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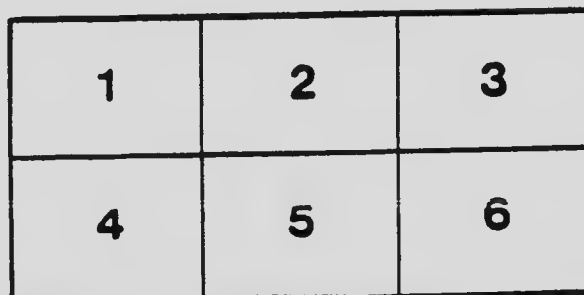
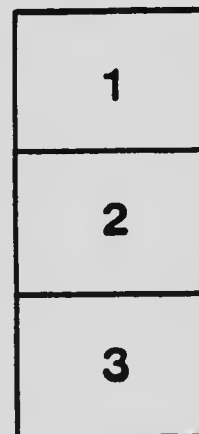
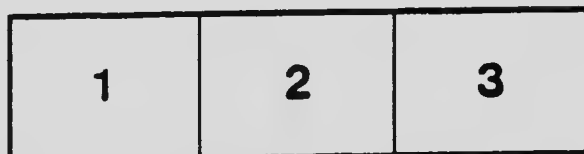
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BULLETIN No. 27

Results of Forty-one Steaming Tests conducted at the Fuel Testing Station, Ottawa

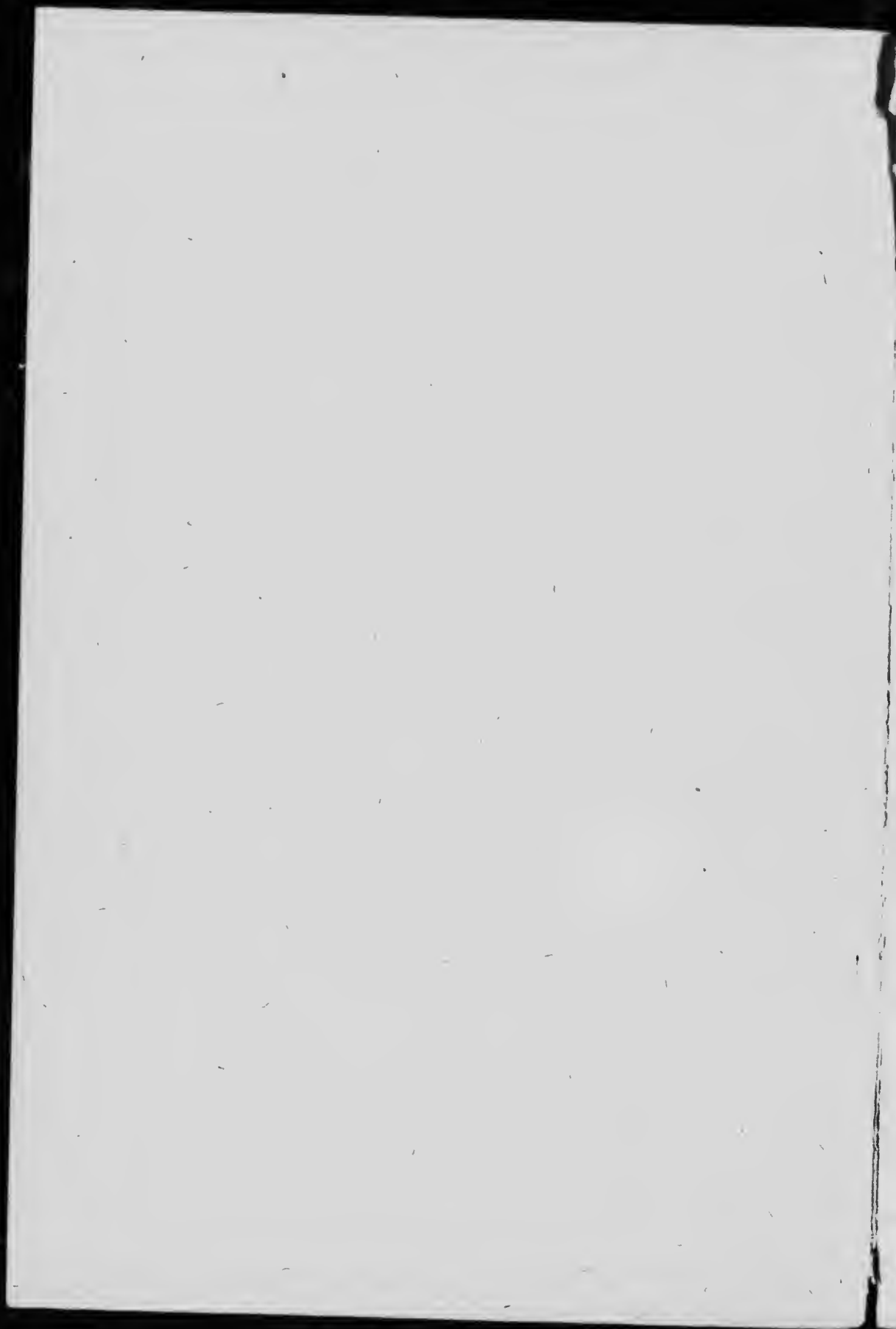
BY
John Blizard, B.Sc.,
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E. S. Malloch, B.Sc.



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EUGENE HAVELL, PH.D., DIRECTOR

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1920

No. 496



LETTER OF TRANSMITTAL.

DR. EUGENE HAANEL,
Director Mines Branch,
Department of Mines,
Ottawa.

SIR,—

I beg to submit herewith, the accompanying report, prepared by Mr. John Blizard and Mr. E. S. Malloch, entitled "The Results of Forty-one Steaming Tests": which includes the results, and comments thereon, of all the steam boiler trials conducted at the Fuel Testing Station since this class of work was first undertaken.

I have the honour to be, Sir,

Your obedient servant,

(Signed) B. F. HAANEL,
Chief of the Division of Fuels and Fuel Testing.

OTTAWA, November 5, 1918.

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" 55 " Pembina Coal Co., Ltd.	
" 52 " Cardiff Collieries, Ltd.	
" 53 " Twin City Coal Co., Ltd.	
" 58 " Drumheller Coal Co., Ltd.	
" 76 " " "	
" 61 " Newcastle Coal Co., Ltd.	
" 111 " Midland Collieries, Ltd.	
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" 51 " Rosedale Coal & Clay Products Co.	
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10	81	"	"	"
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REPORT ON BOILER TRIALS CONDUCTED AT THE FUEL TESTING STATION AT OTTAWA.

INTRODUCTORY.

Since the publication of Report No. 331¹ on a series of boiler trials to ascertain the value of five fuels from Alberta for steam generation, and Bulletin No. 17²—which records a similar investigation for peat fuel, other boiler trials have been conducted at the Fuel Testing Station at Ottawa; the results of which, combined with the results of the trials already published, are embodied in the present report.

Inasmuch as the precise object of the boiler trials, and the method of conducting them, have already been described in Report No. 331, this information is not included in the present report. It may be well to point out, however, that the results of these trials should only be used comparatively, one with another, or with those obtained under similar conditions with other fuels.

ACKNOWLEDGMENTS.

All the coals in the trials were obtained through the office of Mr. John Stirling, Chief Inspector of Mines for the Province of Alberta. His co-operation greatly facilitated the work of this investigation.

The chemical division, under the direction of Mr. Edgar Stansfield, analysed and determined the calorific value of the fuels used, and analysed the flue gases produced during the trials.

Mr. A. W. Mantle, Mechanical Superintendent of the Fuel Testing Station, maintained the boiler in proper working condition, and assisted in carrying out the trials.

FUELS USED FOR THE TESTS.

Of the 19 samples in all, 18 came from the Province of Alberta. These coal samples were received from the following mine operators:—

West Central Alberta, and the Edmonton District:—

1. Jasper Park Collieries, Ltd.,
Miette Mine, Pocahontas.
2. Mountain Park Coal Co., Ltd.,
Mountain Park Mine, Mountain Park.
3. Yellowhead Pass Coal Co., Ltd.,
Yellowhead Pass Mine, Coalspur.
4. Pembina Coal Operators, Ltd.,
Pembina Mine, Evansburgh.
5. Cardiff Collieries, Ltd.,
Cardiff Mine, Cardiff.
6. Twin City Coal Co., Ltd.,
Twin City Mine, Edmonton South.

¹ Results of the Investigation of six lignite samples obtained from the Province of Alberta, by B. F. Haanel, B.Sc., and John Blizard, B.Sc.

² The Value of Peat Fuel for the Generation of Steam, by John Blizard, B.Sc.

Drumheller Coal Area:—

7. The Drumheller Land Co., Ltd.,
Drumheller Mine, Drumheller.
8. Newcastle Coal Co., Ltd.,
Newcastle Mine, Drumheller.
9. Midland Collieries Ltd.,
Midland Mine, Drumheller.
10. Rosedale Coal and Clay Products Co., Ltd.,
Rosedale Mine, Rosedale.

Cascade Coal Area:—

11. Canadian Pacific Railway Co., Dept. of Natural Resources,
Bankhead Mine, Bankhead.
12. The Georgetown Collieries, Ltd.,
Georgetown Mine, Canmore.

Blairmore-Frank Coal Fields:—

13. McGillivray Creek Coal and Coke Co., Ltd.,
Carbondale Mine, Coleman.
14. Hillcrest Collieries, Ltd.,
Hillcrest Mine, Hillcrest.
15. West Canadian Collieries, Ltd.,
Bellevue Mine, Bellevue.
16. West Canadian Collieries, Ltd.,
Greenhill Mine, Blairmore.
17. Franco-Canadian Collieries, Ltd.,
Frank Mine, Frank.

Lethbridge Coal Area:—

18. Chinook Coal Co., Ltd.,
Chinook Mine, Commerce.

For the purpose of simple identification, these samples are named as under:—

TABLE I.
List of Coals and corresponding trials.

No. of Coal.	Name of Coal.	No. of Boiler Trials		
		A	B	C
1	Jasper Park	59	75	
2	Mountain Park	113	107	108
3	Yellowhead	60	74	
4	Pembina	55*		
5	Cardiff	52*		
6	Twin City	53*		
7	Drumheller	58	76	
8	Newcastle	61		
9	Midland	111	103	102
10	Rosedale	51		
11	Bankhead	114	109	110
12	Georgetown	54*	77	
13	McGillivray Creek	69	78	
14	Hillcrest	112	105	106
15	Bellevue	67	80	
16	Greenhill	68	81	
17	Frank	70	79	
18	Chinook		100	101

* Results of trials 51, 52, 53, 54, and 55, have been published in Report No. 331.

All the trials mentioned in Table I, were conducted in a Babcock and Wilcox water tube boiler¹, having 677 square feet of heating surface. The trials referred to in column A, were conducted at a normal rate of steaming on a grate area of 23 square feet, with an air space of $\frac{1}{4}$ " between the bars; the trials in column B at a normal rate of steaming on a grate area of 21 square feet, with an air space of $\frac{1}{2}$ " between the bars; the trials in column C, were conducted using the same grate as for B, but at a higher rate of steaming.

The remaining sample, namely, No. 19, came from the government peat bog at Alfred, Ont. Six complete trials and one short supplementary trial have been conducted with this sample: four trials on the water tube boiler, and three on a fire tube boiler of the locomotive type. Bulletin No. 17 contains a full report of these trials.

RESULTS OF TRIALS.

A full report of each boiler trial appears at the end of this bulletin; but since the results of each trial are, principally, of comparative value, it is necessary, in addition, to show them in the form of tables and diagrams.

Table II compares:—

(a) The quantity of fuel burned to generate a definite quantity of energy, namely, 1,000 lbs. of steam from and at 212° F.

(b) The amount of ash, clinker, and refuse removed while generating the same definite quantity of steam.

(c) The fraction of the total solid refuse which was withdrawn by cleaning and slicing from above the grate bars.

(d) The difference in draft pressure below the bars, and in the flue leaving the boiler.

The cost of generating steam by the combustion of any one of these fuels will be proportional to the values assigned to each of the items in Table II, multiplied by some factor dependent upon the costs of the fuel per ton, labour, installation, and repairs to grates and settings, the production of draft, etc.; all of which vary with the site of the boiler room. An investigation of the magnitude of these factors is outside the scope of this report.

¹ For a description of this boiler, see Report No. 331, *loc. cit.*

TABLE II.

Four Principal Results of the Tests for each Fuel.

- (a) Pounds of fuel fired per 1,000 pounds of steam, from and at 212° F.
 (b) Total refuse removed per 1,000 pounds of steam, from and at 212° F.
 (c) Ratio refuse removed from above the bars to total refuse removed.
 (d) Draft between boiler exit and ash-pit; in inches of water.

No. of Fuel.	Name of fuel and general remarks.	Evaporation rate,			
		Normal.	Normal.	High.	
		Grate area: sq. ft.,			
		23	21	21	
		Air spaces in fire bars,			
		1"	1"	1"	
1	Jasper Park, Run-of-mine coal, 5" lump to dust, coal cakes, clinker in small pieces.	a b c d	146 33.0 0.81 0.64	151 38.5 0.35 0.59	
2	Mountain Park, Run-of-mine coal, mostly 5" lumps with much dust, coal caked, clinker in small pieces.	a b c d	125 17.7 0.91 0.42	125 21.8 0.44 0.20	127 17.7 0.34 0.76
3	Yellowhead, Run-of-mine coal, mostly about 5" lumps with little dust. Clinker spread over bars.	a b c d	144 15.0 0.86 0.47	145 19.6 0.41 0.17	
4	Pembina, Run-of-mine coal, about 2" to 5" lumps, no small stuff. Clinker in small pieces easily removed.	a b c d	176 16.9 0.75 0.63		
5	Cordiff, Run-of-mine coal, 4" and 5" lumps, to very small stuff. Hard clinker, forms in fairly large pieces, does not adhere to the bars.	a b c d	197 16.8 0.74 0.46		
6	Twin City, Run-of-mine coal, not very much small stuff. Clinker in hard and not very large lumps, sticks slightly, does not spread over bars.	a b c d	191 17.7 0.79 0.63		
7	Drumheller, Slack coal, containing much dust and dirt. Clinker formed rapidly and spread over the bars.	a b c d	212 43.2 0.79 0.64	270 65.3 0.38 0.73	
8	Newcastle, Run-of-mine coal, 5" lumps and smaller, very little dust. Clinker gave very little trouble, did not spread.	a b c d	175 16.8 0.85 0.41		
9	Midland, Run-of-mine, fairly large lumps, not much small stuff. Clinker formed in large, thin slabs, easily removed.	a b c d	165 17.7 0.91 0.41	175 19.5 0.51 0.12	183 17.8 0.48 0.79
10	Rosedale, Run-of-mine, lumps and small stuff, very little dust. Thin clinker, spreads on bars, sticks a little.	a b c d	184 14.4 0.83 0.57		

High.

21

1"

27

17.7

0.34

0.76

8

9

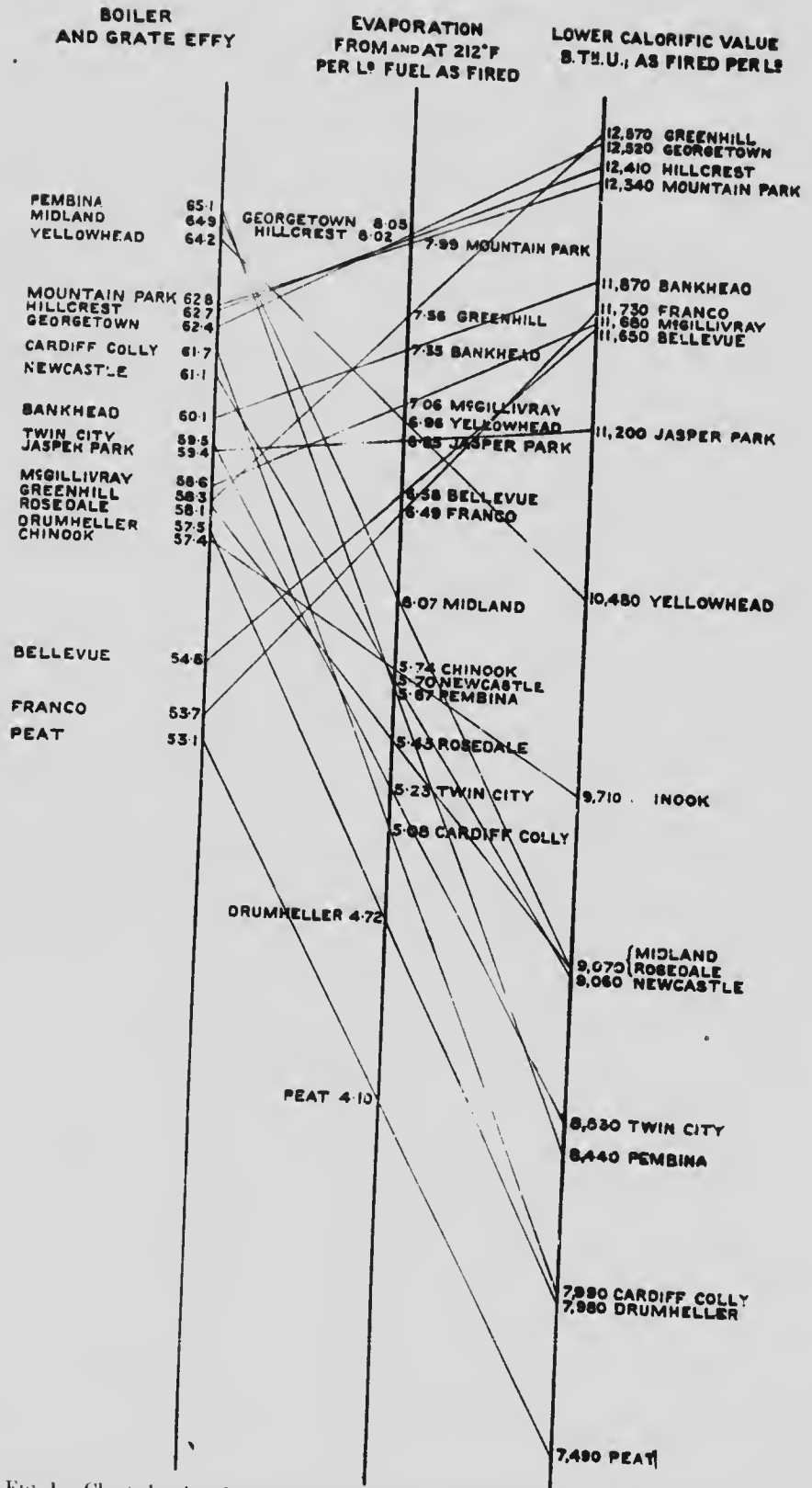
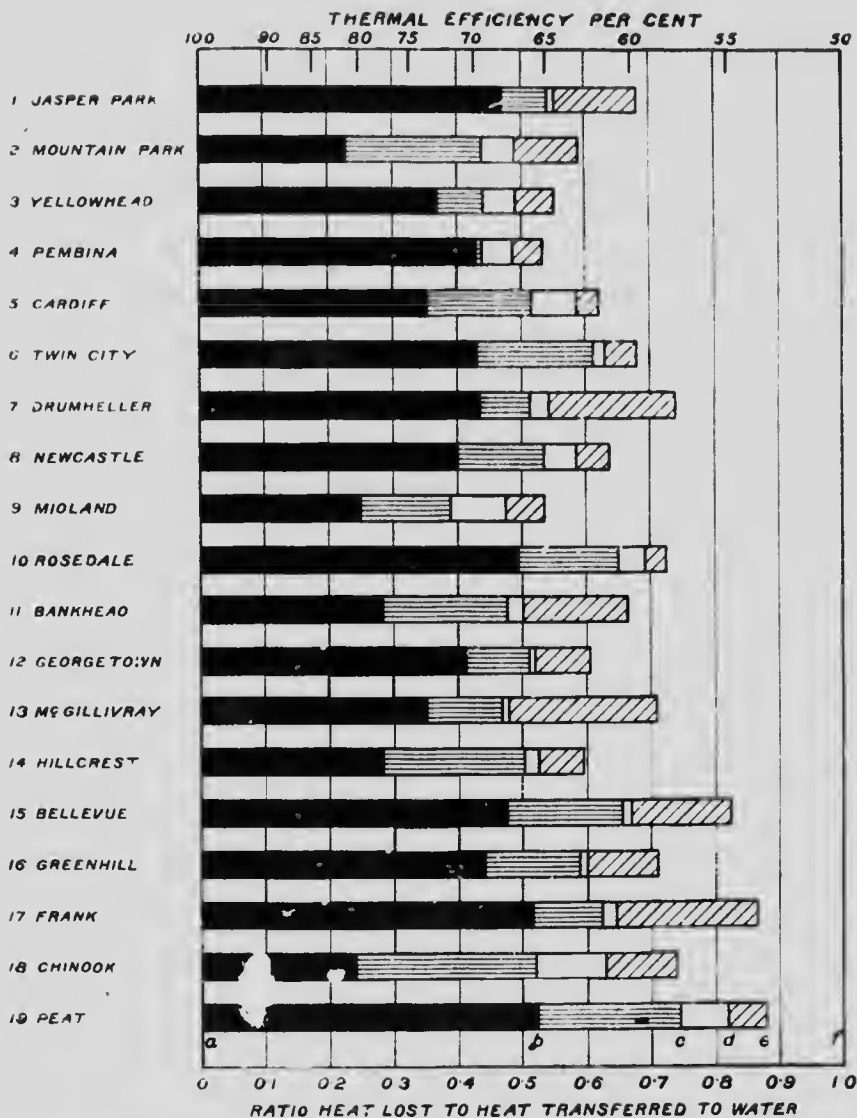
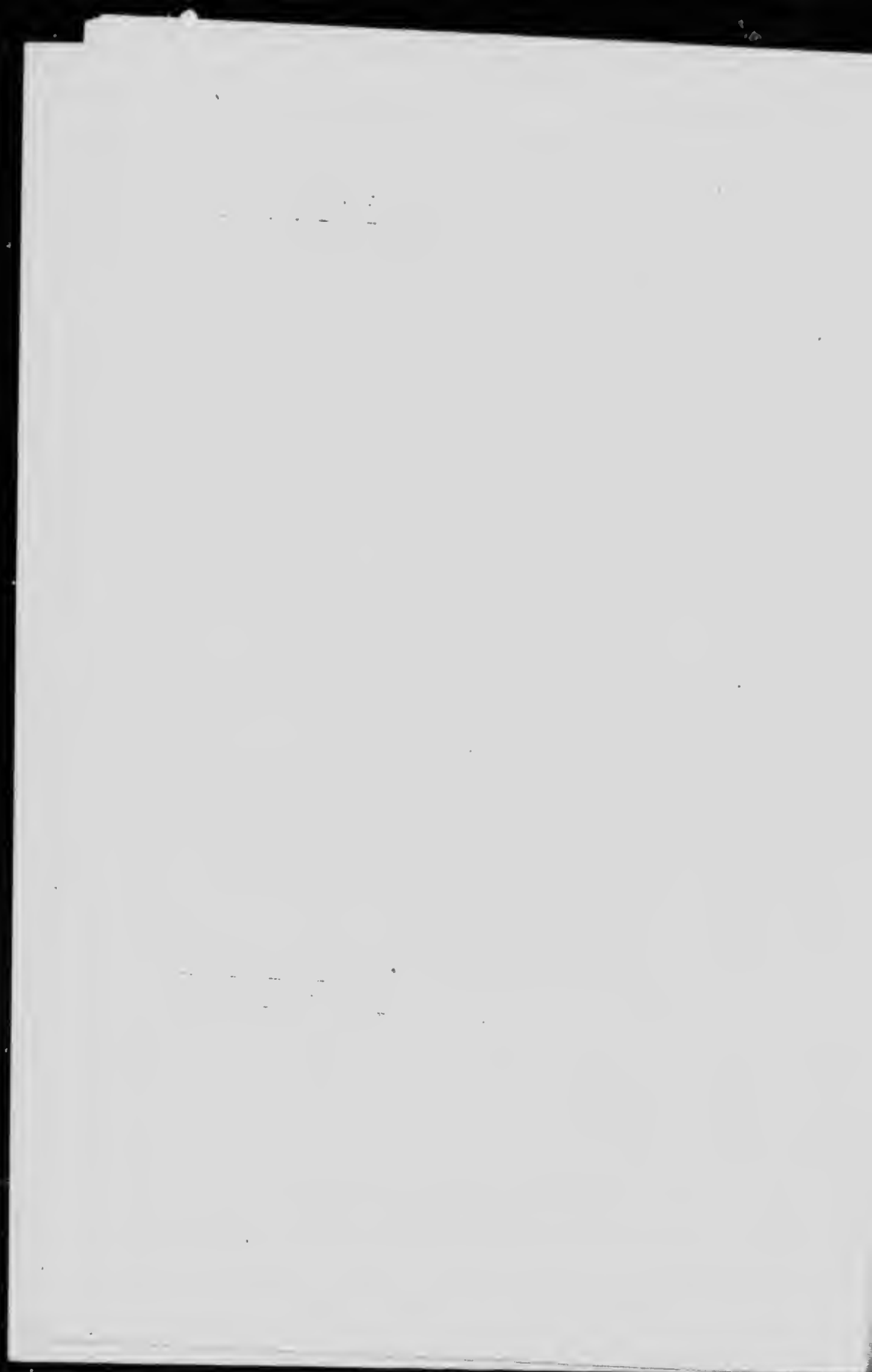


FIG. 1.—Chart showing the relation between the evaporation and calorific value per pound of fuel, and the thermal efficiency of the boiler and grate.



- F HEAT LOSS DUE TO TOTAL HEAT OF FLUE GAS
- R " RADIATION AND UNACCOUNTED FOR LOSS
- C " UNBURNT CARBON MONOXIDE
- S " UNBURNT SOLID MATTER

Fig. 2.—Chart showing the distribution of the heat losses as a fraction of the heat used for steam-raising.



No of Fuel.	Evaporation rate.		Normal.	Normal.	High	
	Grate area—sq. ft.		24	21	21	
	Air spaces in fire bars.		4'	4'	4'	
Name of fuel and general remarks						
11	Bankhead.	Penanthracite. Large pieces of clinker form; steam blown beneath bars to prevent the clinker sticking.	a	142	136	141
			b	37.8	23.8	29.1
			c	0.95	0.47	0.54
			d	0.79	0.64	1.32
12	Georgetown.	Run-of-mine anthracite, very small stuff with some large pieces. Clinker in medium sized pieces; did not spall; sticks slightly to bars.	a	121	136	
			b	18.6	31.8	
			c	0.79	0.36	
			d	0.68	0.59	
13	McGillivray.	Run-of-mine, much small stuff. Clinker in small pieces easily removed. Coal caked, necessitating frequent shing.	a	156	142	
			b	34.3	34.0	
			c	0.85	0.46	
			d	0.71	0.54	
14	Hillcrest.	Run-of-mine, contains much dust and small stuff. Clinker in small hard pieces. Coal caked.	a	125	125	136
			b	17.2	17.0	17.7
			c	0.89	0.18	0.26
			d	0.54	0.28	0.85
15	Bellevue.	Run-of-mine, from medium to small size. Coal caked. Clinker in small pieces.	a	165	152	
			b	35.0	33.7	
			c	0.88	0.45	
			d	0.71	0.60	
16	Greenhill.	Run-of-mine; fairly small pieces, little dust. Refuse from above the bars consisted of small, soft pieces, which were easily removed.	a	136	132	
			b	21.3	23.5	
			c	0.85	0.63	
			d	0.67	0.57	
17	Frank.	Run-of-mine, mostly dust and small stuff. Coal caked. Refuse in small soft pieces, easily removed.	a	162	154	
			b	38.5	41.7	
			c	0.86	0.40	
			d	0.76	0.87	
18	Chimook.	Lump coal. A thin clinker spread over the bars, and stuck to bars a little at the high rate of steaming.	a	.....	174	182
			b	.....	29.2	24.4
			c	.....	0.56	0.61
			d	.....	0.20	0.69
19	Peat.	Machine peat. No trouble from clinker.	a	244		
			b	12.6		
			c	0.86		
			d	0.71		

Ratio Water Evaporated to Fuel Fired.

The figure most commonly used to express the steaming quality of a fuel is the ratio of water evaporated to fuel fired; that is, one thousand, divided by item (a), in Table II.

Fig. 1 shows the best evaporation ratio for each fuel during the series of trials, and its relation to the net calorific value of the fuel, and the thermal efficiency of the boiler.

Distribution of Heat Losses.

In order to show the reasons for the variable thermal efficiencies for each fuel, the various heat losses are shown in Fig. 2—as a fraction of the heat transferred to the water in the boiler. By referring to the diagram

for the pent—(fuel 19, Fig. 2)—it will be seen that the distance ac ($ac = F + R + C + S$) represents the total heat loss to the same scale that af (equal to unity on the lower scale) represents the heat used for steam-raising.

The efficiency is equal to the ratio $\frac{af}{af+ac}$ and, putting af equal to unity, to $\frac{1}{1+ac}$; thus the efficiency—when we have a ratio of heat lost to heat used of 0.88—will be $\frac{1}{1+0.88} = 0.53$, or 53 per cent. Using similar calculations to this, a scale showing the efficiency corresponding to the heat losses has been placed at the top of the diagram. It is possible, by using the upper scale, to compare the different efficiencies; thus the efficiency corresponding to the loss represented by cd or $(F+R+C)$ will be the ratio of the heat used to the heat supplied—excluding that which has been lost as unburnt solid matter (S); or the efficiency based on solid combustible consumed. Similarly, the efficiency corresponding to the loss ab or F , will be the ratio of the heat used to the total heat developed by combustion exclusive of that portion of the heat wasted as a radiation loss.

Loss due to High Temperature of Escaping Flue Gases.

