PART A.

To investigate the combustion in an oil-fired boiler in the Mechanical Engineering Laboratory.

Problem associated with the Combustion in the boiler furnace

The combustion in this boiler has never been satisfactory. A flame could not be established at low fire rate. At high fire rates an excessive amount of smoke resulted. This prevented the boiler being used over a full modulating range. Also the combustion was very poor with high viscosity oils well within the range suited to the design of the boiler.

Some further experimental work was required to give more information on two factors affecting combustion.

1. Photographs showing the nature of the flame under varying fuel metering settings and primary air settings.

2. To measure the velocity profile of the primary air so as to assess its influence on the atomization and combustion.

Laboratory Apparatus.

1. The equipment and the apparatus used in the study was installed in 1956 in the Steam Power Laboratory of the Department of Engineering, Chulalongkorn University. The description of the component parts of the apparatus is as follows.

2. Fully Automatic Rotary-Type Burner.

A very interesting class of low-pressure air burner is the Rotary. The oil is distributed over the air blast from the lip of a rapidly rotating cup. This serves the double purpose of ensuring an even distribution of oil and also initiates atomization. The cup is rigidly mounted on a shaft which can be either directly coupled to an electric motor. The oil is fed on to the inner surface of the cup from a stationary pipe, and thus begins its journey to the lip of the cup with a low velocity. It is obvious, therefore, that not only must one provide a cup large enough to handle the quantity of oil passed by the burner, but that the cup must be so shaped as to ensure that the oil leaves the lip at a sufficiently high velocity. The acceleration due to the rotation of the cup can be converted into an axial velocity.

3. A U-type manometer for the measurement of pressures, vacuums, or differential pressures.

4. A 35 mm-Camera.

Experimental Procedure.

A. Atomization of boiler fuel oil by Photographs and Observations.

Eight test series, one with each Fuel setting (Fig. 7), were performed, (as shown in Fig. 8).

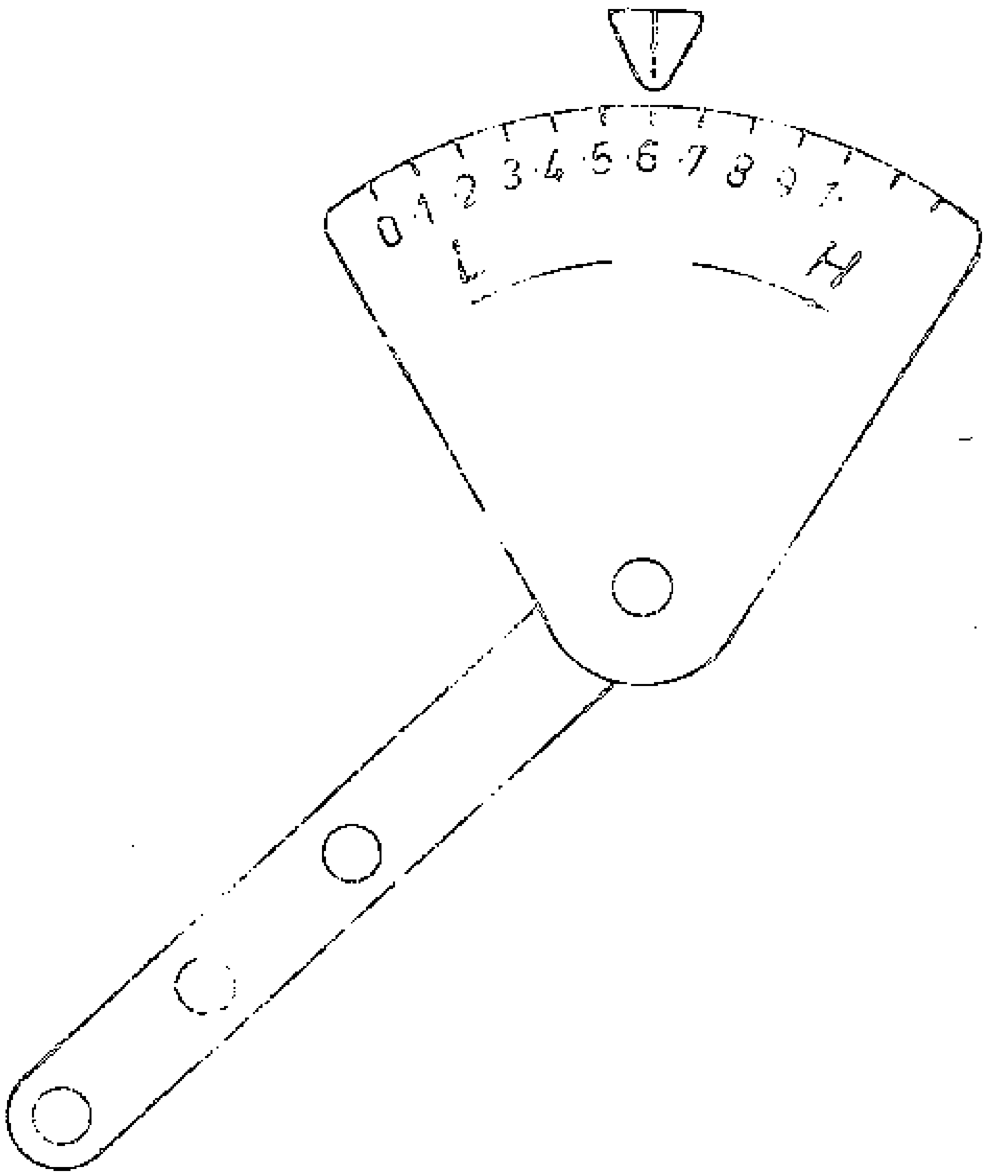
B. Measuring the velocity of Primary Air by Pitot tube.

