its drop "D" hook motion and dome firebox, will repay careful study.

The fourth engine shown in Fig. 2 is the "Experiment," designed by John B. Jervis in 1832 for the Mohawk & Hudson Railroad. It was the first engine to have a swiveling truck—a feature of the American locomotive that has helped to make it so successful.

Then follows in the line the "Puffing Billy," a celebrated English locomotive designed by Blackett and Hedley in the year 1813, for hauling coal trains on the Wylam Colliery Railway, Newcastle-on-Tyne. It has upright cylinders and grasshopper beams, similar to the "Stourbridge Lion," already noticed.

The rest of the engines shown in this illustration become too indistinct in the perspective to be clearly seen, but among them will be found Eastwick and Harrison's "Hercules" of 1837-38, the first locomotive to have equalizing levers; the first American eight-wheel engine, designed by Campbell in 1836; James' engine of 1832, the first engine in the world with link motion, and many others of equal interest. Limitations of space forbid more than a brief reference to one of Ross Winans' celebrated "Camel" engines, that astonished the railway world fifty years ago with its great hauling power. We must not, however, pass by a full-size reproduction of Stephenson's "Rocket" of 1829, which at the celebrated competition at Rainhill, England, attained a speed of 24 miles an hour. It possessed all the essential features of the modern locomotive, and is, perhaps, the most important historical locomotive in the world.

In other parts of the historical display will be found several engines worthy of notice, among them the "Pioneer" of 1848. (See Fig. 5.) This is a working locomotive. It was the first locomotive seen in Chicago, and ran on a railroad that is now a part of the Chicago & Northwestern system. It weighs about 10 tons, and has inside cylinders. The eccentrics are outside, and are fitted with drop "V" hooks. This feature alone makes the engine of special interest.

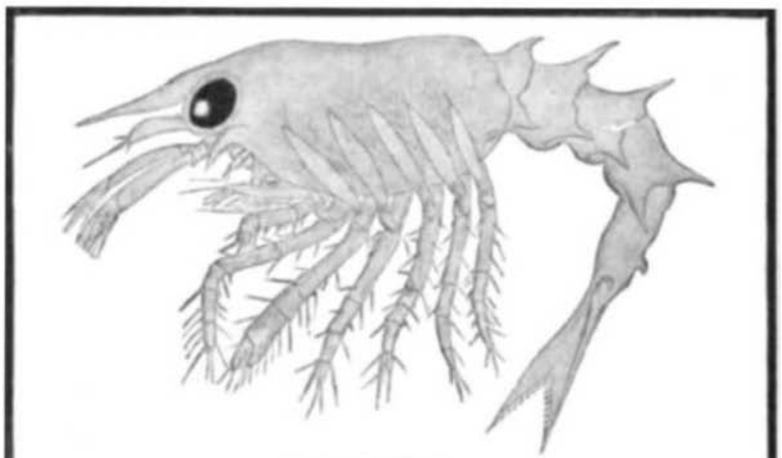
Perhaps the best specimen of a full-size reproduction to be found in the whole display is that of the "De Witt Clinton," which was the first engine to draw a train in the State of New York. The original was built for the Mohawk & Hudson Railroad, now a part of the New York Central & Hudson River Railroad, in the year 1831. This exhibit is complete, as it includes the tender and three passenger cars, and is illustrated in Fig. 4. It will be observed that these cars are built on the lines of the old stage coach. The baggage was carried on the roof, and an outside seat was provided for the guard or conductor.

