European astronomers. He continued with his insignificant equipment until finally an appropriation of $25,000 was secured—still for a depot of charts and instruments. The observatory had been urged time and again, but for partisan reasons it was as often forbidden.

The site chosen by President Tyler was fraught with historic interest. It embraced the whole of reservation No. 4, made by the old commissioners of Washington for a national university—a favorite idea of George Washington. It was the landing place of Braddock, and at a later day was known as Camp Hill, from its being occupied by the American forces the day before their advance upon the retreat from Bladensburg. The square embraced a little over 19 acres and commanded a splendid view of Washington, Alexandria, Georgetown and Arlington.

Berlin, Paris, Greenwich and Vienna presented some 200 rare volumes of the highest standard as a nucleus for an astronomical library. This branch has grown from that to one numbering 22,000 volumes and pamphlets, and stands to-day second to Poulkawa only.

The institution grew rapidly, and in 1874 installed the largest telescope then in existence, the famous 26-inch equatorial. It was set in place just in time to observe the transit of Venus, which occurs but once in a lifetime and offers a valuable method of determining the sun's parallax (the base time measurement of celestial distances). The transit is the astronomers' great event of the century and it befell Prof. Newcomb to be in charge of the greatest telescope.

The site was soon discovered to be a bad location, because, being almost in the heart of the city there was constantly some vibration, but it was not until 1884 that appropriation and other necessary bills could be gotten through Congress for the purchase of enough ground on Georgetown Heights to properly isolate the institution.

In 1893 the new home was ready for occupancy.

The dome that houses the great equatorial is a wonderful piece of mechanism. It is so perfectly balanced that its great weight of six tons can be swung or raised and lowered like a see-saw by one man without much effort. The dome rolls around on a circular wall so as to present an opening toward any part of the heavens. The whole floor rises and falls by hydraulic power to suit the convenience of the observer.

The great equatorial is in the hands of Prof. T. J. J. See, who is now at work measuring by daylight as well as by night the diameters of the principal planets and their satellites. The comparison of the daylight with the night work enables the observer to eliminate the effects of irradiation, which heretofore has been studied very little by astronomers. The light planet against the light sky of day has no irradiation as it has at night. He is also, by an elaborate series of observations in summer and in winter, making a special study of the screw of a new micrometer, designed to eliminate the effects of changes of temperature upon the scale. The degree of accuracy obtainable in this work is about one part in twenty thousand. This will give the micrometer investigation the necessary degree of refinement for the measurement of the stellar parallax, upon which he is at work also, and which is the most delicate work ever undertaken by a practical astronomer.

Beside the 26-inch equatorial, the observatory is equipped with a 9-inch transit circle, a 6-inch transit circle, a 12-inch equatorial, a prime vertical transit instrument, a 6-inch azimuth and a 40-foot photoheliograph. With this last, photographs are taken of the sun daily whenever the weather and other circumstances will permit. During last year one hundred and sixteen photographs were made of the sun. A very delicate plate with a special fine-grained lantern-slide emulsion giving contrast and fine definition has to be used, and the plates specially developed.

The effort to bring the department of meridian observations for time to a state of the highest efficiency and up to the most modern standard of requirement has included not only a recent thorough overhauling of both meridian instruments, but also an examination and improvement in the clock system. In this connection a vault was dug in the basement of the clock house, 8 feet square and 7 high. The construction of the vault is intended to be such that it will keep the temperature very nearly constant throughout the year. A 9-inch brick wall incloses the wooden house of the dimensions stated, with an air space of one foot between, which contains hot-water pipes for heating. The whole is roofed over with boards inclosing a 6-inch layer of asbestos wool. The vault contains three brick piers for clocks and one smaller pier which may be used in mounting a pendulum apparatus for testing the minor irregularities of clock rates. Triple doors are provided and means for slow ventilation. The location is on the summit of a hill, and drainage conditions are such that the basement in which the vault is situated is remarkably dry. There is little fear of damage from rust. In the early days of the observatory, in a similar experiment the clock built by Kessels, a most delicate instrument, and the most valuable of its kind in the country, was almost ruined.

An observation for time is taken about every other day. There are three standard clocks always in use and two to which the Western Union wires are attached for transmitting the noon signals. Every day, except Sundays, these signals go out. An average error of 0.13 seconds is recorded for the past year. The Kessels clock will not stand being attached to the wires, and with the others it gives the time about as accurately as it can be given. The chronometer room is maintained at an even temperature and is treated almost as delicately as is the room for the great clocks.

