Chapter III

EXPERIMENTAL INVESTIGATION

3.1 EXPERIMENTAL EQUIPMENTS DESIGN

3.1.1 Longitudinal Fluidized Bed.

The fluidized bed used in the experiments was formed in the dimension of 50 mm. X 1000 mm. The air distributor was sheet metal of 2 mm. diameter pervious openings with 4 mm. apart by center to center. The openings were orthorhombic arrangement. The bed was resided by sheet metal three sides and left one longitudinal side installed with glass sheet in order that the fluidizing conditions could be inspected. In operation, the polystyrene foam drops (PFD) were fed at one end and while travelling to the other end, agglomeration of drops occurred and went out of the bed by a little adjustable sliding door which was 100 mm. high and 50 mm. wide sited at one end of the column. Both the agglomerated and unagglomerated drops flew out off the bed at the same time like liquid flew through a puncture in its container. The bed is shown in the fiqure 3.1 and the design in details is described next.

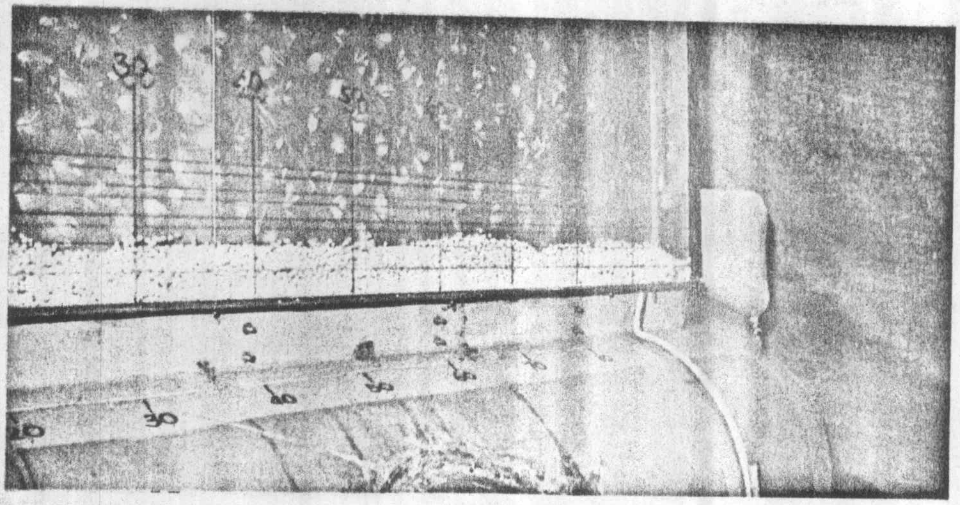

FIG. 3.1 LONGITUDINAL FLUIDIZED BED

3.1.2 Uniform Velocity Distribution of Fluidizing Air Technique

The difficulties to fluidize particles in thelongitudinal bed were

1. The means to distribute thefluidizing air uniformly along the length of the bed.

2. Mixing of agglomerating agent and fluidizing medium homogeneously.

The LP-Gas pipe burner design was employed (14) as follows:-

3.1.2.1 LP-Gas Burner Design Adaptation

In designing a pipe burner, the two following basic rules should be observed if best results are to be obtained.

1. The mixing tube must be at least six times as long as its inside diameter.

2. The inside cross sectional area of the mixing tube should be from 40 to 60 per cent of the total port area.

While a throat to port area ratio of 45 cent may give better performance a variation of 40 to 60 per cent is preferable in connection with pipe burners as it allows considerably more flexibility of design. Figure 3.2 illustrates the conventional design which is generally followe in building pipe burners. In this drawing the pipe part of the burner has been divided into three sections as shown in figure 3.2. By the sam principles, the ring type, atmospheric or bunsen burners as examples ar invented and shown in fig 3.3.

