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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
SAN FRANCISCO, CALIFORNIA

8 February 1946

RESTRICTED

From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Ordnance Research, Article 3 - Torpedo Models.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering Japanese torpedo model research methods outlined by Target 0-39 of Fascicle 0-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lieut. R. R. Morin, USNR.

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30658

JAPANESE ORDNANCE RESEARCH
ARTICLE 3 - TORPEDO MODELS

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE O-1, TARGET O-39

FEBRUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ORDNANCE TARGET

JAPANESE ORDNANCE RESEARCH
ARTICLE 3 - TORPEDO MODELS

All experiments with torpedo models were made at the First Naval Technical Arsenal, YOKOSUKA, Japan. A large water tunnel was constructed during the war with the intention of making detailed studies of torpedo shapes and characteristics. During the last few months of the war, some inconclusive data were obtained on lift, drag, and pitching moment using one-fifth and one-tenth scale models of torpedoes, but much time had apparently been spent testing, redesigning, and calibrating the tunnel equipment itself. For measuring the variables the principle of magnetostriction was employed.

For the study of entrance characteristics and underwater trajectories of various shapes of torpedoes, scale models of aircraft torpedoes were launched into a water tank by means of a catapult. Compressed air was used to operated the catapult, and the angle of launching was easily adjusted. The underwater trajectory of the torpedo could be observed from large windows in the side of the tank, and photographs were taken of both the air travel and underwater run. The model launcher and water tank had been in use since 1943, and many studies were made of the relations between launching velocity, angle of launching, model shape, and water trajectory.

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A. Location of Target:

First Naval Technical Arsenal, KANAZAWA, Japan.

B. Japanese Personnel Who Assisted in Gathering Documents:

Technical Comdr. K. FUKUBA, First Naval Technical Arsenal, KANAZAWA.

C. Japanese Personnel Interviewed:

Technical Rear Adm. S. NARUSE, in charge of the Aerial Torpedo Section at the First Naval Technical Arsenal. (Twenty-two years experience in torpedo design.)

Technical Comdr. K. FUKUBA, Chief Torpedo Designer under Rear Adm. S. NARUSE. (Twelve years experience in torpedo design.).

INTRODUCTION

This report is based upon information obtained through interrogation of responsible personnel connected with torpedo model research for the Japanese Navy and an investigation of their research equipment. The report describes all facilities and methods used in research, and the effect of the experiments on Japanese torpedo design.

THE REPORT

Part I
WATER TUNNEL EXPERIMENTS

In order to make detailed studies of torpedo shapes and characteristics, the Japanese constructed a large water tunnel at the First Naval Technical Arsenal near YOKOSUKA. This water tunnel was used during the last few months of the war to obtain data on the lift, drag, and pitching moment of scale models of aircraft torpedoes.

Construction of the water tunnel was started in 1942 and completed in 1944, but preliminary designs and calculations were made from 1940 to 1942 with a small-scale model of the tunnel. It is the largest water tunnel in Japan. It was designed by Technical Lieut. Comdr. H. NAGASHIMA, who also designed the model projector and water tank. He was later killed in an air raid in the early part of 1945.

The whole tunnel system is located inside a wooden building, with the exception of the large reinforced concrete tank which makes up one end of the tunnel. (See Fig. 1.) This tank supplied the pressure head for the system, and water was pumped around the tunnel against the pressure. The rest of the tunnel is principally of welded steel construction using plates 15mm thick (0.59 inches). It has a maximum inside diameter of 2.22 meters (7.25 feet), narrowing to 1 meter (3.28 feet) at the throat. Fig. 3 shows a diagram of the tunnel with all the principal dimensions.

The speed of flow is regulated by a variable pitch propeller which is controlled by means of a water-servo pump. This pump is easily operated with a handwheel located on the main floor. (See Fig. 2). The propeller is powered by a 500 hp, 3-phase induction motor through a 2:1 reduction gear. The motor runs at a constant speed of 490 rpm and is rated at 370 KW, 3300 volts, 82 amps., 50 cycles. Fig. 4 shows the motor and reduction gear box.

The maximum velocity at the testing point is 13 meters/sec. (about 26 knots), and no excessive vibration occurred at this speed. The velocity of flow is measured with a pitot tube and simple manometers as shown in Fig. 5.

The irregularity of flow was tested by trailing small pieces of string from a steel bar across the throat of the tunnel and observing flow patterns. The flow in the middle 60 per cent of the tunnel was considered regular enough for fairly accurate results.

One-fifth and one-tenth scale models were tested in the tunnel. The models were made of solid wood with steel tail cones and fins. Fig. 6 shows the method used for suspending the models in the tunnel. Piano wire, having a diameter of 2mm. (0.0787 inches) and a breaking strength of 250 kg. (550 lbs.), was used for suspension. Considerable vibration was experienced with piano wire, and it was planned to use small strand wire instead. However, no tests were made with this new wire.

The model was suspended upside down, as in wind tunnel experiments, so that lift acted downward, making it easier to measure.

The principle of magnetostriction was used for measuring the variables. The magnetic material was made of iron containing some nickel, and was wound with an AC excited coil. A separate magnetostriction device was used with each suspension wire as shown in Fig. 6. These magnetostriction devices were connected to separate milliammeters on the instrument panel nearby (see Fig. 7). Any variation in lift or drag caused corresponding changes in magnetization of the iron and resultant changes in milliammeter readings. These readings were taken throughout the tests and later compared with calibrated data.

All data and reports were destroyed by the Japanese, but an electric circuit diagram for the magnetostriction meters was recovered and is included as Enclosure (A) of this report.

The angle of the model could be adjusted by means of a hand crank on top of the tunnel. The details of the adjusting gear are shown in Fig. 6. The model suspension frame, angle adjusting gear, and magnetostriction equipment is all contained in a large steel box mounted on top of the tunnel. (See Fig. 8). The model suspension weights are enclosed in the steel box underneath the tunnel, and two small observation windows are located on each side of the throat.

An access hole, large enough for a man to crawl through, is located on the side of the tunnel about ten feet from the nose of the model. (see Fig. 9). Prior to the installation of this hole, it had been necessary to remove the observation windows in order to fix the torpedo model in position.

To remove eddies from the stream, two large steel gratings are located in the tunnel about ten feet either side of the throat. Each grating has 2-inch square openings. (See Fig. 9.)

The water pressure in the tunnel was attained only by means of the water head in the large concrete tank.

Although the tunnel was completed at the end of 1944, difficulties were encountered which delayed actual experiments with torpedo models until just before the war ended. The curvature of the tunnel at the throat was changed slightly until the present shape was considered satisfactory. Trouble with air bubbles in the stream necessitated the addition of two rotary vacuum pumps with a pipe leading to the top of the large concrete water tank. These pumps were connected in series and driven at 1450 rpm by two 5-horsepower electric motors.

