FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

TECHNICAL MEMORANDUM NO. 30 OF 1967.

OPERATION OF TWO TYPES OF FURY HOT WATER BOILER ON VARIOUS FUELS, HAND FIRED.

(SECOND PROGRESS REPORT)

by:

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(Second Progress Report)

1. SCOPE OF REPORT:

This report deals with:

(a) Three further tests on the Fury No. 3 vertical boiler.
(b) Three tests on a Fury HW20 sectional boiler.

2. TEST PROCEDURE:

In the tests performed on the Fury No. 3 boiler, two types of semi-anthracite (New Cambrian and Balgray) were fired in the same manner as set out in the First Progress Report (Technical Memorandum No. 15 of 1965). In addition one test was carried out with bituminous coal, fired according to a method which is frequently applied in practice, viz. the fire was kindled with 3 kg of wood and 15 kg coal; a further 15 kg of coal was charged 20 minutes after lighting up; after a second interval of 20 minutes the furnace was filled to capacity, which took 70 kg of coal. A further 20 kg was added 3 hours 20 minutes after lighting up.

The sectional boiler, used in the experiments was a Fury HW20 sectional boiler, of a nominal capacity of 440,000 B.Th.U/hour, grate area 5 ft^2, heating surface approximately 71 ft^2.

The boiler, as received, did not have provision for secondary air admission. This was provided by drilling 3 holes ($2\frac{1}{2}$" diameter) in each of the firing doors. Sliding covers were installed to permit adjustment of the overfire air.

The tests were carried out in the same manner as in the case of the Fury No. 3 boiler, with the following modifications: The initial charge consisted of 6 kg firewood and 30 kg fuel, a second charge of 30 kg was fired 20 minutes after lighting up, thereafter the boiler was fired with 15 kg of

fuel ...../

fuel every 20 minutes, with minor departures (e.g. charge omitted, or a double charge added) according to the progress of the combustion.

The boiler was operated under natural draught, since the air ejector was of insufficient capacity to stabilise the draught of a boiler of this capacity. The draught (5-7 mm water column) was however adequate to permit operation near or at the rated capacity.

As the stack temperatures were frequently in excess of 800°C, the smoke density meter was removed since this instrument was likely to be destroyed. Since visible flames frequently extended beyond the smoke meter ports, the smoke meter indication would in any case have been of doubtful value. Where necessary, the smoke plume was therefore visually observed with a "Smokescope" telescope.

In the calculation, the water equivalent of the boiler was assessed at 550 kcal/°C, based on a measured water content of 96.5 gallons and an estimated boiler weight of 2000 lb.

3. TEST RESULTS, FURY NO. 3 BOILER:

Data on the semi-anthracites fired are given in Table No. 1; the results of the three tests (experiments 9, 10 and 11) are presented in Table No. 2.

Experiments 9 and 10 indicate that the performance on semi-anthracite is substantially the same as on an artificial mixture of anthracite and bituminous coal, having a comparable volatile matter content, e.g. at 3.5 mm draught approximately 90% of the rated output was obtained and the fuel burns smokelessly. Unfortunately, both fuels clinker excessively and after 3 hours' operation the grate was completely obstructed by a mass of fused clinker. While an experienced fireman could cope with this difficulty, it appears that these fuels would be unsatisfactory when fired by unskilled attendants. In addition, these fuels are more friable than anthracite or bituminous coal and the high sulphur content may be objectionable.

When firing bituminous coal in the manner indicated, excessive smoke is emitted for a period of 2½ hours (c.f. Figure 1). The CO content of the flue gas is also very high and frequently exceeded the range of the recorder (5%). The stack losses were consequently severe, but since the fire bed

was ...../

was hardly disturbed, during the test, little carbon was lost in the ashes. As this would not happen during operation in practice, the efficiency can thus be expected to be considerably less than the figure of 39.3%, observed here.