The various patterns and designs of the LP Gas burners have been conducted and many mechanical trials have been recruited to make the final optimum dimension for the apparatus used to distribute fluidi air along with which at the same time carried the aggomerating agent, gasoline, through the bed

The design of the distributor was shown in Fig 3.4a

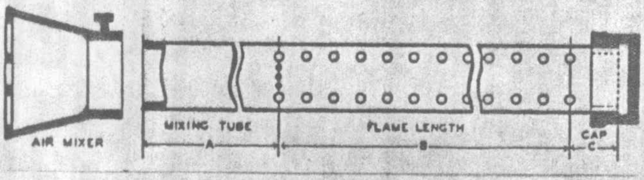

FIG. 3.2 CONVENTIONAL DESIGN OF DRILLED PIPE BURNER

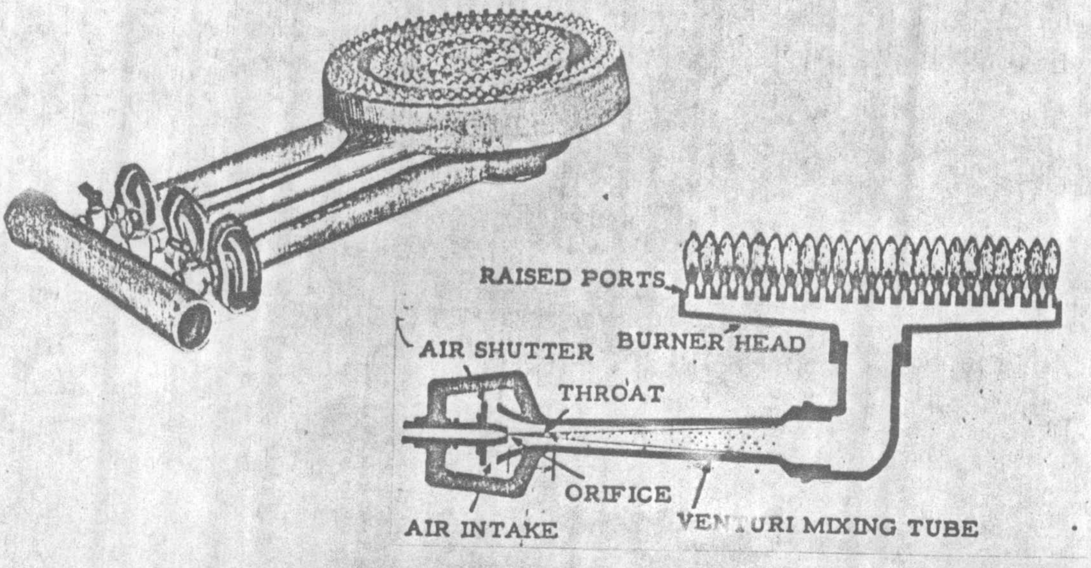

FIG. 3.3 BUNSEN OR ATMOSPHERIC TYPE AND RING TYPE.

