distinct types, according to the work for which they were designed.

The year 1888–89 was memorable for the introduction of the compound engine into America. Compounding had already reached a high state of development in Europe, when the Pennsylvania Railroad determined to give it a trial in American service, and to this end purchased an English compound engine, designed and built by Mr. F. W. Webb, of the London and Northwestern Railway. The Pennsylvania, as she was called, was put to work on the company's regular trains and made an excellent record for economy.

Speaking of its performance, a prominent Pennsylvania official said at the time: "I am not at liberty to give exact figures as to the saving of coal shown by the Webb engine over our regular passenger locomotives, but I will say that it has been considerably over twenty-five per cent." The era of compounding, thus introduced, has resulted in its trial on most of the leading roads of the country, and invariably with a showing of large economy. The outside two-cylinder compound has been the favorite type. Two fine examples of the four-cylinder compound are shown in the accompanying cuts of an express passenger, and a heavy Decapod freight, engine, built by the Baldwin works under the Vauclain patents. By reference to the cuts 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. Piston valves are used, being placed on the inner side of the high pressure cylinders. The engines shown have the Wootton firebox, designed for burning low-grade coal, the total heating surface of the firebox of the passenger engine being 136½ feet, and of the freight engine 234¼ feet.

As illustrating the highest development of the simple eight-wheel express passenger engine, we have selected the New York Central engine No. 999, of Empire State Express fame, which is at present hauling the fastest train in the world, and holds a record speed for the mile of something over one hundred miles an hour.

The dimensions of these three engines, together with those of the Lake Shore and Michigan Southern engine No. 564 (Brooks Locomotive Works), to whose phenomenal run we refer later, are given in the accompanying table:

No. of Engine and Name of Company.	Engine and Builder.	System.	Cylinders.	Drivers.	Weight on Drivers.	Total Weight.	Heating Surface.	Steam Pressure.
No. 999. N. Y. C. and H. R. R.R.	Four-coupled express. N. Y. C. and H. R. R.R.	Simple.	19 in. × 24 in.	86½ in.	84,000 lb.	124,000 lb.	1,930 sq. ft.	190 lbs.
No. 1027. Atlantic City R.R	Four-coupled express. Baldwin.	Compound.	13 in. and 22 in. × 26 in.	84¼ in.	78,600 lb.	143,000 lb.	1,835 sq. ft.	190 lbs.
No. 564. L. S. and M. S. R.R.	Six-coupled express. Brooks.	Simple.	17 in. × 24 in.	66 in.	88,500 lb.	113,500 lb.	.....	180 lbs.
No. 805. L. E. and W. R R.	Decapod freight. Baldwin.	Compound.	16 in. and 27 in. × 28 in.	50 in.	170,000 lb.	192,000 lb.	2,443 sq. ft.	180 lbs.

The Lake Erie freight engine is rated to pull 4,600 tons on the level, and on a run between West Carbondale and Ararat Summit, with a load of 1,107 tons, it consumed 8·28 pounds of fuel per car mile, with a water evaporation of 7·57 pounds per pound of coal. This is a really astonishing performance, when we bear in mind the grades and the loads. From Carbondale to Forest City, 25 cars, weighing in all 818 tons, were hauled for 5 miles over a 1·33 per cent grade; and from Forest City to Ararat Summit, 33 cars, weighing 1,107 tons, were hauled for 13·7 miles over a 0·95 of one per cent grade.

No. 999 is one of the class of New York Central engines which hauled a 361,000 pound train from New York to Buffalo, 436·32 miles, at the rate of 64·22 miles an hour, exclusive of stops. This superb locomotive, which was built at the shops of the New York Central and Hudson River Railroad, was on exhibition at the Columbian Exhibition at Chicago, and is the most popular and widely known engine in America to-day.

No. 564 to-day holds the record for long distance fast runs, having covered 86 miles at the rate of 72·92 miles an hour. This performance formed part of a 510 mile run with various engines from Chicago to Buffalo, at the rate of 65·07 miles an hour, exclusive of stops. The train load was 304,500 pounds, and the 86 mile run of No. 564 included 8 miles at 85·44 miles an hour, and 33 miles at 80·6 miles an hour, with one mile at 92·3 miles an hour. At this last speed the revolution of the drivers was 469 per minute, and the piston speed 1,878 feet per minute! This performance of No. 564 in hauling 152¼ tons for 33 continuous miles at 80·6 miles an hour is unquestionably the greatest locomotive feat that was ever officially recorded. That it should have been done by a six connected 5½ foot driver engine simply proves the value of great boiler capacity and large steam ports.

