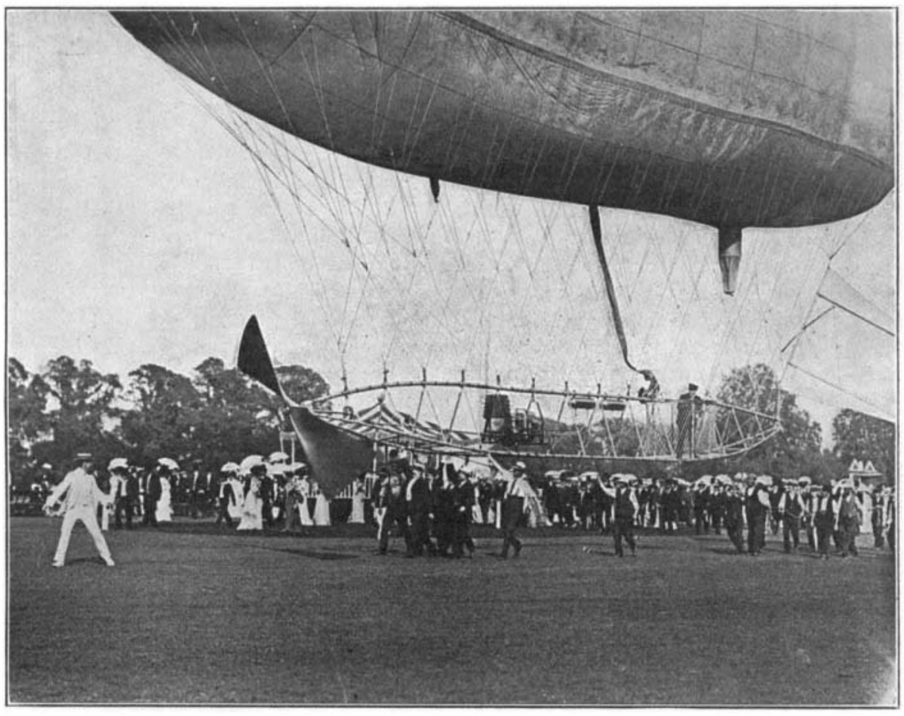
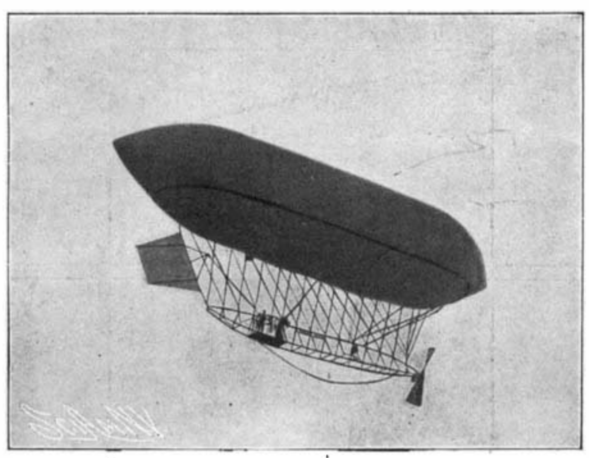
than are dreamed of in our philosophy. In the first finished race, sailed on August 22, over the windward and leeward course, the yachts started at opposite ends of the line, the "Shamrock" 4 seconds in the lead at the easterly end and "Reliance" crossing near the committee boat at the westerly end of the line. The wind was blowing steadily with a strength of from 10 to 15 knots and there was quite a little sea running which, as the event proved, came very near to the undoing of "Reliance" in the 15-mile beat to windward. As will be seen from the accompanying photograph of the start, both yachts were on the starboard tack, with the full length of the line separating them. It was well known that both boats were supposed to be at their very best in windward work, and it was felt that the first half hour's sailing would, barring accidents, determine the result of the race. "Reliance," with her extra sail spread, including her giant club topsail, of 2,300 square feet, was expected to have no difficulty in pulling away from "Shamrock" when running home under spinnakers, provided she could round the mark sufficiently far ahead to get a clear wind. On the other hand, if "Shamrock" should round the outer mark in the lead, or within a minute of "Reliance," it was believed that she might blanket the leading boat sufficiently to save her time allowance of 1 minute and 57 seconds. The yachts had not gone more than a mile on their way before it was seen that "Shamrock" was footing as fast and pointing considerably higher than "Reliance," the sweeter and rounder hull of the challenger taking more kindly to the seas than did the flatter and longer hull of "Reliance." Although neither boat could draw away from the other, "Shamrock" ate up steadily toward "Reliance" until her back wind (that is, the rebound of the wind from her sails) was bothering the American yacht, and, in order to avoid dropping into the wake of "Shamrock," "Reliance" was thrown sharply around on the port tack. Here occurred the first mistake—that is, according to American ideas of boat sailing—of the race, for, instead of coming around sharply on the weather quarter of "Reliance," "Shamrock" was kept on the starboard tack for two minutes before she came about, at which time the American boat had pulled out from her uncomfortable position. What was of greater importance was that "Reliance" was now about half a mile further to the westward, and when the invariable westering of the wind took place, which it did to the extent of a couple of points, "Reliance" was thereby placed a couple of minutes to windward, an advantage which she improved still further before she turned the mark, 3 minutes and 17 seconds in the lead. Between 5 and 6 minutes more was added to the lead of the American boat down the wind, and she finished a winner by the comfortable margin of 7 minutes and 3 seconds in a race which was sailed in the fastest time ever made over the windward and leeward course in the history of the America cup contest.