A NEW SCHNEIDER-CANET NAVAL GUN.

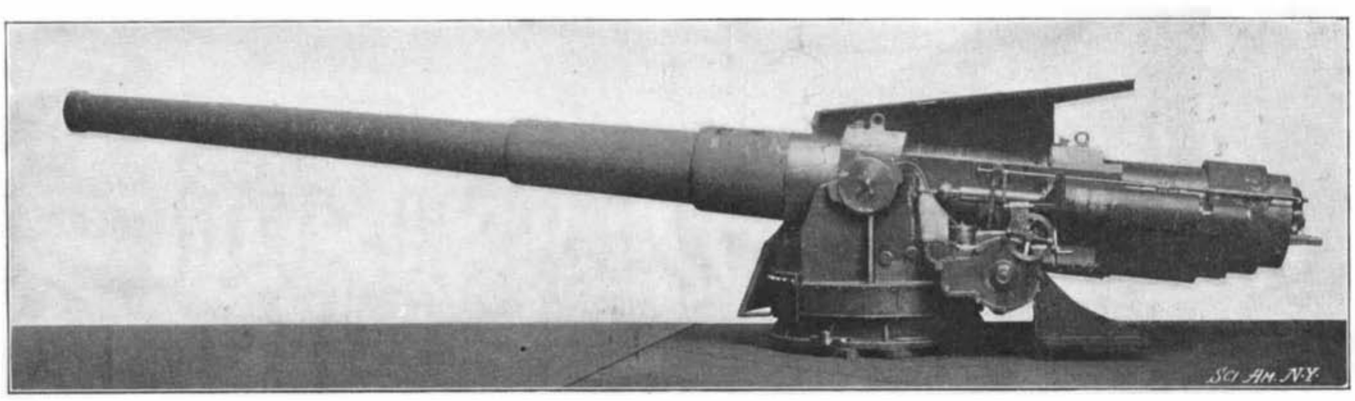
Our illustration shows a new 9.45-inch gun for naval or coast defence purposes, which has recently been brought out by the well-known French firm of Schneider & Co. The weight of the gun itself with breech mechanism is 20½ tons, while that of the carriage without the shield is 13¼ tons. The projectile used weighs 330 pounds and its initial velocity is 2,780 feet per second.

The diameter of the gun at the breech end is 36.22 inches. The breech is closed by a plastic obturator, or metallic plug, that can be locked in place or withdrawn by three and a half turns of the operating handle. Electric or percussion firing is employed as desired, with single control on the left of the gun-carriage. This mechanism is easily accessible for the gunner, who is suitably protected against premature discharges.

The gun-carriage is of forged steel and carries two diametrically opposite recoil cylinders, as well as a compressed-air recuperator, which is independent of them and is placed on the lower side. The recoil cylinders are suitably arranged for putting the gun out of or in battery by means of a pump. This enables the gunner to continue firing in case of damage to the recuperator, whatever may be the angle of elevation.

Vertical aiming is facilitated by the interposition of live roller rings between the trunnions of the carriage and the trunnion bedplate of the frame. The elevating hand-wheel, which is placed conveniently for the gunner, drives a toothed sector fastened to the carriage, by means of an endless screw and special helicoidal wheel furnished with friction packing washers to avoid shocks when firing. Horizontal aiming is accomplished by the traversing of the whole carriage, which turns on a ball-bearing traverse base ring. It is traversed by a hand wheel turned by the gunner. This wheel is connected with a pinion that meshes with a circular rack fastened by means of an irreversible mechanism of great efficiency. This mechanism, while assuring the absolute irreversibility of the system, permits of one man revolving the movable weight of 40¾ tons at a sufficiently rapid rate to follow an object moving at a speed of 34 knots and distant 1,640 feet.

Finally, this new 9.45-inch gun on a naval carriage offers the same facility of manipulation as has heretofore been obtained with rapid-fire guns of smaller bore.



SCHNEIDER-CANET 9.45-INCH GUN ON NAVAL MOUNT.

Weight of Gun, 20.5 tons. Weight of Projectile, 330 pounds. Initial Velocity, 2,780 feet. Muzzle Energy, 17,748 tons. Theoretical Perforation of Iron at Muzzle, 32.8 inches per second.

