THE UNITED STATES EXPERIMENTAL MODEL BASIN.

Through the courtesy of Chief Constructor Philip Hichborn we are enabled to present our readers with a full description of the experimental basin recently completed for the navy. It is usual for information concerning an installation of this kind to appear in a paper before a technical society; but in view of the general public interest in the subject, the Bureau of Construction and Repair has decided to depart from its usual practice.

The value of towing experiments upon small scale models of ships for the purpose of deducing the resistance of a full-sized ship from that of the small model was demonstrated by the late Mr. William Froude, who, at his own expense, started a small tank for such experimental work at Torquay, England, about 1870. The English Admiralty subsequently recognized the value of his work and assisted him in it, later building a larger basin at Haslar, near Portsmouth, which is now in charge of Mr. R. E. Froude, son of Mr. William Froude. Other governments, notably Italy and Russia, were induced to establish model basins, which were largely copies of Froude's basin; and one firm of private builders—Denny Brothers, of Glasgow, Scotland—was sufficiently enterprising to build a basin for its own use.

The Construction Bureau of our Navy Department has appreciated for many years the value of an experimental basin, but it was for a long time unable to secure an appropriation for the purpose. Congress finally, about two years ago, granted $100,000 for this work, the grant being largely due to the efforts of the late Congressman Hilborn. The basin proper was completed the latter part of last year, and the special machinery and apparatus have now been completed and installed, after a good deal of delay, due indirectly to the war with Spain.

The basin is located in the southeast corner of the Washington navy yard. The accompanying photographs give a very fair idea of the external and internal appearance, and Fig. 8 shows the construction of the main body of the tank proper. The building is 500 feet long and about 50 feet wide inside. The water surface of the basin is slightly shorter than the building, being about 470 feet long. The deep portion is about 370 feet long, the south end, from which runs begin, being shallow. The water surface is 43 feet wide, and the depth from top of coping to the bottom of the basin is 14 feet 8 inches. The basin is materially larger than any other in existence. The nature of the ground was such as to render the construction of a thoroughly tight and stable basin somewhat difficult; but owing to the small space available at the Washington yard, it was necessary to locate it upon its present site. The bottom of the basin proper is made up of a layer of broken stone upon which is a thin layer of concrete; then a half inch of Neuchatel asphalt; then about 9 inches of concrete in 16-foot lengths, the keys between the various lengths being filled with Bermudez asphalt, and the whole inside surface covered with the asphalt. The heavy side walls are 6 feet thick at the bottom, 6 feet deep and about 4 feet 6 inches thick on the top, not counting the molded stone coping. They are in 40-foot lengths with a square key between adjacent lengths filled with Bermudez asphalt. The side walls rest upon a double row of piles, and in addition there is sheet piling completely around the deep part of the tank. The shallow part of the tank at the southern extension is also carried on piling, as it actually overhangs the water.

The contractors for the building and basin complete were the Penn Bridge Company, of Beaver Falls, Pa., and the sub-contractors for the concrete work and the basin proper the Cranford Paving Company, of Washington, D. C.

