CHAPTER 4

EXPERIMENTAL INVESTIGATION

4.1 Introduction.

The experiments were conducted in the laboratory at King Monkut's Institute of Technology, Thonburi. A three-dimensional model of selected undistorted scale of 1/100, was designed and constructed to simulate the proposed Ao Phai Nuclear Power Plant. The instruments employed in the experiment and the corresponding method of investigation are described in the succeeding sections.

4.2 Details of the model.

4.2.1 Test basin.

A 2m. by 4 m. basin with 2 m. by 1 m. weir at each end of the basin for controlling the intake and outfall was constructed to house the physical model for the investigation of the three dimensional thermal dispersion due to the discharge of cooling water from coastal Nuclear Power Plant. Basin and weirs were made of wood. The basin walls, made of perspex and 0.5 m. in height, were mounted on the floor of the model which was levelled up 1 m. from the ground. Concrete was employed to prevent any leakage in the basin bed. Approximately 1.2 tons of selected gravel were placed on the concrete and shaped to simulate the sloping nearshore shelf. The coarseness of the gravel satisfied the value of ' n ' mentioned in the preceding chapter.

A centrifugal pump was also installed to feed the water from the pond into the weir by means of a pipe 4" in diameter. From the weir, water could flow into the basin by passing through sluice gates. There were five gates at each end of the basin, and each gate could be slided vertically to control the current speed. Immediately, in front of the gates, a flow straightener was used to ensure an even flow distribution. Consequently, a long shore current could be simulated.

Figure 4.1 shows a schematic diagram of the basic components. Photographs of various subcomponents are displayed in Figures 4.2 and 4.3 .

4.2.2 <u>The nozzle and the cooling water piping system.</u>

The discharge of cooling water was simulated by projecting the commercial Eslon pipe of size 2", horizontally in direction perpendicular to the flow of current. The location of discharge was made to correspond with the point A depicted earlier in Fig. 4.4 . The pipe was buried along the coarse bed of the test basin and fitted at its outlet with a vertical nozzle, the size of which could be changed to accord with the experimental condition to be carried out.

Warm water was discharged by gravity from an elevated tank fitted with two burners for heating water. Four 1.5 kilowatts immersion heaters were used for controlling the water temperature within $\pm$ 0.1 °C. The water to be heated and the water supplied to the test basin were both pumped from the same source in order that density difference between the discharge and receiving water would be due to temperature difference alone and not as a result of a change in turbidity. Figure 4.5 illustrates

