repair and maintenance work of various kinds,



Comparisons Showing Length of Railroads and Bulk of Track and Equipment.

THE GREAT RAILROAD SYSTEM OF THE UNITED STATES.

making a total engaged on track work and general labor connected therewith of 459,704 men. Carrying out our system of comparison with some standard of bulk, we have chosen the Park Row Building, New York, which has a total height of 390 feet. If this army of trackmen and laborers were combined in one typical giant, he would be some 385 feet in height and of proportionate weight and bulk. The next largest item is the machinists, of which there are 34,698, the carpenters, of which there are 48,946, and various other shopmen engaged in the repair and general maintenance of the rolling stock to the number of 120,550, making a total number of skilled and unskilled men in the railroad shops of 204,194. The next largest total is that of the station agents, baggage masters, porters, etc., there being 32,294 station agents and 94,847 baggage masters, porters, etc. Then follow the conductors and brakemen, 32,000 of the former and 84,493 of the latter. There are 92,458 enginemen and firemen, 45,292 of the former and 47,166 of the latter. Employed in the general offices of the various railroad companies, in performing the vast amount of clerical work required, there are 39,701 clerks, while sheltered under the same roof is a body of men upon whom as much as or more than any other in the whole army of railroad employes falls the responsibility of the safety of trains and passengers—the telegraph operators and dispatchers, of whom there are altogether 26,606. The smallest in number, but controlling the whole of this vast organization, are the general officers, presidents, vice-presidents, treasurers, secretaries, etc., of whom there are 4,780.



The upper disk is a red home signal; the lower is a distant signal, green. Both indicate that their respective sections are occupied.

Fig. 1.—Hall Automatic Block Signals on the Philadelphia and Reading Railroad.

Money Value.—Perhaps, after all, the most remarkable figures are those which show the total value of the railroad system of the United States, which expressed in figures is 13,308,029,032 dollars. If this sum were represented in ten-dollar gold pieces, and these pieces were set on edge, side by side, they would reach more than half way from New York to San Francisco, or 1,700 miles. Or were this coin melted and run into a single casting, it would form a column 15 feet in diameter and 259 feet in height.

Railroad Signals.

BLOCK AND INTERLOCKING SIGNALS.

BY B. B. ADAMS.

Signals have come during the last dozen years to be an important feature on many railroads, where, a short time ago, there were but scattered plants here and there. The great increase in traffic has necessitated the introduction of block signals to space fast trains; and at terminals, junctions and large yards interlocking signals are now necessary to celerity and safety, to say nothing of economy. Over 25,000 miles of American railroad are now worked by the block system, and the interlocking machines in yards and at crossings and drawbridges aggregate over 40,000 levers; and it may be remarked in passing that the next few years ought to witness the doubling of these figures. On about 4,000 miles of the 25,000 the signals are automatic, and the more recent installations of these signals embody numerous ingenious refinements in this class of machinery. There is a healthy rivalry between the makers of the different designs, so that within a hundred miles of New York one may see four or five different kinds of automatic signals. The automatic signal is a distinctively American development, the railroads of Europe having only recently begun to take an interest in it, and our illustration, Fig. 4, shows four signals in one of the latest installations—that on the Pennsylvania Railroad westward from Philadelphia. This is a four-track railroad, each track being used only for trains in a given direction.*

As the reader already knows, the essential feature of the automatic block signal is an electric current flowing through the rails of the track. The signal being at the entrance of a block section, which is, say, three-quarters of a mile long, the battery for the current is at the outgoing end; and when the rails of the track, throughout the section (and also the rails of side tracks and crossovers, so far as they foul the main track) are clear—not occupied by wheels at any point—the circuit of the battery is through the right-hand rail of the track to the electro-magnet at the signal, thence to the left-hand rail and by that back to the battery. This circuit being closed, the electro magnet at the signal is energized and holds the signal, through the medium of a stronger electro magnet, worked by a local battery, in the *all-clear* or go-ahead position. The entrance of a train short circuits the current through the wheels and axles, de-energizing the electro-magnet (relay); and the signal, by force of gravity, assumes the stop position, thus warning the next following train not to enter the section. The signal remains at "stop" until every pair of wheels has passed out of the section. The signals marked *A* 17 in the illustration Fig. 4 are for the two westbound tracks of a four-track railroad; those on the right-hand mast being for the right-hand or outer track, and those on the left-hand being for the inner track. The lower arm on each post is a distant or cautionary signal, informing the engineman of the position of the "home" or stop signal at the entrance of the next succeeding block section.* This provision is made for the purpose of avoiding loss of time during fogs, or whenever the engineman can not see a stop signal until he comes within a short distance of it. With the distant signal, he has notice about 4,000 feet before reaching a home signal whether or not he is to expect to a stopped by it; so that in spite of fog or darkness he may run as fast as he pleases,

