FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

TECHNICAL MEMORANDUM NO. 14 OF 1967.

PERFORMANCE OF A ZETA HOT WATER GENERATOR ON BITUMINOUS COAL.

by

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and

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1. PLANT TESTED.

At the request of the Solid Fuels Advisory Bureau a Zeta Model No. 30 boiler, installed on the premises of the United Building Society, U.B.S., Building, Johannesburg was tested under actual operating conditions.

The construction of the boiler is illustrated schematically in Figure 1. The Model No. 30, which was tested, had a double magazine, which, however, does not affect the principle on which the operation is based, e.g. that the combustion air travels downwards through the magazine, so that the tarry fumes are cracked and burnt during their passage through the hot ash layer on the grate. The rated capacity of the No. 30 model is stated to be 200,000 B.Th.U. per hour.

The fuel used was a bituminous coal from the Witbank area, having the following characteristics:

Calorific Value	12.81	lb/lb	6900 kcal/kg
Volatile Matter	26.2	%	
Ash	12.3	%	
Moisture	2.4	%	

2. TEST PROCEDURE.

Since it was not possible to determine the useful output directly (e.g. the heat transferred to the water, which would require the measurement of the quantity actually circulated), the efficiency was determined by means of the indirect method. In this case, the most important losses are determined, expressed as a percentage of the heat input.

Deducting...../

Deducting these percentages from 100% supplies the efficiency plus those losses which cannot be determined directly without great elaboration of the testing technique. In the present case, these are the radiation and convection heat losses from the boiler shell and heat lost in the form of combustible components, present in the fly ash and soot. For boilers of this type, these two losses are likely to amount to approximately 6% (together).

The test procedure was as follows: Immediately before the beginning of the test, the fire was cleaned and the bunker filled to a well defined level. The boiler was operated for a period of 6 hours, during which period the CO_2, CO and O_2 content of the flue gas, its temperature and that of the ambient air were recorded; the fuel was sampled and the quantity of fuel charged into the boiler weighed. At the end of the test, the bunker was filled to the same level (the quantity of fuel used being weighed), the ash box emptied, the contents weighed and subsequently analysed.

Two tests were performed. In the first, the burning rate was maintained at a fairly high level by periodically cleaning the fire. (This was the only method available since no dampers were provided.)

In the second test, the fire was only cleaned when (as indicated by the water unit temperature) a greater output was required. This was according to the firing method normally adopted by the attendant.

The draught at the flue gas outlet was recorded, but since the boiler was connected to a common flue, leading to other equipment, this parameter could not be controlled.

During the first test, it was apparent from the CO_2 content of the flue gas that a considerable air infiltration into the boiler took place. Various seams and joints in the boiler structure were therefore sealed off (viz. the grit collector cover, the top inspection cover, the secondary air holes, and the primary air intake, all this still left sufficient air for proper combustion).

Since these air leaks could be almost completely eliminated by adopting a better construction, the seals were left intact during the tests, since the purpose of the test was mainly an assesment of the potential value of this type of hot water generator and not an acceptance trial of a particular specimen.

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3. TEST RESULTS.

The test results are presented hereunder:

Test No.	1	2
Fuel Fired	67	51 kg.
Output (estimated)	180,000	140,000 B.Th.U./hr.
Efficiency & Radiation and other undetermined losses.	63.9	66.6 %
Stack Loss, sensible heat	22.7	24.8 %
Stack Loss, latent heat	3.1	3.8 %
Unburnt Gases	0.9	1.1 %
Unburnt Carbon in Ash box	9.4	4.3 %
Draught, average	4	5 mm H_2O
Stack Temperature	443	432 ^oC
Carbon Dioxide in Flue Gas	10.4	9.7 %

4. DISCUSSION.

After sealing the various places where air infiltrated, the CO_2 content of the flue gas increased from 8.5 to 11%. Since this corresponds to a reduction of the flue gas volume from 22 to 16 Nm^3/kg carbon burnt, this causes a considerable reduction of the stack losses - the stack temperature increased only slightly (from 410^{o}C to 430^{o}C). It is thus worth while to construct the boiler shell on better lines.

Otherwise, the boiler operated at a reasonable efficiency (of the order of 60%) and virtually smokelessly, a smoke density of the Ringelman No. 1 shade was seldom, if ever, exceeded.

The efficiency attained in these tests is comparable, though not as good, as observed during trials of a similar boiler at the Institute (Reported in Technical Memorandum No. 1 of 1964).

In these tests, the CO_2 content of the flue gas was higher and the stack temperature lower. The heating surface of the boiler tested therefore appears to be rather too small in relation to the rated output.