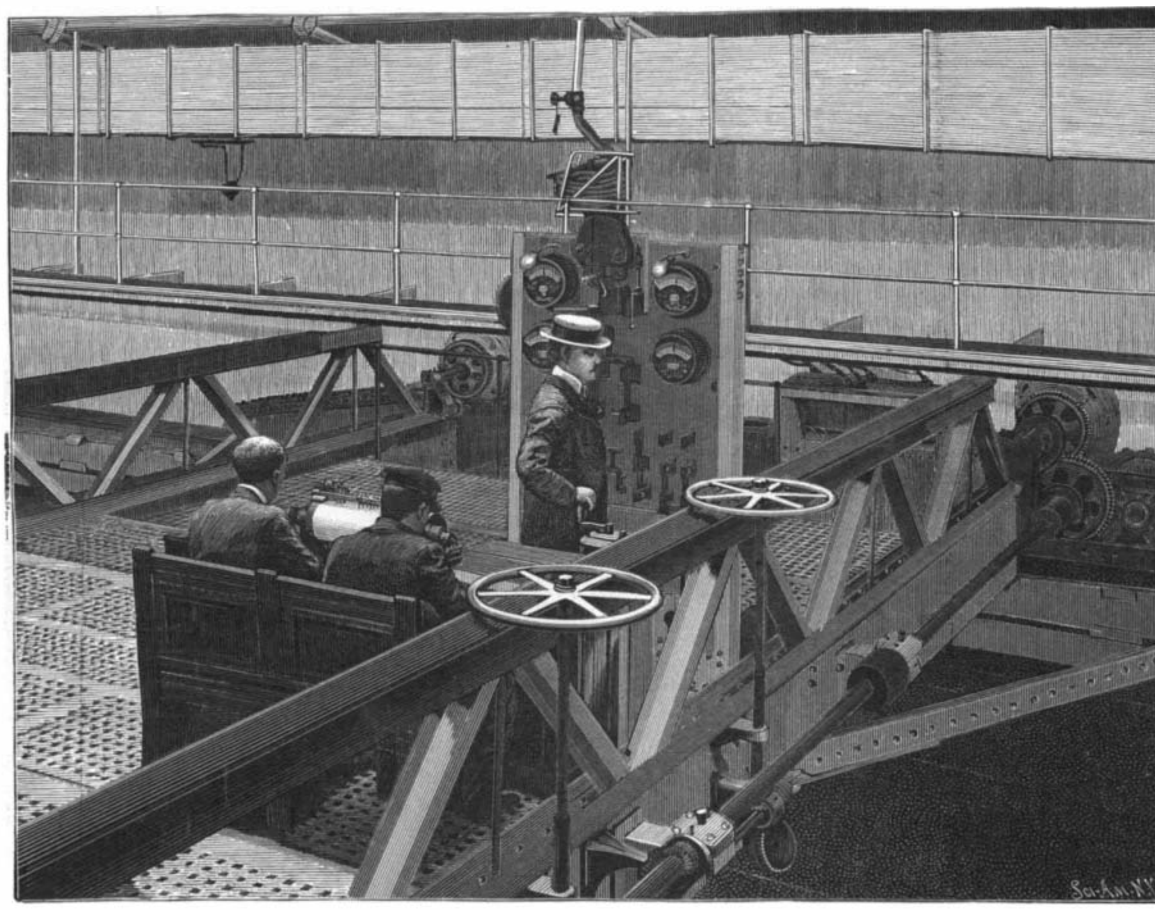

Fig. 6. Towing Carriage with Observers at Work.