* The upper arm (home signal) on the right-hand mast is at "stop," protecting from following trains the train seen in the distance. The lower (distant) arm, being also horizontal, indicates that the home signal of the next succeeding block section may be expected to be found in the stop position. The arms on the left-hand mast are for the second track. Both of these indicate "all clear," showing that on that track the next two block sections are unoccupied. The signals at the extreme left of the photograph, which are for the two eastbound tracks, indicate that both those tracks are occupied in the section immediately ahead, and also in the one next beyond. The train on one of the tracks is seen in the illustration, the arm having assumed the stop position immediately after the first wheels of the engine passed the signal.

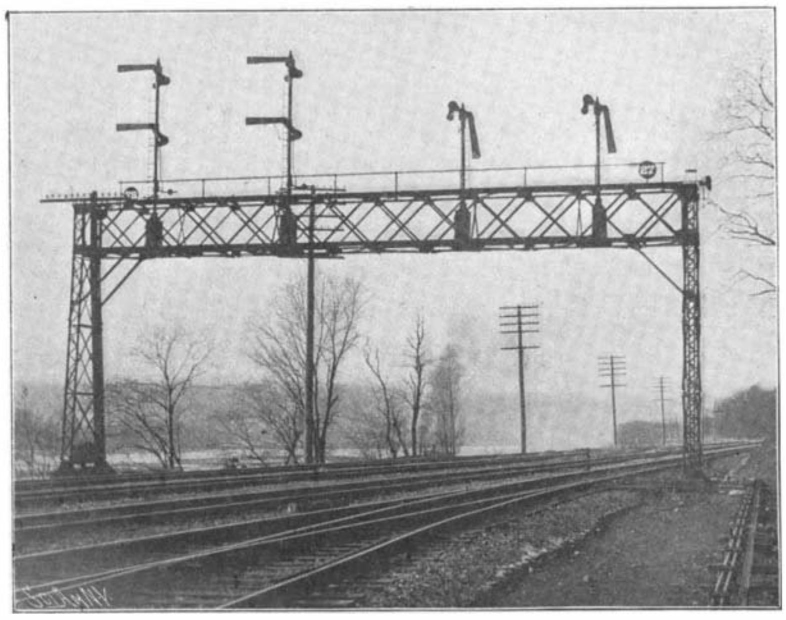


Fig. 2.—Grafton Three-position Automatic Block Signals on the Pittsburg, Fort Wayne and Chicago Railroad.

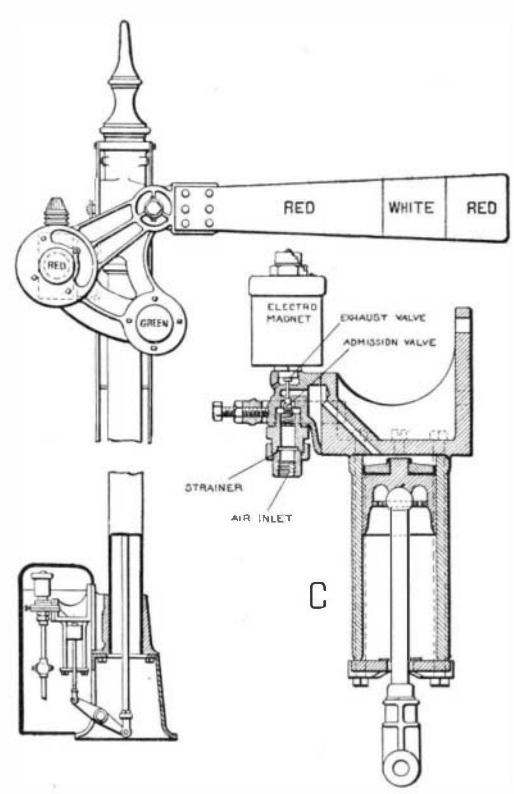


Fig. 3.—Details of Electro-Pneumatic Semaphore.

