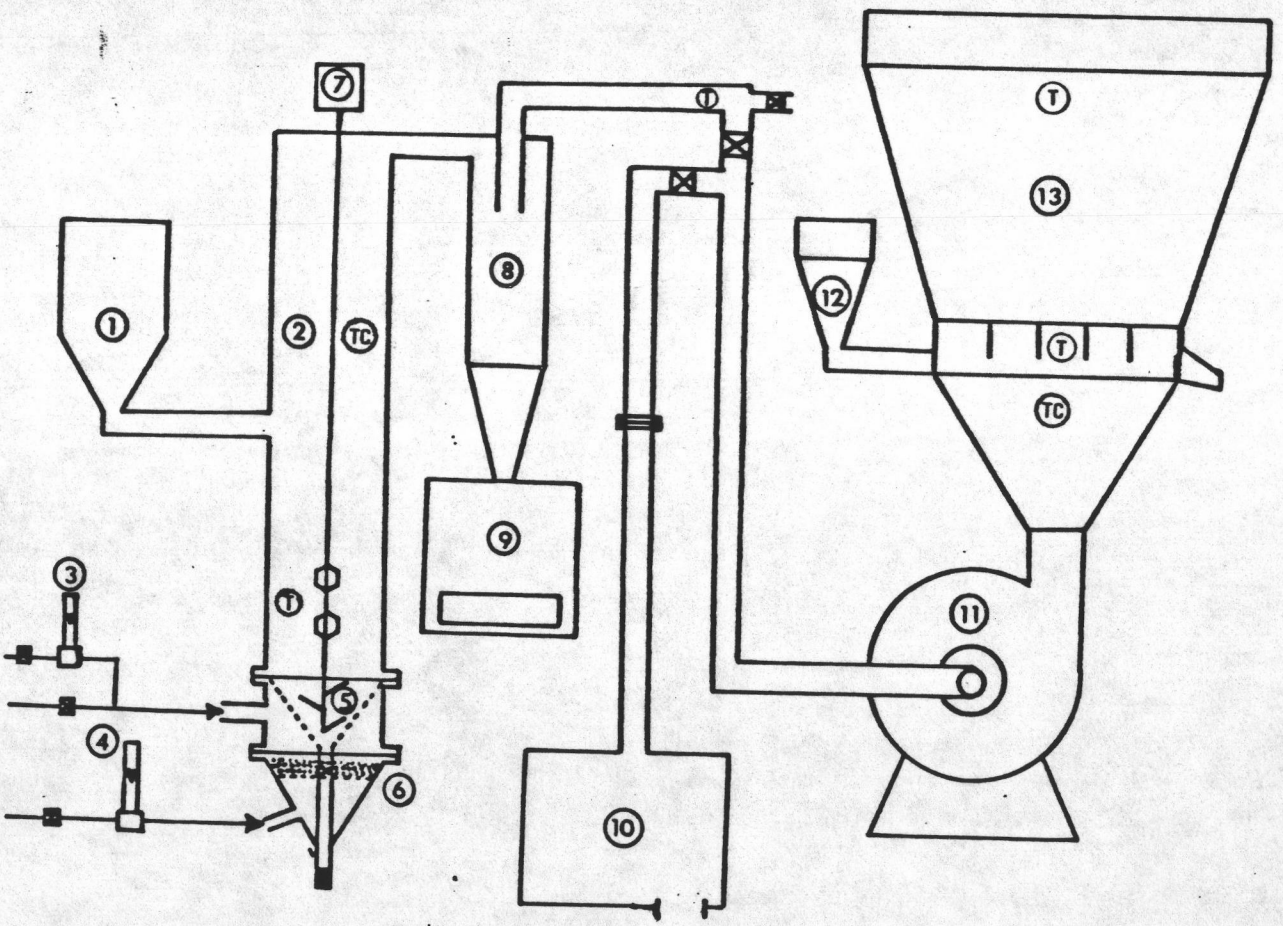
CHAPTER III

EXPERIMENTAL EQUIPMENT

The main feature of this experiment was the coupling of two unit operations, namely, the fluidized-bed combustor and the fluidized-bed dryer. A schematic diagram of the integrated system is shown in Figure 3.1.



