BRAZILIAN BATTLESHIP "MINAS GERAES"—MOST POWERFUL FIGHTING SHIP AFLOAT.

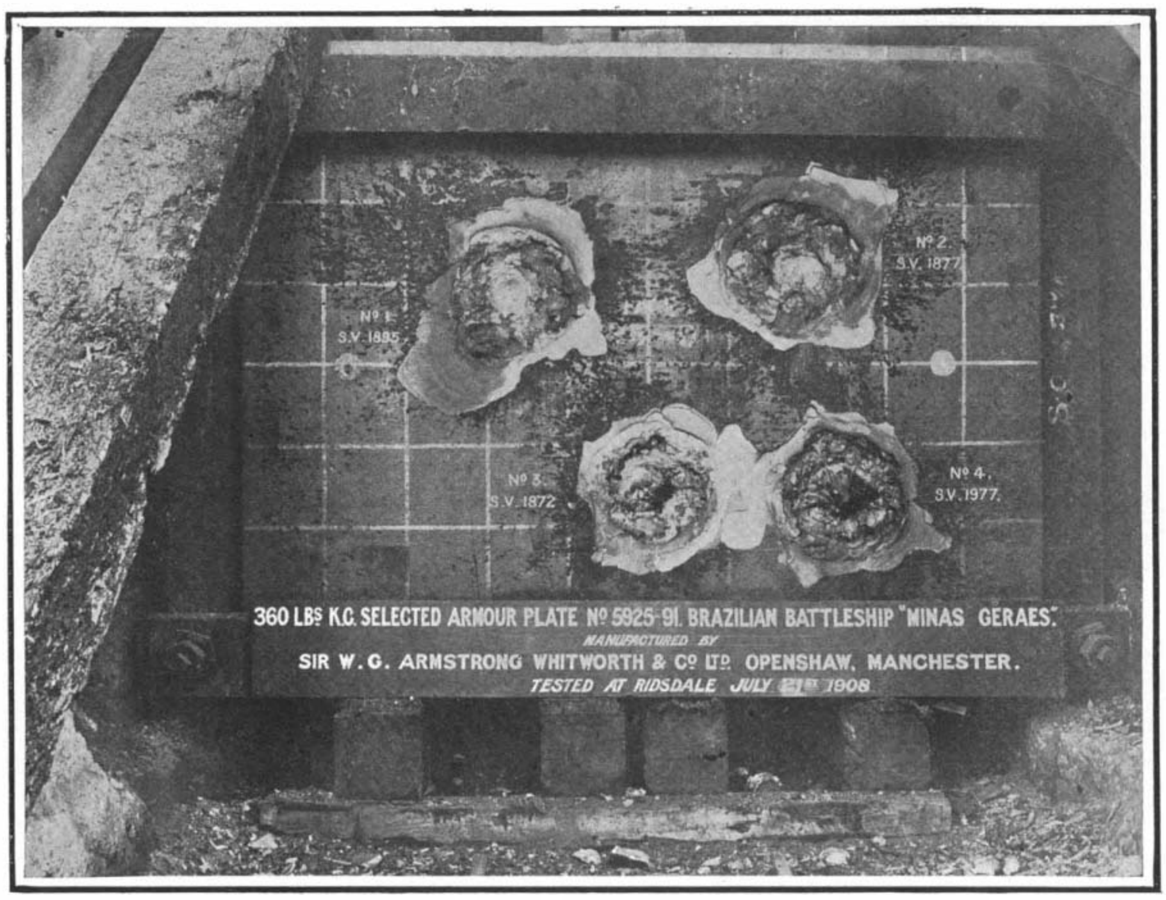
It is a curious anomaly that the most powerful fighting ship afloat should belong to a South American republic. The fact that this ship will fly the Brazilian flag is due to the reorganization of their navy, which is now being undertaken by the Brazilian government. Originally it was their intention to build three battleships of moderate displacement, supplemented with a few armored cruisers, scouts, and destroyers. The events of the Russo-Japanese war, however, and the construction of the British "Dreadnought" led the authorities to greatly modify their plans, by discarding the armored cruisers and putting the contemplated expenditure into three great battleships, which should embody the latest developments of naval construction. The working out of the plans were intrusted to the Elswick firm, who designed the fine ship which forms the subject of our front-page illustration. A sister ship is now under construction by Messrs. Vickers' Sons & Maxim at Barrow-in-Furness.