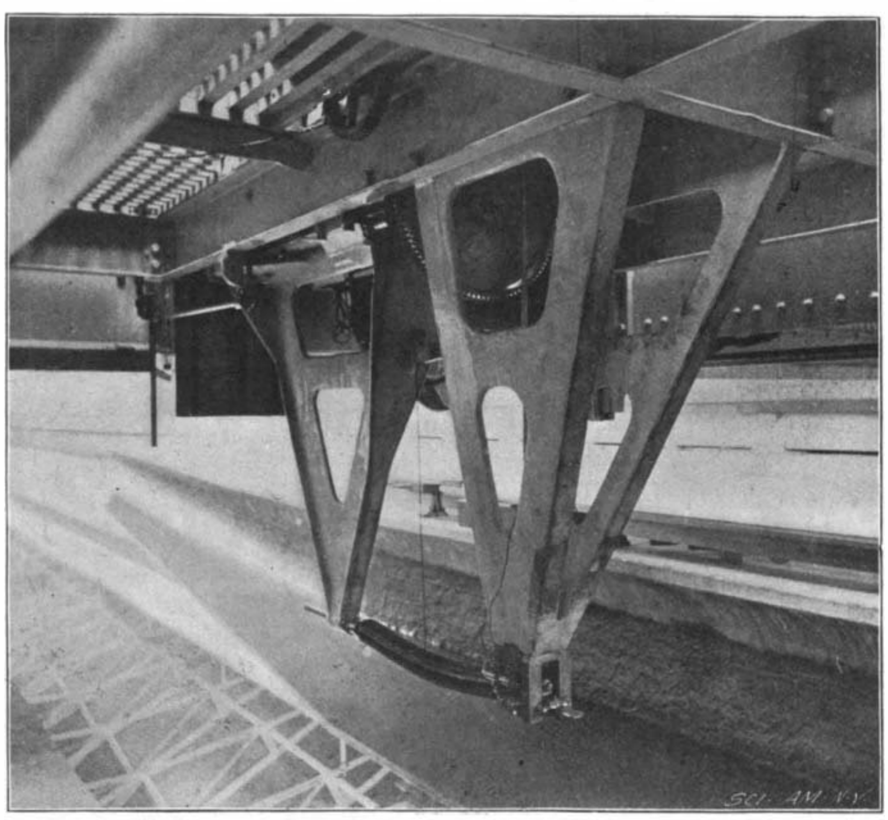

Fig. 7.—Under Side of Carriage Showing Brackets to which Towing-rod is Attached.

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The law authorizing the construction of the model basin also authorized experiments to be made for private shipbuilders, provided they defrayed the actual cost of the same, it being understood, of course, that such experiments should not interfere with naval work. This being the case, it was necessary to lay out the plant with a view to the rapid and economical turning out of routine experiments, and to this end the endeavor has been throughout to use machinery for as many of the operations as possible. The foreign tanks invariably use paraffine for the construction of models, and generally make them from 10 to 14 feet long. The climate of Washington is so warm in the summer that it was found impossible to obtain paraffine which would retain its rigidity satisfactorily, and, moreover, it was the desire of the Bureau of Construction and Repair to make the models as large as possible, thus eliminating one source of inaccuracy in applying the model experiments to full-sized ships. For these reasons wood was adopted as the material for the models, and after some difficulty a satisfactory varnish was found which rendered the surface of the wood to all intents and purposes absolutely water-tight. The standard length of model used is 20 feet. A model 20 feet long may not seem much larger than one 12 feet long, but when it is remembered that the displacements of these two are respectively as 8,000 and 1,728, it will be seen that the 20-foot model is nearly five times the size of the 12-foot model.

The method of building the model is as follows: The "lines" of the ship invariably include a body plan giving sections at moderately close intervals. From this body plan new sections are drawn to the proper size for a 20-foot model, by means of the eidograph or large pantograph shown in Fig. 2. These sections are cut out of paper, and then transferred to wooden boards which are sawed to shape. These boards are next erected in their proper relative positions upon the erecting table shown in Fig. 3, each board section being clamped in a vertical plane. They are then covered with battens about ½ inch thick and tapering from amidships toward the end, making a "former" model, the surface of which is planed smooth. In cutting out the sections allowance is made for the thickness of the battens which have to be nailed upon them. Meanwhile, a rough block of shapes and dimensions to enable the finished model to be cut from it has been prepared and glued together under pressure in a large hydraulic press. This block is placed upon the upper table of the model-cutting machine, illustrated in Fig. 4, the "former" model being placed upon the lower table. The model-cutting machine works upon the principle of the Blanchard lathe, a roller transversing the surface of the "former" model and saws or cutters working upon the surface of the model proper. The bulk of the material is removed from the block by means of the saws, which are shifted along a short distance at a time. Rotary cutters are then applied which finish the surface of the model very close to the desired shape. The model is then removed from the cutting machine and finished by hand; a very small amount of hand work, however, being found necessary. It is now ready for varnishing and the attachment of any appendages, such as bilge keels, struts, etc. It is finally taken to the measuring machine as shown in Fig. 9, and careful measurements made of its exact form and shape, which not only enable the staff to determine whether the model represents the lines desired, but gives an exact record of the actual shape.