The principal heat loss in the series of trials is that due to the total heat of the flue gas as indicated on the chart in Fig. 2. This loss (F), does not include that due to the uncondensed steam, and is therefore equal to $C_p(T_1 - T_2)$ per pound of flue gas; where C_p is the mean specific heat at constant pressure; T_1 the flue gas temperature; and T_2 the temperature of the entering air. The variation of the loss due to the escaping hot gases for approximately the same boiler output is due almost entirely to

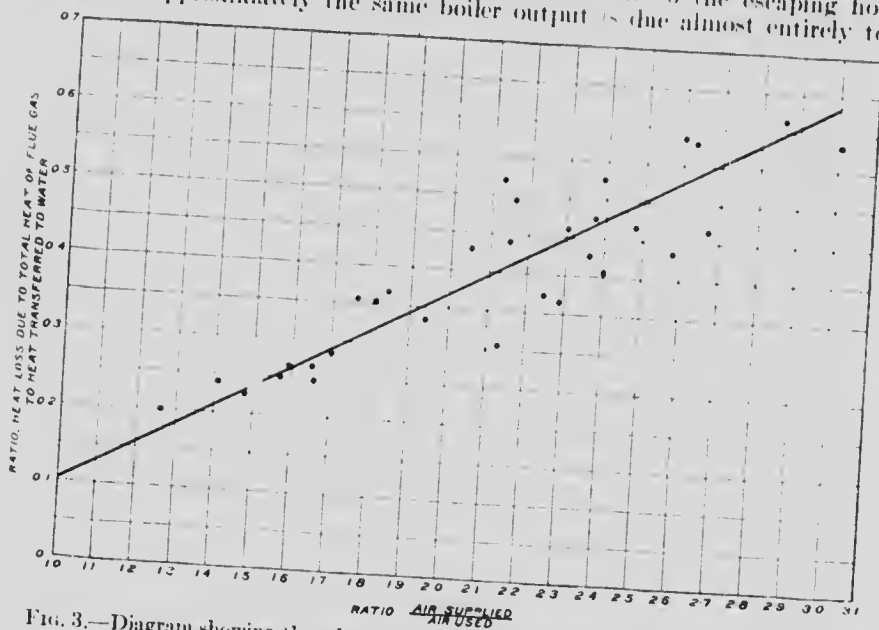


FIG. 3.—Diagram showing the relation between the loss due to the high temperature of the escaping flue gas and the air supply ratio.

the change in the amount of excess air; and Fig. 3 illustrates this by showing the relation between the ratio of the flue gas total heat loss to the heat usefully employed for steam-raising, and the ratio of the total air supplied to the air whose oxygen content is combined with the fuel. This air ratio is calculated from the flue gas analysis, and is equal to $\frac{21}{21 - 0.2 \frac{N_2}{N_2}}$ when

O_2 and N_2 represent the volumes of oxygen and nitrogen in the flue gas, and $\frac{21}{79}$ the ratio of oxygen to nitrogen in the atmosphere. The expression

$\frac{21 [100 + XL]}{100 [X(1+L)]}$ represents the ratio of air supplied to air required in

terms of the carbon dioxide content of the flue gas (X) and the factor L , which depends upon the chemical constitution of the coal, and is equal to $\frac{3}{8} \left(\frac{H}{O} - \frac{O}{C} \right)$, where H , O , and C , represent the relative weights of the hydrogen, oxygen, and carbon contents of the fuel. This expression holds good only for complete combustion of a fuel whose sole constituents which pass off with the flue gas are carbon, hydrogen, and oxygen. The diagram in

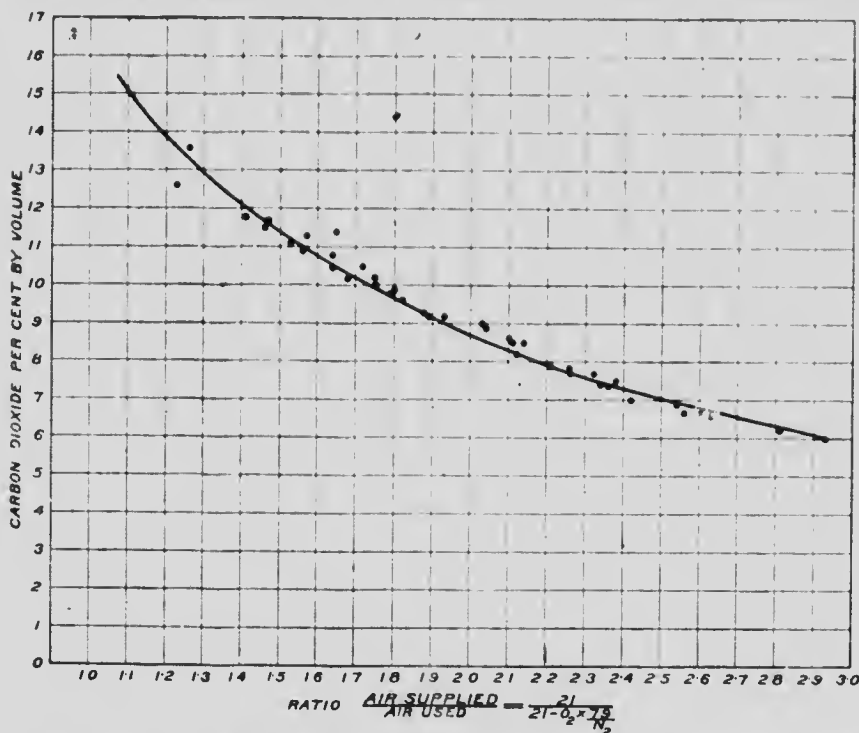


FIG. 4. Diagram showing the relation between the average air ratios for the trials and the average carbon dioxide contents of the flue gas.

Fig. 4, shows the actual relation between the air ratio and the carbon dioxide content of the flue gas during the series of trials.

Variation in Excess Air.

Many factors, such as the chemical and physical characteristics of the fuel, and the form of furnace and grates, are responsible for the differences in the quantity of air used for combustion. Fig. 5 illustrates the effect of

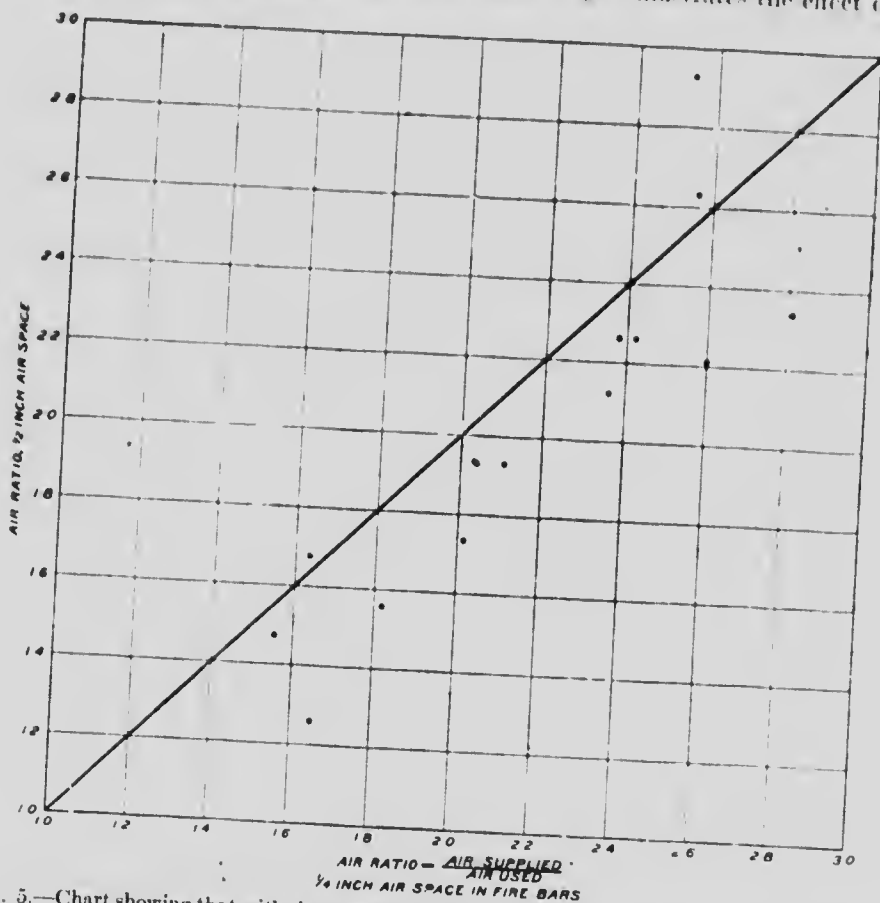


Fig. 5.—Chart showing that with the exception of 3 fuels, the ratio of air supplied for combustion to that used was less when a fuel was burned on a grate with $\frac{1}{2}$ " air space than when it was burned on a grate with $\frac{1}{4}$ " air space.

a change in grate upon this ratio; and shows that with three exceptions (fuels Nos. 7, 14, and 17), the air ratio was less when using a grate of 21 square feet area with $\frac{1}{2}$ " air spaces than when using a grate of 23 square feet area and $\frac{1}{4}$ " air space for the same fuel, and approximately the same rate of steaming. Fig. 6 shows that the excess air increased with an increase in the rate of combustion for four out of five coals.

While a change from the grate with small to one with larger air openings reduced the excess air loss, reference to Fig. 7 will show that the loss

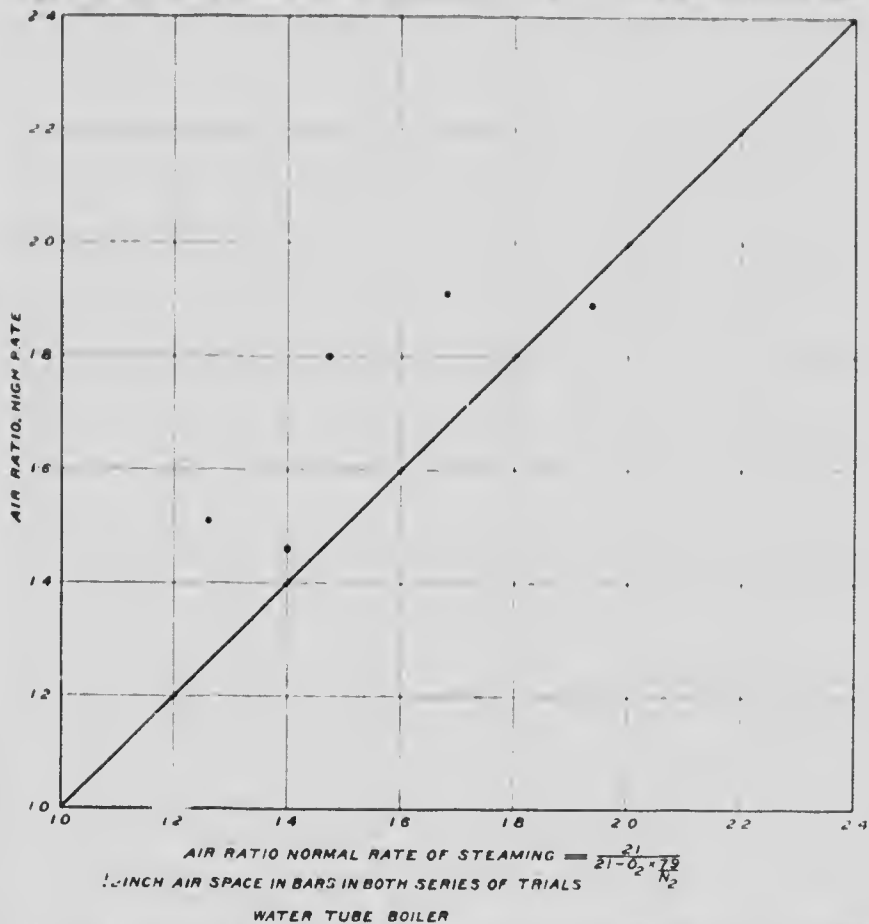


Fig. 6.—Diagram showing the effect of a change in the rate of steaming upon the excess air supply.

due to unburnt solid fuel increased for the trials with the larger air spaces, and that this loss tended to increase considerably, with an increasing ash content.

Briefly then, burning coal on a grate with $\frac{1}{4}$ " air spaces, tends to cause the loss due to solid unburnt carbonaceous material to be less and the loss due to the escape of flue gases to be greater than when using a grate with $\frac{1}{2}$ " air spaces.

Radiation, unaccounted for loss, and that due to unburnt gases.

The principal reasons for the variation in the radiation, and unaccounted for loss, where the rate of steaming remains the same, are variation

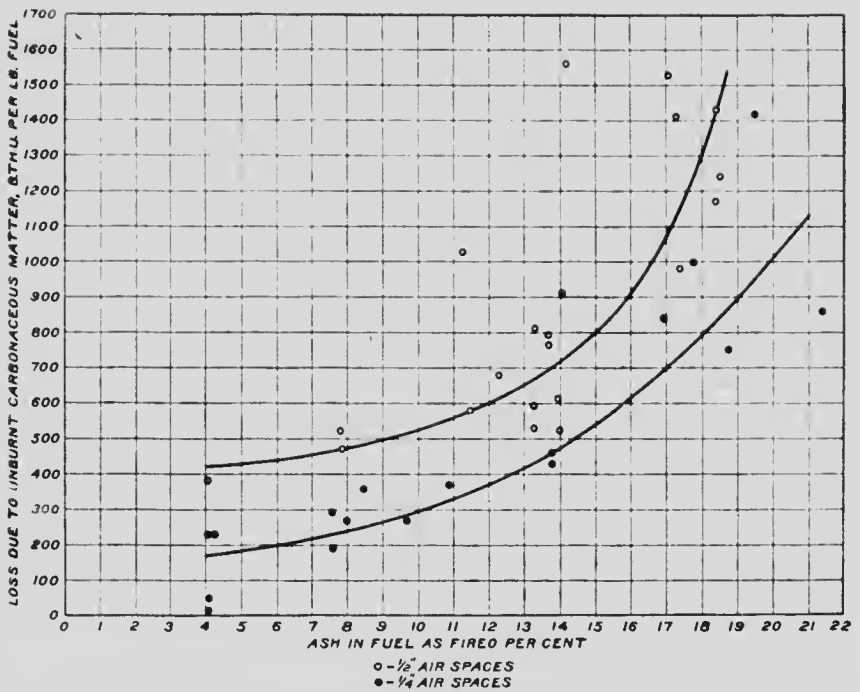


FIG. 7.—Diagram showing the relation between the heat loss due to unburnt solid fuel per pound of fuel fired, and the original ash content of the fuel.

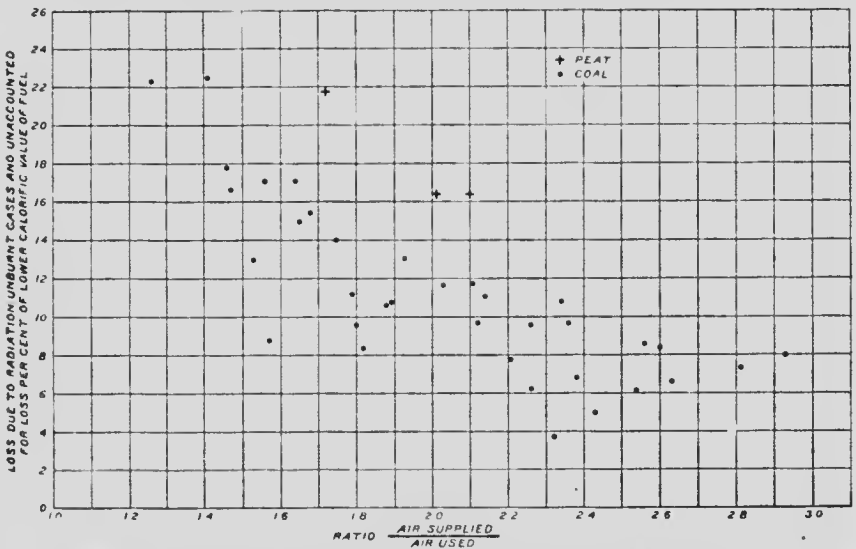


FIG. 8.—Diagram showing the relation which the sum of the percentage unaccounted for losses, and those due to radiation and unburnt gases bear to the air ratio.

in the heat transmitted from the hot gases and incandescent fuel through the boiler setting, and in the variation of the undetermined combustible content of the products of combustion. With the exception of trials 111, 112, and 113, no attempt was made to detect any combustible gases other than carbon monoxide. The estimated losses due to unburnt hydrogen and hydro-carbons, were 2.0 per cent during trials 111, 112, and 113. Probably there were further losses, however, due to unburnt tars and soot. Fig. 8 shows the total loss due to radiation, unburnt gases, and the unaccounted for loss plotted on a base representing the ratio of the air supplied to that used for combustion, from which it would appear that the loss tends to decrease with an increased air supply.

An increase in the air supply ratio, may be expected, therefore, to be accompanied by a decrease in the loss due to incomplete combustion and by an increase in that due to the increased mass of gas escaping at a high temperature; and the efficiency of the boiler based on the solid combustible consumed, will show the net result of the change. In Fig. 9, the boiler

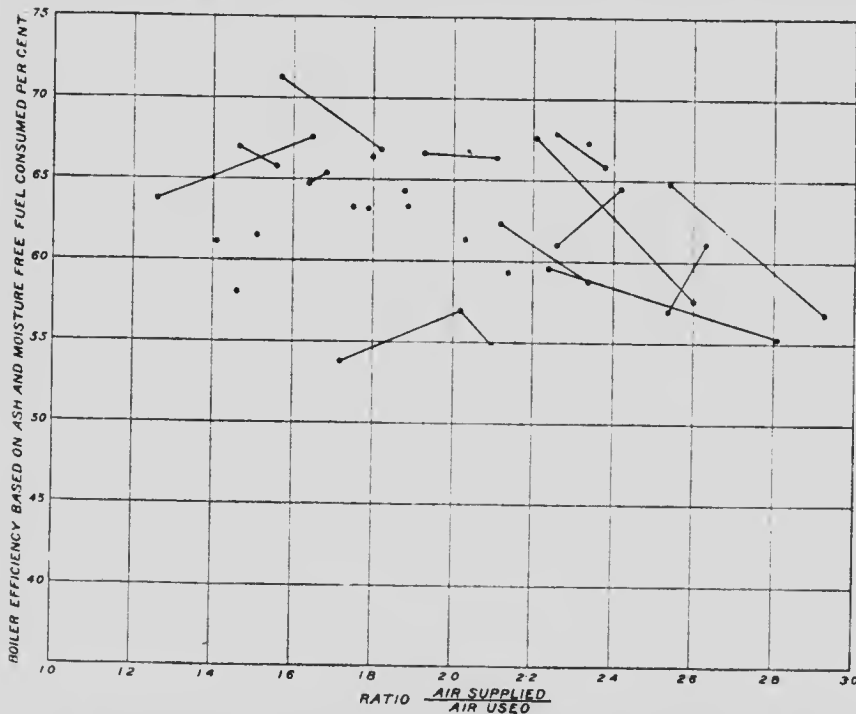


FIG. 9.—Diagram showing the boiler efficiencies at normal evaporation rates on a base representing the air ratio. Trials with the same fuel, are joined by straight lines.

efficiencies for the various trials are plotted on a base representing the excess air ratio; points in this chart obtained from trials on the same fuel are joined by lines.

Examination of this chart shows that while the predominant effect of increasing the air ratio for any particular fuel is to lower the efficiency, nevertheless there are many exceptions.

It should be remembered that the "radiation and unaccounted for loss" is not measured directly, but is found by subtracting the known losses from the heat energy of the fuel not used in steam-raising; and therefore varies with any error in measurement or sampling during the trial. These errors may be all of the same sign, when this loss will be either much too high or too low, as in trial 55 where the loss is only 0.7 per cent of the heat of the fuel.

Effect of rate of steaming on efficiency.

When sufficient fuel was available for an additional trial, it was burnt on the grate with $\frac{1}{2}$ -inch air space, at a comparatively high rate of steaming.

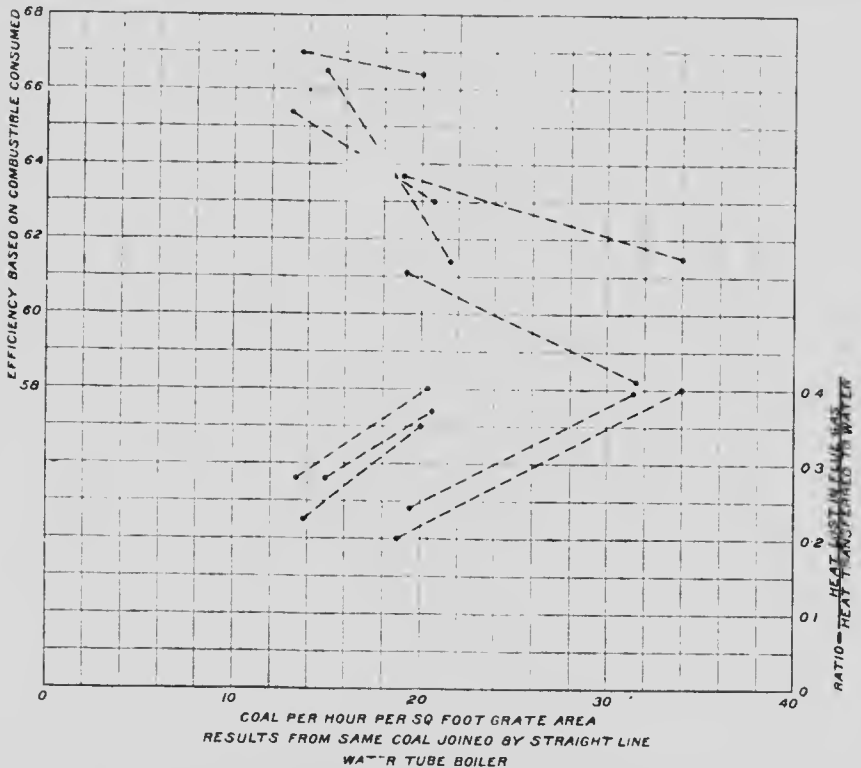


FIG. 10.—Diagram showing the decrease in thermal efficiency based on ash and moisture free fuel consumed and the increase in the loss due to the high temperature of the flue gas, with an increase in the rate of combustion.

Fig. 10 shows the relation between the efficiency based upon the ash and moisture free fuel consumed, and the rate of combustion; the efficiency is shown to decrease with the increased rate, and this decrease is due principally to the increased flue gas loss, which is shown in the same diagram.

This variation in the flue gas loss may be ascribed for the most part to the inability of the boiler heating surface to deal as efficiently with the larger gas flow, permitting the gases to leave the boiler at a higher temperature. That the excess air was generally greater when steaming at the higher rate has been referred to already—(see Fig. 6). The decrease in the efficiency with an increase in the combustion rate was very small when burning Mountain Park coal; the heat balance based on the lower calorific value of the coal shows this to be due to the closer attainment of complete combustion offsetting the loss due to the hot flue gas, as shown in the following table:—

Fuel, per hour per square foot of grate surface, lbs	Mountain Park.	
Air ratio,	13.5	29.0
Flue gas temperature, ° F	1.47	1.80
Thermal efficiency, per cent	590	720
Loss due to total heat of flue gas, per cent	62.8	62.2
Loss due to carbonaceous matter in ash and refuse, per cent	14.3	21.8
Loss due to unburnt carbon monoxide, per cent	6.2	6.4
Loss due to unburnt hydrocarbons, radiation, etc., per cent	3.2	1.1
	13.5	8.5

Draft.—Three manometers, each reading to one-hundredth of an inch of water, were used to measure the draft in the ash-pit, the furnace, and the flue leaving the boiler. The difference between the readings of any two is not a measure solely of the gas flow resistance. It varies also

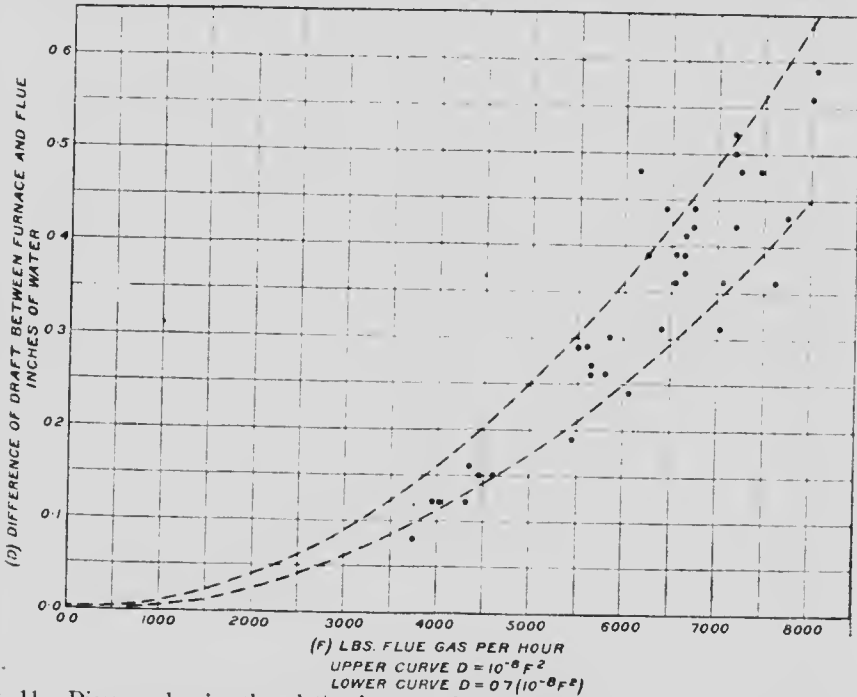


FIG. 11.—Diagram showing the relation between the difference of draft in the furnace and flue and the mass flow of the gases.

with the change in velocity of the gases; the vertical distance between the two places of measurement; and the mean density of the air in the boiler room and the gases inside the boiler setting. But the corrections for velocity head, differences in height of the gauges, and of density of the air and gases, are not very great, and for the same boiler working at the same rate are fairly constant. For this reason, it is permissible to consider the difference between the readings of two manometers as the resistance to the flow of gases between two sections of the boiler.

The resistance to the flow of air through the fuel bed depends upon the rate of gas flow and the general condition of the fire. Its accurate measurement and observation during operation is of great assistance in avoiding an excessive air supply due to poor firing, and shows the necessity for cleaning, breaking up a caking coal, or other operation to reduce the draft. But the characteristics of the various coals used during this series of trials were so different that it is impossible to show any general relation between fuel bed resistance and rate of combustion.

The resistance to the flow of gases from the furnace to the flue depends principally upon the mass flow of the gases. The relation between the gas flow and difference of draft, as measured during the trials at the furnace and flue, is shown in Fig. 11. It is important, since it shows that a simple differential draft gauge connected to the flue and furnace, in conjunction with a thermometer placed in the flue, will give an approximate means of determining the rate of heat loss due to the high temperature of the flue gas.

SUMMARY AND GENERAL REMARKS.

This report contains the results of 41 boiler trials conducted on 19 fuels: 18 of which came from the Province of Alberta, and 1 from the Government peat bog at Alfred. At least one trial, and sometimes two, were carried out at practically the same rate of steaming for each fuel, in order to compare their steam-raising values. To facilitate the comparison, the principal results are shown in Table II, page 10, Table III, page 22, and graphically in Figs. 1 and 2. Where sufficient coal was available, additional trials at a higher combustion rate were undertaken. The thermal losses were separated for each trial, and the effect of various factors upon them examined.

The highest thermal efficiency obtained in the tests was 65.1 per cent. That no higher efficiency was recorded should not be attributed to the quality of the coals; for the boilers used in these trials were neither selected nor modified in design with the view to obtaining efficiencies as high as those realized in large commercial plants where special economizers, stokers, etc., are used, but are of the size and proportions to give efficiencies comparable to those found in the operation of an ordinary small boiler plant. A method of improving the thermal efficiency of a boiler may be seen by referring to the results of trial 75, wherein 20 pounds of flue gas per pound of coal fired passed off from the boiler at a temperature of 690° F. By passing this gas over an additional heating surface, it might have been cooled down to say 400° F., giving up $(690 - 400) \times 20 \times .24$, or 1390 British thermal heat units per pound of coal fired, which would mean an additional evaporation from and at 212° F., of $1390 \div 970.7$, or 1.4 pounds of steam per pound of coal, and have increased the efficiency by 11.8 per

cent. By still further increasing the heating surface, or by using means to cause the gases to more thoroughly scrub the heating surface already in existence, the flue gas temperature could be lowered nearer and nearer to the temperature of the external walls of the boiler heating surface (about 340° F.), while the addition of an economizer would render still more heat available for warming the feed water before entering the boiler.

TABLE III.
Short General Report of Trials.

