

CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN MCLEISH, DIRECTOR

INVESTIGATIONS IN 1922

FUELS AND FUEL TESTING

(Testing and Research Laboratories)

- (I) Carbonization of peat in commercial hardwood distillation ovens: by R. E. Gilmore and Harold Kohl.
- (II) Report on the treatment of oil shale from New Brunswick by the Ryan Oil Digestion process: by A. A. Swinnerton.
- (III) Preliminary gasoline survey: by P. V. Rosewarne.
- (IV) Interim report of the Joint Peat Committee: by B. F. Haanel.

(Annual Summary Report of the Mines Branch, pp. 194-225 and 262-266)



OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1924

No. 609.

FUELS AND FUEL TESTING DIVISION

I

CARBONIZATION OF PEAT IN COMMERCIAL HARDWOOD
DISTILLATION OVENS

R. E. Gilmore and Harold Kohl

In August, 1922, commercial size carbonization experiments were made on a car lot of air-dried-machine peat. These tests were carried out in co-operation with the Standard Chemical Company of Canada in their plant situated at Longford, Ontario. The ovens used were of standard size and the carbonization process was the same as that used in the regular hardwood distillation practice. Every convenience and much appreciated help was freely given by the officials and operators of the Standard Chemical Company, with whom, under instructions from B. F. Haanel, Chief of the Division of Fuels and Fuel Testing, the senior author had made previous arrangements. The junior author was present and supervised the actual carrying out of the experimental runs.

The purpose of these experiments was two fold, first, to determine the feasibility of carbonizing Canadian air dried peat to obtain charcoal and other chemicals by the same destructive distillation process as used for hardwoods; and second, to find out to what extent peat may be considered as a substitute for hardwood in the manufacture of charcoal and chemical products. The scope of the tests were, therefore, limited to the carbonization process as used in the hardwood distillation industry, which may be termed low temperature destructive distillation in which the temperature is controlled in the neighbourhood of 300° C. (572° F.).

Products obtainable from peat, other than charcoal, are peat tar oils, pyroligneous liquor containing ammonium acetate, methyl (alcohol) spirits and gas. The aim was, as with hardwood, to obtain as large a yield as possible of liquid products, viz., methyl spirits and light oils. The charcoal yield, as a result of this procedure, is also high compared with other carbonization processes and is of a good quality. The yield of gas and ammonia obtainable will necessarily be comparatively low.

Results of carbonization experiments carried out on a large laboratory scale by the above authors are on hand and will be used for comparative purposes in this report. The results published by the Fuel Research Board—England—on "The Carbonization of Peat in Vertical Gas Retorts," viz., Technical Paper No. 4, will also be referred to. Besides briefly reviewing the salient features of the carbonization process used commercially for hardwoods a comparative summary of the results on experiments, first, by low temperature carbonization in the laboratory; second, by low temperature carbonization in commercial hardwood distillation ovens; and third, by high temperature carbonization in vertical gas retorts, will be included in this report.

DESCRIPTION OF OVEN AND CARBONIZATION PROCESS

In Figure 13, a sketch of the oven is given, which oven is of the standard rectangular steel plate construction. At the front end is a full size door, and at the rear a 30-inch gas exit opening. The dimensions of this type of oven are roughly 6 feet wide by 8 feet high by 26 feet long. The door, which is of cast iron, is by means of steel keys and asbestos lined grooves made practically gas tight against its frame which in turn is riveted to the oven proper. The bottom of the oven is fitted with steel rails, on which three iron buggies to hold the fuel are run into and out of the oven. The exit pipe links up with a tubular condenser set in a vertical position immediately behind the oven. From the chamber, above the goose neck liquor discharge at the bottom of the condenser, two pipes are provided for the uncondensable gas, one to the gas main to the boiler room and the other to the fire chamber under the front of the oven.

The steel oven is hung from the roof of the firebrick setting—two ovens to one setting—with heating flues on all surfaces except the front. Below and at the front of the oven is the fire chamber for burning soft coal or sawmill waste. Immediately in front of the oven is a turn table to handle the buggies, which is used both in charging and discharging the iron buggies. The top of the firebrick and tile oven settings is used as a drying floor for acetate of lime.

The heating flues are so arranged that the flames and their hot gases travel from the fire box backward along the bottom of the oven and also upward along the sides and back of the oven. The flames do not play directly on the steel oven, but by means of holes suitably arranged in a firebrick archway, properly constructed lengthwise under the whole length of the oven, these hot flames are uniformly distributed. After passing backward along the bottom and upward along the walls of the oven the passage of the flue heating gases is forward over the top of the oven before returning through horizontal flues under the acetate drying floor to the chimney exits at the rear.

The capacity of an oven, such as was used in these peat carbonization experiments, is 6 cords, i.e. of hardwood, equal roughly to 12 tons. As a ton of the air dried peat containing 25 per cent moisture occupies practically the same space as a ton of hardwood of equal moisture content, the capacity of an oven is roughly 12 tons of peat, four tons to each of the three buggies.

The fuel to be carbonized is charged into a hot oven immediately after the previous charge of charcoal has been withdrawn. The duration of the carbonizing period extends from 24 to 30 hours between charging and discharging. The buggies of hot charcoal are withdrawn from the oven into an air tight cooling chamber, where it remains for a time equal to that of the succeeding carbonizing period. After being further cooled for a second period in a second cooling chamber similar to the first, the cooled charcoal is allowed to remain on the buggies in the open sheds for another 24 hours before bagging and loading on railway cars.

In the regular carbonization operation, as soon as the wood is charged into the oven, hot from the previous run, a quick hot fire is made under the oven to start what is known as the primary destructive distillation. The first distillate which commences running within an hour or so after charging, is composed mostly of water and is accompanied with very little if any gas. In about nine hours, tar is noticed in the distillate and the flow of gas increases rapidly. This is known as the "breaking point"

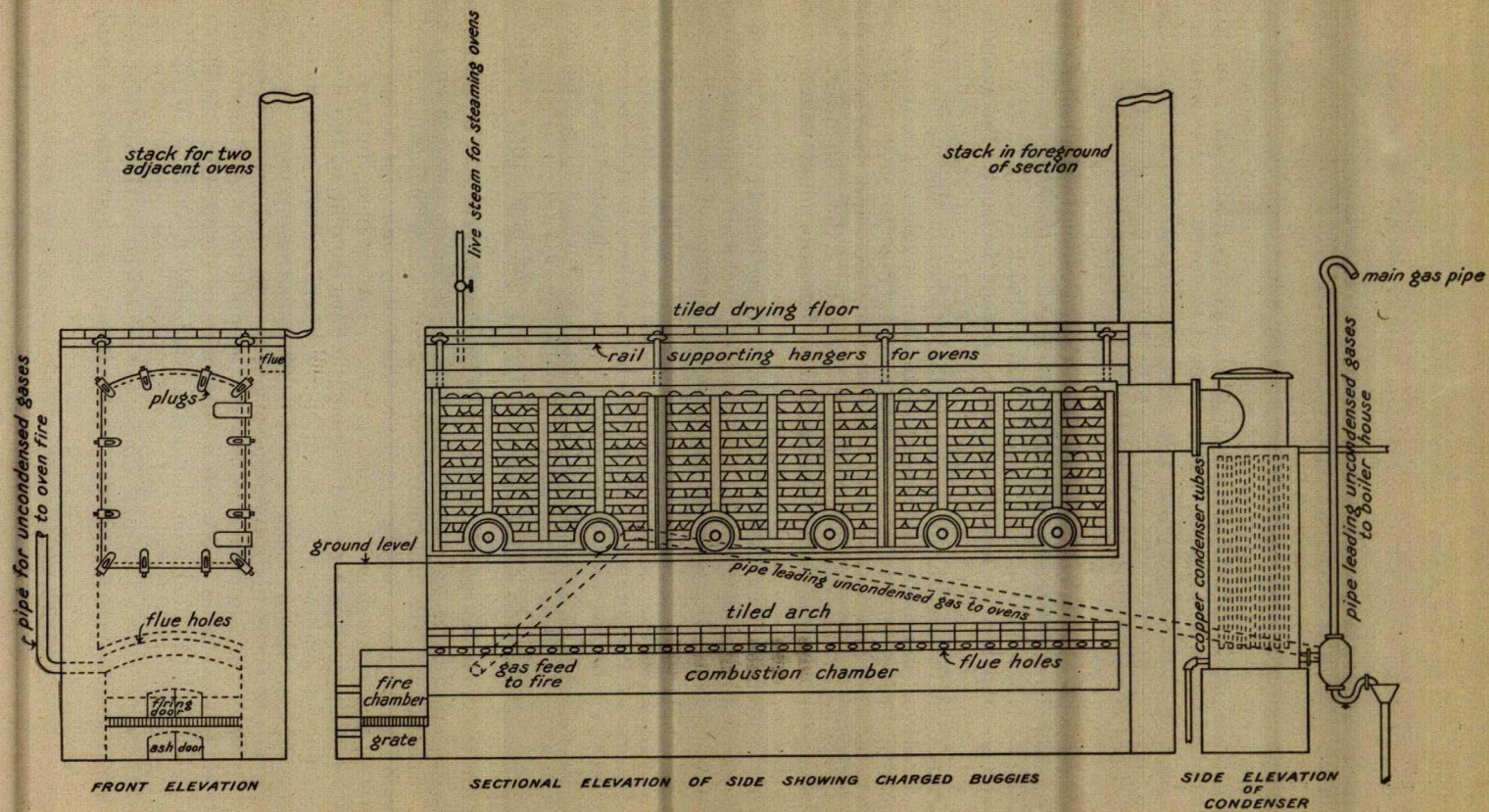


FIG. 13. Carbonizing oven with condenser. Capacity 12 tons of peat.

and is an indication of an exothermic reaction within the oven. At this point or before, depending on the condition of the fuel charged, in respect to age and moisture content, and on the comparative rates of flow of both liquor and gas, the fire under the oven is checked and regulated so that the destructive distillation reaction within the oven is controlled at the proper rate to insure maximum yields of liquid products. By means of recording pyrometers inserted in the gas exit pipe midway between the back of the oven and the condenser, the rate of the reaction is followed and recorded. These exit gas temperature charts are carefully watched and made use of by the fireman. At a certain time the gas given off is allowed to enter and to be burned under the oven, where it either displaces or supplements other fuel necessary to carry out and complete the carbonization. The rate of flow of liquor increases to a maximum at about the sixteenth hour, and is maintained at this rate until the reaction is nearly completed. The last two to three hours are used for completing the carbonization and for sweeping the gases out of the oven with steam before opening the door for discharging the buggies of hot charcoal.

For fuller description of the carbonization process as used for hardwoods, the literature¹ on the subject should be consulted.

The crude products resulting from the destructive distillation of hardwoods, other than charcoal, are tar oils, pyroligneous acid, and gas. The pyroligneous acid is the only raw material from the ovens that requires further treatment to obtain marketable products. By a process of chemical treatment and rectification this pyroligneous acid aqueous distillate is refined to produce (a) crude 95 per cent vol. wood alcohol, containing methyl alcohol, acetone, etc., (b) light naphtha and creosote oils, and (c) acetic acid in the form of grey acetate of lime. Similar products to these, with the addition of ammonia, is to be expected from peat.

The reasons for, and the merits of using this low temperature carbonization process for peat are as follows:—(a) The yield of methyl alcohol and allied products and also of the acetate products will be higher by this process than by carbonization processes generally used for coal. (b) At temperatures used, namely between 300° and 350° C.; as high, if not higher yields of tar oils of high quality are obtainable as with any other low temperature process. (c) The peat charcoal, though still high in volatile matter, closely resembles hardwood charcoal, for which it was hoped peat charcoal would be a substitute.

