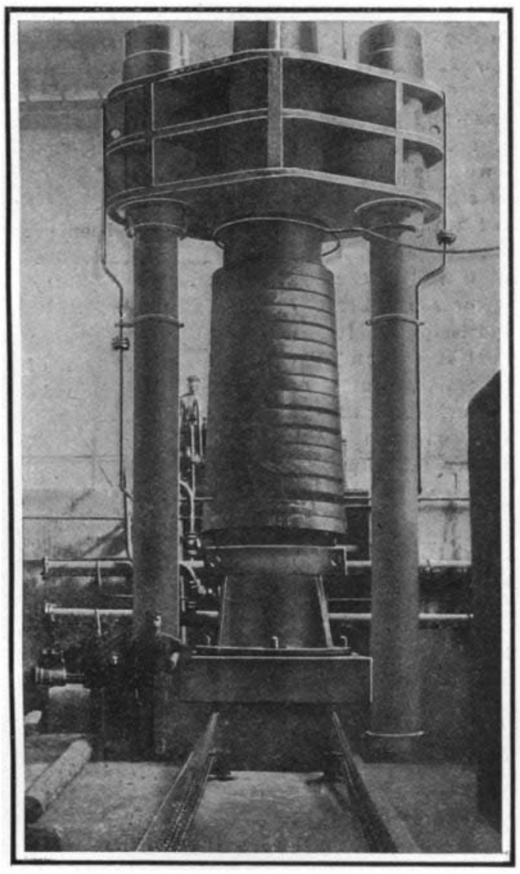
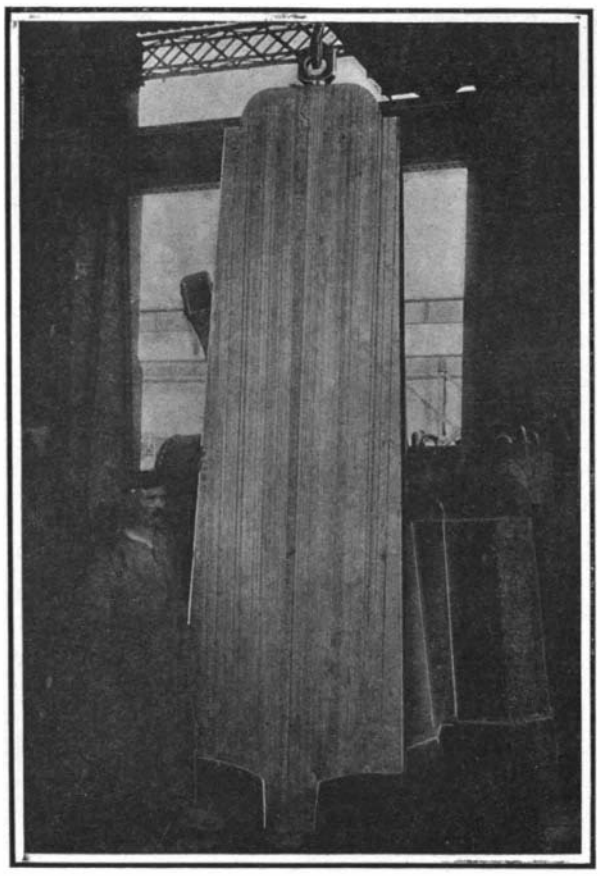
FLUID COMPRESSION OF STEEL INGOTS.

BY J. F. S. SPRINGER.

In the older days, when railway rails were made of wrought iron, the casting of ingots does not seem to have been attended with the grave disadvantage of piping so common to-day. It would appear that the tendency to pipe is clearly traceable to the carbon content of the metal, and that steels having higher percentages of carbon are more subject to this defect than the milder varieties. Consequently, with the high carbon percentages prevalent and necessary to modern rail steel, the piping of ingots has come into especial prominence, on account of the breakages of rails attributed largely to this cause.