The only significant studies made in the tunnel were on the velocity of flow, irregularity of flow, characteristics of a sphere, and drag measurements of the model suspension wires. Figs. 11, 12, and 13 show the arrangements used in the studies. The wire drag was measured by mounting a wooden frame in the tunnel (See Fig. 12) and taking readings. The procedure was repeated using two wooden frames with exactly the same dimensions. The difference in drag of the two systems determined the drag of the wires.

From about May 1945 to July 1945 only six experiments were made with torpedo models and no conclusive data were obtained.

These experiments apparently constituted the extent of this type of investigation, since the Japanese had, in addition to this tunnel at YOKOSUKA, only two other water tunnels, both small. One located at Tohoku Imperial Technical University at SENDAI in which experiments were made with ship's propellers and the other at the Navy Laboratory in TOKYO. Neither carried on any experiments with torpedo models.

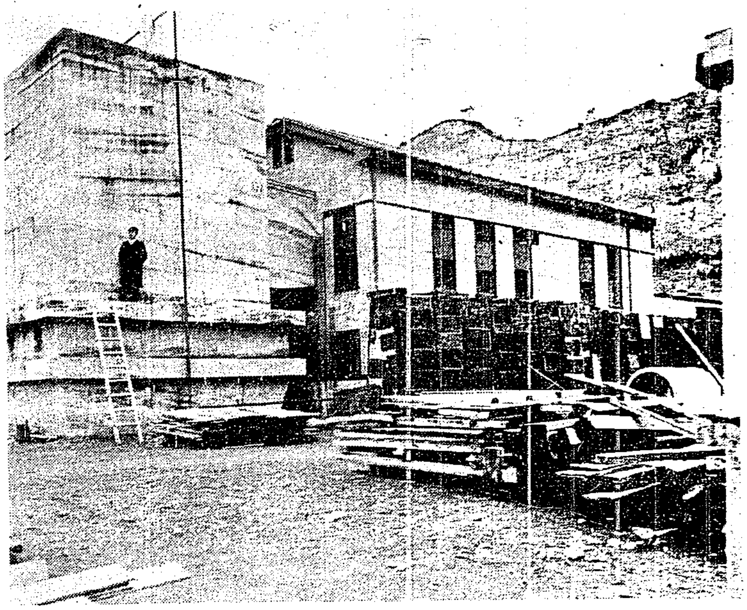

Figure 1
BUILDING WHICH HOUSES WATER TUNNEL AT FIRST NAVAL TECHNICAL ARSENAL

Figure 2
HANDWHEEL FOR REGULATING PITCH OF PROPELLER BLADES

WATER TUNNEL DIAGRAM
FIG. 3

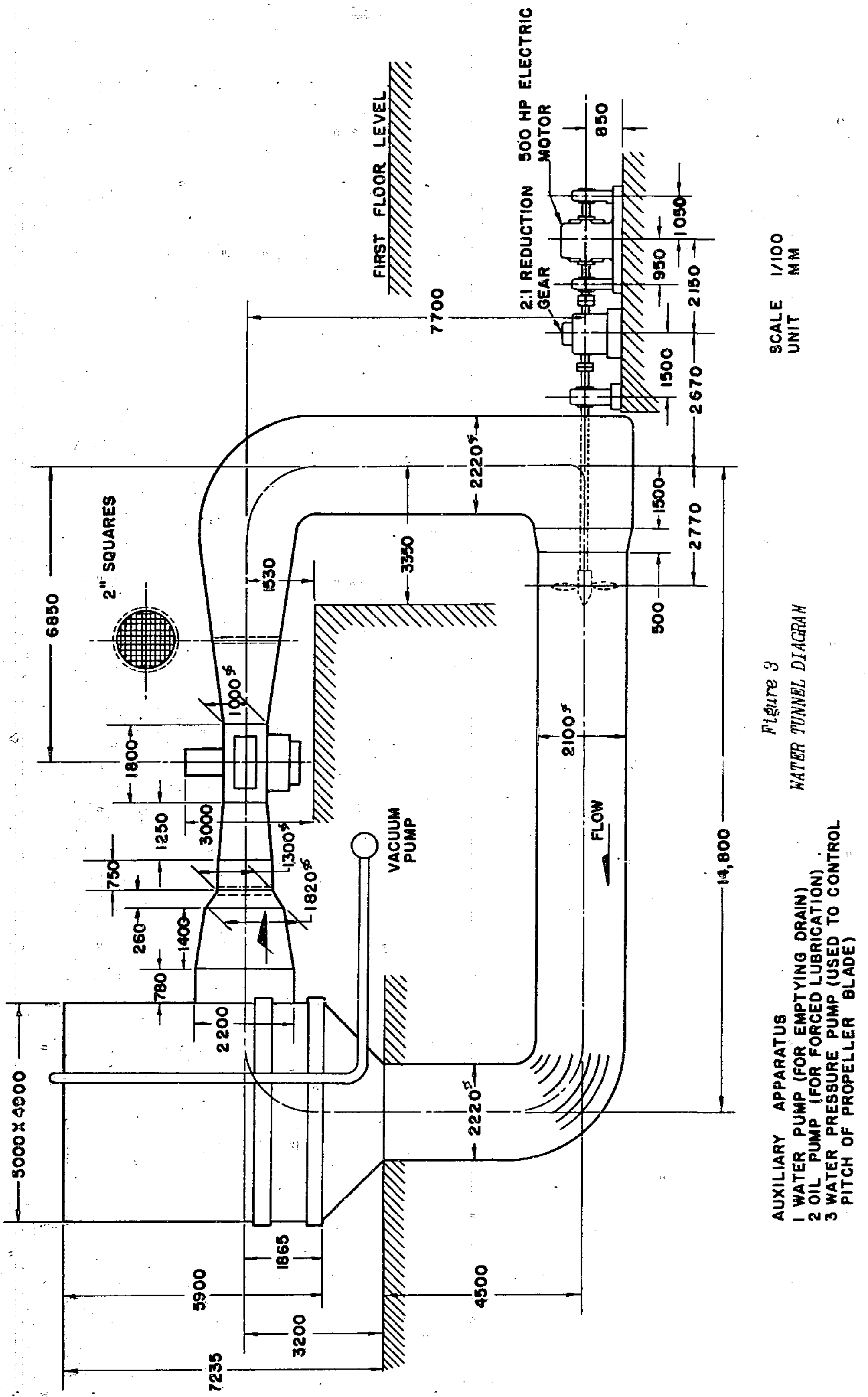

Figure 3
WATER TUNNEL DIAGRAM

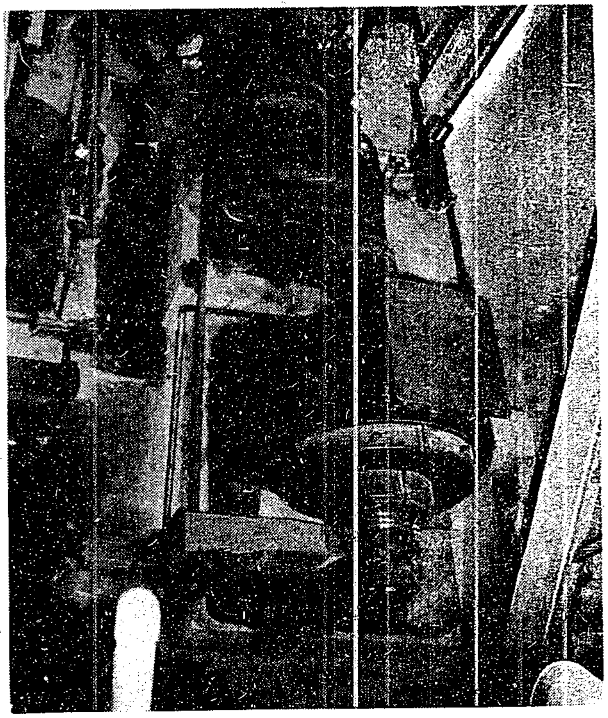

Figure 4
500 HP INDUCTION MOTOR AND 2:1 REDUCTION GEAR

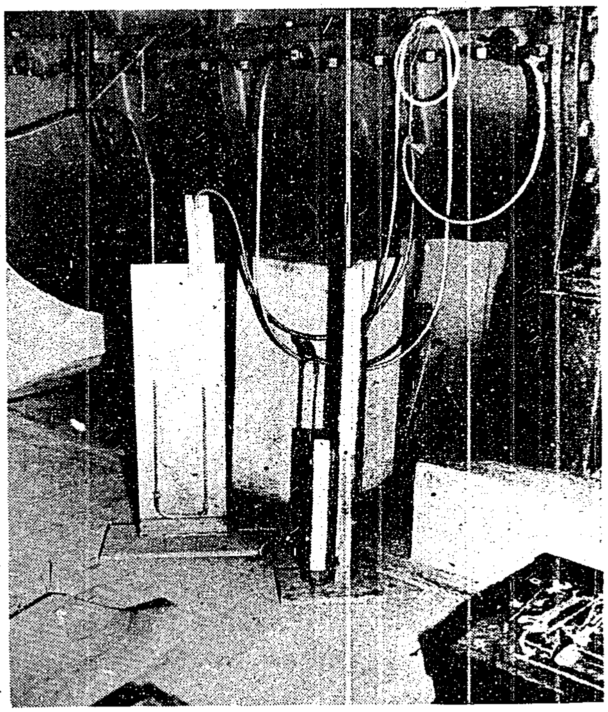

Figure 5
MANOMETERS USED FOR MEASURING VELOCITY HEAD IN STREAM

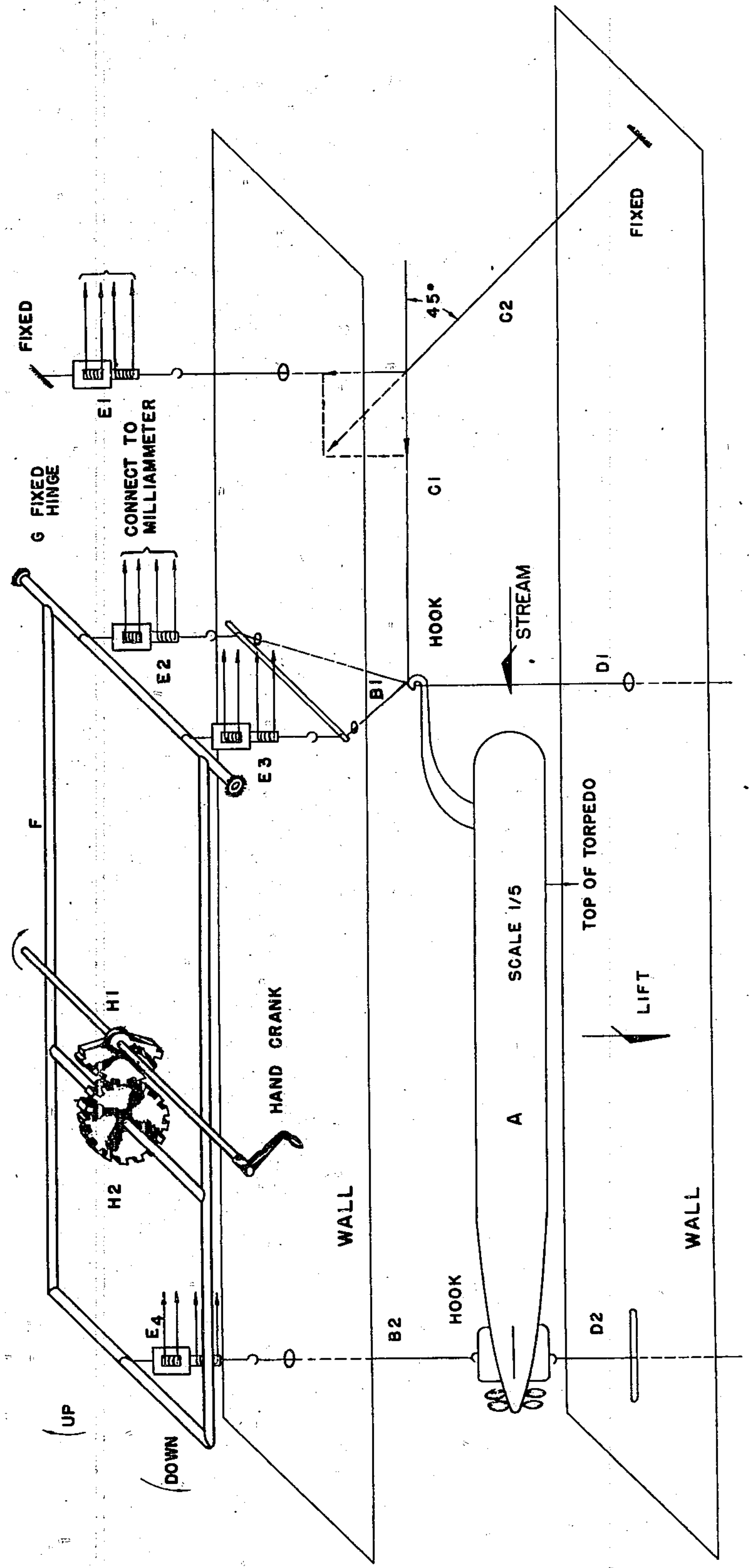

Figure 6
DIAGRAM OF WATER TUNNEL MODEL SUSPENSION SYSTEM

Explanation of Fig. 6 (Diagram of Water Tunnel Model Suspension System).