The model is now ready for the towing experiments. Figs. 5, 6 and 7 show the carriage used in this work, Fig. 6 showing the observers in position upon the carriage. It runs upon eight wheels and spans the full width of the basin, as shown. The platform in the center, carrying the recording apparatus, can be raised or lowered at will. Electricity is used to drive the carriage, and it may be mentioned incidentally that electricity is used for all mechanical work in connection with the model tank. The speed of the carriage is varied not only by making various combinations of the four motors—one to each pair of driving wheels—but by controlling the output of the generator in the power station, which is, perhaps, 100 yards from the tank. This control is on the Ward-Leonard system, and is very similar to that used to control the motion of heavy turrets on board ship. By means of a resistance box on the carriage the current through the field coil windings of the generator is increased or decreased at will. The revolutions of the generator being kept constant by a delicate governor, the amount of current generated varies with the amount of current through the field coils of the magnet. The whole of the current generated is passed through the motors, and in practice it is found that a very exact regulation of speed is obtained by this combination. The carriage itself, with its fittings, weighs in the neighborhood of 25 tons, so that it alone forms a kind of fly-wheel, and is not subject to sudden variations of speed. The speed of the carriage can be varied from $\frac{1}{10}$ knot an hour, or 10 feet per minute, to 20 knots an hour, or 2,000 feet per minute.

The principal difficulty in connection with the use of high speeds, which, while not necessary for the bulk of the experiments, will be of great value in certain special experiments, is to stop the carriage when it is once under way. The electrical control acts as a brake, be-

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Fig. 1.—Exterior View of Experimental Model Basin.

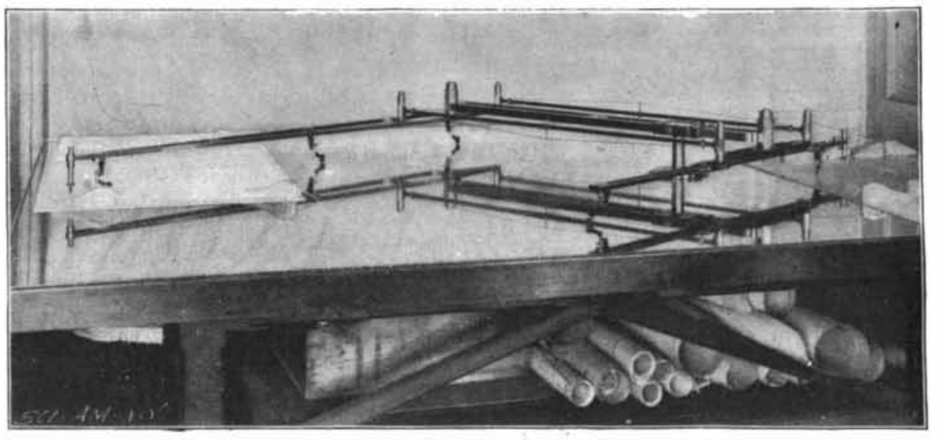

Fig. 2.—Eidograph for Reproducing Sections of Model.