The second finished race was sailed over a 30-mile course of 10 miles to the leg. The wind varied in strength from 6 to as high as 15 knots in the stronger puffs, and the sea was considerably smoother than it was in the first race. The skipper of "Shamrock III." elected to avail himself of the full handicap, but by miscalculation he crossed 19 seconds later than the limit and was handicapped accordingly. In the beat to the outer mark the breeze freshened until the lee rails of the yacht were well awash, and in the smoother condition of the sea "Reliance" was not knocked off her caurse so badly as in the previous race and began to pull out slightly on the challenging boat. At the outer mark "Reliance" was 2 minutes and 32 seconds in the lead, having gained on the first leg of 10 miles 49 seconds in actual time. If we compare this with the gain of 3 minutes and 21 seconds in the 15-mile beat of Saturday's race, it will be evident how much the shift of the wind must have helped the leading boat on that occasion. On the second leg "Reliance" was expected to pull rapidly away from the English boat, chiefly because her easy lines and her great water-line length when heeled, should theoretically make her much faster on a reach than the shorter and deeper English boat. As it was, however, she only gained 1 minute and 23 seconds in the 10 miles of broad reaching. The last leg to the home mark was a close reach, and in the freshening wind the two boats made a magnificent marine spectacle as they rolled down until there was several feet of water on their decks. "Reliance" in particular presented a wonderful and striking marine picture. The water would roll over her lee bow, sweep in seething surges along her deck, and go boiling over the taffrail to add its white smother to that that came surging up from under her counter. On this leg she was carrying a little more canvas than she liked, having sent up at the start of the race when the breeze was lighter, her largest club topsail, whose sprit towers some 35 feet above her topmast truck. "Shamrock" appeared to be the stiffer boat at this angle of heel and carried a small jib topsail throughout the leg. She hung on doggedly to "Reliance," losing only 45 seconds on the 10-knot reach. At the close of the race the excitement was intense, as it became doubtful whether "Reliance" could save her time allowance of 1 minute and 57 seconds plus the difference between the two yachts at starting. This, however, she did and crossed the line with 1 minute and 19 seconds to spare. The race was one of the most picturesque and exciting that has ever been seen on the famous Sandy Hook course.

Two days later the yachts attempted to sail the third race which was expected to be final and conclusive. The wind was light and the sea perfectly smooth, conditions under which "Reliance" has done her very best work. Going over the line with a lead of nearly a minute the defending yacht both outpointed and outfooted the "Shamrock" and secured a commanding lead of 12 minutes and 31 seconds at the outer mark. On the run home the falling wind and head tide prevented the finish of the race, although "Reliance" was within 5 or 6 minutes of the line boat when the time limit expired.



Frame of the Airship, Showing the Motor, Tractor, and Propeller.