4. TEST RESULTS, FURY HW20 BOILER:

In view of the experience obtained with the smaller Fury No. 3 boiler, it was considered sufficient to test this boiler under hand-fired conditions with 3 fuels only, viz. bituminous coal, anthracite and a mixture of 1 part bituminous coal with 3 parts anthracite.

The test results were very similar to those of the earlier experiments, on anthracite, the output is lower than on bituminous coal and the mixture occupies an intermediate position. The test data are represented in Table No. 3. The efficiency of the boiler is of the order of 40%; the stack loss being very high in all tests. This indicates that the heating surface is insufficient. Probably because of the relatively larger volume and the more suitable shape of the combustion chamber, the smoke generation was less than that of the Fury vertical boiler.

When admitting secondary air (by opening two of the 2½" diameter ports), smoke evolution, even with bituminous coal, did not exceed the Ringelman No. 2 shade, once the boiler was hot. This, of course, can only be achieved with careful firing. On the other fuels, the operation was smokeless, though when firing the mixed fuel secondary air had to be admitted in order to achieve completely smokeless combustion (one of the secondary air holes was opened completely, a second port opened halfway).

5. CONCLUSIONS AND FURTHER ACTION:

It is considered that (with the possible exception of a test with char) sufficient information on the hand fired operation of the two Fury boilers, in the unmodified state, has now been obtained.

This information indicates that, with careful firing, the boilers could operate according to the requirements set for smoke-control areas.

In practice, smokeless operation would however not normally be achieved with bituminous coal.

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It will thus be necessary to modify the boiler or the firing method to achieve this. For the smaller boiler a pre-combustion chamber could be considered, while an automatic stoker could be installed in the larger boiler - possibly in the Fury No. 3 as well. Some preliminary experiments have indicated that the HW20 model thus equipped operates smokelessly as long as the process is not interfered with; this is however necessary from time to time in order to remove ashes and clinker.

G.A.W. VAN DOORNUM
CHIEF RESEARCH OFFICER.

PRETORIA.
4th August, 1967.
/HW

TABLE NO. 1.

DATA ON FUELS FIRED.

1. NEW CAMBRIAN.

As fired:	Calorific Value	13.02 lb/lb,	7020 kcal/kg
	Ash	15.3%	C : 75.38%
	Moisture	1.2%	H : 3.36%
	Volatile Matter	13.7%	Total S. : 3.01%
	Ash fusion temp.	1280°C	9 H + M : 0.314 kg water/kg fuel.

D.A.F.	C :	90.28%
	H :	4.02%
V.M. :		16.4%

2. BALGRAY.

As fired:	Calorific Value	13.54 lb/lb,	7300 kcal/kg
	Ash	12.6%	C : 76.98%
	Moisture	1.5%	H : 3.50%
	Volatile Matter	13.3%	Total S. : 2.5%
	Ash fusion temp.	1320°C	9 H + M : 0.330 kg/kg