The growth of the locomotive industry can be best told in figures. In 1846 the Rogers Locomotive Company turned out 17 locomotives; in 1896 their yearly capacity is 300, and they have built 5,150 locomotives in all. In 1846 the Baldwin Locomotive Works turned out 42 locomotives; in 1896 their yearly capacity is 1,000, and they have built nearly 15,000 locomotives to date! It is estimated that to-day there are over 36,000 locomotives in service in America, representing a money value of not less than three hundred millions of dollars.

THE BICYCLE.

Lord Charles Beresford has said, "Whoever invented the bicycle deserves the thanks of humanity." At the present day the bicycle stands unrivaled as a means of healthy exercise and pleasure. The practical uses to which it may be put seem limitless, and now the bicycle is assisting the electric railroad and the automobile carriage to relegate the horse-drawn vehicle to the past. The evolution of the bicycle from the primitive forms has been by a series of positive steps, each step marking a distinct advance in the march of improvement. If for no other reason, the last half century is notable on account of the introduction and development of the bicycle, and nearly the whole history of this evolution falls well within the period we are considering.

THE VELOCIPEDE OF 1868.

It is necessary to go back to the last century for the germ of this great invention, when a strange device called a "hobby-horse" was introduced. It consisted of two wheels connected tandem by a rigid frame of wood. The rider sat on a saddle midway between the wheels and propelled it by means of strides on the ground. Naturally its motion was limited to a straight line. This rigid, non-steering bicycle, propelled by the feet on the ground, was the first step toward the modern machine. The second step was taken in 1818, when Baron Von Drais introduced a vehicle called a "draisienne," which resembled the foregoing machine,

TANDEM VELOCIPEDE OF 1869.

but the front wheel was so arranged that steering was possible. That such cumbersome means of locomotion soon fell into disuse is not to be wondered at. For a long time no real progress was made, though various systems and devices were introduced to enable the rider to propel himself, but they were mostly tricycles and were cumbersome and unmechanical. The third step consisted in the invention of a bicycle which was capable of being steered and which was propelled without touching the feet to the ground. This machine was credited to a Scotchman, Gavin Dalzell. The motion of the pedals was downward, the feet describing a small segment of a circle. The motion was transmitted to a crank attached to the axle of the rear wheel by levers. For a long time it was supposed that this invention dated from 1834, but in 1892 a close scrutiny of the matter resulted in the downfall of the legend, as a blacksmith's bill for the iron work was found, which proved that it was made in 1847, and also that another Scotchman named MacMillan had anticipated Dalzell's invention.

It is to Ernest Michaux, a young French locksmith, fourteen years of age, that we are indebted for the next great step which made the modern bicycle possible. In 1855, while repairing a draisienne, he conceived the idea of applying cranks directly to the front wheel. He tried the device for a couple of days and then showed the machine to his friends. The driving mechanism was improved by Pierre Lallement, to whom the credit of the invention is sometimes given, but the French seemed to have settled the matter by erecting a monument to the memory of Ernest and Pierre Michaux at Bar-le-Duc in 1894. The Michaux bicycle or "velocipede," as it was called, attained great popularity. We illustrate a typical example of the machine as improved and ridden by the Hanlon Brothers, taken from an engraving published in the SCIENTIFIC AMERICAN for August 19, 1868. The popularity of the velocipede or "bone shaker" at that time knew no bounds; riding academies were established, races run and the machine even penetrated to the far East. The columns of the SCIENTIFIC AMERICAN of this period faithfully mirror the enthusiasm of the time. In the issue for March 20, 1869, among the "Velocipede Notes," appears an interesting item to the effect that thirty years previously Michael Faraday could be frequently seen driving his machine through the suburbs of London.

In 1869 M. Magee, a Parisian, still further improved the velocipede by making it entirely of iron and steel. In the same year rubber tires were used; these were both important steps in the development of the bicycle. In 1869 M. Michaux conceived the idea of making the front or drive wheel larger than the rear wheel, and various other improvements, such as a brake, were introduced. In 1874 M. Merchegay showed that weight would be reduced by using a large front wheel and a small rear wheel, and that the rider should be mounted directly over the axle of the front wheel. These ideas were carried out, and the popular "spider" or "ordinary" was the result. This machine remained in the ascendency for nearly fifteen years. In 1875 touring became popular, and the bicycle soon showed that it had come to stay. The new wheel weighed from 35 to 50 pounds, against 80 to 100 for the old velocipede. We present an engraving of a wheel of the best type of "ordinary."

There were certain undeniable dangers connected with the use of the high wheel, and accidents were many and serious. At length came signs that the design and construction of the wheel was in a state of transition. Various expedients were adopted to avoid the dangerous "header." The "Star" bicycle became a prime favorite. In this bicycle the small wheel was placed in front and the rider was mounted over the axle of the high rear wheel. They were propelled by levers, straps and ratchets, which enabled the wheel to be geared up, thus introducing one of the most important principles used in the modern machine.