1	2	3	4	5	6	7	8	9
No. of Fuel.	No. of Trial.	Name of Fuel.	Area of Grate. Sq. ft.	Lb. Steam per hour.	Lb. fuel per sq. ft. grate area per hour.	Evaporation from and at per lb. fuel as fired. Lb.	Boiler and grate efficiency. Per cent.	Grate efficiency Per cent.
1	59	Jasper Park	23	2,226	14.0	6.85	59.4	93.6
	75	"	21	2,130	15.5	6.61	54.6	90.1
2	113	Mountain Park	23	2,240	12.2	7.99	63.5	97.0
	107	"	21	2,270	13.5	7.99	62.8	94.3
	108	"	21	3,330	20.0	7.91	62.2	95.3
3	60	Yellowhead Pass	23	2,450	15.2	6.96	64.4	97.3
	74	"	21	2,210	15.4	6.90	64.2	92.7
4	55	Pembina	23	2,456	18.7	5.67	65.1	97.3
5	52	Cardiff	23	2,404	20.4	5.98	61.7	97.7
6	53	Twin City	23	2,427	20.0	5.23	59.5	97.0
7	58	Drumheller	23	1,911	17.4	4.72	57.5	88.5
	76	"	21	1,530	19.8	3.71	45.6	80.9
8	61	Newcastle	23	2,333	17.6	5.70	61.1	96.8
9	111	Midland	23	2,300	16.5	6.07	64.9	96.4
	103	"	21	2,270	18.9	5.71	60.5	91.9
	102	"	21	3,910	34.0	5.47	58.0	95.2
10	51	Rosedale	23	2,534	20.2	5.43	58.1	98.1
11	114	Bankhead	23	2,230	13.8	7.04	58.3	89.0
	109	"	21	2,290	14.9	7.35	60.1	93.4
	110	"	21	3,100	21.3	6.93	56.6	91.2
12	54	Georgetown	23	2,377	12.7	8.05	62.4	95.2
	77	"	21	2,130	13.9	7.35	57.0	84.1
13	69	McGillivray	23	1,805	12.2	6.39	53.4	93.0
	78	"	21	2,080	14.2	7.06	58.6	88.6
14	112	Hillcrest	23	2,280	12.4	7.99	62.5	97.0
	105	"	21	2,220	13.1	8.02	62.7	96.7
	106	"	21	3,320	20.5	7.70	60.2	96.3
15	67	Bellevue	23	1,880	13.4	6.05	51.7	91.2
	80	"	21	2,060	15.0	6.70	51.8	92.3
16	68	Greenhill	23	2,006	11.8	7.33	56.1	95.4
	81	"	21	2,250	14.3	7.56	58.3	94.0
17	70	Frank	23	1,802	12.6	6.16	52.1	91.7
	79	"	21	2,055	15.2	6.49	53.7	87.9
18	100	Chinook	21	2,310	19.1	5.74	57.4	94.2
	101	"	21	3,020	31.4	5.49	54.9	95.7
19	71	Peat	23	1,950	20.5	4.10	53.1	97.1
	72	"	38	2,322	15.5	3.96	51.3	96.4
	73	"	38	2,250	15.0	3.95	54.8	97.8
83	83	Peat, using small	9	621	17.7	3.89	52.0	99.8
	84	fire tube boiler.	9	802	23.8	3.74	52.1	99.7
	85	"	9	1,054	37.6	3.09	42.2	99.6

TABLE III—*Concluded.*
Short General Report of Trials—*Continued.*

10	11	12	13	14	15	16	17
Efficiency combustible consumed. Per cent.	Ratio air supplied to air used for combustion.	Carbon dioxide, per cent.	Ratio flue gas loss to heat used for steam generation.	Flue gas, Temp. °F.	Net calorific value fuel as fired, B.Th.U. per lb.	Ash, per cent.	Moisture, per cent.
64.5	2.43	7.0	.471	660	11,200	21.4	2.3
61.0	2.26	7.7	.461	690	11,760	18.5	1.4
65.8	1.56	10.9	.251	590	12,220	13.8	2.8
67.0	1.47	11.7	.228	390	12,340	13.7	2.2
66.4	1.80	9.9	.351	720	12,340	13.7	2.2
66.9	1.82	9.6	.367	730	10,480	10.9	5.9
71.2	1.57	11.3	.267	680	10,430	11.3	5.9
67.4	2.32	7.7	.427	645	8,410	9.7	17.0
63.2	1.75	10.2	.355	670	7,990	7.6	21.2
61.4	2.03	9.0	.430	690	8,530	8.0	18.0
64.9	2.51	6.0	.434	580	7,980	14.1	18.3
56.8	2.93	6.0	.586	690	7,900	14.2	18.8
63.1	1.79	9.8	.402	730	9,060	7.6	16.5
67.6	1.65	11.4	.248	580	9,070	8.5	16.3
63.8	1.26	13.6	.200	560	9,160	7.9	16.2
61.5	1.51	11.1	.401	840	9,160	7.9	16.2
59.4	2.14	8.5	.493	730	9,070	7.6	15.3
66.3	2.11	8.5	.306	540	11,720	19.5	1.0
66.6	1.93	9.2	.282	550	11,870	18.4	1.1
64.4	1.88	9.3	.363	680	11,870	18.4	1.1
65.9	2.38	7.5	.407	630	12,520	12.3	2.9
67.9	2.26	7.8	.366	620	12,510	13.2	2.1
67.6	2.60	6.7	.581	710	11,620	17.0	2.5
67.6	2.21	7.9	.348	610	11,680	17.1	2.0
64.9	1.64	10.8	.268	610	12,400	13.8	2.0
65.4	1.68	10.2	.283	610	12,410	14.0	1.9
63.4	1.89	9.2	.400	740	12,410	14.0	1.9
55.2	2.81	6.2	.663	705	11,360	18.8	2.7
59.6	2.34	7.4	.473	670	11,650	17.4	2.1
58.8	2.36	7.4	.528	720	12,700	11.5	2.5
62.4	2.12	8.2	.439	710	12,570	13.3	1.6
57.0	2.56	6.7	.588	720	11,490	17.8	2.8
61.1	2.63	6.6	.516	670	11,730	17.3	1.7
61.1	1.41	11.8	.244	580	9,710	13.3	9.8
58.4	1.46	11.5	.398	840	9,710	13.3	9.8
54.9	2.10	8.6	.513	720	7,490	4.1	15.7
53.9	1.72	10.5	.453	750	7,490	4.1	15.7
56.8	2.02	8.9	.463	715	6,990	4.3	20.3
51.0	1.74	10.0	.429	690	7,130	4.1	19.2
52.5	1.63	10.5	.411	690	6,970	4.7	20.1
42.5	1.24	12.6	.410	750	7,110	4.2	19.2

TABLE IV.
Detailed Report of Trials.

No. of Trial	General Particulars of Trial						Description of Boiler.									
	Name of Fuel.	Date when fuel was received.	Date of the trial.	Duration.	Rate of steam-ing.	Boiler.	Description of Grate.					Heating surface.			Ratio heating surface to grate surface.	
							Type of bars.	Width.	Length.	Area.	Air space.	Ratio air space to total area.	Tubes.	Total.		
							ft. in.	ft. in.	sq. ft.	inches.	percent.	sq. ft.	sq. ft.			
1	2	3	4	5	6	7	9	10	11	12	13	14	15	16		
59	Jasper Park	Jan 19, 1915	Feb. 1, 1915	12 0	1,900	Water tube	4 9	4 10	23.2	0.25	30	633	677	29		
73	"	" 19, 1915	June 22, 1915	10 6	1,900	"	4 4	4 9	20.8	0.30	50	633	677	32.5		
113	Mountain Park	May 17, 1916	Dec. 14, 1916	11 0	1,960	"	4 9	4 10	23.2	0.25	30	633	677	29		
107	"	" 17, 1916	Nov. 28, 1916	10 2	1,960	"	4 4	4 9	20.8	0.5	50	633	677	32.5		
108	"	" 17, 1916	" 30, 1916	6 0	2,800	"	4 4	4 9	20.8	0.5	50	633	677	32.5		
60	Yellowhead Pass	May 27, 1914	Feb. 3, 1915	12 0	2,000	"	4 9	4 10	23.2	0.25	30	633	677	29		
74	"	" 27, 1914	June 17, 1915	12 0	2,000	"	4 4	4 9	20.8	0.5	50	633	677	32.5		
55	Pembina	"	Mar 27, 1914	12 0	2,030	"	4 9	4 10	23.2	0.25	30	633	677	29		
32	Cardiff	Aug. 29, 1912	Mar 20, 1914	12 0	1,980	"	4 9	4 10	23.2	0.25	30	633	677	29		
53	Twin City	Aug. 30, 1912	Mar. 23, 1914	12 0	2,040	"	4 9	4 10	23.2	0.25	30	633	677	29		
58	Drumheller	June 10, 1914	Jan. 28, 1915	11 55	1,600	"	4 9	4 10	23.2	0.25	30	633	677	29		
76	"	" 10, 1914	June 24, 1915	10 17	1,350	"	4 4	4 9	20.8	0.35	30	633	677	29		
61	Newcastle	Oct. 17, 1914	Feb. 5, 1915	12 0	2,000	"	4 9	4 10	23.2	0.25	30	633	677	29		
111	Midland	Sept. 30, 1915	Dec. 11, 1916	10 50	1,980	"	4 9	4 10	23.2	0.25	30	633	677	29		
103	"	" 30, 1915	Nov. 21, 1916	0 0	1,970	"	4 4	4 9	20.8	0.5	50	633	677	32.5		
102	"	" 30, 1915	Nov. 20, 1916	5 57	3,250	"	4 4	4 9	20.8	0.5	50	633	677	32.5		
51	Rosedale	Dec. 18, 1912	Mar. 18, 1914	12 0	2,100	"	4 9	4 10	23.2	0.25	30	633	677	29		

114	Bankhead	June 6, 1916	Dec. 13, 1915	1,950	"	"	4 91	4 10	23.2	0.25	30	633	677	29
109	"	" 6, 1916	" 1, 1916	1,980	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
110	"	" 6, 1916	" 4, 1916	2,620	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
54	Georgetown	Dec. 5, 1913	Mar. 25, 1914	1,960	"	"	4 91	4 10	25.2	0.25	30	633	677	29
77	"	" 5, 1913	June 29, 1915	1,800	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
7	McGillivray	May 13, 1914	April 20, 1915	1,600	"	"	4 91	4 10	23.2	0.25	30	633	677	29
112	"	" 13, 1914	June 30, 1915	1,850	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
105	Hillcrest seam No. 1	Jan. 5, 1916	Dec. 12, 1916	1,970	"	"	4 91	4 10	23.2	0.25	30	633	677	29
106	"	" 5, 1916	Nov. 24, 1916	1,980	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
67	"	" 5, 1916	" 27, 1916	2,800	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
80	Bellevue	Nov. 19, 1914	April 13, 1915	1,650	"	"	4 91	4 10	23.2	0.25	30	633	677	29
81	"	" 19, 1914	July 14, 1915	1,800	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
68	Greenhall	Mar. 1, 1915	April 15, 1915	1,800	"	"	4 91	4 10	23.2	0.25	30	633	677	29
79	"	" 1, 1915	July 16, 1915	2,060	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
70	Frank	Nov. 24, 1914	April 22, 1915	1,630	"	"	4 91	4 10	23.2	0.25	30	633	677	29
100	"	" 24, 1914	July 7, 1915	1,820	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
101	Chimook	Oct. 18, 1915	Nov. 15, 1916	1,400	"	"	4 41	4 9	20.8	0.5	50	633	677	29
71	"	" 18, 1915	" 16, 1916	3,000	"	"	4 41	4 9	20.8	0.5	50	633	677	32.5
72	Machine peat from Al- fred, Ont.		Mar. 18, 1915	1,740	"	"	4 91	4 10	23.2	0.25	30	633	677	29
73	"		" 26, 1915	2,060	"	"	6 91	5 7	37.9	0.5	50	633	677	18
83	"		June 1, 1915	1,990	"	"	6 91	5 7	37.9	0.25	30	633	677	18
84	"		Oct. 1, 1915	530	Locomotive	"	3 0	3 0	9	0.25	31	168	215	24
85	"		" 5, 1915	680	"	"	3 0	3 0	9	0.25	31	168	215	24
	"		" 26, 1915	900	"	"	3 0	3 0	9	0.25	31	168	215	24

TABLE IV.
Detailed Report of Trials—Continued.

No. of Trial.	Name of Fuel.	Thick-ness of fire	SIZE.	Particulars of the Fuel											Calorific value of fuel per lb.			
				Analysis (by weight) as fired.											As fired		Com- bustible Gross	
				Ultimate					Proximate.						Fuel Ratio F C	V M	Gross	Net	H	Th. U.	B. Th. U.	R. Th. U.
Carbon	Hydro- gen.	Ash.	Sulphur	Oxygen and nitrogen (F. C.)	Fixed carbon (F. C.)	Volatile matter (V. M.)	Ash	Moist- ure	percent	percent	percent	percent	percent	percent				
17			18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
59	Jasper Park	10	Run-of-mine lump to dust.	66.8	4.0	21.4	0.8	7.0	57.8	18.5	21.4	2.3	3.12	11,380	B. Th. U.	11,540	15,170	
75	"	7 to 8	"	70.0	4.1	18.5	0.8	6.6	60.7	19.4	18.5	1.4	3.13	12,150	B. Th. U.	11,760	15,160	
113	Mountain Park	4 1	Run-of-mine with much small stuff.	72.2	4.7	13.5	0.3	9.0	59.6	23.8	13.8	2.8	2.50	12,670	B. Th. U.	12,220	15,200	
107	"	4 1	"	72.8	4.6	13.7	0.4	8.5	60.0	24.1	13.7	2.2	2.50	12,780	B. Th. U.	12,340	15,200	
108	"	4	"	72.8	4.6	13.7	0.4	8.5	60.0	24.1	13.7	2.2	2.50	12,780	B. Th. U.	12,340	15,200	
60	Yellowhead Pass	6	Run of mine mostly 5 lump very little dust	64.5	4.7	10.9	0.2	19.7	48.0	35.2	10.9	5.9	1.36	10,930	B. Th. U.	10,480	13,140	
74	"	6 1	"	64.1	4.7	11.3	0.2	19.7	47.8	35.0	11.3	5.9	1.37	10,880	B. Th. U.	10,430	13,140	
55	Pembina	4 to 6	Run of mine 5" to 5" no small stuff.	54.4	5.7	9.7	0.2	30.0	43.8	29.5	9.7	17.0	1.48	8,900	B. Th. U.	8,440	12,250	
52	Cardell	6	Run-of-mine varies 4" to 5" lumps to very small.	51.5	6.1	7.6	0.2	34.6	39.1	32.1	7.6	21.2	1.22	8,570	B. Th. U.	7,900	12,000	

53	Twin City	4	Run-of-mine not very much small stuff.	53-7	5-9	8-0	0-4	32-0	41-0	37-1	8-0	18-0	1-17	9,000	8,500	11,000	12,200
58	Drumheller	5	Slacks, contains much dust and dirt.	50-1	5-1	11-1	0-4	30-0	38-7	28-9	14-1	18-1	1-34	8,400	7,900	10,300	12,500
76	"	4	"	49-6	5-5	14-2	0-4	30-3	38-4	28-6	14-2	18-8	1-34	8,420	7,900	10,300	12,370
61	Newcastle	5	Run-of-mine, 5 lump and smaller, very little dust.	56-3	5-6	7-6	0-4	30-1	43-8	32-1	7-6	16-5	1-35	9,500	9,000	11,200	12,600
111	Midland	4	Run of mine, fairly large lumps, little small stuff.	56-7	5-5	8-5	0-4	28-9	45-3	29-9	8-5	16-7	1-30	9,300	9,070	11,400	12,700
103	"	1	"	57-3	5-5	7-9	0-4	28-9	45-6	30-7	7-9	16-2	1-30	9,680	9,160	11,500	12,700
102	"	5	"	57-3	5-5	7-9	0-4	28-9	45-6	30-7	7-9	16-2	1-30	9,680	9,160	11,500	12,700
51	Resdale	4 1/2 to 5	Run-of-mine	56-9	5-6	7-6	0-6	29-3	45-0	32-1	7-6	15-7	1-40	9,600	9,070	11,200	12,400
114	Bankhead	4	1 to 5, 16"	71-8	3-3	19-5	0-4	5-0	69-7	5-5	19-5	1-0	2-10	12,000	11,720	12,150	13,150
109	"	5	"	72-7	3-3	18-4	0-5	5-1	70-5	5-1	18-1	1-1	2-10	12,180	11,870	12,310	13,150
110	"	6	"	72-7	3-3	18-4	0-5	5-1	70-5	10-0	18-4	1-1	2-10	12,180	11,870	12,310	13,150
54	Georgetown	6 to 7	Run-of-mine, 5" very small stuff.	70-2	4-2	12-3	0-8	6-5	71-7	13-1	12-3	2-9	5-47	12,900	12,320	13,800	15,200
77	"	5	"	76-1	4-1	13-2	0-8	5-8	41-6	13-1	11-2	2-1	5-47	12,900	12,310	13,170	15,200
69	McGillivray	8 to 9	Run-of-mine, much small stuff.	69-3	4-4	17-0	0-7	8-6	56-5	24-0	17-0	2-5	2-35	12,040	11,620	12,320	15,000
78	"	6 to 7	"	69-6	4-4	17-1	0-7	8-2	56-5	24-1	17-1	2-0	2-36	12,100	11,680	12,320	15,000
112	Hillyrest	5	Run-of-mine	72-2	4-5	13-8	0-6	8-9	59-0	25-2	13-8	2-0	2-5	12,800	12,400	13,000	15,200
105	"	4 1/2	"	72-1	5	11-0	0-6	8-8	58-0	25-2	14-0	1-9	2-35	12,840	12,410	13,000	15,200
106	"	4 1/2	"	72-1	4-5	14-0	0-6	8-8	58-0	25-2	14-0	1-9	2-35	12,840	12,410	13,000	15,200
67	Bellevue	8	Run-of-mine, no. 1 down to small	67-9	4-5	18-8	0-5	8-7	53-0	25-5	18-8	2-7	2-10	11,700	11,300	12,140	15,000
80	"	4	"	69-6	4-5	17-4	0-6	7-9	54-4	26-1	17-4	2-1	2-10	12,000	11,650	12,450	15,010
68	Greenhill	8 to 10	Run-of-mine, fairly small, little dust.	75-3	4-6	11-5	0-6	5-0	61-1	24-9	11-5	2-5	2-45	13,140	12,700	13,470	15,200
81	"	4	"	74-5	4-5	13-3	0-6	7-1	60-5	24-6	13-1	1-6	2-45	13,000	12,570	13,210	15,200
70	Frank	8	Run-of-mine, mostly dust & small stuff.	68-0	4-4	17-8	0-6	9-2	53-2	26-2	17-8	2-8	2-05	11,910	11,490	12,250	15,000
79	"	6	"	69-4	4-4	17-3	0-6	8-3	54-2	26-8	17-3	1-7	2-05	12,150	11,730	12,500	15,000

TABLE IV.
Detailed Report of Trials—Continued.

No. of Trial	Name of Fuel.	Thick-ness of fire.	Particulars of the Fuel												Calorific value of fuel per lb.						
			Analysis (by weight) as fired												As fired		Dry Grains		Com- bustible Grains*		
			Ultimate						Proximate						Fuel Ratio F C	A M	Gross	Net	R Th I	R Th I	R Th I
			Carbon	Hydro- gen	Ash	Sulphur	Oxygen and nitrogen	Fixed carbon matter (F C)	Volatiles (V M)	Ash	Moist- ure	percent		percent							
2	17	1 8	19	20	21	22	23	24	25	26	27	28	29	30	31	32					
100	Chimney	6 inches	58.7	5.3	13.3	0.7	22.0	43	31.1	12.3	9.8	1.65	R Th I 10.210	R Th I 9.740	R Th I 11.320	R Th I 11.500					
101	"	6	58.7	5.3	13.3	0.7	22.0	43.5	31.4	13.1	9.8	1.45	R Th I 10.240	R Th I 9.740	R Th I 11.320	R Th I 11.500					
71	Machine pent from Alfred, Ont	4 to 5	47.0	6.1	4.1	0.1	42.7	25.6	34.6	4.1	15.7	0.47	R Th I 8.070	R Th I 7.490	R Th I 9.570	R Th I 10.000					
72	"	4 to 5	47.0	1	4.1	0.1	42.7	25.6	34.6	4.1	15.7	0.47	R Th I 8.070	R Th I 7.490	R Th I 9.570	R Th I 10.000					
73	"	5	41.2	6.3	4.1	0.1	45.1	24.5	34.3	4.1	20.3	0.47	R Th I 7.500	R Th I 6.920	R Th I 9.570	R Th I 10.000					
83	"	"	45.0	6.3	4.1	0.1	44.5	24.5	34.3	4.1	19.2	0.47	R Th I 7.730	R Th I 7.150	R Th I 9.500	R Th I 10.000					
84	"	"	44.1	6.3	4.7	0.1	44.8	24.0	34.7	4.1	20.1	0.47	R Th I 7.520	R Th I 6.940	R Th I 9.470	R Th I 10.000					
85	"	"	44.9	5.3	4.2	0.1	44.5	24.5	34.1	4.2	19.2	0.47	R Th I 7.270	R Th I 6.690	R Th I 9.550	R Th I 10.000					

* * * Combustible means "Ash and Moisture Free Fuel."

TABLE IV.

Detailed Report of Trials *Continued*

No. of Trial	Name of Fuel	Fuel, total quantities.						Ash and Refuse												
		Fuel fired.		% combustible		Fuel fired per 1000 lbs. water evaporated from 212° F.		Refuse removed from			Weight of ash in			Estimated weight of unburned refuse combustible		Ratio refuse moved from grate to total refuse movable		Total refuse removed		
		As fired.	Dry fired.	Fuel	%	Com- bustible	per 1000 lbs.	Above fire bars.	Ash pit	Ash pit above fire bars.	Total weight of refuse movable	Com- bustible	Calor value	Total weight of refuse movable	Fuel loss.	Fuel loss.	Per cent of total refuse movable	Per cent of fuel fired	Per cent of steam raised	Total refuse removed
1	2	33	31	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
59	Jasper Park	3,884	3,896	2,960	2,720	146	713	16	878	21.7	1,150	61	682	801	26	6.81	25.6	15.9	33.9	18
55	Carbide	4,261	3,217	2,614	2,334	151	290	540	820	31.7	4,660	26	362	601	26	6.25	25.4	18.3	38.3	18
113	Mountain Park	3,086	3,000	3,354	3,482	125	398	78	426	17.7	2,750	77	359	426	92	9.91	14.1	17.7	17.7	18
107	"	2,844	2,781	2,391	2,231	159	258	496	27.8	4,650	118	358	390	450	159	14.4	17.1	21.7	17.7	18
108	"	2,318	2,461	2,118	1,981	127	121	251	352	28.4	4,126	109	272	335	112	6.34	14.0	17.7	17.7	18
60	Yellow Local Pass	4,220	3,957	3,511	3,404	144	377	64	401	18.7	2,741	83	557	498	178	9.89	19.1	15.9	15.9	18
54	"	3,898	3,668	3,225	2,950	115	257	399	526	38.7	5,620	264	122	148	278	6.41	13.5	19.6	19.6	18
57	Pembina	3,203	4,320	3,810	3,711	176	174	125	499	16.1	2,340	80	419	316	97	6.75	9.6	19.8	19.8	18
52	Carbide	3,653	4,459	4,040	3,865	195	357	127	484	14.9	2,160	72	412	439	73	6.71	8.5	16.8	16.8	18
53	Two Cities	5,577	4,573	4,157	4,023	191	408	107	515	18.9	2,714	97	408	446	164	6.79	9.2	17.7	17.7	18
58	Drumheller	4,821	3,940	3,260	2,956	212	779	295	984	16.9	4,180	207	680	680	261	5.78	20.4	41.2	41.2	18
76	"	4,242	3,441	2,842	2,386	276	391	667	1,028	43.1	6,236	41	565	602	476	4.8	23.1	62.3	62.3	18
51	Newcastle	4,910	4,100	3,727	3,630	175	398	72	476	20.6	3,016	80	371	373	97	6.53	9.6	16.8	16.8	18
111	Midland	1,164	3,485	3,131	3,027	165	406	42	448	22.7	3,260	162	146	250	104	6.91	16.8	17.7	17.7	18
13	"	3,977	3,333	3,019	2,804	173	526	417	441	28.8	4,150	128	417	314	128	9.31	11.1	19.1	19.1	18
12	"	4,236	3,267	3,231	3,080	183	400	210	413	11.1	4,511	158	336	336	151	4.8	9.2	17.8	17.8	18

70	Frank	3,462	3,365	2,719	2,511	162	705	117	832	57.7	1,030	616	238	0.86	23.7	38.5
79	"	3,152	3,098	2,553	2,216	154	342	510	852	59.1	5,210	545	307	0.10	37.0	41.7
100	Chinook	4,009	3,616	3,083	2,921	171	371	297	671	23.0	3,380	533	159	0.56	16.7	29.2
101	"	3,939	3,553	3,029	2,881	182	318	298	526	21.7	3,110	521	145	0.61	13.4	24.1
71	Machine rest from Alfred Co.	4,663	3,431	3,710	3,661	211	207	31	211	28.5	4,130	191	76	0.86	5.2	12.6
72	"	5,814	4,927	4,687	4,536	252	None	278	278	38.7	5,610	210	151	0.0	4.8	12.1
73	"	5,690	4,535	4,295	4,197	253	116	78	234	27.6	1,060	215	93	0.65	3.9	10.0
83	"	1,371	1,027	1,575	1,542	232	None	27	27	4.3	620	52	2	0.0	2.1	5.5
84	"	1,715	1,370	1,280	1,282	367	None	33	33	6.6	950	81	6	0.0	1.9	5.1
85	"	2,720	2,198	2,081	2,075	321	"	76.5	76.5	7.5	1,090	111	9	0.0	2.8	9.1

* "Combustible" means "Ash and Moisture Free Fuel".

111	Midland	91	21,710	21,590	23,280	111	126	0.9	80	29.82	0.0	0.21	10.7	7.7	1.3
103	"	56	19,650	19,500	22,700	110	125	1.1	90	30.35	0.0	0.64	8.6	7.3	1.2
102	"	70	18,100	18,910	23,250	109	115	1.26	79	30.19	0.0	0.20	10.5	7.3	1.4
31	Rosedale	38	25,287	25,130	30,645	108	123	0.9	79	29.57	0.0	0.21	15.3	7.3	2.1
114	Bankhead	107	21,440	21,270	24,530	105	120	1.0	70	29.69	0.0	0.53	17.6	9.2	1.9
109	"	80	19,910	19,750	23,170	108	122	1.0	80	29.60	0.0	0.45	16.9	9.3	1.8
110	"	68	15,830	15,650	18,500	108	123	1.48	80	29.50	0.0	0.84	16.0	9.3	1.7
54	Georgetown	37	23,520	23,370	28,530	105	120	0.8	82	30.12	0.0	0.32	23.1	10.0	2.3
77	"	104	18,400	18,300	21,670	107	122	0.8	88	29.88	0.0	0.29	19.5	10.0	1.9
99	McGillivray	113	19,015	18,920	21,480	113	128	1.1	78	29.81	0.0	0.37	22.9	9.1	2.5
78	"	122	18,250	18,130	20,520	97	112	0.8	90	29.68	0.0	0.23	18.2	9.2	2.0
112	Hillcrest, seam No. 1	93	21,650	21,460	25,100	111	126	1.1	78	29.30	0.0	0.39	14.9	9.5	1.6
105	"	94	19,270	19,120	22,360	113	124	0.92	78	29.10	0.0	0.13	17.0	9.5	1.7
106	"	71	16,400	16,170	19,950	108	122	0.99	90	29.93	0.0	0.29	17.9	9.5	1.9
67	Bellevue	107	19,750	19,590	22,660	92	107	1.1	66	30.26	0.0	0.28	24.3	9.1	2.7
80	"	108	18,250	18,370	20,820	105	120	0.8	93	29.70	0.0	0.28	20.6	9.2	2.2
68	Greenhill	110	21,185	21,040	24,070	96	111	0.8	74	30.08	0.0	0.31	23.2	10.0	2.3
81	"	129	20,060	20,130	22,330	113	128	0.8	87	29.56	0.0	0.18	20.4	9.9	2.1
70	Frank	119	18,950	18,810	21,310	94	109	0.9	76	30.12	0.0	0.37	21.9	8.9	2.5
79	"	133	18,350	18,230	20,150	106	121	0.8	85	29.89	0.0	0.37	21.8	9.2	2.4
100	Chinook	97	69,910	69,750	73,000	105	120	1.02	78	30.01	0.0	0.04	10.1	7.7	1.3
101	"	75	18,378	18,190	21,670	107	122	1.3	70	29.98	0.0	0.16	10.1	7.7	1.3
71	Machine-peat from Alfred, Ont	124	17,045	16,930	19,120	99	111	0.9	71	29.87	0.0	0.21	11.9	5.7	2.1
72	"	118	20,560	20,350	23,150	101	116	0.8	72	29.8	0.0	0.11	10.2	5.7	1.6
71	"	115	19,900	19,750	22,140	94	109	0.9	83	29.9	0.0	0.18	10.5	5.4	2.0
81	"	59	4,232	4,133	4,446	95	100	2.9	70	29.9	0.0	0.11	9.5	5.4	2.0
81	"	60	5,504	5,371	6,388	94	109	3.2	70	29.6	0.0	0.14	8.9	5.4	1.7
81	"	54	7,2109	7,007	8,398	80	95	3.6	68	29.8	0.0	0.22	6.2	5.5	1.6

TABLE IV.
Detailed Report of Trials—Continued.