EXPERIMENTAL

The carload of air dried peat used in these tests was supplied by the Peat Committee from the bog at Alfred, Ontario, the analysis of which was as follows:—

<i>Proximate analysis—</i>	As received basis	Dry basis
Moisture, per cent.....	25.6	
Ash, per cent.....	4.6	6.2
Volatile matter, per cent.....	48.5	65.3
Fixed carbon, per cent.....	21.3	28.5
Sulphur, per cent.....	0.25	0.33
Nitrogen, per cent.....		1.5
<i>Calorific value—</i>		
B.Th.U., per pound.....	7040	9470

¹See bibliography at end of Bulletin No. 74, Forestry Branch, Department of the Interior, Ottawa, viz.,—"Distillation of Hardwoods in Canada."

This peat consisted of irregular lumps varying in size from 2 to 3 inches in diameter to pieces as large as an ordinary brick. The process of manufacture at the bog consisted of macerating the wet peat containing about 90 per cent water, and then after spreading on the ground and cutting into the required sizes allowing it to dry in the open air. The condition of the air dried peat on arrival at Longford was not as good as that sold as household fuel. It was loaded into the buggies from a pile on the ground by means of a steam shovel, and in this way differed from hardwood, which must be loaded by hand.

Two experimental runs were made on August 7 to 10 inclusive. In the first run three buggies containing slightly over four tons each were charged into the oven, and for a second each of the three buggies used contained about three and one-third tons. The data sheets for the runs are as follows:—

Run No. 1

Weight of peat charged—25,868 lbs.....	12.9 tons
Equivalent of dry peat—19,360 lbs.....	9.7 tons
Time and date charged into oven.....	8 a.m., August 7
Time and date drawn from oven.....	7 a.m., August 9
Duration of run, 36 hours.	

Flow and Composition of Oven Liquor

Time in hours	Temperature of exit gas		Gals. per hour	Total liquor gals.	Wet tar p.c.	Aqueous p.c.	Acidity as acetic	Remarks
	°F.	°C.						
0	100	38						
2	170	77	6	12				
4	270	132	22	56				
6	360	182	29	114	0.5	99.5	0.40	
8	420	216	46	217	10.0	90.0	0.96	Condenser hot.
10	420	216	51	320	1.0	99.0	0.54	“ “
12	420	216	44	408	0.0	100.0	0.72	“ cold.
14	460	233	35	478	0.5	99.5	0.81	“ “
16	500	260	38	555	5.0	95.0	0.84	“ hot down.
18	510	265	41	638	5.0	95.0	0.96	“ “
20	510	265	41	720	7.0	93.0	0.78	“ “
22	510	265	34	788	8.0	92.0	0.78	“ “
24	500	260	30	848	12.0	88.0	0.70	“ “
26	515	265	29	906	28.0	72.0	0.70	“ “
28	535	270	28	963	31.0	69.0	0.60	“ “
30	560	295	28	1,014	31.0	69.0	alkaline	“ “
32	580	310	30	1,081	40.0	60.0	“	“ “
34	580	310	18	1,128	43.0	57.0	“	“ “
36	580	310	13	1,144	45.0	55.0	“	“ “

Average temperature of exit gases, 560°F. (293°C.).

Fuel used under the oven, 1 load of wood waste—sawdust and wood chips—(i.e. other than peat gas) equivalent to about 1½ tons of soft coal.

Yield of peat charcoal, 9,728 lbs. (15 p.c. Breeze).

Total oven liquor measured 1,144 imp. gallons.

Tar oils 208 “

Aqueous (liquor) 936 “

Methyl (alcohol) spirits in liquor—1.10 c.c. per 100 c.c.

Ammonia (NH₃) in liquor — 0.45 grams per 100 c.c.

Run No. 2

Weight of peat charged—20,408 lbs. 10.2 tons.
 Equivalent to dry peat—15,183 lbs. 7.6 tons
 Time and date charged into oven 8 a.m., August 9
 Time and date drawn from oven 2 p.m., August 10
 Duration of run, 30 hours.

Flow and Composition of Oven Liquor

Time in hours	Temperature of exit gas		Gallons per hour	Total liquor	Wet tar	Aqueous liquor	Acidity as acetic	Alcohol (methyl)
	°F.	°C.						
0.....	270	130		gals.	p.c.	p.c.	p.c.	p.c. vol.
2.....	275	135	7					
4.....	320	160	8	29				
6.....	375	190	36	102		100	0.2	
8.....	420	215	34	169		100	0.5	0.5
10.....	465	240	46	262	5	95	0.6	1.6
12.....	500	260	52	366	5	95	0.6	1.6
14.....	520	270	42	451	10	90	0.6	1.6
16.....	540	280	38	508	8	82	0.9	1.7
18.....	560	290	35	583	11	89	0.6	2.7
20.....	560	290	42	653	13	87	0.6	2.3
22.....	560	290	33	719	6	94	0.6	2.3
24.....	570	295	17	747	16	84	0.6	2.2
26.....	576	295	16	790	20	80	0.4	2.0
28.....	580	300	14	823	25	75	alkaline	2.6
30.....	600	310	8	852	30	70	"	3.0

Average temperature of exit gases, 570° F. (309° C.).

Fuel used under the oven, 2,654 lbs. of slack coal (soft).

Yield of peat charcoal, 7,868 lbs. (15 p.c. Breeze).

Total oven liquor as measured, 852 imp. gallons.

Tar oils, 124 "

Aqueous liquor, 728 "

Methyl (alcohol) spirits in liquor, 1.30 c.c. per 100 c.c.

Ammonia (NH₃) in liquor, 0.45 grams per 100 c.c.

Operation remarks.—In the first run the buggies used were loaded nearly to the top of the side bars. The same buggies loaded to this level with hardwood cordwood held two cords each, equivalent to roughly 2 tons per cord. It was, therefore, noticed that peat of 25 per cent moisture content had practically the same bulk as hardwood of equal moisture content.

In experiments previously carried out on peat in the laboratory it had been necessary to allow the condenser water to warm up, to prevent the thick tar oils from clogging the (spiral) condenser tube. At the same time it was necessary to keep the water, especially at the bottom of the condenser, cool enough to condense the low boiling alcohol constituents. These were kept in mind, but despite precautions a little difficulty was experienced during the first half of run No. 1. In the latter part of this run, however, and in run No. 2, the flow of oven liquor was fairly uniform. In regular practice, using peat, a combination of a warm condenser followed by a cold condenser or scrubber would overcome any difficulty of condensing both the thick tar and the low boiling liquids.

Care was taken to look for indications of exothermic reaction. With hardwoods with moisture contents of about 25 per cent and lower, as previously remarked, more or less sudden increases of liquor and gas are noticed at about the seventh to the ninth hour, and if the fire under the oven is not checked and controlled at this point or previous the temperature within the oven rises too high and the consequent rate of reaction increases to such an extent that serious loss in valuable liquid products is more than likely to ensue. As, however, the moisture content of the hardwoods ranges higher than say 25 per cent the exothermic reaction is not so noticeable. For the high moisture hardwoods constant external heat is required to carry on and complete the reaction. During the two experimental runs with peat no appreciable exothermic reaction was noticeable. Whether this was due to too high a moisture content or was normal to peat of this moisture content is difficult to say. The shape of the curves in the constituents of the gas—*see* Diagram IX—was, however, the same as those on a typical run using hardwood.

The comparative quantities of tar oils and aqueous distillate in the oven liquor were observed from samples taken in a graduated glass cylinder every hour. After standing, a more or less complete separation took place when readings were taken. The total oven liquor was pumped to a tank and measured. After settling, measurements of the total separated clean liquor and settled tar respectively were made.

A flowsheet of the process is given as Fig. 14, and Fig. 15 is the temperature curves on the recording pyrometer chart for run No. 2. The crude factory operations follow closely those used for hardwoods, but the laboratory refining of the crude peat products is slightly different from that for hardwood.

Examination of Products

The peat charcoal produced was passed over a square, $\frac{3}{8}$ inch meshscreen, and what passed through was termed breeze. The percentage of screened lumps and breeze was roughly 85 and 15 respectively. Bag samples of each were taken for analysis. Barrel size samples of both the aqueous distillate and settled tar were taken to the laboratory in Ottawa for analyses and reserve samples. The aqueous distillate, which may be termed peat pyroligneous acid, was a clear straw colour, and the tar oils were of a consistency that flowed readily when poured from one vessel to another.

The pyroligneous acid from peat differed from that from hardwood in that the former contained an appreciable amount of ammonia and amine compounds. On the other hand, the acid content of the peat liquor was small as compared to that from hardwood. In ordinary hardwood pyroligneous acid practice the liquor is neutralized with lime before distilling off the crude alcohol. The residue on evaporation would yield brown acetate of lime.

For the recovery of the alcohol product from the peat liquor two different methods are feasible. When the settled liquor is over-neutralized with lime and distilled, similar to the practice for liquor from hardwoods, the ammonia compounds are liberated and come over with the alcohol vapours. By this method nauseous vapours are given off which are troublesome to work with in the laboratory. For this reason, and also for the reason that for the recovery of the alcohol free from amine compounds, the peat liquor was distilled from acid reaction.

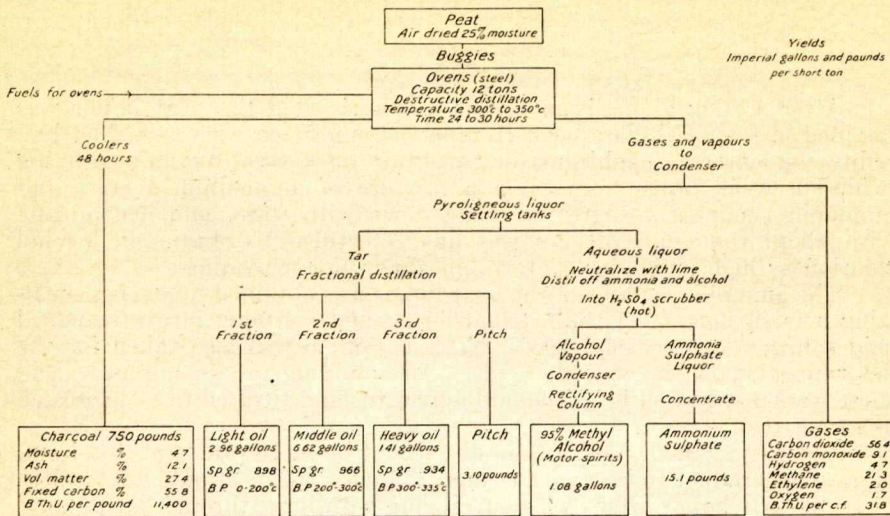


FIG. 14. Flow sheet, destructive distillation of peat.