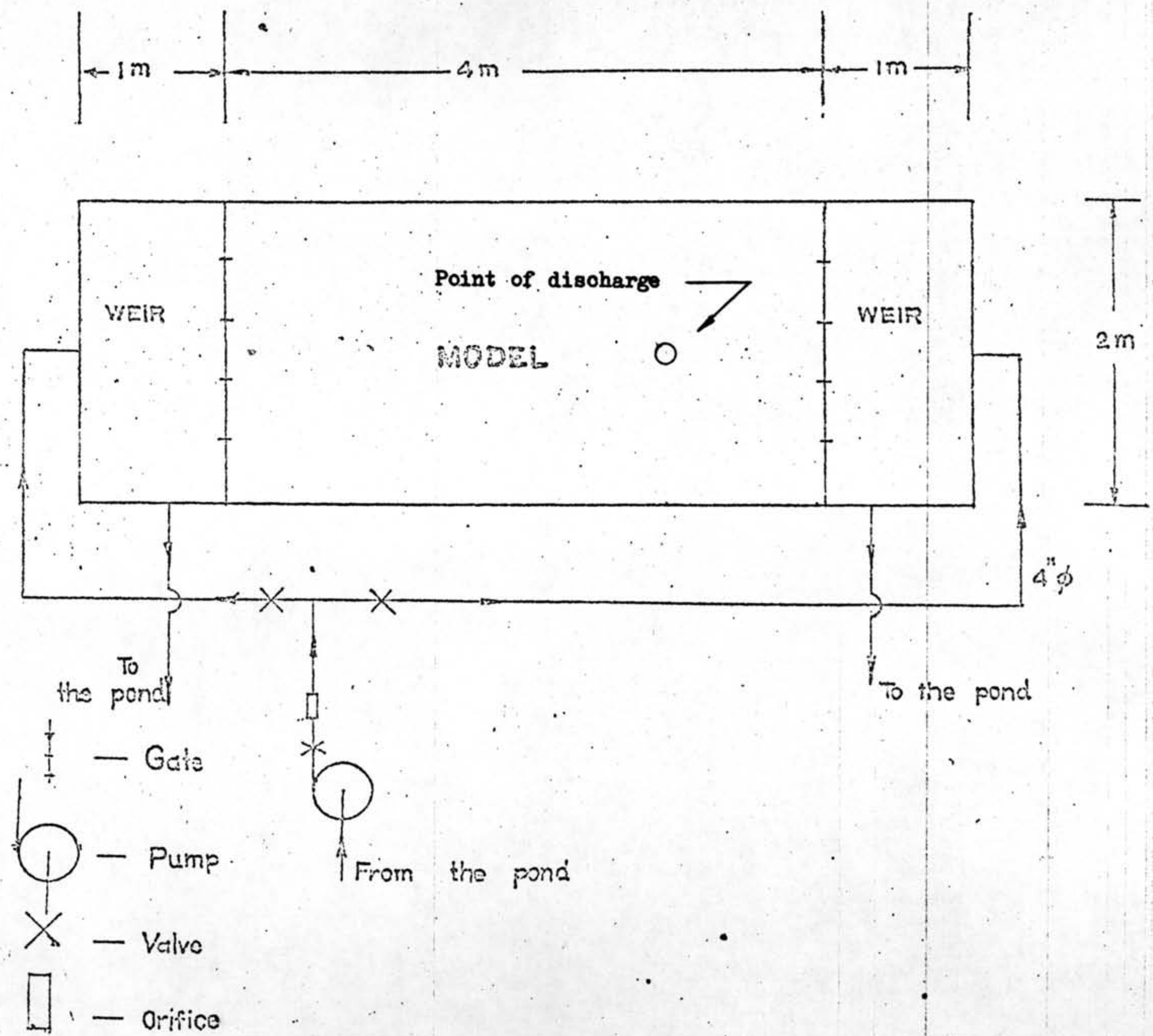

FIGURE 4.1 A SCHEMATIC DIAGRAM OF THE MODEL

FIGURE 4.2 OVERALL VIEW OF TEST BASIN

FIGURE 4.3 CENTRIFUGAL PUMP AND PIPING

FIGURE 4.4 NOZZLE

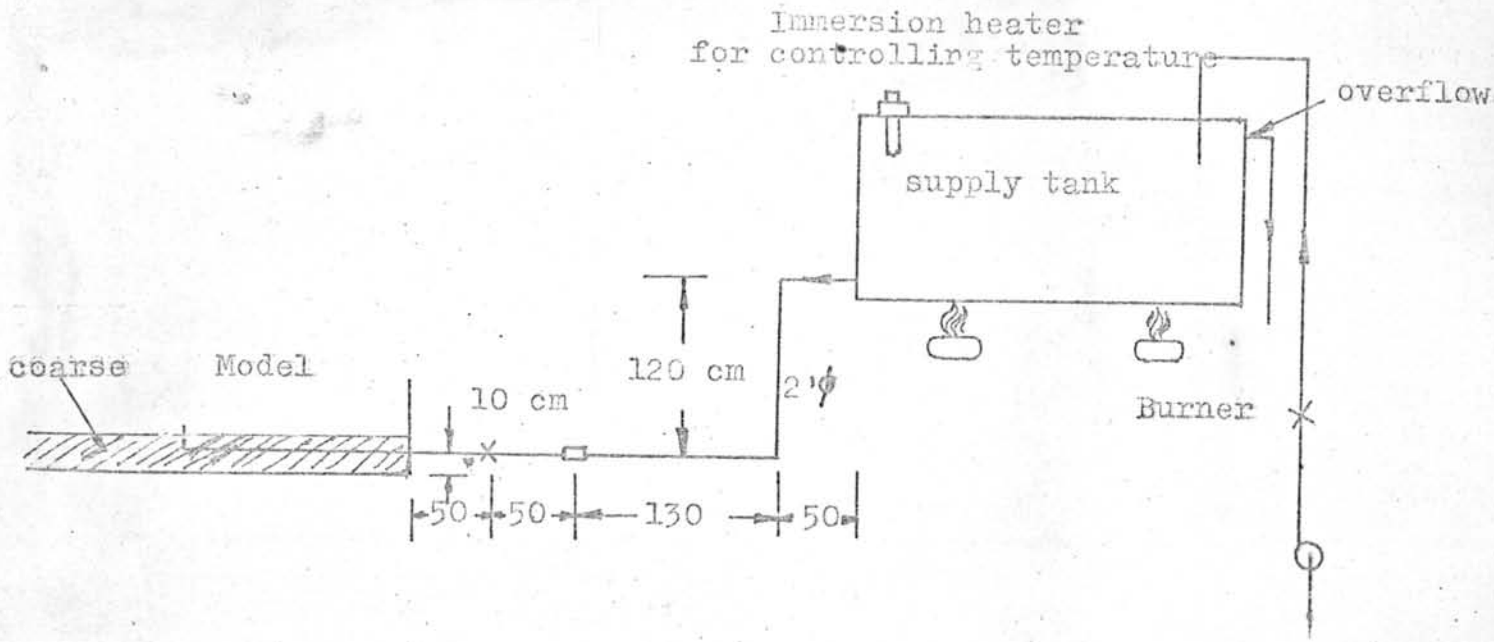

FIGURE 4.5 SCHEMATIC OF WARM WATER SYSTEM

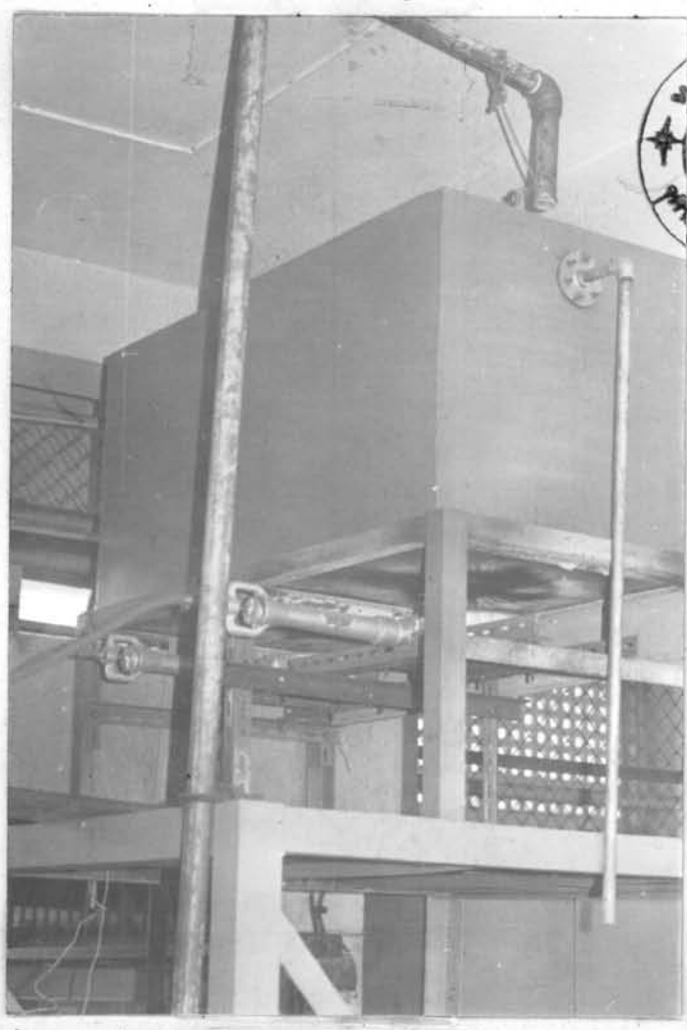

FIGURE 4.6 ELEVATED TANK WITH TWO BURNERS

a schematic diagram of warm water system and the photograph in Fig. 4.6 depicts the elevated tank.

4.3 Instrumentation for temperature measurement.

Temperature measurement in the basin was carried out with laboratory calibrated thermocouple. A thermocouple is made by joining together one end of two conductors of dissimilar materials to form a common junction at which the conductors are in good thermal and electrical contact. This point of connection is called the measuring 'hot' junction. The other ends of the thermocouple wires are connected to a recording instrument called potentiometer which will measure electromotive force and the point of connection is the 'reference' or 'cold' junction. If heat is applied to the measuring junction, an electromotive force will be generated; the magnitude of the e.m.f. depends upon the difference in temperature between the measuring and the reference junctions. This recorded electromotive force can then be converted into degree Celcius by referring to the thermocouple manufacturer's chart of thermal equivalence. In this experiment, Chromel-Alumel thermocouples (sensitivity 1 microvolt , accuracy $\pm$ 0.1 °C) were employed in the measurement.