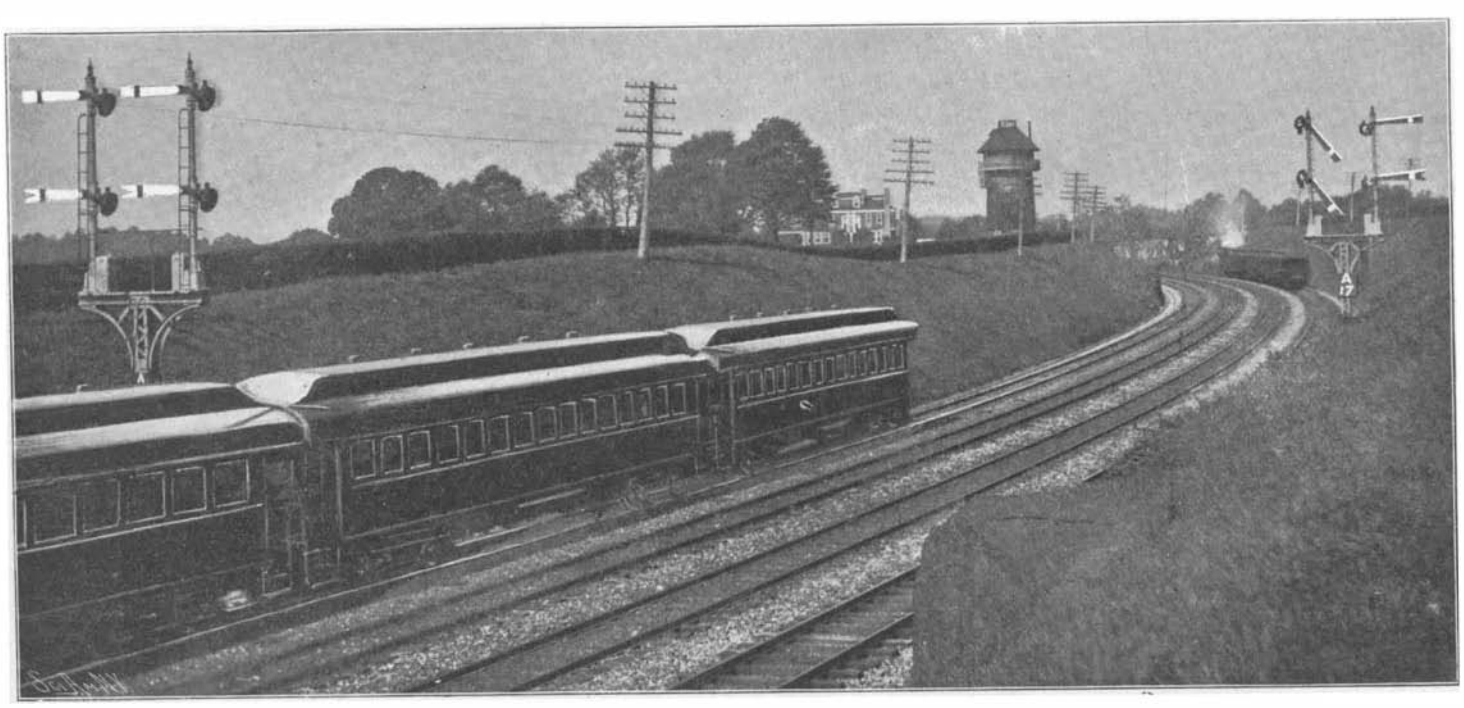


Fig. 4.—Westinghouse Electro-Pneumatic Semaphore Block Signals on the Pennsylvania Railroad.

BLOCK AND INTERLOCKING SIGNALS.