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FUEL RESEARCH INSTITUTE

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SUBJECT :
ONDERWERP: TESTS TO DETERMINE THE SUITABILITY OF SELECTED FUELS IN S.A.R. DINING SALOON STOVES.

DIVISION :
AFDELING: CHEMISTRY AND ENGINEERING.

NAME OF OFFICER:
NAAM VAN AMPTENAAR: G.W.A. VAN DOORNUM & C.C. LA GRANGE.

FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

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TESTS TO DETERMINE THE SUITABILITY OF SELECTED FUELS IN S.A.R. DINING SALOON STOVES.

by
G.W.A. v. Doornum & C.C. la Grange

During 1948 the South African Railways and Harbours Administration approached the Institute with the request for collaboration in an investigation aimed at rendering fires in dining saloon stoves smokeless while trains were in large stations - more especially the new Johannesburg station where every effort was to be made to eliminate the smoke nuisance.

In a subsequent discussion with officials of the Administration, it was decided to investigate the possibilities of alternative fuels before attempting to achieve the desired end by modifications to existing stoves or considering their replacement.

The fuel normally used in these stoves is a long flame bituminous coal from the Breyten-Ermelo coalfield, and the design of these stoves is such that smokeless operation on this coal for any length of time is not possible if the desired temperatures on the stove plates and in the ovens are to be maintained.

Trains leaving Johannesburg are made up at Braamfontein and are brought into Johannesburg station half an hour before the train is scheduled to depart. According to regulations fires have to be started in the saloon stoves 1½ hours before the scheduled departure of the train. There is apparently no serious objection to a smoky fire while the train is standing at Braamfontein, but operation should be smokeless when the train arrives in Johannesburg station and until it leaves that station.

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The chefs insist on fairly high operating temperatures (a figure of 600°F. in the oven has been mentioned) These are attained with the fuel normally used and any alternative fuel should therefore be satisfactory in this respect also.

The requirements which an alternative fuel would have to satisfy may therefore be summed up as follows :-

1. It should be suitable for use in the existing stoves.
2. It should burn smokelessly.
3. It should be sufficiently reactive to develop (and maintain) an active fire readily so that the desired temperature levels of plates and ovens could be attained within a stipulated period (according to a previous paragraph in not more than 1½ hours) and maintained at these levels.

This suggests a suitably graded solid fuel of low volatile matter content. Semi-cokes and anthracites fall in this class but many of these have a comparatively low reactivity and there was some doubt at the outset whether they would be capable of satisfying the requirement No.3. The most promising alternative fuel appeared to be charcoal which is generally recognised as a highly reactive fuel. It has the disadvantages of being relatively expensive and not as readily obtainable as coal and e.g. gasworks coke.

Samples of the following fuels were finally made available for tests :-

Natal Anthracite.
Natal Ammonium Anthracite.
Gas works coke (ex Johannesburg gas works).
Enyati nuts (a medium volatile matter content coal).
Charcoal (ex Forest Products Institute, Pretoria).

Analytical data on these fuels appear in <u>Table 1</u>.

TABLE 1....../

TABLE 1.

ANALYTICAL DATA ON FUELS.

Fuel	Natal Anthracite	Natal Ammonium	Gasworks Coke	Enyati	Charcoal
Size.	1" -2"	1" - 2"	1"-3"(appox.)	1"-2"	1"-4"(approx.)
Moisture, %	1.6	1.7	2.9	1.4	4.1
Ash, %	14.4	12.6	19.1	17.8	2.5
Vol.Mat. %	9.3	10.5	2.3	17.4	11.0
Fix.Carbon %	74.7	75.2	75.7	63.4	82.4
Cal.Val.(lbs/lb.)	13.1	13.5	11.3	12.6	13.9

THE TEST STOVE:

The tests described in this report were carried out in the dining saloon "Wildebeeste" at Pretoria Station.

This is a small type of saloon seating twelve people. The dimensions of the stove are approximately :-

Width - 38 ins.
Depth - 24 ins.
Height - 24 ins.

It is uninsulated and its top has six plates of 8 inches diameter, there being only one oven.

The dimensions of the fire box are :-

Length - 19 ins.
Width. - $6\frac{1}{2}$ "
Depth - 9 "

and a boiler is fitted on one side of it. The grate is of the rocking type.

There is no provision for secondary air and the only control is a damper which allows gases to pass either directly (over the top) from the fire box to the chimney ("open" position) or over and around the oven and then to the chimney ("circulating" position).

In the present tests the damper was set in the "open" position for the first few minutes after starting the fire and was then kept in the "circulating" position until the test was completed.