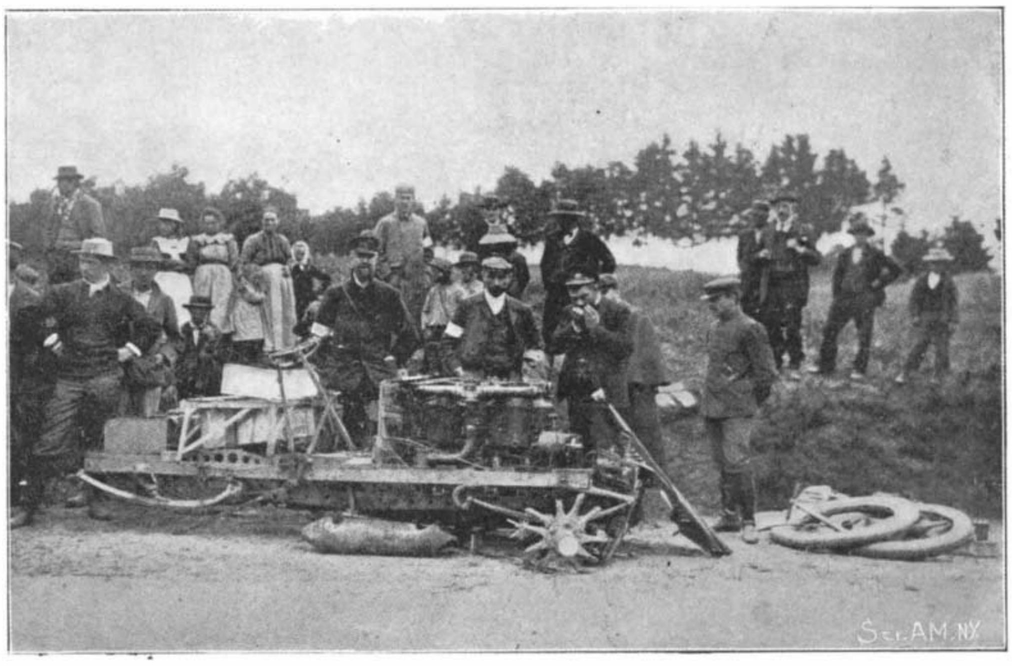
THE ARDENNES CIRCUIT.

With the completion of the *Circuit des Ardennes*, Englishmen have again scored a signal victory. The winner of the race was Mr. Charles Jarrott, who finished some nine minutes ahead of his nearest competitor, in a 70 horse power Panhard.

The race was run on a sort of huge track, measuring 85.4 kilometers to the lap, with no great grades to speak of. There were no controls, no halts of any kind to check the contestants. The race may, therefore, be regarded simply as a test of powerfully engined, high-geared cars under conditions offering the least resistance. For that reason the contest stands in sharp contrast to the hilly Paris-Vienna race.

Eighty-five kilometers in the opinion of many is a rather short lap. Indeed, the many accidents which happened in the circuit amply bear out the criticisms that have been made on this score. Pierre de Crawhaze, toward the end of a third lap, collided with M. Coppee. One wheel of de Crawhaze's car flew off, the other broke from the axle, and the car was dragged along for two hundred yards. No one was hurt. On the second lap one of Jenatzy's front wheels whirled through the air, while the car was traveling at about 65 miles an hour. The vehicle was overturned, and the driver and his assistant crawled out from under the ruins, not seriously injured. De Caters, on a Mors, was lost on the third lap in a cloud of dust raised by Jarrott, jumped on a wall, and impaled his car. On the same lap Roland in a Gobron-Brillié ran off the road and out of the race. Charron collided with a carriage at a speed of 90 kilometers an hour, and reduced his own vehicle and the carriage to splinters and scrap iron.

The race itself offered not a little excitement. It was a nip and tuck struggle between Jarrott and Gabriel. They were never more than 6 minutes apart at any of the turning points. For a long time it was uncertain whether Jarrott or Gabriel would win. At the end of the first lap Gabriel had gained two minutes; at the second he had gained one minute. At the half Jarrott led by less than half a minute. When



THE WRECK OF JENATZY'S CAR.