The principal dimensions of the "Minas Geraes" are as follows: Length 500 feet, breadth 83 feet, and displacement, on a normal draft of 25 feet, 19,500 tons. The vessel will be driven by reciprocating engines at a speed of 21 knots. She will be able to stow 2,000 tons of coal in her bunkers; and arrangements have been made for the storage also of several hundred tons of oil fuel in her double bottom.

The armor protection is very complete. It consists of a belt 9 inches in thickness which extends from stem to stern, being slightly tapered toward the ends. This armor, throughout the lengtth of the citadel, is carried to the upper deck, and affords an unusually complete protection to the broadside battery of 4.7-inch guns. In addition to protecting the secondary battery, the side armor will prevent the entrance of shells below the gun deck, on which fourteen of the 4.7-inch guns are mounted, and its association with a protective deck carried slightly above the waterline will insure excellent protection to the machinery, boilers, and magazines. A novel feature in the protection is the provision of an extra thick steel deck above the central citadel. In addition to the fourteen 4.7-inch guns on the gun deck, eight of the same caliber are carried at a higher level on the superstructure, where they are mounted behind shields and are otherwise protected.

The most interesting feature of the ship is the unusually heavy main battery, which consists of no less than twelve 12-inch guns mounted in pairs in six barbettes. Four of these guns are mounted forward of the superstructure, four aft, and two on either beam. The mounting of the forward and after guns is similar to that adopted in our own "South Carolina" and "Michigan," four of the guns being mounted in twin-gun turrets on the upper deck, and the other four being carried at a sufficiently higher level to enable them to swing clear of the roof of the upper deck turrets, as shown in our illustration. The two remaining turrets are mounted well out on either beam amidships, the superstructure forward and aft being cut away so as to permit their guns to fire parallel with the axis of the ship. This arrangement allows an end-on concentration of fire, which is much greater than that of any other ship of the "Dreadnought" type except the German vessels of the "Nassau" class, the concentration of fire being as follows: Ahead and astern, eight 12-inch and six 4.7-inch; upon either broadside, ten 12-inch and eleven 4.7-inch. These figures are interesting for comparison with the broadside fire of other ships of the all-big-gun type. Thus comparing merely the guns of the main battery, the British "Dreadnought" can concentrate six 12-inch ahead, six astern, and eight on the broadside. Our "North Dakota" can fire four ahead, four astern, and ten on the broadside. The Japanese "Aki" can concentrate two 12's and four 10's ahead or astern, and four 12's and six 10's on the broadside. The German "Nassau" can fire eight 11-inch ahead or astern, and twelve on the broadside. The 11-inch, however, is a much less powerful piece than the 12-inch carried by the Brazilian ship, whose end-on fire must be considered as more powerful, and her broadside of about the same power as that of the "Minas Geraes."

The 9-inch armor was fabricated by the Krupp process, and it will be seen from the accompanying illustration, showing the results of a test of one of the plates at the proving ground, that the armor is of exceedingly fine quality. The attack on the plate was made by a 9.2-inch gun, firing 380-pound Firth shells, three rounds being fired at a velocity of not less than 1,850 foot-seconds from a distance of a little under 100 yards. The first shot, which struck with an energy of 9,497 foot-tons, was completely smashed against the plate, the penetration being very slight, and no cracking of the plate being apparent. The second shot penetrated about 2 inches without being able to crack the plate; and the third, which struck the lower part of the plate in the center, failed also to produce any cracking, and merely served to shake out of the plate the points of the other shots which had become imbedded. The plate was accepted on the strength of these results, but it was determined to give it an additional and more severe test, by firing one more shot at a velocity of 1,977 feet per second and an energy of 10,312 foot tons. This severe test also failed to crack the plate; the penetration was not over a few inches, and the



RESULTS OF THE ATTACK OF ARMOR FOR THE "MINAS GERAES" BY FOUR 9.2-INCH ARMOR-PIERCING PROJECTILES. MAXIMUM PENETRATION, 3 INCHES. NO CRACKS. PROJECTILES BROKEN UP.