D.A.F.	C :	89.62%
	H :	4.07%
V.M. :		15.5%

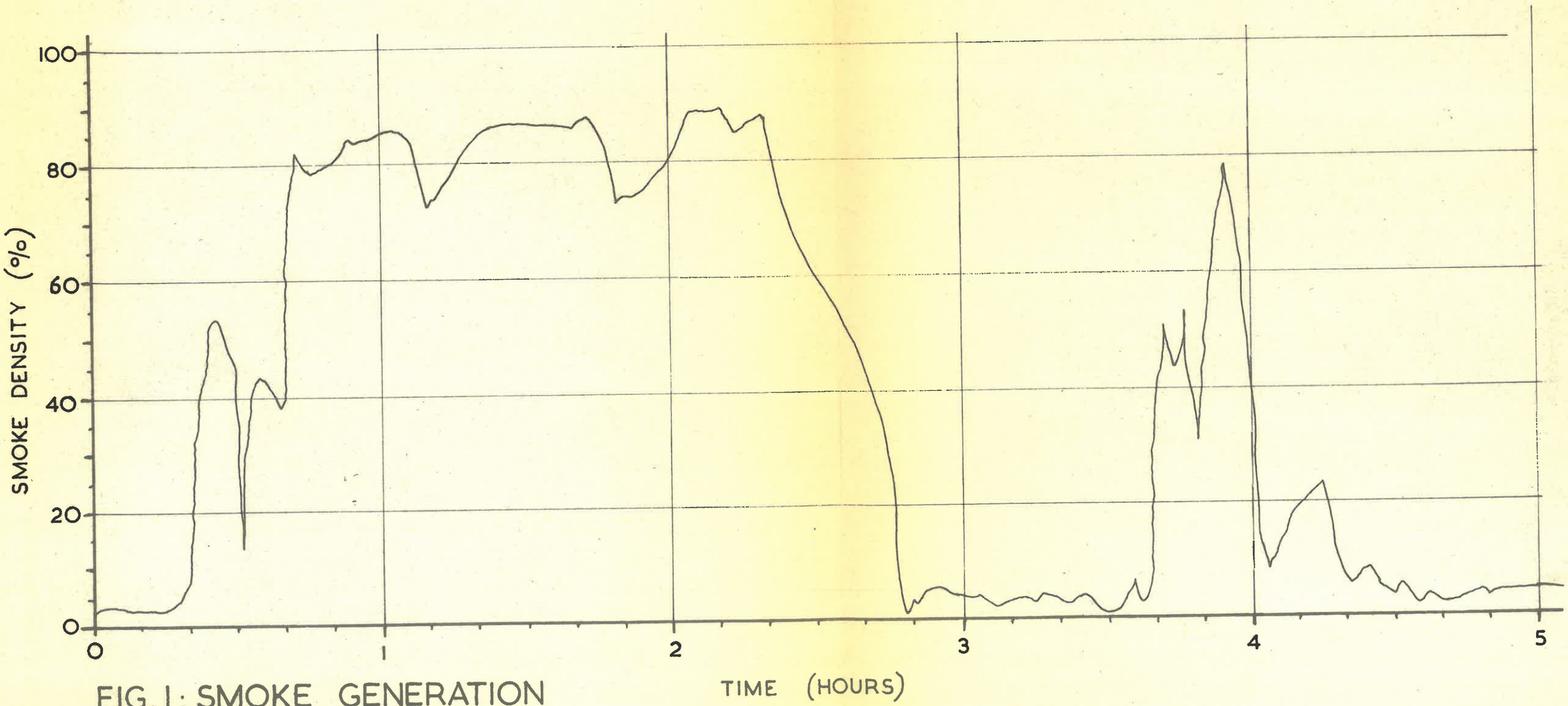

FIG. 1 : SMOKE GENERATION