Twelve test series, one with each Fuel Meter setting were performed. (as shown in Fig. 9 and Fig. 10) The sequence of procedure in each experiment was as follows:-

a. Setting the Pitot tube at zero point in the center of the Rotary cup burner and startup the primary air inlet, Keep the primary air in the Closed position and reading the pressure head on the U-type manometer.

b. Resetting the Pitot tube on the line out of the Center of the Rotary Cup burner in the position as the data.

c. Removed the Primary Air inlet in the position of ¼ open, ½ open, ¾ open and Full open, and the sequence of procedure as above.


0 1 2 3 4 5 6 7 8 9 1
L
H

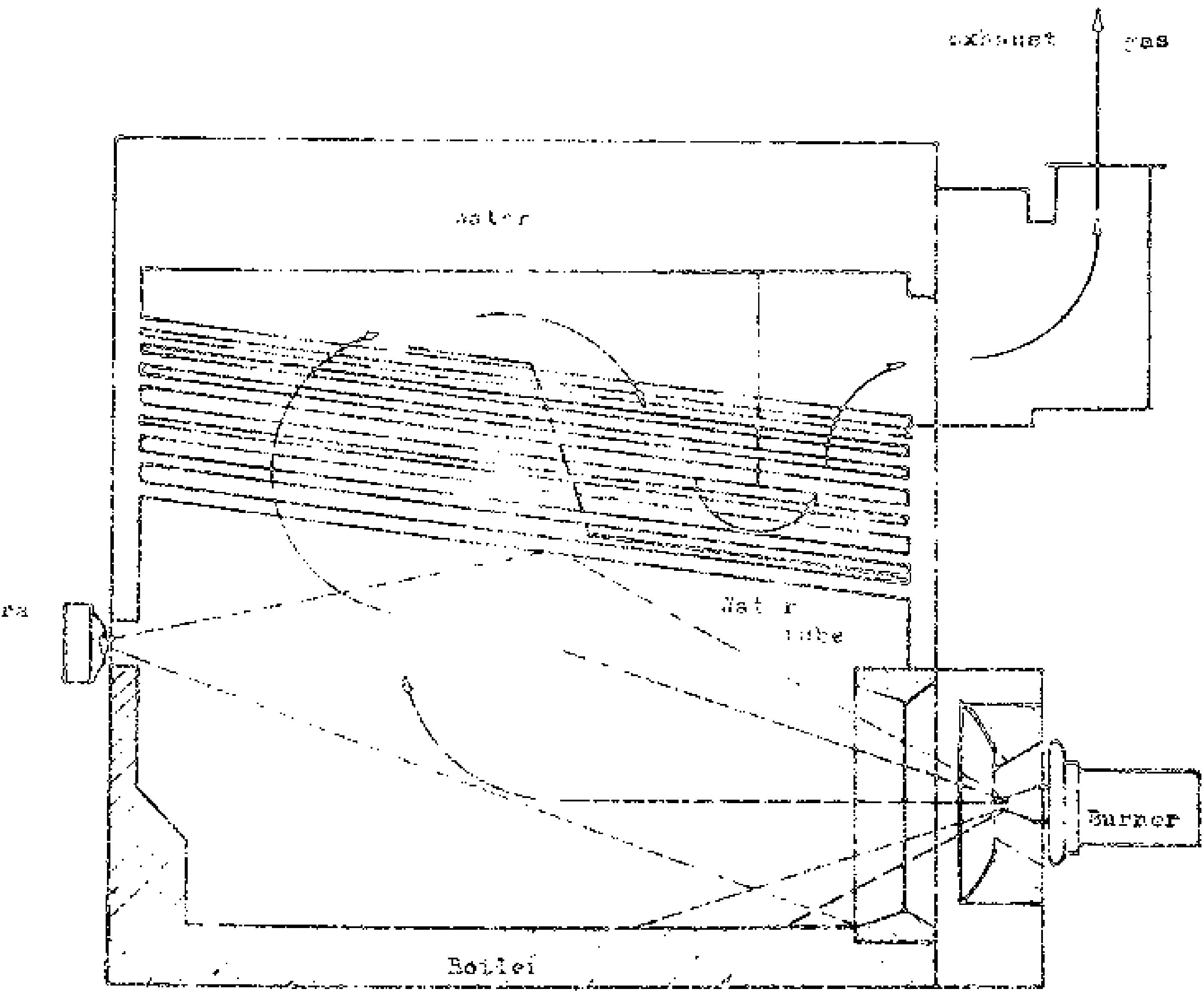


Fig.[illegible] Schematic diagram of Photographs and Observations.