No. of Trial.	Name of Fuel.	Flue Gases.						Hourly Quantities and Rates.						Water Fuel Ratios.				
		Analysis of dry flue gases by volume.			Dry flue gases per lb.			Temp-erature in flue leaving boiler.	Fuel fired.	Fuel fired per sq. ft. of grate surface.	Dry fuel fired per sq. ft. of grate surface.	Equi-valent evap-oration and at 212° F.	Equi-valent evap-oration from and at 212° F. of heating surface.	Boiler power.	Equi-valent water evap-erated per lb. of fuel as fired.	Equi- Evap. from and at 212° F.		
Carbon dioxide.	Carbon monoxide.	Oxygen.	Nitrogen.	Carbon in gas.	Fuel as fired.	percent.	percent.									lb.	lb.	lb.
1	2	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
59	Jasper Park	7.0	0.1	12.6	80.3	34.8	21.3	690	324	14.0	13.6	2,220	3.27	64.2	5.84	6.85	7.01	9.74
75	"	7.7	0.1	11.9	80.3	31.7	19.6	660	323	15.5	15.3	2,130	3.15	61.8	5.78	6.61	6.71	9.24
114	Mountain Park	10.9	0.6	7.7	80.8	21.8	15.0	590	281	12.2	11.9	2,240	3.31	64.9	6.93	7.99	8.22	9.93
107	"	11.7	0.7	6.9	80.7	20.3	13.7	590	284	13.5	13.2	2,270	3.35	63.8	6.86	7.99	8.18	10.14
108	"	9.9	0.2	9.5	80.4	24.7	16.7	720	420	20.0	19.6	3,330	4.32	96.5	6.65	7.91	8.08	10.04
60	Yellowhead Pass	9.6	0.6	9.6	80.2	24.4	15.2	730	352	15.2	14.3	2,450	3.62	71.0	5.92	6.96	7.40	8.63
74	"	11.3	0.6	7.8	80.3	21.1	12.2	680	320	15.4	14.5	2,210	3.3	64.1	5.98	6.90	7.33	9.12
55	Pembina	7.7	0.4	12.1	79.8	30.6	16.1	645	434	18.7	15.5	2,456	3.63	71.2	4.64	5.67	6.83	7.94
52	Cardiff	10.2	0.7	9.1	80.0	27.9	11.5	670	473	20.4	16.1	2,404	3.55	69.7	4.16	5.08	6.45	7.28
53	Twin City	9.0	0.2	10.3	80.0	22.1	14.0	690	465	20.0	16.8	2,427	3.59	70.4	4.27	5.23	6.37	7.24
58	Drumbeller	6.9	0.2	12.9	80.0	34.7	15.3	580	405	17.4	14.3	1,911	2.82	55.4	3.88	4.72	5.78	7.71
76	"	6.0	0.1	14.0	79.9	40.3	13.9	600	412	19.8	16.1	1,850	2.26	44.4	3.26	3.71	4.57	6.60
61	Newcastle	9.8	0.5	9.4	80.3	24.2	13.2	730	409	17.6	14.7	2,333	3.45	67.6	4.83	5.70	6.83	7.72
111	Midland	11.4	0.7	8.3	79.4	20.6	11.2	580	379	16.5	13.8	2,300	3.4	66.7	5.18	6.07	7.25	8.35
103	"	13.6	1.7	4.4	80.3	16.5	8.9	560	393	18.9	15.9	2,270	3.35	65.8	4.91	5.71	6.81	7.85
102	"	11.1	1.4	7.3	80.2	20.0	10.7	840	715	34.0	28.5	3,910	5.78	113.4	4.44	5.47	6.52	7.56

No.	Name	8.5	0.3	11.3	79.9	28.2	15.7	730	470	20.2	17.1	2,354	3.77	74.5	4.46	5.43	6.41	7.17
114	Rosedale	8.5	0.1	11.2	80.2	28.0	17.0	540	318	13.8	13.7	2,230	3.29	64.6	6.10	7.04	7.11	10.09
109	Bankhead	9.2	0.2	10.3	80.3	26.5	17.2	550	312	14.9	14.7	2,290	3.38	66.4	6.26	7.35	7.43	10.10
110	"	9.3	0.3	10.0	80.4	25.9	16.3	680	448	21.3	21.1	3,100	4.38	90.0	5.80	6.93	7.00	9.80
57	Georgetown	7.5	0.05	12.35	80.01	32.8	23.5	630	205	12.7	12.3	2,377	3.51	68.9	6.9	8.05	8.29	10.03
77	"	7.8	0.05	11.09	80.25	31.5	19.8	620	289	13.9	13.6	2,130	3.15	61.7	6.3	7.35	7.51	10.39
60	McGillivray	6.7	0.1	13.1	80.1	36.3	23.2	710	282	12.2	11.9	1,805	2.67	52.3	5.63	6.39	6.56	8.56
75	"	7.9	0.1	11.7	80.3	31.0	18.4	610	295	14.2	13.9	2,080	3.06	60.4	6.24	7.06	7.21	10.04
112	Hillcrest	10.8	0.4	8.3	80.3	22.1	15.3	610	285	12.4	12.2	2,280	3.37	69.1	6.84	7.99	8.16	9.86
105	" secum No. 1	10.2	0.3	8.7	80.8	23.8	16.3	610	276	13.1	12.9	2,270	3.28	64.3	6.88	8.02	8.18	9.97
106	"	9.2	0.1	10.1	80.6	26.5	18.2	740	430	20.5	20.1	3,320	4.90	96.2	6.43	7.70	7.85	9.64
67	Bellevue	6.2	0.1	13.7	80.0	39.1	24.6	705	310	13.4	13.0	1,880	2.77	54.4	5.27	6.05	6.21	8.24
80	"	7.4	0.1	12.2	80.3	33.0	20.9	513	313	15.0	14.7	2,060	3.04	59.7	5.81	6.58	6.72	8.92
68	Greenhill	7.4	0.1	12.3	80.2	33.0	23.6	730	273	11.8	11.5	2,036	2.96	58.1	6.41	7.33	7.52	8.95
81	"	8.2	0.1	11.3	80.4	29.9	20.7	710	297	14.3	14.1	2,250	3.32	65.1	6.79	7.56	7.68	9.50
70	Frank	6.7	0.1	13.0	80.2	36.3	22.1	730	292	12.6	12.2	1,892	2.66	52.2	5.43	6.16	6.34	8.49
79	"	6.6	0.1	13.2	80.1	36.8	22.2	670	317	15.2	15.0	2,035	3.04	59.6	5.78	6.49	6.60	9.11
100	Chirook	11.8	1.5	6.2	80.5	18.9	10.4	580	402	19.1	17.3	2,310	3.4	67.0	4.93	5.74	6.36	7.87
101	"	11.5	1.6	6.7	80.2	19.1	10.5	840	660	31.4	28.4	3,620	5.4	104.8	4.62	5.49	6.08	7.49
71	Machine part from Alfred, Ont	8.6	0.6	11.4	79.7	27.0	12.2	720	476	20.5	17.3	1,950	2.88	56.5	3.63	4.10	4.87	5.22
72	"	10.5	1.1	8.8	79.6	21.6	9.6	790	586	15.5	13.1	2,322	3.43	67.3	3.49	3.96	4.70	5.10
73	"	8.8	0.8	10.7	79.6	25.6	10.9	715	569	15.0	12.0	2,250	3.32	65.2	3.47	3.95	4.70	5.10
83	"	10.0	1.0	9.1	79.6	21.9	9.8	690	160	17.7	14.3	621	2.89	18.0	3.25	3.89	4.90	5.08
84	"	10.5	1.5	8.2	79.8	20.8	9.1	690	211	23.8	19.0	802	3.73	23.2	3.13	3.74	4.69	5.08
85	"	12.6	4.7	4.0	78.7	14.3	6.5	750	341	37.9	30.7	1,054	4.9	30.5	2.57	3.09	3.82	4.05

* "Combustible" means "Ash and Moisture Free Fuel"

TABLE IV.
Detailed Report of Trials—Concluded.

No. of Trial.	Name of Fuel.	Efficiencies.					Heat Balance based on Fuel as Fired, and gross Calorific Value										Balance of heat account, after deduction of observations and unmeasured losses such as those due to radiation, heat in hot ashes, etc.					
		Efficiency of					Total heat value of one lb. of fuel as fired and gross value.	Heat transferred to the water.	Loss due to steam formed from moisture in fuel and that formed by combustion of hydrogen.	Loss due to heat carried away in the dry flue gases, due to its high temperature.	Loss due to unburnt combustible in the refuse.	Loss due to unburnt carbon monoxide.	B. Th. U. percent.	B. Th. U. percent.	B. Th. U. percent.							
		Boiler, furnace and grato based on calorific value.	Grate based on calorific value.	Net.	Boiler based on combustible supplied and net calorific value.	B. Th. U. percent.										B. Th. U. percent.		B. Th. U. percent.	B. Th. U. percent.	B. Th. U. percent.	B. Th. U. percent.	B. Th. U. percent.
1	2	82	59.4	54.6	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
59	Jasper Park	57.4	59.4	54.6	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
75	"	52.8	59.4	54.6	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
113	Mountain Park	61.2	63.5	62.2	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
117	"	60.7	63.5	62.2	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
108	"	60.0	63.5	62.2	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
60	Yellowhead Pass	61.8	64.4	62.2	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
74	"	61.5	64.2	62.2	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
35	Pouabina	61.2	65.1	61.7	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
32	Cardiff	57.5	61.7	59.5	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
33	Twin City	55.8	59.5	57.0	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
38	Drumbeller	54.0	57.5	45.6	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
76	"	42.8	45.6	41.1	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		
61	Newcastle	57.7	61.1	58.8	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98		

111	Midland	61.4	64.9	96.1	67.6	9,590	5,890	61.4	61.0	6.7	1,540	14.4	360	3.8	320	3.3	1,040	10.8
103	"	57.2	60.5	94.9	63.8	9,680	5,520	57.2	63.0	6.5	1,000	16.3	470	4.9	610	6.3	1,340	14.8
102	"	54.9	58.0	95.2	61.5	9,680	5,310	54.9	70.0	7.2	1,050	20.2	520	5.3	610	6.3	990	6.1
51	Rosedale	54.9	58.1	98.1	59.1	9,690	5,270	54.9	68.0	7.1	2,450	23.5	190	2.0	190	2.0	820	8.5
115	Bunkhead	56.8	58.3	89.0	66.3	12,030	6,830	56.8	380	3.1	2,020	16.8	1,420	11.8	70	0.6	1,310	10.9
106	"	53.2	60.1	93.4	66.6	12,180	7,130	58.5	380	3.1	1,940	15.9	1,170	9.6	140	1.2	1,420	11.7
110	"	55.2	56.6	91.2	64.4	12,180	6,720	55.2	400	3.3	2,350	19.3	1,430	11.7	290	1.6	1,080	8.9
54	Georgetown	60.4	62.4	95.2	65.9	12,920	7,810	60.4	490	3.8	3,090	23.9	680	5.3	50	0.4	800	6.2
77	"	55.3	57.0	84.1	67.9	12,900	7,130	55.3	480	3.7	2,520	19.5	2,020	15.7	50	3.3	710	5.5
69	McGillivray	51.6	53.4	83.0	67.6	12,040	6,210	51.6	530	4.4	3,500	29.0	840	7.0	190	0.8	860	7.2
78	"	56.6	58.6	85.6	67.6	12,100	6,590	56.6	510	4.2	2,330	19.0	1,530	12.7	80	0.7	820	6.8
112	Hillcrest, seam	60.5	62.5	97.0	64.9	12,830	7,760	60.5	560	4.4	1,950	15.2	490	3.5	250	2.0	1,850	14.4
105	"	60.6	62.7	96.7	65.7	12,840	7,780	60.6	560	4.4	2,070	16.1	520	4.1	200	1.5	1,710	13.3
108	"	58.2	60.2	96.3	63	12,810	7,480	58.2	580	4.6	2,840	22.1	610	4.5	70	0.5	1,760	9.8
67	Bellevue	49.8	51.7	94.2	55.2	11,790	5,870	49.8	510	4.3	3,770	32.0	750	6.3	190	0.9	790	6.7
80	"	52.8	54.8	92.3	59.6	12,080	6,390	52.8	490	4.1	2,620	24.2	980	8.1	90	0.7	1,210	10.1
68	Greenhill	54.2	56.1	95.4	58.8	13,140	7,120	54.2	530	4.0	3,680	28.0	580	4.4	100	0.8	1,130	8.6
81	"	56.4	58.3	94.0	62.4	13,040	7,330	56.4	590	3.9	3,110	23.9	810	6.3	80	0.6	1,170	8.9
70	Frank	50.2	52.1	91.7	57.0	11,910	5,960	50.2	560	4.1	3,400	28.5	1,090	8.4	90	0.8	950	8.0
79	"	51.8	53.7	87.9	61.1	12,130	6,300	51.8	560	3.8	3,140	25.8	1,410	11.6	90	0.8	750	6.2
100	Chinook	54.5	57.4	91.2	61.1	10,210	5,570	54.5	610	6.0	1,250	12.2	590	5.8	630	6.2	1,560	15.3
101	"	52.2	54.9	95.7	58.1	10,210	5,330	52.2	680	6.6	1,910	19.0	530	5.2	690	6.8	1,040	10.2
71	Machine-peat from Alfred, Ont.	19.3	53.1	97.1	54.9	8,670	3,980	49	720	8.9	1,960	21.6	240	3.0	300	3.8	930	11.4
72	"	47.0	51.3	96.4	53.9	8,670	3,840	47.0	730	9.0	1,590	19.7	370	4.6	430	5.3	1,110	13.8
77	"	50.5	54.8	97.8	56.8	7,590	3,830	50.5	730	9.7	1,640	21.6	240	3.2	260	4.0	720	15.2
83	"	48.8	52.9	99.8	53.0	7,730	3,770	48.8	790	9.8	1,490	18.9	230	6.3	560	7.2	1,160	15.2
84	"	38.9	48.8	99.7	52.5	7,370	3,630	48.8	750	9.9	1,330	17.9	50	0.7	560	7.4	1,230	16.1
85	"	38.0	42.2	99.6	42.5	7,710	3,060	38.9	770	10.0	1,090	13.7	50	0.6	1,270	16.0	1,600	20.8

"Combustible" means "Ash and Moisture-Free Fuel".

GENERAL REMARKS.

Trial No. 59: Jasper Park.—This fuel cakes considerably and it was necessary to break up the fuel bed frequently during the trial. The fire was cleaned twice during the trial, the clinker was in small pieces, and it was difficult to separate it from the coal when cleaning.

Trial No. 75: Jasper Park.—The fire was cleaned twice during the trial; it was sliced frequently to counteract the caking tendency of the fuel. The clinker was easily removed, it neither spread nor adhered to the bars.

Trials Nos. 59 and 75.—A comparison of the results of these trials shows that the grate bars with the smaller air space as used in trial 59 to be better adapted for this fuel.

Trial No. 113: Mountain Park.—The fire was cleaned twice during the trial, and raked frequently to break up the fuel bed and counteract the caking tendencies of the fuel. The clinker was in small pieces and would pass through a shaking grate. Considerable quantities of smoke were given off.

Trial No. 107: Mountain Park.—The fire was cleaned twice during the trial, and sliced three times; the clinker was in small pieces which were easily removed. The coal caked and it was necessary to break it up with a rake from time to time. Considerable heavy black smoke was given off.

Trial No. 108: Mountain Park.—The fire was cleaned once during the trial; it was raked frequently to counteract the caking tendency of the coal. Considerable quantities of smoke were given off.

Trials Nos. 107, 108, and 113.—There is very little difference in the economical results of these three trials. The evaporation per pound of fuel was as high as 7.91 when the boiler steamed $1\frac{1}{2}$ times as rapidly as during the remaining two trials when the evaporation was 7.99. This small difference in evaporation was unusual, since at the higher rate of steaming the flue gas loss is considerably increased, and it is to be accounted for by the more complete combustion of the fuel at the higher rate of steaming.

Trial No. 60: Yellowhead Pass.—The fire was cleaned twice during the trial; the clinker spread over the bars, and was removed in fairly large pieces. Considerable quantities of black smoke were given off after firing, which soon cleared off.

Trial No. 74: Yellowhead Pass.—The fire was cleaned twice during the trial and sliced three times; the clinker spread over the bars, but there was no difficulty about its removal.

Trials Nos. 60 and 74.—A comparison of the results of both trials shows that they were both carried out at the same rate of fuel consumption per square foot of grate. There was very little difference in the net result; with the larger air space in the bars (Trial 74) the grate efficiency was lower. This loss was almost entirely counteracted by the smaller excess of air (column 62). Both efficiencies are high (column 83), compared with similar trials on this boiler.

Trial No. 55: Pembina.—See report No. 331.

Trial No. 52: Cardiff.—See report No. 331.

Trial No. 53: Twin City.—See report No. 331.

Trial No. 58: Drumheller.—Steam-raising with this fuel was rendered difficult by the rapid formation of clinker which spread over the bars and

obstructed the air supply. The clinker had to be removed on nine separate occasions during the trial, and the fire was frequently sliced to raise the clinker off the bars. Very little smoke was observed.

Trial No. 76: Drumheller.—The fire was cleaned six times during the trial, this was necessary on account of clinker spreading over the bars. On refiring after cleaning considerable quantities of fuel passed through the wide air spaces, which accounts for the low grate efficiency.

Trials Nos. 58 and 76.—A comparison of the results of both trials shows the smaller air space between the bars (trial 58) to have been better adapted for this fuel, which consists principally of very small particles which passed in large quantities through the wider bars when refiring after cleaning. During both trials much labour was necessary for the removal of clinker from the grate bars. The fuel burned with very little smoke.

Trial No. 61: Newcastle.—The fire was cleaned twice during the trial; there was very little trouble with the clinker, most of which would have passed through a shaking grate. A fairly dense black smoke was given off.

Trial No. 111: Midland.—The fire was cleaned twice and raked or sliced occasionally. The clinker, which was in large, thin slabs, was easily pried off the bars with a slice bar. Very little smoke was given off. The flue gas during this trial was analysed for methane and hydrogen and gave the following results. Methane 0.1 per cent and hydrogen 0.1 per cent. This represents a loss due to unburnt hydrogen and hydro-carbons of 190 B.Th.U. per pound of fuel fired or 2.0 per cent of its gross calorific value.

Trial No. 103: Midland.—Occasional slicing was necessary, owing to a thin clinker which spread over the bars. There was little trouble in removing this clinker, which was easily broken up. The fire was cleaned twice during the trial. A small amount of light smoke was given off.

Trial No. 102: Midland.—This fuel formed a clinker which spread over the bars, requiring occasional slicing; it was broken up easily and removed without difficulty. The fire was cleaned twice during the trial. A small amount of light smoke was given off.

Trials Nos. 102, 103, and 111.—The use of a larger grate and smaller air spaces in trial 111 led to more economical results than those obtaining in trial 103, due to more perfect combustion of the solid and gaseous components and products. This was partially due to the admission of air over the bars. Unless special precautions are taken, a fairly large quantity of unburnt gases will pass off with the flue gases when burning this fuel.

Trial No. 51: Rosedale.—See report No. 331.

Trial No. 114: Bankhead.—The fire was cleaned three times during this trial, and sliced once. The small air spaces between the bars were not suited to this coal since practically all the refuse had to be removed from above the bars, which meant a poor grate efficiency (column 84) due to the large amount of unburnt fuel removed with the refuse (columns 41 and 43). See also remarks for trial 109.

Trial No. 109: Bankhead.—This coal is rather difficult to handle on an ordinary fixed grate owing to the formation of large pieces of clinker which do not pass through the bars. It is probable that much of the clinker would be removed before it collects into large pieces were a shaking grate used. After removing the refuse when cleaning the fire it was difficult to ignite the fresh fuel, also some of the fuel passed through the bars before the formation of a new bed of fuel. The fire was cleaned twice during the trial and sliced four times. The clinker stuck to the bars at first, but stuck

less after blowing some steam beneath the bars. Practically no smoke was observed.

Trial No. 110: Bankhead.—Clinker formed in the fire in large pieces, and adhered to the bars a little, this adhesiveness was reduced by passing steam beneath the bars with the air supply. The fire was cleaned twice and sliced twice during the trial. Very little smoke was given off.

Trials Nos. 109, 110, and 114.—From Table IV it will be observed that trial 110 was carried out at a much higher rate of steaming (see column 75) than the remaining two trials which were carried out at practically the same rate. A comparison of the two latter trials (109 and 114) shows the results of 109 to be the better, which is to be attributed to the use of a grate with wider air openings than those used for trial 114, which reduced the quantity of refuse to be removed from above the bars, this refuse was so intermingled with the fuel that it was impossible to remove it without removing fuel with it.

Trial No. 54: Georgetown.—See report No. 331.

Trial No. 77: Georgetown.—The fire was cleaned twice, and sliced three times during the trial. The clinker was in medium size pieces and did not spread, though it was found occasionally to be sticking very slightly. Practically no smoke was given off.

Trials Nos. 77 and 54.—For the purpose of comparison a summary of the results of trial 54, (see Report No. 331) has been reproduced above. In this trial fire bars with a smaller air space were used which suited this coal better than the fire bars used in the subsequent trial (77). The loss in efficiency (columns 78 and 83) is seen to be due to the large amount of fuel which escaped unburnt (columns 49 and 84), this loss however was partially counteracted by the reduced excess air supply (columns 62 and 92) due probably to the larger air openings in the fire bars during trial 54.

Trial No. 69: A. Gillivray.—The fire was cleaned twice during the trial, and sliced about once every hour to break up the fuel, which caked considerably. The clinker consisted principally of small pieces which were easily removed. Considerable quantities of smoke were emitted. (See also trial No. 78.)

Trial No. 78: McGillivray.—The fire was cleaned twice during the trial, when the clinker, which consisted of small pieces, was easily removed. Owing to the caking tendency of the fuel it was necessary to frequently break up the fire with the rake or slice bar. A shaking grate is recommended for this coal. Considerable quantities of black smoke were emitted. (See also trial 69.)

Trials Nos. 69 and 78.—Fire bars with $\frac{1}{2}$ -inch air space were used for trial 78 and $\frac{1}{4}$ -inch air space for trial 69. The larger air spaces enabled the ash to pass to the ash-pit more readily, consequently less draft was required to burn the fuel, and the excess air (column 62) was reduced considerably, thereby decreasing the flue gas loss and improving the overall efficiency in spite of the reduction in grate efficiency due to the wider air spaces.

Trial No. 112: Hillcrest.—The fire was cleaned twice during this trial, and the fuel bed was frequently broken up with the rake or slice bar to counteract its caking tendency. (See also general notes for trial 105). The flue gas during this trial was analysed for methane and hydrogen and gave the following results in percentages: methane 0.1; hydrogen 0.1. This represents a loss due to unburnt hydrogen and hydro-carbons based

on the gross calorific value of the fuel as fired of 2.0 per cent, or 250 B.Th.U. per pound of fuel fired.

Trial No. 105: Hillcrest.—The fire was only cleaned once during the trial; the clinker was in small, hard pieces, which were rather difficult to separate from the coal in cleaning. A shaking grate would improve the operation of a boiler with this fuel. The coal caked together, which necessitated frequent breaking up in order to allow the air to pass through. A considerable quantity of black smoke was emitted.

Trial No. 106: Hillcrest.—The fire was cleaned once during the trial, and broken up with the slice bar or rake frequently. (See also general notes for trial 105).

Trials Nos. 105, 106, and 112.—A comparison of the results of trials Nos. 105 and 112, during which the same rate of evaporation prevailed, shows that the efficiencies were almost identical. The wider air spaces used during trial 112, however, are preferable, since it is easier to remove refuse from the ash-pit than from above the bars.

Trial No. 67: Bellevue.—The fire was cleaned three times during the trial; the refuse removed from above the bars was in small pieces which would have easily passed through a shaking grate. Owing to the small air space in the bars, the high ash content of the fuel, and because the fuel caked, difficulty was experienced in keeping up the rate of evaporation. A shaking grate would have undoubtedly improved the boiler efficiency and reduced the labour involved in tending the fire. It was necessary to frequently break up the fire with the slice bar. A considerable quantity of black smoke was observed.

Trial No. 80: Bellevue.—The fire was cleaned twice during the trial, and broken up four times to counteract the slight caking tendency of the fuel. The operation was much improved over that of trial 67, by using bars with a wider air space, which permitted more of the ash to pass through the bars.

Trials Nos. 67 and 80.—Wider air spaces between the fire bars were used for trial 80, which reduced the grate efficiency, but improved the efficiency as a whole by decreasing the surplus air supply.

Trial No. 68: Greenhill.—The fire was cleaned twice during the trial, the refuse consisting mostly of small, soft dirt, easily removed. A considerable amount of black smoke was emitted.

Trial No. 81: Greenhill.—The fire was cleaned twice during the trial. The refuse removed contained a few hard pieces of clinker. A shaking grate would be suitable for this fuel. A small amount of air was admitted over the bars through the grills in the fire door. A considerable quantity of black smoke was given off.

Trials Nos. 68 and 81.—Burning the coal over larger air spaces between the fire bars (Trial 81) was a more economical method than using a larger grate area and smaller air spaces, owing to a smaller excess of air supply, the gain due to which was partially offset by a poorer grate efficiency.

Trial No. 70: Frank.—This coal cakes a great deal, and had to be broken up frequently during the trial. The fire was cleaned twice during the trial; the refuse was in small soft pieces, most of which would be removed by means of a shaking grate. A fair amount of black smoke was emitted.

Trial No. 79: Frank.—This coal cakes a great deal, and the fuel bed was sliced frequently to enable the air to pass through it. The fire was

cleaned twice during the trial; the refuse removed consisted of soft dirt, which was removed easily. A fair amount of black smoke was given off.

Trials Nos. 70 and 79.—For trial 70 the fuel was burned on a larger grate with smaller air spaces than for trial 79. The results for the latter trial will be seen to be the better, in spite of a lower grate efficiency. By comparison with other fuels burned under similar conditions the overall efficiency (column 83) is rather low.

Trial No. 100: Chinook.—A thin clinker spread over the bars; it did not stick and was easily broken up. The fire was cleaned twice, and sliced six times. Owing to the high carbon monoxide content of the flue gas, air was admitted through the fire doors, in spite of which the loss due to unburnt gases was high. A fairly dense, chocolate-coloured smoke was given off.

Trial No. 101: Chinook.—This fuel was burnt at a much greater rate than in the previous trial. The clinker spread over the bars and was sticking to them a little; on blowing a small amount of steam in with the air the conditions were improved and the clinker no longer adhered to the bars. Air was admitted through the fire door to burn some of the carbon monoxide. Considerable smoke was emitted.

Trials Nos. 100 and 101.—This fuel was used for two trials, one at the normal rate of steaming, and the other (101) when the boiler was forced. The efficiencies were fairly good; the loss due to unburnt gases was very high. A specially large furnace and properly arranged supplementary air supply would probably mean an increase in efficiency of three or four per cent by providing means for the combustion of these gases.

Trial No. 71: Machine Peat.—Air was admitted over the bars during most of the trial. Dense rather light-coloured smoke was emitted. There was no clinker. The fire was cleaned twice during the trial.

Trial No. 72: Machine Peat.—Air was admitted over the bars. Dense light-coloured smoke was given off.

Trial No. 73: Machine Peat.—Air was admitted over bars. Considerable smoke. Fire cleaned twice during the trial.

Trial No. 83: Machine Peat.—The fire door was kept open during the first part of the trial and the grills were open in the fire door during the whole trial. The flame from the burning peat filled the combustion chamber. A considerable quantity of smoke was given off.

Trial No. 84: Machine Peat.—The peat burnt with considerable flame which filled the combustion chamber, the fire door was kept partially open during most of the trial in order to augment the air supply. A thin fire was maintained. A good deal of smoke was given off.

Trial No. 85: Machine Peat.—The small grill in the fire door was kept open to admit air above the bars. Considerable quantity of smoke was emitted.

Trials 71, 72, 73, 83, 84, 85.—See Bulletin No. 17. The Value of Peat Fuel for the Generation of Steam.

Chart No. 1.

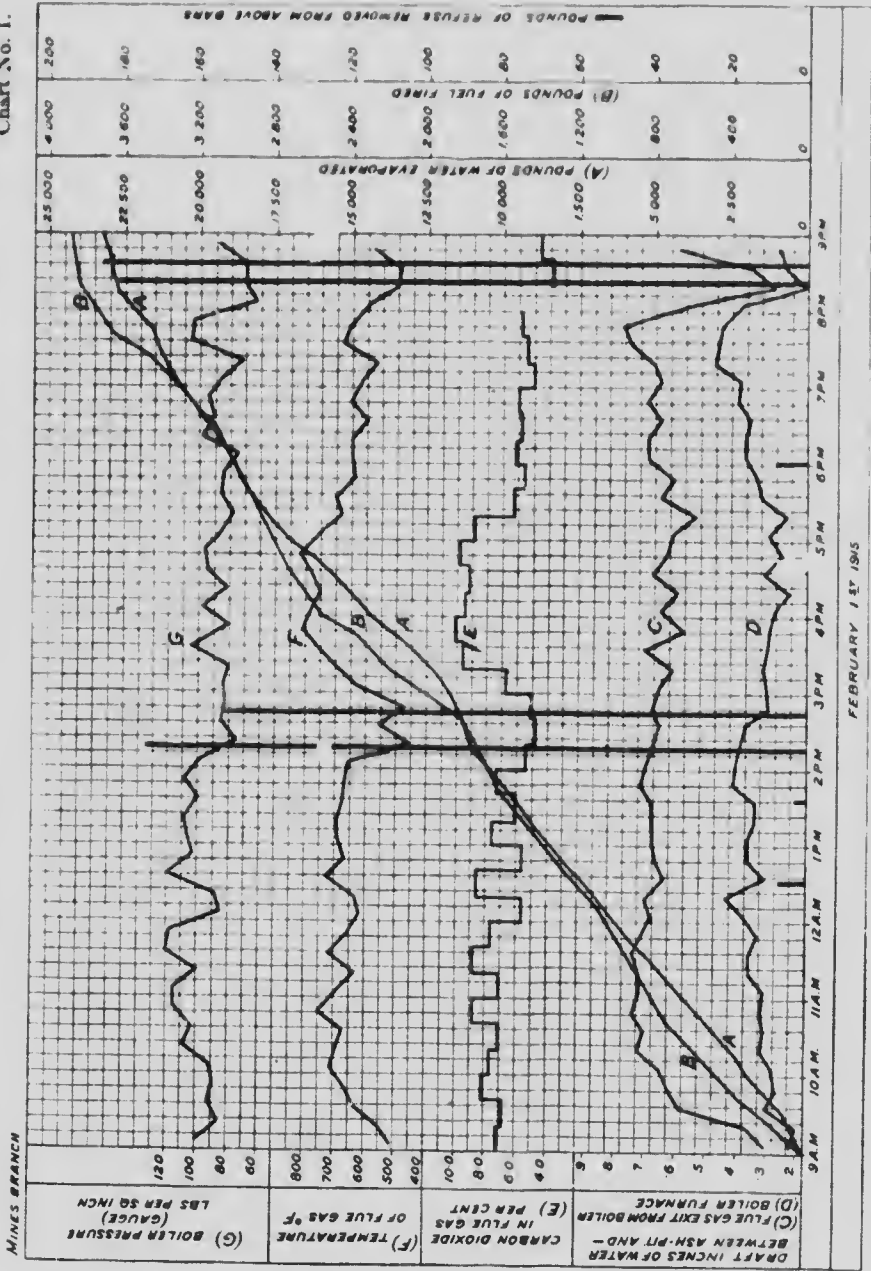
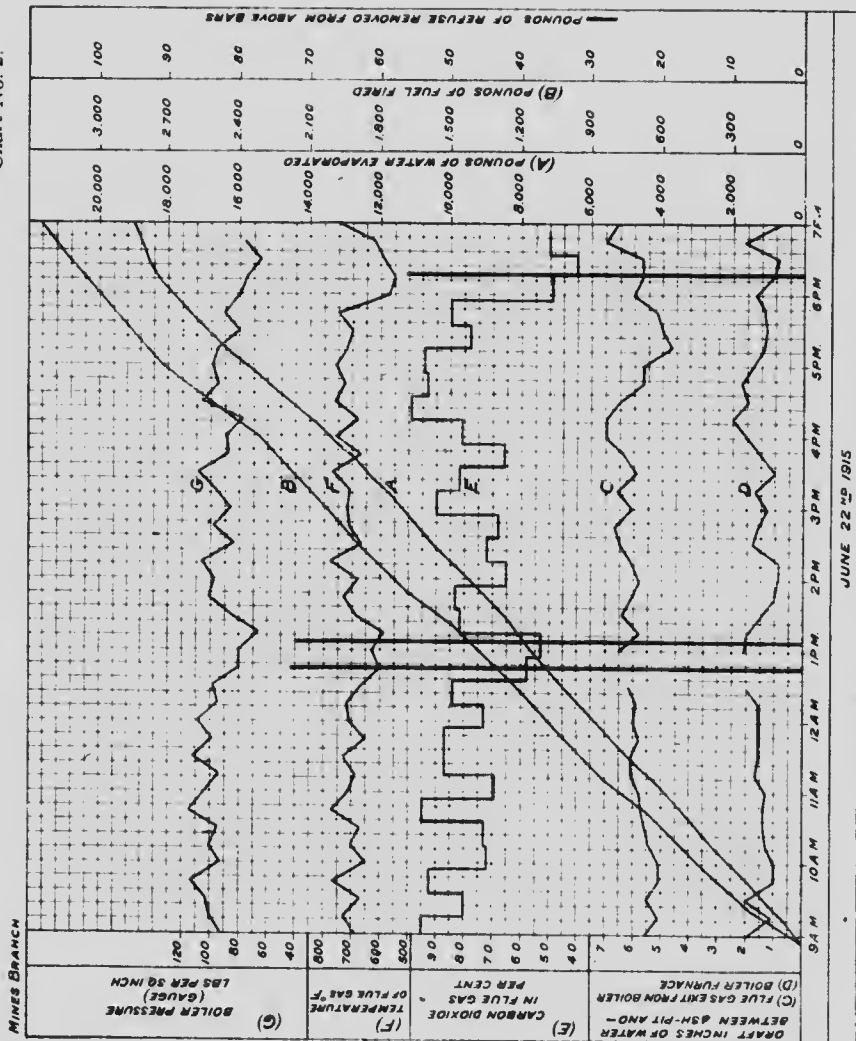
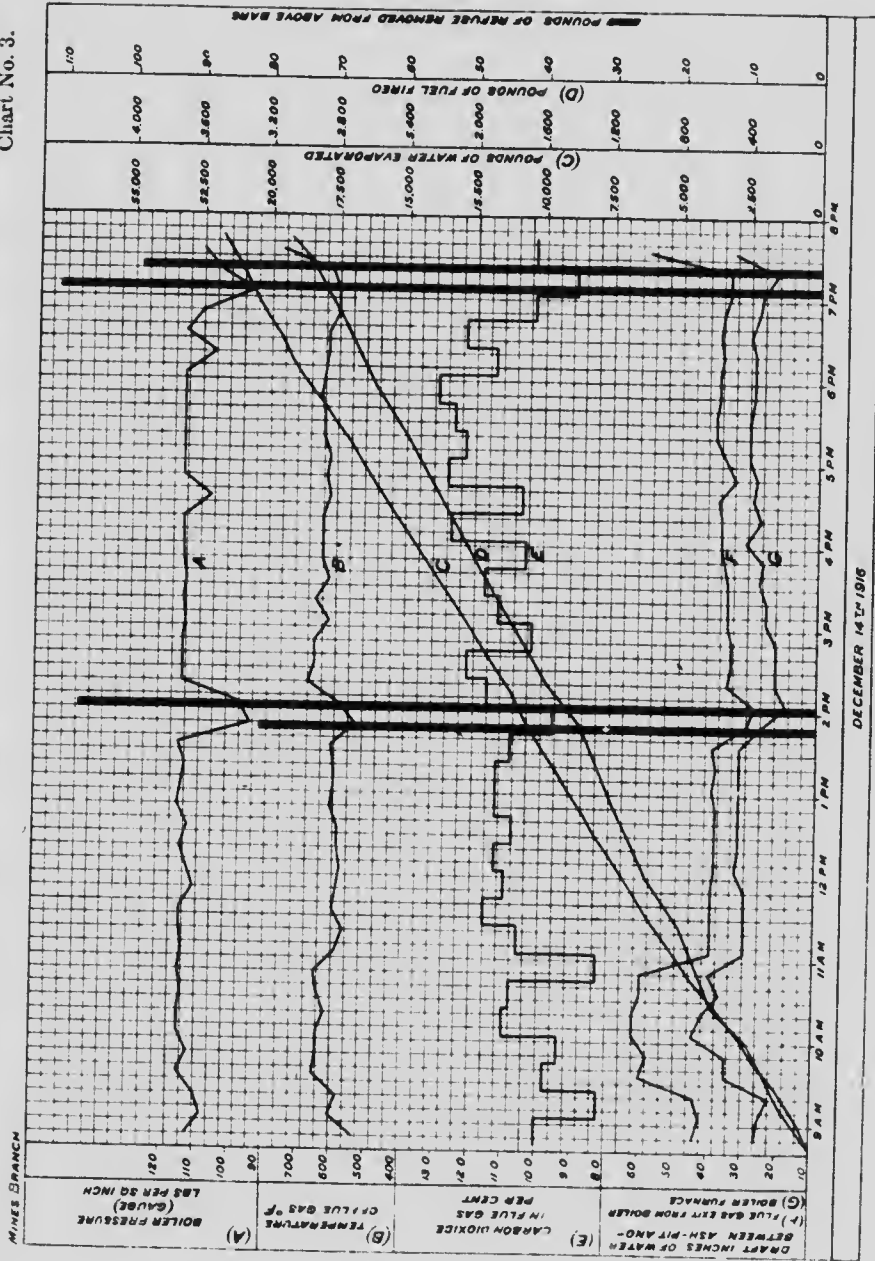