The method of controlling the burning rate should be improved. A comparison of the results of the two tests indicates that the carbon losses in the first test were appreciably higher, due to more frequent poking. Some alterations to the

grate...../

grate design might therefore also be beneficial. For proper control, a damper should however be installed; this again emphasises the need for reducing the air leakage of the system.

The output, attained during test No. 1 is approximately 90% of the rated figure of 200,00 B.Th.U./hour. It thus seems likely that the rated output can be attained when a rather higher draft is available. The stack loss under this condition would probably increase still more.

PRETORIA.
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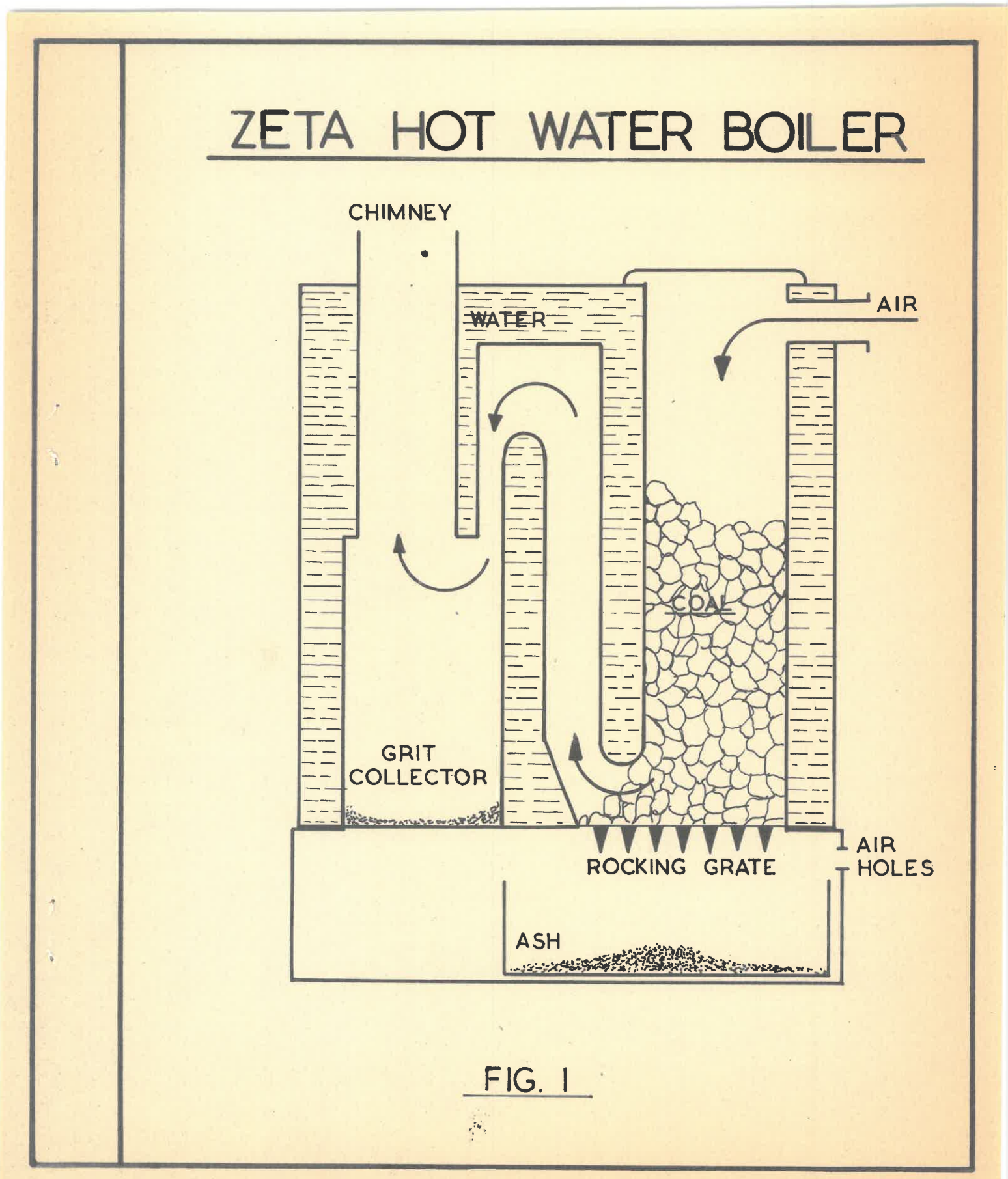
ZETA HOT WATER BOILER
CHIMNEY
WATER
AIR
COAL
GRIT
COLLECTOR
ROCKING GRATE
AIR
HOLES
ASH

FIG. 1