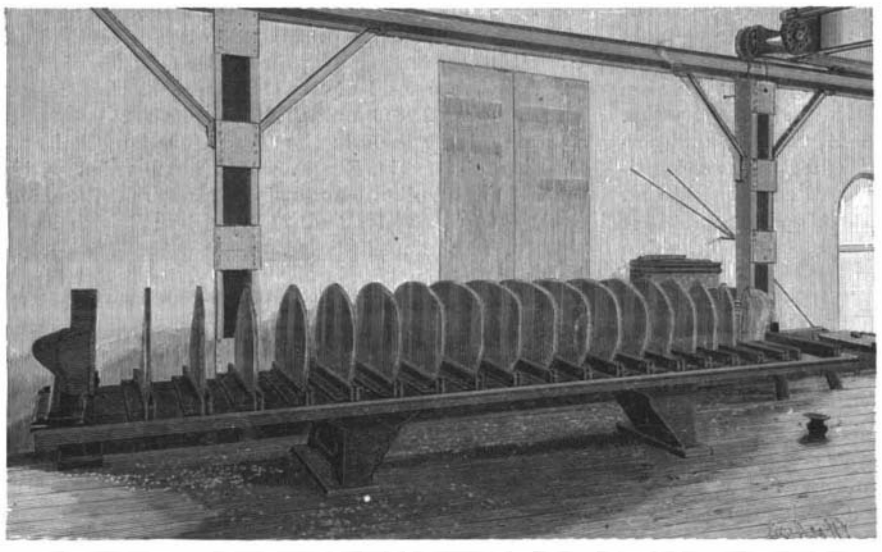

Fig. 3.—Board Sections for Making "Former" Model, on Erecting Table.

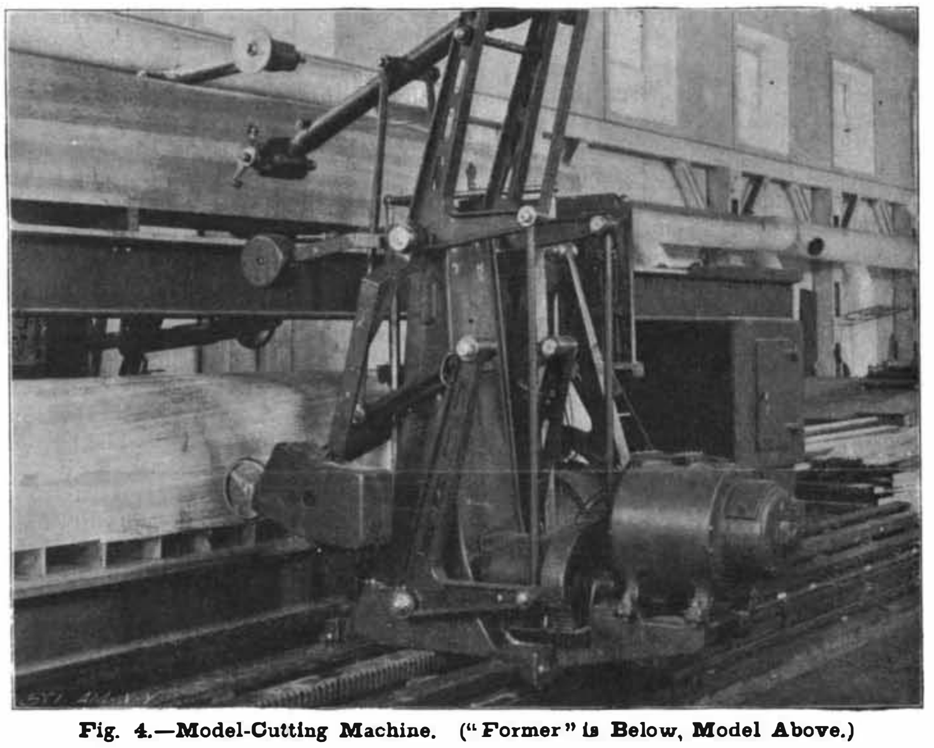

Fig. 4.—Model-Cutting Machine. ("Former" is Below, Model Above.)

Fig. 5.—Interior View Showing Basin and Towing Carriage.