① Rice husk screw feeder with hopper ② Rice husk combustor ③ LPG flow cell ④ Air flow cell ⑤ Conical distributor ⑥ Metal packed-bed ⑦ Sweeper ⑧ Cyclone ⑨ Residue ⑩ Electric air heater ⑪ Blower ⑫ Parboiled paddy screw feeder with hopper ⑬ Fluidized-bed dryer

Figure 3.1 A schematic diagram of combined system

The fluidized-bed combustor and fluidized-bed dryer were able to operate independently. The two sections were able to operate together by by-passing hot flue gas from the combustor section to the dryer section. There were several pieces of equipment used in this study. the details of which were described as follows:

3.1 Fluidized-Bed Combustor Section

The fluidized-bed combustor section consisted one of each of the following units: air compressor, air measuring device (flow cell), fluidized-bed column, LPG burner, cyclone and ash collector, feeder, temperature indicator and controller.

3.1.1 Air Compressor

The air compressor was of a small-sized reciprocating type SP sold by IWATA AIR COMPRESSOR MFG. Co., Ltd. (Figure 3.2).

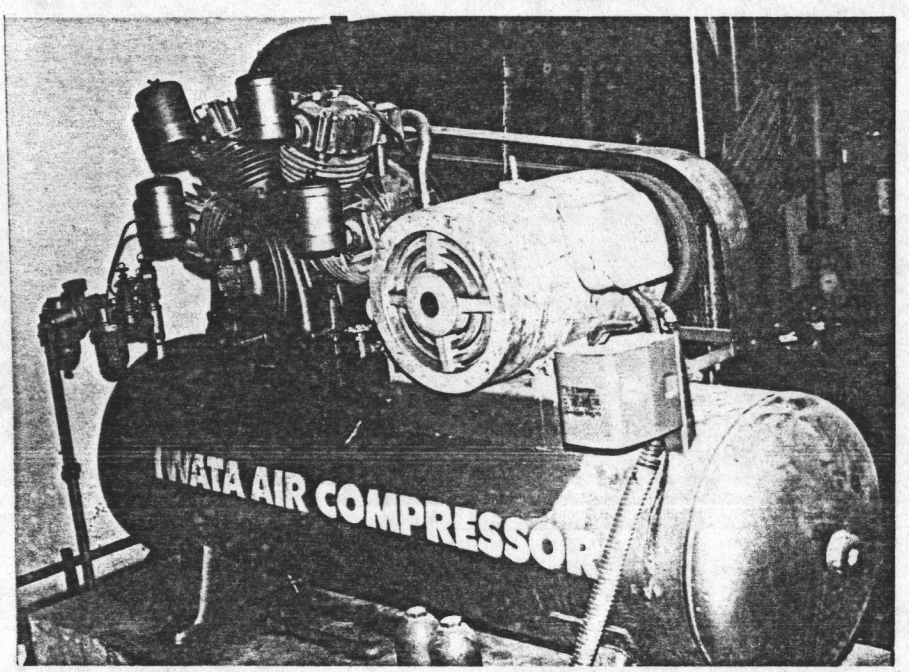


Figure 3.2 The air compressor

It delivered maximum flow rate of 40 cfm of air at 140 psi to the fluidized-bed column and the LPG burner.

3.1.2 Air Flow Measurement

The air flow measuring device was a flow cell of type FLT with a measuring range of 12-60 Nm^3/hr (Figure 3.3). It controlled and measured inlet air flow rate to the fluidized-bed combustor column.

