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.

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.

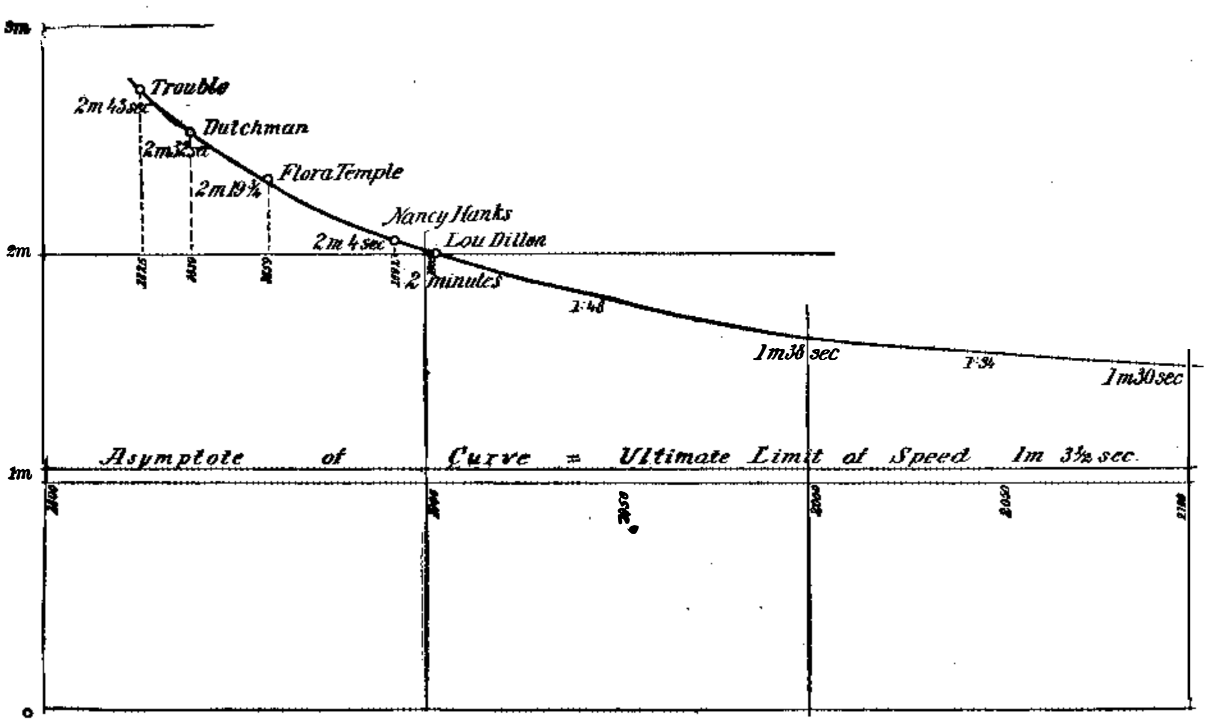
The tractor is driven by spur gearing. The crank shaft from the motor to the bow of the keel, is supported upon adequate bearings. The pinion at the end of this propeller shaft meshes in a spur wheel. As the motor is balanced to 1,500 revolutions per minute, and it is only desired to drive the tractor 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.



EQUILATERAL HYPERBOLA SHOWING THE LAW OF TROTTING IMPROVEMENT.

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.