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cause when the current is shut off the motors become generators, but this could not be relied upon for high speeds, since the sudden rush of current due to possible unskillful manipulation would throw the circuit breakers, thus opening the circuit and cutting off the current entirely. For these reasons there is at the north or terminal end of the basin a double system of brakes to take hold of the carriage. The first is a friction brake consisting of two strips of iron on either side pressed together by hydraulic cylinders. These are forced apart by a slipper on the carriage about 10 feet long, which, as well as the brake strips, is kept thoroughly oiled, so that the coefficient of friction for stopping, though low, is fairly definite, and sudden jerks are avoided. The pressure in the hydraulic cylinders is controlled by an accumulator and a pump driven by electricity. Great care has been taken in connection with this part of the installation that it may be always in working order, and any trouble or breakdown, except that of the pump itself, which runs all the time, will simply result in setting the pressure at a maximum. This maximum is 600 pounds, but it has been found by actual experiment that with 500 pounds pressure the carriage is brought safely to rest when it enters the brakes at a speed of 20 knots. It is not expected in practice to repeat this often, since even for the high speed runs the electrical brake will be used to reduce the speed of the carriage before the friction brake is used. In addition to the friction brake there is what is called the emergency brake, so that in case the friction brake fails for any reason, the carriage would still be caught. This brake consists simply of a piston about 16 inches in diameter working in a cylinder which is submerged in the water of the tank and connected by wire cables to a hook which takes hold of the carriage. The head of the cylinder has a round hole and the piston rod is tapered so that as the rod is drawn out by the motion of the carriage the hole is gradually closed, the whole being almost exactly upon the principle of the hydraulic gun recoil brake. An escape is provided for the water around the piston when it starts from rest to avoid sudden accelerations from the whole mass of water in the cylinder.

The dynamometric apparatus is designed to avoid entirely the use of multiplying levers or other devices involving the possibility of friction, and here again electricity is enlisted. The recording drum is fitted with apparatus for recording the time and distance, as usual. The resistance is measured directly by a spring, the arrangement being as indicated in Fig. 7, which is a view underneath the carriage. The forward end of the spring is attached to a bracket, which is screwed forward or back by an electric motor, and a rigid arm runs up from the bracket, with a pencil recording its position on the drum. The record then is of the position of the forward bracket. The after end of the spring takes hold of a small cross-head to the other end of which again is attached a towing rod which takes hold of the model. This cross-head has a very slight play between stops in the after fixed bracket, and when it touches either stop closes an electrical contact which again throws an electric clutch by means of which the motor, running all the time, screws forward or back the forward bracket, thus increasing or decreasing the tension of the spring until the contact is opened again.

There are many refinements which cannot be indicated in this brief description; for instance, the operator can throw either clutch at will or set them to work automatically. In practice, when about to make a run, the operator works the bracket forward to the immediate vicinity of the position which he knows it will assume during the run, the approximate speed of which he knows. The carriage is then started and after a uniform speed has been obtained, which, for speeds up to 12 knots, is done within 50 feet, he throws in by a single motion of one handle the automatic appliances which start the drum and record time, distance and resistance. In this way the resistance pen has to move but a small distance to reach the position of equilibrium and almost immediately becomes steady. It will be seen that with this device friction is eliminated. The accuracy obtainable depends upon the closeness with which the automatic stops at the after end of the spring can be set. In practice it is found that these can be set to give a play of about the fiftieth of an inch, and as the springs will extend 10 inches, the results obtained are practically exact as indicating the pull of the spring.

It now remains to describe the method by which the amount of this pull can be determined in any instance. There is fitted at the starting end of the basin a kind of weighing machine with one vertical and one horizontal arm. This is delicately balanced, and when the model has been connected up and is ready for towing, a certain spring being in use, the vertical arm, or rather a knife edge which bears upon the vertical arm, is connected to the model. A known weight is then put into the scale pan attached to the horizontal arm. The automatic attachment in connection with the dynamometer spring is thrown into gear, and the weighing machine is screwed forward or backward until it is in perfect balance and the record pen recording the position of the spring is at rest. It is evident then that the pull of the spring is exactly equal to the weight in the scale pan. There are a number of pens which can be shifted parallel to the recording pen and set in a definite position to record upon the drum. One of these pens is set to correspond to the position of the resistance pen, then another weight is put into the scale pan, a second pen set to record the resistance, and so on. It is evident then that when the run is made these fixed pens mark off upon the paper a scale for resistance, avoiding all complications of corrections for temperature of spring or anything else. A complete double outfit of springs is already provided for measuring resistance from 1 pound up to 500 pounds, and for special work additional special springs will be obtained.

