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FUEL RESEARCH INSTITUTE

OF SOUTH AFRICA

ONDERWERP:
SUBJECT: REPORT ON THE PERFORMANCE OF THE

4" COMPOUND WATER CYCLONE

AFDELING:
DIVISION:

NAAM VAN AMPTENAAR:
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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA

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REPORT ON THE PERFORMANCE OF THE 4" COMPOUND WATER CYCLONE

1. INTRODUCTION

The investigation was undertaken as a preliminary study of the 4" Compound Water Cyclone, with regard to its separation efficiency, range of yields obtainable and throughput capacity.

The main purpose behind this work was to gain some experience with the operation of this type of cyclone and to get an idea of its performance before starting investigations with an 8" Compound Water Cyclone.

The cyclone used in these tests is the property of Nortons-Tividale South Africa (Pty)Ltd., Johannesburg. It was borrowed by the Fuel Research Institute and mounted on the existing test rig, consisting of a reservoir tank, feeding pump, recirculating pump and sampling apparatus. A representation of the apparatus and test rig is given in Diagrams 1 and 2.

As the cyclone was supplied without the set of interchangeable parts, the number of operating variables was considerably reduced. Because of this fact, together with that of having only one type of coal available, the study cannot be regarded as a very extensive investigation. It describes some of the results of initial tests and gives the basic information on performance of this, in South Africa still new, type of coal separator.

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2. THE TESTING PROCEDURE

2.1 Description of method

The method employed was the batch operation in closed circuit. The known volume of water was placed into the reservoir tank and the recirculating pump was started to provide turbulence in the tank and thus a reduction in the settlement of coal. The corresponding amount of coal was then added and the feeding pump was started so that the inlet pressure was slowly increased up to the desired value. Both product and discard were returned to the reservoir tank for some 15-20 minutes, which is about the time required for reaching the steady state in the cyclone.

During the operation a hindered settling bed is formed in the cyclone, amounting to about 50 gramms and consisting of the heavier fractions of the feed. This leads to a change of the feed composition. In order to avoid this change, or rather to reduce it as far as possible, it is necessary to start with a sufficiently large batch. In these tests it was 600 kg of the pulp, containing 30 kg of the coal, so that the amount of coal in the cyclone was practically negligible.

2.2 Sampling

After reaching the steady state inside the cyclone, the overflow and underflow were sampled simultaneously by means of the sampling apparatus (two sampling boxes fixed on a trolley).

The duration of sampling was measured and used for the calculation of the flow rate. The samples were weighed as pulp in order to calculate the solids concentration and the flow ratio. They were then drained, dried, weighed as dry products and analysed as desired.

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2.3 Coal

The origin of the coal used in these tests was the Landau No. 2 seam. The washability characteristics and screen analysis of this coal are shown in Tables 1 and 2 and Figure 1.

3. FACTORIAL TEST

The operating variables of the Compound Water Cyclone are as follows:

a. The tricone type (large, medium and small)
b. The vortex finder diameter.
c. The vortex finder clearance (VFC)*.
d. The apex diameter.
e. The inlet pressure.
f. The percentage of solids in the feed.

The settings of these variables should match the nature of the raw coal as they depend on the washability characteristics and particle size consists of the coal and on the desired yield and cut point, respectively.

Usually these settings are found from a statistical test, called the "Factorial Test". Briefly this test deals with the effects of changes in two, three or four operating variables on the performance of the cyclone. Each of the variables requires at least two, but preferably three settings, a high, medium and a low one.

/As ...

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* The vortex finder clearance is the vertical distance between the lower edge of the vortex finder and the intersect of the upper and middle sections of the compound tricone. See Diagram 2.

As stated above, the apparatus was available without accessories, i.e. with only one size of the vortex finder and one size of the apex. The type of tricone was a large one. From the remaining three operating variables, i.e. vortex finder clearance, inlet pressure and percentage of solids in the feed, the first two were chosen for this test, each of them at three different levels. The reason for this was that the effect of solids percentage is less than the effects of other variables. A strong deteriorating effect will only occur when increasing the feed solids to about 8 percent.

The settings of the selected operating variables were as follows:

	low	medium	high
Vortex finder clearance (in)	$1\frac{1}{4}$	2	$2\frac{3}{4}$
Inlet pressure (lb/in^2)	5	8	10
Vortex finder diameter (in)		2	
Apex diameter (in)		1	
% solids in the feed		5	
Compound cone type		Large	

Each individual test at certain cyclone setting was done in duplicate, using the same batch. For each of these double tests a new batch was used because of the possibility of size degradation of coal in the cyclone and pumps. The dry clean coal was screened on 75 microns (200 mesh) screen and both size fractions were analysed for ash content.