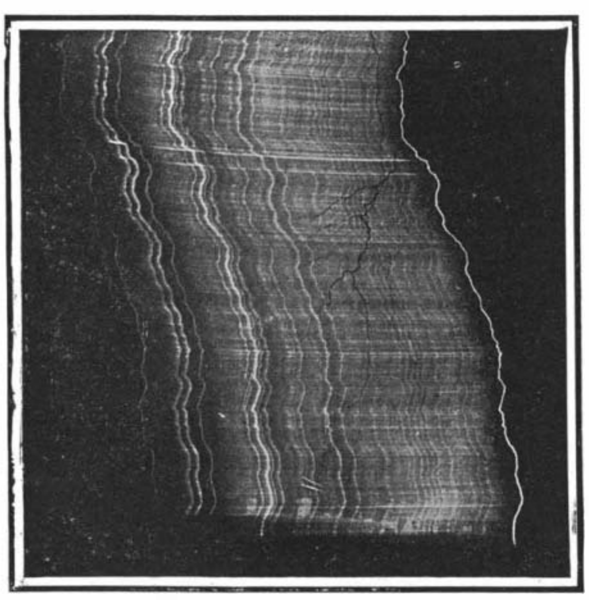


Fig. 1.—Lightning flashes showing separate rushes and black discharge.

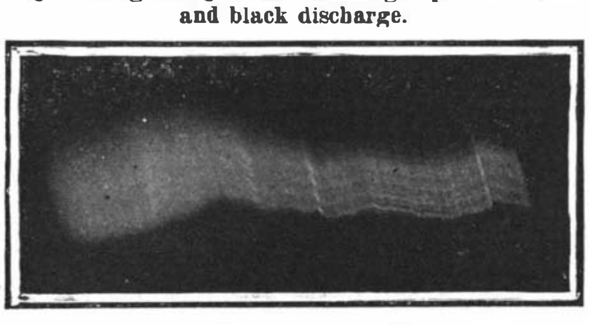
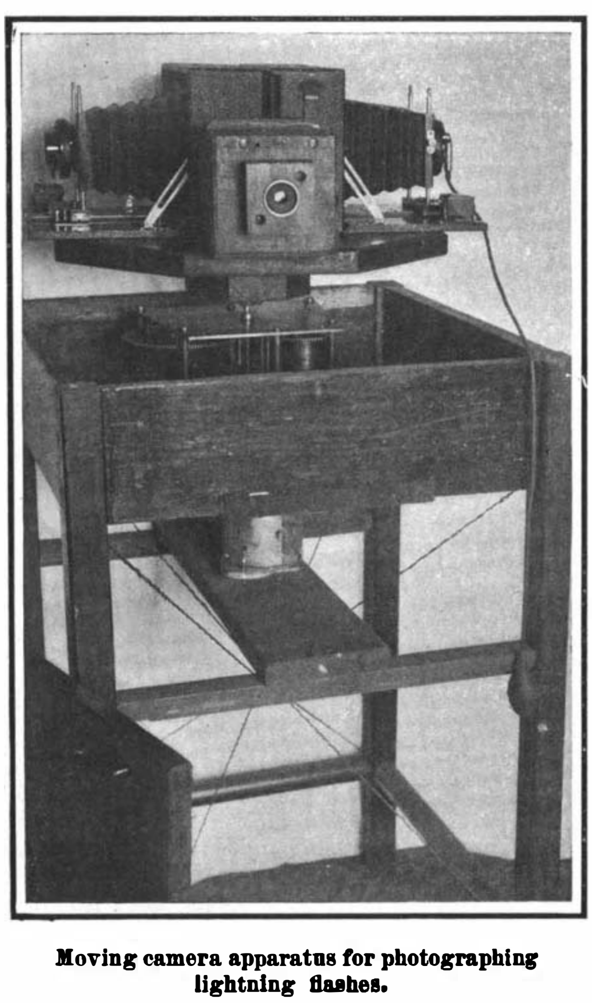