In connection with the question of temperature, it is impossible to avoid a certain variation of the temperature of the water, but as ample heating facilities are provided, as indicated in the pictures of the building, where the heater pipes are shown, it is not expected that the variation of temperature during the year will be sufficient to necessitate correction in the results of experiments on this account. The basin is filled from the water system of Washington, and will hold 1,000,000 gallons. Two electrical centrifugal pumps are provided, the larger of which will empty the tank in about four hours. The smaller pump is a 4-inch pump, used for draining the last water from the basin and also for pumping the water from outside the basin, to avoid the possibility of undue pressure upon it in case it is left empty for some time. This is necessary, since the basin is but a short distance from the Potomac River, and extends 8 or 9 feet below mean tide level. A gage indicates the level of the outside water, which is found to be, as a rule, about 6 feet below the water in the basin.

The leakage from the basin, which is very slight, and the evaporation, are made up with filtered water, an animal bone filter being installed with a capacity of from 50 to 100 gallons per minute, depending upon the turbidity of the water. In practice a small stream of fresh filtered water is kept running into the basin all the time, and the level maintained wherever desired by an adjustable overflow.

The building and tank or basin proper were designed by the Bureau of Construction and Repair, as well as the machinery for making models. The electrical installation was fitted by the General Electric Company, many of the electrical details of design being also due to them. The carriage proper was built by the William Sellers Company, the dynamometer apparatus partly by the Sellers Company and partly by Saegmuller, of Washington, who also built the large eidograph. All of these are upon the designs of the Bureau of Construction and Repair. The model-cutting machinery was built by Detrick & Harvey, of Baltimore, Md., to the designs of the Bureau of Construction and Repair.

The model basin staff is now at work upon experiments to determine frictional coefficients of varnished surfaces and other constants needed in its use. Experiments are being made as opportunity serves upon models of the naval vessels already built and tried for the purpose of accumulating data which will be constantly needed during the life of the tank. As soon as preliminary lines of the new third-class cruisers authorized at the last session of Congress are completed, experiments will be made with them in the tank with a view to introducing any refinements or improvements found desirable.

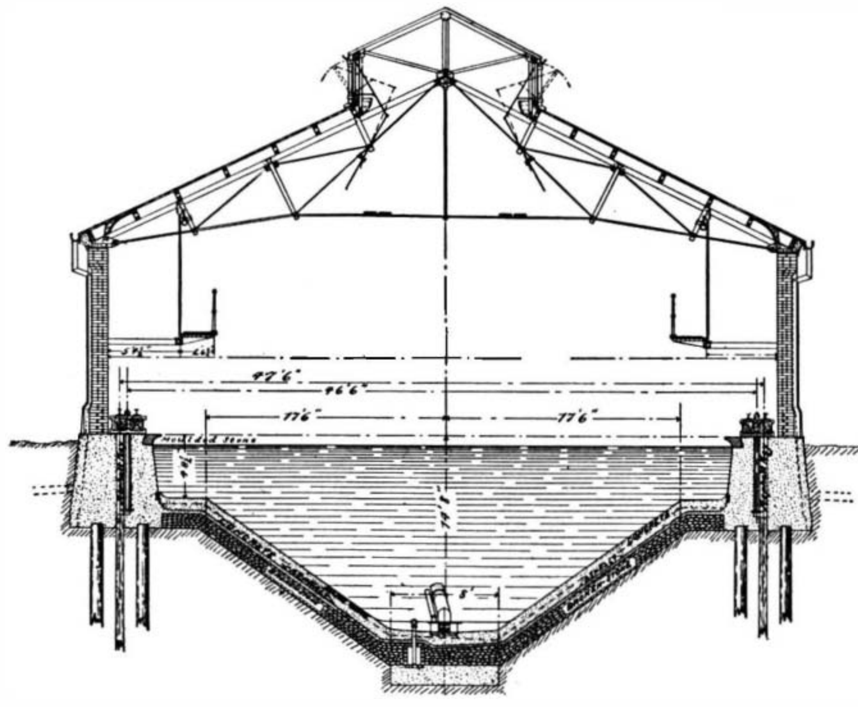

Fig. 8.—Cross-section Showing Construction of Model Basin.