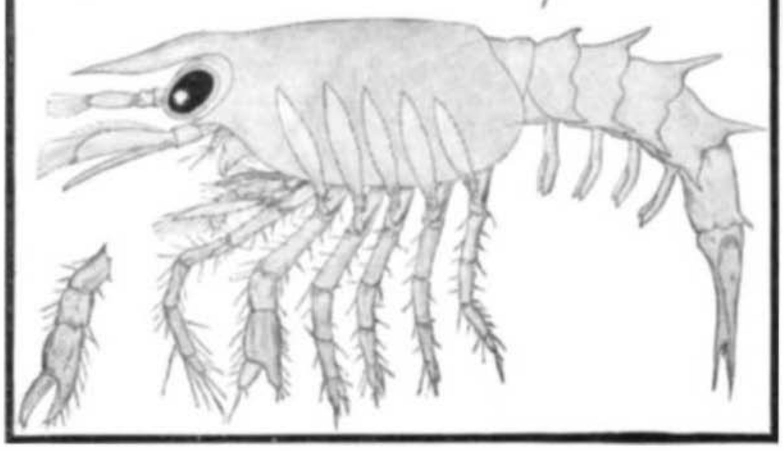
Passing over the rest of the engines in this great exhibit, it may be said in conclusion that the Baltimore & Ohio Railroad Company have supplemented it by the addition of several modern locomotives of the most approved design, including the Mallet articulated compound engine, which has the distinction of being the heaviest locomotive ever built. It has four cylinders and twelve driving wheels arranged in two sets of six wheels each, the frame for the front set of wheels being pivoted to the rear section of the frame, thus enabling the engine to round the sharpest curves with ease. The total heating surface of this mammoth machine amounts to 5,586 square feet—the largest heating surface ever put into a locomotive. Its enormous power may be conceived in the drawbar pull of 70,000 pounds which it exerts when working compound, but when in simple gear the tractive effort reaches over 80,000 pounds. The weight of the engine in working order is 334,500 pounds.

A good idea of the great increase in the size and power of locomotives since Stephenson's time may be obtained by comparing his engine with the one just described. The total heating surface of the "Rocket" was 137.75 square feet; its drawbar pull was about 785 pounds, and its weight in working order was but a little over 9,000 pounds.

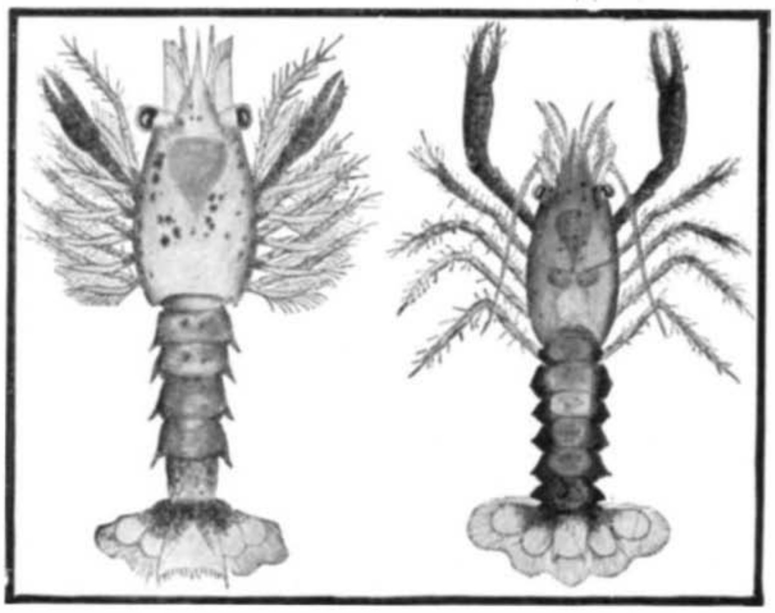
It is gratifying to know that this valuable collection will not (as at one time seemed possible) be broken up at the close of the St. Louis Fair, arrangements having been practically completed for placing it in a permanent home in one of the eastern cities, with ample provision for its subsequent safe keeping.

First Stage—A Few Days After Hatching from Egg.