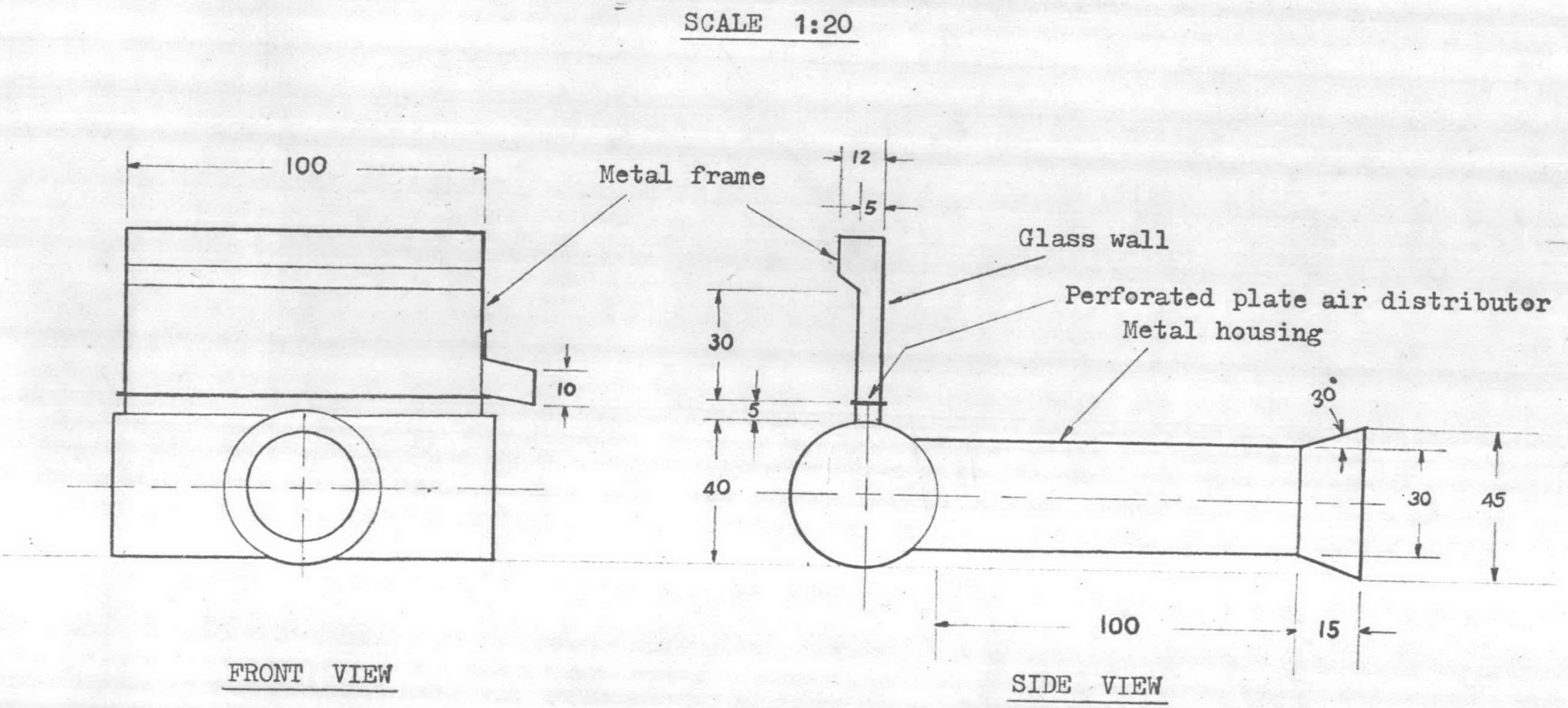

FIG.3.4a DESIGN OF FLUIDIZING AIR DISTRIBUTOR

and the equipments in operation were shown in fig 3.4b. The general installation of the apparatus was to fix the spray nozzle, which the paint spray bottle was employed, infront of the inlet of the mixing zone duct. The pressurized gasoline was ejected as jet stream bywhich induced the surrounding air mixing with the gasoline mist and expanded into the perpendicular duct after that went through the pervious metal sheet to fluidize the PFD in the bed uniformly and particulately. One end of the bed was assumed to be the inlet of PFD fed by feeder and the other was the outlet of agglomerated PFD by means of a sliding little door.