The results of the Factorial Test are shown in Table 3 and <u>Figures 2 - 4</u>.

4. TEST USING THE OPTIMUM SETTINGS FOUND

From the results of the Factorial Test it was decided to do a few tests with the optimum settings of operating variables. According to the Factorial Test the best conditions, for a given coal, seem to be operating the cyclone at lower feed pressure and larger vortex finder clearance. These settings cover the range of yields varying from 50 to 70 percent and result in an ash improvement of 4 to 5 percent.

The clean coal contains about 40 to 50 percent of the minus 75 micron (200 mesh) fraction with practically the same ash content as the feed. As this fraction constitutes only 32,9 percent of the feed, and the size degradation of fine coal in the cyclone is very low, it is clear that most of the minus 75 micron material goes to the clean coal, following the water split in the cyclone.

As a result of the very poor separation of the finest particles the following tests were done with the coal from which the minus 75 micron fraction had been removed by means of wet screening. Its size consist is shown in Table 4 while the results of these tests appear in Table 5.

Promising results in ash improvement were obtained in these tests, but the efficiency of separation could not yet be evaluated. It is believed that these results can still be improved, especially when cleaning plus 150 micron (100 mesh) coal only. This can be illustrated by results of tests found in the literature*. These results concern the two-stage operation.

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* J. Visman - "Two-stage Benefication of Washery Effluents with Compound Water Cyclones," Trans. Fifth International Coal Preparation Congress, 1966, pp. 57/72.

Size fraction (microns)	Cut point	Probable error	Error area (cm^2)
1190 x 74	1,49	0,07	68
1190 x 590	1,49	0,04	22
590 x 297	1,43	0,04	29
297 x 149	1,52	0,07	58
149 x 74	1,92	0,30	153

5. CONCLUSION

When taking into account the fact that the coal used in the Factorial Test contained almost 33 percent of minus 75 micron (200 mesh) fraction, and even some 50 percent of this coal was smaller than 150 micron (100 mesh), the results obtained with the Compound Water Cyclone can be considered as satisfactory. As for given coal the range of yields of clean coal obtainable lies between 45 and 80 percent and the ash improvement is between 3,2 and 5,4 percentage units. The results of the tests with plus 75 micron (200 mesh) coal show an ash improvement of 7,0 to 8,7 percentage units. For comparison, the conventional water cyclone gives an ash reduction of only some 2 to 3 percentage units.

Unfortunately the float and sink data on washery products are not yet available because of some analytical difficulties with the separation of such fine coals. The quality of separation, expressed as probable error, and the range of the cut points are still open questions which will require further investigation.

(SIGNED) A. SALER.
RESEARCH OFFICER.

PRETORIA.
14th February, 1972.
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TABLE 1

WASHABILITY DATA OF THE COAL FOR THE "FACTORIAL TEST"

S.G.	Fractional		Cum. Floats		Cum Sinks		Charac-teristic
	% Yield	% Ash	% Yield	% Ash	% Yield	% Ash	
F 1,3	3,91	2,6	3,91	2,60	69,09	17,99	1,96
1,3 - 1,4	5,03	3,8	8,94	3,27	91,06	18,77	6,42
1,4 - 1,5	24,06	6,9	33,00	5,92	67,00	23,04	20,97
1,5 - 1,6	19,45	12,1	52,45	8,21	47,55	27,51	42,73
1,6 - 1,8	15,13	16,5	67,58	10,07	32,42	32,65	60,01
1,8 - 2,0	13,98	22,3	81,56	12,16	18,44	40,50	74,57
S 2,0	18,44	40,5	-	-	-	-	90,78
Whole Coal	100,00	-	100,00	17,39	-	-	-

TABLE 2

SCREEN ANALYSIS OF THE COAL FOR THE "FACTORIAL TEST"

Size Fraction	Yield	Ash
0 - 75 microns	32,9%	17,6%
75 - 150 "	17,0%	17,3%
150 - 251 "	17,9%	16,8%
251 - 500 "	30,6%	16,6%
Over 500 "	1,6%	17,7%

/TABLE 3 ...