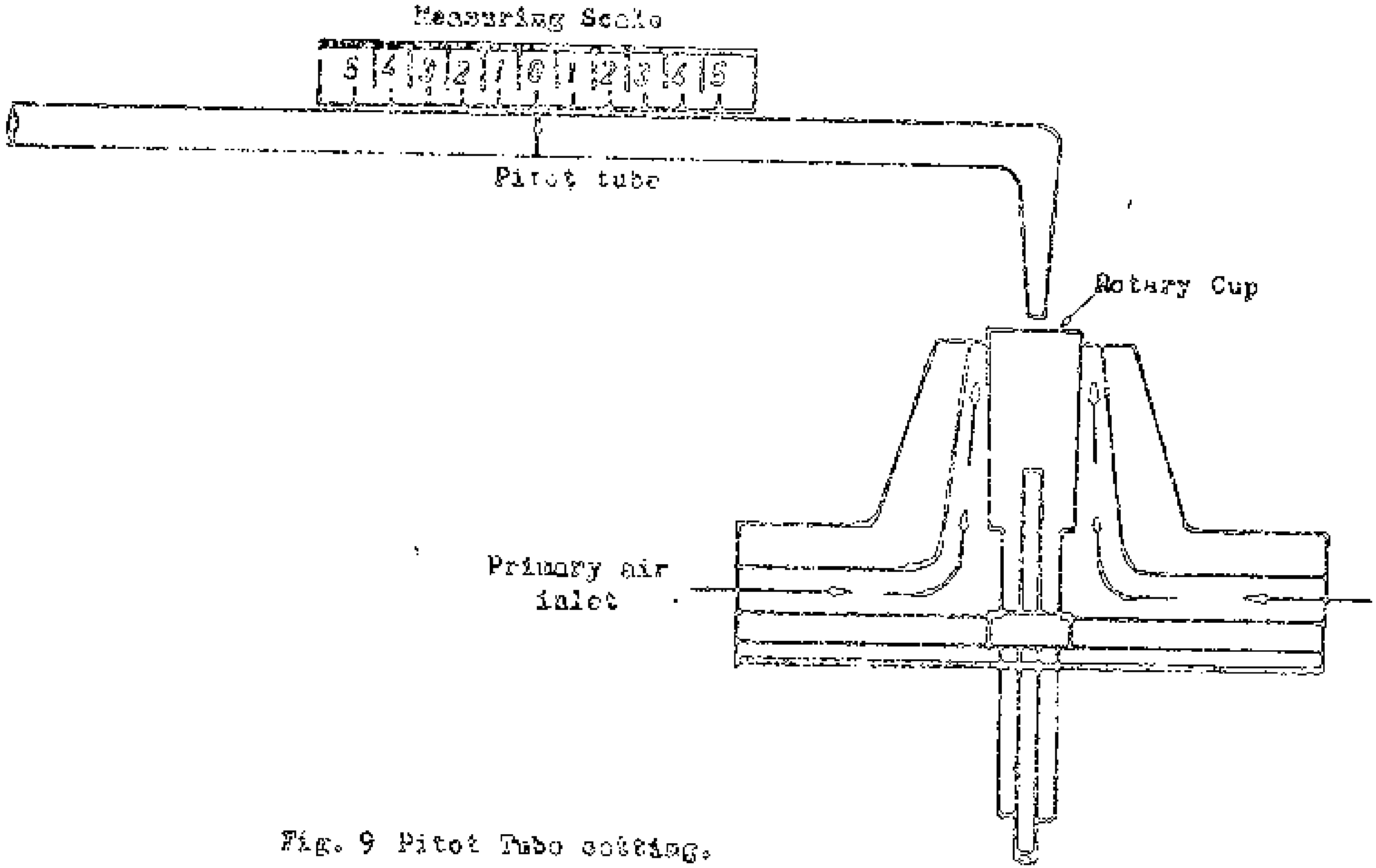


Fig. 9 Pitot Tube setting.

CONCLUSIONS

1. A series of photographs of combustion in the boiler furnace were taken in order to obtain a picturial assessment of the quality of combustion, (as shown in Fig. 11).

2. A plot of primary air velocity was made at various setting in order to investigate the influence of the primary air velocity on atomization. (as shown in Fig. 12 and 13)

3. The atomization is generally poor at low metering rates (0.3, 0.4), it was impossible to hold the flame continuously. This is apparently due to large droplets of oil coming from the atomizing cup and being unable to burn continuously. Higher metering rates improved the atomization and readily supported combustion. There was however still to large a droplet of oil for good combustion and smoke resulted. The photograph (0.8 - metering) is interesting as the combustion is greatly improved by the presence of the pilot flame. (Fig. 11)

4. Evidence points to the lack of a stabilised flame at the burner outlet. The flame, when the pilot flame is extinguished, is carried from the burner causing flame failure and shut down.

For small fuel metering rates the primary air must be severly restricted. For all metering rates it seems that the primary air has too high a velocity. (Fig. 12)

It could well be, however, that the secondary air flow be adjusted in order to obtain a relationship between the secondary and primary to give a flow pattern containing a stationary air zone.

Further experimental work.

This could be of two types.

(a). To plot by means of a small pitot-static tube a better pattern of the actual air flow under working conditions but without oil firing

(b). To use visualization techniques with a water-perspex model of the combustion chamber.