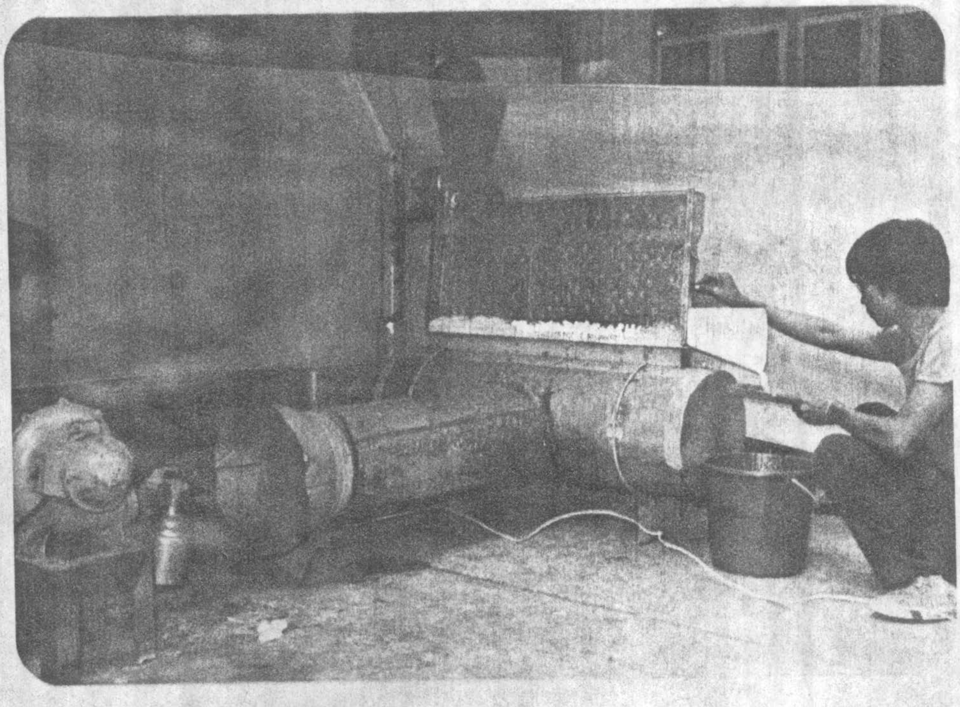

FIG.3.4b.FLUIDIZED BED IN OPERATION

3.1.2.2 Gasoline Spray Bottle

The paint spray bottle was pressurised by a $\frac{1}{2}$ HP air compressor and gasoline filled in the bottle was ejected through a nozzle so that very fine drops of solution liked mist occured and worked as agglomerating or wetting agent. The spray bottle was shown in Fig 3.5a. While the gasoline was ejected through the duct of the distributor, air was also induced and mixed thoroughly with gasoline mist.

It was conducted as shown in Fig 3.5b. The gasoline was compressed in the spray bottle by about 4 kg/cm^2 air compressor.