The.../

The tests conducted between 24/3/49 and 28/3/49 are summarised in the tables 2 to 8* and presented graphically in Figure 1*

In this figure, the preliminary period (i.e. the period during which the stove is brought up to temperature has only been indicated for Test No. 7); t = 0 is the moment at which the test fuel has been fired.

These tests have confirmed that the anthracitic coals and the coke are generally not reactive enough to give satisfactory results in this stove. The Natal Ammonium anthracite has to be ruled out because of the objectionable sulphur dioxide fumes which permeated the saloon.

Charcoal definitely shows the greatest promise. It is a completely smokeless fuel and is sufficiently reactive to give the required oven temperature within an hour of starting the fire (Test No. 1.) It may be used after the fire has been started with a bituminous coal and maintains an active fire so that no loss in temperature is experienced. It should therefore be possible to start the fire with any desired fuel and to add the charcoal approximately 45 minutes before the train enters the station. Thus the amount of charcoal required could be reduced.

On the assumption that the saloon stays for a period of 30 minutes in the station and that it is to arrive in a "smokeless" condition, the charcoal is required to burn for 75 minutes (45 minutes to attain smokeless operation, under worst conditions, and 30 minutes in the station).

As a charge of one bucket (765 cubic inches) of charcoal lasted one hour from firing up to the time that oven temperatures commenced to drop, a supply of 1½ of these buckets or approximately 1200 cubic inches of charcoal should provide a safe margin. It would be a matter for the operator to decide whether this quantity should all be charged before the train enters the station or whether only part should be charged and the rest kept in reserve.

A disadvantage of the charcoal is that the ash content is very low and glowing charcoal consequently rests on the grate bars

which..../

* For these tables and figure see end of report.

which become red hot. This may decrease the life of grate bars appreciably, but if charcoal is only used while the train is detained at stations and coal is used en route the grate would only be subjected to such heating for comparatively short periods, so that the damage may not be excessive.

There are comparatively few regular producers of charcoal. The Department of Forestry should be able to provide the Administration with the names of these producers.

Should the Administration consider the production of charcoal on its own account, a pamphlet issed by the Fuel Research Institute on this matter could be consulted. The existing Standard Specification for Wood Charcoal for use in Portable Gas Producers, S.A. 19-1942, South African Standards Institution, may also prove useful for consulting when buying charcoal, although it would probably not be necessary to lay down very strict specifications for charcoal to be used in stoves.

PRETORIA.
11/4/49

(Signed) G.A.W. v. DOORNUM
and
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SENIOR RESEARCH OFFICERS.

TABLE 2.

TEST NO. 1.

PRELIMINARY TEST ON CHARCOAL.

DATE: 24/3/49 Saloon standing in the open. No pots etc. on stove or in oven.

Oven temperature determined by thermometer.

Time	Oven Temp.		Condition at Top of Stove	Smoke Evolution	Fuel	General Remarks.
hr. min.	°C.	°F.				
a.m. 11 - 15	Atmospheric temp.		Atmospheric temp.		Charcoal	Fire started on wood and charcoal x)
11 - 22			Match ignites when applied to plate over fire box.	very faint	"	
11 25				no smoke	"	
11 37	95	203		"	"	
11 40	105	221		"	"	
11 47	152-160	306-320		"	"	
11 55	190	374		"	"	
12 -	245-265	473-509		"	"	
p.m. 12 15	330-355	626-671		"	"	
12 18				dense smoke	Bituminous coal	When Breyten coal was placed on the glowing charcoal in the firebox dense smoke was immediately evolved.

x Ignition of charcoal with paper only was not successful.

TABLE 3.

TEST NO. 2.

NATAL ANTHRACITE:

DATE: 25/3/1949

Saloon in shed. A saucepan and a kettle filled with water were placed on top of stove. A saucepan with water was placed in the oven. Temperatures recorded by means of thermometer. Fire had to be started with Breyten coal as anthracite was difficult to light.

Time (a.m.) hr.	Time (a.m.) min.	Oven Temp. °C	Oven Temp. °F	Condition at Top of Stove	Smoke Evolution	Fuel	General Remarks.
9	40				Smoke dense	Breyten coal	Fire started with wood and Breyten coal.
10	10			Centre plate 350°C.(662°F.)	Heavy smoke	"	Breyten nuts charged again
10	45	195	383	(by thermo-couple)		"	
10	50					"	Fire raked.
11	0			Water boiling in pot and kettle		"	
11	10	280	536		Smokeless	"	Coal completely carbonised.
11	10				light bluish smoke remains for some time	Natal Anthracite	Anthracite charged on glowing coal.
11	23	220	428		Slight haze	"	
11	50	220	428		Smokeless	"	No sign of recovery of oven temperature.

