Chapter IV

EXPERIMENTAL EQUIPMENT

The equipment used for this research work is shown schematically in Figure 4.1. It consists of two electric timersand two control valves a double pipe heat exchanger, thermometers, thermocouples and a potentiometric recorder, orifice meters and a vacuum pump. The details of each part of the equipment are as follow.

4.1 The Double Pipe Heat Exchanger

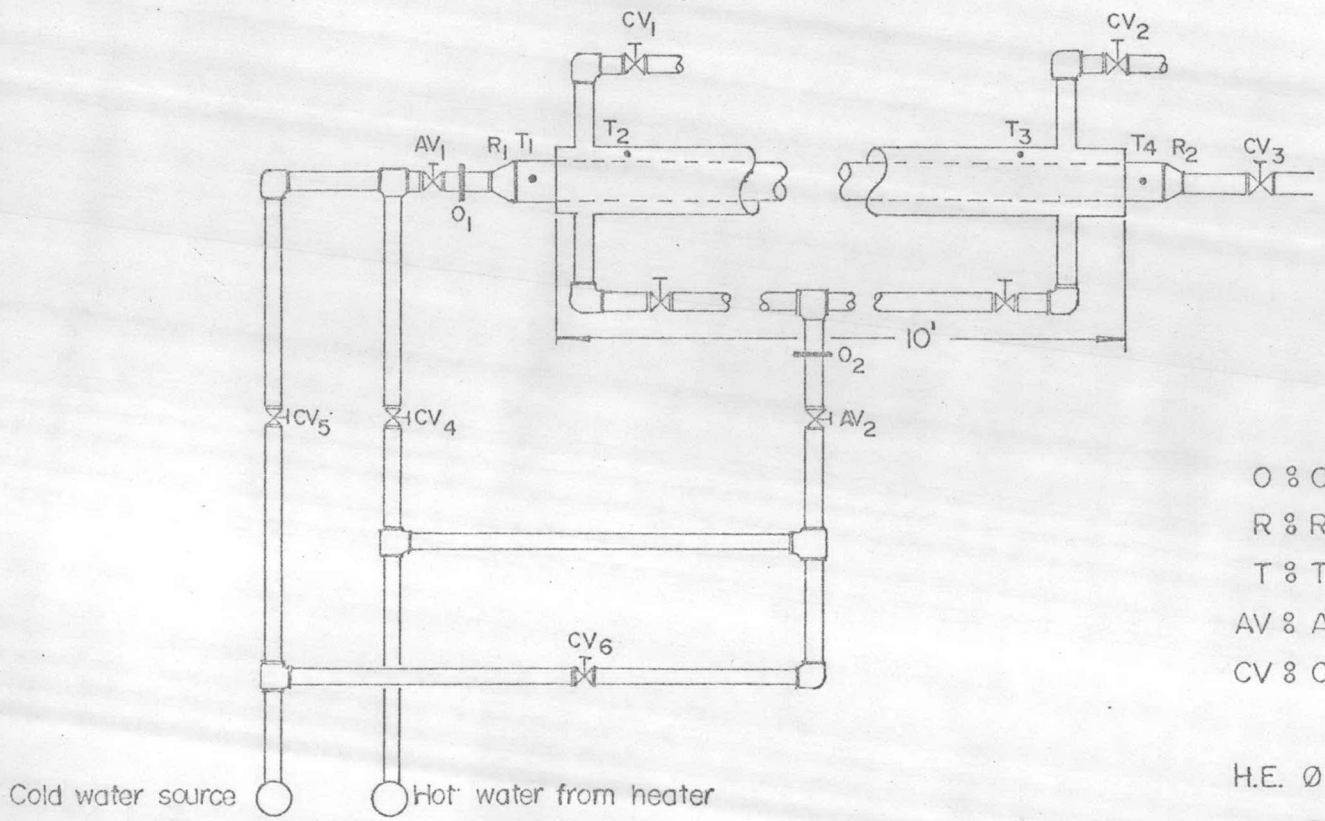
The double pipe heat exchanger consisted of the following parts:

4.1.1 The inner pipe

The inner pipe used in the exchangr was 3/4 inch, schedule 40 commercial steel pipe. The pipe was 10 ft long.