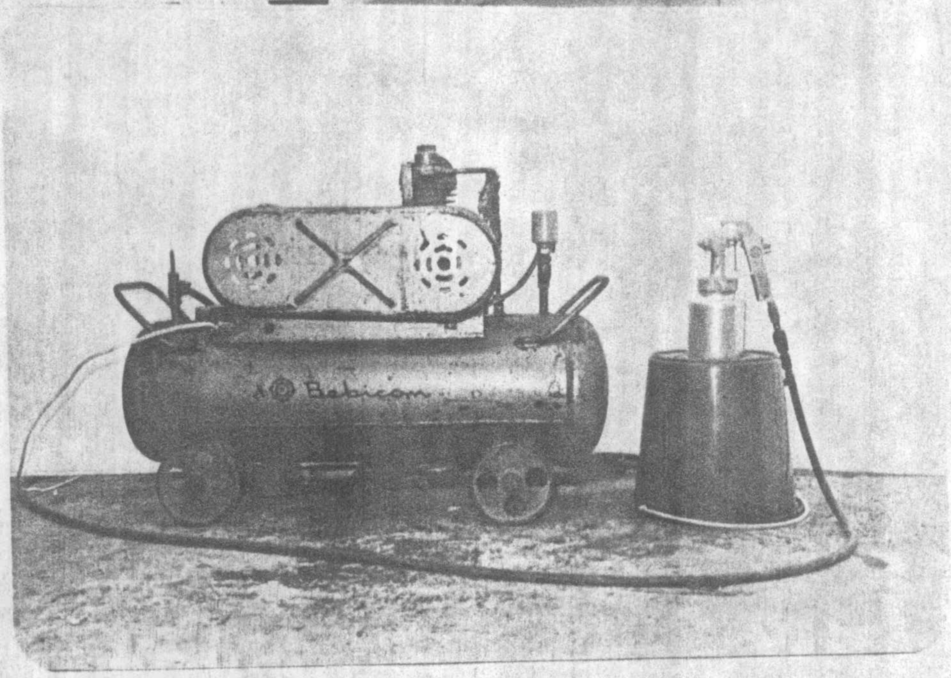

FIG. 3.5a. AIR COMPRESSOR AND SPRAY BOTTLE

3.1.2.3 Blower

A centrifugal blower of 6.25 cm. outlet was spared in order to supply fluidize air for clearing the bed or keeping the height of the fluidize air con stant if the pressure of the ejected gasoline dropped sharply. The blower was shown in the far left of fig 3.4b.

3.1.3 PFD Feeder

The feeder of PFD was put over an end of the bed. There was a thread installed in the bottom of the feeder and drived by a 1/8 HP. motor. The rate of feed could be adjusted by varying different diameter of driving pulley, the arrangement was shown in shown in fig 3.6

FIG. 3.5b GASOLINE JET SPRAYED THROUGH THE MIXING TUBE OF THE DISTRIBUTOR

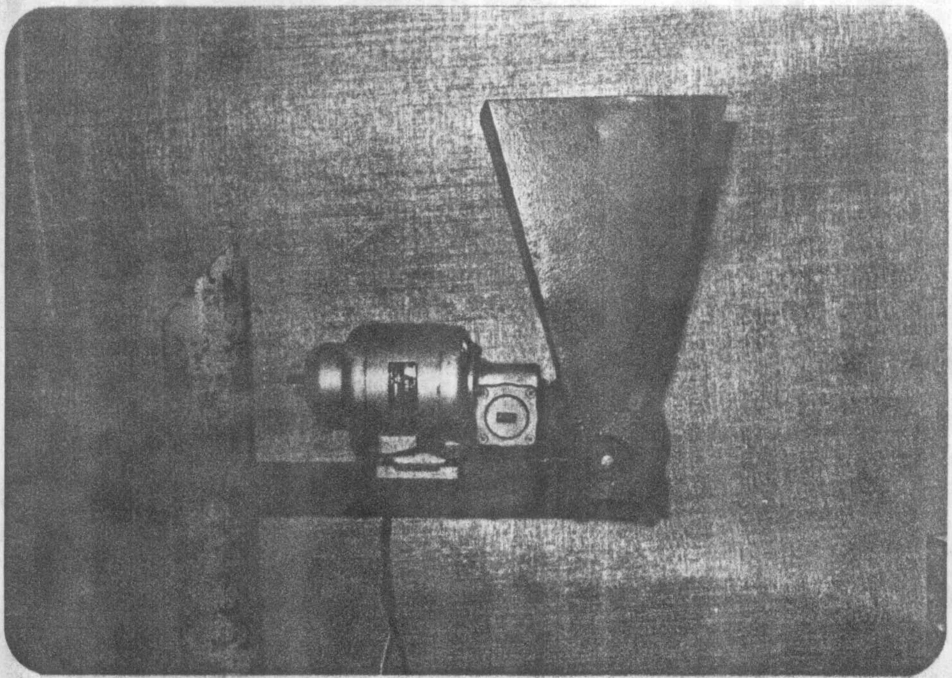

FIG. 3.6 PFD FEEDER

3.2 PARAMETER APPROACHES

In general, the bed was fluidized by ambient air at about 30°c comprising gasoline mist sprayed from the spray bottle. The gasoline mist in the air behaved as agglomerating agent for PFD in the long bed, while PFD travelled gasoline dissolved the foam gradually to give tacky surfaces and randomly collided each other, With the surface tension of the sticky PFD the foam agglomerated to various sizes of cluster by a definite strength.