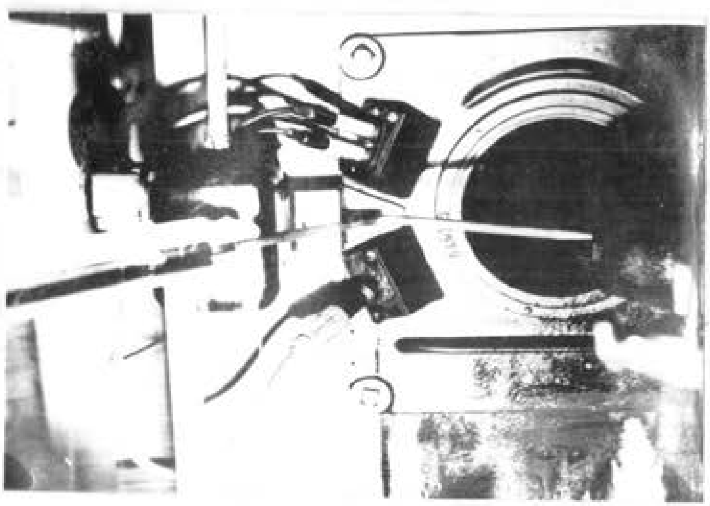
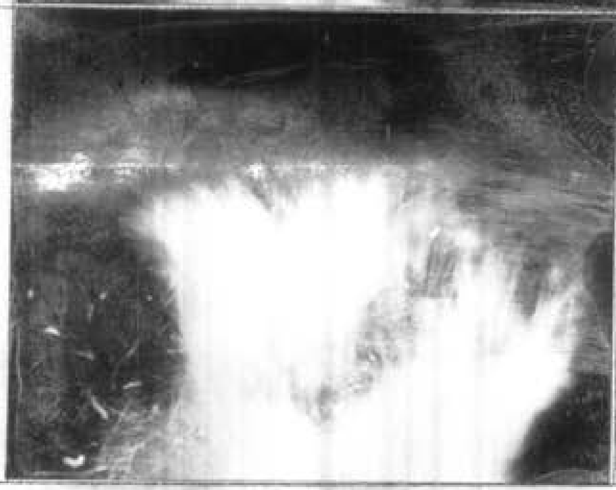


Fig. 10 Measuring the velocity of Primary air by Pitot tube.

Fig. 11 Results of the Atomization of fuel oil for Comhustion in boiler by Photographs and Observations

No.of testing	Photograph	Observation	Fuel meter setting	Primary air	Secondary air
1		Slight smoke in flame	1.0	Full open	Full open
2		Slight smoke in flame	0.9	Full open	Full open

No.of testing	Photograph	Observation	Fuel meter setting	Primary air	Secondary air
3		Pilot flame with oil flame	0.8	Full open	Full open
4		Some sparks in flame	0.6	Full open	Full open

No.of testing	Photograph	Observation	Fuel meter setting	Primary air	Secondary air
5		Sparks but no smoke	0.55	Full open	Full open
6		Heavy sparks but no smoke	0.4	Closed	Full open

No.of testing	Photograph	Observation	Fuel meter setting	Primary air	Secondary air
7		Flame failed with heavy smoke	0.4	Full open	Full open
8		Heavy sparks but no smoke, flame held for a period about 1 minute	0.3	Closed	Full open