TABLE 4.

TEST NO. 3.

CHARCOAL:

DATE: 25/3/49 Saloon in shed. Pots with water as in Test No. 2.

Time (p.m.)		Oven Temp.		Smoke evolution	Fuel	General Remarks.
hr.	min.	°C.	°F.			
1	30			Dense smoke	Coal	Fire started on Breyten coal and wood in practically cold stove.
2	15			Dense smoke	Coal	Fire levelled. Coal not completely carbonised.
2	15	230	446	Smoke immediately less dense, more bluish.	Charcoal	$\frac{3}{4}$ Bucket[1] of charcoal charged.
2	25	245	473	Slight bluish haze	"	
2	28			Faint haze		
2	34	260	500	No smoke		Fuel bed burning throughout (top to bottom).
2	40	275	527			
2	50	282	540			
3	00					Fire-box about half full
3	15	278	532			Fuel bed becoming thin.

Charcoal did not cause a drop in oven temperature. With partly burned coal immediate smoke reduction followed addition of charcoal. Ten minutes after addition of charcoal smoke hardly visible and fire was completely smokeless after 20 minutes.

[1] The bucket referred to had dimensions :- Top diam 10 ins., bottom diam 8", height 12", capacity about 765 cu.ins.

TABLE 5.

TEST NO. 4.

ENYATI NUTS:

Test followed immediately on test No. 3.

Time (p.m.)		Oven Temp.		Smoke evolution	Fuel	General Remarks.
hr.	min.	°C.	°F.			
3	25			Immediate evolution of smoke almost as dense as with Breyten coal.	Enyati	Layer of Enyati nuts charged on glowing charcoal from test No. 3
3	40	255	491	White smoke.		
3	55	271	520	White smoke.		
4	00	275	527	White smoke.		

The fuel is not smokeless and is less reactive (slower burning) than the Breyten coal.

TABLE 6.

TEST NO. 5.

GAS WORKS COKE:

DATE: 28/3/49   Saloon in shed.   Pots with water as in previous tests.

Time (a.m.)		Oven Temp.		Smoke Evolution	Fuel	General Remarks.
hr.	min.	°C.	°F.			
9	30			Dense smoke	Coal	Fire started with Breyten coal and wood.
10	05	180	356			
10	15	215	419			
10	30	245	473	Dense smoke		Fire-box still half full of Breyten coal not completely carbonised.
10	30				Coke	Half bucket of coke charged.
10	32			Smoke as before	"	Fuel box full.
10	42	220	428	Less smoke		Fire not burning as actively as with coal.
11	00	215	419			Fire appears to improve.
11	15	223	433	Light blueish smoke		
11	30	230	446	No smoke		

Fuel smokeless but due to low reactivity oven temperature not recovered after 1 hour.

TABLE 7.

TEST No. 6.

NATAL AMMONIUM ANTHRACITE:

DATE: 28/3/49 Test follows immediately on Test No. 5.

Time	Oven Temp.		Smoke Evolution	Fuel	General Remarks.
hr. min.	°C.	°F.			
a.m.11 45	235	455		Coke and Charcoal	Fire boosted with charcoal.
12 00	245	473		"	
12 00			Light bluish smoke. Objectionable SO_2 odour.	Anthracite	Natal Ammonium charged.
p.m.12 15	228	442			
12 30	241	466	Almost smokeless. Objectionable SO_2 odour persists.		
12 45	255	491	Smokeless. SO_2 persists.		

Burning properties of fuel fair, reasonably smokeless combustion. Nuisance from sulphur dioxide fumes considerable.

TABLE 8.

TEST NO. 7.