A	Torpedo Model.
B_1	Forward suspension wires.
B_2	Tail suspension wire.
C_1 & C_2	Drag suspension wires.
D_1	Wire for forward weight.
D_2	Wire for tail weight.
W_1	Forward weight.
W_2	Tail weight.
E_1	Magnetostriction material for measuring drag.
E_2 & E_3	Magnetostriction materials for measuring forward lift.
E_4	Magnetostriction material for measuring tail lift.
F	Model angle adjusting frame.
G	Frame fulcrum.
H_1 & H_2	Model adjusting gears.

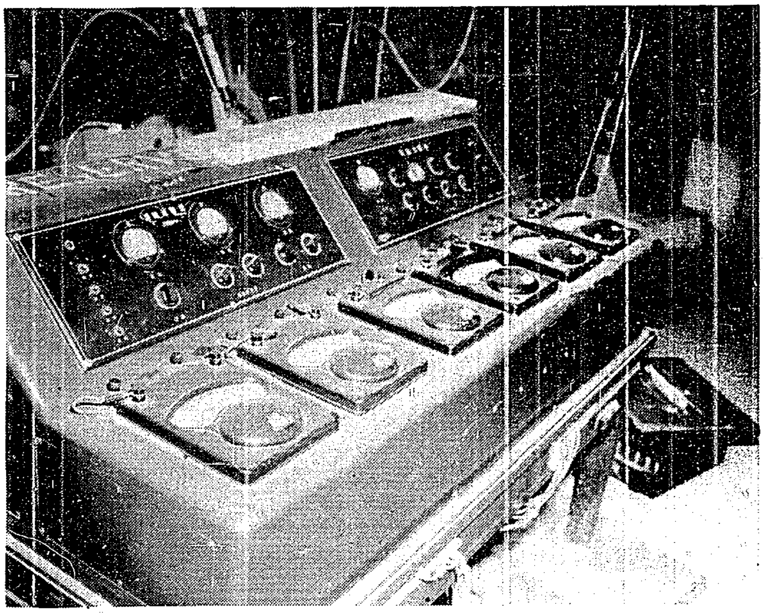

Figure 7
INSTRUMENT PANEL FOR RECORDING WATER TUNNEL EXPERIMENTAL DATA

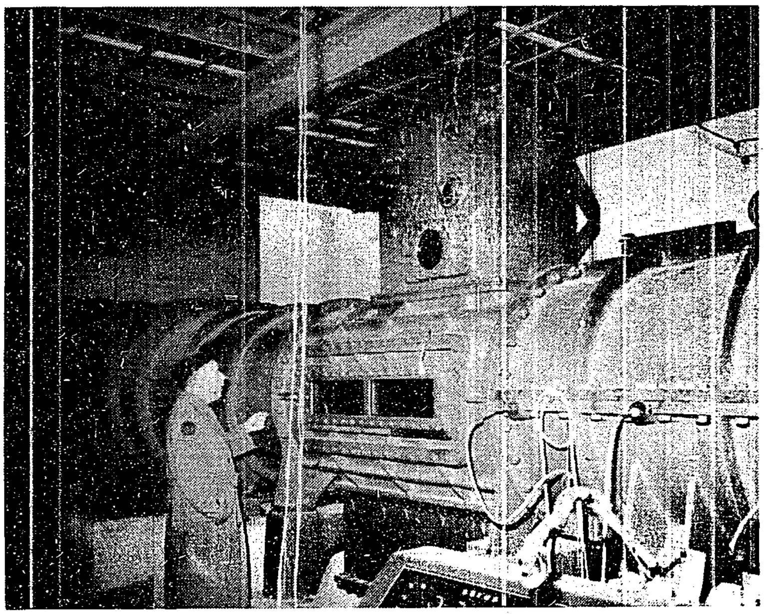

Figure 8
GENERAL VIEW OF WATER TUNNEL THROAT

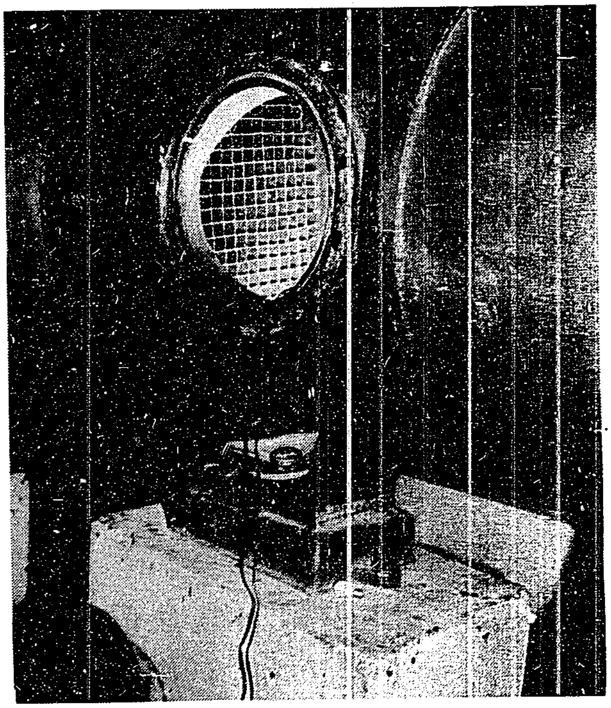

Figure 9

ACCESS OPENING IN THE SIDE OF WATER TUNNEL