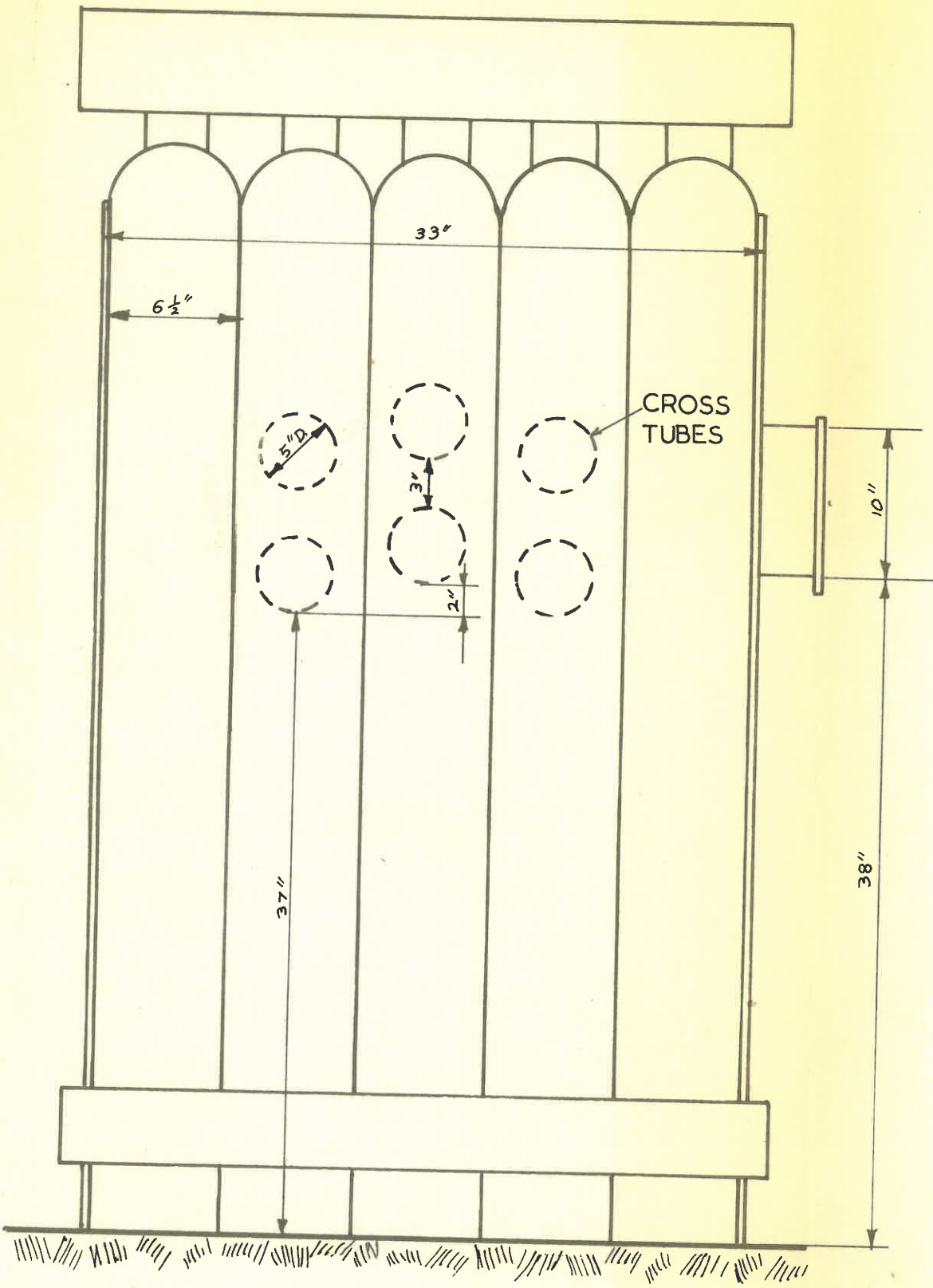

FIG. 2: FURY HW20 SECTIONAL BOILER

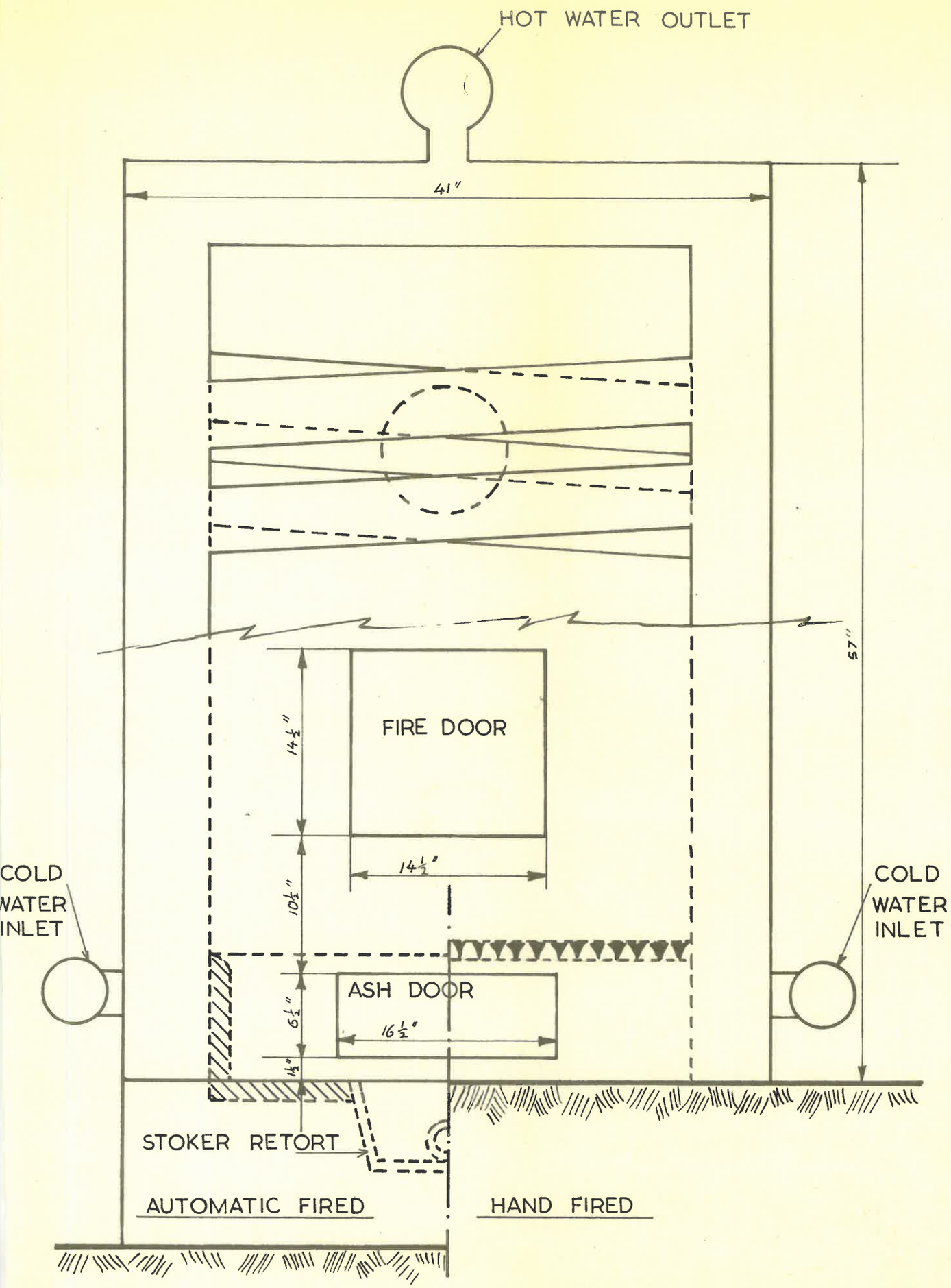
HOT WATER OUTLET
41"
57"
FIRE DOOR
14½"
14½"
10½"
ASH DOOR
16½"
6½"
4½"
COLD WATER INLET
COLD WATER INLET
STOKER RETORT
AUTOMATIC FIRED
HAND FIRED

TABLE NO.

