gear for closing the same; (2) the lamps to indicate the closure of each door or hatch; and (3) a fuse box in which each wire is provided with the proper fuse. On each door or hatch-plate there is a direct-current motor, reversible, compound-wound, bipolar, constructed for intermittent service and entirely inclosed in a water-tight case. This motor is capable of one horse-power under normal conditions, but will carry without injury an overload of 50 per cent for five minutes and 400 per cent for 10 seconds. Each door is also provided with a hand controller for opening the door when the current from the emergency station is on and with a hand gear for opening and closing the door without the aid of the motor.

The operation of the system is briefly as follows: If the ship is in danger of collision or ramming, it is the duty of the officer or seaman nearest to the emergency station to pull a latch similar to that of a fire alarm box, which releases the gearing within the station. This gearing automatically closes the circuits operating the emergency switches located in the controller in each door. It does not start all of the motors at the same time, thus avoiding the necessity for the enormous supply of current which would arise if all were started at once; but so nicely is the operation of the emergency station adapted that twenty-five doors and hatch gears can be closed in 1 minute and 15 seconds without more than four motors being in operation at any one time. As each door shuts it closes automatically a circuit running to the emergency station and connected with an incandescent electric light therein located. These lamps show in the photograph of the station in the form of a border of transparent disks each numbered to correspond with one of twenty-five doors or hatches. If there is an obstruction at any door such as to prevent its closure, the fact will be indicated by the failure of the lamp back of the corresponding disk to light. During the time the emergency current is turned on a red indicator lamp burns continuously so that a mere glance at the station shows whether the emergency is on or off.

The door controllers contain three independent switch mechanisms, the most important of which is the one used to open the door while the emergency current is on. This is to avoid the possibility of members of the crew being imprisoned and suffocated in compartments closed from the emergency station. By simply raising the hand lever the door is made to move backward, allow time for passage and then close again. The second switch is operated from the emergency station, and is the one by which the doors are closed. Its operation can only be suspended temporarily in the manner just described, and the door will always close as soon as the controller lever is released. The third switch is made necessary by the fact that blowouts of fuses would otherwise occur if the door in closing should encounter an obstacle such as a bag of coal or piece of timber left in the opening. This switch is operated by mechanical connection with the door or hatchway, and after an obstruction is removed the switch will again close the circuit to the motor and the door will go on its way toward its grooves without further attention. This switch is an essential part of the system, for without it an obstruction would result in a blowout of the fuses protecting the motor and prevent subsequent operation until these fuses had been replaced.

Another important part of the new device is the tightening gear. This was a feature of the power door which involved some difficulty for the reason that the door must be allowed room for free action between the guides and must at the same time fit so well as to prevent escape of water under pressure equivalent to a head of 35 feet. The tightening gear in the door is a great improvement over the old method of using two wedge surfaces. It substitutes an arrangement consisting of a wedge acting against a curved surface, thus securing more water-tight closure while avoiding the possibility of jamming. It also makes it impossible for coal and other material to find lodgment between the wedges—something that was very likely to occur in the power doors between coal bunkers and the fire rooms.