3.2.1 Relationship Between Variates.

In particular, it was to study what were controlling factors of the agglomeration. The following variables have been considered.

3.2.1.1 Particle size.

Different sizes of PFD was classified to three ranges by sieves with 4 mm. and 6 mm. openings. It was engaged as 2.5 mm.-4.1 mm. averaged to be 3.3 mm. 4.2 mm.-5.9 mm. averaged to be 5.1 mm. and 6.0 mm. 6.8 mm. averaged to be 6.4 mm. in diameter. In operation, while one factor was varied the others were fixed and it was performed the same for all other factors.

3.2.1.2 Agglomerating Agent.

Gasoline feed rate was varied increasing from 30,50,80,100, 120,140, and 160 ml/minute which were respect to 20,34,54,67,80,94 and 107 gm/minute respectively. The gasoline density is 0.669 gm/ml.

3.2.1.3 PFD Feed Rate

The feeder was adjusted to operate at 2 speeds for varied particle size so there were two feed rates in this experiment

3.2.2 Fixed Parameters

Several assumptions have to be set up in order to remit the bias in the experiment, it was assumed that, in the operating condition there were fixed parameters as

1. The bed was fluidized isothermally at a constant pressure of fluidizing air which was induced by the jet stream of the agglomerating agent from the gasoline spray bottle. The height of the fluidized bed was also assumed constant with the same mode through the whole experiment.

2. Because of the very low fluidizing air velocity the evaluation of the pressure drop across the distributor was so difficult that it could not be measured in this experiment so it has to be assumed that the characteristics of the fluidized bed followed the fluidization theory and the pressure drop across the bed was negligible. The side effects in the bed such as friction loss, fouling of fluidization due to the bed wall were inattentive.

3. Each particle size range of PFD was fluidized by a constant fluidizing air velocity which actually was the mixture of air induced by air-pressurised gasoline spraying through the mixing zone of the distributor and gasoline mist.

4. The bulk density of PFD in the three ranges and voidage were constant. Meanwhile the densities of fluidizing air with gasoline mist, for each fluidizing velocity of individual PFD sizes were calculated as shown in appendix A.1, so there would be three different fluidizing air densities because there were 3 different ranges of PFD size and each value was assumed constant for the experiment concerning each size range

5. The weights of PFD inlet and outlet through the bed were equal and hence resulted the bed height and voidage constant along the fluidizing bed

6. The surface tension of PFD which was a factor for calculation of agglomerating strength while the particle adhered was calibrated in fig. 4.5 to be 28 dyne/cm and constant along this experiment.

3.3 MEASUREMENT OF THE FACTORS

3.3.1 Fluidizing Velocities

The minimum fluidizing velocity was determined by the relationship between the pressure drop across different height of beds and air velocities which gave the same minimum velocity at the maximum pressure drop of any bed height. The pressure drop was measured by water manometer in mm. H_2O and the air velocities were measured by a wet test meter in term of volume of air flow in a time period which after divided by the cross sectional of the bed the velocity was obtained. The bed used for this calibration was a column of 9.5 cm diameter as shown in Fig 3.7. For each particle size, three curves of the