PERFORMANCE OF FURY
BOILER ON VARIOUS FUE

	EXPERIMENT NO.		9	10
	FUEL.		S.A.1	S.A.2
1	Calorific Value, as fired,	kcal/kg	7020	7300
2	Volatile Matter, as fired,	%	13.7	13.3
3	Volatile Matter (D.A.F.)	%	16.4	15.5
4	Moisture	%	1.2	1.5
5	Ash	%	15.3	12.6
	FIRING CONDITIONS.			
6	Draught	mm H_2O	3.5	3.5
7	Secondary Air		No	No
8	Firing Rate	kg/h	18.6	17.15
	PERFORMANCE.			
9	Output	kcal/h	44,800	45,5
10		B.Th.U./hour	178,000	181,0
11	Efficiency	%	41.6	44.4
12	Smoke		nil	nil
	OBSERVATIONS.			
13	Duration of Test	hours	7	7
14	Fuel Fired	kg	130	120
15	C.M.L.	kg	32.19	32.51
16	C.M.L. Combustible	%	72.7	65.1
17	C.M.L. Ash	%	26.6	34.6
18	Ash	kg	16.64	8.04
19	Ash Combustible	%	72.0	69.6
20	Ash	%	27.4	29.2
21	Water Temperature, Out	°C	70.1	70.2
22	Water Temperature, In	°C	17.8	17.1
23	Temperature Rise	°C	52.3	53.1
24	Total Quantity	gl	1307	1290
25	Flue Gas, CO_2	%	9.32	10.8
26	Flue Gas, CO	%	0.1	0.1
27	Flue Gas, O_2	%	7.6	7.2
28	Flue Gas, Temp.	°C	718.8	724
29	Ambient Temperature	°C	16.5	21.1
30	Temperature Diff.	°C	703.3	702.9
	CALCULATED DATA.			
31	Carbon Input	kg	99.5	95.4
32	Carbon in C.M.L.	kg	23.4	21.4
33	Carbon in Ash (C_3)	kg	11.8	8.6
34	Carbon Burnt (C_b)	kg	64.3	65.4
35	9 H + M	kg	45.3	41.4
36	Heat Input in Fuel	kcal	924,600	888,0
37	Heat Credits	kcal	187,200	171,2
38	Nett Input	kcal	737,400	717,8
39	Useful Output	kcal	306,800	318,4
40	Efficiency	%	41.6	44.4
41	Stack Loss, Sensible	%	40.5	39.4
42	Stack Loss, Latent	%	3.3	3.1
43	Unburnt CO	%	0.5	0.5
44	Unburnt Carbon	%	12.8	9.6
45	Radiation, etc.	%	1.3	3.0
	Experiment No.		9	10
	Log Book Reference		354	355

A : Anthracite
B : Bituminous Coal

S.A.1 : New Cambrian
S.A.2 : Balgray

2.

TABLE NO. 3.

NO. 3 VERTICAL LS, HAND FIRED.	PERFORMANCE OF A FURY HW20 SECTIONAL BOILER ON VARIOUS FUELS, HAND FIRED.		
11	12	13	14
B	A	1B3A	B
6860	7800	7565	6860
26.9	10.5	14.6	26.9
32.0	11.66	16.5	32.0
2.3	1.7	1.85	2.3
13.7	8.3	9.65	13.7
3.5	5.1-5.7	5.2-6.0	5.3-7.5
No	No	Yes	Yes
20	31.3	30	36.4
00 51,500	85,200	89,000	98,500
00 204,000	338,000	353,000	392,000
39.3	42	39.2	41.4
heavy	nil	nil	some
6	7	7	7
120	240	210	255
17.15	73.73	20.85	33.75
36.2	80.5	51.8	40.4
63.4	18.8	48.0	59.1
6.78	18.28	25.52	19.21
35.8	75.3	68.0	40.6
63.9	23.7	31.5	59.4
71.6	64.4	69.5	71.6
17.6	22.7	22.8	19.4
54.0	41.7	46.7	52.2
1230	3100	2985	2850
11.1	12.42	11.41	13.4
0.82	0.18	0.24	0.45
4.3	6.24	8.0	5.3
786.5	716	750	803
20.1	18	16.6	22.5
766.4	698	733.4	780.5
86.2	199.5	169.0	183
6.2	59.4	10.8	13.65
2.4	13.8	17.4	7.8
77.6	126.3	140.8	161.55
46.2	79.9	73.06	98.0
00 836,000	1,896,000	1,674,000	1,774,000
00 49,600	475,200	86,400	109,200
00 786,400	1,420,800	1,588,600	1,664,800
70 309,100	596,700	622,800	690,000
39.3	42.0	39.2	41.4
49.2	33.8	37.4	35.2
3.2	3.0	2.5	3.2
3.9	0.7	1.1	1.8
2.5	7.8	8.8	3.8
1.9	12.7	10.7	14.6
11	12	13	14
356	360	361	359