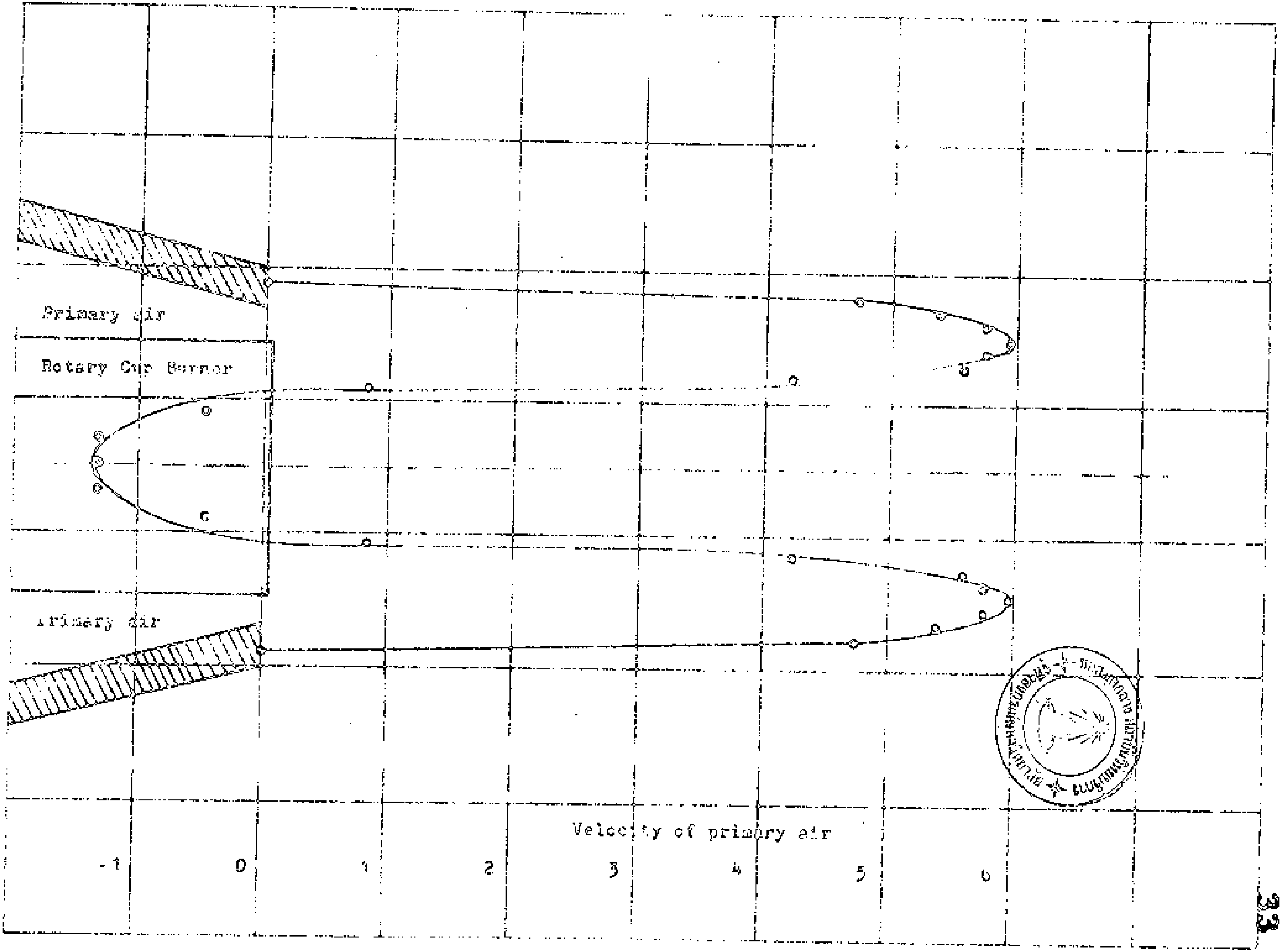


Fig. 12 Graphical [illegible] the rotary cup burner.