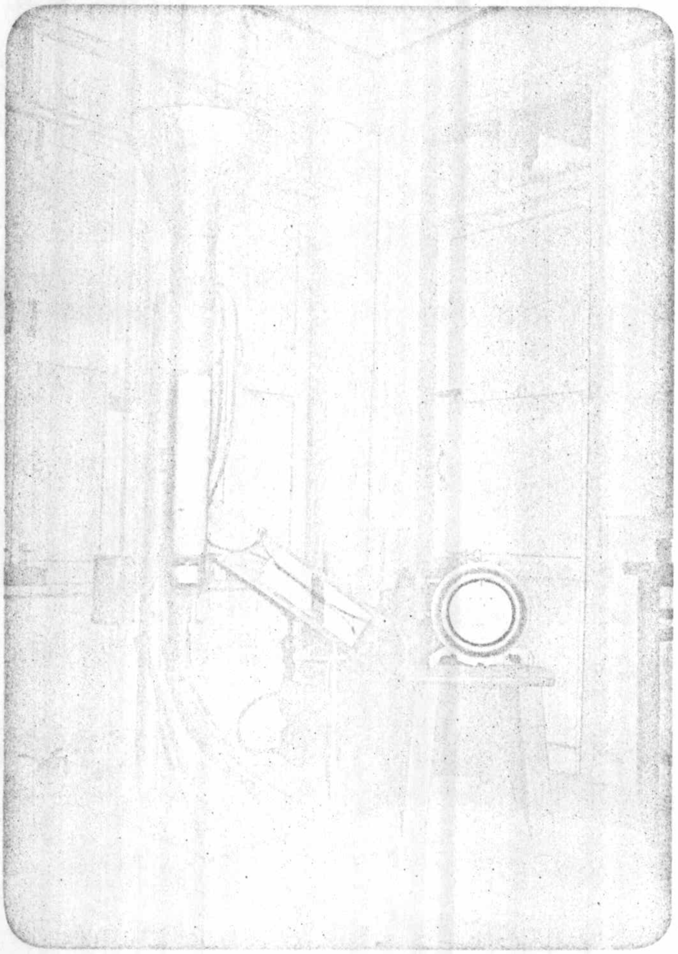

FIG. 3.7 FLUIDIZED COLUMN FOR U_{mf} DETERMINATION

relationships between pressure drop across three different height of bed and air velocities were calibrated to find the minimum fluidizing velocity for that particle size. The superficial velocity was measured by the anaemometer at the top of theexperimental bed. The anaemometer shown in fig 3.8 was placed at the top of the column and measured the velocities along the bed length point by point at every 10 cm. apart. The velocities obtained could not be used because they were velocities of air at the enlarged area, hence these values had to be reimbursted to be the velocities at the actual fluidized bed area for the height of bed, it was revealed by the scale marked on the glass. For each point it was measured three times, the first time the distance was recorded in one minute, the second time in two minutes and the third time in three minutes. The distance measured in each period at all points was prior averaged, so there were three values of velocity, they were the averaged distance measured in one minute, two and three minutes, then they were finally averaged in distance per minute. The terminal air velocity was of no value for this experiment so there was no measurement but calculated for information as shown in appendix A.2