TABLE 4

SCREEN ANALYSIS OF THE COAL FOR THE TESTS WITH OPTIMUM CYCLONE SETTINGS

Size Fraction	Yield
75 - 150 microns	25,3 %
150 - 251 "	26,7 %
251 - 500 "	45,6 %
Over 500 "	2,4 %

TABLE 5

RESULTS OF THE TESTS WITH OPTIMUM CYCLONE SETTINGS

Operating variables		Yield %	Ash Content			R*
VFC(in)	IP(lb/in^2)		Feed	Clean Coal	Refuse	
2	5	48,17	17,29	10,10	23,97	7,2
2	8	66,44	18,04	10,96	32,06	4,7
2¾	5	36,62	18,55	9,86	23,64	7,3
2¾	8	54,55	17,85	10,56	26,39	6,2

* R signifies "Yield reduction factor"; it is calculated from the following formula

$$R = \frac{100 - Y}{A_F - A_C}$$

where Y = clean coal yield
A_F = feed ash
A_C = clean coal ash

In other words, this factor expresses the percentage of discard per one percent of ash improvement.

DIAGRAM I

SCHEME OF THE CYCLONE AND TEST RIG.

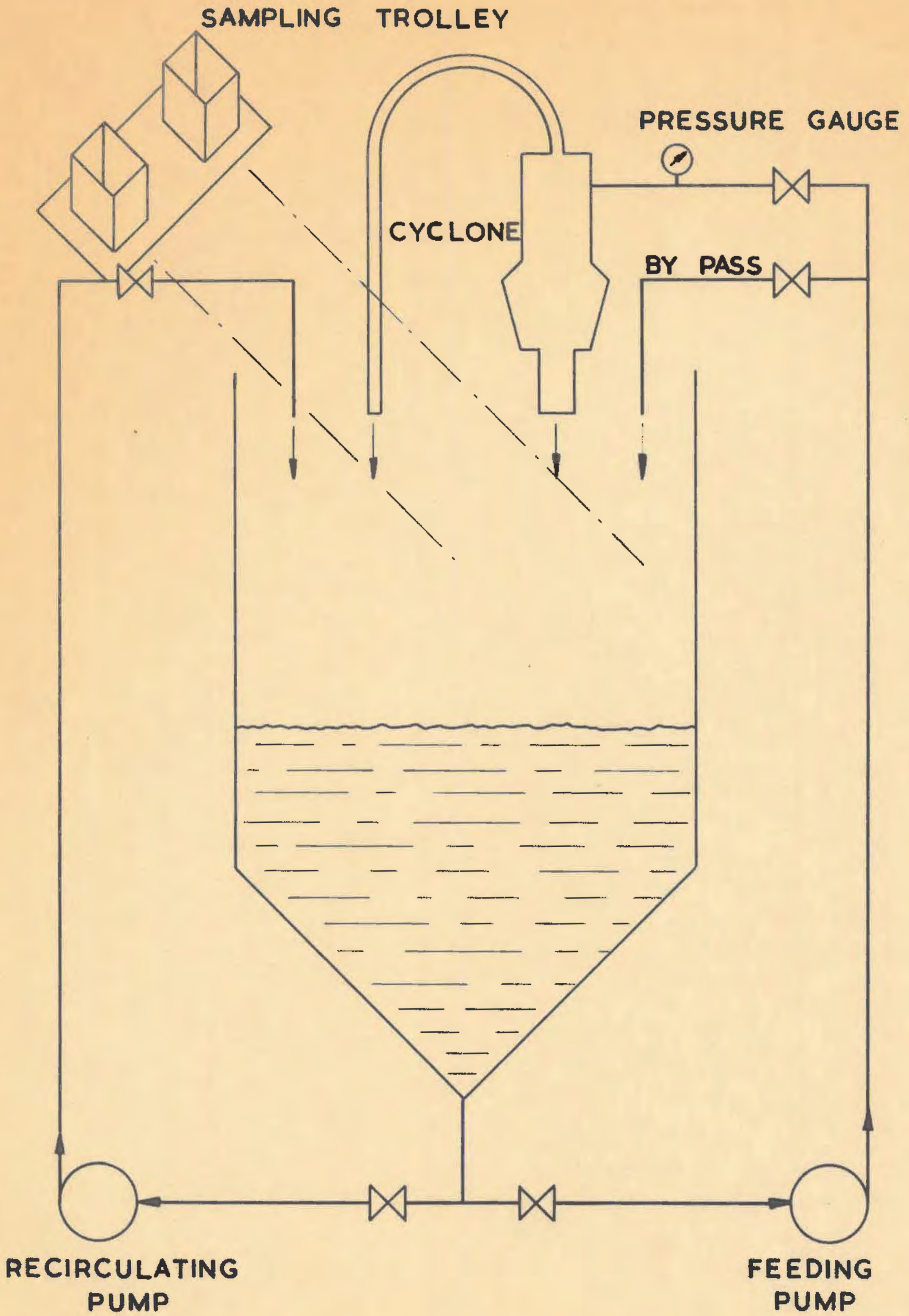


DIAGRAM 2

COMPOUND WATER CYCLONE

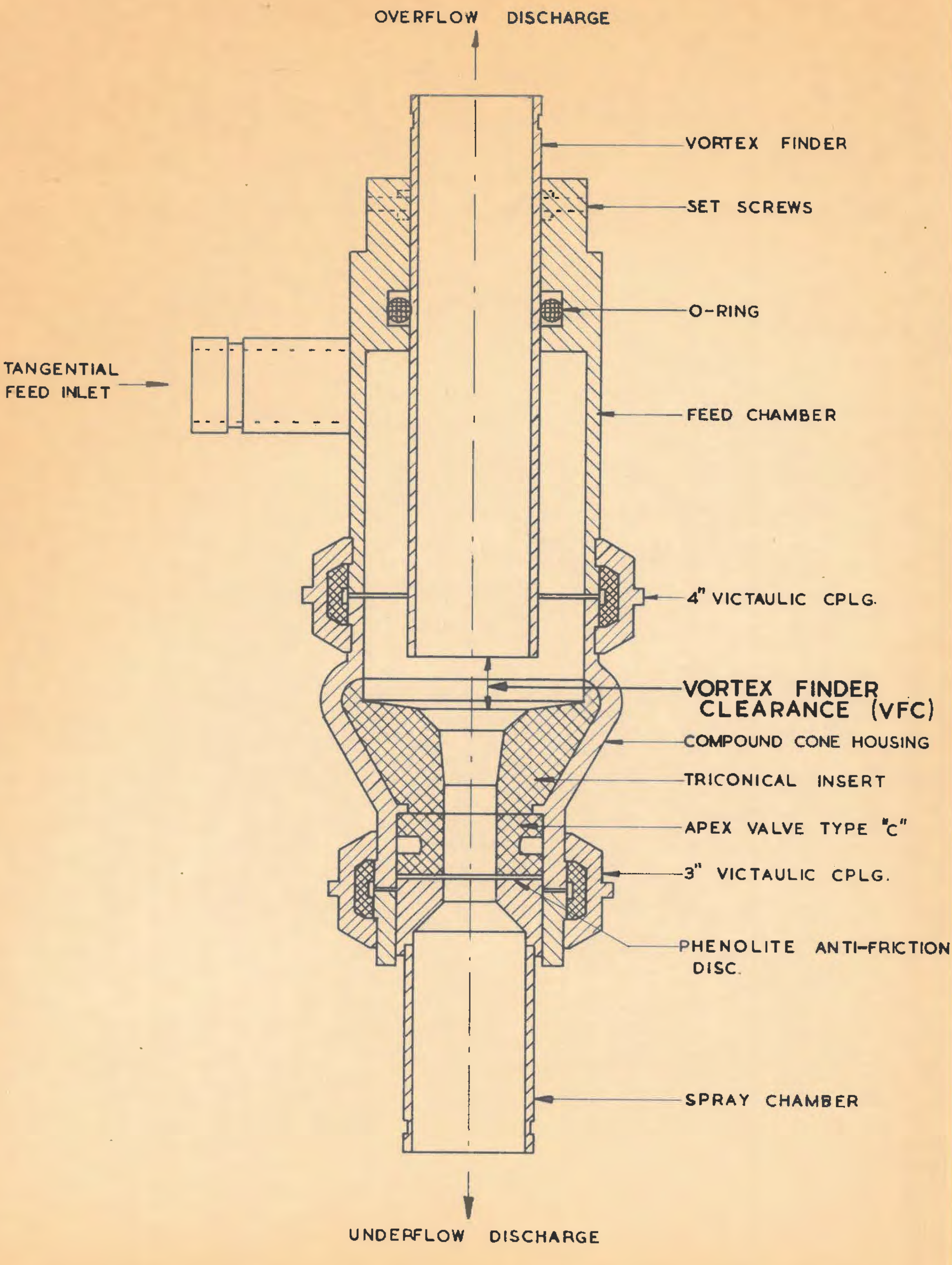
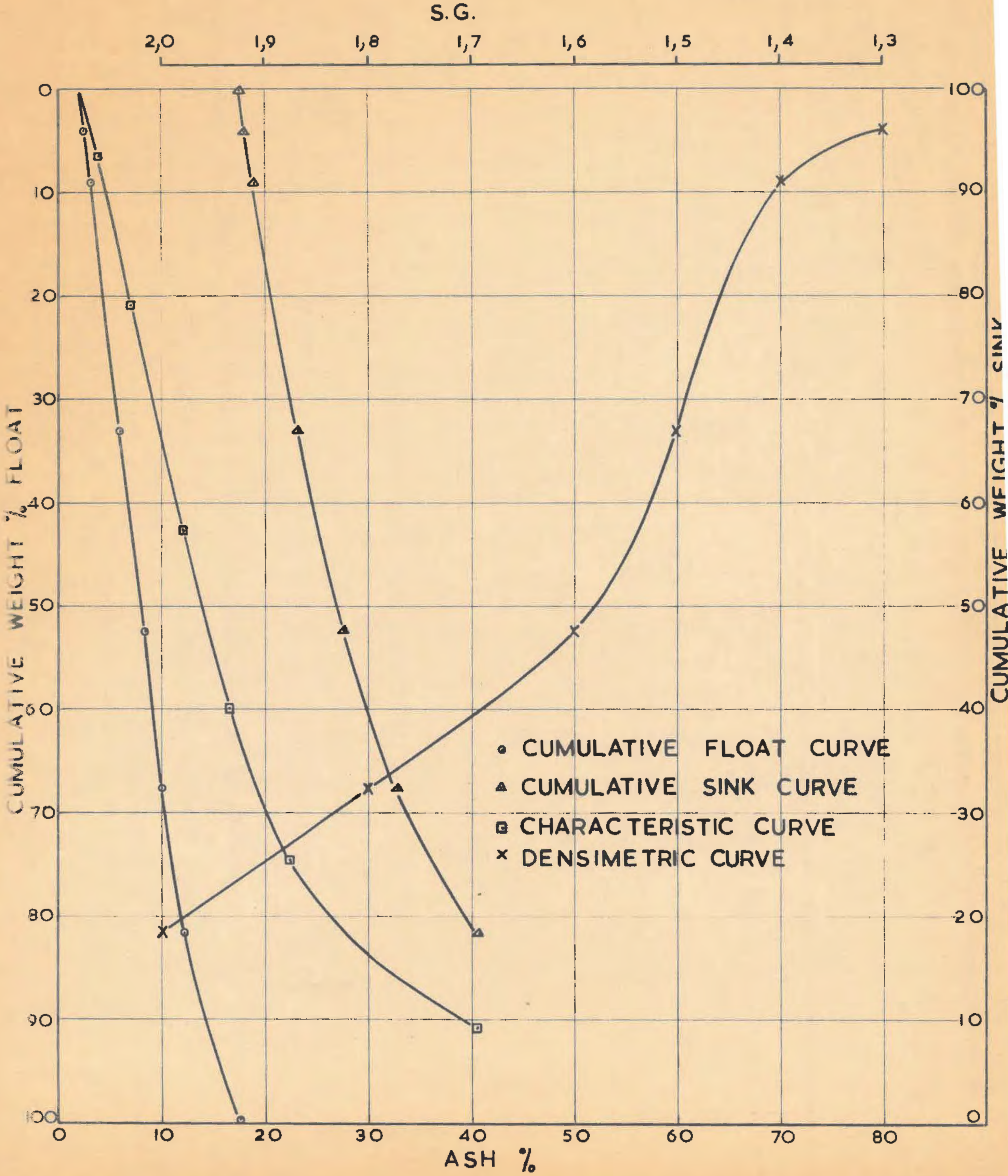