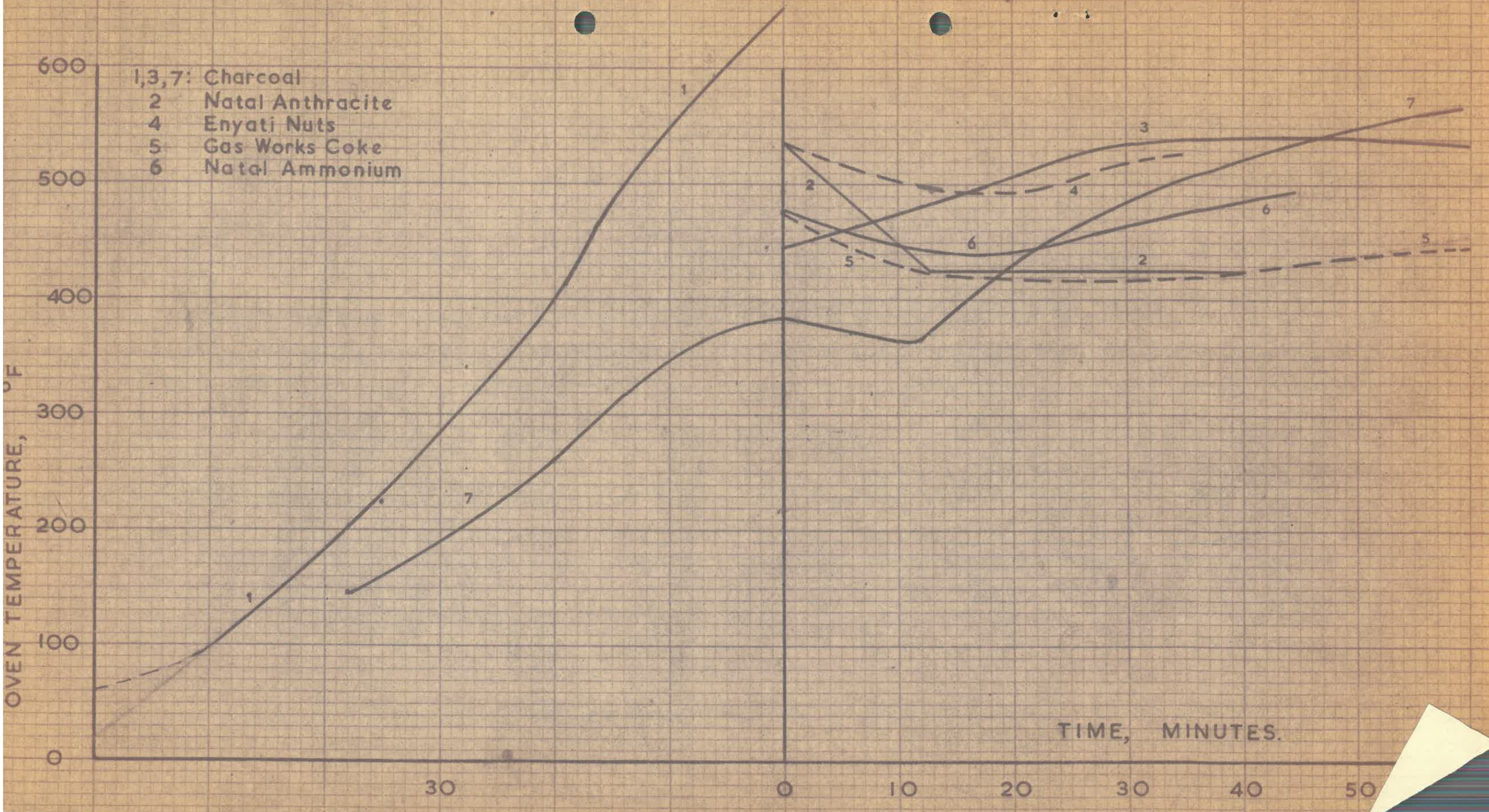
CHARCOAL - Drastic Test.

DATE: 28/3/49 Saloon in shed. Pots of water as before.

Time (p.m.)		Oven Temp.		Smoke Evolution	Fuel	General Remarks.
hr.	min.	°C.	°F.			
2	12	65	149	Dense smoke	Coal	Fire started with Breyten nuts ($\frac{1}{2}$ bucket) and wood.
2	30	128	262			
2	43	186	367	Dense smoke		Fire levelled and 2" layer of fresh coal added. (Fire-box half full).
2	50	198	388	Dense smoke	Coal	Fire stirred.
2	50				Charcoal	Fuel-box filled completely with charcoal (nearly 1 bucket).
3	02	184	363	Smoke as before		
3	10			Smoke diminishing		
3	15			Greatly reduced		
3	17	240	464			Fuel bed stirred.
3	20			Light bluish smoke		
3	28			Smoke almost disappeared.		
3	34	280	536	Smokeless		
3	49	298	568	Smokeless		
4	05			Smokeless		Fuel bed $2\frac{1}{2}$" down.
4	20	303	577			Fuel bed 3" down after shaking falling to about half depth of fire-box. Grate bars red hot.

Notwithstanding extremely adverse conditions (green coal on fire immediately before adding charcoal (extreme smoke production); overloading fire-box with fuel (charcoal) thereby reducing intensity of fire) smokeless operation obtained within 45 minutes with only temporary drop in oven temperature.

FIG. 1.


1,3,7: Charcoal
2 Natal Anthracite
4 Enyati Nuts
5 Gas Works Coke
6 Natal Ammonium
OVEN TEMPERATURE, °F
0
100
200
300
400
500
600
TIME, MINUTES.
30
0
10
20
30
40
50
1
2
3
4
5
6
7