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the fourth lap began Jarrott led by a minute, and at the fifth lap Gabriel was one minute ahead. But when the sixth and last lap came, a chain accident put Gabriel out of the race, and Jarrott shot ahead. Zbrowski and Mr. Vanderbilt, both Americans, finished creditably. The times of the chief contestants for the total distance of 512.41 kilometers are as follows: Jarrott, 5h. 53m. 39s.; Gabriel, 6h. 2m. 45s.; Vanderbilt, 6h. 22m. 11s.; Rigolly, 6h. 52m. 16s.; Zbrowski, 6h. 44m. 40s.; Girardot, 6h. 55m. 55s. After racing 512 kilometers Mr. Jarrott made a run of 100 kilometers to Sedan to get a bed.

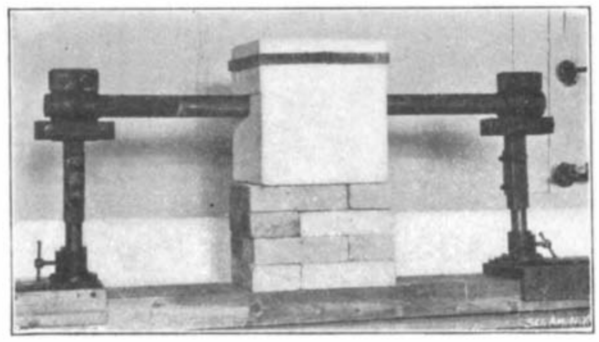
FORMATION OF THE DIAMOND BY THE ELECTRIC FURNACE.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

Among the important discoveries made by M. Moissan with the electric furnace, none is more striking than the artificial production of the diamond. While the specimens he obtained were of almost microscopic size, it is none the less true that crystallized carbon has been obtained, and it is the object of the present article to show some of the steps in the process and the results which were finally reached. Before commencing the work M. Moissan made a series of researches upon the different forms of carbon, both those which occur in nature and the different varieties of graphite formed by the electric furnace. From these studies he became convinced that if the diamond could be reproduced, the first crystals obtained would be of microscopic size.

It may be considered that the diamond of nature has been formed in the midst of a liquid or pasty mass, and the natural question is, what solvent has been used for the carbon. M. Moissan found that iron in fusion is the best solvent for carbon, and he was led to search for the crystallization of carbon in melted iron under high pressure. A meteoric iron from the Diablo Cañon, Arizona, shows in the midst of the metallic mass two small transparent diamonds. Here nature seems to have been taken in the act. The iron containing the carbon must have been at first in the liquid state, and owing to a sudden cooling there occurred a violent contraction of the mass, and the carbon passed from a density of 2.0 to that of 3.5, giving the diamond. From these considerations M. Moissan was led to the experiments in which he succeeded in producing microscopic crystals of carbon which gave all the characteristics of the diamond.

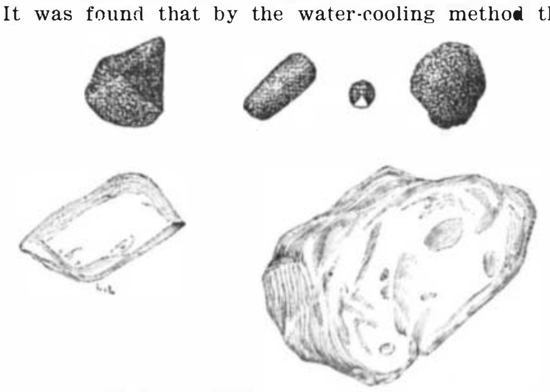
To carry this out he utilized the pressure produced by the increase in volume of a mass of iron when passing from the liquid to the solid state. Solid iron, as is well known, has a less density than the melted metal; pig iron, for instance, floats on a bath of melted iron. Like water, iron increases in volume at the moment of solidifying. The iron is now to be saturated with carbon at a high temperature and then suddenly cooled at the surface. The interior, while still liquid, is thus subjected to a high pressure. The iron must be saturated with carbon at a high temperature, and for this the electric furnace is used; the iron then dissolves a great quantity of carbon which it afterward abandons in the form of graphite or crystallized carbon. The electric furnace is of the type shown in the engravings. A block of chalk or quicklime, having a cover of the same material, contains a central cavity for the carbon crucible. The carbons are moved back and forth on their sliding supports and the arc is formed just over the crucible. In the first experiment 15 ounces of soft Swedish iron were placed in the crucible and covered with sugar-charcoal. The crucible is then heated under the arc with a current of 350 amperes at 600 volts; the cover of the furnace is removed and the crucible taken out and plunged into cold water. When cold, the metallic mass is attacked by hydrochloric acid to dissolve all the iron, and there remain three kinds of carbon; graphite, a brown-colored carbon (such as was observed in the Diablo Cañon specimen) and lastly a very small quantity of a denser carbon. All the carbon except the latter was dissolved out by a series of reactions, and the portions of very high density were separated by placing in bromoform. This liquid has a density as high as 2.9, and only the heavy particles fell to the bottom, consisting of black and transparent diamonds. By using a still denser liquid, the iodide of methylene, which has a density of 3.4, the black diamonds were made to float, and only the transparent crystals fell to the bottom. The former were first examined; under the microscope they have a gray-black appearance and their density is above 3. Some of them have well-defined angles and approach the cubical form. They will easily scratch the polished surface of a ruby. It only remained to burn them in oxygen, and this was done by placing them on a support inside a platinum tube through which a current of oxygen was passed; the tube was heated to 1,200 deg. C. by a blowpipe flame. The black diamonds were found to burn easily in oxygen, giving carbonic acid gas and leaving a trace of residue. The transparent fragments were, of course, the most interesting. They had the characteristic brilliant appearance and oily luster of the unpolished diamond. Their surface showed a number of parallel striæ. Some of them were round and others appeared as broken fragments; others, again, were cubical or of irregular form. The density of all these specimens was about 3.5 (seeing that they sank in the iodide of methylene). They scratched the ruby very deeply and could be burned in oxygen with scarcely a trace of ash. The yield of crystallized carbon is very small by this method, and a long series of reactions must be made in order to obtain a minute