Fig. 4.—Spectrum of a spark from a static machine.



Moving camera apparatus for photographing lightning flashes.

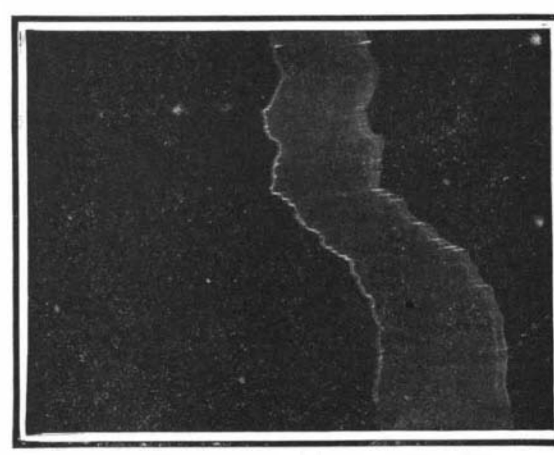


Fig. 2.—Lightning flash showing long interval between rushes.

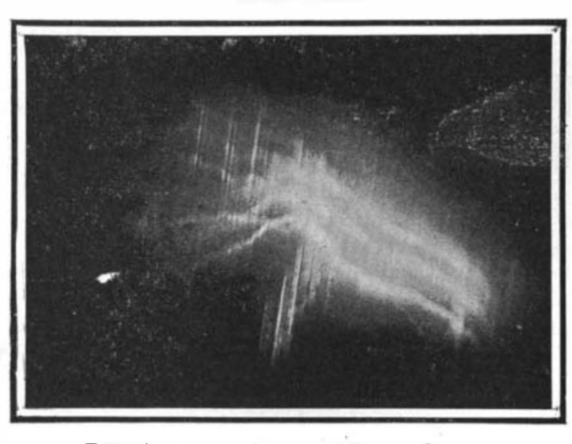


Fig. 3.—A spectrum photograph of a lightning flash.