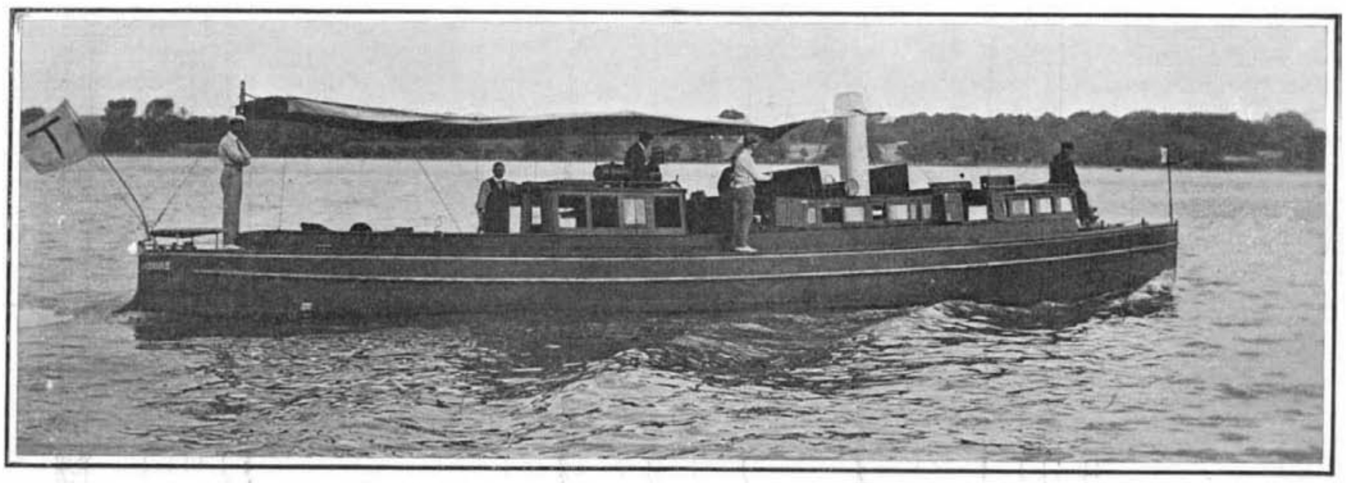
Reference to the illustrations will clear up any doubt the reader may have as to the details of the operation of the system so far as the doors are concerned. In the picture of a vertical coal-bunker door the controller is shown on the left, the motor on the right. At the time the picture was taken the door was being closed by the auxiliary hand wheel. In the photograph of the horizontal door the controller box is also on the left and the motor in the center. In this picture will also be noticed the double rack in which operate cog wheels attached to the vertical shaft turned from above by the motor. In the case of hatch-plates a lifting mechanism is substituted for the rack and cog wheels.

The "long arm" system, just described, is now installed on the armored cruisers "Colorado," "Pennsylvania," "Tennessee," "California," "South Dakota," "West Virginia," and "Maryland," the battleships "Louisiana," "Minnesota," "Connecticut," "New Jersey," "Rhode Island," and "Vermont." Besides its direct value in increasing the efficiency of the cellular structure—providing, as it does, absolute assurance that bulkhead openings will be closed in time of danger—the adoption of the system results in a standardization of doors, openings, and parts of the operating mechanism. To put an end to the present endless variation in types and sizes of bulkhead doors and fittings is in itself a great advantage, and in time it is believed that these parts of a ship will be as thoroughly standardized as railway equipment is now. The cost of the electrical system is less than one per cent of that of the hull.

THE FIRST PRODUCER-GAS BOAT.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

A short time ago we drew attention in the pages of the Scientific American to the development of the gas producer engine for marine purposes. The system described therein was that recently devised by Herr Emil Captaine, of Frankfort (Germany), which the inventor has applied to small vessels engaged in sheltered and still-water traffic on the European Continent with conspicuous success. As we mentioned at the time, Messrs. Thornycroft & Co., the well-known shipbuilders of London, have adopted the idea for more extensive application, and were at that time conducting several experiments with the system with a view to its installation upon a commercial or pleasure vessel. These efforts have now been brought to a successful issue, and at the recent reliability trials carried out in the Solent great interest was manifested in the vessel entered by Messrs. Thornycroft & Co., the engines of which depend upon fuel generated on the Capitaine suction gas producer principle.



THE "EMIL CAPITAINE," A 75-HORSE-POWER YACHT DRIVEN BY PRODUCER GAS.—THE FIRST OF HER KIND.

This is the first practical attempt to prove the commercial possibilities of the system for open-sea work. The first recorded instance of a vessel being propelled by an internal combustion motor is that which was made as far back as the sixties, when the Marquis d'Nare d'Aubaie's auxiliary yacht "Djesirèly" was fitted with a Lenoir motor. In this instance, however, the gas was not produced on board, but generated in a stationary apparatus on shore and stored on the vessel under pressure in cylinders.