Chart No. 2.



Boiler Trial No. 75: Fuel—Jasper Park Collieries, Ltd.

Chart No. 3.



Boiler Trial No. 113: Fuel—Mountain Park Collieries, Ltd.

Chart No. 4.

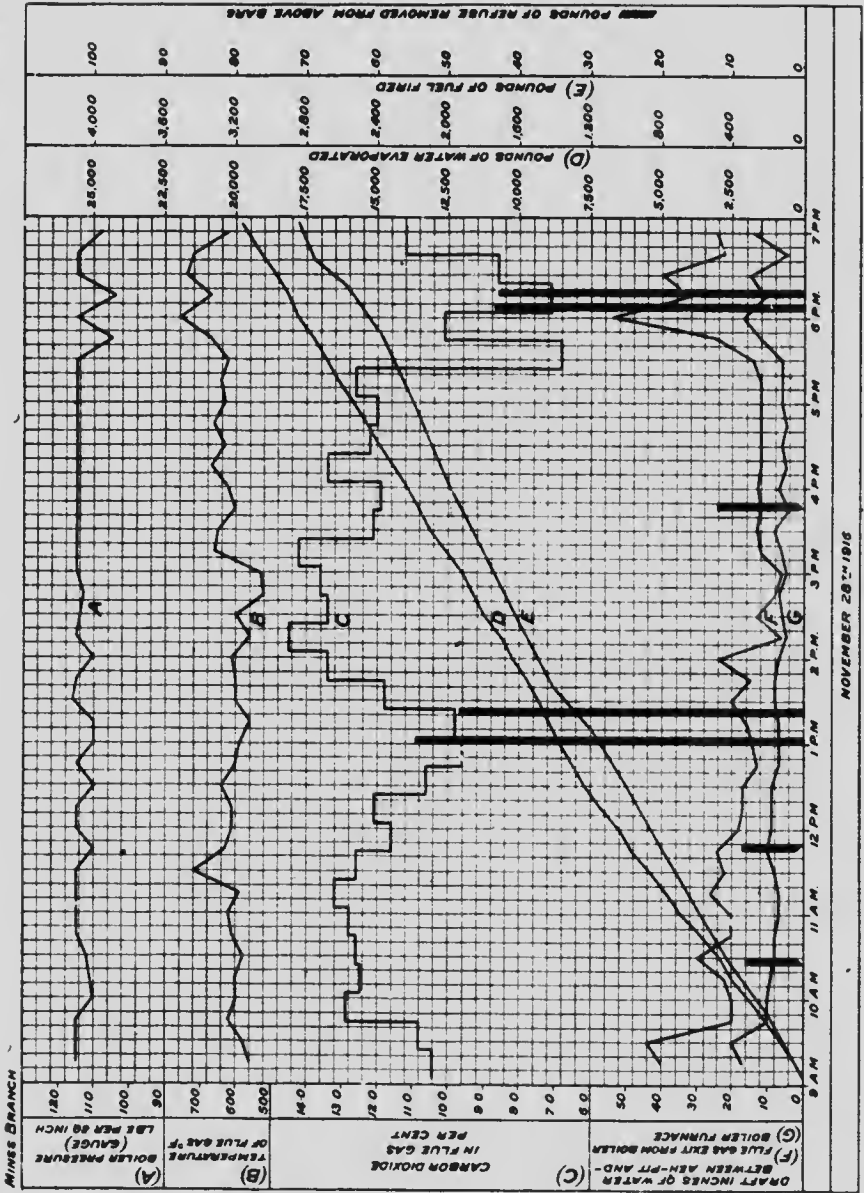
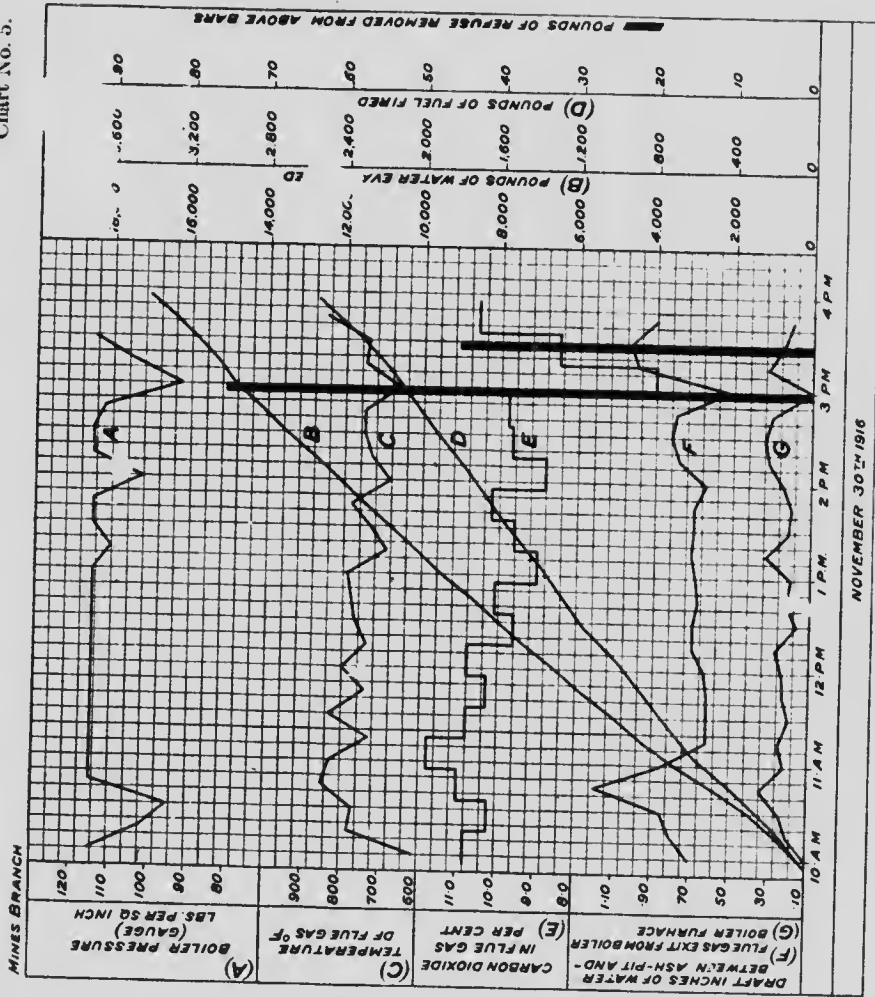


Chart No. 5.



Boiler Trial No. 108: Fuel—Mountain Park Collieries, Ltd.

Chart No. 6.

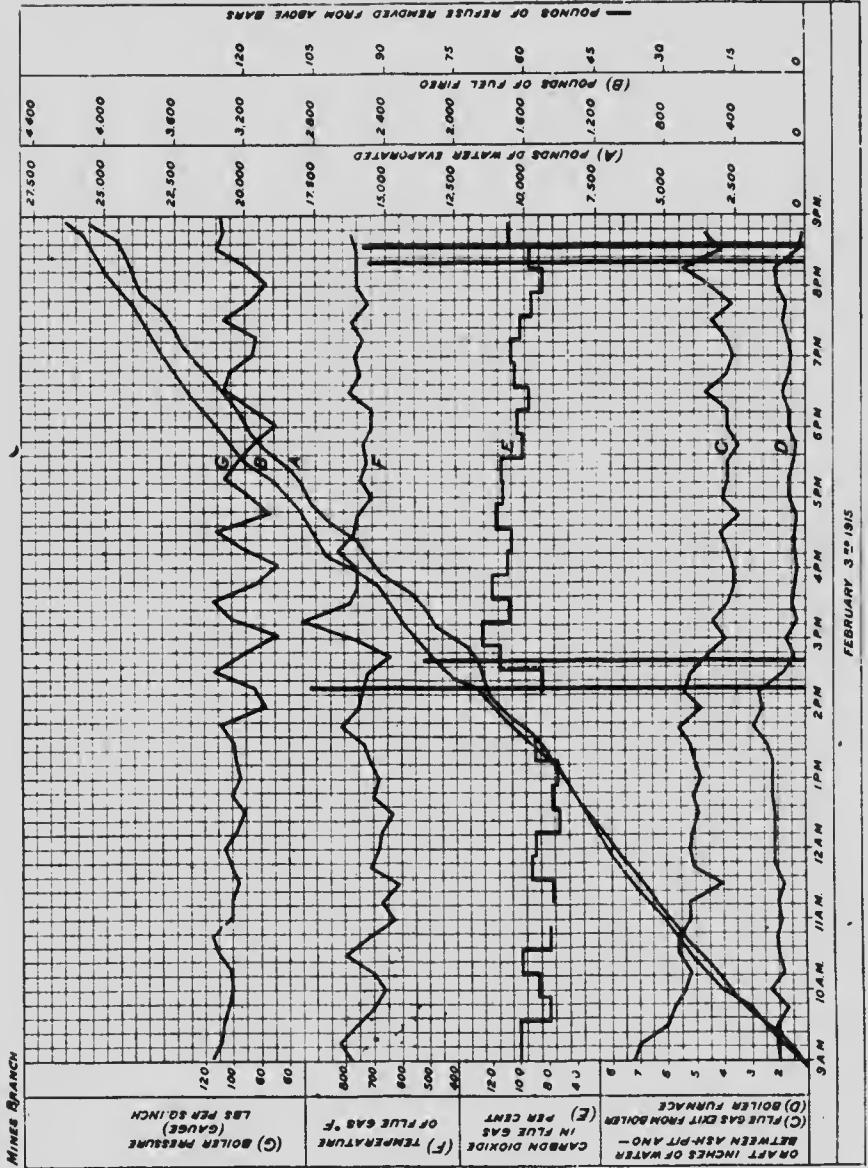
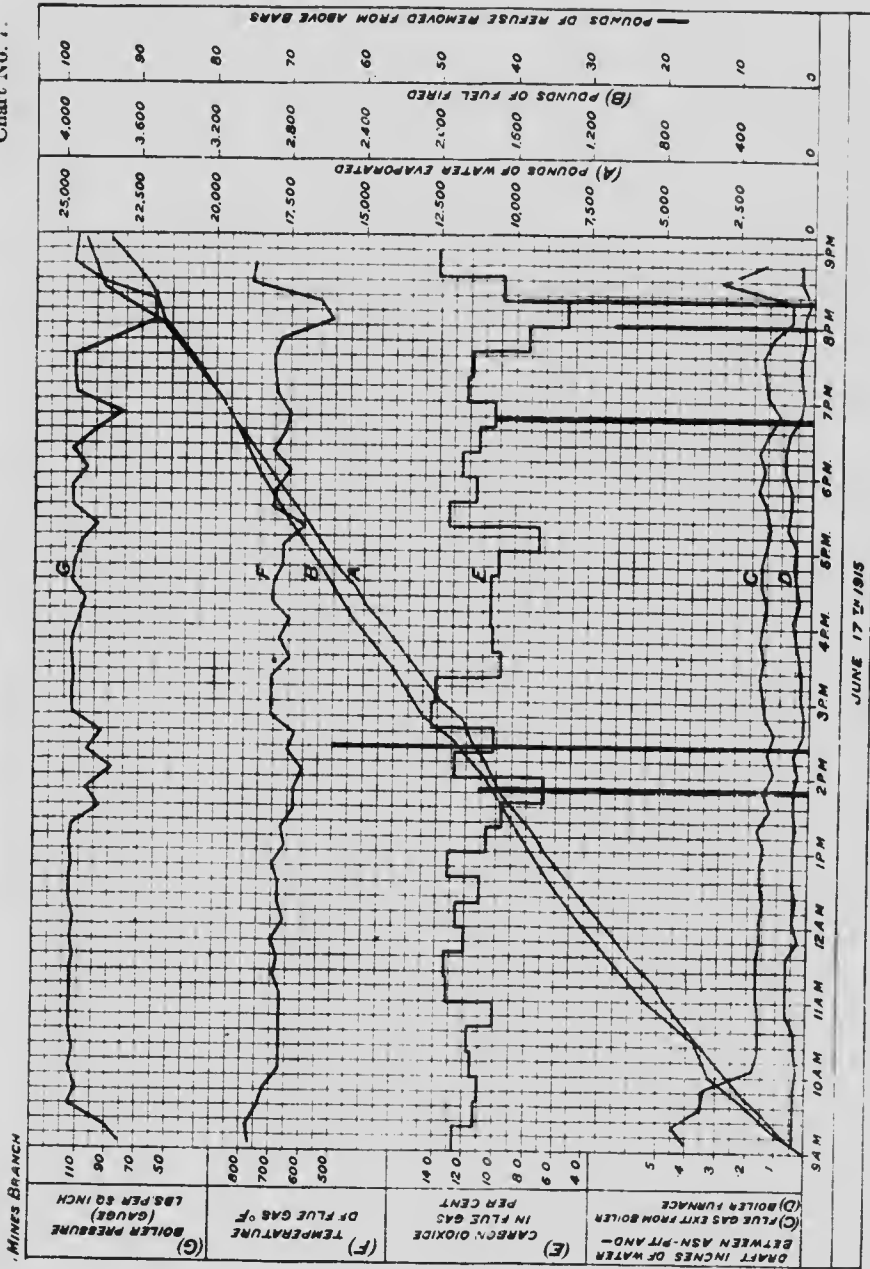
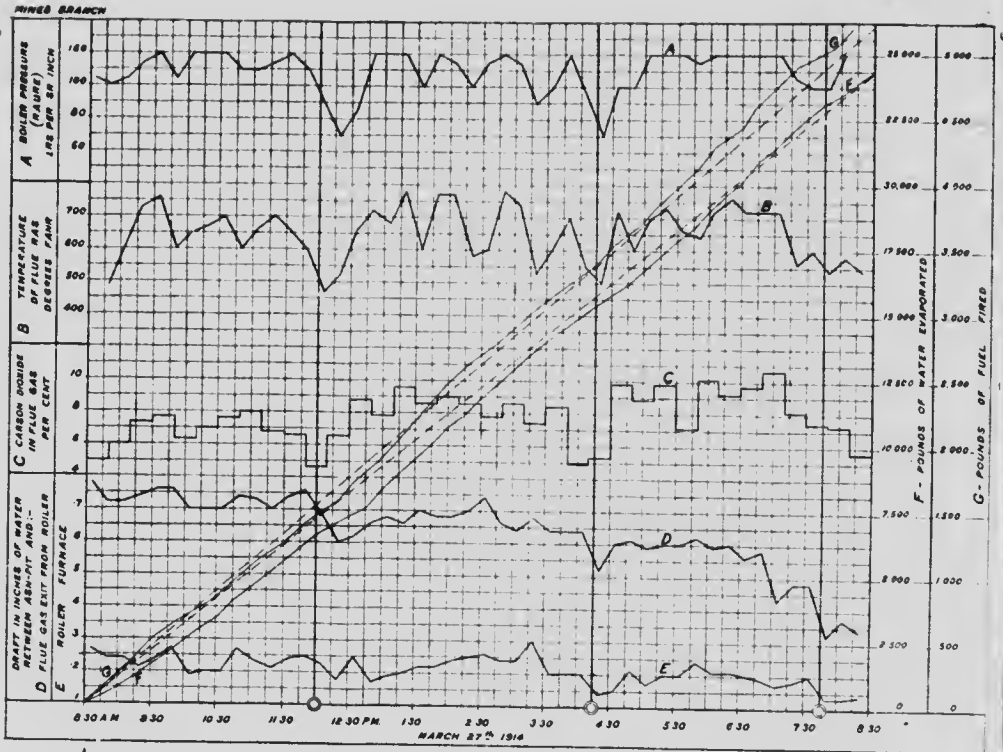


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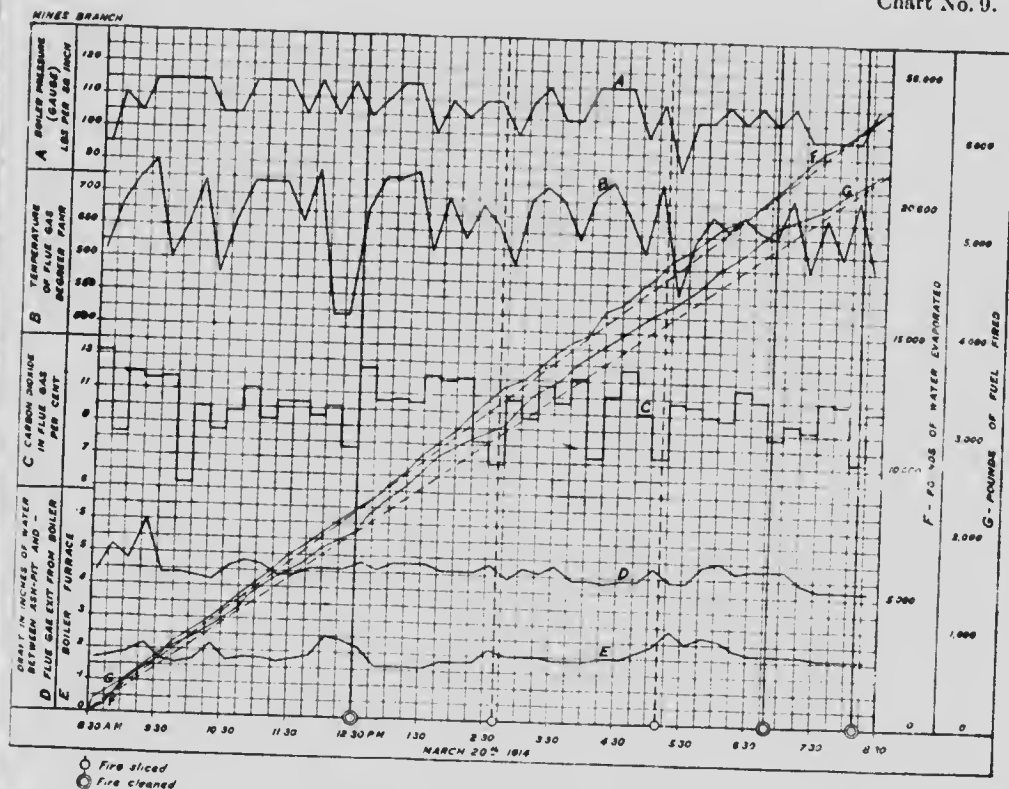
Boiler Trial No. 74: Fuel—Yellowhead Pass Coal and Coke Co., Ltd.

Chart No 8.



Trial No. 55: Fuel—Pembina lignite.

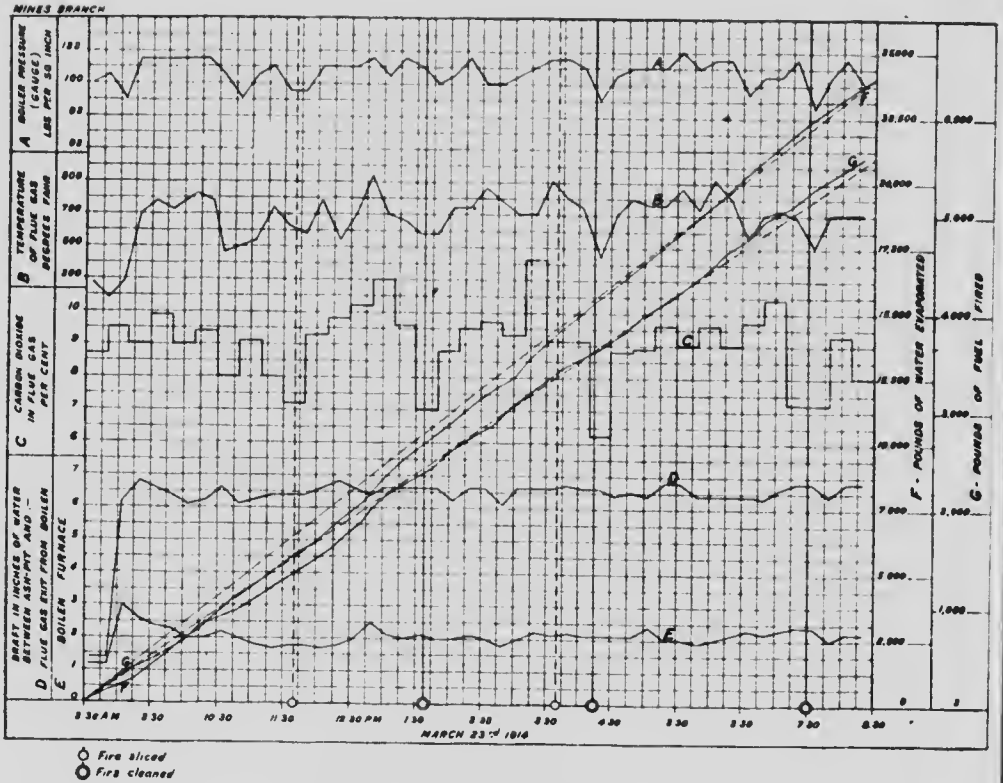
Chart No. 9.



Trial No. 52: Fuel—Cardiff colliery lignite.

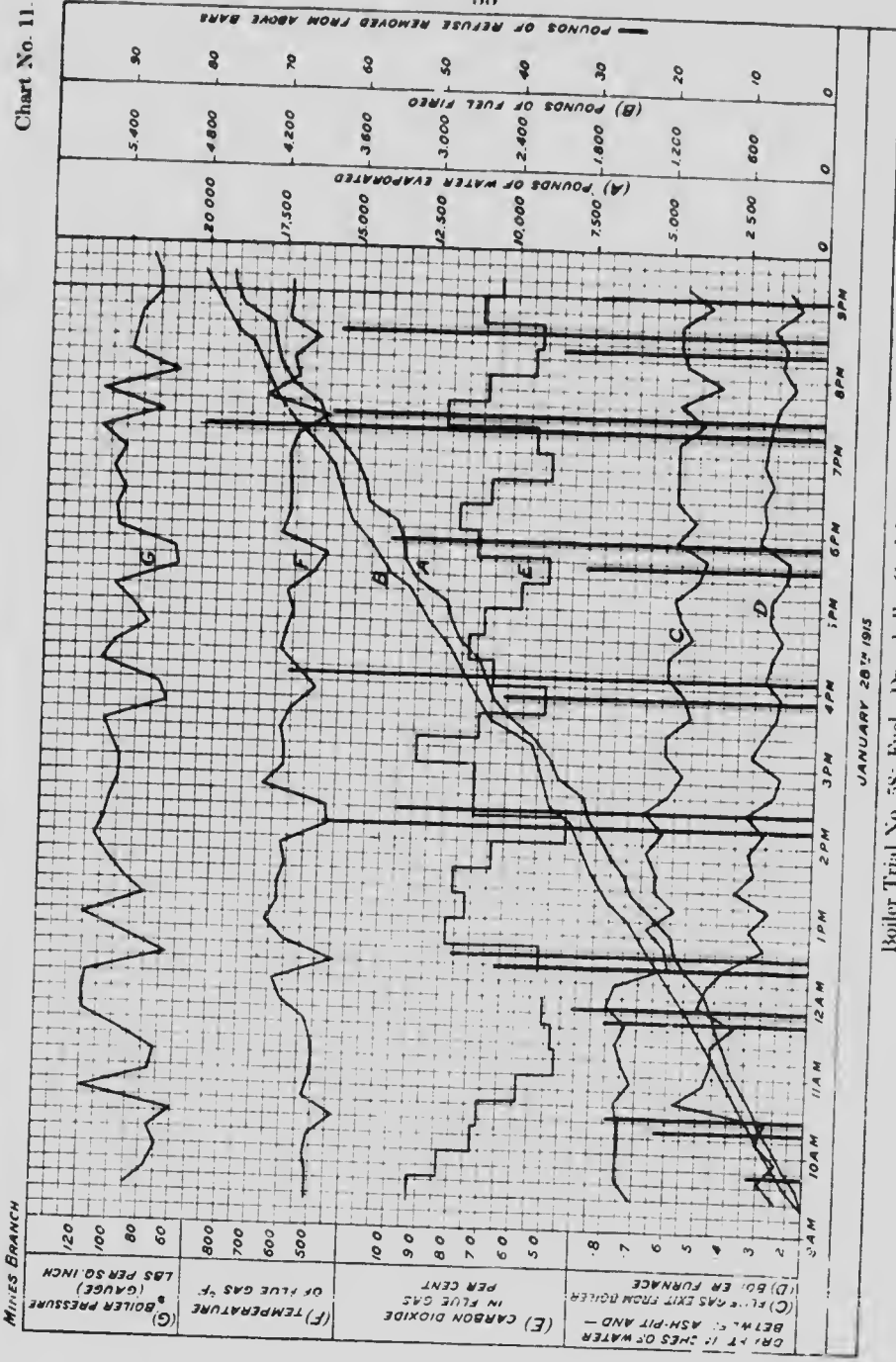
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Chart No. 10.