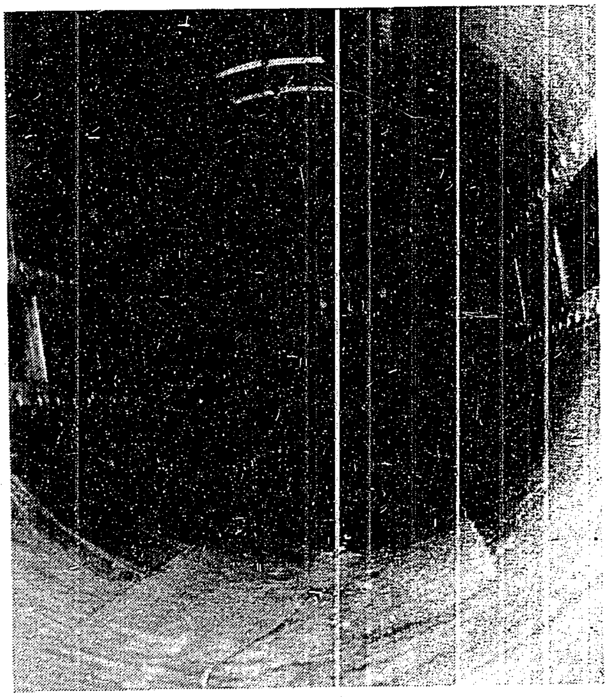

Figure 10

INTERNAL VIEW OF WATER TUNNEL SHOWING MODEL SUSPENSION WIRES, OBSERVATION WINDOWS, AND GRATING

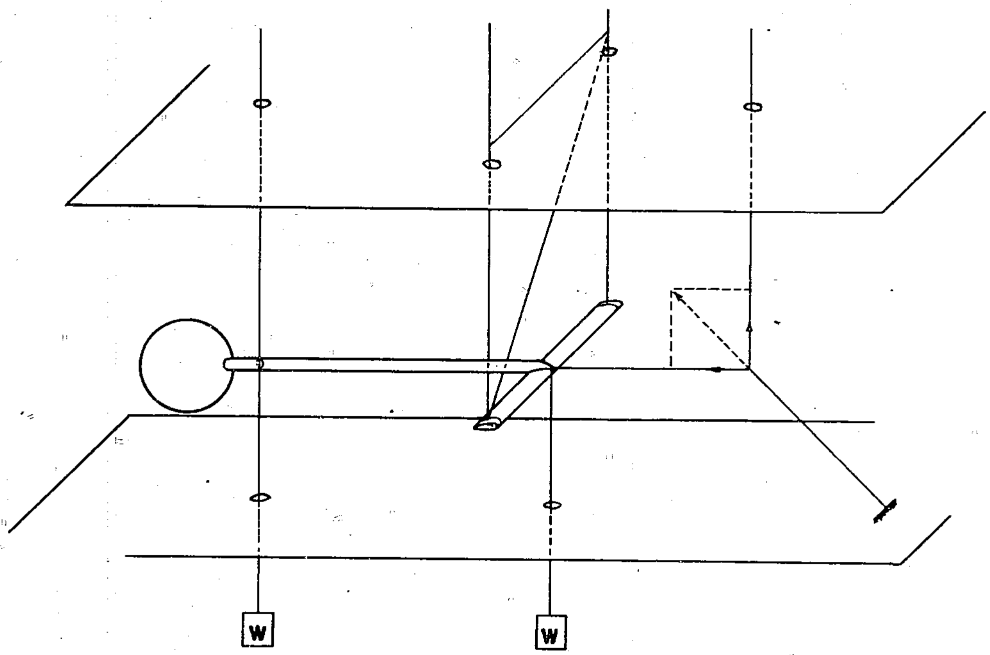

Figure 11

TEST ARRANGEMENT FOR SPHERE WITH KNOWN REYNOLD'S NUMBER

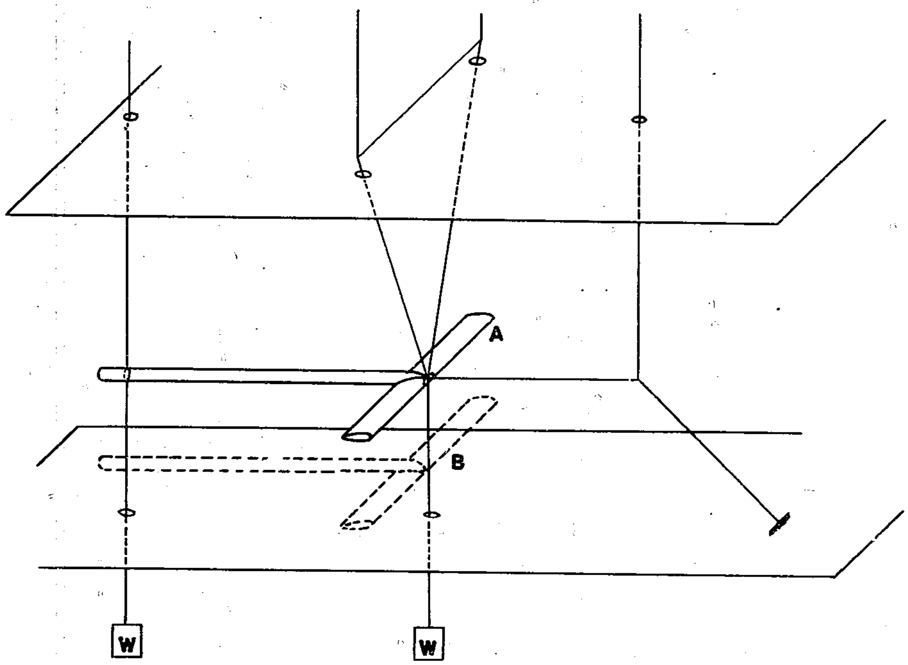

Figure 12

WATER TUNNEL ARRANGEMENT FOR MEASURING DRAG OF SUSPENSION WIRES

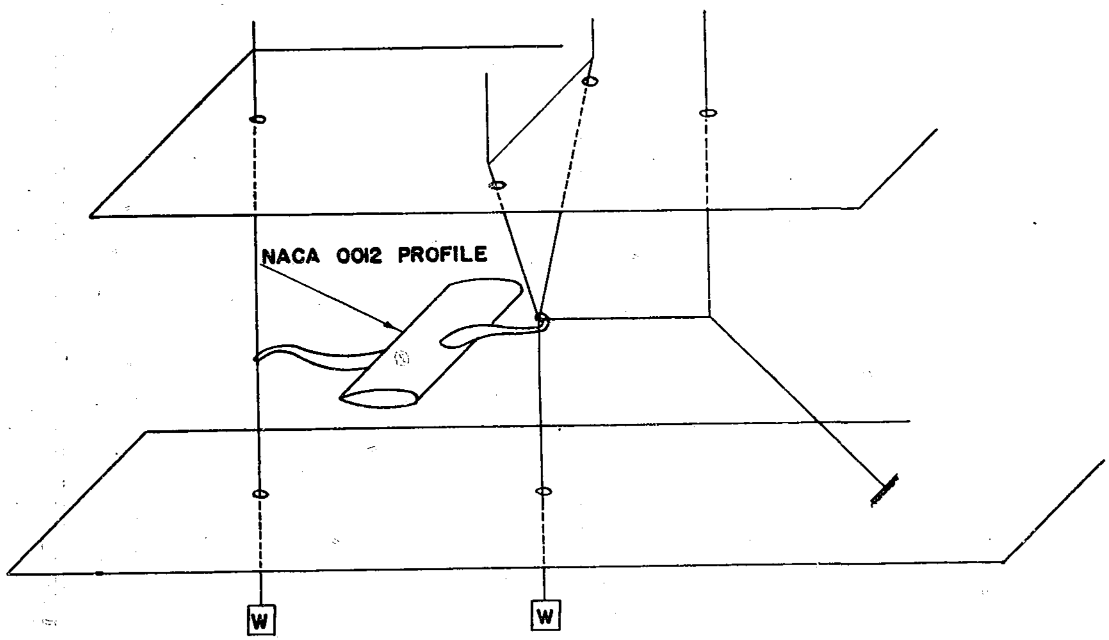

Figure 13

METHOD OF MEASURING IRREGULARITY OF FLOW

Part II
MODEL LAUNCHER AND WATER TANK

Also located at the First Technical Arsenal is a catapult which was used to launch scale model torpedoes into a large concrete water tank. With this equipment it was possible to study entrance characteristics, and underwater trajectories for various shapes of torpedo models.