FIG. 1



S.G.
2,0
1,9
1,8
1,7
1,6
1,5
1,4
1,3
CUMULATIVE WEIGHT % FLOAT
CUMULATIVE WEIGHT % SINK
0
10
20
30
40
50
60
70
80
90
100
CUMULATIVE FLOAT CURVE
CUMULATIVE SINK CURVE
CHARACTERISTIC CURVE
DENSIMETRIC CURVE
ASH %

FIG. 2

DEPENDENCE OF THE YIELD UPON THE CYCLONE SETTINGS

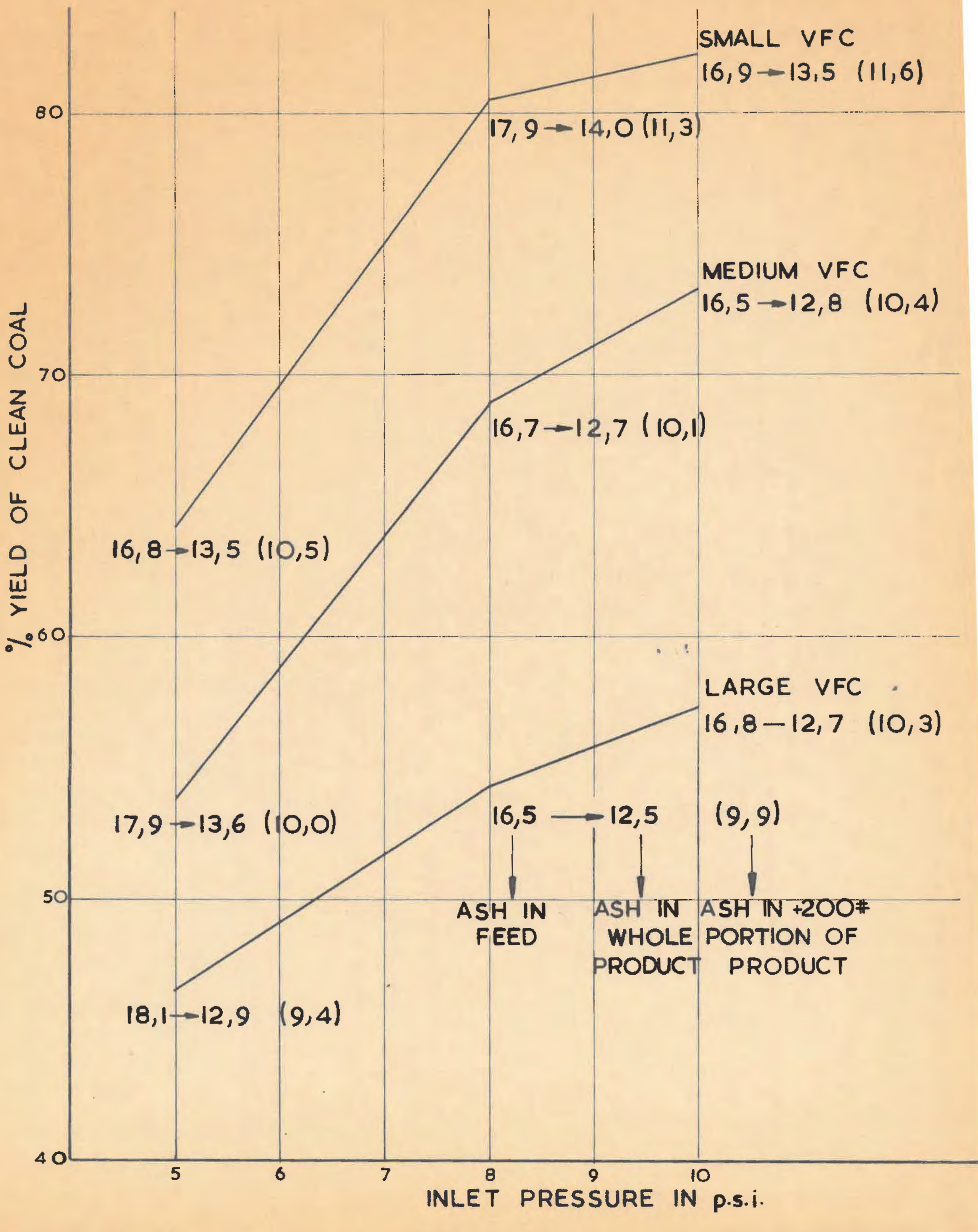


FIG. 3

DEPENDENCE OF FLOW RATIO UPON THE CYCLONE SETTINGS

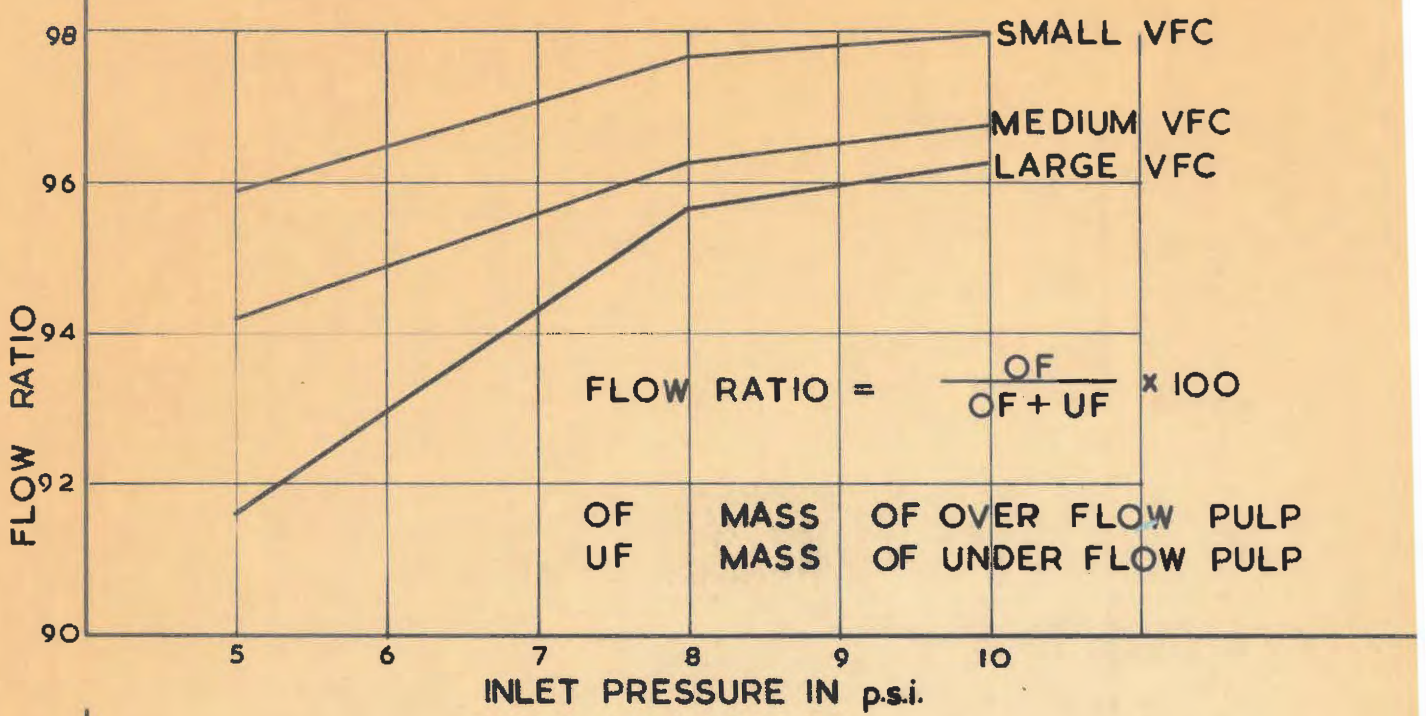


FIG. 4

DEPENDENCE OF THROUGHPUT CAPACITY UPON CYCLONE SETTINGS

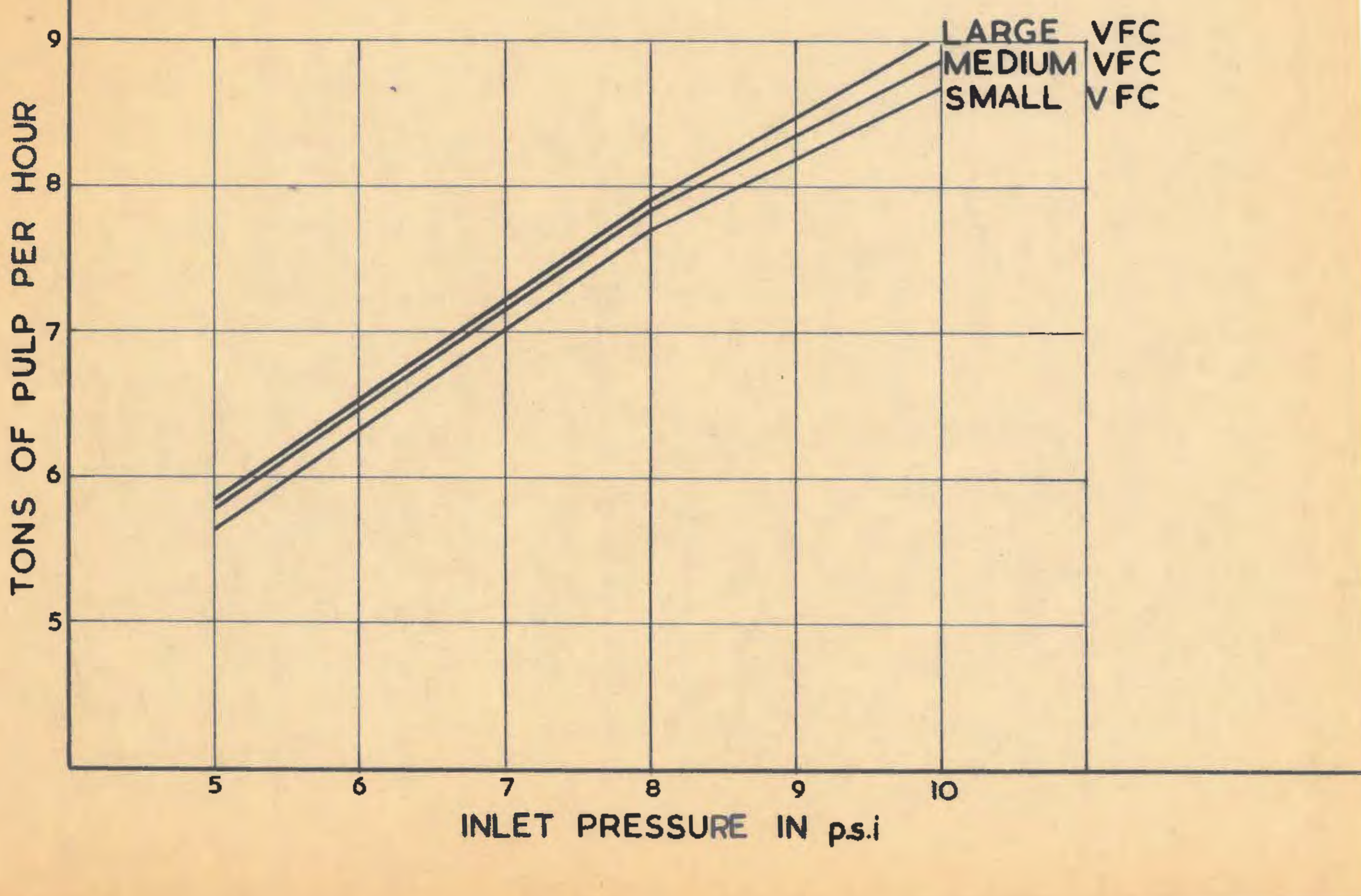


TABLE 3

RESULTS OF THE FACTORIAL TEST

Test No.	Operating Variables		% Yield of clean coal		% Ash			% of minus 200 mesh fraction in product	% Ash in Product		% Solids		Flow Rate t/h of pulp		Flow Rate % Overflow	