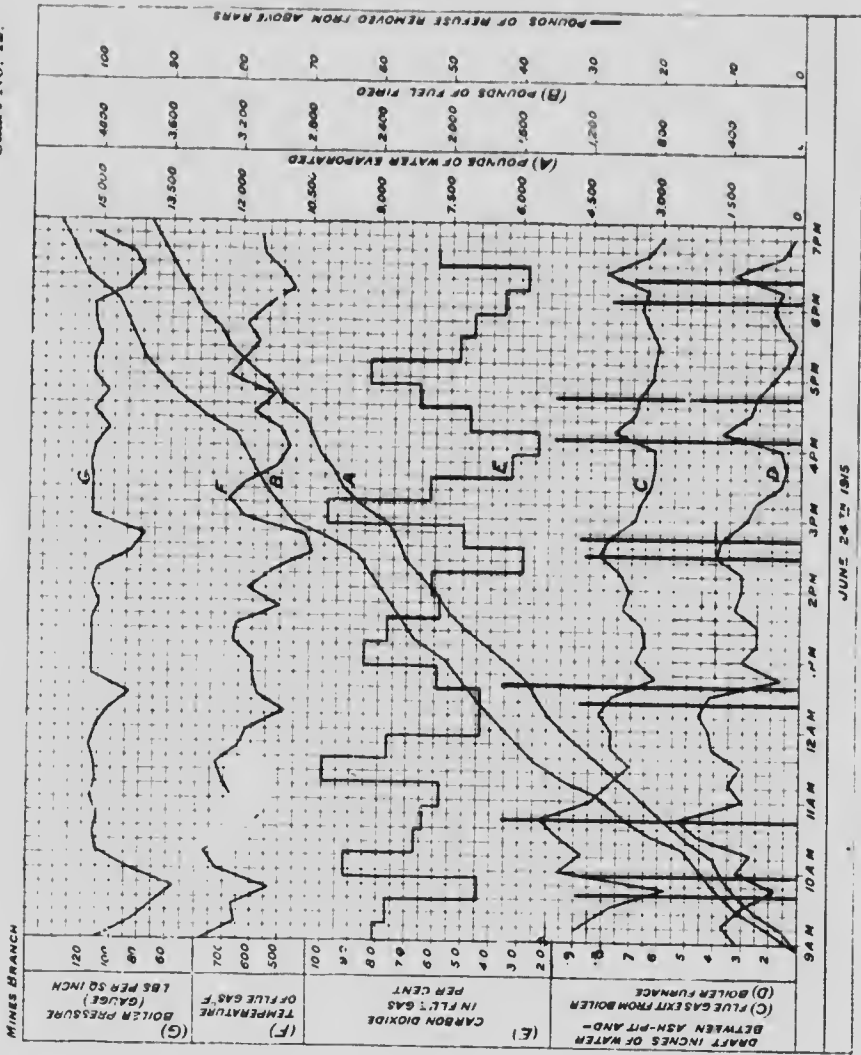
Trial No. 53: Fuel—Twin City lignite.

Chart No. 11.



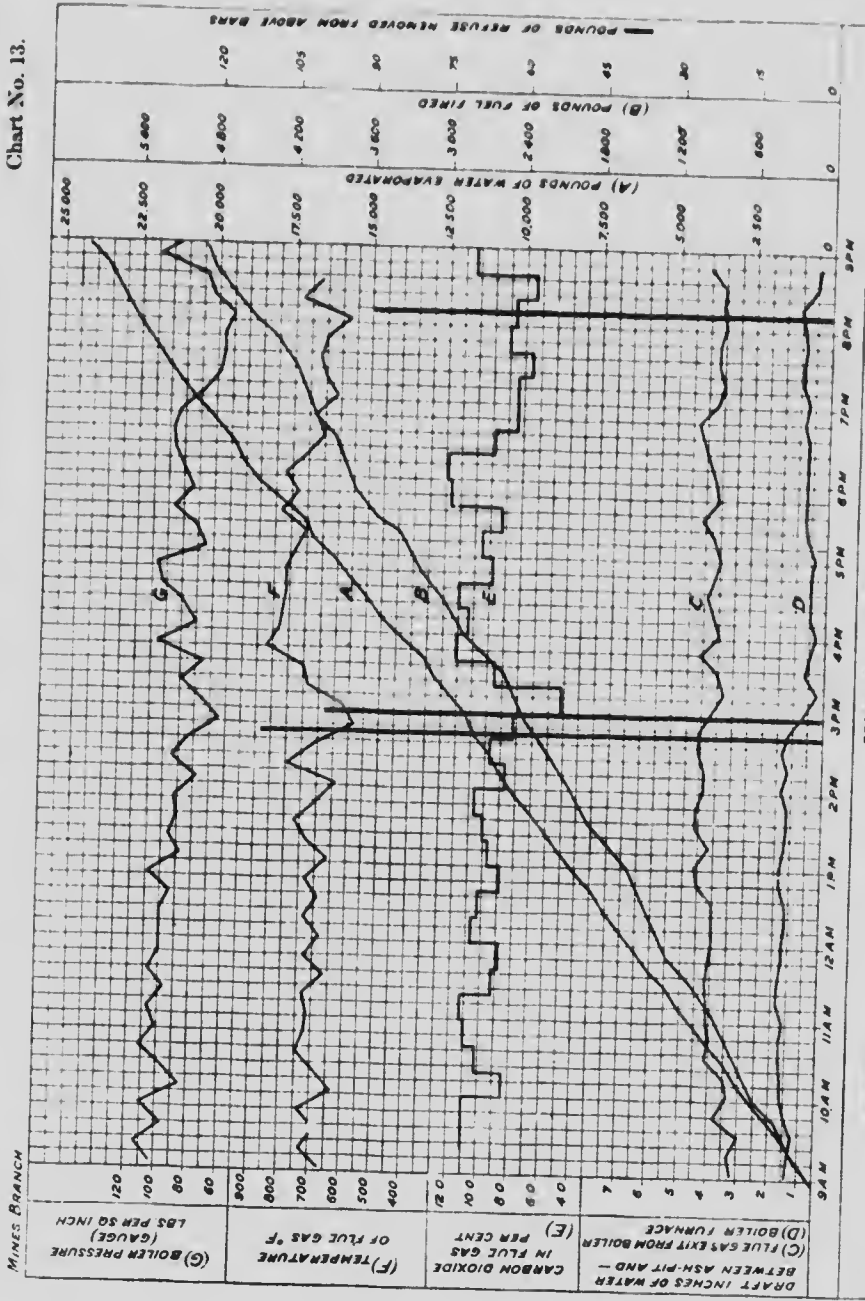
Boiler Trial No. 58: Fuel—Drumheller Coal Co., Ltd.

Chart No. 12.



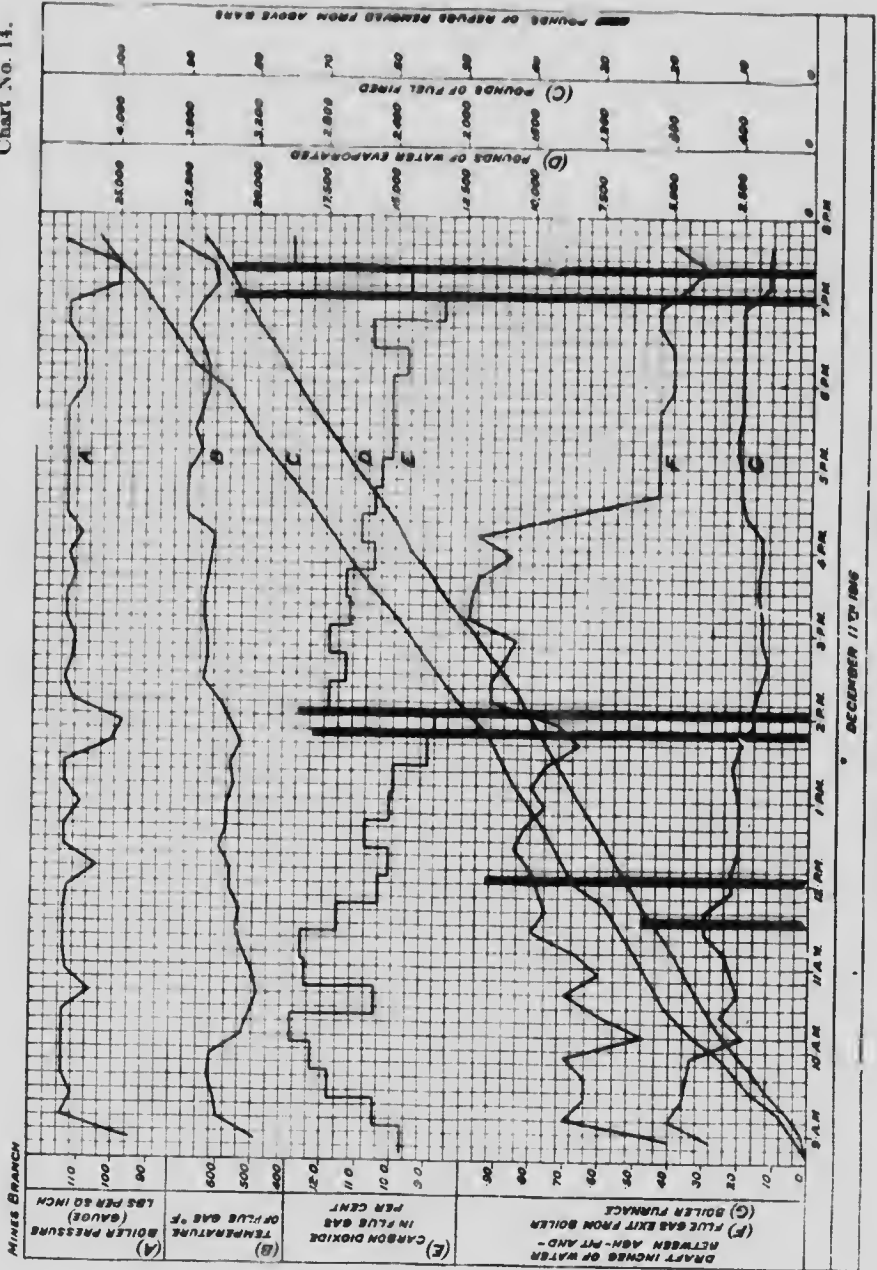
Boiler Trial No. 76: Drumbeller Coal Co., Ltd.

Chart No. 13.



Boiler Trial No. 61: Fuel Newcastle Coal Co., Ltd.

Chart No. 14.



Boiler Trial No. 111: Fuel—Midland Collieries, Ltd.

Chart No. 15.

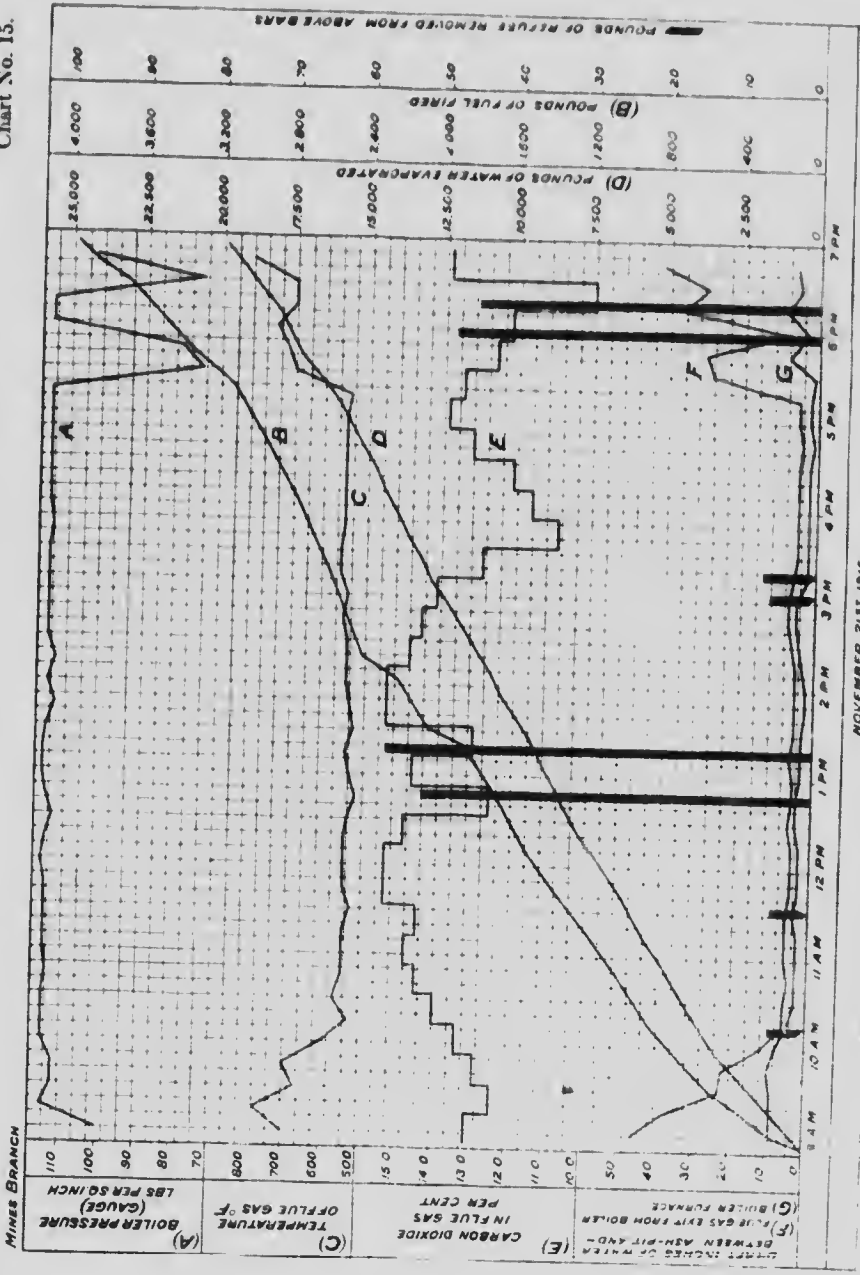
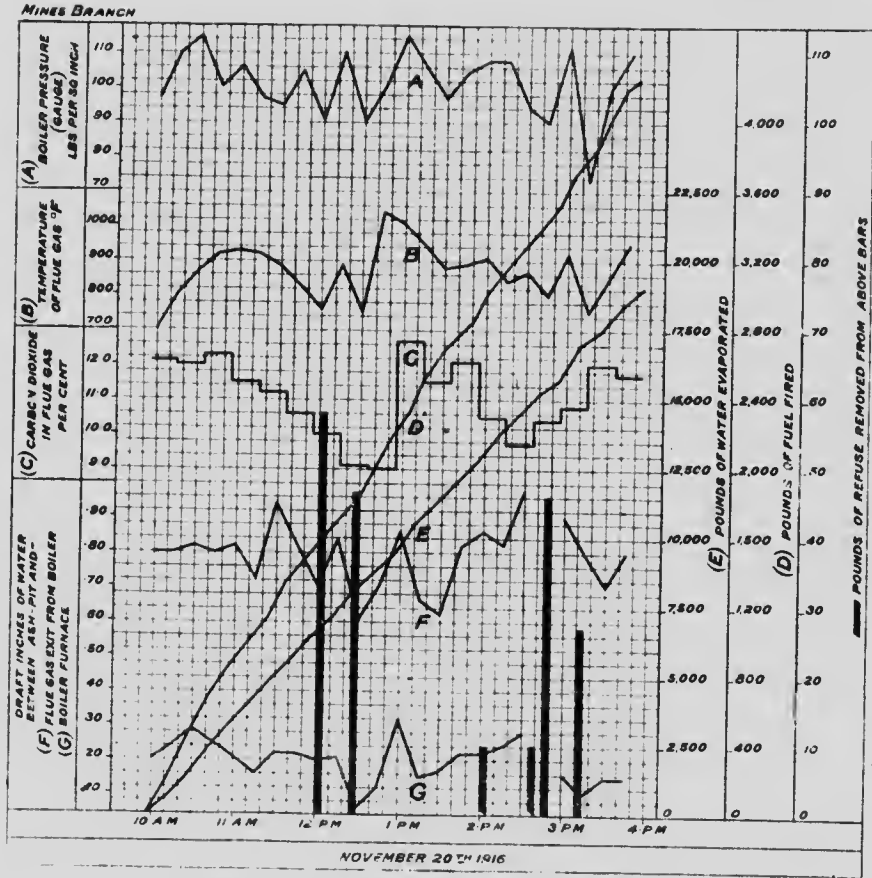
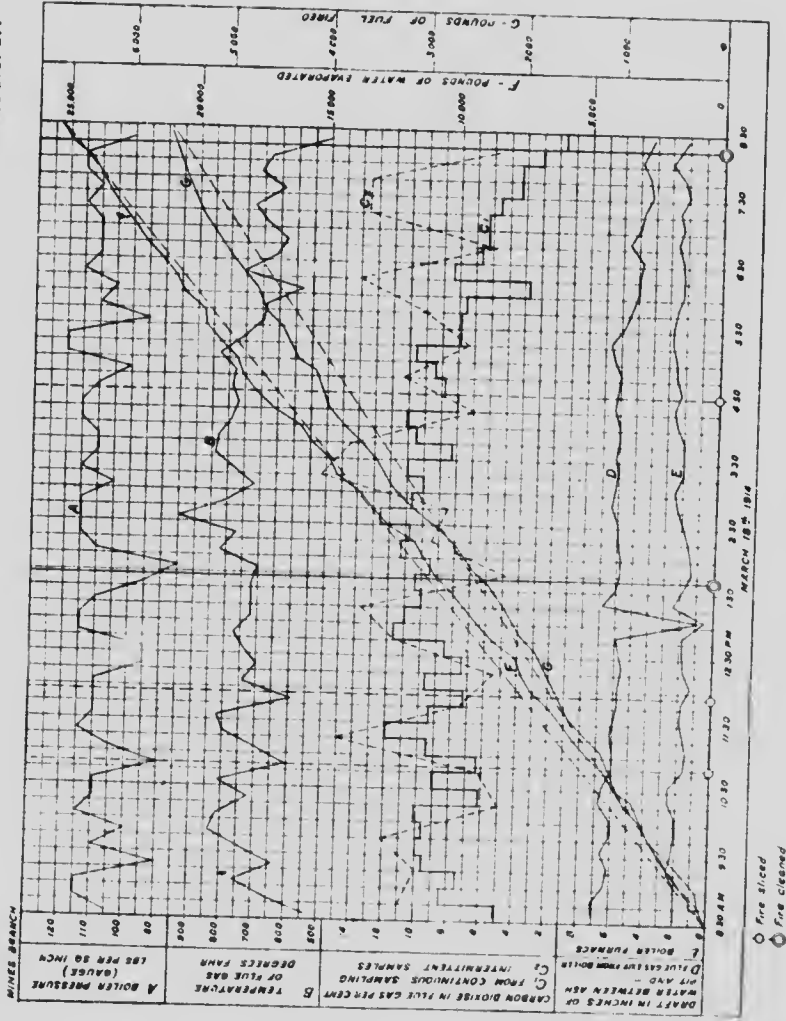


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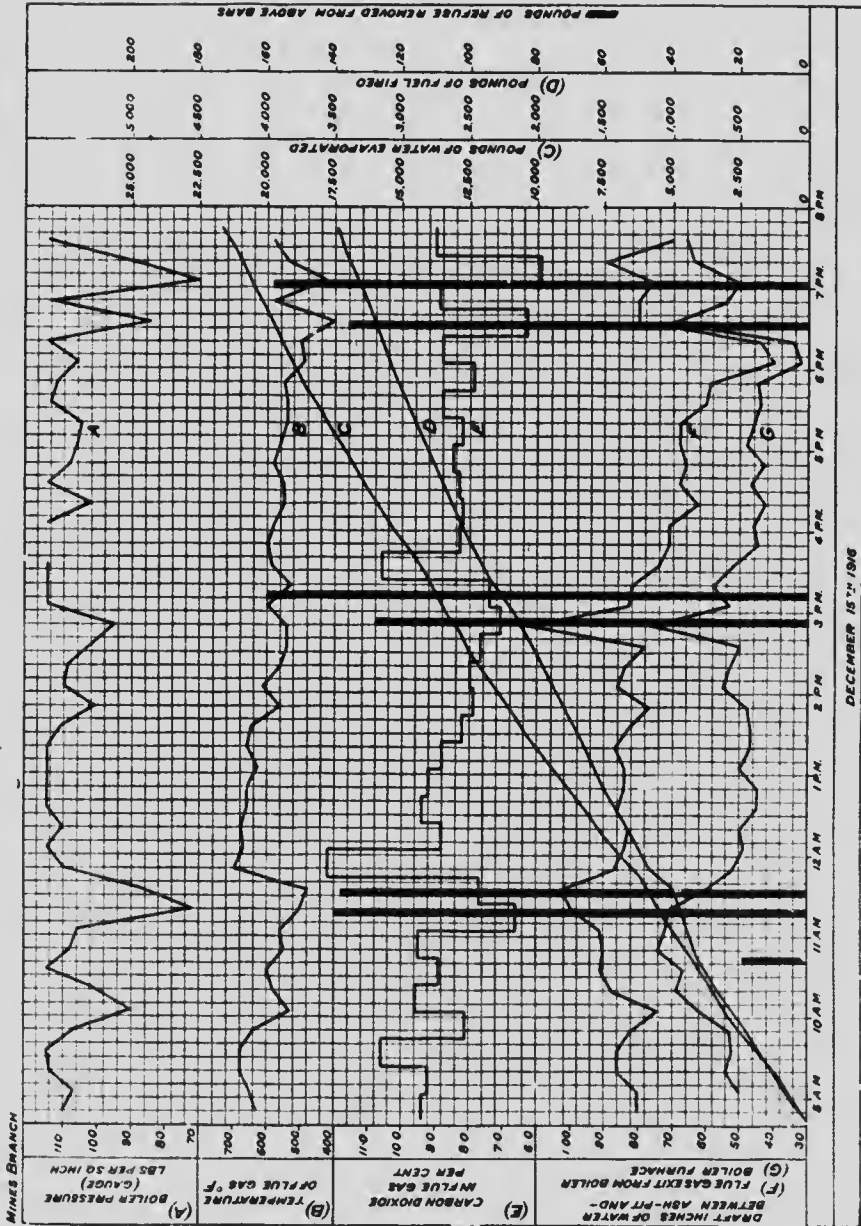
Boiler Trial No. 102: Fuel—Midland Collieries, Ltd.

Chart No. 17.



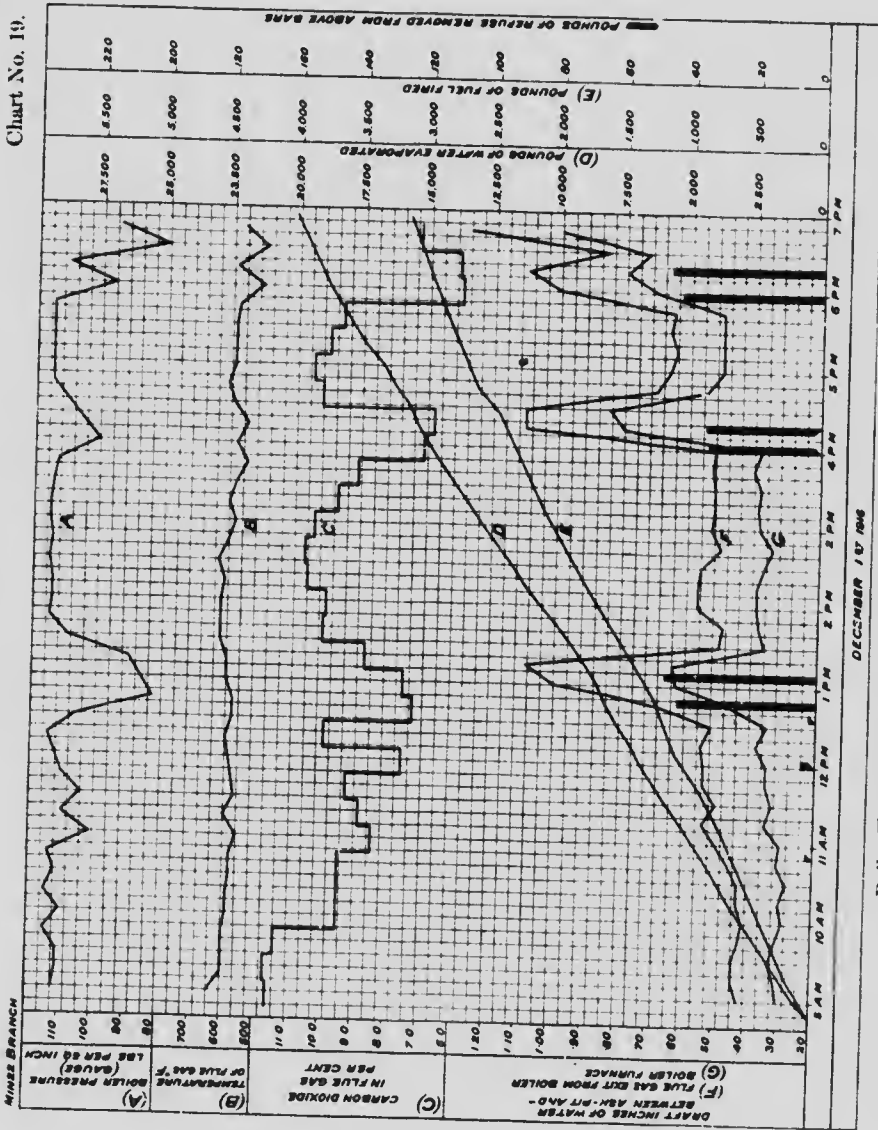
Trial No. 51: Fuel—Rosedale lignite.

Chart No. 18.



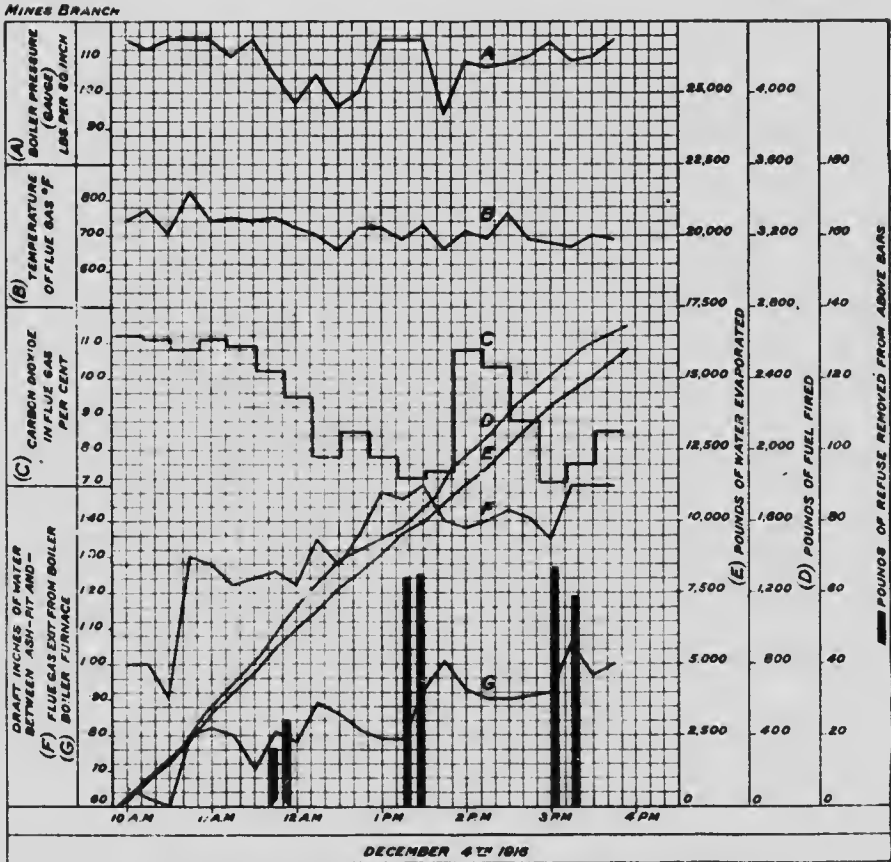
Boiler Trial No. 114: Fuel—Canadian Pacific Railway, Bankhead.

Chart No. 19.



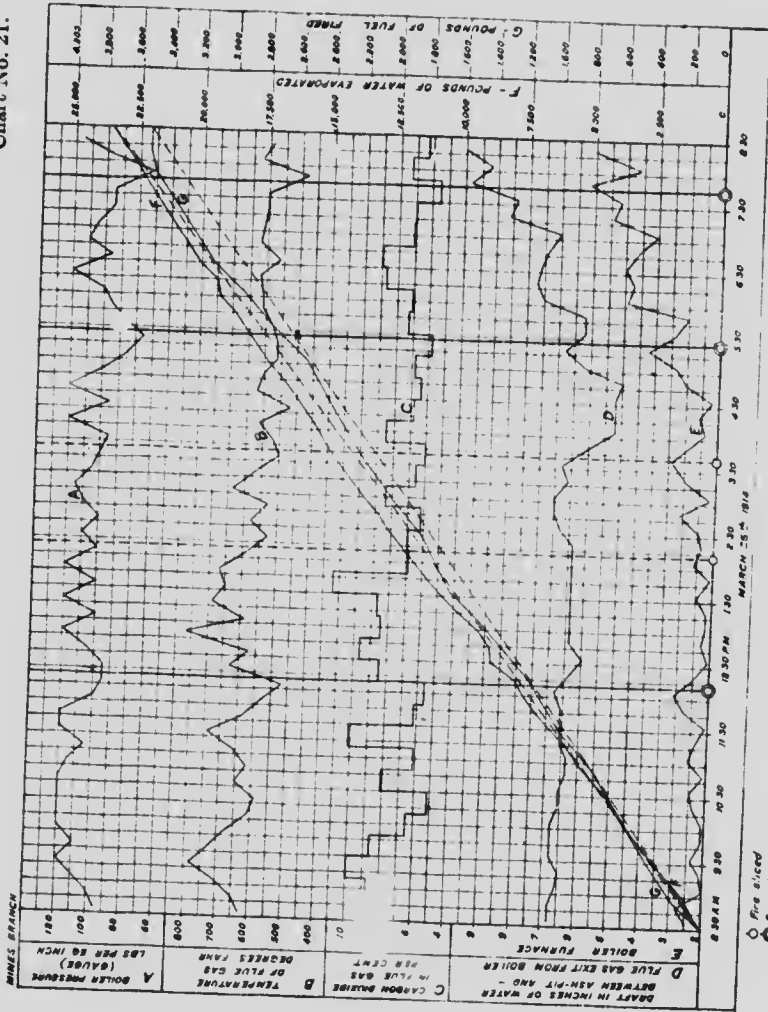
Boiler Trial No. 106; Fuel—Canadian Pacific Railway, Bankhead.

Chart No. 20.