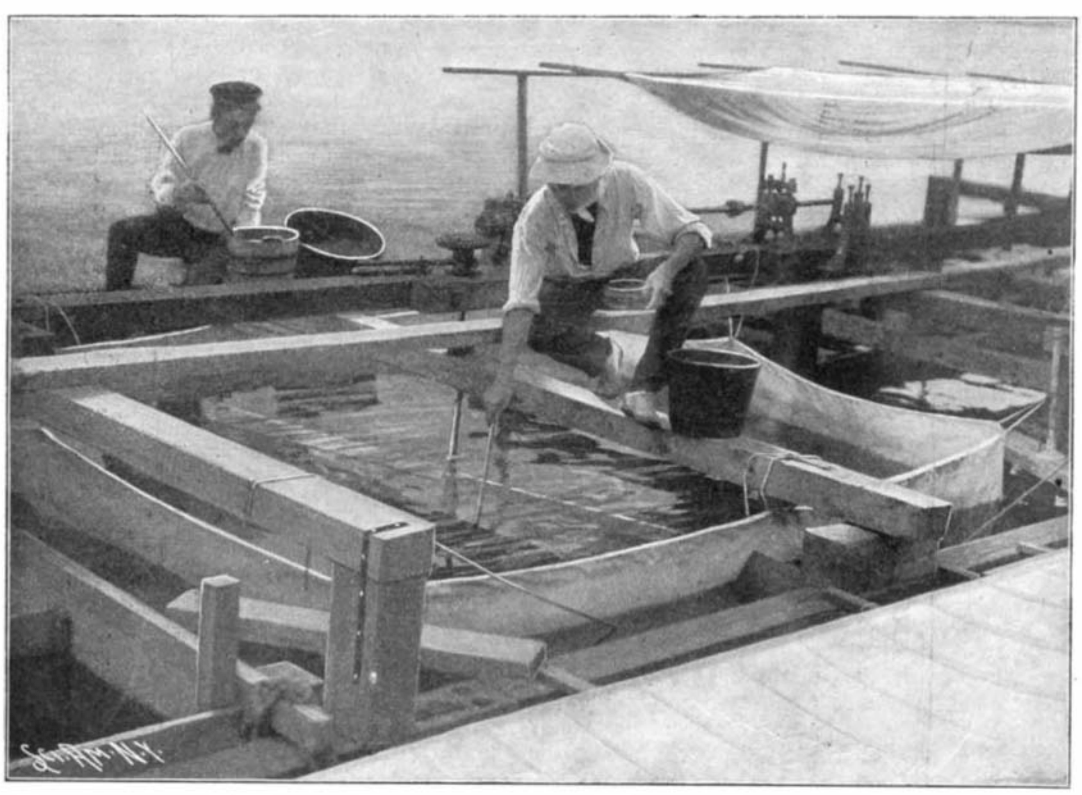


Second Stage in the Growth of a Lobster.



Third Stage—Nearing Maturity. Fourth Stage (Last)—Young Lobster Ready for Liberation.

The Four Stages in a Lobster's Life.



Submerged Bag with Stirrers for Breeding Lobsters. Getting Out "Fourth-Stagers" for Liberation.

ARTIFICIAL PROPAGATION OF LOBSTERS.

ARTIFICIAL PROPAGATION OF LOBSTERS.

BY WALTER L. BEASLEY.