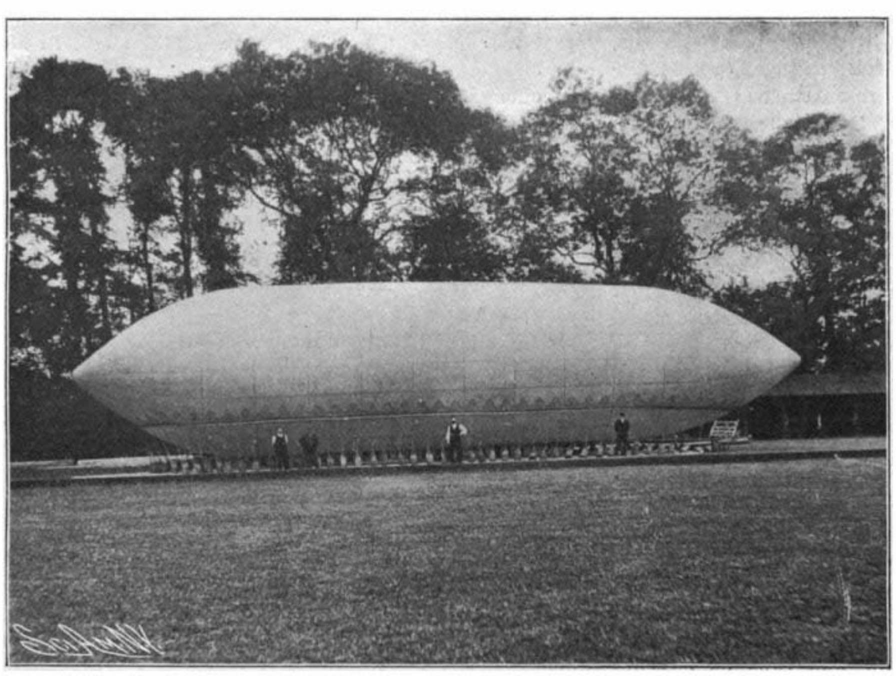


The Airship in Flight.

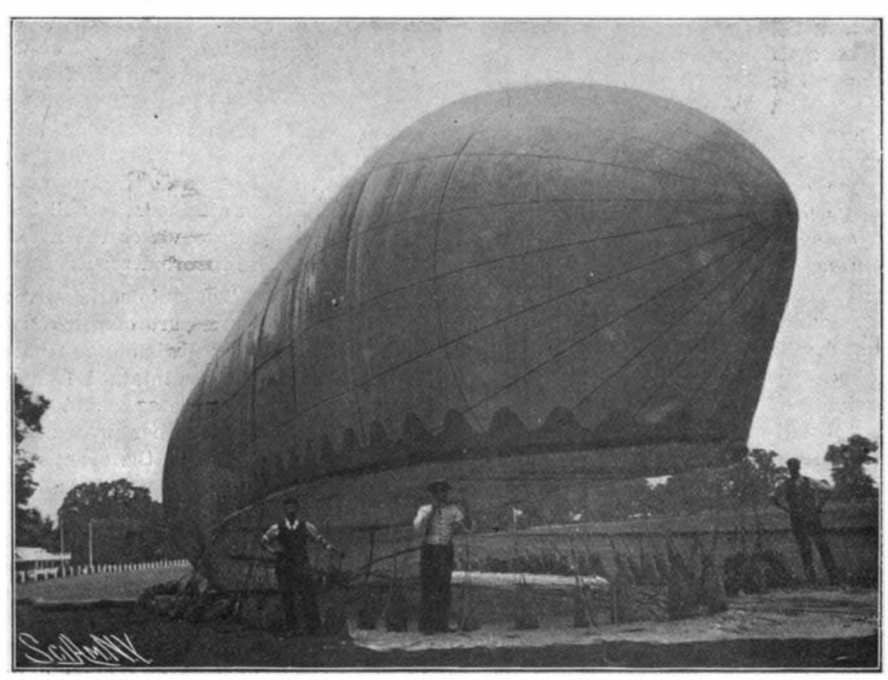
THE SPENCER AIRSHIP FOR 1903.

BY FREDERICK A. TALBOT.

The Spencer airship of 1903 is built on similar lines to that which proved so successful last year, with many improvements, which suggested themselves from time to time, during the experiments, embodied. It consists of the balloon or gas bag, with the deck or keel suspended below. The gas bag measures 87 feet in length from tip to tip, while its greatest diameter is 21 feet 9 inches, as compared with the 75 feet length by 20 feet diameter of the first vessel. It is in the same "fusiform" shape, to quote the inventors' description, which is the most suocessful design for a solid which it is desired to pass easily through a liquid. In this design the nose of the balloon is somewhat blunt, the contour of the vessel curving rather rapidly from the nose or bow of the balloon for a distance of one-third its entire length—29 feet—at which point is its maximum diameter of 21 feet 9 inches. The curve then decreases slightly during the next third of its length, at which point the diameter is 20 feet 3 inches; thence the taper is rather rapid during the last 29 feet to the end. From this design it will be seen that at no two points is the diameter of the gas vessel the same. The capacity of the balloon, which is made of varnished silk, is 24,000 cubic feet, which with coal gas will give it a lifting power of 960 pounds, while when inflated with pure hydrogen the lifting power will be 1,680



Broadside View of the Spencer Airship. The Gas-bag Gradually Tapers so that the Greatest Diameter is to be Found Near the End.