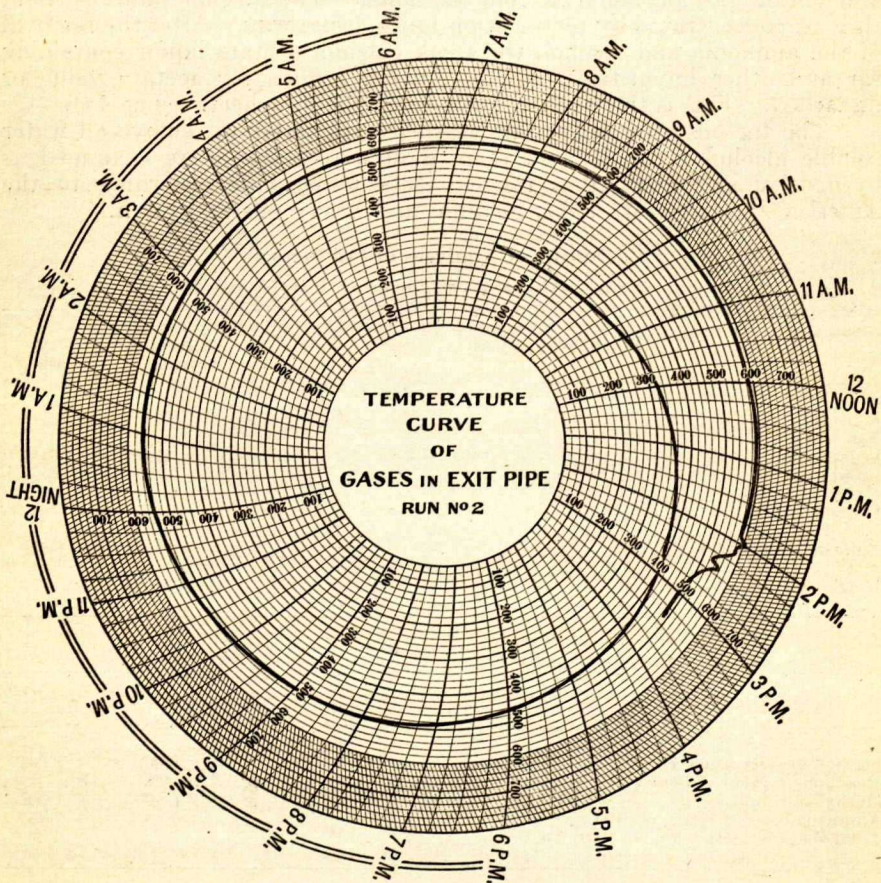


FIG. 15. Temperature curve of gases in exit pipe.

After adding a small amount of sulphuric acid the peat liquor was distilled in a special glass bead Hempel column fitted with a Soxhlet ball reflux condenser as dephlegmator to obtain an alcohol distillate, leaving behind a weak liquor containing a mixture of ammonium acetate and ammonium sulphate. After breaking down with water and neutralizing with alkali the crude alcohol was again rectified to obtain an alcohol solution as high as 90 per cent volume hydrometer reading.

The ammonia content of the peat liquor was obtained by over-neutralizing a fresh portion of the original liquor and distilling into a standard acid solution in the usual way. A fresh sample was also taken for the determination of the volatile acids. After adding excess sulphuric acid these were distilled off in a Kjeldahl apparatus and titrated to be expressed as acetic acid.

Another method, which no doubt would be more practical, to obtain an alcohol product to be used for such as motor spirits, would be to distil or rectify the liquor after over-neutralizing with lime, through a sulphuric acid scrubber, and thus recover the ammonia early in the refining process and obtain the alcohol free from ammonia. The alcohol solution could then be concentrated by rectification in the usual way. After the removal of the ammonia and alcohol, the weak calcium acetate liquor containing tar and other impurities could be further refined for acetate value or discarded. This is the method outlined in the flowsheet. (Fig. 14).

The tar oils after being first washed with water to remove all water soluble alcohol products, and then allowed to settle, were examined as to density and distillation range. Cuts were made according to the American practice into light, medium and heavy oils and pitch.

Results of Analyses of Products

Peat Charcoal—Average of Composite from Runs (1) and (2)

Proximate analysis	As received basis	Dry basis
	p. c.	p. c.
Moisture.....	4.7	
Ash.....	12.1	12.7
Volatile matter.....	27.4	28.7
Fixed carbon.....	55.8	58.6
Sulphur.....	0.27	0.28
Calorific value B.Th.U. per lb.....	11385	11940
Weight per bushel.....	Ave. 35 lbs.	

Peat Pyroligneous Acid

	Run 1	Run 2
Specific gravity at 60° F.....	1.003	1.005
Reaction of liquor to litmus (Sl. Alk.—slightly alkaline).....	Sl. Alk.	Sl. Alk.
Methyl (alcohol) spirits—c. c. per 100 c. c.....	1.10	1.30
Ammonia content—gms. per 100 c. c.....	0.45	0.45
Total acids as acetic—gms. per 100 c. c.....		0.60

Peat Tar Oils—Composite Sample Runs 1 and 2

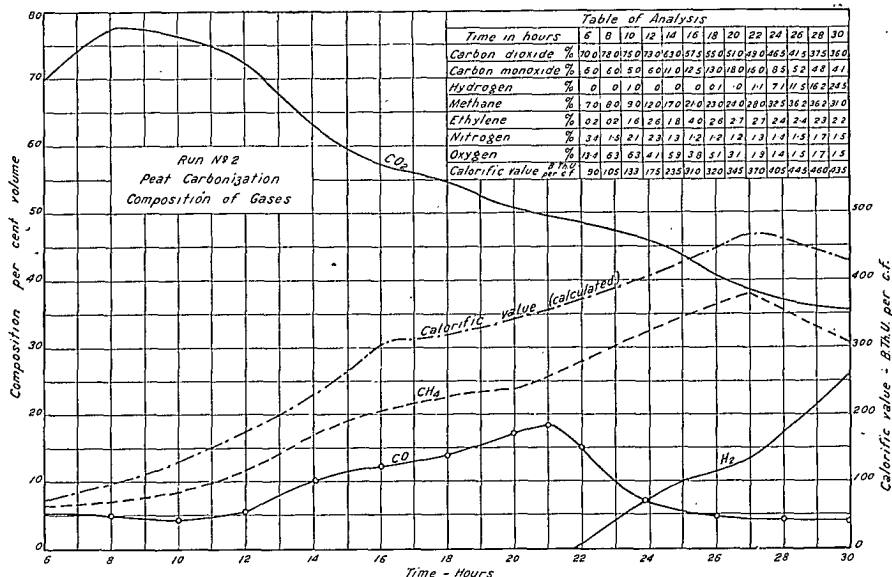
Specific gravity at 60° F. of the crude oil—0.968

Distillation results	Per cent volume		Sp. gr. of fraction
	Wet	Dry	
Water.....	3.0		
Light oil up to 200° C.....	18.0	18.5	0.898
Middle oil 200 to 300° C.....	47.0	48.5	0.966
Heavy oil 300 to 335° C.....	10.0	10.3	0.934
Pitch (by diff.) above 335° C.....	22.0	22.7	

PEAT GASES—BY LOW TEMPERATURE CARBONIZATION

The yield of oven gas during the commercial scale run was not obtained. Some idea of this yield is, however, available from the laboratory scale runs referred to in the next paragraph. During the runs at Longford, samples of the uncondensed gas were taken at intervals of two hours. Table No. I gives the analyses of these samples taken during No. 2 run and Diagram IX shows the results of these analyses in curves where percentage composition is plotted against time. The figures in the table inserted in Diagram IX were taken from the rounded off curves.

DIAGRAM IX



As referred to in the early part of this report laboratory scale tests had previously been carried out. These tests were on 12 to 13 pound samples of air dried peat averaging 12.5 per cent moisture and under

conditions similar to laboratory efficiency experiments on different hardwoods. Two runs only on peat were made, and while they were not entirely satisfactory, the results are of interest here in comparison with those obtained on the commercial scale. In Table II the laboratory results have been recalculated for air dried peat on a 25 per cent moisture basis. For the sake of comparison, or rather contrast, the average yield per ton of hardwoods (4,000 lbs. per cord) has been added.

TABLE I
Composition of the Gases—Run No. 2

Samples taken at intervals of 2 hours

Sample No.....	1	2	3	4	5	6	7	8	9	10	11	12
Time in hours....	6th	8th	10th	12th	14th	16th	18th	21st	23rd	25th	27th	30th
Carbon dioxide %	70.1	78.0	75.2	74.0	62.2	56.6	57.0	48.8	49.0	44.2	37.8	36.4
Carbon monoxide %.....	6.2	6.3	4.0	4.2	11.8	12.1	12.4	19.5	10.6	6.0	5.5	4.1
Hydrogen %.....	.....	.....	1.1	.....	.....	.....	0.1	.....	.....	10.4	13.0	24.5
Methane %.....	6.7	8.9	9.1	12.0	18.4	21.2	23.4	24.2	31.6	31.2	37.7	30.5
Ethylene %.....	0.2	.....	1.6	2.6	1.8	4.1	2.6	2.5	2.9	2.7	2.4	2.2
Oxygen %.....	3.4	1.5	2.1	2.3	1.3	1.2	1.2	1.2	1.2	1.5	1.8	0.7
Nitrogen %.....	13.4	5.3	6.9	4.9	4.5	4.8	5.3	3.5	4.7	4.0	2.8	1.6
Calorific value (calc'd).....	90	109	133	175	240	316	316	316	344	396	408	434
Density (calc'd) air=1.....	1.32	1.37	1.32	1.29	1.25	1.20	1.21	1.15	1.12	0.97	0.91	0.84

TABLE II
Comparison of Yields of Commercial Products per Ton (2,000 lbs.) of Air Dried Peat and Hardwoods

Commercial products	Air dried Peat		Hardwoods
	Average of two laboratory runs	Average of two commercial runs	Commercial yield per $\frac{1}{2}$ cord
Charcoal..... lbs.	700	756	540
Oven liquor—imp. gals..... gals.	.....	86	100
Gas as measured..... c.f.	3,675	.....	.....
Ammonia as sulphate..... lbs.	11.7	15.1	Nil
Tar oils from liquor..... gals.	12.6	14.1	8.5
Acids as acetic..... lbs.	11.8	6.8	.....
80 per cent acetate of lime..... "	19.5	8.3	105
Alcohols as methyl—	.....	.....	.....
Imp. gals. 100 p.c. vol. basis.....	1.07	1.03	4.00
Imp. gals. 95 per cent vol. basis.....	1.12	1.08	4.25

Attempts to obtain a reliable weight balance were not successful due to lack of facilities necessary for measuring the gas and also to loss of charcoal, both by burning while transferring from oven to coolers and to fines in handling. A rough balance sheet, totalling runs 1 and 2, may be drawn up as follows:—

Total—25 p.c. moisture—air dried peat charged.....	47,267 lbs.	
Charcoal as weighed 17,596 lbs.....	37.2%	of peat charged
Oven liquor including tar 19,960 lbs.....	42.2	" "
Gas—from laboratory estimate.....	13.5	" "
Unaccounted for loss.....	7.1	" "
	100.0%	

As will be noticed the figure of 1.000 has been used as the density of the oven liquor, and the gas yield used is the same as that determined by laboratory runs, the results of which on other products checked the commercial run fairly closely.

Technical paper No. 4, Fuel Research Board, entitled "The Carbonization of Peat in Vertical Gas Retorts," has also been referred to above. The air dried peat used in these commercial size experimental runs, on the 25 per cent moisture basis as received from the bog, conformed to an average analysis as follows:—3.3 per cent ash, 46.6 per cent volatile matter, and 25.1 per cent fixed carbon with a calorific value of 7215 B.Th.U. per lb. This analysis corresponds closely with the air dried peat used for the low temperature runs at Longford, with the exception of ash, viz.: 3.3 as compared with 4.6. A comparison of yields and composition of the commercial products as given in Table III should be of interest here.