As there are a large number of locations at which the knowledge of temperature is required, it is necessary to use three multiway switch-boxes. A diagramatic representation of multiway switch-box connection is shown in Fig. 4.7 whereas Fig. 4.8 displays the potentiometer.

Each of thermocouple wires, 50 cms. in length was inserted into the Aluminium pipe. 1 cm. in diameter, in order to straighten the wires which would be submerged in the water. Aluminium pipes were mounted on

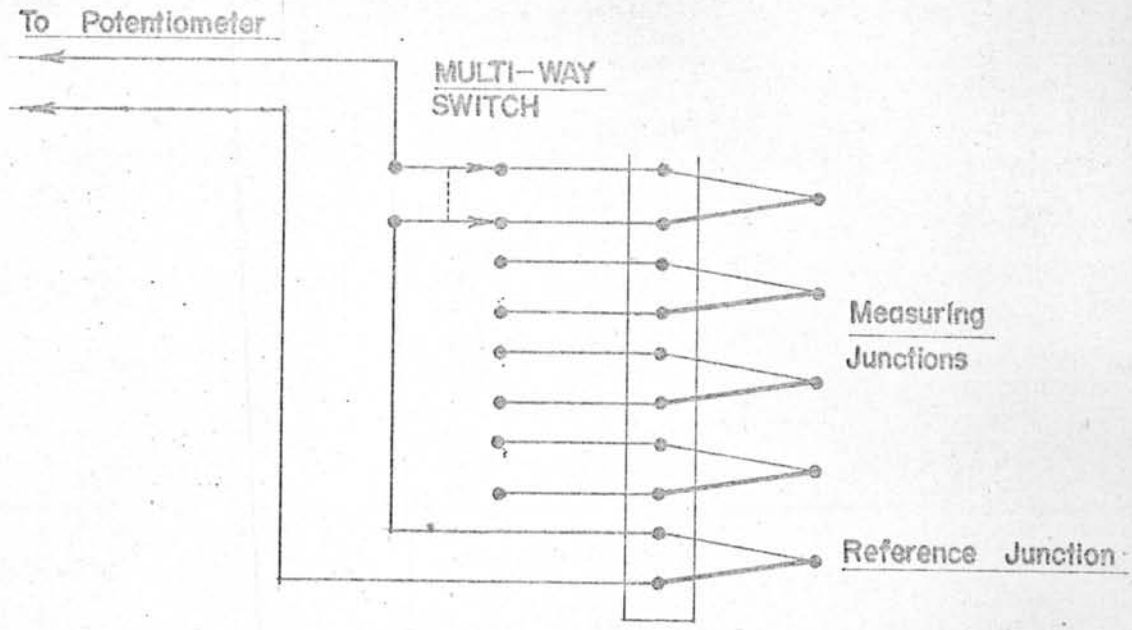

FIGURE 4.7 MULTIWAY SWITCH-BOX

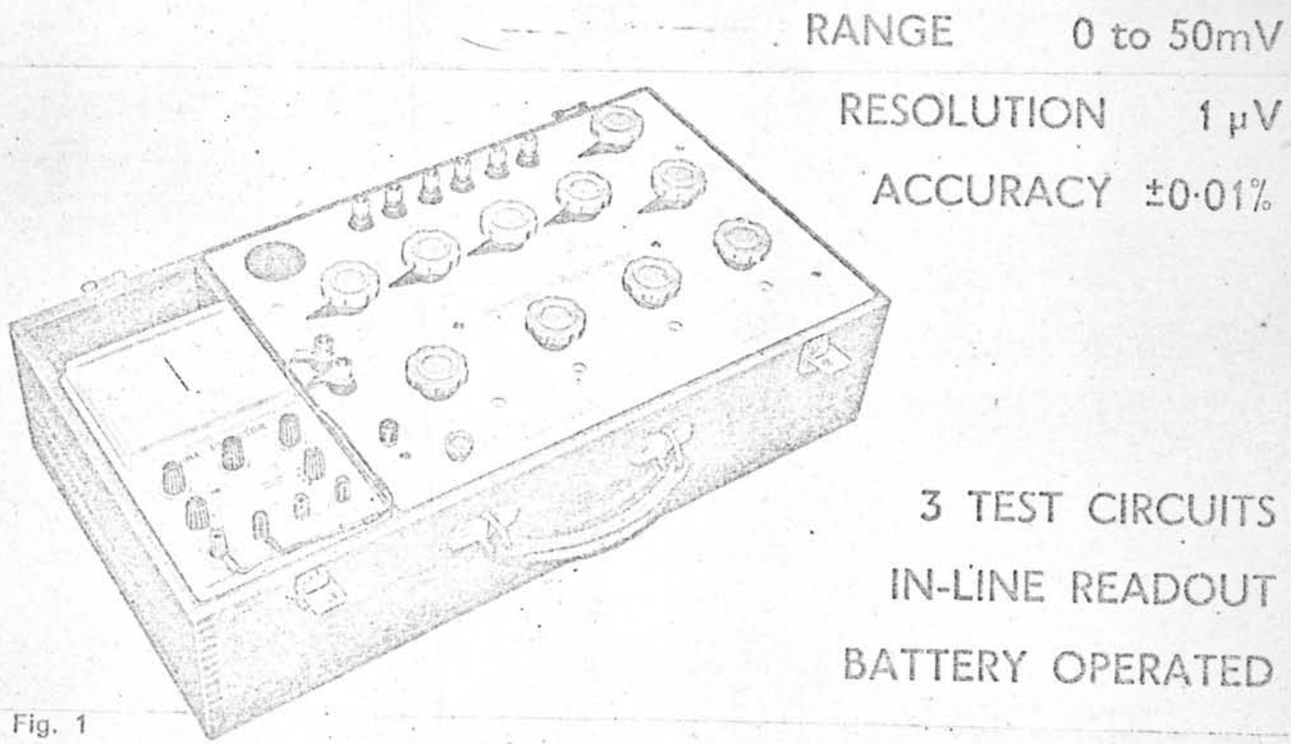

FIGURE 4.8 POTENTIOMETER

on bars of wood lying on the walls of the basin. A total of 120 thermocouples was placed throughout the model in such a way that the temperatures recorded could be used to plot maps of the isothermal lines in the vicinity of the nozzle. Figure 4.9 shows the way in which thermocouples were mounted on to the wooden frame of the test basin.

4.4 Velocity and flow measurement.

4.4.1 Cooling water system.

An orifice located in the discharge line of the supply tank was used to monitor the flow rate of the cooling water. This orifice was made of brass (3). The ratio of the diameter of the orifice hole to the inner pipe diameter was chosen to be 0.35 . Consequently the diameter of the orifice hole fabricated was 0.724 " and the inner pipe bore size was 2.067". The thickness of the orifice plate was 1/8 ". The outlet corner of the orifice was beveled at an angle of 45 degree to the face of the plate sufficiently to provide the minimum face width and to smoothen the flow. This orifice after calibration gave the discharge coefficient of 0.610 .

4.4.2 Ambient current.