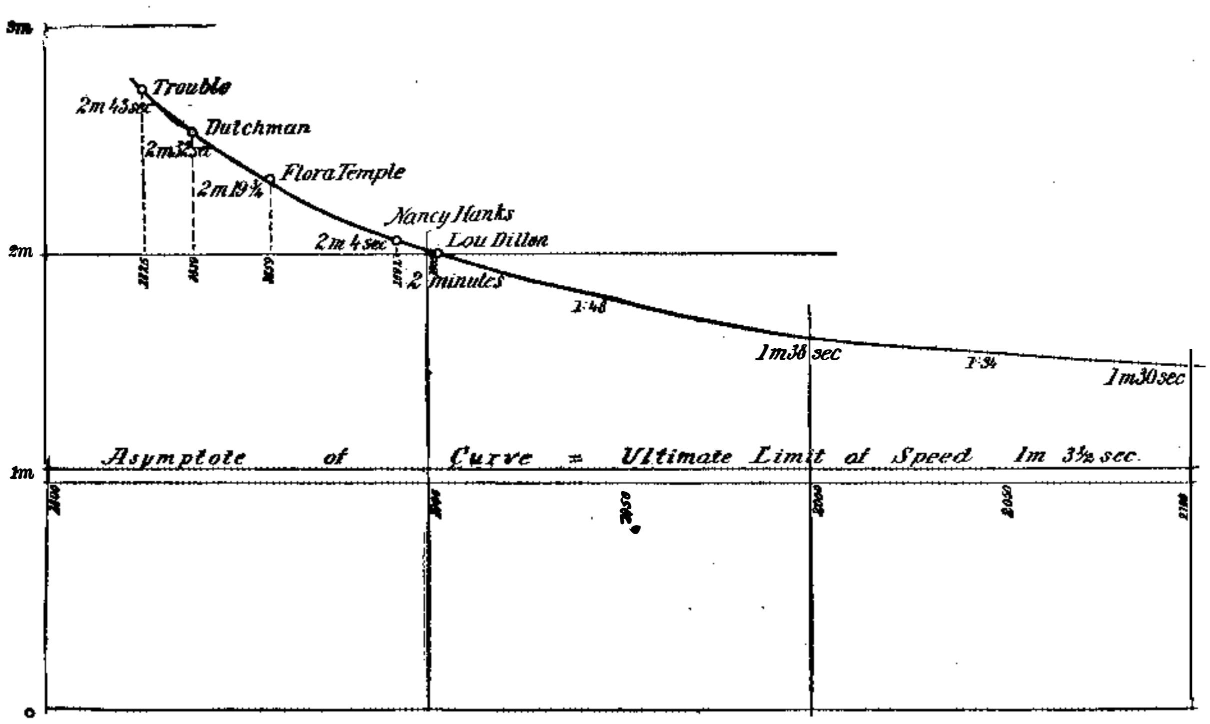
End View of the Airship, Showing the Belt from which the Framework Carrying the Deck is Suspended. The Gas-bag is Flat at the Bottom.

THE SPENCER AIRSHIP FOR 1903.

pounds. Beneath the balloon is suspended the car or keel. This is a framework structure of bamboo of the same design as employed in the first vessel. It is about 50 feet in length, and is constructed of three horizontal ribs arranged in the form of a triangle with the apex uppermost. The top rib has a slight downward curve from the center to the ends, the two lower ribs rising up a little to meet it at each extremity. The top rib has a vertical height of 4 feet 3 inches above the base, while at intervals of 3 feet 4 inches are placed cross struts to give strength and support to the ribs, and to insure rigidity to the whole structure. An end sectional view of the frame at one of these strengthening points has the shape of an isosceles triangle. The upper rib is built up of lengths of bamboo 3 inches in diameter, while the bamboo for the lower ribs is slightly thinner. The lengths are joined together by means of metal sockets, while the triangular bamboo struts, which are much thinner, are secured to the ribs by means of metal clips. At the point of the keel where the motor is placed the bamboo cross supports are replaced by angle steel frames in order to supply the necessary support to carry the engine.