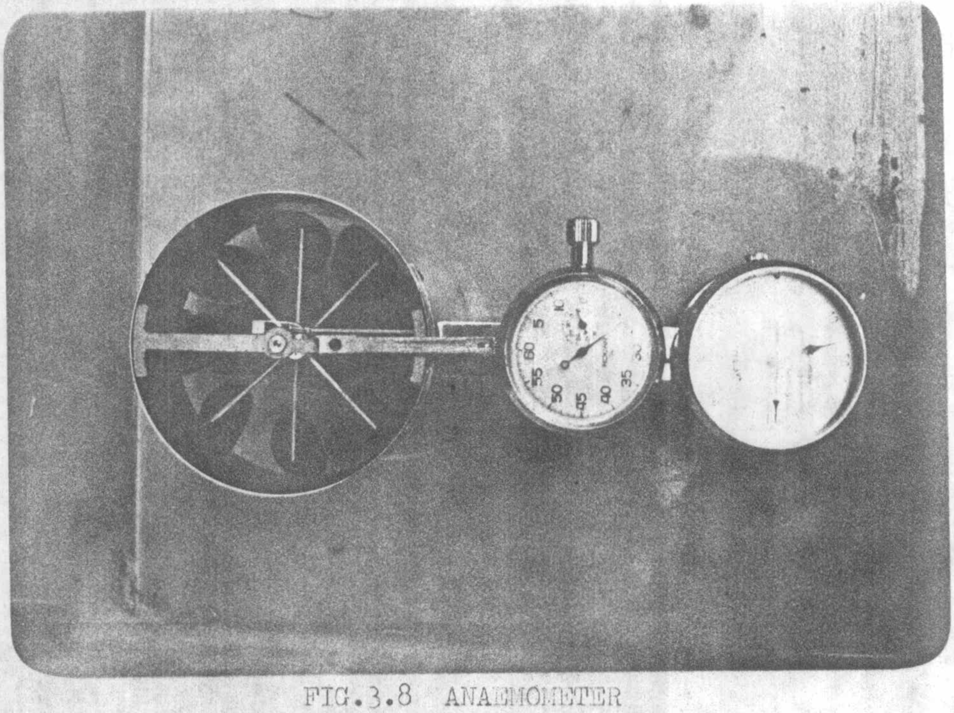

FIG.3.8 ANAEMOMETER

3.3.2 The Polystyrene Foam Drop Feed Rate and Voidage.

The feed rate was determined by weighing the PFD agglomerate several times and averaged. Two feed rates were used for each particle size.

The voidage and bulk density of each size were determined at the same time. Each size of PFD was fill in a 1500 ml. flask and weighed, then the bulk density was found. The voidage of each size was measured by substituting air trapped among foam drops by water, the volume of water divided by 1500 ml was the voidage for that size.

3.3.3 The Surface Tension of Polystyrene Solution in Gasoline

The value of surface tension or in other word the gas-liquid interfacial tension as described in 2.6.2 was obtained by the surface tensiometer shown in fig 3.9 which was calibrated with the known value and after that the surface tension of polystyrene solution in gasoline was measured at various polystyrene concentration in order to find the reliable range of the polystyrene solution's surface tension to be used as reference.

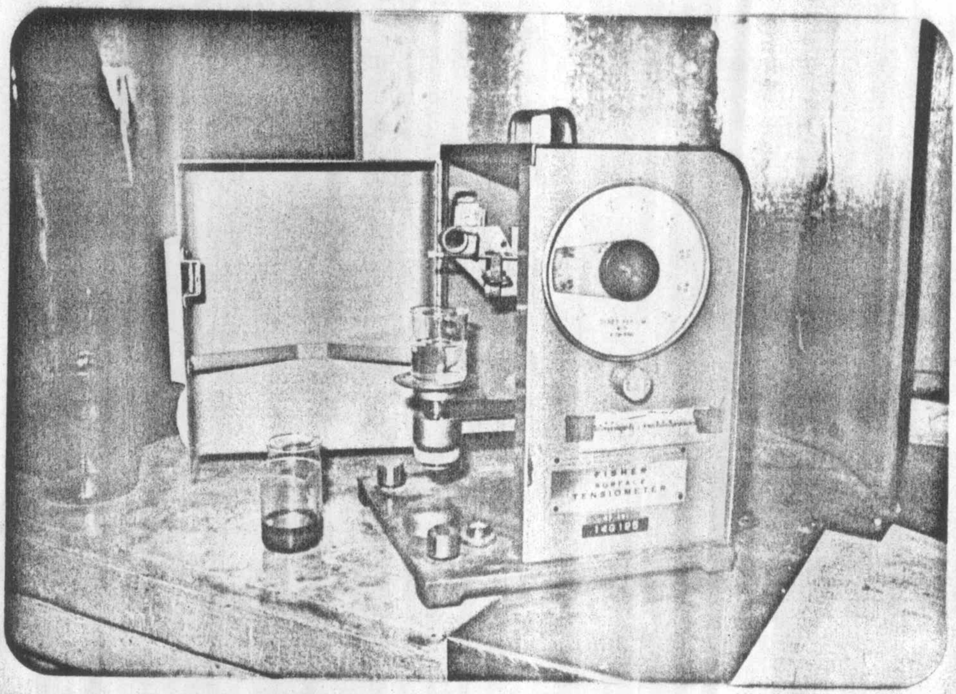

FIG. 3.9 SURFACE TENSIOMETER