The appearance of the model launcher is shown in the photographs in Figs. 14 and 15, and its principal dimensions are shown in the drawing of Fig. 16. The angle of launching was adjusted by means of a hand crank, and could be clamped in any desired position. The whole apparatus was mounted on rails, making it possible to move the launcher nearer or farther away from the water tank.

The model was placed in the tube at the rear of the launching rails, and held inside by a small adjustable spring clamp. This tube had a separate air bottle attached underneath which could be charged to a maximum pressure of 25 kg/sq. cm. (356 psi). The tube with model inside was catapulted along the launching rails; at mid-position a cam tripped the stop valve and compressed air shot the model out into the water tank. A guide slot is cut along the top of the tube, and the inside diameter is 1mm. larger than the model diameter. The angle of the tube can be adjusted so that it does not coincide with the angle of the launching rails.

The tube is catapulted along the rails by means of cables connected to a piston rod. The piston is forced back by compressed air from the larger air bottle at the forward end of the launcher. The speed of the catapult is regulated by air bottle pressure which never exceeds 25 Kg/sq. cm. (356 psi). Adjustable spring clamps hold the tube in position at the rear end of the rails until firing.

When the tube reaches the end of the rails, its forward momentum is absorbed by coil springs and an oil piston similar to that used in gun recoil mechanisms. The air pressure used to eject the model from the tube also helps to brake the forward motion.

The catapult is fired by means of a long lanyard which is connected to a smaller rocker arm on the firing valve body. The rocker arm has a small cam which lifts the firing valve off its seat and releases the air pressure on top of the main air valve. The air supply is shut off after firing by a small wire cable attached to the piston rod and wound around a steel spool. As the piston is shot back, the spool is rotated around a worm which is screwed upward, closing the main air valve.

Either one-fifth or one-tenth scale models could be used by changing the size of the tube. The models were made of wood with steel tail cones and fins, and sometimes a steel nose cap.

The maximum launching velocity was 100 meters/sec. (328 feet/sec.) with 70 meters/sec. from the tube air pressure and 30 meters/sec. from the catapult. Velocities were measured by calibrating the photographs of the air trajectories, but this method was not very accurate. A more accurate system was planned using thin copper sheets (0.05mm.) at intervals along the trajectory. Two copper sheets were to be suspended closely together at each interval. When the torpedo model was fired, it pierced the first pair of sheets and completed an electric circuit to the timing instruments. This procedure was duplicated as the model passed through the second pair of copper sheets, thus making it possible to obtain accurate time and distance measurements. However, this system was never put into operation.

Fig. 17 shows a diagram with principal dimensions of the water tank used for model launching experiments. The walls of the tank are made of reinforced concrete, and it has a maximum depth of eight meters (26.3 feet) at the launching point. There are four observation windows on the left side, two o which run above and below the water surface as shown in Fig. 19.

Photographs were taken from above and below the water surface to study the entrance characteristics and underwater trajectories. A high-speed motion picture camera was used for the air trajectory, and an ordinary still camera, with an external, rotating, slotted shutter for the underwater trajectory.

Constant illumination was provided by two 3 KW lamps from directly above with four 2 KW, 100 volt spotlights and six 500 watt, 100 volt lamps mounted on the catwalk around the tank. Some lamps were tried under the water surface, but results were not satisfactory. Difficulties were encountered with underwater photographs due to dirty and cloudy water which made it necessary to refill the tank frequently.

The model launcher and water tank had been in use since 1943. Many studies were made of the relations between launching velocity, angle of launching, model shape, and water trajectory. The angles of launching varied from 10 to 30 degrees, but at less than 12 degrees the models skipped and ricocheted off the tank walls.

From the data compiled in experiments, the Japanese concluded that sharp, pointed noses result in skipping and that the best shape for the aircraft torpedo nose is a compromise between a hemisphere and a blunt ogival shape. They considered the nose of the Type 91 service torpedo as the best of all the types studied.

The Japanese claimed to have destroyed all records and photographs and none were recovered.