MOISSAN DIAMOND-MAKING FURNACE.

quantity of the crystals. A second method was employed, using a small cylinder of soft iron which is bored out and closed by a screw stopper. The cavity formed is nearly filled with sugar carbon, which is strongly compressed by the screw. A quantity of soft iron is melted in the crucible and the cylinder is quickly plunged in the liquid bath. The crucible is then taken out and plunged into a bucket of water. In the meantime the cylinder has melted and the center of the mass is saturated with carbon. By the sudden cooling, a layer of solid iron is formed on the surface of the mass, and when this crust is at low redness the whole is taken out and cooled in the air. On breaking the mass a portion rich in carbon is found at the center in which are minute diamonds, both black and transparent. One of the clear specimens measures nearly 0.02 inch and answers to all the tests for the diamond. Another specimen was very pure and well crystallized.

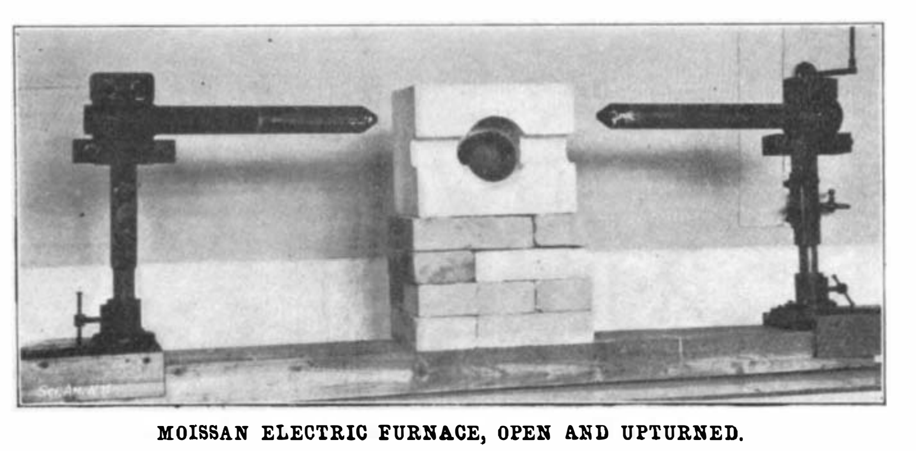
It was found that by the water-cooling method the



DIAMONDS MADE BY THE ELECTRIC FURNACE.