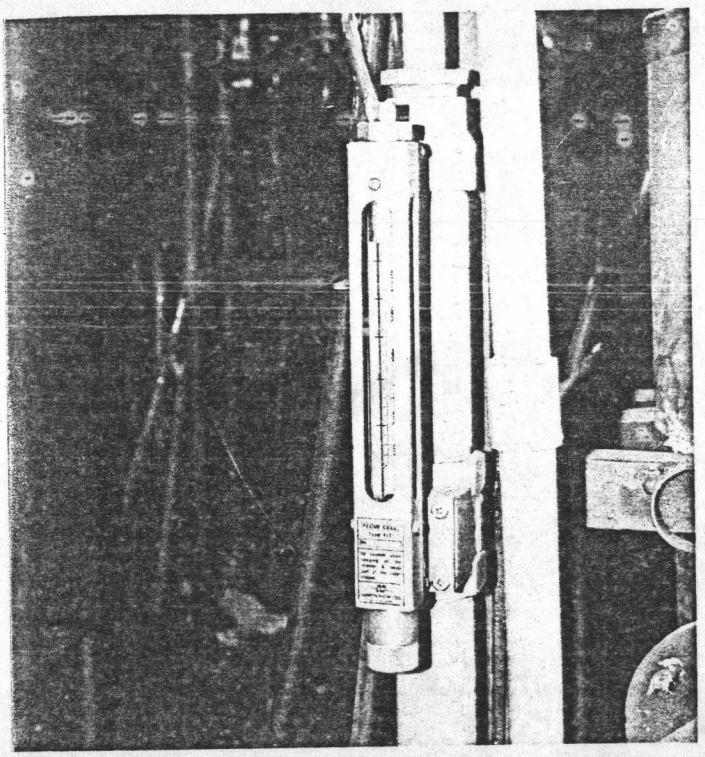


Figure 3.3 The air flow measuring device

3.1.3 Fluidized-Bed Combustor Column

The fluidized-bed combustor column was a stainless steel column of 15 cm diameter and 150 cm high with a conical base and has air inlet opening of 2.5 cm diameter (Figure 3.4). The distributor was of two layers. The first layer was formed metal balls (0.5 cm diameter) placed on a round metal sieve plate

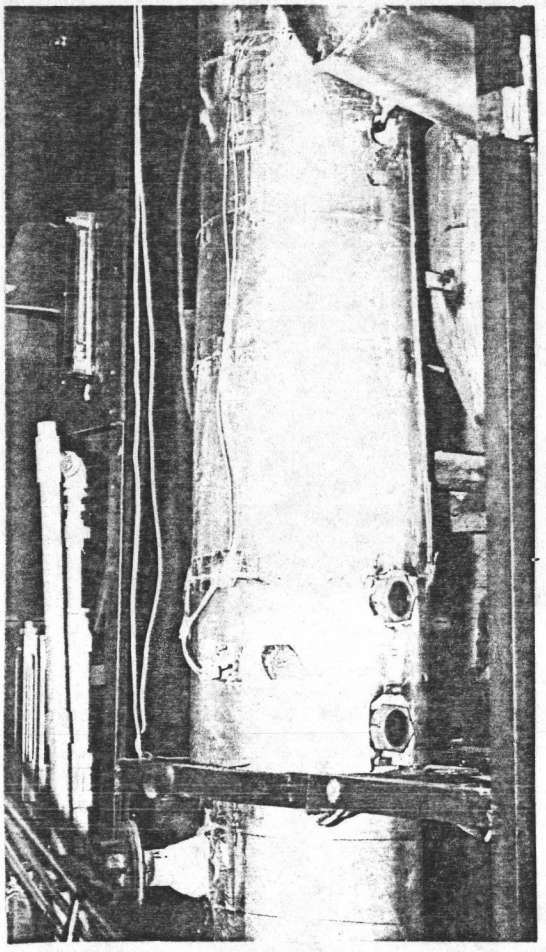


Figure 3.4 The fluidized-bed combustor column

to develop good air distribution (more homogeneous bed) and the second layer was a metal conical sieve. There was a sweeper inside the column to prevent the rice hull accumulation on the distributor and prevent the channelling phenomena in the column. The sweeper was a stainless steel shaft and three 5 cm branches driven by a small motor on the top of the column. The column was well insulated with refractory bricks and fired cement and covered with aluminium sheet. The flue gas outlet at the top of the column was 5 cm in diameter.

3.1.4 LPG Burner

The LPG burner was attached to the fluidized-bed column (Figure 3.5) under the metal packed-bed. It fired LPG to heat up the column during the starting period before feeding rice hull. It was shut down when the column was heated up to the desired temperature.