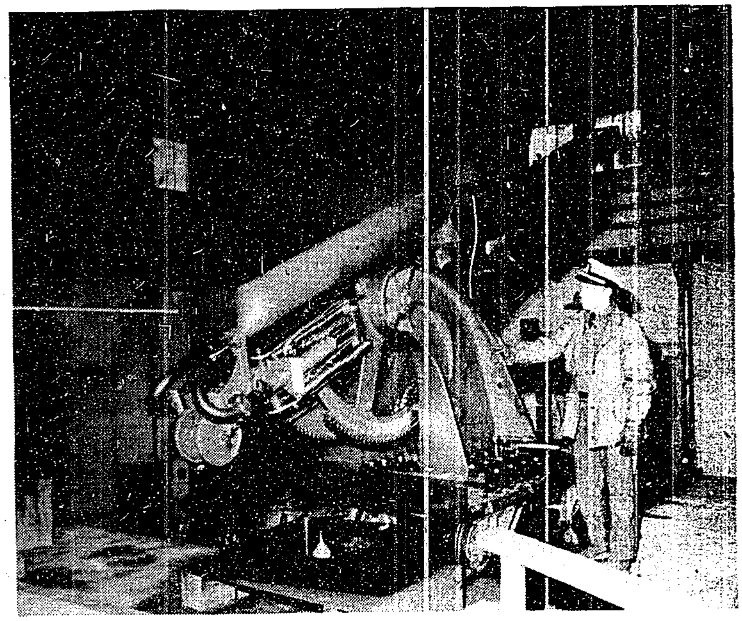

Figure 14
SIDE VIEW OF MODEL LAUNCHER

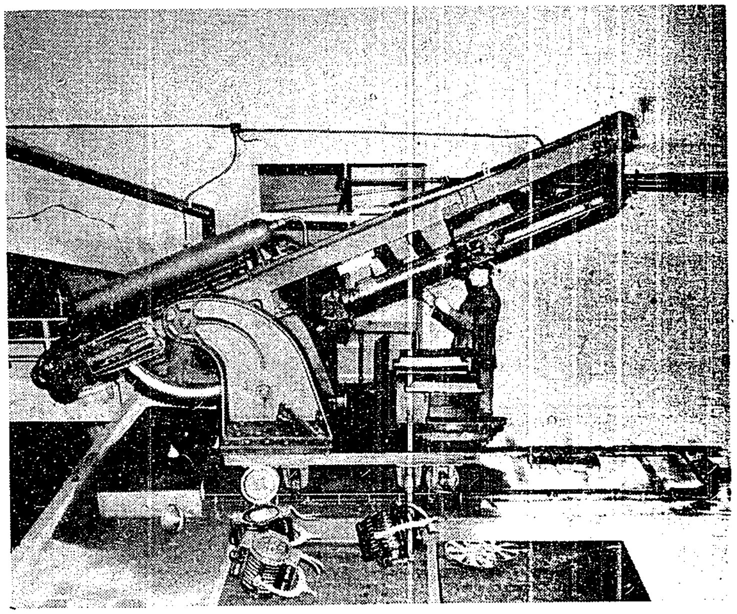

Figure 15
VIEW OF FORWARD END OF MODEL LAUNCHER

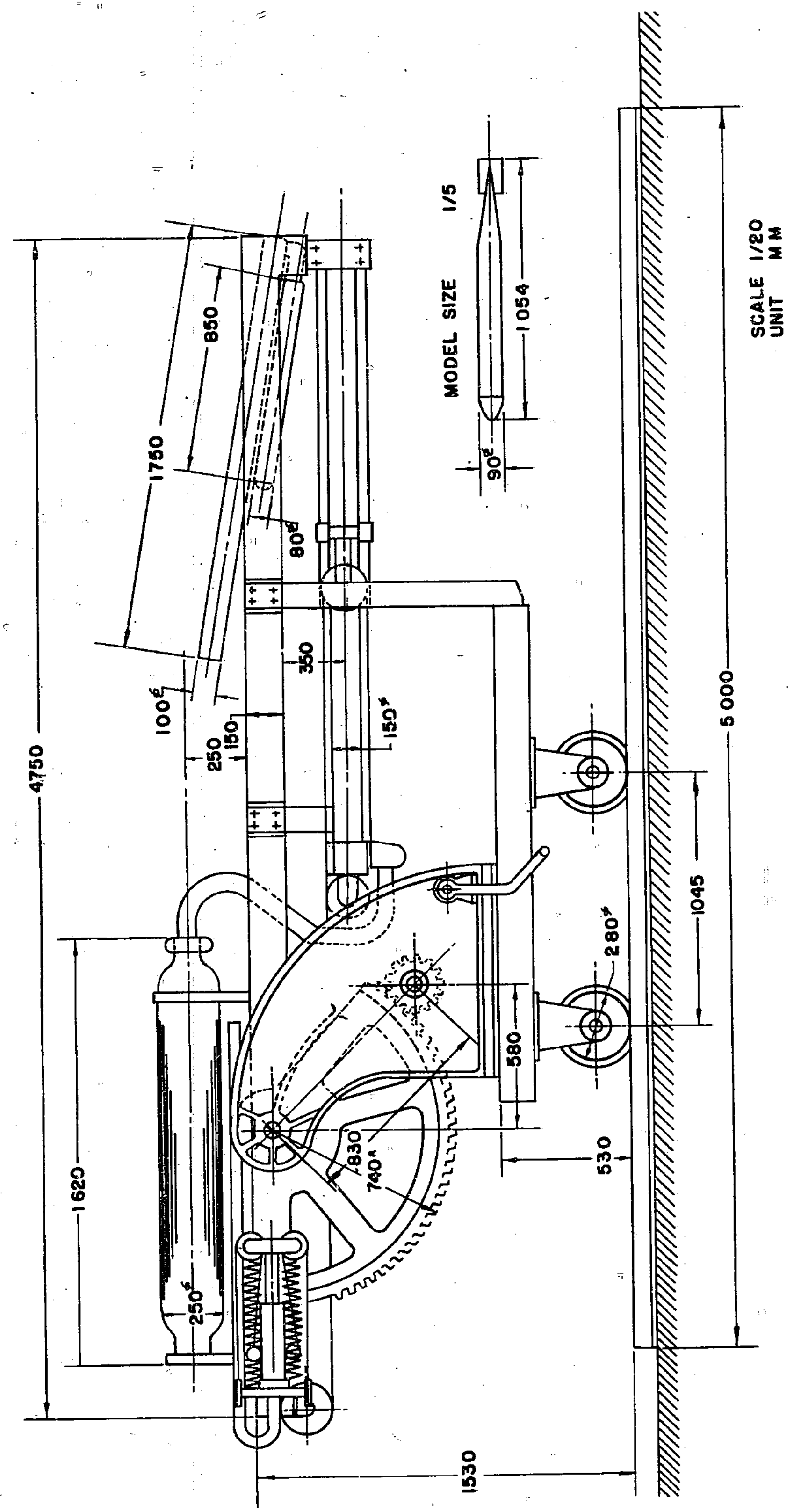

Figure 16
DIAGRAM OF TORPEDO MODEL LAUNCHER