The Thornycroft vessel, named "Emil Capitaine," in honor of the inventor, is a small yacht 60 feet in length by 10 feet beam, and with a draft of 2 feet 6 inches. The boat is designed upon the well-known Thornycroft lines which have been adopted in many of their boats with conspicuous success. The stern is broad and flat, and the single propeller works in a tunnel, thereby insuring great steadiness in running without causing the stern to settle down unduly, and further causing a clear and unobstructed flow of water to be maintained to the propeller. The hull is constructed of galvanized steel plates. Roomy accommodation is provided, there being two saloons, one forward and one aft, respectively. The machinery is installed just forward of the aft cabin, between watertight bulkheads.

The suction gas producer plant, together with the specially designed engine for working with the same, have been built by the Thornycroft Company from the designs of Herr Emil Capitaine. The motor is of the inclosed vertical type, having four single-acting cylinders, each having a bore of 8½ inches with a stroke of 11 inches running at a normal speed of 300 revolutions per minute.

The special designs involved in the construction of this engine may be gathered from the following description of the plant. The engine frame is comprised of mild steel plates connected by angle bars, so that a box-like structure is provided, of great rigidity. The crank pit is formed by carrying the steel plates right around. The cylinder trunks are each cast separately and are contained in the framing. The cylinder heads are also cast separately and are supported between plates riveted to the transverse members of the frame. The result of this design is that the latter plates serve to absorb all the shock of the explosion which is transmitted directly to the crank-shaft bearings, which are also bolted to the frame plates. Heavy bolts for the purpose of connecting the cylinder heads to the trunk, which practice is usually adopted in this type of combustion motor, are thereby dispensed with, while possibility of leakage is reduced to the minimum. This principle also renders the engines more accessible, it being possible to remove all the mechanism concerning the ignition and valves with facility and celerity when it is requisite to carry out cleaning, inspection, or other operations. In fact, the gearing can be disconnected and replaced within the short space of six minutes.

All valves are mechanically operated by cams, the latter being actuated from the crank shaft by means of suitable gears. The cam shaft is placed above the top of the cylinders and slightly out of the center line, the motion being imparted to the valves through rocking levers. The cam shaft is hollow and carries in it a sliding shaft which, by means of radial arms projecting through slots in the cam shaft, operates the strikers of the low-tension magneto igniters. The longitudinal motion of this internal shaft, which is controlled by the governor of the engine, varies the time of ignition, advancing or retarding it as the speed of the engine increases or decreases. There is also an arrangement introduced whereby the timing of the magneto machine is simultaneously varied to correspond with the point of ignition. The engine itself is controlled by means of a throttle valve in the induction pipe connected by a special device to the governor. There is furthermore provision for completely cutting out the electrical circuit when the speed of the engine exceeds a certain limit.

The engine is fitted with half compression gear for starting purposes. The latter function is carried out by means of a separate single-cylinder Thornycroft motor of 6 horse-power through a belt drive. The half-compression cams are automatically thrown out of action by means of an attachment fitted to the governor when the motor reaches its normal running speed. The cylinder heads are water-cooled, the circulation being carried out with a centrifugal pump driven off the engine. The exhaust is also water-jacketed, and the gases escape into the outer atmosphere through a funnel, thereby dispensing with a silencer. Forced lubrication is adapted to all bearings by a specially designed reciprocating oil pump. Access to the bearings of the crank shaft and connecting rods of the pistons is obtained through doors fitted in the lower part of the engine. At the forward end of the crank shaft is a pulley for driving a gas drier and a centrifugal pump for pumping the heated and dirty water from the gas purifier. Reversing is carried out by means of epicyclic gear and a cone clutch placed in the line of shafting forward of the thrust block. The engine is freed and reversed in either direction by a single hand wheel.

The suction gas producer is of the ordinary cylindrical shape, comprising a steel shell with a firebrick lining surrounding the hot zone. The fire bars are of channel section to enable them to withstand better the intense heat and also to hold the ash. They are carried on cams and can be lowered toward either side to facilitate clinkering. There are three charging doors in the top which deliver into a conical annular hopper, while in the lower part are provided the usual air and steam inlets. The steam generator is placed in the upper part of the producer and comprises a shell with field tubes. This serves the dual function of cooling the gases and generating steam which is decomposed in the fire in order to supply the necessary gases for the explosive mixture. An ingenious alternative arrangement is fitted whereby the steam may be generated by the exhaust gases from the engine. After production the gas passes into a cooling tower in which a spray of water falls by gravity from the top, while a finely divided spray of water is also injected into the bottom part of the tower by compressed air. Any impurities that may be impregnated in the gas are thus completely arrested. No solid material, such as is usually required in the scrubber, is employed, and this arrangement forms a conspicuous feature of the apparatus.