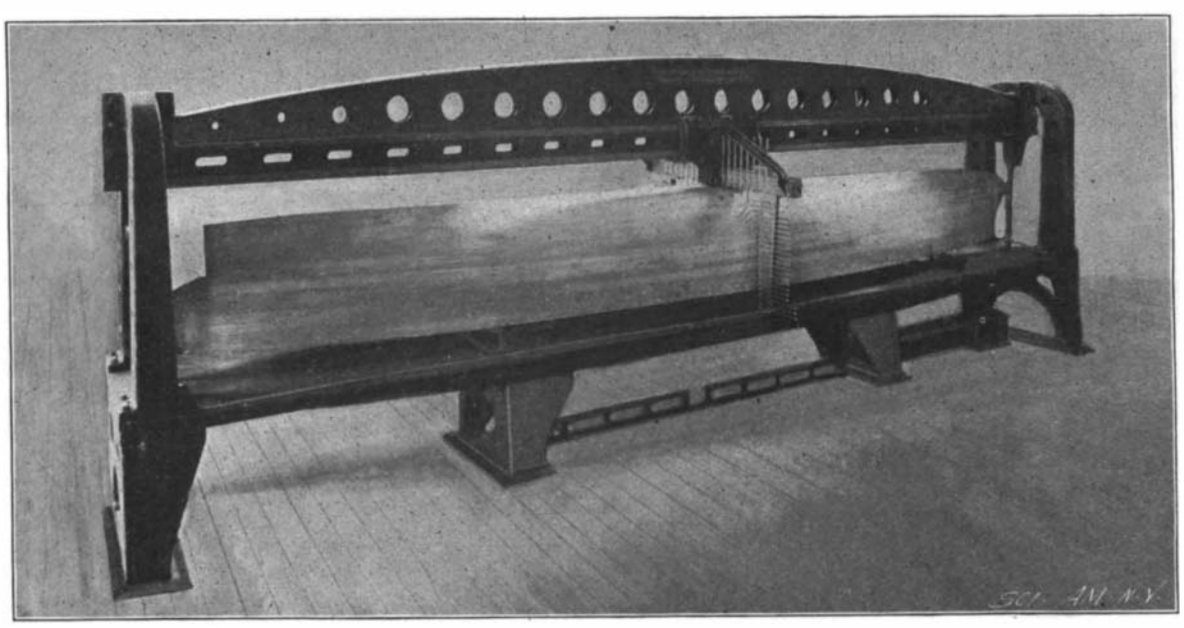

Fig. 9.—Model Measuring Machine.

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A Trans-Continental Automobile Trip.

The first trans-continental automobile trip will be begun on July 1. Mr. and Mrs. John D. Davis will start from The New York Herald building for the longest automobile run on record. Besides the length of the trip, it will be a remarkable test of American self-propelled vehicles over the worst of American roads. In Europe the longest run that has been made was 621 miles over the most perfect of roads. The trip from the Atlantic to the Pacific will cover about 3,700 miles. There are some good stretches of road in the East and some fair roads in the middle West, but in the Rocky Mountains the coach routes will be most trying. The vehicle is what is known as a "continental touring car." It was built in Stamford, Conn., by the National Motor Company specially for the trip, the parts being made stronger than the same type of vehicle used for good roads. The motor is a gasoline one. The carriage has special gears which will enable it to climb mountains of quite a steep grade.

The route will be up the Hudson Valley to Albany, then by way of Syracuse, Rochester, Buffalo, Erie, Cleveland, Toledo, South Bend, Chicago, Davenport, Des Moines, Omaha, Denver, Ogden, Sacramento, and San Francisco. If the vehicle reaches the latter city, the stop will be made at The San Francisco Call building. Mr. Davis expects to reach San Francisco early in August.