	VFC* in	IP** lb/in^2	In Test	Average	Feed	Product	Discard		+200 mesh fraction	-200 mesh fraction	In product	In discard	In test	Average	In test	Average
1	1¼	5	63,40	64,2	16,9	13,5	22,7	44,9	10,3	17,6	3,6	36,9	5,59	5,7	95,78	95,9
2	1¼	5	65,07		16,7	13,5	22,6	43,8	10,7	17,6	3,6	36,3	5,72		96,03	
3	1¼	8	78,27	80,5	18,1	13,7	33,8	36,0	11,1	18,3	4,1	39,4	7,59	7,7	97,44	97,7
4	1¼	8	82,78		17,7	14,2	34,2	36,4	11,5	17,9	4,3	38,8	7,85		97,94	
5	1¼	10	82,48	82,2	17,1	13,6	33,5	34,1	11,8	17,6	4,3	40,8	8,72	8,7	97,97	98,0
6	1¼	10	81,96		16,7	13,3	31,8	37,0	11,3	17,5	4,3	41,9	8,64		98,01	
7	2	5	54,34	53,8	18,0	13,3	23,5	51,1	9,8	17,6	3,0	39,3	5,83	5,8	94,31	94,2
8	2	5	53,18		17,9	13,8	22,5	49,4	10,2	17,5	2,9	38,9	5,72		94,08	