mass is surrounded by a layer of water vapor, and the cooling takes place rather by radiation across the vapor than by conduction, and is thus not rapid enough. To cool the mass more quickly and give a more sudden compression a bath of melted metal, preferably lead, was employed, and the resulting diamonds were found to be of better quality. In this case the crucible containing the iron, melted and saturated with carbon at 3,000 deg. C., is quickly plunged to the bottom of a bath of melted lead. The mass, which was at first pasty, becomes liquid on cooling and sends to the surface of the lead bath a number of small globules of iron, like shot. These globules contain the diamonds, which are separated as before. The striking point about this method is the brilliancy of the specimens which are obtained. One of the transparent diamonds whose diameter reached 0.02 inch, presented a triangular form with rounded angles. A curious fact is to be remarked in the case of this specimen; after three months it split into several fragments, and a second specimen became almost reduced to powder. This phenomenon is identical with that which occurs with some of the Cape diamonds, and it may be attributed to the unstable equilibrium of the mass which has been formed at a high pressure. Some of the specimens from the latter process are smooth and brilliant, while others have a shagreen surface; widely varying forms are obtained, from those which appear to be an assemblage of crystalline masses to specimens looking like a drop which has been suddenly solidified. The shagreen surface of the latter is identical with that of certain Brazil diamonds.

An interesting experiment was that of letting the melted iron fall through a hole in the bottom of the electric furnace in the form of globules or shot. One of the carbons is hollow, and through it an iron rod can be slid into the arc (Fig. 2). The melted globules drop into a vessel of mercury placed underneath the furnace. The spheres thus obtained gave black and transparent diamonds; the latter were small, but remarkably regular in form. Some of them were octahedra, measuring less than 1-1000 inch in their greatest length. One of the best methods is that of cooling the mass by direct contact with solid metal. A block of copper has a cylindrical hole bored in it in which fits a stopper of the same metal. The iron saturated with carbon is run into the block and the hole quickly corked; in this way the cooling is very rapid. When cold the copper and the outer iron are turned off in a lathe and the diamonds are found in the interior. This method gave a better yield and the specimens were fine and transparent.



MOISSAN ELECTRIC FURNACE, OPEN AND UPTURNED.

Increased Use of Oil Fuel.

BY E. P. WATSON.

The discovery of new sources for the supply of fuel oil has reawakened the possibility of using it in Atlantic liners and other high speed vessels. The objections hitherto have been uncertainty as to the continuance of the present oil fields, the slight margin of saving in comparison with coal in many localities, and want of success in obtaining good results through inexperience in the management of oil fuel, but these disappear, in great part, with the apparently unlimited production of the Texas and other new oil wells, and new types or systems of burners which are an improvement upon their predecessors. Many of the naval powers are now fitting out war vessels to use oil fuel, and others are experimenting with a view to its adoption later on. The German Admiralty have used oil on their China station for auxiliary purposes for months in lieu of coal. The Hamburg-American Company has four ships using liquid fuel wholly, and the North German Lloyd two, while the Dutch mail and cargo boats in the Far East employ oil solely as fuel. There are over thirty depots, or stations now where oil can be procured regularly by vessels, and more are being laid down as rapidly as possible.

Oil fit for fuel purposes has the following chemical composition: Carbon, 88 per cent; hydrogen, 10.75 per cent; oxygen, 1.25 per cent. The two other impurities present in the mass are water and sulphur. The action of water is obvious, while the sulphur if free, not in chemical combination, attacks both iron and steel, and mechanical means to separate the water, if oil is used on ship-board, are necessary. Recent experiments show that two tons of oil are equivalent to three tons of coal, while by volume 36 cubic feet of oil are equal to sixty seven cubic feet of coal as ordinarily stowed in bunkers. This increases the radius of action of a war vessel 50 per cent upon the bunker weight allotted and nearly 90 per cent upon the bunker space, without any alteration of the ship. It is also urged in favor of oil that it is easily supplied in mid-ocean—from transports—while coal presents great difficulties under the same conditions. In commercial work the gains predicted for oil vs. coal are surprising. In high-speed ships the weight and space occupied by the propelling machinery leave no room of any account for freight. The change from coal to oil would add nearly two thousand tons to the carrying capacity of a given ship, while, as oil fires never have to be cleaned, the speed would be constantly maintained. With these and many other advantages in favor of liquid fuel it is not unreasonable to look for its general adoption in the near future, both on land and sea. Many locomotives are now using it, and others are being built for oil service, both in this country and abroad.

Announcement is made that the United States War Department has arranged with Ehrhardt, of Düsseldorf, to re-arm the United States field artillery with Ehrhardt's new piece. The gun which the United States has acquired the right to use is said to be an improvement on the models supplied to Great Britain, of lighter weight and of longer range.

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