Bamboo is employed for the keel, as it has been proved to be the most suitable for this purpose, owing to its combined lightness and strength. Ash and hickory, though very strong, are deficient in that lightness which is such a prominent characteristic of bamboo, and in the construction of a framework for such an airship as this, the maxim, "the minimum of weight with the maximum of strength," must be rigidly adhered to. On the other hand, pine, though sufficiently light if made thin enough, and strong, does not possess the flexibility and elasticity of bamboo. Aluminium or steel tubes might also be used, but owing to their liability to kink and buckle when brought end on into sudden contact with an obstacle, such as the ground, hedges, or the branches of trees, their utilization is not advisable. Bamboo is of such a springy nature, that it gives and takes with the shock, and so does not sustain any permanent injury.

At the bow of the vessel is placed the tractor or propeller which imparts the traveling motion to the craft. This innovation constitutes a prominent feature of the Spencer airship, which is *drawn* instead of being *forced* through the air. It is of the two-bladed form, with a total diameter of 12 feet, and a pitch of 15 feet. This tractor will make 300 revolutions per minute, and will just consume the power generated by the petrol motor, which is placed about 17 feet distant from the bow of the keel.



EQUILATERAL HYPERBOLA SHOWING THE LAW OF TROTTING IMPROVEMENT.

The petrol motor is of the four-cylinder type and is exactly the same as those employed for motor cars. It develops 24 brake horse power, and will have a thrust of 250 pounds. The petrol is carried in a small vessel placed above the water tank, the spirit gravitating therefrom to the carbureter. Sufficient petrol will be carried for five hours' journey, but this supply can be easily augmented if longer journeys are contemplated.

To avoid any possibility of the gas exuding from the balloon being ignited by any hydrogen flame issuing from the exhaust of the motor, the exhaust gases empty into a specially designed safety box of wire gauze. By this device there is no danger of any repetition of the lamentable disaster which befell Severo in Paris.

Amidships is placed a large water tank, which constitutes one of the novelties of this latest vessel. It is for the dual purpose of cooling the motor, to which the water is conducted through tubes, and also as ballast for lightening the airship to counteract the variations of temperature which are constantly altering the weight and buoyancy of the vessel. For ballasting, the water will be discharged from the tank until the minimum level is reached, this minimum level being that requisite for the cooling of the engine. The circulation of the water from the tank to the cylinder heads is maintained by means of a centrifugal pump, driven by the motor, as in the automobile. The tank has a capacity of 25 gallons of water, which is equivalent to approximately 250 pounds of ballast.

About 34 feet from the bow of the keel is the car which contains the aeronauts. It is oval in form, the top rail being made of bent ash, with a wicker-work platform upon which to stand, and rope lattice sides.

The rudder at the rear of the keel consists of a quadrilateral surface of balloon fabric stretched on a bamboo frame. Its dimensions are 15 feet by 20 feet. Two lines lead from it to the aeronauts' car, and it is easily and quickly manipulated in any manner desired by the aeronaut.

A further distinct improvement in this year's airship is the communication between the motor and all its driving parts from the car. This is carried out by Bowden wires, attached to levers placed in the car. By this means, perfect control is insured over the engine, the levers actuating and regulating, respectively, the sparking and the air mixture to the petrol. The ignition is the Simms-Bosch magneto-electric. The motor is started from the car, the lever for which communicates with the crank shaft, so that the engine may be started whenever desired, either on the ground before leaving, or after the balloon has ascended. This is a most valuable improvement since should the engine have to be stopped for any reason while the ship is in mid-air, it can be immediately and easily started again without necessitating return to the ground.

The balancing gear also communicates with the aeronaut in his car by means of the pendent trail or guide rope, and the upward and downward motion of the balloon can be altered at will. If the guide rope is drawn to the front of the keel, naturally the bow of the vessel will point downward in the direction of the earth, and will descend by the action of the tractor. If, on the other hand, the guide rope is drawn to the rear, then the front of the vessel rises and the tractor has a tendency to increase the altitude of the airship.

The inflator is also placed at the car and is in the form of a fan actuated by hand. By means of this contrivance the constant distension of the gas vessel is insured. In the event of a lower pressure causing the gas to contract inside the balloon, by bringing this pump into action air is forced into the balloon to replace the lost gas. The employment of this pump dispenses with the necessity of placing a ballonette within the gas bag, which principle has been adopted in some air vessels built on similar lines to the Spencer craft. The hand pump has the further advantage of enabling the aeronaut to vary the weight of the whole airship. Should the vessel continue to rise above the desired point, through the lifting energy of the gas, by pumping air into the balloon the gas can be displaced, escaping through the automatic valves, and so lessen the specific gravity of the whole, causing the vessel to be slightly heavier than the air and thus to exert a downward motion until the desired equilibrium is attained. It will be seen that this ingenious system also obviates the necessity of opening the main valve to insure descent.