The facilities for drying the gas thoroughly and at the same time removing any traces of tar that may have escaped through the cooler constitute a prominent characteristic of the plant. It is absolutely essential for the most efficient operation of the engine that every trace of moisture should be removed from the gas, and this drying is effected by means of the centrifugal drier which is driven off the engine through a belt transmission as previously mentioned. This drier is made to run at a high velocity. A double-seated valve is fitted in the induction pipe near the engine for mixing the gas with air, the proper mixture being automatically regulated according to the speed of the engine. Should, however, a richer proportion of gas or air be desired, this can be regulated by hand. The hopper of the gas producer carries sufficient anthracite for a 10 hours' run at a speed varying from 10 to 12 miles per hour. The installation occupies but little space, the whole plant being contained in a floor area of 12 feet 6 inches by 9 feet 4 inches, while the maximum height is 6 feet 8 inches.

Unfortunately, owing to the short time which was available between the launching of this boat and the reliability trials in the Solent, it was impossible to make any preliminary runs for tuning-up purposes. The yacht was towed round from the Thames to the scene of the trials and entered at once in the contest. On the first day she proved highly successful, making a non-stop run for the whole 10 hours of the trial. During this time she covered the sheltered course six times and the open-sea course once—a total distance of about 80 miles—in 9 hours 12 minutes. This gives an average speed of 13.04 miles per hour which, considering all circumstances, was highly satisfactory. The boat, however, is capable of much higher speed, though it has not been constructed for fast running. During this 10 hours' run 467 pounds of anthracite was consumed, representing a cost of $1.08. The low cost of running a vessel with this type of fuel is thus conclusively demonstrated, since no other system can compare so favorably with it. On this basis it will be seen that a ton of coal would be sufficient for nearly two days' cruising at 13 miles an hour.

On the second day the vessel broke down, owing to the bearings of the water-circulating centrifugal pump seizing through a slipping belt. Still it was recognized that the vessel had justified the builders' anticipations and its future possibilities from a commercial point of view were realized. In recognition of the Thornycroft company's efforts to adapt the suction producer gas type of motor to marine purposes a special gold medal was awarded to them.

The trials proved that the gas engine in conjunction with a suction gas producer if properly designed is the most economical generator of power yet devised. The consumption of anthracite works out as low as 1 pound of fuel per brake-horse-power per hour. A compound condensing steam engine consumes from 1 1-3 to 3 pounds of fuel per brake-horse-power per hour according to size and type, while with the oil engine the consumption is approximately one pint of kerosene per brake-horse-power per hour. Anthracite costs only about $4.75 per ton, while on the other hand, kerosene costs about $30 for the same quantity. The respective cost of fuel per horse-power-hour for the three systems works out approximately as follows:

For the oil engine .... 1.47 cent
For the average steam engine...... 0.42 cent
For the producer gas plant........ 0.21 cent

—showing that the advantages in economy and relative efficiency are completely in favor of the suction producer gas engine. Messrs. Thornycroft & Co. have arranged to carry out a series of trials in the open sea upon the measured mile with the "Emil Capitaine" when she has been tuned up, and the experiments will be closely followed by all marine engineers both for commercial and naval purposes. Already the patents have been acquired for extending the system to large vessels by another prominent British shipbuilding firm, the Thornycroft company confining their efforts to its application to the smaller type of craft.

The use of superheated steam in locomotives does not entail the multitude of practical difficulties that so generally accompany any invention or improvement that is introduced to improve the economic results obtained from a locomotive, and indeed, it is probable that as experience with its application develops, some of the expenses that are incurred in the locomotive of to-day will be diminished rather than increased. There would only appear to be two possible sources of additional cost, the wear of valves and cylinders due to defective lubrication, and the cost of maintaining the superheater itself.