3.1.5 Feeder for Fluidized-Bed Combustor

It was a screw feeder driven by 1/2 hp repulsion start single phase induction motor with a 1:10 reducing gear. Above the

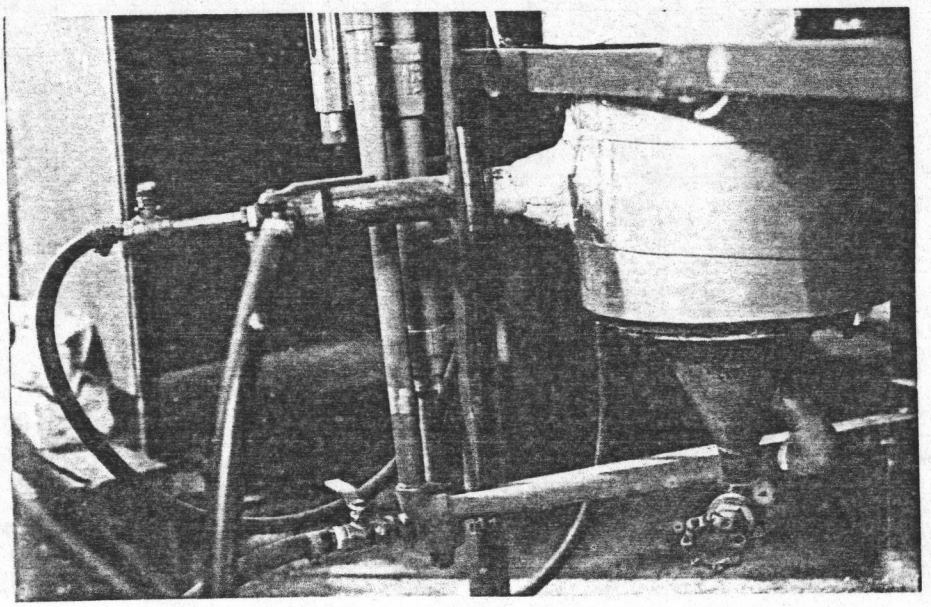


Figure 3.5 The LPG burner

feeder was a metal hopper of 40 cm diameter and 50 cm height with a conical base. The screw feeder had a dimension of 2.5 cm diameter and 2.5 cm pitch width (Figure 3.6).

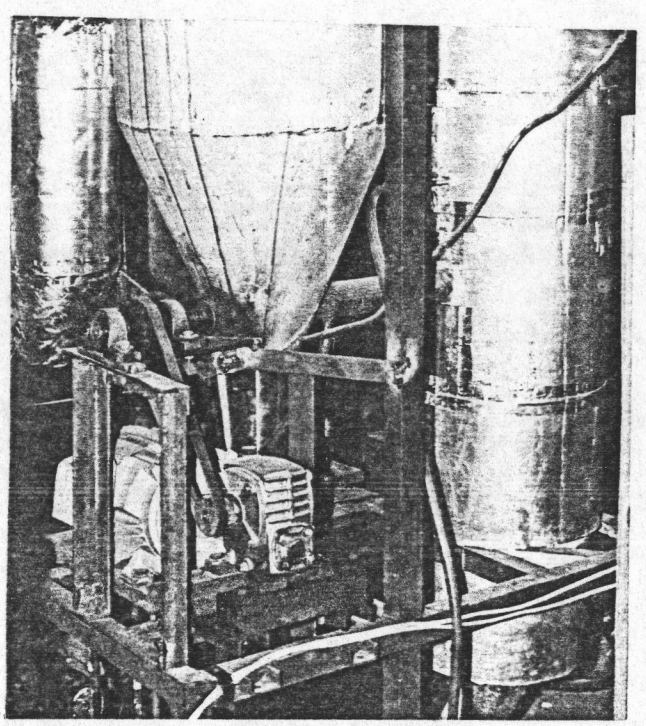
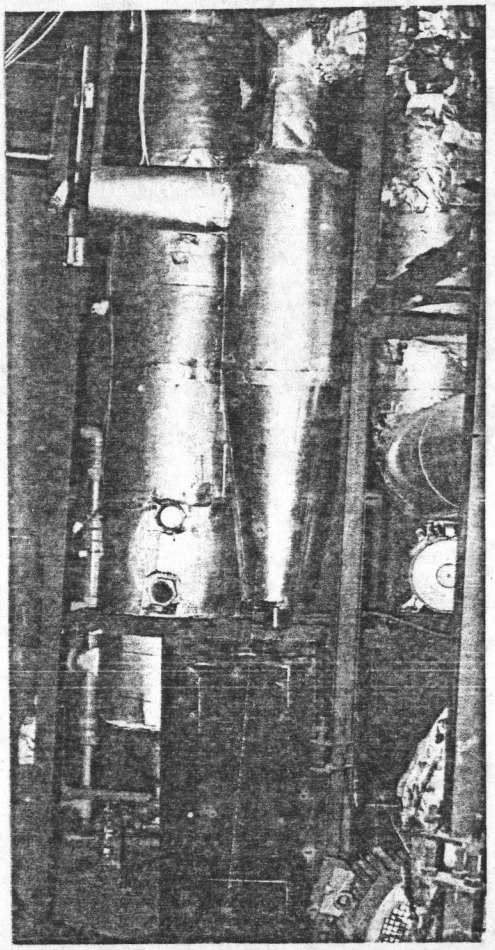