TABLE III

Comparison of Commercial Products in Hardwood Oven and in Vertical Gas Retorts

Yields given on a basis of short ton (viz., 2,000 lbs.) of peat charged

Products	Low temperature carbonization in wood ovens	High temperature carbonization in gas retorts
<i>Peat charcoal</i>		
Per cent of air dried peat charged.....	37.2	25.1
Pounds per ton.....	74.5	50.3
Per cent ash (dry basis).....	12.7	9.9
Per cent volatile matter (dry basis).....	28.7	3.9
Calorific value B.Th.U. per lb.....	11940	12650
<i>Peat tar oils—imp. gals. per ton</i>		
Total produced.....	14.1 gals.	14.2 gals.
Specific gravity at 60° F.....	0.968	0.992
Fraction to 170° C. (dry basis).....	6.7%wt	2.5% wt
" 170 " 230° C.....	25.8	13.9
" 230 " 270° C.....	17.5	15.4
" 270 " 335° C.....	24.0	34.7
Pitch and loss (by difference).....	26.0	33.5
<i>Aqueous liquor products per ton</i>		
Total liquor (imp.) gallons.....	86	87
Ammonium sulphate, lbs.....	15.1	22.6
Crude alcohol (imp.) gallons.....	1.08	0.34
<i>Gas—c.f. per ton.....</i>	less than 4,000	about 12,000
<i>Crude motor spirits, (imp.) gallons</i>		
Alcohol—plus oils below 170° C.....	2.10	0.75

VALUE OF PEAT CARBONIZATION PRODUCTS

Peat charcoal is to be considered the main product of low temperature carbonization with the tar oils, gas and alcohol as by-products and of importance in the order given. By the high temperature processes especially where a large yield of gas is desired, the charcoal may be an equal or secondary product as compared with the gas. The charcoal produced by the wood ovens in many respects closely resembles wood charcoal. Its weight per bushel, however, is heavier, averaging 35 lbs. as compared with 21 pounds for hardwood charcoal. At these weights per bushel, a ton of air dried peat will yield only 21 bushels as compared with 26 bushels from a ton (half a cord) of hardwood. In view of the sale of the hardwood product in paper bags as domestic fuel, peat charcoal to be sold by bulk in a similar way is of less value per unit weight. The value of the peat charcoal from a ton of air dried peat is, therefore, disappointing in comparison with wood charcoal from an equal weight of hardwood. As a substitute for hardwood charcoal to be handled and sold in bags, at the same price per bag or bushel, 35 pounds of peat charcoal will net no more than 21 pounds of hardwood product.

Special uses of peat charcoal may be considered the same as hardwood charcoal, such as starting and maintaining short lived fires as in kitchen ranges, train dining room stoves, and in locomotive engines. For metallurgical purposes peat charcoal, or coke as it is sometimes termed, may prove adaptable. Should its structure be such that it could be used for this purpose its low sulphur content should be in its favour.

Peat charcoal as a household fuel, other than having much higher heating value, has not many superior merits to air dried peat, say with moisture content 20 per cent or below. The charcoal besides being dirty and difficult to handle in bulk tends to burn too fast in a furnace. As an open grate fuel, however, it may be considered a substitute for cannel coal, and should be worth in small or large sacks as much as cannel coal which sells as high as \$1 per 100 pound lots. Discounting this figure, say 25 per cent, we may arrive at a conservative (wholesale) value of peat charcoal of $\frac{3}{4}$ cents per pound, or \$15 per short ton.

The peat tar oils on preliminary examination appear to be an oil mixture containing both creosotes and paraffin, resembling wood tar oils on one hand and crude petroleum on the other. A certain amount of light oils may be recovered as crude motor spirits, and other valuable products may be there, but for the time being it would be unwise to consider the heavier oils other than as crude fuel oil, say at a value of 10 cents per gallon. Peat tar oils are good flotation reagents¹, and for this purpose may be worth as high as 20 to 25 cents per gallon as crude unrefined oils.

The alcohol yield from peat was not as high as had been expected. The highest strength obtained so far in the laboratory was 90 per cent volume as per alcoholmeter reading. The alcohol obtained in these commercial runs has a similar boiling point range to that of crude wood alcohol, and is miscible with water. As a motor fuel the 95 per cent product should be of value, especially when blended with certain of the

¹ Crude peat tar oils as such and fractions from the same have been experimented with in the laboratories and plant of the Ore Dressing and Metallurgical Division of the Mines Branch, and found to be quite satisfactory in the treatment of many Canadian ores by the flotation process.

light tar oils. This methyl spirits light peat oil product in the semi-refined state should be worth at least 20 cents per gallon for motor fuel purposes. Another possible use for these methyl spirits is as denaturant for grain alcohol for the denatured alcohol market.

The cost of obtaining the different products from the peat liquor in comparison with their value, is a point to be considered. In respect to alcohol it is questionable if its value would be appreciably above the cost, as its percentage in the aqueous liquor is near the 1 per cent figure, at which point the cost of refining is said to approach the value as a concentrated (crude) product. In respect to recovering the acid value of the liquor as acetate of lime the cost is considered prohibitive. For this reason no credit should be claimed for an acetate by-product.

The gas produced by carbonizing peat by the hardwood distillation process would be burned under the ovens, thus allowing no credit from this product. The ammonia content of the uncondensed gases was not determined.

The ammonium sulphate yield given is that from the oven liquor to be obtained by the method outlined in the flow sheet. Its value may be placed at say 2 cents per pound.

The estimated value of the products from 2,000 pounds of air dried peat may be summed up as follows:—

Peat charcoal, 745 lbs. at $\frac{1}{2}$ cents per lb.....	\$5 60
Heavy tar oils, 13 imp. gals. at 10c. per gal.....	1 30
Motor spirits, 2 imp. gals. at 20c. per gal.....	0 40
Ammonium sulphate, 15 lbs. at 2c. per lb.....	0 30
Total value of products per short ton.....	\$7 60

A rough estimate of the value of the products of a cord (4,000 lbs.) of hardwood at the crude factory, using recently prevailing wholesale prices, is as follows:—

Hardwood charcoal, 1,100 lbs. at 1c. per lb.....	\$11 00
Crude alcohol, 8 $\frac{1}{2}$ imp. gals. at 50c. per gal.....	4 25
Acetate of lime (80%), 210 lbs. at 2c. per lb.....	4 20
Tar oils, 17 $\frac{1}{2}$ gals. at 10c. per gal.....	1 75
Total value of crude products per cord (2 tons).....	\$21 20

Using these figures for the value of charcoal and other products from peat which would likely vary considerably from time to time, similar to the market value changes for hardwood products, and noting that a ton of hardwood is equivalent to only half a cord, the following comparison may be made:—

Value of products per ton of hardwoods.....	\$10 60
Value of products per ton of peat.....	7 60

It will be noticed that the ratio of the value of charcoal to the total value of products from peat would, according to the above figures, be roughly 75 per cent as compared with about 50 per cent for hardwoods.

Further work is being carried out on the examination of both the alcohol product and the tar oils from these commercial size low temperature runs on air dried peat, the results of which will be published in future reports of investigations.

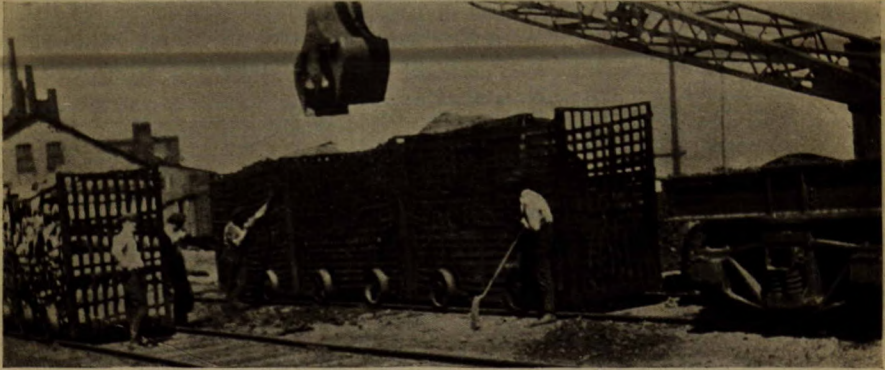
PLATE IV.



Air dried peat and peat charcoal

1. Large size (machine made) briquettes; 2. Peat—broken pieces—as carbonized;
3. Peat charcoal produced

PLATE V.



Loading the peat into the buggies by steam shovel

SUMMARY AND REMARKS

In this investigation a car lot of air dried peat with slightly over 25 per cent moisture content was carbonized in plant size hardwood distillation ovens, under low temperature conditions. The rate of reaction was controlled at about 300° C., and the yields of the commercial products were measured, a preliminary examination of which has been made.

Air dried peat bricks when handled and carbonized in the same manner as hardwoods responded to the same method of oven firing, but required slightly more fuel to carry on the carbonization during the later half of the run, which extra fuel was supplied by the oven gases produced. Although the oven firing did not require special attention to avoid a too rapid increase of the internal temperature of the ovens, there were indications of exothermic reaction, but not to the same extent as with hardwood. The moisture in the peat, however, apparently masked any appreciable outward signs of such reaction. The commercial products obtained were peat charcoal, peat tar oils, crude alcohol, and ammonia, of value in the order given. The alcohol when blended with certain light oils may be considered as a crude motor spirits product.

Peat charcoal in many respects resembles hardwood charcoal, and as a special fuel for quick, hot and short lived fires may be considered a substitute. The quality of the alcohol from peat, the yield of which is disappointingly low in comparison with hardwoods, has not yet been thoroughly examined.

The weight per bushel of peat charcoal averaged 35 pounds as compared with 21 pounds per bushel for hardwood charcoal, and the yield per ton of raw material carbonized was roughly 21 bushels from peat and 26 bushels from hardwood. At the same price per bushel to be marketed in bulk similar to the hardwood product, the value of peat charcoal is, therefore, only about 0.8 of the value of the charcoal from equal weight of hardwood.

The lumps of peat charcoal produced by carbonizing air dried peat were irregular in shape and not as jet black as wood charcoal. Although apparently more friable than charcoal from hardwood, the handling properties of the peat charcoal are such that it can be used as a fuel in the condition produced and does not need to be briquetted.

The value of the products from air dried peat is estimated as three-quarters of the value of the products from an equal weight of hardwood and for peat the value of the charcoal as a percentage of the value of the total products is much higher than for hardwood.

When once the cost of air dried peat in large quantities is known, the yield figures given in this report may be used for determining the economic feasibility of carbonizing peat similar to the low temperature process as used for hardwood. Until such a time, however, as the production of air dried peat more than meets the demand as a household fuel, it is doubtful if the price of the raw material will allow the carbonization of peat to develop into an industry to either supplement a successful peat harvesting enterprise or in conjunction with the already established hardwood distillation industry.

II

REPORT ON THE TREATMENT OF OIL SHALE FROM NEW BRUNSWICK BY THE RYAN OIL DIGESTION PROCESS

A. A. Swinnerton

In order to ascertain the merits of a new process for the treatment of oil shales the so called Ryan oil digestion process was examined. This was in accordance with the plan of investigational work on Canadian oil shales provided for in the Mines Branch investigations for 1921. A demonstration of this Ryan process was given in New York by Mr. Wm. H. Hampton in the presence of Mr. B. F. Haanel, Chief of the Fuel Testing Division.

The experimental retort as used to demonstrate this process was duplicated, and further experiments on oil shale from New Brunswick were made by the author in the Fuel Testing Laboratory during 1922. Examination of the patent drawings for larger continuous operating scale apparatus has also been made. The purpose of this paper is, therefore, to report on the technical points of the process, keeping in mind the application of the same to a commercial scale, according to the claims and drawings of patentee.