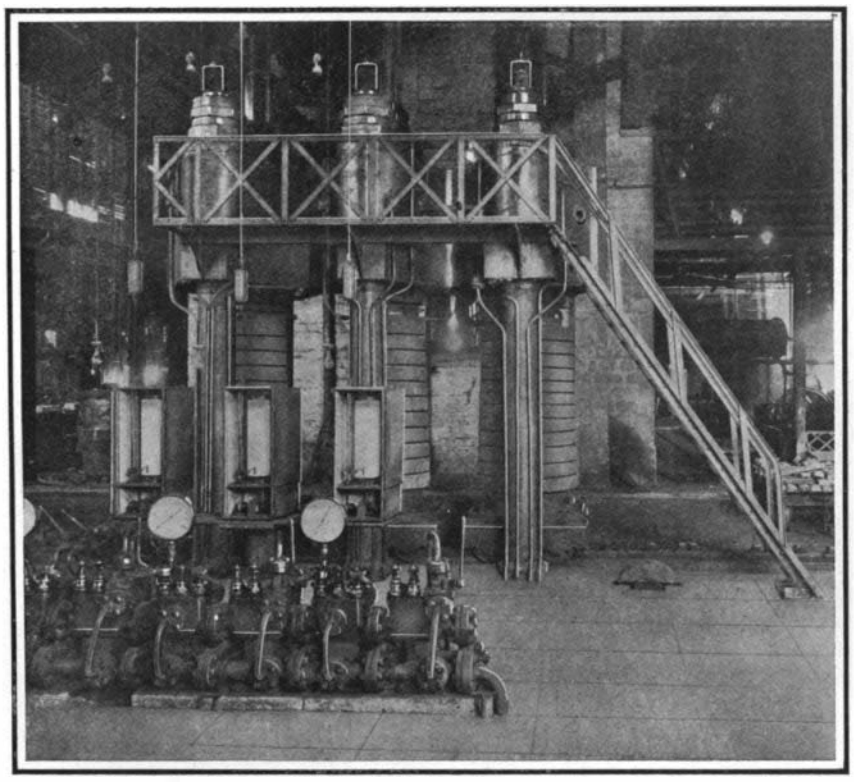
A pipe is a cavity—of the form of an inverted cone—which forms in the upper part of the ingot as it cools subsequent to the pouring process. This cavity is sometimes short; at other times it extends downward 30 or 40 per cent. of the length of the ingot. Apart from special methods of treating the steel, it is necessary to cut off this unsound portion in order to get perfect steel. In fact, it is really necessary to discard more than the portion actually piped in order to eliminate a further evil. This is the segregate. It is a locality where the carbon, sulphur, phosphorus, and other components of the steel are found in excess. This defective steel is usually found near the bottom of the pipe. To eliminate it, somewhat more than the strongly piped portion of the steel should be cut off.


A 3,500-ton fluid-compression press capable of taking a 22-ton ingot.

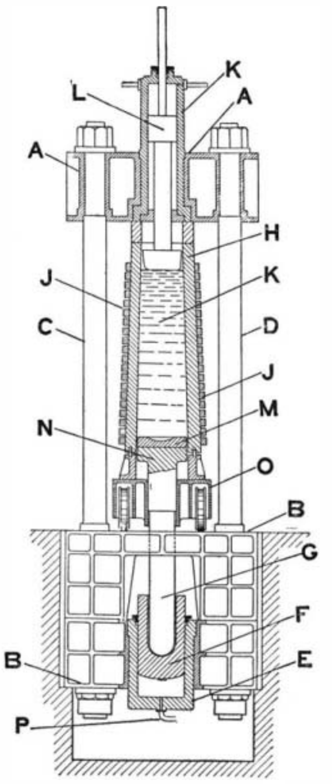

An 18-ton ingot sawn in two to show absence of piping.

Now, the great expense of securing sound steel by reducing to scrap such enormous percentages of the ingot as cast, long ago induced inventors to seek a more profitable solution of the problem.