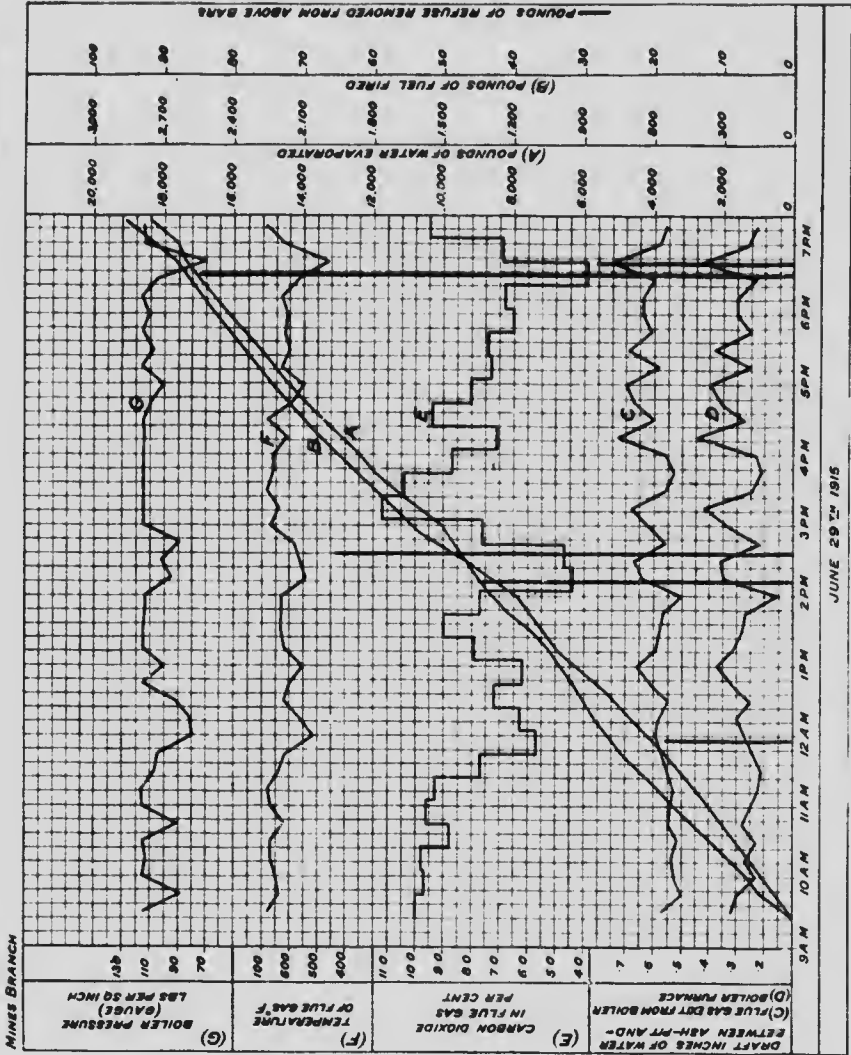
Boiler Trial No. 110: Fuel—Canadian Pacific Railway, Bankhead.

Chart No. 21.



Trial No. 54: Fuel—Cannore Coal.

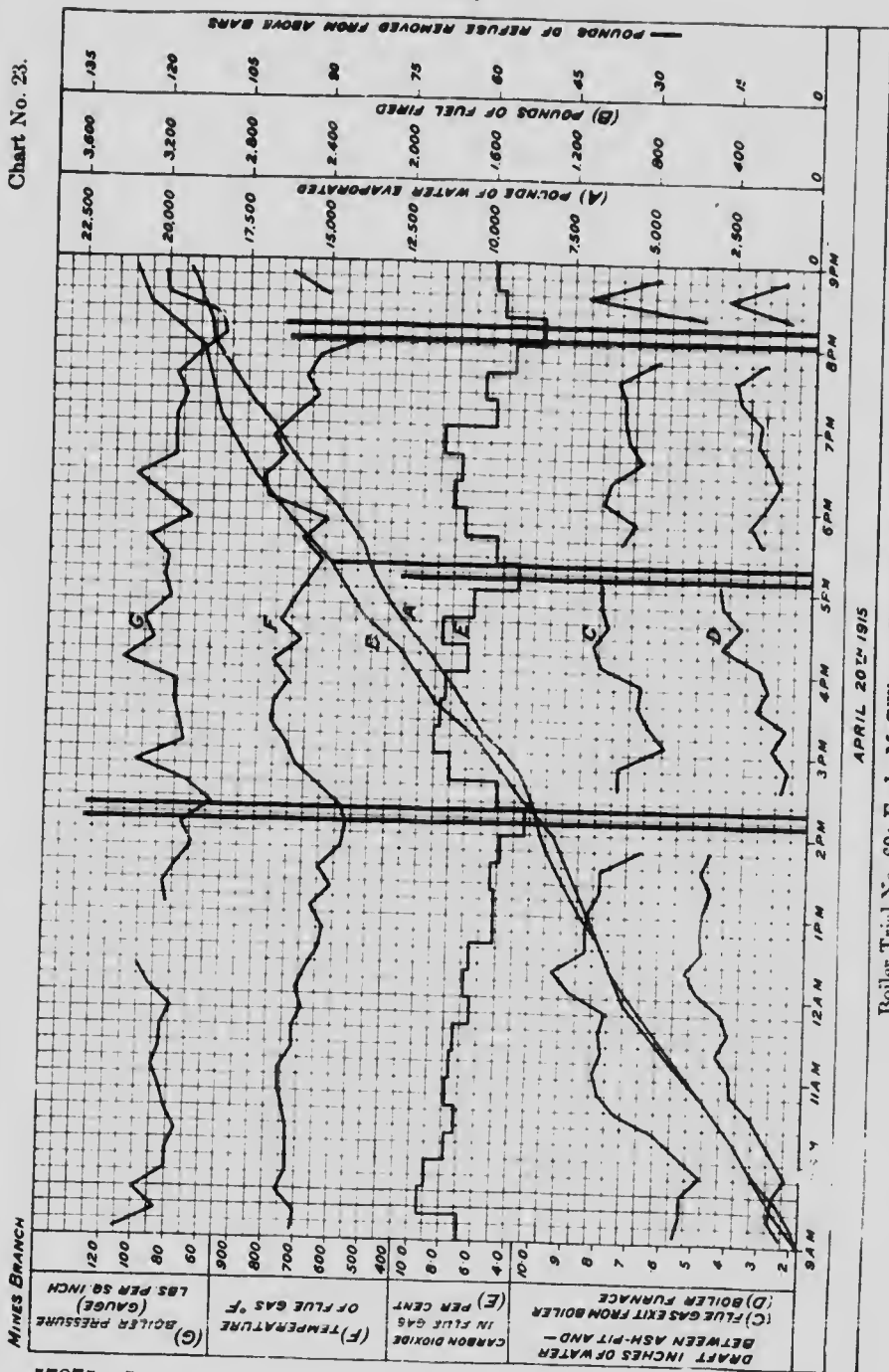
Chart No. 22.



JUNE 25th 1915

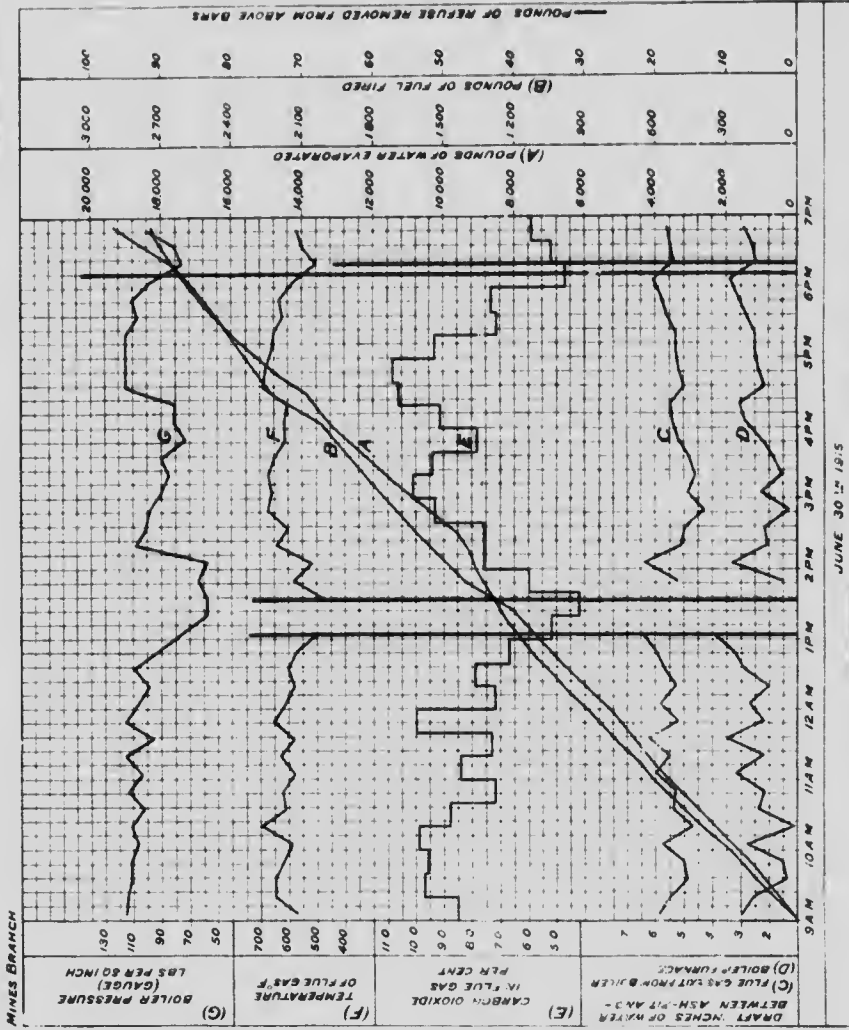
Boiler Trial No. 77: Fuel—Georgetown Collieries, Ltd.

Chart No. 23.



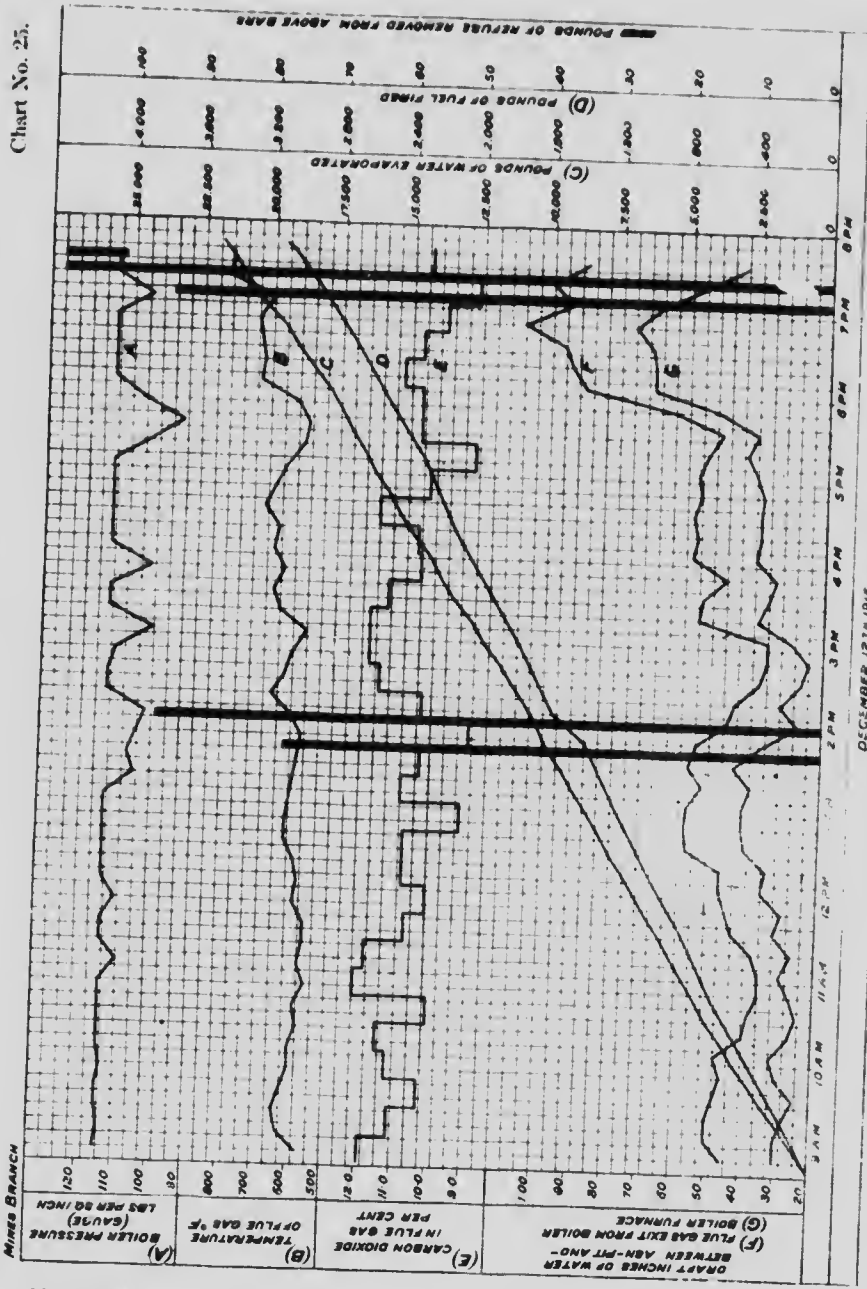
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Chart No. 24.



Boiler Trial No. 78: McGillivray Creek Coal and Coke Co.

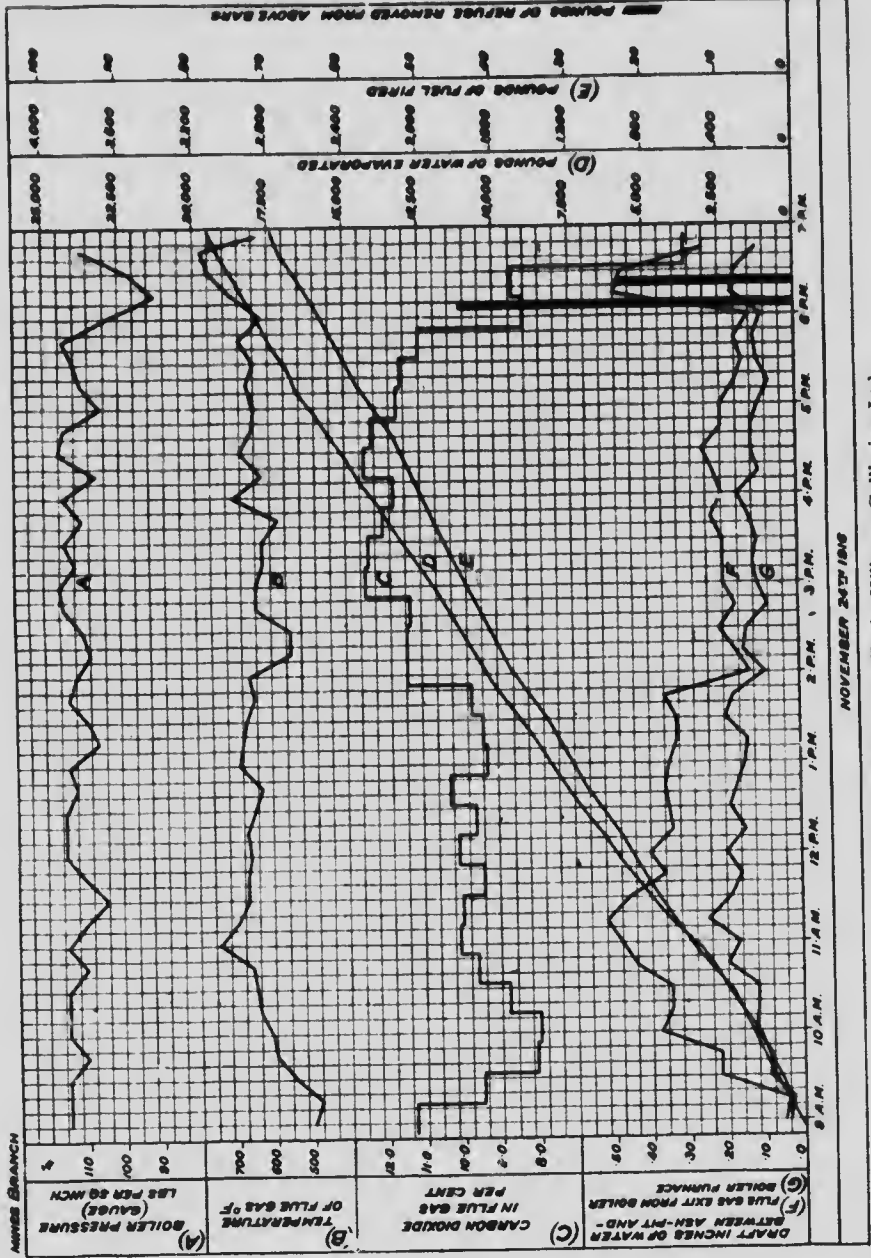
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Boiler Trial No. 112: Fuel—Hillcrest Collieries, Ltd.

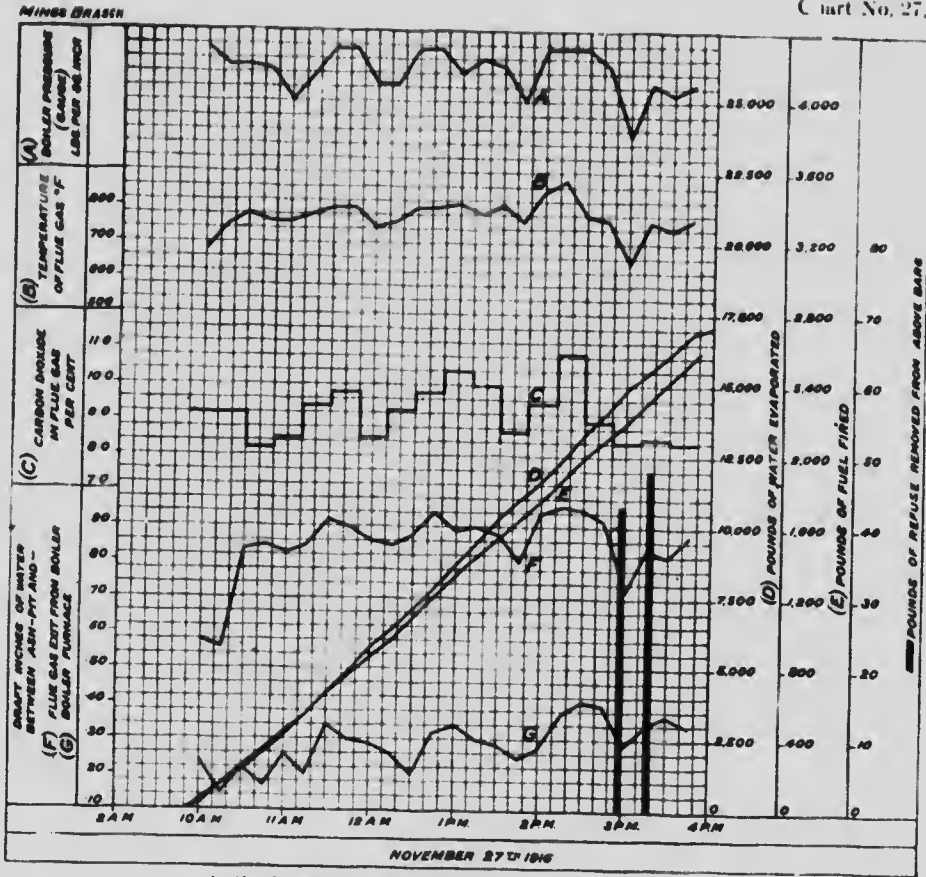
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Char. No. 26.



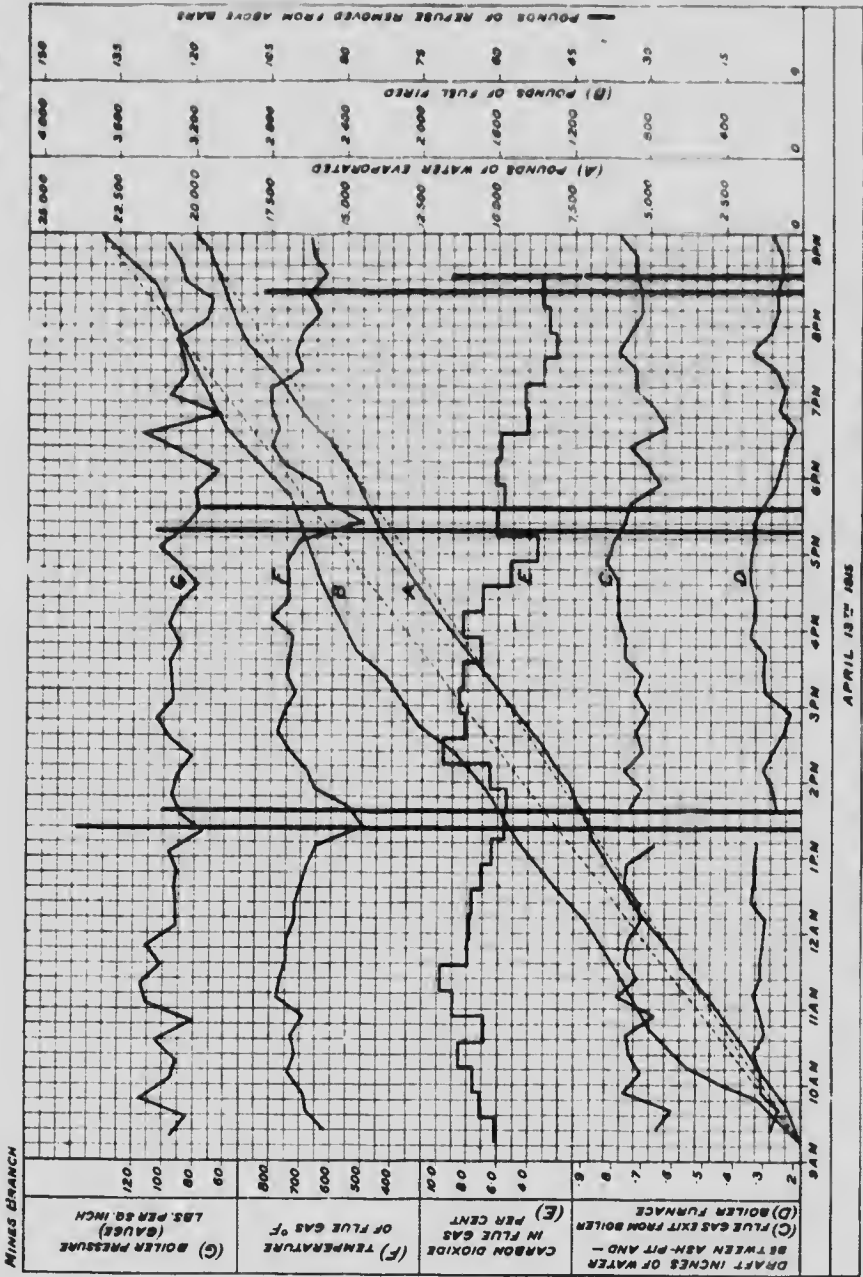
Boiler Trial No. 105: Fuel—Hillcrest Collieries, Ltd.

Chart No. 27.



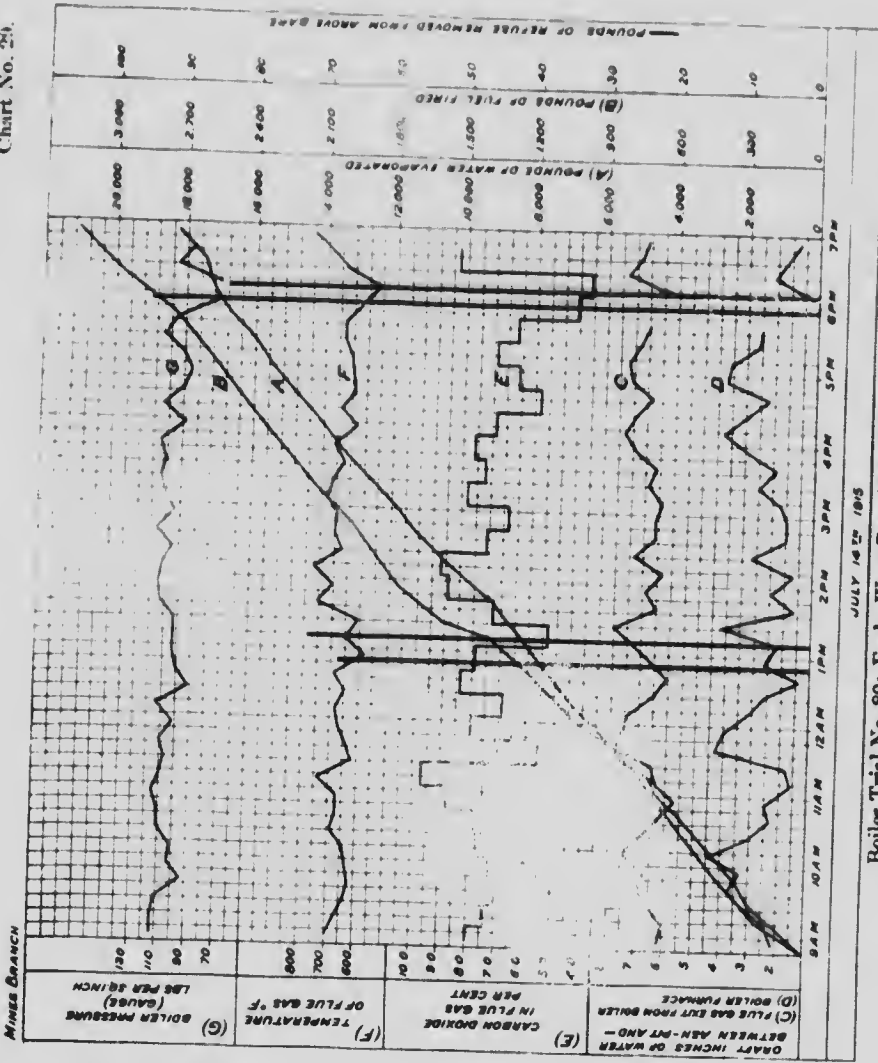
Boiler Trial No. 106: Fuel—Hillcrest Collieries, Ltd.

Chart No. 28.



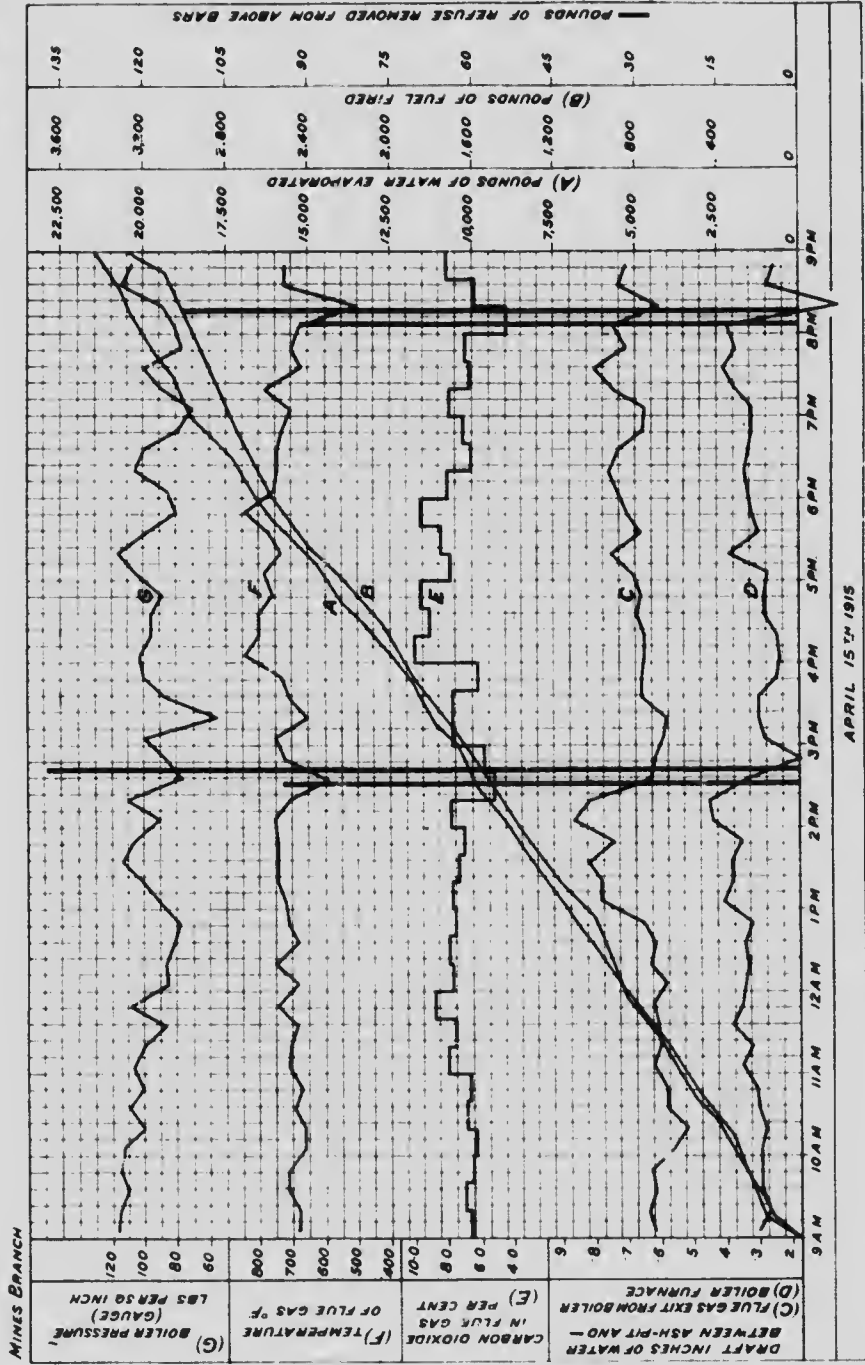
Boiler Trial No. 67: Fuel—West-Canadian Collieries, Ltd., Bellevue.

Chart No. 29.



Boiler Trial No. 80: Fuel—West-Canadian Collieries Ltd., Bellevue.