4.1.2 The outer pipe

The outer pipe was ½ inch., schedule 40 commercial steel pipe. The length of the pipe was 10 ft. It was preliminarily estimated that with a length of 10 ft the temperature change of either the hot or cold fluid stream through the entire exchanger would be significantly high. Thermometers and thermocouples were installed at



O ⁘ Orifice meter.
R ⁘ Reducer.
T ⁘ Thermocouple
AV ⁘ Automatic valve
CV ⁘ Control valve

H.E. Ø inside 3/4"
Ø outside 1 1/2"
Ø pipe line 1/2"

Fig. 4.1 Experimental Equipment.

1 ft from the end of the exchanger, for measuring the inlet and outlet temperature of fluid flowing in the inner pipe in the annulus, and at the inner pipe wall.

4.2 Electric Timers and Control Valves

Two electric timers were used to control the cyclic operation of two solenoid valves. They are shown schematically in Figure 4.2

4.2.1 Parts of the electric timers

i) A synchronous motor with an attached unit of reducing gears. The gears reduced the shaft speed of the motor from 1400 rpm to the order of 10 rpm. The motor was 1/3 horse power, 2.75 Amp, and 220 volts.

ii) The reducing gears consisted of the following gears sizes.

Diameter (inch)	Nos of gears
3/4	1
1	1
1½	1
2	5
4	1
6	3

By using the proper combination of reducing gears, the speed of the output shaft could be varied in the range of 5-10 rpm,