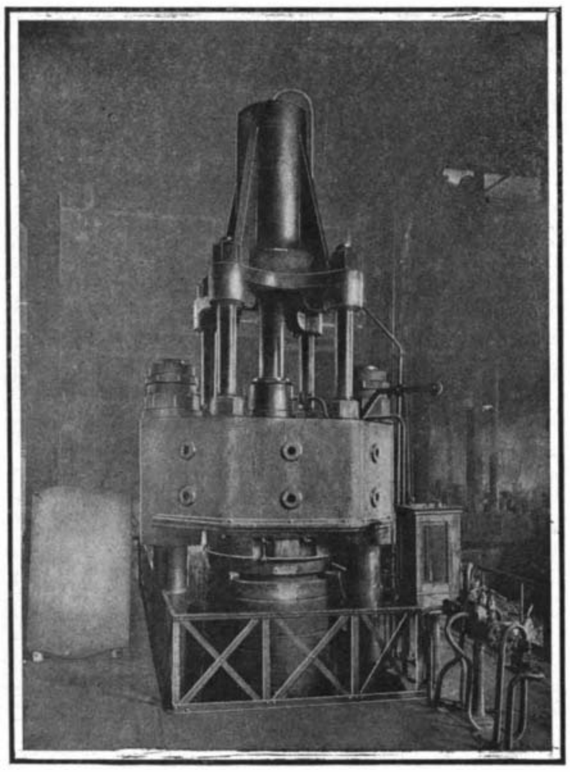
Some few years ago a new process was developed in France, which seems to be exceedingly effective in eliminating the pipe and reducing the tendency to form segregates. This is the Harmet system of fluid compression by "wire drawing." It has been rather extensively adopted in Europe. The ingot is cast in a tapering mold, the smaller end being up. As the mold is at a much lower temperature than the molten metal, and is quite massive in addition, the freshly cast ingot soon solidifies upon its base and on the sides. While this shell-like portion goes on contracting as cooling proceeds, still it is at a slow rate. It remains of approximately the same size as when first formed.


Group of three 1,000-ton presses.

In front of these are the three recording drums and the controlling apparatus.



Section through a Harmet fluid-compression press.


View of large Harmet press at St. Etienne.

View from the operating platform, showing the stripping cylinder, the cross-head, the massive tie bolts, and the upper part of reinforced mold.

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However, the contraction which took place upon solidifying has the effect of withdrawing the sides of the ingot from the mold. Moreover, the mold, expanding from the influx of heat, increases this separation. By the Harmet process, the bottom of the mold, which is movable, is forced upward by hydraulic means, bringing the ingot and the sides of the mold again into contact. The forcing of the bottom upward continues, however, and this results in the sides being forced in upon the fluid interior. The tapering form of the mold is the controlling factor in this compressing process. As it goes on, the internal mass feels the effects, and any cavity-forming tendencies are counteracted from the outset. This method has been termed a "wire-drawing" process. This is scarcely correct, seeing that, although a wire is passed through a reducing plate to which the tapering mold indeed corresponds, still the ingot is pressed from behind while the wire is drawn from the front—an essentially different procedure. In the diagram, we have a vertical sectional view of a Harmet press. There are two cross pieces, *AA* and *BB*. These are kept separated by the tie bolts, *C* and *D*. The lower cross piece may be sunk below the surface of the shop floor. Within this cross piece is arranged a hydraulic cylinder *E*, which is served by the pipe *P*. Within the cylinder is a piston, *F*, containing a well in which lies the plunger *G*. These three pieces, *E*, *F*, and *G*, are of forged steel. The cross pieces are cast iron. The plunger *G* passes up through an opening in the cross piece *BB*, and projects above the surface during the operation of the press. Within the upper cross piece *AA* is the cylinder *K*, containing a double-acting piston *L*. These are the main essentials of the press proper.

When it is desired to compress an ingot, the car *O*, which runs on a suitable track, is brought over the lower cross piece into an exact position mechanically determined. Upon this car is the mold *H*, reinforced by the metal bands *JJ*. This mold contains the freshly-cast ingot *K*. The double-acting piston *L*, controlling a plunger, may be let down until the plunger rests on the upper surface of the molten metal. The piston or plunger *N* forms a movable bottom for the mold. However, in order to preserve the surface of this piston, the removable piece *M* is inserted.

The tie bolts may be hollow. This permits of one (*D*) being used for the purpose of conducting the water to the cylinder *E*, by the pipe *P*. The hollow space in the other (*C*) affords a conduit for two cords attached to the piston *F*. These are not shown, however, in the diagram. Both of the cords pass through to the upper part of the apparatus, where one is connected with a recording device, while the other is connected with the accumulator.

In operating the press, the upper piston and plunger do not serve as compressors. They may rest idly, however, upon the top of the molten ingot. The lower piston *F* is the compressor. It is actuated by hydraulic power. As it is thus forced upward, it carries with it the plungers *G* and *N*, forcing the ingot upward into the tapering mold.