NEW DISCOVERIES ABOUT LIGHTNING.—**[For description see page 430.]**

SCIENTIFIC AMERICAN

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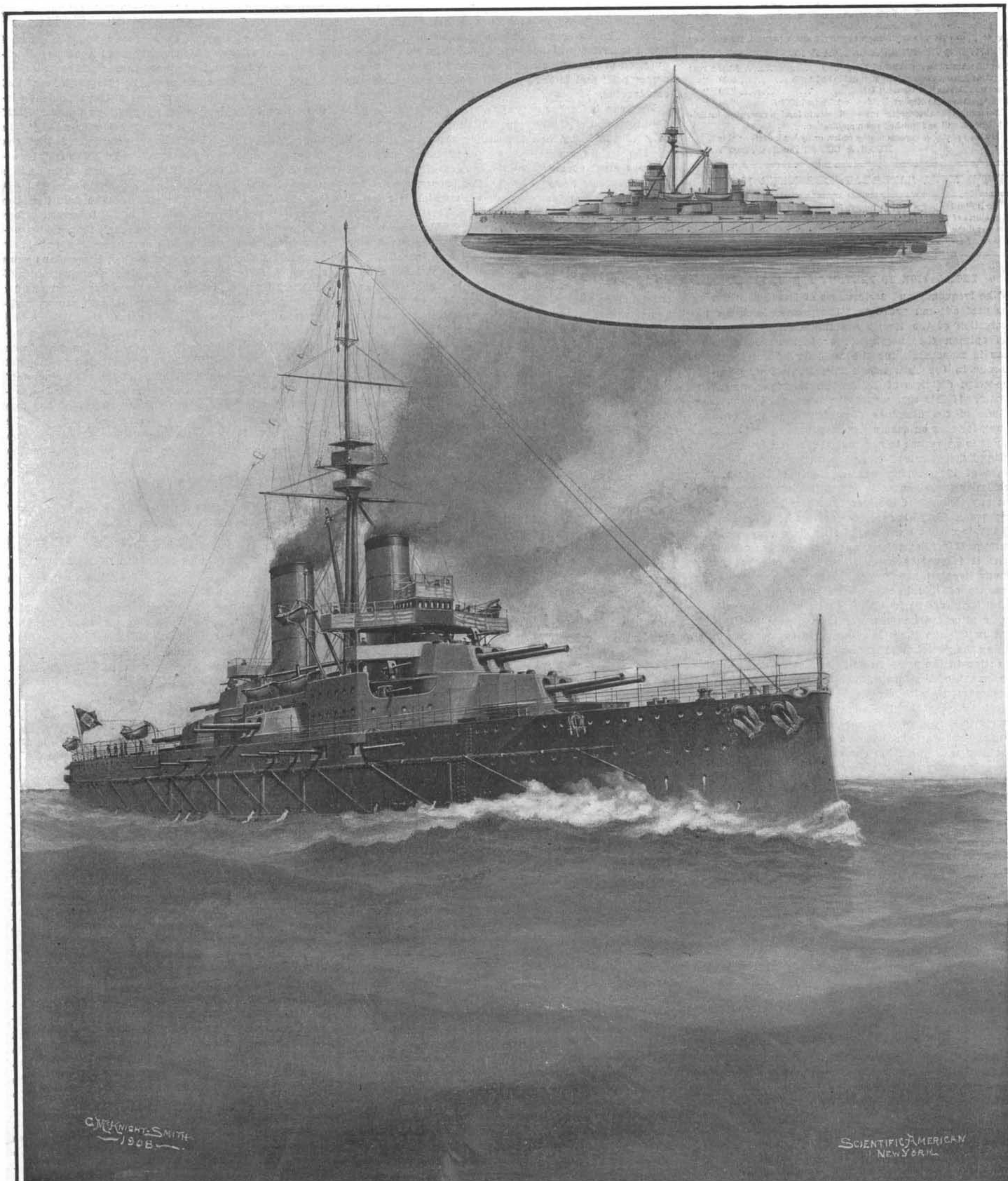


Displacement, 19,500 tons. **Speed,** 21 knots. **Coal,** 2,000 tons. **Armament:** Twelve 12 inch; twenty-two 4.7-inch guns. **Armor:** Belt, 9-inch; turrets, 9-inch; deck, 2½-inch.

This is one of three sister ships which will form the backbone of the new Brazilian navy.

THE NEW BRAZILIAN "DREADNOUGHT" TYPE BATTLESHIP "MINAS GERAES."—[See page 428.]