The automatic valves are so made as to open when a pressure of gas equal to one-half the bursting point of the balloon is reached. A constant pressure is therefore maintained in the gas envelope, but not such a pressure as would cause the fabric to break.

A further precaution has been adopted by means of which in the event of the balloon bursting, the fall of the airship may be lessened in force. The keel or car is suspended from the balloon itself by means of a horizontal hempen webbing extending completely round the lower part of the gas bag. Consequently, should the balloon burst either below or above the line at which this horizontal webbing is attached to the fabric of the envelope, the remains of the silk would float upward and form a parachute, and thus by offering sufficient resistance to the air, prevent a too rapid descent, and avert a disaster which otherwise would be inevitable.

The tractor is driven by spur gearing. The crank shaft from the motor to the bow of the keel, is supported upon adequate bearings. The pinion at the end of this propeller shaft meshes in a spur wheel. As the motor is balanced to 1,500 revolutions per minute, and it is only desired to drive the tractor at 300 revolutions per minute at full speed, a ratio of 5 to 1 drop is made; i.e., the spur wheel is five times the size of the driving pinion. The motor is provided only with two speeds, one forward and one reverse. It is furthermore provided with a free wheel clutch so that the tractor may be thrown out of action without stopping the engine, and the racing of the latter under such conditions can of course be prevented by retarding the ignition lever in the car.

A NEW RECORD IN HORSE TROTTING.

BY S. W. BALCH.

The gradual lowering of the trotting record during the last century from a mile in three minutes to the new record of Lou Dillon on August 24 has led many to question if a limit is ever to be reached. The mathematician has a rule to guide him in a guess at the answer to just such questions. In 1892 the writer undertook to discover the law of trotting improvement and published his results in the SCIENTIFIC AMERICAN of September 24 of that year. A gradual lessening of the rate of improvement which would indicate an ultimate limit did not then appear. The chart accompanying that article did indicate, however, that at the end of the century the trotting record would lie between 2:03 and 2:04, as has proved to be the case, The Abbott in 1900 lowering the record to 2:03¼.

With our new record a new chart becomes necessary. The vertical lines represent the years in which the record has been lowered, the spaces between the lines indicating the time interval, the length of each vertical line indicating the record for that year.

A curve is next sought that will pass through as many of the points as possible, or close to them, and the continuation of this curve across lines indicating future years shows the best answer to the main question that the facts warrant.

If the curve proves to be a hyperbola, it will afford confidence in the accuracy of the solution, for a peculiar property of the hyperbola is that it constantly approaches but never reaches a straight line called an asymptote, and this asymptote represents the ultimate rate of speed. With Lou Dillon at the two-minute mark, a point is indicated on the chart showing this hyperbolic curve as the law of improvement. It is now possible to pass the curve of a hyperbola through the record points of Trouble in 1826, Dutchman in 1839, Nancy Hanks in 1892, and Lou Dillon in 1903. This curve will be within a few seconds of many other records in which the time was notably reduced.

The hyperbola is represented by the equation

$$xy = 10{,}000,$$

in which x equals the number of years since 1726, y equals the number of seconds over 63½ seconds to trot a mile. The notable records of Maud S. in 1881 and 1885, with the high-wheel sulky are 2¼ to 3¼ seconds above the curve, which would indicate that the change to the pneumatic sulky will account for this measure of the improvement. This curve places the ultimate limit of trotting speed at a mile in 63½ seconds, which, though constantly approached, will never be reached actually, and it indicates the minute and a half mark as two centuries away.

The New Pennsylvania Railroad Bridge.

On August 23 the bridge constructed by the Pennsylvania Railroad Company between Trenton and Morrisville across the Delaware River was opened for eastbound traffic. The new bridge will bring Philadelphia and New York twenty minutes nearer each other. The length of the new structure is 1,080 feet; its width 55 feet. The bridge is wide enough for four tracks, two for passenger service and two for freight and coal trains. With the exception of that at New Brunswick, this is the only bridge on which four parallel tracks are laid.

The actual cost of the bridge was $1,000,000, but about $2,500,000 additional was spent on approaches and in removing several grade crossings. Two bad curves have been done away with, so that much faster time can be made by the trains. The total number of grade crossings abolished between the two cities is 125.