In 1877 Rousseau, of Marseilles, introduced the "Kangaroo," in which a smaller front wheel was used. Power was communicated to the axle by means of independent chains and sprockets, to the latter of which power was applied by pedals; this arrangement allowed the wheel to be slightly geared up. About the year 1880, Starley introduced his famous "Rover." At the first blush the "safety" of to-day is unrecognizable in this machine, but it really embodied the vital points of the modern bicycle in its form. The wheels were both low, though not of the same size, and the rear wheel was driven by chains and sprockets, as in our latest wheels. The great superiority of this machine over the ordinary was soon recognized. Cycling became more popular, and by degrees the high wheel was abandoned by all the makers. The pneumatic tire was the greatest of all the advances since Michaux, and marks the last step in the improvement of the wheel of to-day.

The modern bicycle is distinguished from the older types of wheels on account of the difference in materials, frames and tires. Complex shapes, once thought impossible to produce except by casting, are now forged. Great improvements have been made in brazing together the parts and in cold swaging also, so that the joints are no longer considered the points of weakness.

Great improvements made in the manufacture of tubing during the last few years have rendered it possible to construct a good road wheel which weighs, when complete, only 19 to 22 pounds. By a series of careful

tests on the strength of the material used, the liability of breakage has been greatly reduced. The use of interchangeable parts and automatic machinery has also tended to standardize the product. Great advances have also been made in the rims, and at the present day in this country the heavy steel rim has given place to the wooden rim, which, as now constructed, has considerable strength.

Changes in the frame have been notable. The original Rover frame, which was not strong enough, was soon practically abandoned, and, after a time, the diamond frame took its place. At first, however, the frames were built on dissimilar lines, every manufacturer having a model of his own. Soon the frames of the wheels began to have a general resemblance, and at last the almost universal straight line pentagonal diamond was adopted. Gradually the top bar of this frame was raised until to-day, in the latest machines, it is parallel with the ground. In its frame the bicycle is now a veritable mechanical and engineering achievement. The bearings received more and more attention, until now a wheel with ball bearings will travel thousands of miles without showing any appreciable wear either to the balls or to the bearing cones. There has been a gradual improvement also in the sizes of the wheels; at first even in the modern safety the wheels were of different sizes, but now they are almost universally of the same size. In the old velocipedes, the frame was rigid, then springs were introduced into the saddle and the different parts of the frame, and rubber was introduced into the tires. Then the cushion tire was introduced, which made riding more enjoyable. Finally the pneumatic tire was resurrected from the old patent records, thus furnishing the ideal spring between the rider and the ground, minimizing the jar due to inequalities of the road and giving the maximum of ease and comfort to the rider. In 1845 R. W. Thompson patented in England the first pneumatic tire, but it was only in 1889 that it was adapted to the bicycle by an Irish veterinary surgeon named Dunlop. The cushion tire, in which there was a hollow space in the rubber, was known as far back as 1870, but it became very popular only when the pneumatic tire began to be introduced. It soon succumbed, however, to the pneumatic. It is to the pneumatic tire that we are indebted for a large part of the popularity which cycling now enjoys, and it may be regarded as one of the most important improvements. By these gradual steps the bicycle has been brought to its present state of perfection. An impressionable Italian has well defined the bicycle as "a poem in metal."

In connection with the bicycle, it is necessary to take notice of the tricycle, which was at one time very popular.

The mechanical difficulties connected with the tricycle were less than those connected with the bicycle. The large, cumbersome vehicles which traveled over our streets some years ago are now rarely seen. There appears, however, to be a considerable demand for tricycles built upon the lines of the modern bicycle, and the machines which have been produced within the last few years are comparable in design and workmanship with the bicycle itself. There have been a number of special forms of bicycle, which, from time to time, have been put on the market, and many of which have been very successful. The tandem is the best example of these special forms of bicycle. As far back as April 10, 1869, the SCIENTIFIC AMERICAN published an illustration of a tandem velocipede, which was probably the earliest known example of the tandem. The back seat was intended to be used either as a side saddle for women or a man's saddle. The inventor also had in view the placing of two side saddles over the rear wheel, thus foreshadowing a modern type of special machine. The advantages connected with a tandem are so great that it is little wonder they have achieved a wonderful popularity. Geared up to high speeds, they are able to cover the ground with great ease. Not only are the two riders able to carry on conversation, but the absence of vibration, and the power which it has against a head wind, have all conduced to make the tandem popular. Gradually came the demand for higher and higher speeds; so the number of riders was increased until now, for pacing and racing purposes, we have six or even seven riders mounted on a single pair of wheels. A sextuplette wheel truly represents an engineering achievement, as the truss may have to support a thousand pounds. Such a wheel is geared to 153, so that every revolution of the pedals carries the wheel 38¼ feet.

THE BICYCLE OF 1879.

THE "ROVER" OF 1880.