The process, according to U.S. Patent 1,327,572, January 6, 1920, Henry D. Ryan, Colorado, consists of the "digestion of the shale in a closed retort with a body of relatively heavy oil under the influence of

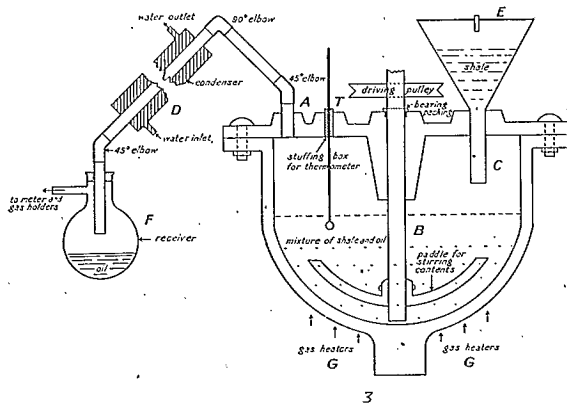


Fig. 16. Diagram of laboratory Scale Digester for oil shale.

heat," and "at a temperature insufficiently high to effect substantial distillation of heavy fractions, but high enough to effectively liquefy heavy hydrocarbons in the said solids." The claim is made that this treatment results in the conversion of the bitumen in the shale from its relatively solid state into a liquid, and this without the evolution of any considerable quantity of fixed gases, presumably at the expense of the heavier oil fractions.

The apparatus used in the laboratory experiments reported herein consisted of a cast iron retort or pot ten inches internal diameter and eight inches deep, having a flange, so that by means of gaskets, bolts and nuts the cover could be made tight in order to prevent gas and oil leaks. As seen in Fig. 16 this cover was fitted with the following: an offtake A leading to a condenser D; a thermometer receptacle T, shaft B carrying a paddle for agitating the contents, and a brass charging funnel C. The retort was heated by gas, using a large special high power burner. Besides the retort and burner the apparatus train consisted of a 36-inch Liebig condenser, fitting into an adapter which in turn was fitted to a large flask F. From a second opening in the top of the flask, a continuation of the closed system consisted of rubber and glass tube connections through a gas meter to a gas holding tank. In the condenser and separating collecting flask respectively ice cold water and ice was used to insure condensing maximum oil vapours.

The procedure as witnessed in the experimental run made in New York, and as duplicated in the Fuel Testing Laboratory experiments, was as follows: 3,500 grams, i.e. approximately $7\frac{3}{4}$ pounds of heavy lubricating oil were poured into the retort and the top bolted on. The retort was then heated by a gas heater to a temperature of 680–700° F., and 1,800 grams or more, i.e. about 4 pounds of finely divided shale was slowly introduced through the funnel C, Fig. 16, care being taken to prevent the escape of vapours by always having the funnel full of shale. When all the shale had been introduced the cover E was screwed on and heating continued for an hour.

During the reaction the contents were kept stirred by means of the paddle, which was driven by an electric motor (not shown). The small amount of vapours obtained by heating the heavier oil and the vapours given off during the reaction escaped by the offtake pipe A, and after passing through the condenser D, collected in the receiver F.

The retort was then allowed to cool down to room temperature, when the cover was removed and the contents transferred to a basket centrifuge, kerosene being added to thin down the mixture of shale and heavy oil and to wash out the digester.

The mixture of shale, heavy oil and kerosene was then centrifuged, further kerosene being added if necessary to wash the last traces of the heavy oil from the shale residue. The liquid obtained from the centrifuge was collected and the dry residue in the basket transferred to a retort and distilled, the oil driven off being added to that already obtained. The light oils were distilled off and the heavy oil remaining could be used for digestion of more oil shale.

The following is the summary of the results of the demonstration run made in, and reported from New York:—

Oil charged in still.....	lbs.
Stripping to 680° F.....	7.00
	0.045
Net oil.....	6.955
Uncondensed vapours during reaction.....	0.105
	6.850

Digestion oil recovered by distillation.....	lbs. 6.390
Apparent shortage.....	0.460
Total diluting and wash oils used.....	12.500
Vaporizing, atomizing transfer and leakage losses.....	0.210
	12.290
Uncondensed vapour during distillation.....	0.065
	12.225
Distillation recovery.....	11.420
Oil with tailings.....	0.805
Oil recovered from tailings by heating to 750° F.....	0.890
Wash and diluting oils charged to tailings.....	0.805
Oil gain.....	0.085
Oil and water from distilling tailings to 920° F.....	0.225
Oil and water from shale reaction 680-690° F.....	0.775
	1.065
Less water from both sources.....	0.055
Oil.....	1.010
Less apparent digestion oil shortage.....	0.460
Net oil gain.....	0.550
Shale charged.....	4.00

This yield of 0.550 pounds per 4.00 pounds shale is equivalent to 38.63 U.S. gallons per ton. Gravity (38° Be. equivalent 0.83 sp. gr.).

The composition of the shale used was given as follows:—

	per cent
Water.....	1.375
Oil.....	12.250
Gas (by difference).....	2.500
Fixed carbon.....	4.375
Ash.....	79.500
	100.00

The quantity of oil obtained from 4 pounds shale by destructive distillation was reported as 8.75 fl. ozs. gravity 29° Be. equivalent to 34.12 U.S. gallons per ton. So that according to these figures the net gain by the Ryan process was 38.63 minus 34.12 U.S. gallons per ton, equivalent to 3.76 imp. gallons.

In the above figures, the net oil gain of 0.550 lbs. includes the losses resulting from the digestion and from centrifuging, viz. 0.105 and 1.210 pounds respectively. This method of figuring the oil gain is apparently based on the assumption that the losses may be accounted for as recoverable light oil vapours. In the experimental runs made as a check on the above run, there were losses first as uncondensable gas during the digestion and second while washing the residue with kerosene in the centrifuge.

Accordingly the net gain of oil due to shale oil should not include these losses. The following summary of the (New York) run would seem to be more proper:—

Shale used.....	4.00 lbs.
Oil used—	
Digestion oil.....	7.00 "
Wash oil.....	12.500 "
Total.....	19.500
Oil obtained—	
Stripping digestion oil.....	0.045 "
Distillate from shale.....	0.755 "
Oils from centrifuge.....	17.875 "
Oils from tailings by distillation.....	1.115 "
Total.....	19.790 "
Less water.....	0.055 "
Total.....	19.735 "
Yield—	
Oil obtained.....	19.735 lbs.
Oil used.....	19.500 "
Gain.....	0.235 "

This gain of 0.235 pounds would be the net gain due to oil extracted from the oil shale and is equivalent to a yield of 17 U.S. gallons per ton, which is approximately only half of that obtainable by destructive distillation.

EXPERIMENTAL

In the apparatus described above, of which the retort as shown in Fig. 16 was the main part, several experimental runs were made for the purpose, first, of checking the results already reported from the demonstration run, and second, to determine what happened at each stage of the operation.

The oil used for digestion was Veedol heavy, which on analysis gave the following results:—

Specific gravity at 60° F.....	0.896
Flash point (closed test. P.M.).....	410° F. (210° C.)
Fire point (open).....	464° F. (240° C.)
Viscosity (Redwood) at 100° F.....	332 secs.
210° F.....	51 secs.
Evaporation test—	
400° F. for 6 hours.....	Loss 3.9 p.c.

Several mechanical difficulties were encountered in operating the retort. A mechanical screw feed for the shale was tried but had to be abandoned as the finely divided shale would not feed properly, so feeding by hand was resorted to. The brass funnel was kept full of shale and pushed in with a rod, and when the weighed amount of shale had been charged and the funnel was empty, the lid was screwed down. The 200 mesh woven wire filter cloth supplied with the centrifuge was found to be too coarse to retain the shale residue. It was therefore reinforced with sheets of filter paper as no finer mesh screen could at the time be procured, and this combination gave quite satisfactory results.

The following table gives the details of various runs made, Nos. 1, 2, and 3 were runs made in this laboratory and No. 4 is a recapitulation, for comparison, of the results obtained at New York, reduced to grams.

	No. 1	No. 2	No. 3	No. 4
<i>Weight of shale used (grams)</i>	1,850	1,812	1,812	1,816
<i>Weight of oil used (grams)—</i>				
Digestion oil.....	2,860	2,575	2,949	3,178
Wash oils.....	1,987	1,233	1,931	5,680
	4,847	3,808	4,880	8,858
<i>Oil obtained (grams)—</i>				
Stripping digestion oil.....	205			20
During reaction.....	567	225	640	343
From centrifuging.....	3,753	3,270	3,844	8,118
From tailings by distillation.....	480	530	519	506
	5,005	4,025	5,009	8,987
Less water.....	8	10	7	25
<i>Net oil obtained (grams)</i>	4,997	4,015	5,002	8,962
<i>Total oil added</i>	4,847	3,808	4,880	8,858
<i>Oil gained from shale by digestion process (grams)</i>	150	207	122	104
<i>Oil from same amount of shale by destructive distillation in lead bath temperature control app. (grams)</i>	245	239	239	222

In the above runs, difficulty was experienced in accounting for the losses, and attempts to obtain a reliable weight balance were unsuccessful, due mainly to loss of light oil vapours, both from creeping past the retort gasket during digestion and during the washing with kerosene in the centrifuge. The impracticability of trying to carry out this process as per laboratory scale directions was at this stage quite evident. It will be noticed that the largest yield of shale oil was obtained in run No. 2, where the amount of digestion oil was the smallest, and vice versa.

There was in each case a certain amount of uncondensed gases which were measured, but the unaccounted for losses which varied for the different runs ruined all attempts to determine just how much of these losses should be assigned to recoverable oil vapours. Until such a time therefore as the process can be carried out in a closed system similar to the patent drawings as shown in Fig. 17, thus necessitating doing away with open centrifuging, it is concluded that no satisfactory results from such laboratory experiments will be available.

In order however to determine at what stage or stages the losses occurred a further run was made with the following results:—

<i>Input—</i>	
Weight shale treated.....	1,800 grams
Weight digestion oil.....	3,039 "
Weight wash oil used.....	1,383 "
Total	6,222 "
<i>Recovery—</i>	
Distillate.....	154 grams
Oil shale.....	6,006 "
Gas.....	49 "
Total	6,216 "

Loss so far in the process, 6 grams.

The shale and oil mixture was thinned with kerosene oil and centrifuged, the yields being as follows:—

<i>Input—</i>		
Oil and shale.....	6,006	grams
Wash oil.....	2,075	"
Total.....	8,081	"
<i>Recovery—</i>		
Oil.....	5,827	grams
Shale.....	1,981	"
Total.....	7,808	"
Loss during centrifuging.....	273	grams
Total oil vapour loss.....	279	"
Total gas and oil loss.....	328	"

The digestion temperature maintained in these experiments was as per directions from 690 to 700° F. and the shale used was a standard laboratory sample No. 1517 from Albert Mine, the maximum yield from which averaged 13·6 per cent weight by destructive distillation equivalent to slightly over 30 imp. gallons per 2,000 pounds ton.

As a result of a study of temperature conditions in previous oil shale investigational work, and also during the above runs, indications were that the digestion temperature was not high enough to insure the breaking down of the so called kerogen oil forming compounds of the New Brunswick shale used. The shale, after digesting at different temperatures, was extracted in Soxhlet thimbles with carbon disulphide and then submitted to destructive distillation. In all digestions below say 750° F. (400° C.) it was found that varying quantities of shale oil still remained in the shale in a form not readily extracted by kerosene or other low boiling solvents. In the neighbourhood of 750° F. or above, the oil forming constituents of the shale were found to be practically all digested. This is in accordance with the minimum temperature required for the recovery of maximum oil yields from shales by destructive distillation. See Mines Branch Investigations in 1921, page 243.