9	2	8	68,39	68,9	16,9	12,6	26,1	38,5	9,9	17,2	3,6	41,0	7,77	7,9	96,19	96,3
10	2	8	69,42		16,6	12,9	25,1	39,4	10,3	17,2	3,6	41,6	7,94		96,49	
11	2	10	73,54	73,3	16,7	12,9	27,2	36,2	10,4	17,1	3,8	41,4	8,95	8,9	96,78	96,8
12	2	10	73,12		16,3	12,8	25,8	37,5	10,4	17,0	3,8	41,6	8,83		96,89	
13	2¾	5	45,61	46,5	18,2	12,8	22,8	51,7	9,4	16,7	2,6	30,6	5,86	5,9	91,44	91,6
14	2¾	5	47,29		17,9	13,0	22,4	52,0	9,4	16,8	2,7	30,9	5,91		91,80	
15	2¾	8	64,01	64,3	16,6	12,5	23,8	38,7	10,2	16,5	3,5	42,2	7,98	8,0	95,90	95,7
16	2¾	8	64,49		16,4	12,6	23,3	42,0	9,6	17,0	3,4	40,8	7,94		95,57	
17	2¾	10	65,52	67,4	17,6	12,8	26,9	40,4	10,1	17,5	3,5	44,1	9,09	9,1	96,17	96,3
18	2¾	10	69,32		15,9	12,5	23,4	37,7	10,5	17,0	3,6	42,6	9,03		96,49	

* Vortex finder clearance.
** Inlet pressure.

/TABLE 4 ...