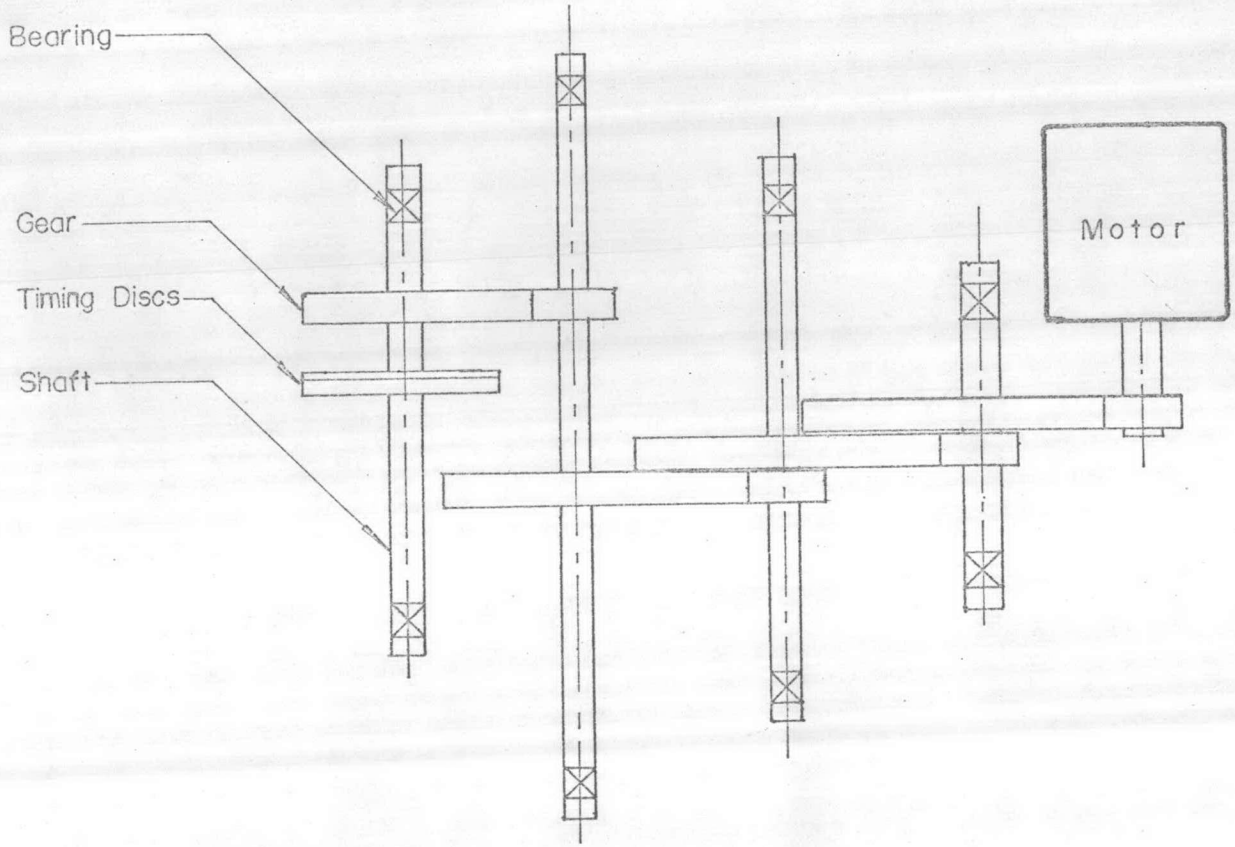


Fig. 4.2 The electric timer

as shown in Figure 4.2

iii) Two sets of timing discs, each having two discs, as shown in Figure 4.3. The diameter of one half of each disc was 3½ inches and of the other half was 3¼ inches. Each pair of discs was fixed tightly together by a nut on the output shaft.

iv) A microswitch. It consisted of a switch box, an attached contact arm with a rolling ball at its free end, and a switch button. The switch was fixed in a position, as shown in Figure 4.4, so that the rolling ball touched the perimeter of the discs. As the rolling ball touched the part of 3½ inch. diameter, the circuit was closed, and as the rolling ball touched the part of 3¼ inch. diameter, the circuit was open.

4.2.2 Methods of changing the cycle time and the fraction open

The cycle time could be varied by changing the gear ratios of the twelve gears used in the timer. In order to change the gears, the movable base of the device had to be adjusted, then fixed by nuts,

The fraction open could be changed by varying the relative position of the two parts of the discs, as shown in Figure 4.4. In order to do this, the disc nut was merely loosened and any part of the discs was moved. After that, the disc nut had to be tightened again.