A GOVERNMENT-BUILT BATTLESHIP.

It takes but a glance at the handsome engraving that forms the front page of this issue to be convinced that the policy of the government in placing the order for the construction of the battleship "Connecticut" at the government yard was a far-sighted act that has been abundantly justified by the results. When we bear in mind that the keel of this, the largest battleship afloat, was laid in March, 1903, and that she will be ready for her official trials during the spring of next year, we can see that in the construction of this ship, the Navy Department has buried once and forever the old popular fiction that the construction of warships in a government yard is necessarily slow and expensive, and the work indifferently done. For the origin of this popular impression, we have to go back some twenty years or more to the date of the building of the two second-class battleships "Maine" and "Texas," both of which took a long time to build and cost an unconscionable sum of money. The cause was to be found in the fact that at that time the government yards were largely dominated by political influence. "Pull" was rampant, and the hands of the naval constructors were tied, or if not tied, were at least greatly hindered by the fact that incompetent and lazy employes who believed that political influence would prevent their discharge, were to be found in every yard and in every department at these yards.

The breaking up of the political system was due mainly to efforts of the naval constructor at the Norfolk yard, who subsequently, on coming to New York, became an ardent advocate of the construction of some of the new warships at the more important government yards. He argued that the yards having been rid of political interference and brought up to a high state of efficiency, ships could be built with greater expedition, with equal thoroughness, and for but very little greater cost than they were at private shipyards. Furthermore, it was urged that by having a government ship always on hand at the more important yards, it would be possible to maintain a large and efficient staff of workmen constantly in government employ, instead of being under the disastrous necessity of discharging a large proportion of the force when the annual repair work on the ships in commission was completed.

Congress very wisely determined to give the matter a trial, and of the two sister battleships authorized in the same year, one was given to a private yard, and the other to the Brooklyn navy yard, New York.

The results thus far achieved have more than fulfilled expectations. The "Connecticut" has not only been built faster, and considerably faster, than any previous battleships constructed for our navy, but she is to-day slightly ahead of the sister ship at the Newport News yard, and this in spite of the fact that great enthusiasm prevails at the southern yard, and there is an unspoken understanding among the workmen to push the boat along and have her completed ahead of the government-built ship. In the report of August 1 of this year, the "Connecticut" was 0.83 per cent ahead of the "Louisiana." During the month she was advanced 2.48 per cent toward completion, so that on September 1, 86.15 per cent of the work was done. The indications are now that she will be ready for her preliminary trials in the spring of next year, and ready for her final sea trial two or three months later.

Perhaps the most valuable result of the successful construction of the "Connecticut" is the stimulating effect which it has had on government work in the private shipyards. At the time that the building of the "Connecticut" was commenced, the five battleships of the "Georgia" class were making very slow progress, indeed. The act of Congress authorizing these five ships was passed on March 3, 1899. Three years later, on July 1, 1902, was passed the act authorizing the building of the "Louisiana" and "Connecticut." On August 1 of the present year, the "Nebraska," one of the ships authorized in 1899, was only 77 per cent completed, the "Georgia" 85 per cent, and the "New Jersey" 87 per cent; while the "Connecticut" and the "Louisiana," in spite of the three years' handicap, were respectively 83.67 and 82.81 per cent advanced toward completion. The stimulating effect of the "Connecticut" upon the construction of other ships is shown in the case of the three battleships "Vermont," "Kansas," and "Minnesota," practically sister ships of the "Connecticut," which were authorized in March, 1903, and are already respectively 57.1, 57.8, and 69.9 per cent completed.

The argument in favor of government-built ships, based upon the fact that there is not sufficient repair work in the yards at all times to keep a large force constantly employed, does not have the force that it did six or eight years ago, when our navy was considerably smaller. At the present time there are few months of the year when the navy yards, and particularly the larger ones like that of New York, are not well supplied with ships that are undergoing refitting and repair. No doubt ultimately we shall reach a point where repair work alone will keep our present navy yards thoroughly busy all the time. But until that point is reached, we think it would be advisable, in view of the good results obtained in the "Connecticut" experiment, to have at least one warship upon the stocks at all times at our principal navy yards.