The artificial propagation of lobsters, one of the most interesting of biological problems, and of great economical importance to the United States, has been successfully solved. This noteworthy discovery, which has baffled scientists up to the present, has been practically worked out by the Rhode Island Commission of Inland Fisheries through the investigations carried on by Dr. A. D. Mead, of Brown University, who is director of the floating laboratory of the Commission at Wickford, R. I. The U. S. Fish Commission also co-operated in these experiments. For the past three years or more this has been anchored in Mill Cove and turned into a lobster experimental station, with specially-devised apparatus, and is to-day the first successful lobster-hatching plant in the world. New life is now assured to the declining lobster industry, which otherwise seemed doomed to extinction. The annual output is smaller each year, due partially to the unceasing trapping and reckless destruction of the female egg and short lobsters by certain of the crafty and ignorant fishermen, who fail to observe the regulations, and evade the fishing laws. It should be stated, however, that early experiments were carried on on behalf of the United States Fish Commission at Wood's Holl in 1899-1900 by Prof. Herman C. Bumpus, then director of the United States Biological Laboratory. His series of promising investigations awakened general interest in the artificial rearing of lobsters, and many different devices for the inclosures were tried, all of which proved unsatisfactory and resulted more in killing than in the rearing of the lobster fry. Later the experiments were transferred to the Wickford Station. The writer, in July of this year, at the Wickford Laboratory, had the opportunity of visiting the lobster-hatching plant, when Dr. Mead outlined the apparatus and his successful method of rearing the young lobsters from the eggs through the critical four stages of two to three weeks which is necessary before they become fitted for the struggle for existence. The following narrative embodies the salient and latest features of Dr. Mead's investigations, obtained from an interview and his official report. The hatchery is installed in a house-boat, some fifty feet in length, built on two pontoons, having a house ten by ten on each end, which is used for a laboratory, sleeping apartments, and the storing of appliances. A well of twenty feet is arranged between the two houses. Two large floats on both sides of the house-boat contain the essential apparatus for the breeding and rearing of the young fry. This, the most vital and important feature of the whole work, viz., the inclosure used to harbor the young fry, consists of a stout canvas bag twelve feet square, submerged to the depth of four feet and supplied with a rotating propeller. After innumerable experiments, it was found that the keynote to success was that the water in which the young fry were inclosed should be kept in continuous motion. This accomplishes two things: it prevents the fry from settling into pockets to smother or devour one another, and it keeps food in suspension, so that they can obtain it. In order to admit a free circulation of water in these bags, windows of copper screens are placed in the bottom and in the sides near the top. The bottom ones are twenty by thirty inches, through which the water enters the bag. The side ones are five feet long and ten inches broad, and placed ten inches from the top, through which the water escapes in the bag. The windows are covered on the inside with linen scrim, which prevents the lobsters from being caught in the copper screen. The rotating propellers create an upward current through the bottom windows, which flows out through those on the side. The paddle blades are four feet long and operated by a gasoline engine, which turns the main shaft, revolving the whole series. The largest number of "lobsterlings" raised to the fourth stage at one time was 12,750, being over fifty per cent. In a series of experiments in which the fry were counted at the beginning and at the end, from sixteen to fifty per cent of the fry in the first stage were carried through to the required final fourth. In the experiment which yielded fifty per cent 1,000 specimens were used, with 2,500 forty per cent were carried through, and over twenty per cent in an experiment with 5,000, kept together in a small inclosure. A percentage of fifty-four was obtained in one case. Hitherto the best percentage under the old method and with most favorable conditions at Wood's Holl yielded only a quarter of one per cent. The Norwegian investigator Appellöf, who has recently conducted experiments, reports that by the use of the greatest precautions he succeeded in carrying over, out of 1,500 larvæ of the second stage, only one hundred individuals into the fourth, less than ten per cent. The first step in the artificial propagation is obtaining eggs from the female lobsters. These are bought from the Creek Newport fishermen in July and August. The eggs are carried through the winter and spring under the tail of the female, attached to the swimmerets, and the hatching begins in May and ends about the middle of July. The number of eggs produced varies with the size of the lobster, and ranges all the way from three thousand to ninety thousand. The maternal care which the female lobsters display for the young is small. The newly-hatched fry are entirely free, have no means of attachment, and are readily scattered by the tide and waves and become easy prey for the other marine animals. The eggs are combed from the female into a bag occupying the space between the two cabins on the house-boat, and after being hatched are transferred into the regular canvas bags with propellers. Here they are carried through the interval of two to three weeks. The chief difficulty in rearing fry through this period in any considerable numbers consists in so confining them that they will not die from the effects of suffocation, mechanical shock, starvation, cannibalism, or parasites. This is remedied effectively by keeping the water constantly stirred, and the lobsters and their food suspended in the water. The attack from parasites constitutes one of the most serious difficulties to contend with. Frequently the young lobsters are so completely covered with a growth of parasites, which hinders their movements, that it interferes with feeding and with moulting, so much so as to finally cause death. Of unusual interest is Dr. Mead's observations on the early life habits and appearance of the young lobsters, hitherto not generally known, during the four stages of their infancy. The huge white bag, swarming with millions of the tiny creatures, furnishes at all times a fascinating and kaleidoscopic picture of marine life. The best food so far discovered for the young fry is the soft part of clams, the bodies of which were cut out and chopped into fine pieces and then thrown into the bag. Their habit of cannibalism made the question of ample food supply an important one. The only way found to prevent them from destroying one another was to give them an abundance of food. In the process of hatching, the first stage lasts about three days, the second about four or five, and the third five or six, though the length of each period varies greatly, depending upon the water temperature, the food supply, and the general health of the young fry. From nine to sixteen days are required for the larvæ to pass from the first to the fourth stage. The young, immediately after hatching, are designated as belonging to the "first stage"; after they have moulted once, as belonging to the "second stage," and so on. The surest and quickest means of distinguishing the different stages is by the appendages along the underside of the abdomen (tail). In the first stage there are none; in the second stage several pairs of swimmerets are present; in the third stage appendages appear upon the end segment of the tail. The fourth stage is so different from the preceding ones that no difficulty is ever experienced in distinguishing it.