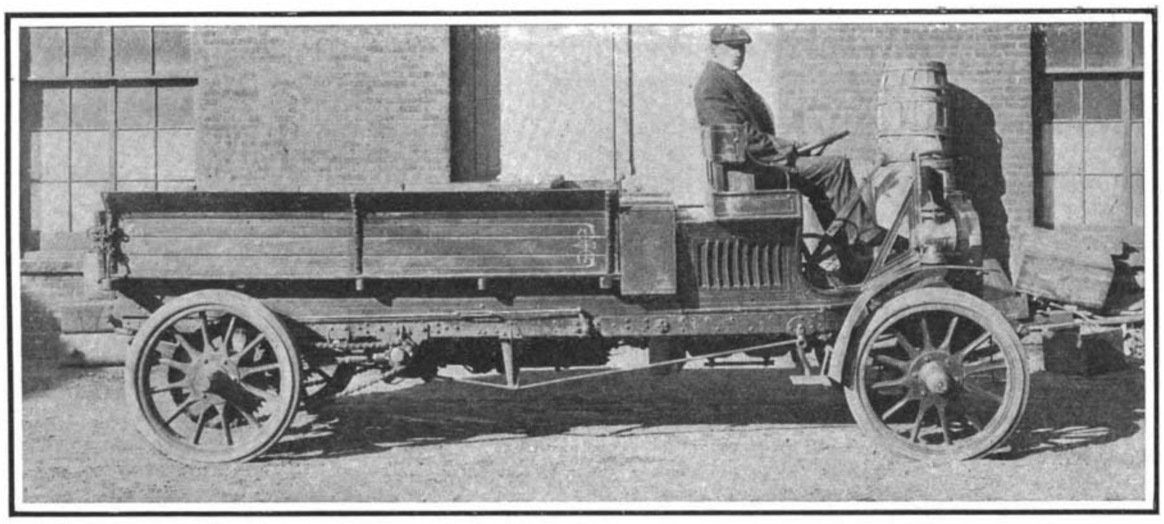
point remained imbedded in the plate. The maximum amount of bulging at the back of the plate, in the line of points of contact, was not over 1.5 inches.

A HYDRAULIC DRIVE SYSTEM.

The fact that the internal-combustion engine depends upon momentum of its moving parts to bridge the gaps between explosions, makes it impossible to start the engine under load, and materially lessens its efficiency as its speed is reduced under load. For this reason it is necessary to provide clutches and variable speed gears, which will permit of reducing the speed at the point of application of the power, while the engine itself operates under such a speed as will yield the highest efficiency. A perfect mechanical variable-speed gear has yet to be discovered, and so far we have been obliged to worry along with systems, so abhorrent to the mechanical engineer, of operating by jerks from one speed to another. From time to time efforts have been made to overcome the difficulty by the use of a flexible medium such as electric or hydraulic drive, between the gasoline engine and the point of application of the power. But, hitherto, the operation of these systems has not been such as to warrant their commercial application.

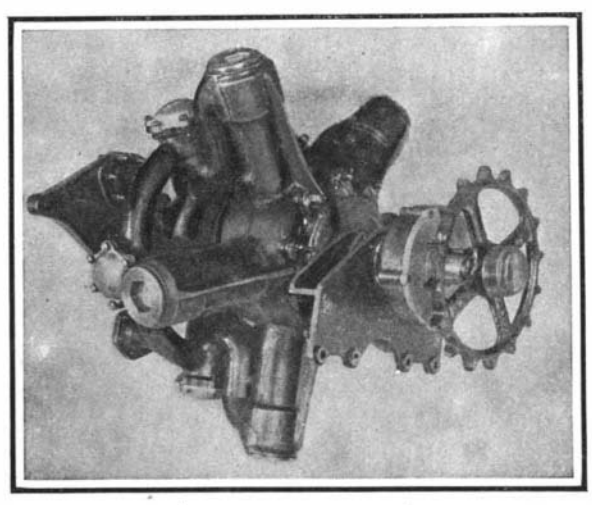
A new system has just been developed by Charles M. Manly, who is probably best known for his work with the late Samuel P. Langley in the development of an extremely light gasoline motor for use on the Langley aeroplane. Mr. Manly's transmission is hydraulic; but oil is used instead of water, because of its lubricating and non-freezing qualities. The oil is circulated in a closed cycle by means of a pump driven directly by the internal-combustion engine, and in the oil circuit one or more motors are included, which are located where the power is to be applied and which are driven by the circulating oil. The key to this system lies in a special form of double eccentric, the throw of which may be varied from the central or zero position, in either direction, so as to vary the stroke of the pistons to any degree within the limits of the mechanism.