Figure 3.6 The rice hull screw feeder

3.1.6 Cyclone and Ash Collector

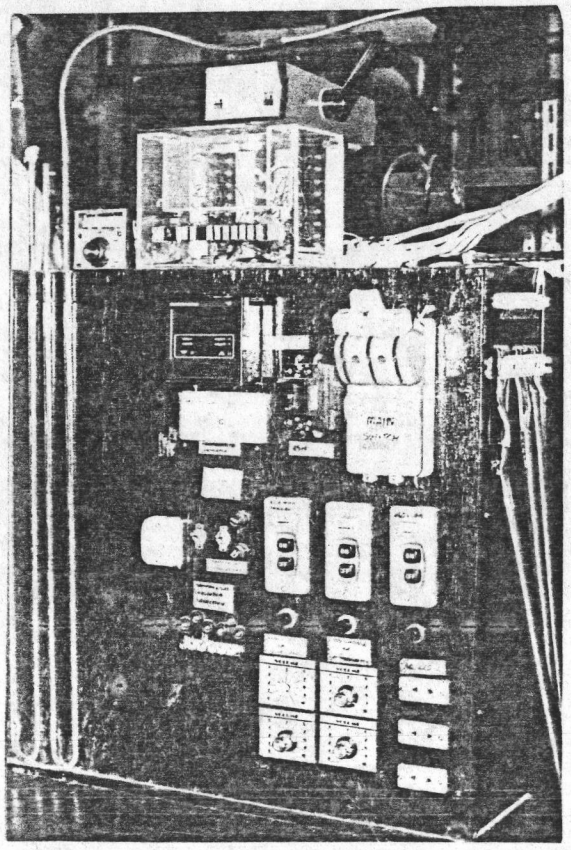


The cyclone was used to separate fly ash from hot flue gas to the bottom and collected in the ash collector (Figure 3.7). The hot flue gas either flowed through the cyclone and out to the atmosphere or was by-passed to the dryer section.

Figure 3.7 The cyclone and ash collector

3.1.7 Temperature Indicator and Controller

In this section, chromel-alumel thermocouples were installed at three separated places along the height of the column; 15 cm above the distributor, one at the middle of the column and one at the cyclone outlet. They were connected to the indicator selection switches and the OMEGA multi-type digital thermometer. Only the thermocouple in the middle of the column was connected to the temperature controller RKC SERIES RE-96



(Figure 3.8) with a measuring range of Ø-8ØØ °C to control the temperature of the column by switching on-off the feeder motor.

Figure 3.8 The control system

3.2 Fluidized-Bed Dryer Section

The fluidized-bed dryer section consisted of an electric heater, a fluidized-bed dryer column, a blower, a feeder, a temperature indicator and controller.

3.2.1 Electric Heater

The electric heater was of rectangular shape, 56 cm wide, 7Ø cm long and 4Ø cm high (Figure 3.9). It consisted of six electric heating elements, each of 4 kW. Three of the elements were controlled by an on-off switch and the rest by the temperature controller.