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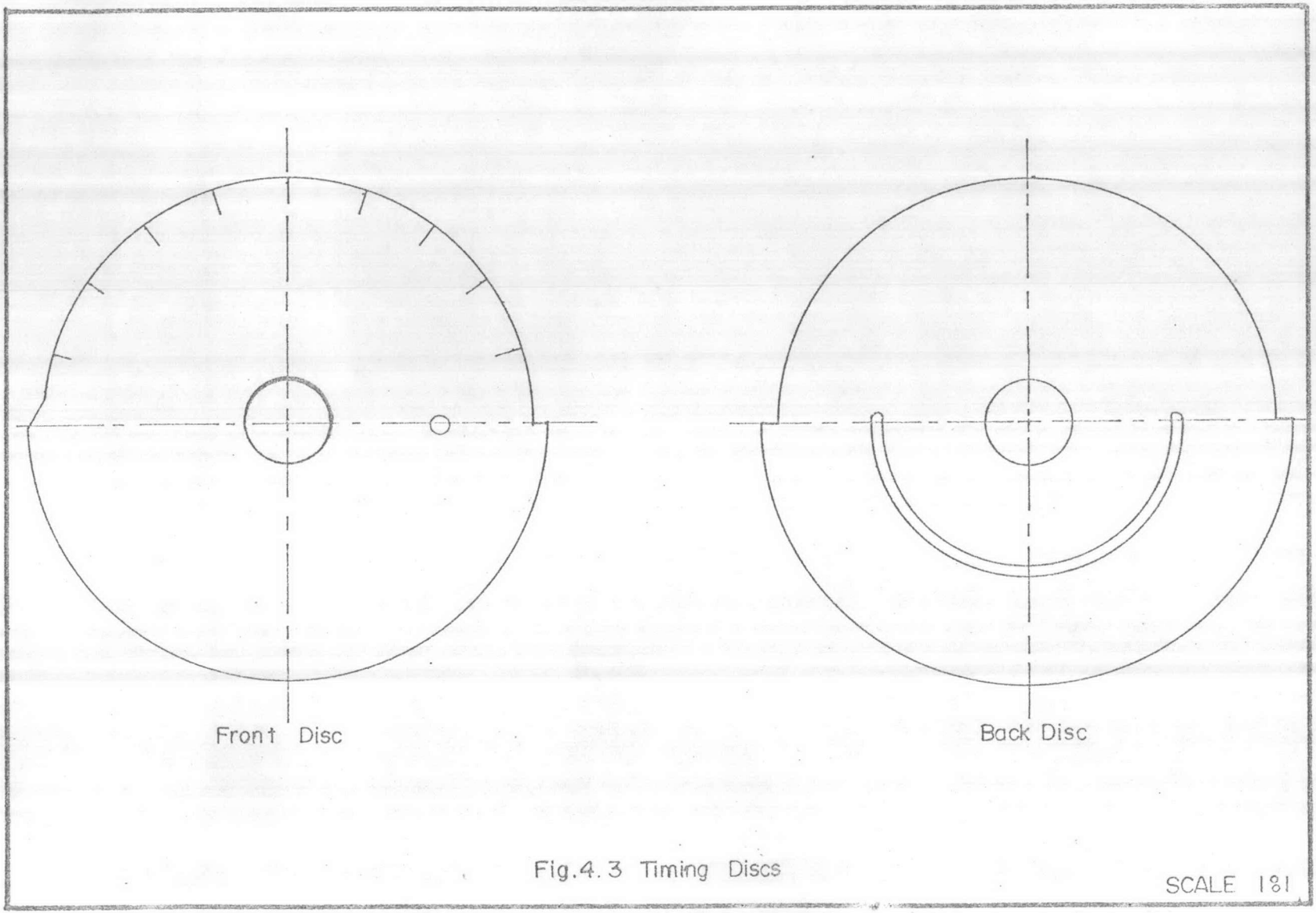