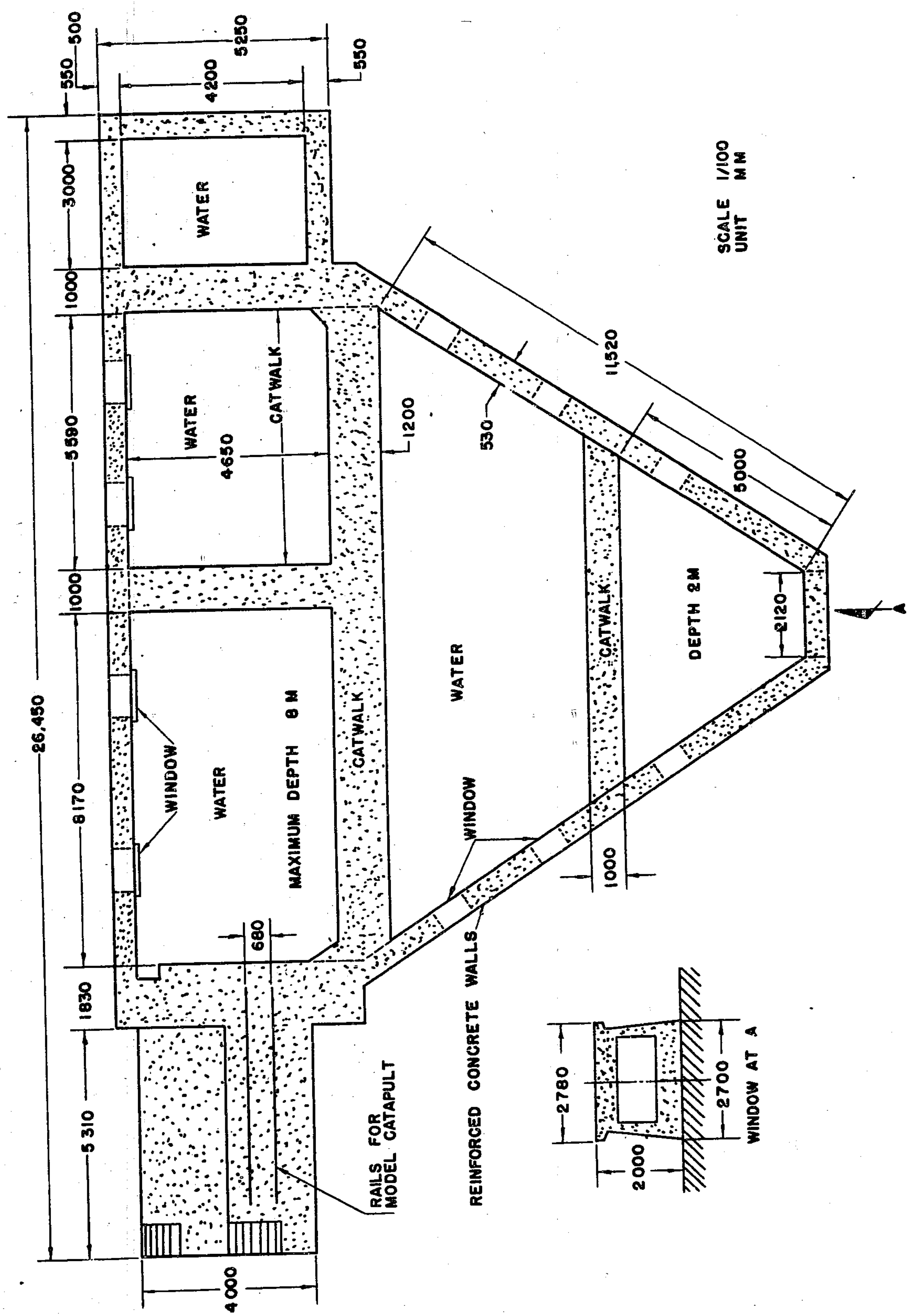

Figure 17
WATER TANK FOR TESTING TORPEDO MODELS

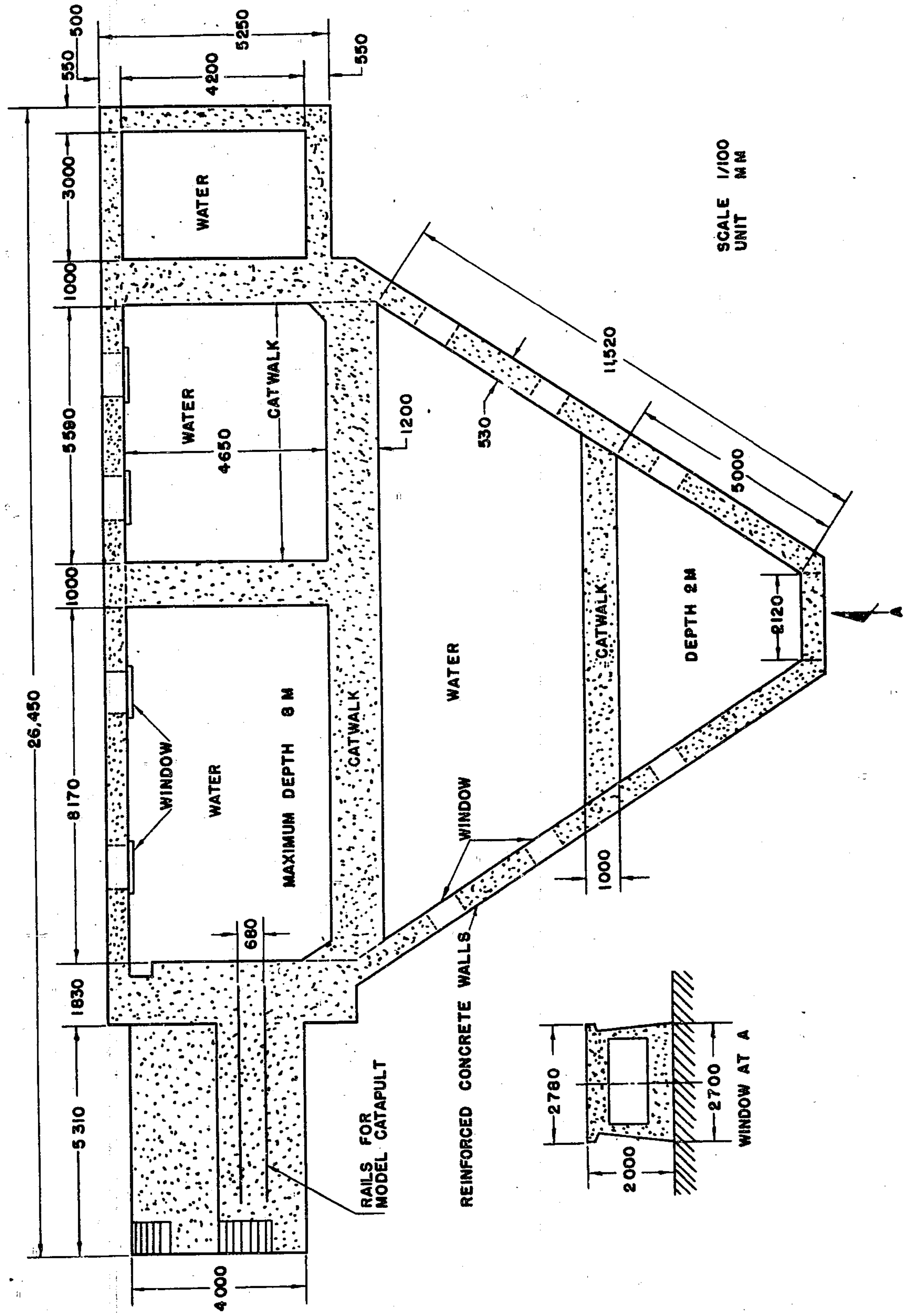

Figure 17

WATER TANK FOR TESTING TORPEDO MODELS

ELECTRIC CIRCUIT DIAGRAM FOR MAGNETOSTRICTION METER