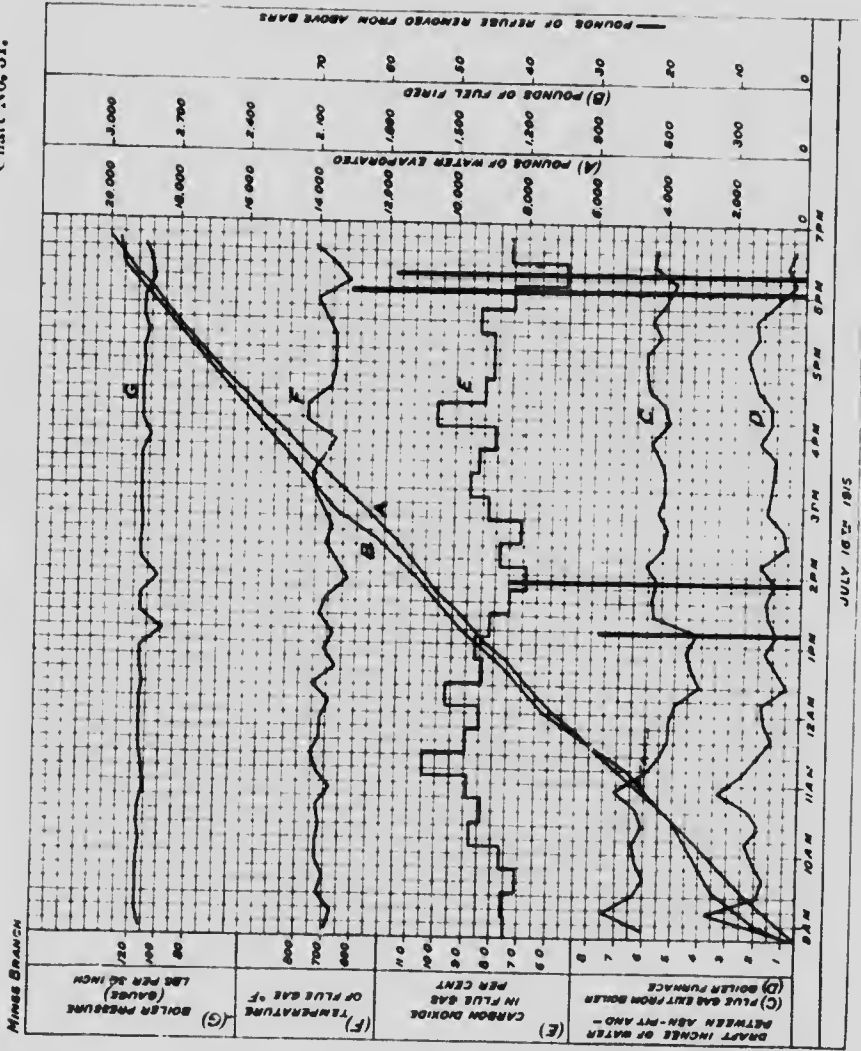
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APRIL 15TH 1915

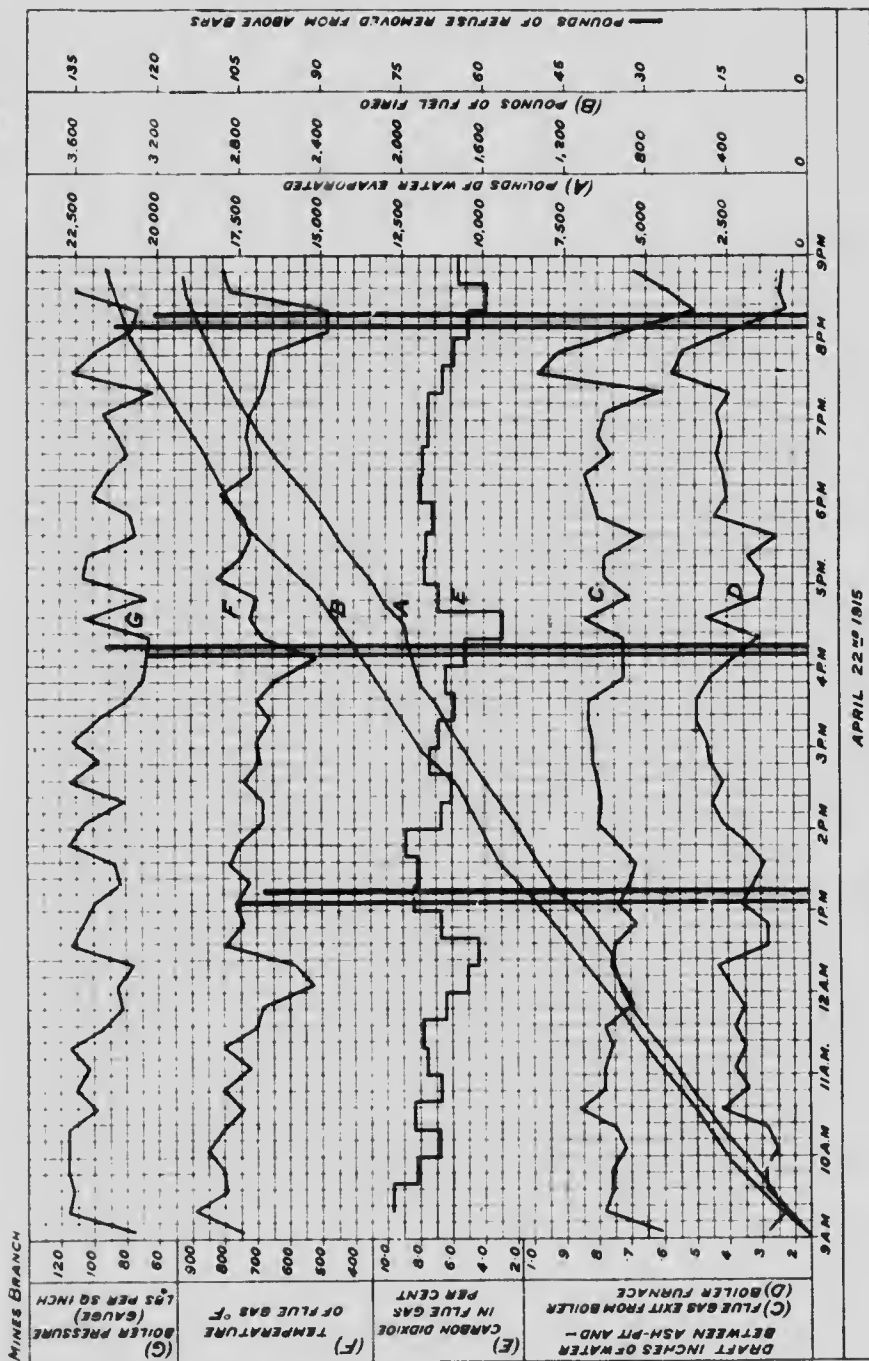
Boiler Trial No. 68: Fuel—West-Canadian Collieries Ltd., Greenhill.

Chart No. 31.



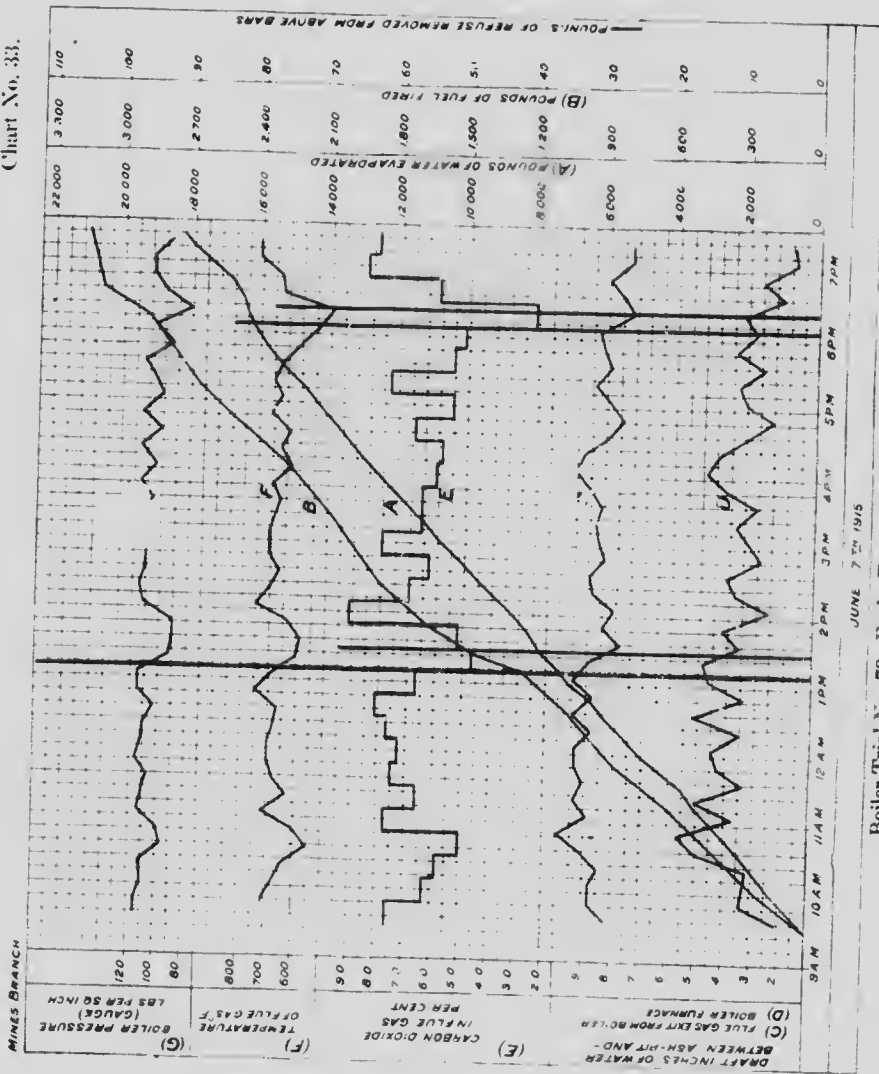
BOILER TRIAL NO. 81: FUEL—West-Canadian Collieries Ltd., Greenhill.

Chart No. 32



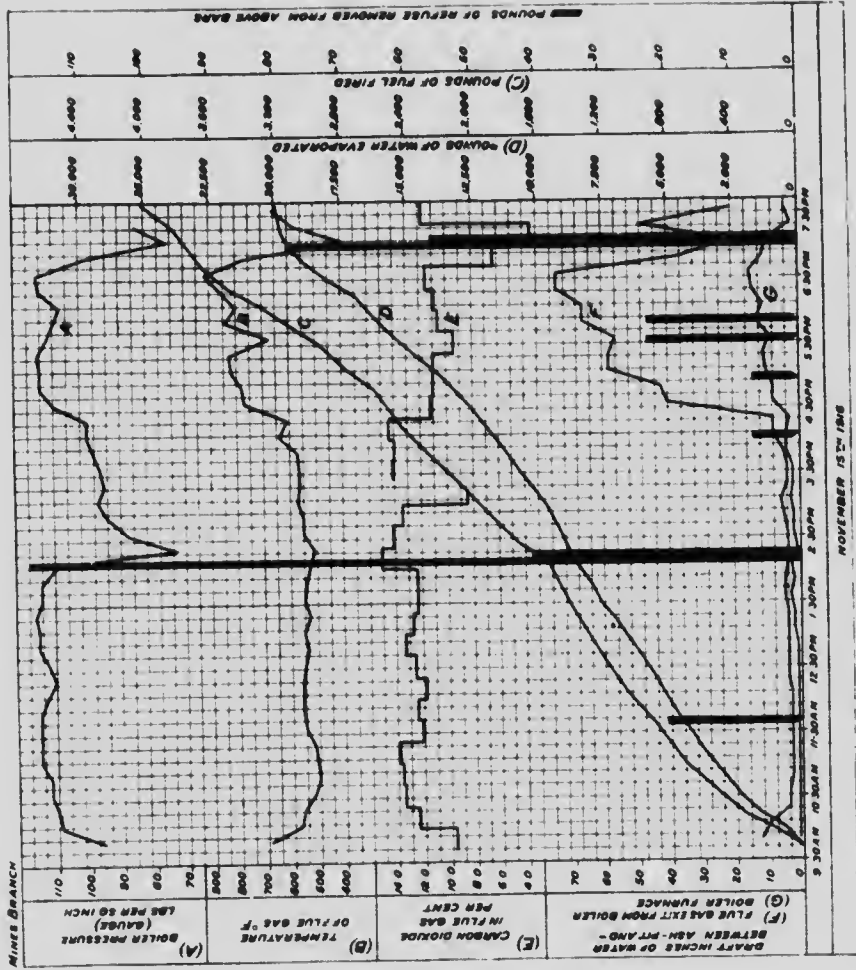
Boiler Trial No. 70: Fuel—Franco-Canadian Collieries, Ltd.

Chart No. 33.



Boiler Trial No. 79. Fuel—Franco-Canadian Collieries, Ltd.

Chart No. 34.



NOVEMBER 15TH 1916
 Boiler Trial No. 100: Fuel—Chimook Coal Co., Ltd.

Chart No. 35.

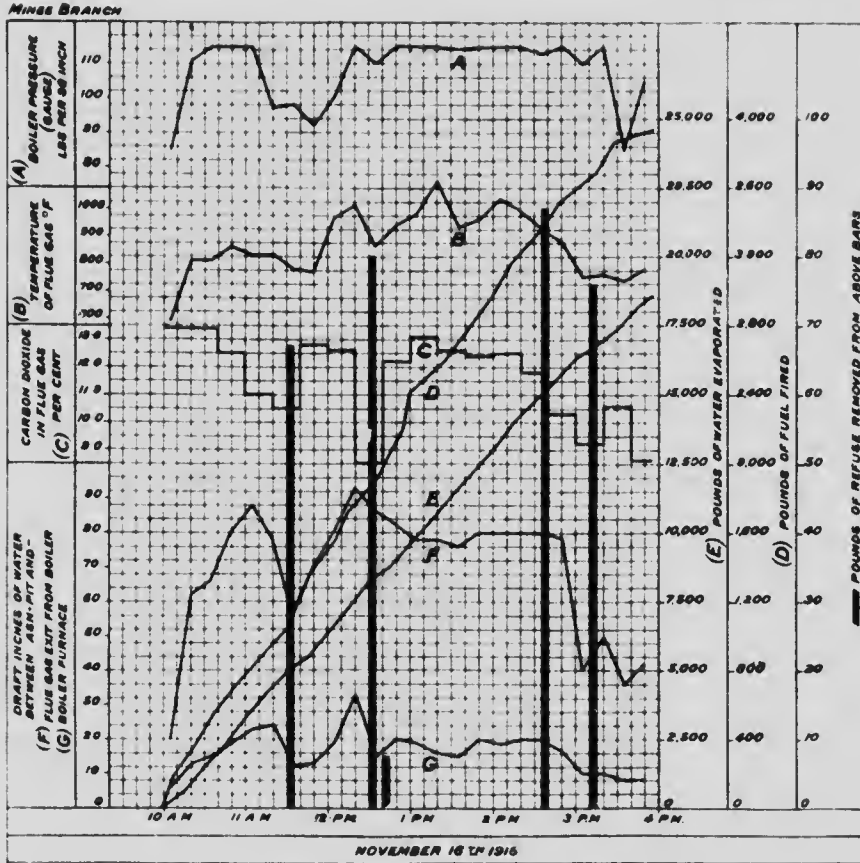
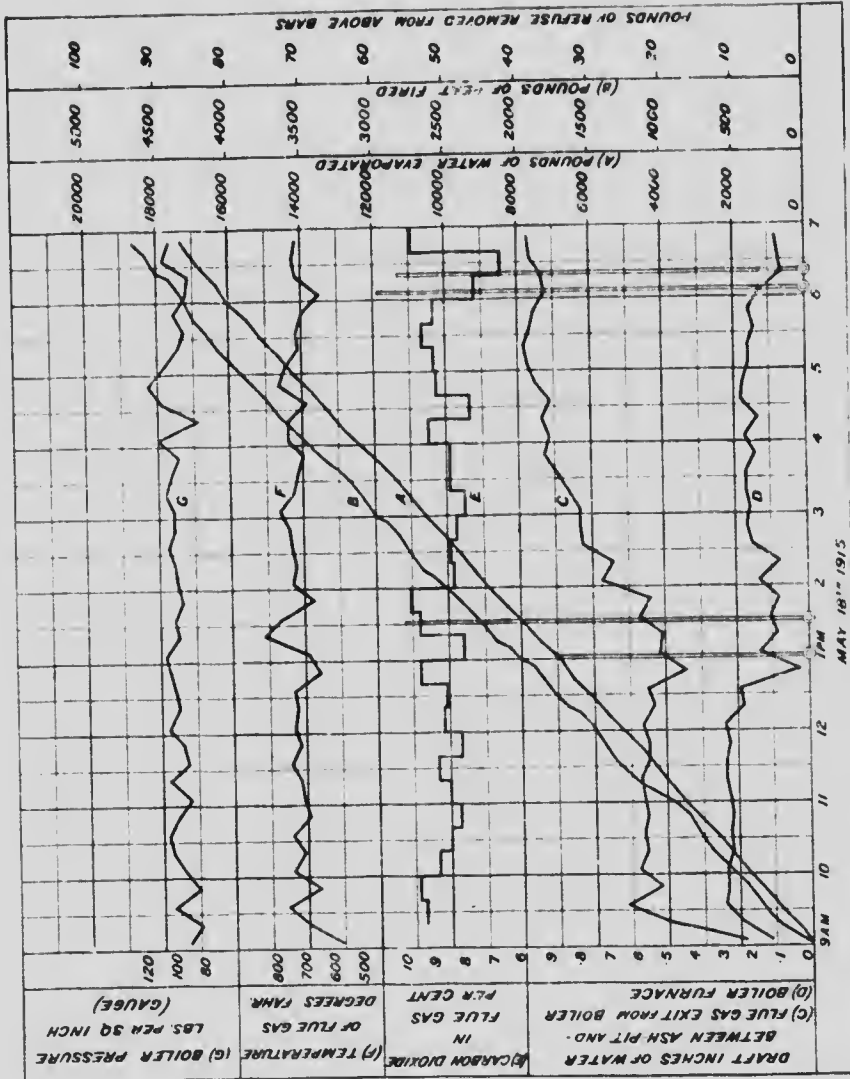


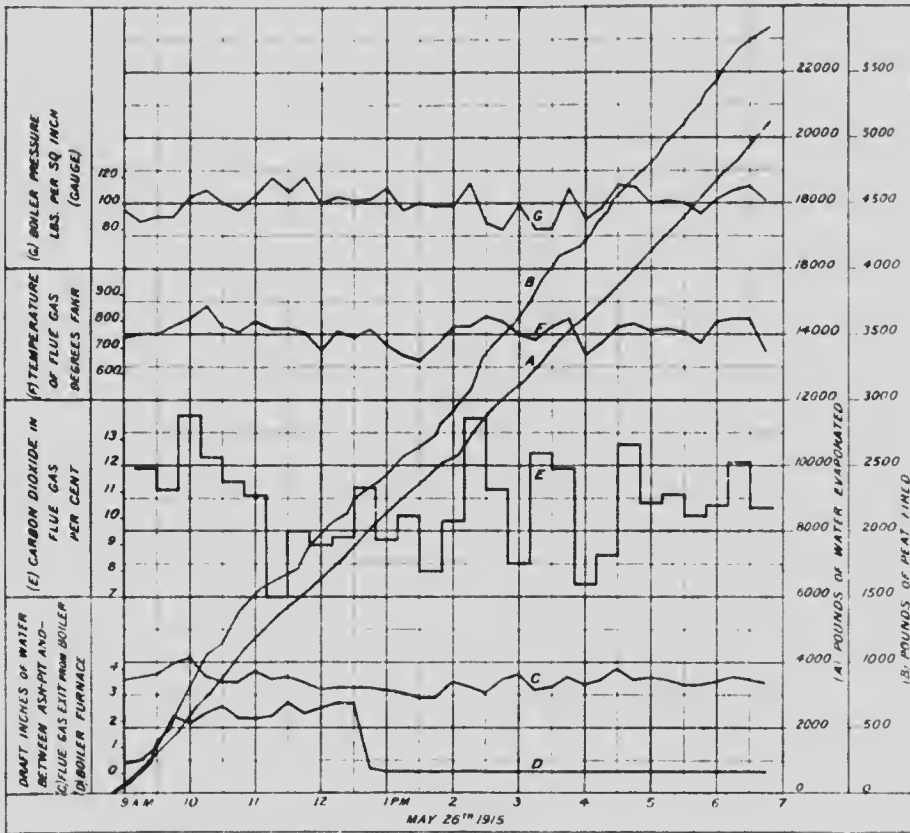
Chart No. 36.



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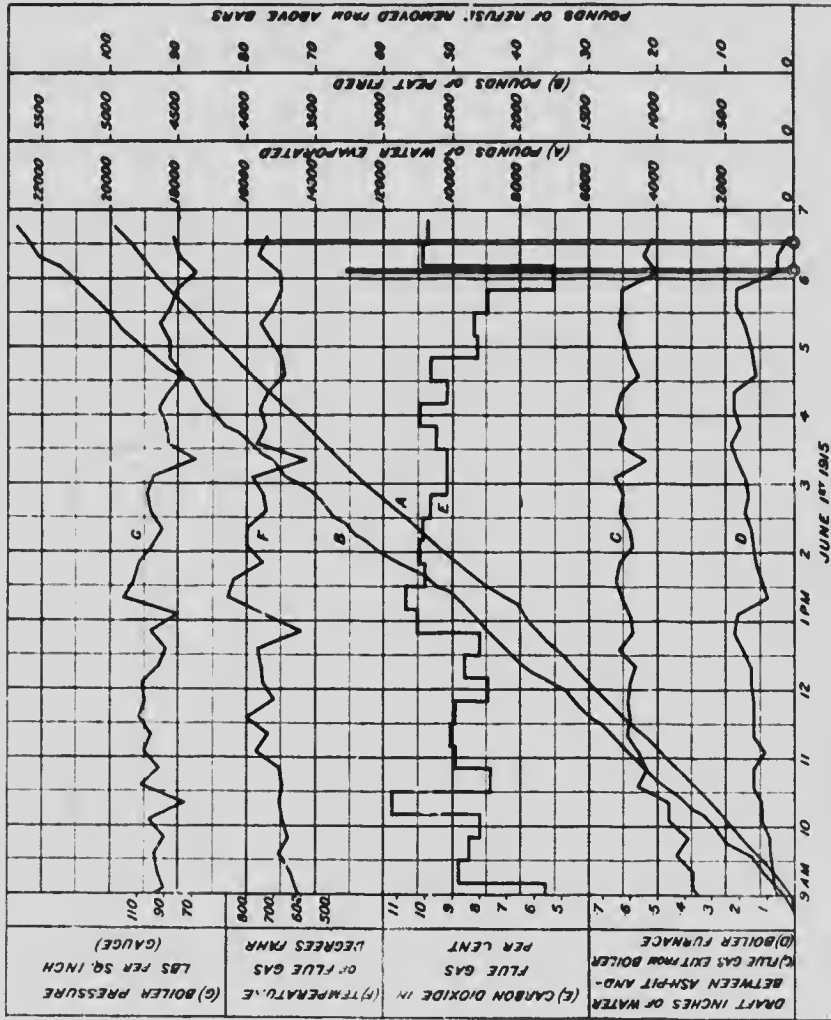
Trial No. 71: With water tube boiler, using peat from Alfred peat bog.

Chart No. 37.



Trial No. 72: With water tube boiler, using peat from Alfred peat bog.

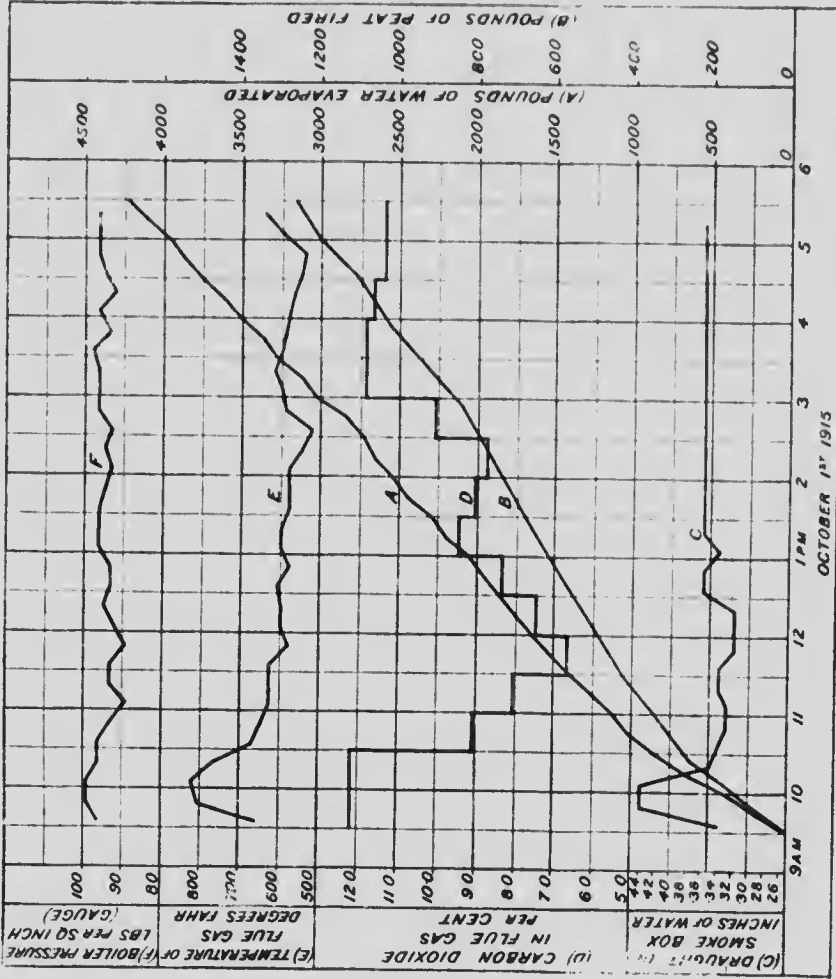
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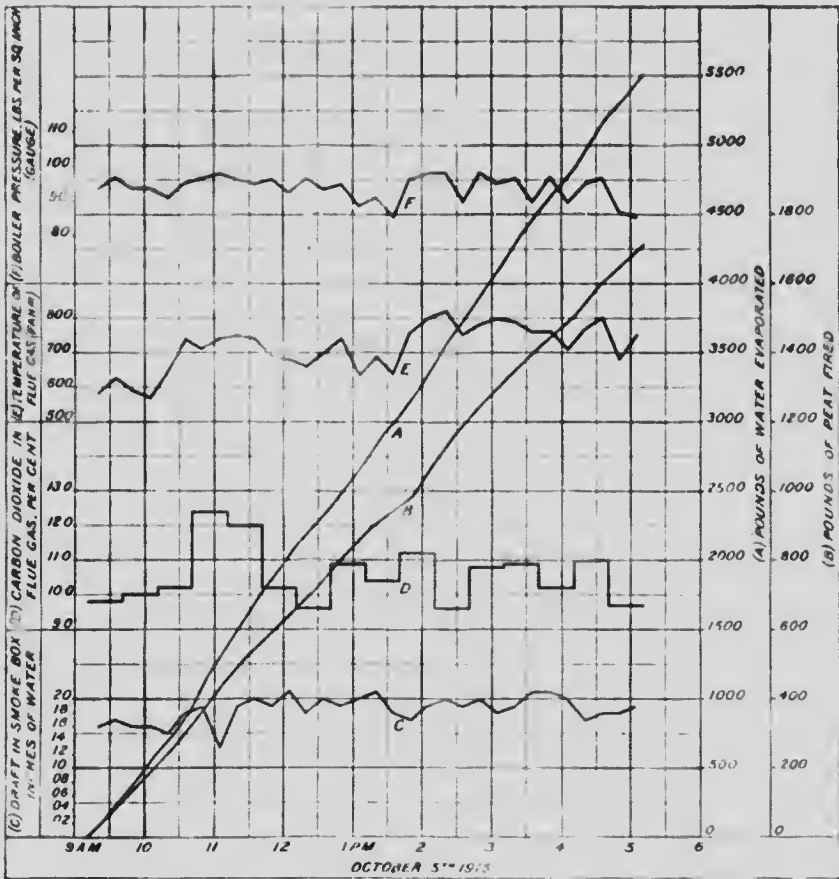
Trial No. 73: With water tube boiler, using peat from Alfred peat bog.

Chart No. 39.



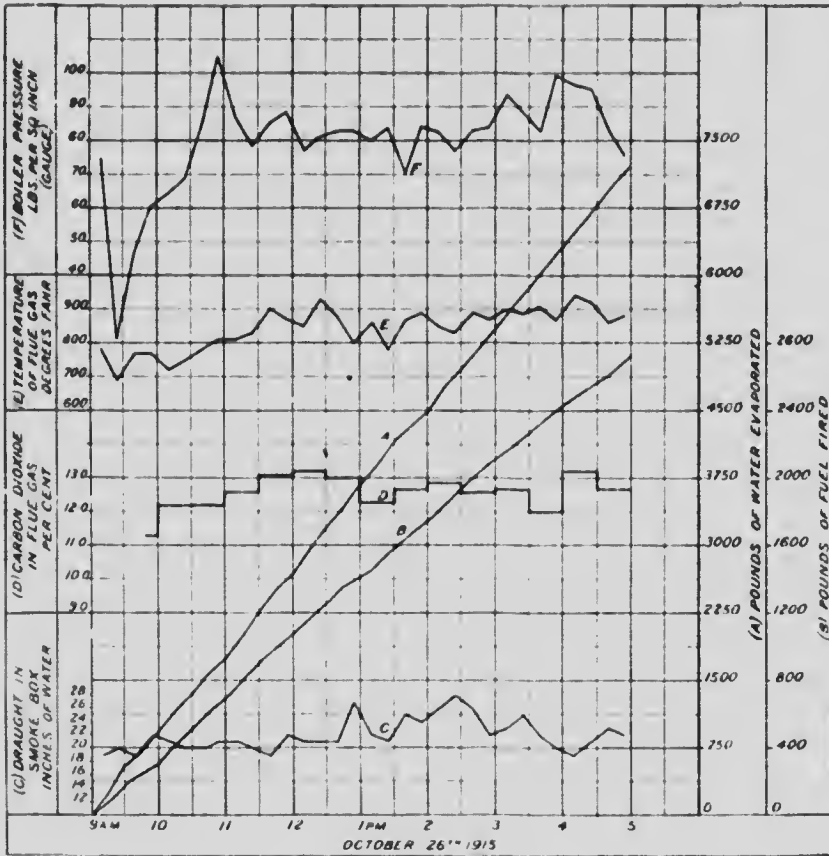
Trial No 83: With locomotive type boiler, using peat from Alfred pent bog.

Chart No. 40.



Trial No. 84: With locomotive type boiler, using peat from Alfred peat bog.

Chart No. 41.



Trial No. 85: With locomotive type boiler, using peat from Alfred peat bog.