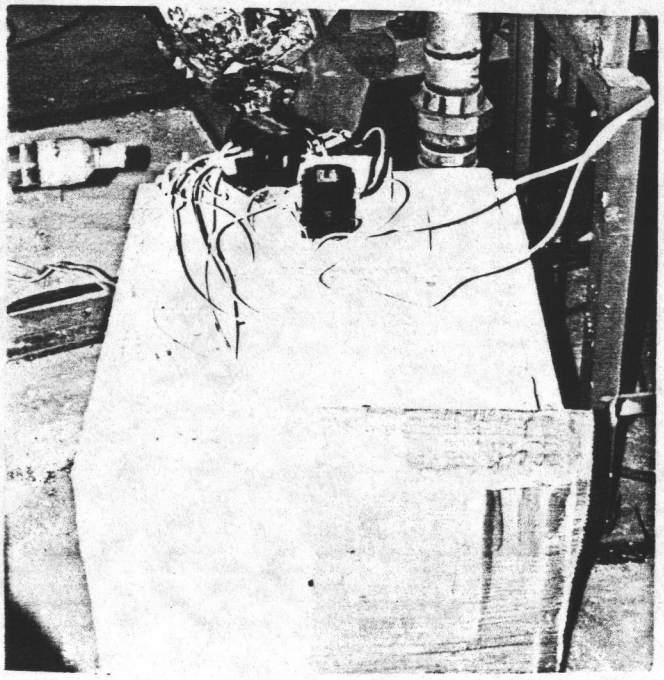


Figure 3.9 The electric heater

3.2.2 Fluidized-Bed Dryer Column

The fluidized-bed dryer column was a horizontal multi-chamber continuous fluidized bed dryer (Figure 3.10). It was a metal cylinder 6 cm wide, 60 cm long, 30 cm high enlarged at the top to 16 cm wide, 80 cm long and 50 cm high. The bottom was drawn to the base, 6 cm wide and 10 cm long and 50 cm deep and air inlet was 10 cm wide, 10 cm high at the bottom-back of the base. The base was separated into five chambers by four vertical baffle plates installed 2 cm above the distribution plate. The fluidized-bed column was well insulated width fiberglass insulation 2 inches thickness.

3.2.3 Blower

The blower was installed to suck hot flue gas from the heater and/or the fluidized-bed combustor section. It has a capacity of about 250 m^3/hr driven by a 3 hp 3 phase induction

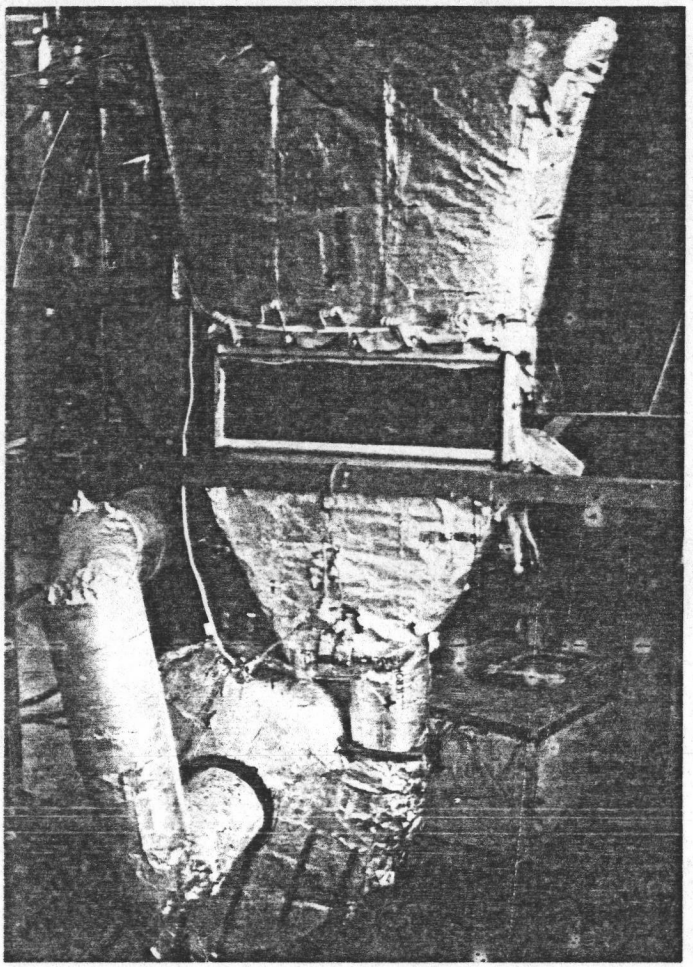


Figure 3.10 The fluidized-bed drying column

motor. The outlet was 10 cm wide and 10 cm long and was connected to the dryer inlet. The inlet was 15 cm in diameter and was reduced with a conical cone to connect to a 9 cm metal pipe connecting to the heater and fluidized-bed combustor cyclone outlet. The flow rate was controlled by two valves (Figure 3.11).

3.2.4 Feeder for Fluidized-Bed Dryer

The feeder was a screw feeder with a hopper. The screw feeder was installed at one end of the chamber of the fluidized-bed column to feed wet paddy into the column passing through the five chambers and leaving the column at the other end. The screw was driven by a motor with a 1:20 reducing gear.