Establishment of a uniform flow field across the model was accomplished by careful manipulation of the valve and sliding the gates to the proper positions. Dye was used to detect backflow or stagnant areas in the model basin. The rate of drifting of corks were used to indicate current speed at the surface of the reservoir water. The current meter, ' KENT MINIFLOW TYPE 265 ' was employed to measure 'surface'

FIGURE 4.9 THERMOCOUPLES MOUNTED IN THE BASIN

and ' subsurface ' current speeds.

4.5 Experimental procedure.

At the start of the experiment, the basin was filled until the water level reached the desired level of 8 cms. The sluice gates were adjusted to give the required ocean current direction. The pump was run for about 30 minutes to allow the steady state current to be established. Then the surface velocity was measured by observing the travel time of corks between the fixed points. Current meter was also employed to measure 'surface ' and 'subsurface ' velocity. The hot water discharge at the temperature 10°C above the temperature of water in the basin was then turned on slowly. Thirty to forty minutes were allowed before the system attained the steady state condition. Then dye was injected into the discharge water and the thermal plume observed. After the dye run, the surface temperatures of water in the basin were measured and recorded. These experimental data were used to plot the surface isotherms in the vicinity of discharge. In each experiment, the temperature variations in vertical direction were also measured at the point 30 cms* downstream from the outlet.

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* This distance is the distance measured in the basin.