Fig.4.3 Timing Discs

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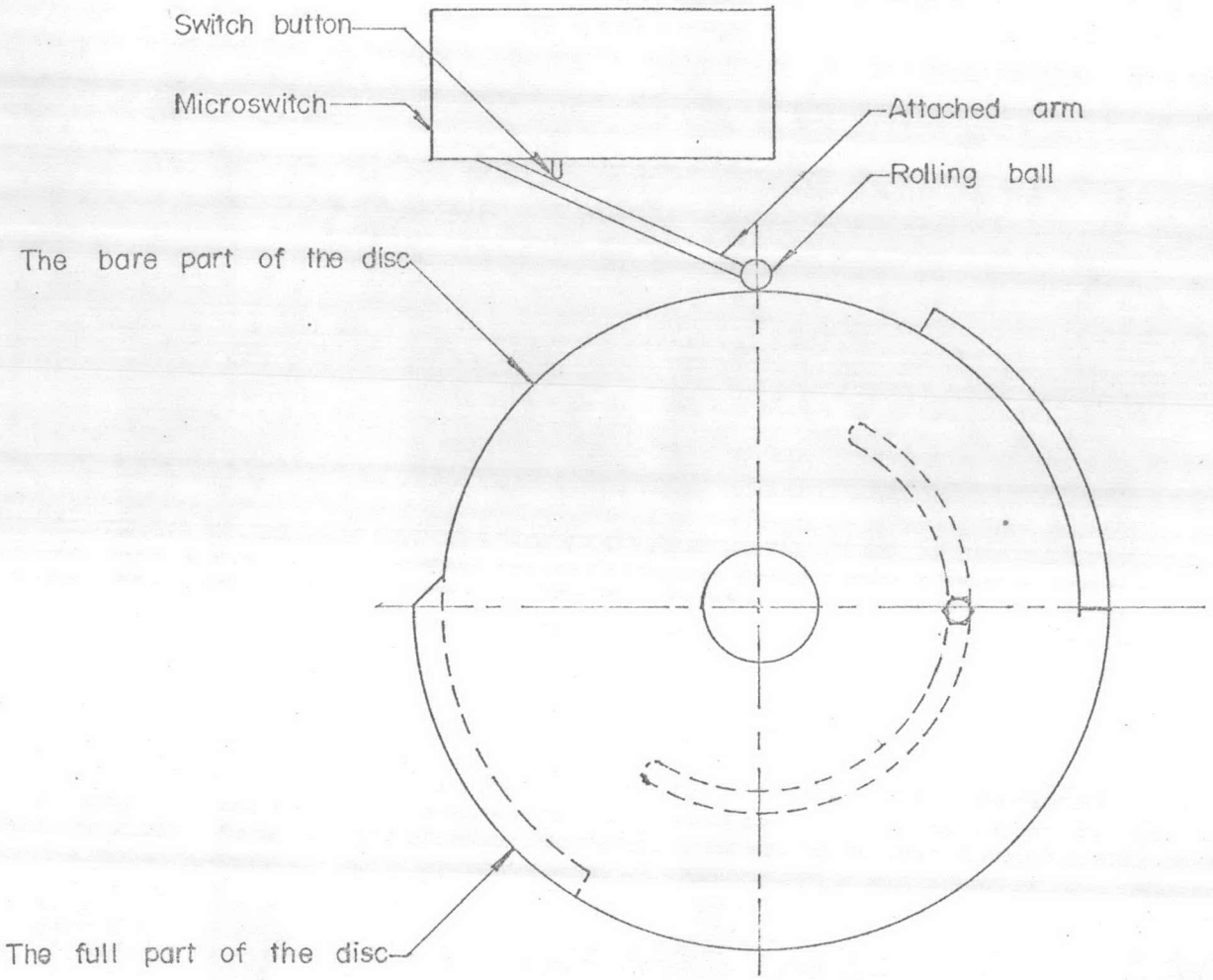

Fig.4.4 The Position of the Microswitch

SCALE 1 : 1

4.2.3 Control valves

Two solenoid valves, each was controlled by one of the two electric timers by being connected into the circuit of the corresponding microswitch, were installed on the inlet lines of fluid flowing in the inner pipe and annulus. They were ½ inch valves using 220 volts alternating current. When the circuit was closed the valves were in the fully open position, and it was completely closed when the circuit was open.

4.3 Hot Water Heater

It was a shell and tube heat exchanger of 66 cm. high and 17 cm. inside diameter, with 19 tubes of 0.95 cm. inside diameter arranged in triangular pitch with center to center distance of 3.5 cm., and made of mild steel. The exchanger was heated by saturated steam which entered the shell side, and the steam condensate discharged through a steam trap to atmosphere. There were a regulating valve and a pressure gauge installed on the steam inlet line for controlling the steam flow rate.

4.4 Temperature Measuring Devices

Four mecury thermometers were used for measuring inlet and outlet temperature of fluids flowing in the inner pipe and in the annulus. The measuring range of the thermometer was 0-100°C with a precision of 0.1°C.

Two thermocouples of copper and copper constantan were used to measure the inner pipe wall temperatures at the fluid inlet and outlet positions. The temperatures were recorded in term of emf (millivolts) by a Serfram Paris Potentiometric Recorder. The emf readings were converted to degrees of Celcius by calibrating the thermocouples.

4.5 Fluid Flow-Meters

Two orifice-meters were designed and constructed for measuring the rates of fluid flowing in the inner pipe and in the annulus.