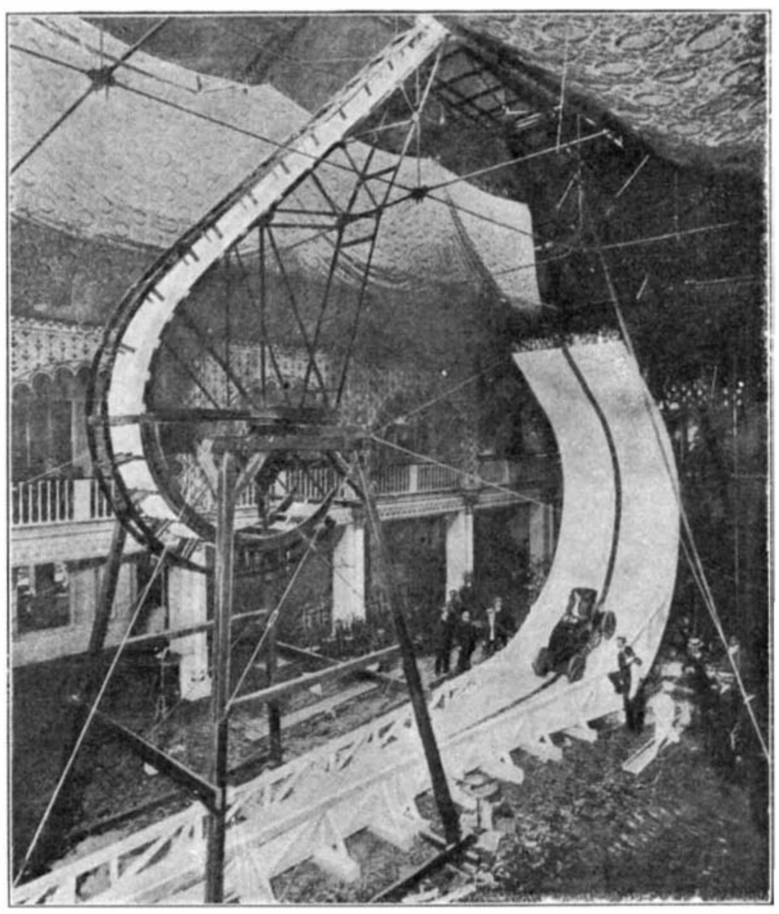
During the first three stages the lobsters swim near the surface in an aimless, jerky way. They are entirely unfitted for a bottom life. The thorax bears five pairs of forked limbs, which ultimately become the walking limbs of the lobster. One branch of each leg—the lower—extends forward and downward, and is used solely for feeding; the other, which is fringed with long hairs, bends upward to the side of the thorax, and by vigorous downward strokes helps to keep the larva afloat. The abdomen (tail) of these lobsters is bent downward at right angles to the body and is the chief swimming organ, and by means of rapid, irregular, downward strokes sends the animal tumbling over and over. When the lobster has nearly reached the surface, it often rests for a little, and sinks gradually toward the bottom.

The most marvelous and astonishing change of form and habits occurs at the third moult. The emerging fourth-stage lobster has the general form of the adult. The abdomen is no longer bent down, at right angles with the body, but now extends straight behind. The downward stroke of the abdomen, which was the chief means of motion during larval life, is now used, as in the adult, only for rapid retreat. All five pairs of walking legs have lost their upper branches, and the first pair, which are now the large, characteristic nippers, are extended straight in front of the head while the lobster is swimming. The other walking legs are relatively shorter than in the larvæ, and are fitted for walking. These structural changes are accompanied by more radical differences in habits and instincts. He is no longer helpless upon the bottom, but burrows under shells or stones for a home, crawls over the bottom or swims about in search of food, avoids enemies, and instantly retreats from danger when attacked. A new style of locomotion is adopted, and he swims forward in a straight and perfectly definite course by the strokes of the swimmerets. In the fourth stage the lobster has passed the most crucial period of its entire life, and is vastly better fitted for the struggle for existence than in any earlier stage. After lobsters have been carried through to the fourth stage, they are liberated in lots of one to five thousand at various points. One of the most suitable methods adopted was to set them free in the morning upon a stony shore, when the tide was out. Here they could find a satisfactory place to burrow and hide from their enemies, also a chance to obtain food. If thrown overboard in large quantities in deep water at one place, they would undoubtedly attract large numbers of fishes and other enemies, and consequently be devoured. The hiding and burrowing habits which are taken up when the fourth stage is reached, continue to be characteristic of the lobster during the earlier period, and doubtless throughout life. In the cars where they are confined, the lobsters show a ready appreciation of anything which will serve as a hiding place, such as shells, stones, seaweed, etc. Aside from rearing the young fry up to the last stage, many new and important problems are being worked out, such as the rate of growth, age of maturity, regeneration, migration of adult lobsters along the coast, to and from deep water. These are copper-tagged with a number and request to return, when caught, to the hatchery. The record one for traveling up to date covered a distance of ten statute miles in less than eight days. By experiment it has also been proved that the young lobster could withstand the cold of winter and the freshened water of early spring. They were submerged in cars in November, and were sunk in the channel in from eight to ten feet of water and left undisturbed until spring. No food was given them, although they may have obtained some from the water or from the animals which grew in the car. In the spring they were raised, and seemed not to have suffered from their long fast and winter's exposure. They were all in a healthy condition, but so torpid with the cold that they could be picked up with the hand, becoming very lively, however, when warmed. It was found that the size of the lobsters of the same age varied greatly, though reared in exact conditions. The immediate cause of these differences is probably due to the amount of food taken, as some are more courageous than others in foraging.