The compressing process is continued slowly from the moment a sufficient shell is formed until the entire ingot is solidified. This is a period which varies greatly on account of the difference in size of the ingots. An ingot of thirty tons would require about five hours, while the tiny block of 100 pounds would probably "freeze" in a very few minutes. Of course, form enters here, but the extremes given will afford an idea of the usual conditions.

When the ingot has been compressed to the moment of solidification, the upper piston and plunger are operated to discharge it from the mold. However, it is of advantage—if the press be of sufficient power—to continue compression until the ingot has fully cooled to some reasonably low temperature. This latter procedure is, however, scarcely applicable to the large ingots, on account of the enormous pressure requisite to maintain compression after the solidifying point has been reached. But for the small blocks this process is said to produce freedom from these defects arising from the internal stresses set up by contraction of the solid mass.

In carrying on this compression, it is important to go neither too fast nor too slow. The effort is just to exceed the continual contraction, thus producing a compressive effect. But to do this is not so simple as might at first blush appear. The molten mass lies within the solidified shell, and the purpose is that compression shall proceed just fast enough to have the fluid continually on the point of overflowing. The top of the ingot is, however, down within the apparatus and not favorably situated for observation. So, in order to determine the precise rate, the upper piston and plunger are removed, and a mirror fitted at an angle of forty-five degrees at the top of the press, in such position as to reflect to the eye the conditions at the top of the molten ingot. In this way one or more experimental ingots may be compressed. These may, indeed, be split open and examined. In the meantime, a record has been made through the agency of one of the cords running from the lower piston. This is kept in tension by a small drum and spring coil. The cord controls a pencil which slides up and down, in a vertical direction, in accordance with the rise and fall of the lower piston. While the pencil moves thus vertically, it traces a line on paper wound upon a drum which is rotated by clockwork. In this way a curve is drawn recording the movements of the piston in compressing the successful experimental ingot. In practice, this curve is duplicated, an attendant keeping watch during the operation of the machine.

Two of the very largest presses are now in operation in Great Britain—one capable of compressing a 34-ton ingot being in Scotland, the other competent to handle an ingot of 40 tons being in England. There are, scattered over Europe, thirty-two Harmet presses in actual operation.

It may be sufficient to say in reference to the quality of the steel that the French government accepts Harmet ingots with only a 5 per cent discard from the top of the block.

THE NEW UNITED STATES BATTLESHIP "MISSISSIPPI."

On March 3rd, 1903, Congress authorized the construction of two battleships, which were to be of 13,000 tons displacement and carry the maximum armor and armament and have the maximum speed compatible with this limited displacement. In the previous year two battleships, the "Connecticut" and "Louisiana," had been authorized; but in their case the displacement had been set by Congress at 16,000 tons. On that more generous allowance the naval constructors were able to provide an armament consisting of four 12-inch guns, eight 8-inch, twelve 7-inch, and twenty 3-inch. The protection consisted of a waterline belt from 9 to 11 inches in thickness, 12 inches of armor on the 12-inch gun turrets and 6½ inches on the 8-inch gun turrets, and the speed, with 16,500 horse-power, was 18 knots. Coal bunkers were provided with a capacity of 2,275 tons.

With a ship of the above characteristics before them, the naval constructors were presented with the problem of seeing how many of its effective elements they could retain in a ship of 3,000 tons less displacement. The result is seen in the two sister ships, "Mississippi" and "Idaho." Their length is 375 feet, beam 77 feet, and mean draft 24 feet 8 inches, as against 450 feet length, 76 feet 10 inches beam, and 24 feet 6 inches mean draft in the case of the "Connecticut." The distribution of the armor is as follows: There is a waterline belt 9 inches in thickness amidships, which extends from stem to stern, and gradually reduces to a thickness of 4 inches at the ends. Above the belt the sides of the ship are protected by 7 inches of armor to the level of the gun deck, and the 7-inch guns mounted upon the gun deck are also protected by 7 inches of armor. The protective deck, which is located at the level of the top of the main belt armor, is 1½ inches thick on the flat portion, and 3 inches in thickness where it slopes down to a junction with the bottom of the armor belt. The 12-inch gun turrets are protected by 12 inches of armor on the front plate and 8 inches on the sides and rear. The 9-inch gun turrets carry 6½ inches of armor on the front plate and 6 inches elsewhere.