For the New Brunswick shales the digestion must be carried out at temperatures not less than about 750° F. (400° C.). This is evidently not necessary for oil shales from certain other regions. For example, the Californian shales are reported to be different in that the oil is in a readily digestible form and they yield their oil when digested at comparatively lower temperatures¹. Once however digestion at temperatures as high as 750° C. is necessary, trouble is encountered by the cracking of the heavy digestion oil into lighter oil fractions, with the formation of permanent gases. When this reaction takes place the claims of the process according to the reading of the patent are not substantiated as "the principal object of the invention is the obviation of such losses."

For the purpose of determining the nature of the light oil distillate or strippings during the digestion at temperatures sufficiently high to break down the kerogen oil forming compounds, a series of runs were made on the heavy Veedol oil, first alone, next with sand, then with spent shale, i.e. shale from which the oil had been extracted, and finally with

¹U. S. Geological Survey Bull. 729, p. 14.

fresh oil shale, all under practically the same conditions. The temperature during the digestion was carried slowly up to a maximum of 750° F. In each case a light yellow acrid distillate along with uncondensable gas was given off and collected. Following are the comparative results obtained:—

	Veedol oil alone	With sand	With spent shale	With oil shale
Veedol oil used (grams).....	1,082	943	1,901	3,039
Other material used ".....	none	732	500	1,800
Maximum temperature °Fahr.....	750	750	750	750
c.f. of gas obtained	—	—	0.21	1.64
Light oil distillate obtained (grams)...	83	121	156	154
Sp. gr. of " at 60° F.....	0.788	0.794	0.782	0.799

Distillation Range of Light Oil Strippings

	64° C.	71° C.	65° C.	64° C.
1st drop.....	101	117	106	120
10 p.c. vol.....	131	147	128	154
20 ".....	157	170	147	176
30 ".....	184	197	166	199
40 ".....	203	220	188	217
50 ".....	223	245	206	242
60 ".....	247	277	225	263
70 ".....	278	284	250	295
80 ".....	328	320	288	342
90 ".....				

On examining the above distillation ranges and allowing for variations in rate of heating it will be noticed that the light oil distillates from the heavy (lubricating) oil used did not vary appreciably when digested alone or with different finely divided solids. The strippings from Veedol alone correspond quite closely with that from Veedol and oil shale, which shows that when oil shale is digested with a heavy oil such as Veedol lubricating oil, at a sufficiently high temperature to break down the kerogens of the oil shale, there is a partial cracking which reacts (though apparently not as readily) on the heavy digestion oil as well as on the heavier bitumen fractions of shale oil itself.

DISCUSSION OF PATENT DRAWINGS

Fig. 17 is a copy of what is termed "the single sheet of drawings" accompanying the patent application referred to above. Designations of the main parts of the apparatus have been added to the drawing alongside the original numbers.

A brief description of the apparatus is interpreted as follows. The crushed shale is fed into retort 2 heated by fire on grate 15. In the retort it is rotated and digested by means of a revolving screen 5 in heavy oil 14. The light oil vapours or strippings pass up and are condensed in 50. The hot digester oil, carrying with it the extracted shale oil and finely divided shale residue, is dropped into an upward flow of kerosene wash oil in

conical shaped tank 18. The kerosene wash oil laden with the shale oil passes on into tanks 36, 37 and 38, which are fitted with heating coils 39, while the clayey residue drops into chamber 25, fitted with steam jacket 26, from which the dry (supposedly solvent free) residue is discharged at 28. The oil mixture in tanks 36, 37 and 38 after being rid of the light oils is returned through pump 45 to the digesting retort. The light oils, which will be the main product of the process after being distilled off by means of pressure steam in coils 39, are condensed and cooled in 32 before passing into holding tank 47 to be drawn off at valve 48.

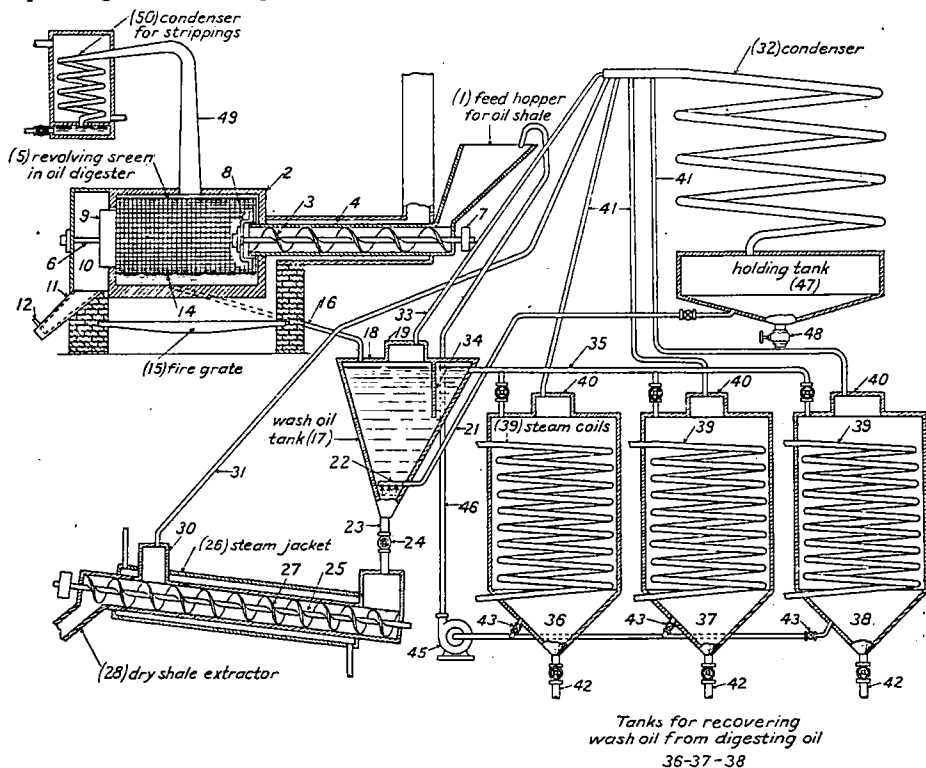


FIG. 17. Copy of patent drawings, Ryan Oil Digestion Process. U.S. Patent, 1,327,572.

The apparatus as shown in the drawing is a closed system, evidently necessary in order to prevent evaporation losses. No provision is made for uncondensable gases, presumably on the assumption that none are formed. The results of the foregoing experiments indicate that this assumption, when applied to oil shales from New Brunswick, is questionable. The process and apparatus were apparently designed to treat oil shales that do not require temperatures as high as 750° F. to liberate the oil from their oil bearing components. For shales that require this temperature or above, to break down the kerogen constituents either in the digestion operation or in a final heat treatment of extracted shale residue, it is doubtful if this oil digestion process has superior merits to an ordinary destructive distillation process.

The heat for distilling off the light wash oils from the heavy digestion oil, in tanks 36, 37 and 38 is evidently that contained in pressure steam, say a maximum of 328° F. (164° C.) at 100 pounds absolute pressure. Unless live or superheated steam, or both, is used this restricts the consistency of the wash oils to that of a light to medium gasoline or crude naphtha and does not allow of kerosene, such as advised for laboratory experiments, being used, as the average initial point of kerosene is above the temperature of steam at ordinary boiler pressures. Again, unless the washing of the heavy digestion oil from the clayey shale residue is highly efficient, it is doubtful, if steam heat around chamber 25 is adequate, to assure the recovery of the oil from the shale residues about to be discharged.

CONCLUSIONS

The results of experimental runs on a laboratory scale and their application to a continuous closed system process as per patent drawings may be summed up as follows:—

(1) In attempting to determine the merits of the Ryan oil digestion process, as per directions given for carrying out laboratory scale tests, no definite conclusions were forthcoming, due mainly to excessive handling losses, the bulk of which took place in the centrifuging operation.

(2) As a minimum temperature of about 750° F. (400° C.) is necessary for the complete digestion of the kerogen oil-forming constituents in the oil shales from the maritime provinces, and since at this temperature uncondensable gases are given off as the result of the cracking of the heavier oil fractions, the claims made for this process in respect to the absence of fixed gases are not substantiated when treating New Brunswick shales.

(3) Examination of the shale oil obtained by this process was not made, as it was impossible to separate the shale oil from the oil used as a digesting medium, and since there was evidence that light oils resulted from the cracking of both the digestion oil and the shale oil, the special claim that this process accomplishes the recovery of the hydrocarbons as they exist originally in the shale, is not substantiated when treating oil shales from New Brunswick.

III

PRELIMINARY GASOLINE SURVEY

ANALYSES OF GASOLINE SAMPLES COLLECTED IN OTTAWA,
DECEMBER 1922

P. V. Rosewarne

INTRODUCTION

At different times there has arisen in various parts of Canada a spasmodic agitation for a standard specification for gasoline. It would seem logical before attempting to set a standard, if such action were deemed advisable, to first find out the characteristics of the gasoline being sold on the open market in different parts of the country.

This report covers the analyses of twenty samples sent to, or collected by the Fuel Testing Laboratory in December, 1922. In the future it is planned to extend this preliminary local survey to a Dominion wide survey to be reported annually in the Mines Branch Summary of Investigations.

To this report has been added, for the benefit of the non-technical reader, a few paragraphs as an appendix to explain the meaning and significance of the different tests. It is hoped that it may help toward a better understanding of a rather complex subject.

ANALYSES OF SAMPLES COLLECTED

Of the twenty samples, five samples were from the wholesale dealers and the remaining fifteen were from the retail distributing stations in the city of Ottawa. In general the analyses of the wholesale and retail samples sold under the same trade name checked quite closely, but there was considerable variation between the gasolines of different grades, and between gasolines of the same grade, for example, Grade II as discussed later.

After determining the specific gravity, corrected to 60 degrees, Fahrenheit, each sample was subjected to a distillation range test and was examined for unsaturated compounds by determining the iodine absorption value. All determinations were made in duplicate and the values given are the average of the two estimations.

The specific gravity was found by means of the hydrometer and the Westphal balance. The distillations were run according to the method recommended by the United States Bureau of Mines¹. The iodine values were determined by the Hanus method², which gave very consistent results.

TABLE I
Results of Analyses

Sample No.	Sp. gr. at 60° F.	Baume degrees at 60° F.	First drop ° F.	20 per cent ° F.	50 per cent ° F.	90 per cent ° F.	End point ° F.	Per cent recovered	Iodine values
2128.....	0.717	65.3	126	176	221	309	388	.....	2
2129.....	0.735	60.5	129	197	246	342	423	.....	32
2130.....	0.734	60.7	126	199	261	339	390	.....	37
2131.....	0.717	65.3	132	181	225	304	364	.....	1
2132.....	0.722	63.9	117	174	226	320	400	.....	4
2134.....	0.719	64.7	133	187	227	316	367	97	4
2135.....	0.731	61.5	122	194	251	354	423	98	29
2136.....	0.725	63.1	133	185	228	322	399	98	10
2137.....	0.736	60.2	123	208	268	342	388	97.5	31
2138.....	0.736	60.2	127	208	268	342	395	98	31
2139.....	0.735	60.5	118	205	258	347	388	98	31
2140.....	0.735	60.5	129	207	270	344	397	97.5	31
2141.....	0.723	63.6	117	180	229	327	408	98	4
2142.....	0.718	65.0	135	186	227	306	365	98	1
2143.....	0.731	61.5	90	141	315	444	478	95	10
2144.....	0.737	60.0	127	209	268	347	408	98	31
2145.....	0.724	63.4	90	145	252	430	471	95	5
2146.....	0.727	62.6	123	183	227	329	405	98	12
2147.....	0.718	65.0	133	187	227	307	361	98	2
2148.....	0.717	65.3	135	186	227	306	363	98	2
Average.....	0.727	62.6	123	187	246	339	399	.....	16

¹ U.S. Bureau of Mines Technical Paper 298. "Methods for Testing Petroleum Products."