In the accompanying illustrations we show the drive system as applied to the operation of an automobile truck. The pump which circulates and generates the pressure in the oil is indicated at *A* in the diagram, while one of the motors, of which there are two, one for each of the rear wheels, is indicated at *B*, the other being removed for clearness. It will be observed that the drive system does away with all gearing between the engine and the wheels, with the exception, of course, of sprocket and chain connections between the motors and the wheels. The differential gearing and the brake are done away with, as well as all variable-speed devices. A single lever controls the stroke of the pump pistons, and the pressure of the oil being directly dependent upon the pump stroke, this controls the speed of the wheel motors, and consequently of the truck. The engine may be run continuously at full speed, in fact there is no necessity for changing it for any purpose; setting of the eccentrics in the no-throw position brings the pump to rest, when its stationary pistons will completely block the circulation of the oil, preventing the motor from operating, and thus providing an efficient brake. As the motors are connected "in parallel," to borrow an electrical term, differential gearing is unnecessary, for they will adapt themselves to the variations in load on the two wheels, as the car is rounding a curve; in fact, there can be no more perfect differential system. The advantage of this drive for use on trucks is that it does away entirely with all complicated mechanisms that would require a skilled operator. The truck shown in our illustration is loaded with sand to a weight of 9,000 pounds.



A 5-ton motor truck fitted with a hydraulic drive system.

It has been in constant use under this load, and under the most exacting road conditions, for over a year, and always in the hands of unskilled operators. The Manly Drive Company keeps this truck so loaded for testing and demonstrating, and frequently brings in a load of an additional ton or two of material over the roughest kind of roads without troubling to remove the dead weight always carried. For this purpose a small gasoline engine, formerly used in a run-about of 16 nominal horse-power, is amply sufficient. Motor trucks now in use for similar work require a 30- or 40-horse-power engine. Makers will admit that for a gross weight of say 10 tons, a speed of 6 miles per hour, grades not to exceed 5 per cent, and average road conditions, the drawbar pull requires only one-fourth to one-third of that power, but the balance is necessary for reserve, especially for starting on up grades. The great advantage of the Manly drive is that the available power can be increased inversely as the speed, the maximum torque being available exactly when it is most needed in starting from rest without increase of engine power, and the maximum engine power being required only under the most favorable conditions, i. e., under the maximum speed of the car or truck with radiator and circulation giving their maximum effect. This is just what is least possible with drive systems at present in vogue for gasoline automobile use, as is evident to anyone who has tried to start his car up a steep grade. The engine must be run up to speed to attain its efficiency, the brake cautiously released to avoid running back, and the clutch as cautiously engaged, even if there be no necessity for a change of gear in such a situation, all of which difficulties are eliminated by the Manly drive on account of the above-mentioned features and the absolute braking effect of the oil under pressure in the system whenever the pump is even momentarily stationary.