The battery for a ship of 13,000 tons displacement is unusually powerful. It consists of four 45-caliber 12-inch guns, mounted in two turrets forward and aft. These guns are of great length, measuring 47 feet from breech to muzzle; and although the bore is 12 inches, they are so long that, in the deck view of the guns on our front page, this length, assisted by the fore-shortening of the photograph, makes the gun look like the proverbial "pipe stem." The intermediate battery consists of eight 45-caliber 8-inch guns, mounted in four turrets on the main deck, in the positions shown in our photograph. The axes, both of these and of the 12-inch guns, are about 26 feet above the water. On the gun deck is a battery of eight 7-inch guns mounted in broadside, two of which can be trained dead ahead and two dead astern. They are protected by side armor of 7 inches of steel and by circular gunshields fitting snugly in the opening, which are 6 inches in thickness. For torpedo defense a dozen 3-inch rapid-fire guns and fifteen smaller guns are mounted in various suitable positions throughout the superstructure and bridges. There are two submerged torpedo tubes for firing the new 21-inch turbine-driven torpedo.

So far, so good. The powers of defense and attack as represented by the guns and armor are very formidable for a ship of this size. When we come, however, to the questions of speed and coal supply, there is a serious falling off as compared with the "Connecticut," the bunker capacity being reduced from 2,275 tons to 1,800 tons; and the speed, which in the case of the "Connecticut" was 18.78 knots on her trials, falls to 17.11 knots in the "Mississippi." It is when we consider this question of coal supply and speed that the folly of Congress, in arbitrarily limiting the displacement to 13,000 tons, is evident. In these days of 19, 20, and 21-knot battleships, the possession of only 17 knots speed practically relegates the "Mississippi" to the position of a second-class battleship. If she took her place in line with our own "Dreadnoughts," their speed in battle would be limited to the 15 or at most 16 knots, which would probably be the best that the "Mississippi" could be depended upon to do, if called upon suddently during the long period of wear and tear incidental to a naval campaign. As a matter of fact, she would prove to be something of a handicap to the average battleships of the pre-"Dreadnought" period, such as the "Connecticut" and "New Hampshire," or the 19-knot vessels of the "Georgia" class. It is quite conceivable that in some critical maneuver of a sea fight, in which the possession of a knot or two of additional speed was of vital importance, the 17-knot "Idaho" and "Mississippi" might prove to be a decided handicap upon the remainder of the fleet.

This, however, is pure theorizing, and the chances are that if the "Mississippi" were ever called upon to cast loose her guns for an engagement, she would be able, at least with vessels of her own pre-"Dreadnought" type, to give and take the hard knocks of a sea fight with credit to herself and the flag she flies. Particular interest attaches to the "Mississippi" at the present time because of her voyage up the noble river of the same name.

The contract for the "Mississippi" was signed January 25th, 1904; her keel was laid May 12th, 1904; she was launched September 30th, 1905; and she went into commission February 1st, 1908.

Sir William Ramsay on the Transformation of the Elements.