² Ellis and Meigs. "Gasoline and other Motor Fuel."

DISCUSSION OF RESULTS

The average figures shown above cannot be taken as the actual analysis of the average gasoline sold in Ottawa, because it takes no account of the varying amount handled by the different wholesalers and retailers. It is simply an average of the samples taken. However, it may be considered to be a quite close approximation to the true value and as such it is interesting to compare it with other results obtained in a somewhat similar way and with some published specifications. Diagram X gives in graphic form the average distillation curve for Ottawa as determined above, the average distillation curve for the United States as determined by the Bureau of Mines¹, and a distillation curve representing the specification for gasoline adopted by the Federal Specifications Board of the United States for the use of the various departments and independent establishments of the United States government.

A study of the results shows that these samples can be divided into three distinct grades or groups of gasoline. Grade No. 1 is distributed by two companies² under two trade names. Grade No. 2 is distributed by three companies and is retailed to consumers under at least six trade names. Grade No. 3 is distributed by one company and is retailed to consumers under at least two trade names.

It will be noticed that the results of the analysis of some samples in Grade No. 2 come very close in some respects to the results of some samples in Grade No. 1. It was felt, however, that if the limits were enlarged to admit those samples into Grade No. 1, that then samples much more inferior than they are would also come within those limits.

Diagram XI shows graphically the difference in the average results of the distillation ranges of the gasoline in the different groups.

TABLE II
Analyses by Grades

GRADE No. 1

Laboratory No.	Sp. gr. at 60° F.	Iodine value	First drop ° F.	20 per cent ° F.	50 per cent ° F.	90 per cent ° F.	End point ° F.
2128.....	0.717	2	126	176	221	309	388
2131.....	0.717	1	132	181	225	304	364
2134.....	0.719	4	133	187	227	316	367
2142.....	0.718	1	135	186	227	306	365
2147.....	0.718	2	133	187	227	307	361
2148.....	0.717	2	135	186	227	306	363
Average.....	0.716	2	132	184	226	308	368

¹ United States Bureau of Mines, Report of Investigations, Serial No. 2444, "Seventh Semi-Annual Motor Gasoline Survey."

² In this report the word "company" or "distributor" refers to a wholesale dealer.

DIAGRAM X

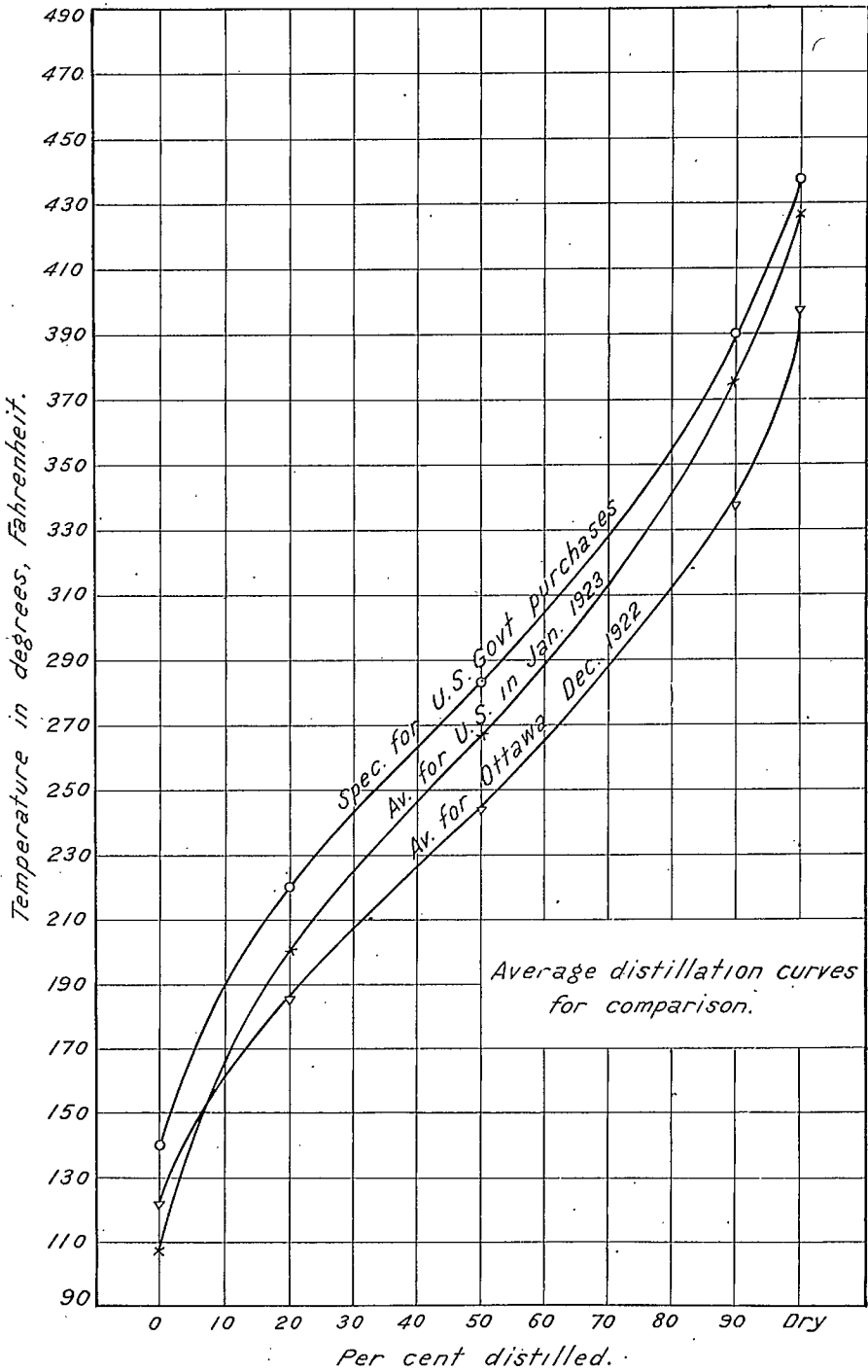


DIAGRAM XI

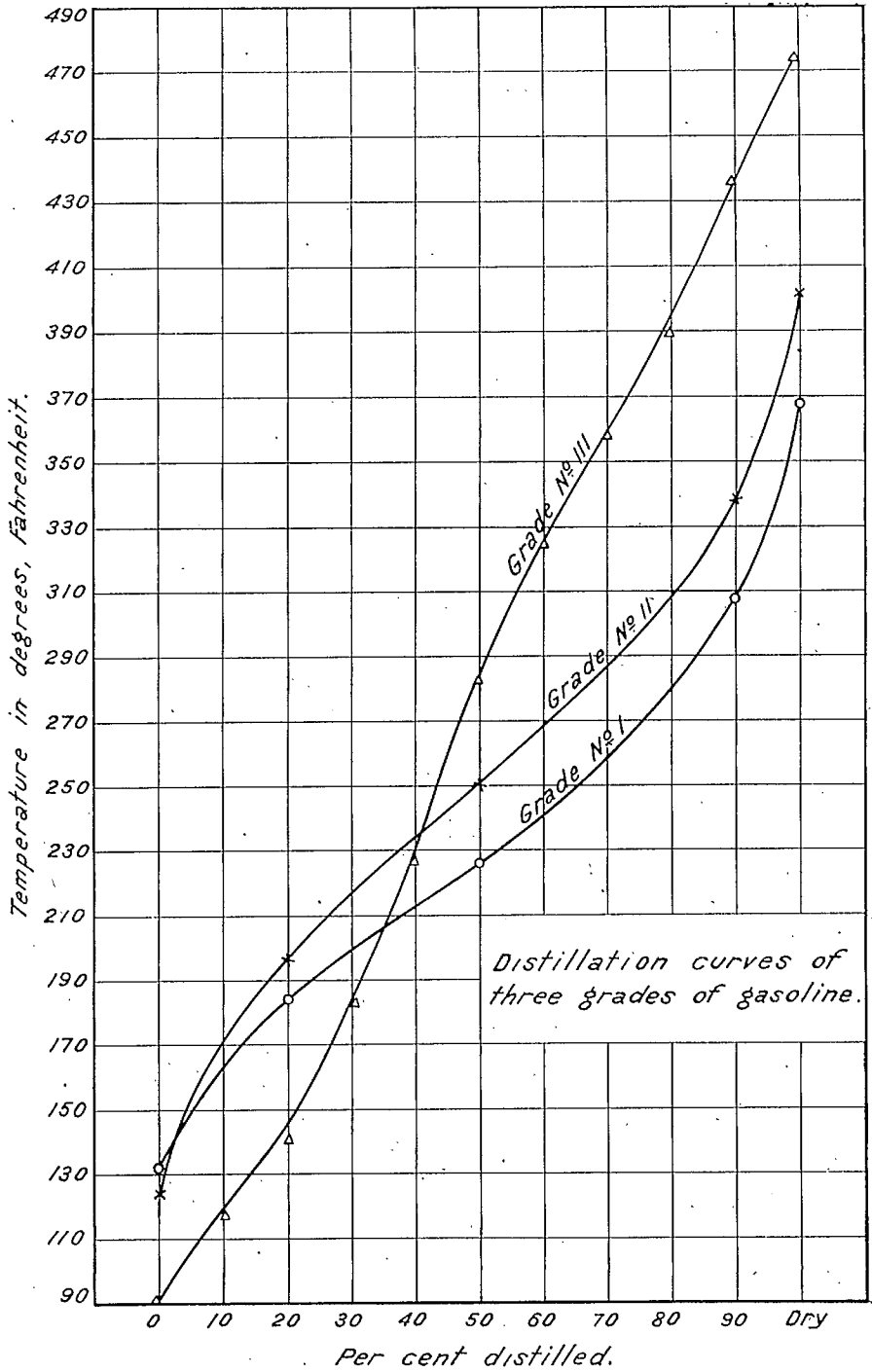


TABLE II—Concluded
Analyses by Grades—Concluded
GRADE No. 2

Laboratory No.	Sp. gr. at 60° F.	Iodine value	First drop ° F.	20 per cent ° F.	50 per cent ° F.	90 per cent ° F.	End Point ° F.
2129.....	0.735	32	129	197	246	342	423
2130.....	0.734	37	126	199	261	339	390
2132.....	0.722	4	117	174	226	320	400
2135.....	0.731	29	122	194	251	354	423
2136.....	0.725	10	133	185	228	322	399
2137.....	0.736	31	123	208	268	342	388
2138.....	0.736	31	127	208	268	342	395
2139.....	0.735	31	118	205	258	347	388
2140.....	0.735	31	129	207	270	344	397
2141.....	0.723	4	117	180	229	327	408
2144.....	0.737	31	127	209	268	347	408
2146.....	0.727	12	123	183	227	329	405
Average.....	0.731	24	124	196	250	338	402

GRADE No. 3

2143.....	0.731	10	90	141	315	444	478
2145.....	0.724	5	90	145	252	430	471
Average.....	0.728	8	90	143	284	437	475

TABLE III
Averages for Three Grades

Grade	Sp. gr. at 60° F.	First drop ° F.	20 per cent ° F.	50 per cent ° F.	90 per cent ° F.	End ° F.	Iodine value
No. 1.....	0.716	132	184	226	308	368	2
No. 2.....	0.731	124	196	250	338	402	24
No. 3.....	0.728	90	143	284	437	475	8
Average.....	0.725	115	174	253	361	415	11

TABLE IV
Summary of Analysis by Grades

	Grade I		Grade II		Grade III	
	Above	Below	Above	Below	Above	Below
Specific gravity at 60° F.....	0.715	0.720	0.720	0.740	0.723	0.732
Baume degrees at 60° F.....	65.8	64.4	64.4	59.2	63.6	61.3
Iodine value.....	0	7	4	37	5	10
Distillation range:						
Initial point.....		135° F.		135° F.	89° F.	91° F.
20 per cent by Vol.....	175° F.	188° F.	180° F.	210° F.	140° F.	146° F.
50 per cent by Vol.....	220° F.	228° F.	225° F.	270° F.	251° F.	316° F.
90 per cent by Vol.....	305° F.	317° F.	320° F.	355° F.	429° F.	445° F.
End point.....		388° F.		425° F.		479° F.