Ladies' wheels early attracted attention after the safety was in use, and to-day the lady riders are numbered by hundreds of thousands. The lady's wheel presented a more difficult problem than the ordinary bicycle, as the diamond frame was necessarily abandoned. A lady's wheel is now produced of strength equal to that of a man's wheel, with a slight increase of weight. As far back as 1875 we find the Starleys bringing out a high wheel for women. The rear wheel no longer tracked with the driver; it ran upon the end of an axletree which protruded twelve or fifteen inches to one side of the machine, so that a two-track bicycle was the result. This permitted the fair driver to ride side-saddle position. It seems almost impossible that the lady's wheel could be the outcome of this mechanical atrocity, and we may rather look for its origin in the "Rover." The first drop-frame or lady's machine was patented in the United States in 1887.

When it is considered in its economic aspect, it will be seen the bicycle has wrought a veritable revolution, rehabilitating many industries and causing the downfall of others, while travel is diverted into new channels. It is estimated that at present there are 4,000,000 bicycle riders in the United States, while New York City alone possesses 200,000 riders. There are at least 250 reputable wheel manufacturers in the United States, besides a host of smaller concerns that cannot be strictly called manufacturers. Over $60,000,000 are invested in the plants, which give employment to more than 70,000 persons. It is estimated that the wheels turned out this season will exceed 1,000,000. A whole army of workmen are engaged in making bicycle sundries and in repairing. The wheel has brought prosperity to numberless country hotels and road houses which had become almost extinct since the decline of coaching. One great benefit conferred by wheeling is the agitation in favor of good roads. This has been of untold value to the country at large.

"The wheel took a holiday to join in the sport and recreation of men, but the yoke of business is upon it and it cannot escape the bondage. It took the race untold ages to capture the magic circle and harness it to human need, and it is too precious for man to give it a long tether." For many years the cycle has been a plaything of man, but the developments of the last few years have rendered it a valuable aid for business purposes. It makes the slow fast, and now telegraph messengers, postmen, lamplighters, building and street inspectors, "walking delegates," policemen, firemen, coast patrollers, express messengers, doctors, and others are all using the bicycle in their respective avocations. The experiments used to demonstrate the applicability of the bicycle for war purposes have been entirely successful, so that this opens up a new field of usefulness. Bicycles propelled by electricity or one of the petroleum products have been made, but are not in use to any extent.

An eminent physician has said that not within two hundred years has there been any one thing which has so benefited mankind as the invention of the bicycle. Thousands of men and women are now devoting half their time to this healthy recreation and are strengthening and developing their bodies and minds, and are not only reaping benefit themselves but are preparing the way for future generations which will be born of healthy parents; and in brief this epitomizes the hygienic side of the bicycle.

THE BICYCLE OF 1896.

THE PROGRESS MADE IN THE GENERATION OF ELECTRIC ENERGY AND ITS APPLICATION TO THE OPERATION OF MOTORS DURING THE PAST FIFTY YEARS.

The advancement of science during the past fifty years has been so great that many are inclined to believe that we have found out more within this period than all that was known before. While this conclusion may not be strictly correct, there can be no doubt that the value of the principles, the truth of which has been conclusively demonstrated during this period, is greater than that of all discoveries previously made. This is true even of the purely theoretical development of science, but when we come to consider the question of the practical application of the knowlege thus acquired we can, without hesitation, say that the last half of the nineteenth century has not only produced greater advancement than any previous period of equal length, but more than all the centuries that have gone before it.

This may seem an extravagant statement, but any one who will consider the difference between the present state of advancement and the condition of the world fifty years ago will come to the conclusion that it is substantiated by the facts. The steamship, the railroad, the telephone, the telegraph, the electric light, the electric motor, electric railways, and all the numerous collateral industries that have been brought into existence thereby, have been developed within this period. It is true that the telegraph, the locomotive and the steamboat were invented previous to this time, but their reduction to a thoroughly successful form and their extensive practical application has taken place almost wholly since 1845.

Although progress in every department of science has been very great, that which overshadows everything else is the wonderful development of electricity, specially within the last twenty years.

Previous to 1850, this science was in a very crude state. Even the most eminent physicist of those days knew little about the fundamental laws of the subject, and some of them held views that in the light of our present knowledge were absurd in the highest degree. During the succeeding twenty-five years (from 1850 to 1875) great advancement was made in the way of development of electrical theories, and the demonstration of the laws that govern electro-magnetic actions. Since 1875 the progress has been more in the direction of practical applications of electric energy than in the expansion of theoretical knowledge, and this is just contrary to the general impression in relation to the subject. Any one who has doubts as to the correctness of this statement, however, can have them dispelled by a careful study of the masterly treatise on electricity and magnetism by Prof. James Clerk Maxwell, the first edition of which was published in the early seventies.