The Wickford hatchery, through the painstaking and scholarly researches of Dr. Mead, has conclusively proven that artificial lobster culture upon a large scale is now practicable; while the establishment of numerous hatching plants, liberating millions of young fry annually, is destined ultimately to reclaim the valuable waning lobster industry of this country. The author acknowledges his indebtedness to Dr. A. D. Mead for data incorporated in the foregoing sketch, and to Mr. Hadley for drawings reproduced of the newly-hatched "lobsterlings."

THE AUTO-BOLIDE.

The latest of those daring contrivances which seem to defy all dynamic laws, and for which Parisians in particular seem to have an overweening fondness, is the "Auto-Bolide"—compared with which "looping-the loop," "the circle of death," and other felicitously-named "amusement" apparatus seem tamely commonplace. The accompanying illustration, which is reproduced from L'Illustration, shows the apparatus clearly enough, but the account which that paper gives of the principle upon which Mlle. de Tiers whirls around this structure, in a specially-constructed automobile, is anything but clear. We are simply vouchsafed the information that a platform is situated a considerable distance from the ground, from which platform two rails descend at an angle of 45 degrees, terminating in a sharp though graceful upward curve. Separated from the end of this curve by an air gap of some 30 feet is an ordinary loop-the-loop track. The entire contrivance resembles more the letter S than anything else. Indeed, at the Folies-Bergère this piece of acrobatic foolishness is called "*la boucle en S.*"



The Auto-bolide, on which an Automobile and Its Occupant Travel at the Rate of 130 Miles an Hour and Incidentally Turn a Complete Somersault in the Air.

From the very obscure description of Mlle. de Tiers' automobile, it would seem that the vehicle is provided with rollers which grip the track on the downward plunge, leaving it at the air gap, and allowing the automobile to finish the last stretch of this hazardous course on its own wheels. Since the occupant of the vehicle must turn a complete somersault in the air, a heavy counterweight is secured to the front part of the machine, to assist it in its revolution. The leap across the gap is said to be "impressive." Startling, would be a more fitting description. The tires receive a violent shock, but seem to stand it well enough. The entire distance of 50 meters (164 feet) is covered in four seconds, or at a speed of about 130 miles an hour. It may be a matter of rejoicing to engineers to know that not a member of their profession is the inventor of this absurdity, but a painter, M. Alonzo Perez by name.

Fiala Rescue Expedition Fails.

W. S. Champ, leader of the expedition that started to relieve Ziegler's North Pole expedition under Anthony Fiala, telegraphs as follows:

"I regret to report my failure to reach Franz Joseph Land. The ice is insurmountable. The approaching winter and heavy frost have compelled me to abandon further effort."

Fiala left New York in May, 1903, for Norway, where his ship, the "America," was waiting. His plan was to go to Camp Ziegler, Alger Island, for winter quarters, and in the spring of this year to make the dash for the pole.

A notable locomotive engineer, Mr. William Adams, M.I.C.E., has recently passed away in his eighty-first year at Putney, England. He was one of those most closely associated with the development of the present type of locomotive, and was the first to produce an engine especially adapted for short-distance traffic. This engine, which was designed in 1868 for stopping and starting with great acceleration, has served as a model for this class of work ever since. During the course of his brilliant career Mr. Adams was the locomotive engineer for three of the most prominent trunk railroads in Great Britain.