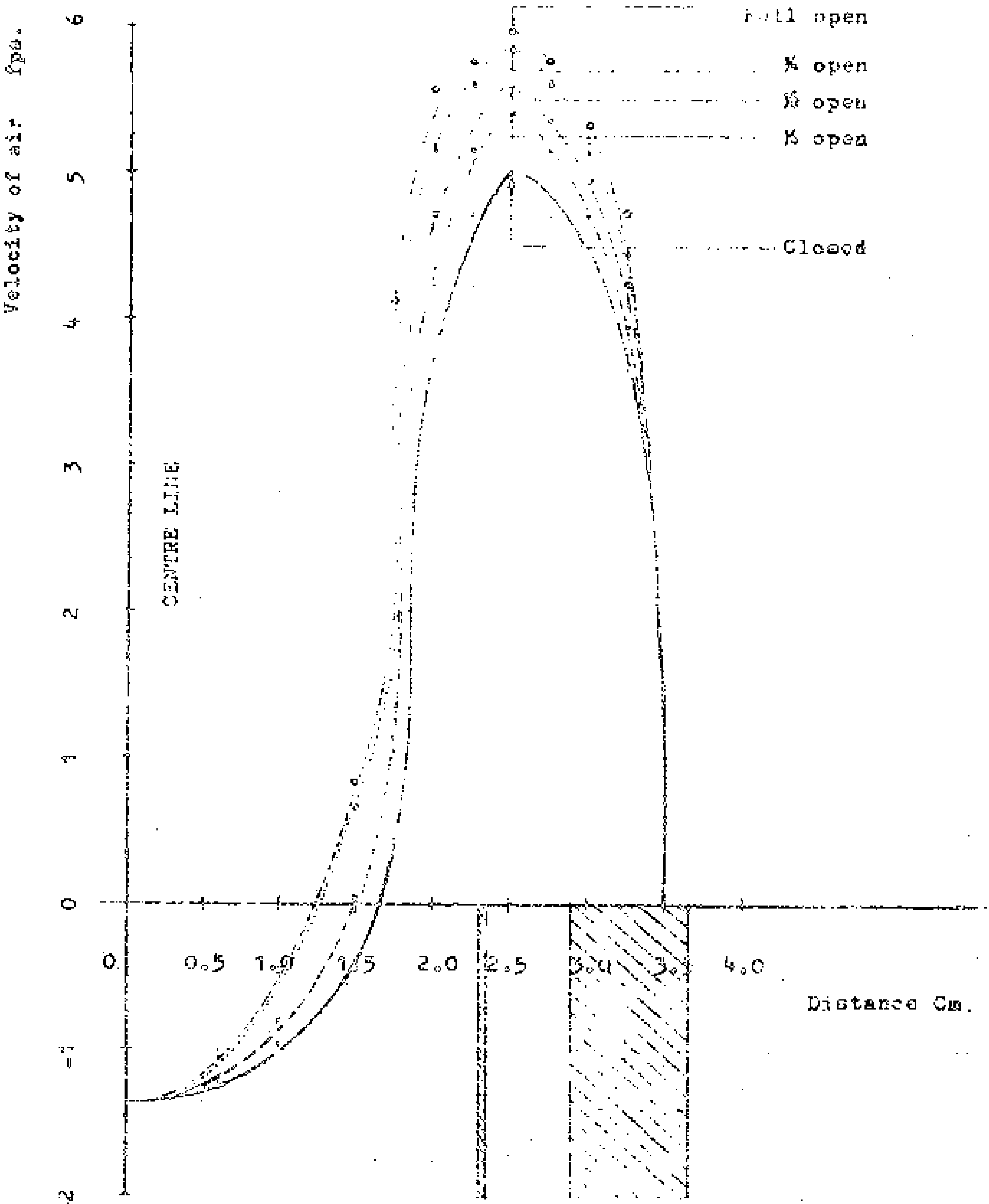


Fig. 13 Primary air velocity at various settings.

Table 1 Variable Pitot tube setting and Closed Primary air inlet

No. of testing	Pitot tube setting cm.	Scale reading in in.	ft. of water (h)	$\sqrt{h}$	Velocity of air in fps (V)
1	0.00	-0.40	-0.0277	-0.166	-1.33
2	0.50	-0.40	-0.0277	-0.166	-1.33
3	1.00	-0.20	-0.0380	-0.117	-0.94
4	1.50	-0.05	-0.0034	-0.058	-0.46
5	1.75	0.20	0.0138	0.117	0.94
6	2.00	3.00	0.2070	0.455	3.65
7	2.25	4.00	0.2770	0.526	4.22
8	2.50	5.60	0.3870	0.622	5.00
9	2.75	5.00	0.3450	0.587	4.71
10	3.00	4.50	0.3110	0.557	4.47
11	3.25	3.00	0.2070	0.455	3.65
12	3.50	0.00	0.0000	0.000	0.00