Correspondence.

The Lunar Rainbow.

To the Editor of the Scientific American:

I read with interest the different discussions concerning the lunar rainbow in some recent issues of your paper, and would say that, in some respects, I quite agree with your correspondent, Mr. Harry Clifford Doane. Although the occurrence of the so-called lunar rainbow may be comparatively rare, I, too, think that the phenomenon is not generally known because of lack of observation. Before coming to this country I often had occasion to witness lunar rainbows, and I think I can give some explanation as to their origin.

The city of Luxembourg (Grand-Duchy of Luxembourg) is situated at an altitude of over three hundred meters above the sea level and a peculiarity of the air of this city is, that during the greater part of the winter, the atmosphere seems to contain an exceptional amount of humidity. Now, I can recall that I saw lunar rainbows quite often during the winter in that city, and always under the same circumstances. I never saw a bow unless the moon was full or very near its fullness. The air was always hazy and misty and very humid. I [illegible] saw the phenomenon before 11 P. M. or after 1 A. [illegible] The moon was then always very high. As far as I could see, the diameter of the bow which surrounded the moon sometimes was five and sometimes ten times that of the moon. I always could plainly distinguish the spectrum colors, but never saw them as brilliant or perfect as those of the solar rainbow; probably the mist is a little too dense. Also the color band of the bow seemed to measure only half that of the solar rainbow. This is doubtless due to the great distance of lunar bows from the earth.

My own theory as to the formation of the lunar bows is as follows:

The moon rays, upon entering our atmosphere, will be refracted to a certain degree, and after traveling further touch the dense layer of the humid air. As very humid air is nothing else but rain in a very minute form, the moon rays will be refracted in the millions of small water drops and will form a bow similar to the solar rainbow, which we know takes place under quite analogous circumstances.

I do not think that lunar bows can be formed in an absolutely dry atmosphere. Huck Gernsback.

New York, August 29, 1905.

The Largest Dam in the World.

To the Editor of the Scientific American:

In the very interesting article that appears in your issue of July 1, on the subject of the Wachusett reservoir, it is claimed that this is "by far the largest fresh-water reservoir in the world."

This statement is evidently made under the misapprehension that the largest reservoirs in India are those shown in the list (on page 11) in the article in question. Those lakes there mentioned are merely those in the Bombay Presidency, and do not include the largest in India.

In the native state of Udaipur in Rajputana, some 30 miles south of the city of Udaipur, is the great Jaisamand, the Dhebar lake. The dam of this lake was built some 200 years ago by the Maharana Jai Singh to rival the beautiful and extensive lake built by his predecessor at Rajnagar, 60 miles further north.

This lake covers an area which, according to careful planimeter measurements from the 1-inch-to-the-mile topographical maps, is 25 square miles. The old and now out-of-date Imperial Gazette I see, however, speaks of it as 21 square miles, so I will take this figure.

The depth of water at the dam is 90 feet. The average depth of the water is not known, but assuming that it bears somewhat the same ratio to the height of the dam as the lakes given in your list do, the average depth would be roughly 35 feet—a not improbable figure.

Taking this average depth and 21 square miles of area, this lake would have a volume of 2.43 times as much as the Wachusett reservoir, and holds therefore 2.43 × 63 = 153 billion of gallons.

This lake is a remarkable one in many ways, but is unfortunately in a very inaccessible part of the country and is therefore not very well known.

The dam is only about 1,000 feet long and is of the style favored by those old chiefs of Rajputana. It consists of two massive and ornamental masonry walls some 500 feet apart with the space between filled in with earth and ornamented with gardens.

The overflow is not provided for in the dam at all, but some five miles off at the end of a spur in the range of hills, and consists merely of a light cut.

I send you this information, as it may be of interest to your readers. G. E. Lillie,

Divisional Consulting Engineer for Railways.

Government of Bombay, Public Works Department, August 4, 1905.