In the course of his recent presidential address before the Chemical Society, London, Sir William Ramsay said, as reported in the London Times, that his subject was the hypothesis that the genuine difference between elements was due to their gain or loss of electrons. The question was whether, to take a concrete example, an atom of sodium by losing or gaining electrons remained an atom of sodium, or whether the loss or gain of electrons did not cause it to change into some other element or elements. Having stated some theoretical arguments in favor of the possibility of transformation, he went on to describe some experiments bearing on the question. He first mentioned the transformation of radium emanation into helium, which had been amply established. He next referred to his experiments on the action of emanation on solution of copper sulphate and nitrate. Four experiments were made, and with each exactly similar duplicate experiments were tried in which no emanation was employed. A larger residue was obtained in each case from the emanation solutions than from the duplicates, and while the residues from the emanation solutions showed a faint trace of lithium, those from the duplicates failed to give spectroscopic evidence of the presence of that element. The fact of the experiments having been carried out in duplicate rendered inapplicable the criticism of Prof. Hartley that accidental contamination with lithium was probable. As regards the alleged repetition of the experiments by Mme. Curie and Mlle. Gleditsch, who, using platinum vessels, obtained no greater residue and no trace of lithium, there were two possible replies—either the conditions were varied, or conceivably a trace of lithium from the glass vessel employed (which, however, had been tested for lithium with negative result) was dissolved in presence of emanation and copper but escaped solution in absence of copper or of emanation. A research on the action of emanation on solution of silver nitrate contained in a silica bulb yielded negative results, but he had stumbled across a case of apparent transformation while working in a totally different direction. On December 20th, 1905, 270 grammes of purified thorium nitrate was dissolved in about 300 cubic centimeters of water, and the flask in which the solution was contained was repeatedly evacuated by a mercury pump until no gas could be pumped off. The stopcock attached to it was then closed, arrangements being made so that if any leakage occurred it would be detected. After the flask had stood for 168 days the gas in it (5.750 cubic centimeters) was pumped out and examined for helium with doubtful results. The flask was again closed, and on August 3rd, 1907, after 173 days, the gas in it was again examined. Again the presence of helium was questionable, but 1.08 cubic centimeter of carbon dioxide was found. At the next examination, on March 30th, 1908, there was distinct evidence of a helium spectrum, and the gas contained 1.209 cubic centimeter of carbon dioxide. It was then thought possible that the carbon dioxide had been produced from the grease of the stopcock, and therefore a little mercury was introduced into the capillary tube leading to the stopcock so that the latter was protected from contact with the thorium solution. After 310 days the gas was again withdrawn. Instead of three or four cubic centimeters, no less than 180 cubic centimeters was collected; it was almost pure nitrogen, but in all 0.622 cubic centimeter of carbon dioxide was separated from it. These experiments, Sir William Ramsay said, rendered it at least probable that thorium engendered carbon dioxide, or, in other words, that carbon was one of its degradation products. Experiments further indicated that the action of radium emanation on thorium nitrate solutions was also attended with the formation of carbon dioxide, and the same was the case with an acid solution of zirconium nitrate. An experiment with lead chlorate proved blank, but with bismuth perchlorate the formation of carbon dioxide appeared certain. In conclusion Sir William Ramsay, after mentioning that every precaution which could be thought of was taken to exclude foreign gas, said that while these were the facts, no one was better aware than he how insufficient was the proof, and that many other experiments must be made before it could be confidently asserted that certain elements, when exposed to "concentrated energy," underwent degradation into carbon.

Oxygen and Water Vapor on Mars.

After a careful study of the spectrum of Mars, Director W. W. Campbell of the Lick Observatory has decided that oxygen and water vapor in the atmosphere of Mars do not exist "in sufficient quantities to be detected by the spectroscope as available." Prof. Campbell refers to the study of this subject by such eminent scientists as Sir William Huggins and Vogel and others in the sixties and seventies and by himself in 1894 and 1895. Prof. Campbell quotes the words of Mr. Slipher of the Lowell Observatory at Flagstaff, Arizona, whose observations of the spectrum of Mars show no selective absorption not found in that of the moon photographed under the same conditions. This conclusion from the Lowell Observatory, confirming the visual observations of Prof. Campbell in 1894 and of his photographic work in 1895, and of Prof. Keeler's photographic work of 1897, is opposed to the well-known theories of Huggins, Vogel, Maunder, and others.

Transatlantic Record Reduced.

The transatlantic record from Queenstown to Sandy Hook was again reduced on the last trip of the "Mauretania." She left Queenstown on Sunday, and anchored at Quarantine on Thursday night, reaching her dock in New York at 7:30 Friday morning, May 21st. The time of the passage from Daunt's Rock to Ambrose Channel lightship was 4 days, 16 hours, and 53 minutes, and the average speed for the whole trip was 25.62 knots.

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Another victory for the air-cooled Franklin engine was in the third annual Harrisburg endurance contest recently concluded. The contest included four days of touring, covering 694 miles of very varied and often very bad roads, followed by a minute examination of all parts of the competing machines by a committee of experts, marks being deducted for wear or any dislocation of working and other parts after the trials as well as for any stops for repair during the run. The fact that not a single perfect score remained at the end of the third day shows the severity of the conditions; and the combination of this with the fact that not a single complaint or protest was made by contestants, is a tribute to the tact and justice with which the officials conducted the trial. The winning Franklin car was a 4-cylinder 28-horse-power driven by C. S. Carris; a 30-horse-power Pullman, and a 50-horse-power 6-cylinder "Peerless" were second and third, only two marks apart; and a 20-horse-power White steamer car was fourth out of fourteen cars, of which only two failed to finish.