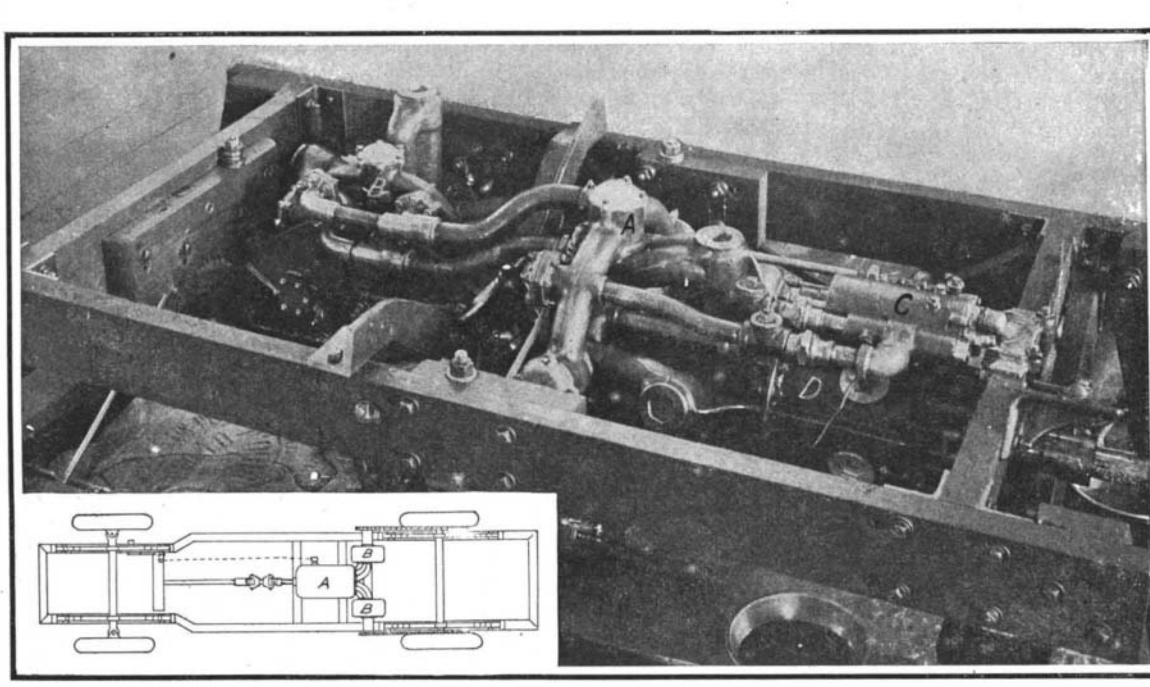
The hydraulic engine. An engine drives each wheel.

In the demonstrations made for the Scientific American, the bulky motor truck with its 9,000-pound load was backed and maneuvered into and out of close corners, both in the yard and in crowded street traffic, with the utmost ease and quiet, and none of the starting and stopping of engine, engagement and disengagement of clutch, and screech of changing gears, so noticeable when an automobile merely draws up to a sidewalk in a crowded street, while quick changes from full speed ahead to reverse were made, which, with the momentum accumulated by the 20 tons gross of car and load, would have torn the teeth out of any known system of change-speed gear.

The driver of the truck, who is shown in the photograph, has never driven an automobile, and would not know how to drive one. All he knows about the auto truck is that when he moves the lever forward, the truck will move forward at a speed proportionate to the position of the lever; that on bringing the lever back to central position, the truck will be brought to an absolute standstill without requiring any brake; and that on further withdrawing the lever, the truck will move backward in the same proportion. It is obvious that the alteration of the throw of the eccentric must be against the pressure of the oil, which would be a laborious and sometimes impossible operation if the actual movement of the parts were effected by the manual lever. This is overcome by the introduction of an ingenious device, by which the oil pressure itself changes the eccentric throw. The hand lever operates only a pilot valve, the casing of which is shown at *C*, admitting oil from the circulation to the eccentric-operating mechanism, and returning to a neutral position when sufficient movement of the latter has been made.

During the entire year of operation, the hydraulic drive system of the truck has required no repairs whatsoever. The mechanism was provided with adjustments, so as to take up any wear of parts, but so little wear has resulted, due largely to the lubrication of the oil circuit, that, in the machines now building, no such provisions for adjustment are considered necessary. The only attention the hydraulic system requires is that at the end of each week a pint of oil must be added to replace the oil lost by friction in the stuffing boxes.

The possibilities of this system for trucking are very alluring. Instead of gasoline engines, kerosene engines could be used. Heretofore, kerosene engines have failed for automobile work, because they do not permit of the variations in speed that are possible in gasoline engines. A number of these automobile trucks could be started from a central station by a skilled man, who would see that the engines were in proper working condition. Once the engines were started running, they could be left in operation the entire day. An ordinary truckman could then drive the machine without giving thought to the engine, his only attention being devoted to the steering wheel and the single lever that controls the starting, stopping, and reversing of the machine. A truckman would be much better fitted for this work than the skilled chauffeur, because he would know better how



Top view of the hydraulic drive, showing control valve (C) pressure pump (A) and one engine (B) assembled in truck chassis.

A HYDRAULIC DRIVE SYSTEM.