Table 2 Variable Pitot tube setting and ¼ open Primary air inlet

No. of testing	Pitot tube setting cm	Scale reading in in.	ft. of water (h)	$\sqrt{h}$	Velocity of air in fps (V)
1	0.00	-0.40	-0.0277	-0.166	-1.33
2	0.50	-0.40	-0.0277	-0.166	-1.33
3	1.00	-0.15	-0.0104	-0.102	-0.82
4	1.50	0.00	0.0000	0.000	0.00
5	1.75	0.25	0.0173	0.131	1.05
6	2.00	3.00	0.2770	0.526	4.22
7	2.25	5.00	0.3450	0.587	4.71
8	2.50	6.60	0.4550	0.674	5.41
9	2.75	6.00	0.4140	0.643	5.16
10	3.00	5.00	0.3450	0.587	4.71
11	3.25	3.50	0.2420	0.492	3.95
12	3.50	0.00	0.0000	0.000	0.00

Table 3 Variable Pitot tube setting and ½ open Primary air inlet

No. of testing	Pitot tube setting cm.	Scale reading in in.	ft. of water (h)	$\sqrt{h}$	Velocity of air in fps (V)
1	0.00	-0.40	-0.0277	-0.166	-1.33
2	0.50	-0.40	-0.0277	-0.166	-1.33
3	1.00	-0.15	-0.0104	-0.102	-0.82
4	1.50	0.05	0.0034	0.058	0.46
5	1.75	3.00	0.2070	0.455	3.65
6	2.00	5.00	0.3450	0.587	4.71
7	2.25	6.00	0.4140	0.643	5.16
8	2.50	7.00	0.4830	0.695	5.58
9	2.75	6.50	0.4480	0.669	5.35
10	3.00	5.50	0.3800	0.616	4.95
11	3.25	4.00	0.2770	0.526	4.22
12	3.50	0.00	0.0000	0.000	0.00

Table 4 Variable Pitot tube setting and ½ open Primary air inlet

No.of testing	Pitot tube setting cm	Scale reading in in.	ft.of water (h)	$\sqrt{h}$	Velocity of air in fps (V)
1	0.00	-0.40	-0.0277	-0.166	-1.33
2	0.50	-0.40	-0.0277	-0.166	-1.33
3	1.00	-0.05	-0.0034	-0.058	-0.46
4	1.50	0.10	0.0069	0.083	0.66
5	1.75	0.35	0.0242	0.155	1.25
6	2.00	6.00	0.4140	0.643	5.16
7	2.25	7.00	0.4830	0.695	5.58
8	2.50	7.60	0.5250	0.724	5.82
9	2.75	7.00	0.4830	0.695	5.58
10	3.00	6.00	0.4140	0.643	5.16
11	3.25	4.50	0.3110	0.557	4.47
12	3.50	0.00	0.0000	0.000	0.00

Table 5_Variable Pitot tube setting and Full open Primary air inlet

No. of testing	Pitot tube setting cm.	Scale reading in in.	ft. of water (h)	$\sqrt{h}$	Velocity of air in fps (V)
1	0.00	-0.40	-0.0277	-0.166	-1.33
2	0.50	-0.40	-0.0277	-0.166	-1.33
3	1.00	-0.05	-0.0034	-0.058	-0.46
4	1.50	0.15	0.0104	0.102	0.82
5	1.75	4.00	0.2770	0.526	4.22
6	2.00	7.00	0.4830	0.695	5.58
7	2.25	7.50	0.5180	0.719	5.75
8	2.50	8.00	0.5500	0.741	5.95
9	2.75	7.50	0.5180	0.719	5.75
10	3.00	6.50	0.4480	0.669	5.36
11	3.25	5.00	0.3450	0.587	4.71
12	3.50	0.00	0.0000	0.000	0.00