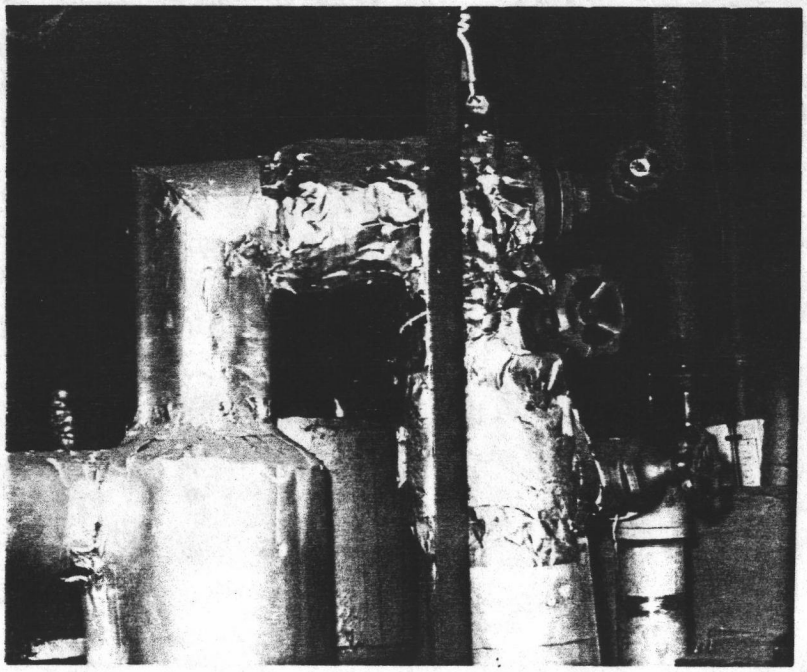


Figure 3.11 The controlled valves of gas to dryer

3.2.5 Temperature Indicator and Controller

Eight thermocouples were installed, two in the inlet chamber of the dryer, one in each of the five chambers of the fluidized-bed dryer and one in the top of the column. The one in the inlet chamber was connected to the temperature controller to control the heater and others were connected to the same temperature indicator selection switch of the fluidized-bed combustion section.

3.2.6 Pitot Tube with Manometer

A pitot tube with manometer was installed to measure the air flow rate from the electric heater. It was calibrated against a standard anemometer.

3.3 Gas Chromatography and Recorder

The gas chromatography was fabricated by GOW MAC company series 150 (Figure 3.12). There were two separated columns,

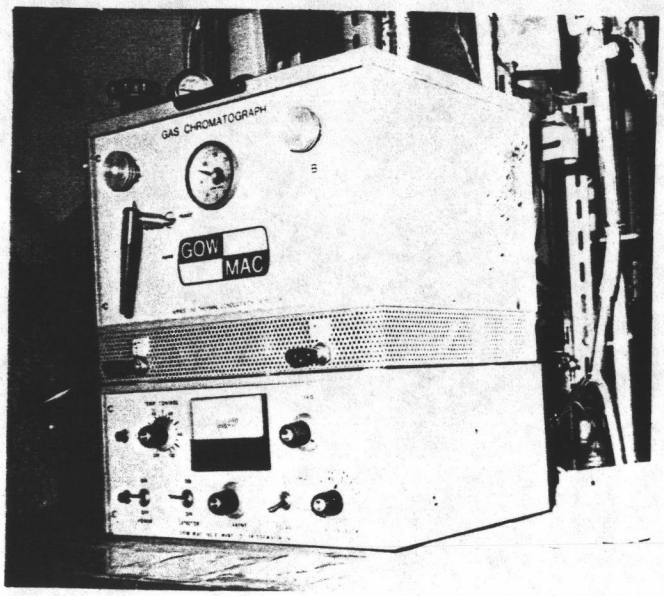


Figure 3.12 The gas chromatography

column A and column B. Column A was packed with MS-5A (Molecular Sieve 5A). It was able to separate H_2, O_2, N_2 and CO from the sample gas. The column B was packed with Porapax Q and able to separate CO_2. The separated gases were carried to the thermal conductivity detector which sent the electric signals to the recorder made by OHGURA Company. The electric signals were then changed to chromatograms. The sample gas chromatograms were compared with the standard gas chromatograms.