APPENDIX

SOME NOTES ON THE MEANING AND SIGNIFICANCE OF THE
DIFFERENT TESTS

Specific Gravity.—The relation between specific gravity and Baume degrees is often imperfectly understood. The specific gravity of a

substance is the weight of a certain volume of the substance divided by the weight of an equal volume of water. It is evident from the above definition that the specific gravity will be high for substances commonly called heavy, such as lead or iron, and will be low for substances commonly called light, such as wood or cork. The same thing applies to liquids. There are heavy liquids, as the sulphuric acid in a storage battery, and light liquids, as ether and gasoline. The two latter liquids are lighter than water and from the definition of specific gravity must accordingly be represented by a fractional or a decimal number less than 1.

The easiest method of comparing the specific gravity of liquids is by means of a hydrometer. A hydrometer is merely a bob or float weighted at one end so that it stands upright in the liquid to be tested. A scale is attached to the upper end. The scale may be divided so that the true specific gravity can be read off directly, or any convenient set of numbers can be used. The Baume scale for light liquids, that is, for liquids lighter than water, is simply a consecutive set of whole numbers, each of which has a definite specific gravity. There was formerly some uncertainty regarding the exact value of the Baume scale and a great deal of confusion arose because different scales gave slightly different readings. In an effort to avoid this confusion the American Petroleum Institute has urged the acceptance of one particular method of calculating the subdivisions of the Baume scale, and this scale is sometimes referred to as the A.P.I. scale.

Practically all liquid petroleum products have a specific gravity less than 1, and the Baume scale for light liquids has been used almost exclusively in the petroleum industry because it avoids the use of fractions and decimals. It is not satisfactory because a high figure on the Baume scale is equivalent to a low specific gravity, and vice versa. Accordingly, many people refer to a high specific gravity or high gravity when in reality a high Baume figure is meant. This accounts for the familiar terms "High Test" and "Low Test" gasoline. "High test" used in this sense means that the Baume figure is high and therefore the specific gravity is low, while "low test" has the opposite meaning. The following table may be used to compare Baume degrees and specific gravities at 60° F.

TABLE V

Specific gravity at 60° F.	Degrees Baume at 60° F.	Specific gravity at 60° F.	Degrees Baume at 60° F.
0.700	70.0	0.755	55.4
0.705	68.6	0.760	54.2
0.710	67.2	0.765	53.0
0.715	65.8	0.770	51.8
0.720	64.4	0.775	60.6
0.725	63.1	0.780	49.5
0.730	61.8	0.785	48.3
0.735	60.5	0.790	47.2
0.740	59.2	0.795	46.1
0.745	57.9	0.800	45.0
0.750	56.7		

Although the specific gravity of gasoline has been used for many years as a test for its quality, at the present time it is not of very much value, because a gasoline may be so mixed or blended as to give any desired gravity within reasonable limits. It may be used as an aid, however, in interpreting the results of the distillation range test.

Distillation Range.—The distillation range is the most important single test used to determine the quality of a gasoline, because it gives the most information regarding the composition of the fuel. A good gasoline should consist of a certain amount of material that boils at a low temperature so that an explosive mixture can be readily obtained. However, a large amount should not be present since then the evaporation loss would be large. A good gasoline should all distil over before too high a temperature is reached or the fuel will not burn satisfactorily. The writer is inclined to believe that the gasoline having the smallest temperature range between the point at which 20 per cent distils over and the point at which 90 per cent distils over is best, providing the initial and end points are within reasonable limits. If the distillation ranges of two or more gasolines are plotted on squared paper, as in Diagram X and Diagram XI, the more desirable sample as far as volatility is concerned has a curve which lies below and is flatter between the above mentioned points than the other. If the curve is very steep, as in Grade III, Diagram XI, the gasoline usually will be unsatisfactory in service because the higher boiling portions will not vaporize and mix properly with the lighter boiling portions so as to form a mixture of gases which will burn evenly and completely in the cylinder of the motor. On the other hand the curve should not be too flat, because then there is a tendency towards knocking and to low mileage due to excessive evaporation.

The amount of evaporation is indicated by the recovery from the distillation. If a very high recovery is obtained, there is likely to be difficulty in starting the cold motor in which the gasoline is being used; if a very low recovery is found, there will be considerable loss through handling, but that defect will be somewhat counterbalanced by greater ease in starting, especially in the winter. It is to be remembered that prevailing temperature has a decided influence on the carburation of gasoline, and that a fuel that is satisfactory in the summer may not be desirable during the winter months.

In view of the possible exhaustion of the petroleum fields an effort should be made by all users of gasoline to use as low a grade for motor fuel as will operate satisfactorily, and thus make available as large a percentage as possible of the crude petroleum.

Iodine Value.—The iodine value indicates the presence of those chemical compounds which are termed unsaturated. Gasoline which has been obtained by a simple distillation and refining of crude petroleum is composed largely of saturated compounds which give a very low iodine value. When gasoline has been produced by one of the cracking processes a comparatively large amount of unsaturated compounds are present and the iodine value is high. The general tendency has been to condemn unsaturated compounds in gasoline as wholly undesirable, but nevertheless their presence materially increases the available supply of motor fuel without very definitely affecting its combustion. It is reported¹ that up to 12 per cent unsaturates may be present in a gasoline without seriously reducing its value in ordinary use. This is approximately equivalent to an iodine value of 36.

¹ United States Bureau of Mines, Technical Paper 181, "Determination of Unsaturated Hydrocarbons in Gasoline."

APPENDIX

INTERIM REPORT OF THE JOINT PEAT COMMITTEE

(December 5, 1922)

B. F. Haanel*Secretary to the Committee*

The original objective which the Joint Peat Committee had in 1918, the year of its appointment, was the testing of peat machines under commercial conditions, in order to determine if a type suitable for manufacturing peat fuel on a commercial basis could be developed. By a process of elimination two types were selected, the well known Anrep peat machine, largely used in European countries—in the smaller sizes—and the Moore machine. The latter, while not fully developed, appeared to possess so many advantages that the Federal government, before the appointment of the Peat Committee, decided it should be given a trial.

On account of the precedence given to war contracts, the two machines were not delivered at the Alfred bog, Ontario, until the spring of 1919, and their erection was only completed in time to enable a short mechanical test to be conducted before cold weather set in. It was not, therefore, until the spring and summer of 1920 that manufacturing operations were actually begun.

Up to this time the Committee was under the impression that its work would be completed at the conclusion of 1920, and that sufficient data would be available to enable an opinion to be expressed concerning the commercial possibilities of the two machines. The results of that season's operations, however, disclosed inherent weaknesses in both plants, and the Committee was unable to approve either type for commercial work. Recognizing the great value to the Dominion at large, of a healthy peat development, the Committee recommended that a new combination be effected embodying the best features of the two types which had been tried. This recommendation was approved by the two governments and funds were allotted for carrying out the construction and operation of the new combination. The construction was completed late in 1921 and operations were concluded in 1922.

DEVELOPMENT OF PEAT MACHINERY

The success of any such machine depends largely upon the elimination of manual labour to the greatest possible extent and on the production of a manufacturing unit of large capacity at the lowest possible cost commensurate with good service.

Attempts to meet these two conditions led to the trial of many mechanical devices which heretofore have not been used in this connection. The most noteworthy features involved were the adoption of caterpillar

elements and the substitution of a portable belt conveyer and automatic spreading machinery for the track system and field presses formerly employed. The development of these and other mechanical features proved difficult, and occasioned the expenditure of much time. While the machine has not actually been constructed according to the design which the Committee considers would be reasonably free from defects, the problems involved have, in their opinion, been thoroughly investigated, and drawings for a complete standard equipment with power plant, pulverizing unit, conveyer and spreading system are now under way.

NECESSITY FOR FURTHER GOVERNMENT OPERATION

While the Committee has completed research work requisite to the development of a successful peat manufacturing plant, and is able to place at the disposal of those interested construction data and operating statistics, it is of opinion that the establishment of a peat industry is of such importance to Canada, and especially the province of Ontario, that the governments should undertake the construction and operation of a perfected plant until its possibilities are fully demonstrated.

COST OF MANUFACTURING FUEL WITH A COMBINATION PLANT

The Committee after careful consideration arbitrarily fixed the price f.o.b. cars peat plant siding, at which peat fuel could in its opinion be sold for consumption, within a 100-mile radius and still compete with anthracite coal. The price was \$5 per ton of standard peat fuel containing 30 per cent moisture, and comprises the following items:—

1. Production cost.
2. Overhead charges.
3. Manufacturer's profit.

The production cost depends mainly upon the cost of the raw material, the prevailing price of labour, and number of employees, seasonal variations, and the quantity of saleable fuel produced per unit per working season.

Overhead charges include interest on capital invested, depreciation and administration.

Manufacturer's profit as would be arrived at by the investor.

The figures employed in this report are considered fair by the Committee, but those who desire to engage in such an enterprise would naturally estimate their own overhead charges and profit.

In order to keep items 1 and 2 sufficiently low to enable a fair manufacturer's profit to be realized and still bring the selling price of peat f.o.b. cars within the limit of \$5, it was estimated that the minimum capacity of the unit must be 10,000 short tons of saleable standard peat fuel for a working season of one hundred days. This type of machine should be capable of producing a sufficiently high hourly average of peat fuel throughout an entire season, irrespective of seasonal variations and delays due to breakdowns or other causes, to enable the 10,000 ton figure to be realized. This we believe could be accomplished by constructing the complete unit sufficiently large to produce a maximum capacity considerably in excess of the minimum required.

The improved plant, exclusive of harvesting equipment, consists of four components:—

1. Excavating.
2. Macerating.
3. Distributing and spreading.
4. Power.

The excavating element proved of sufficient capacity to meet all requirements, and the distributing and spreading system was sufficient to deliver and spread the maximum quantity of peat excavated. The macerating element, however, failed to deliver the required quantity with the power available. This was due to the adoption of a new type of macerator, a Swing Hammer Pulverizer, which it was considered would prove far more reliable, cheaper and more efficient than the Anrep macerator heretofore employed. This machine had not before been employed for macerating peat, and, therefore, its capacity and the power required to operate it for such purpose were not known. A portion of the operating season had to be devoted to experimentation with and calibration of this unit.

On account of the lateness of the season, and lack of funds, the Committee could not possibly consider the purchase of a power plant sufficient to operate the combined plant to full capacity. The power plant used was improvised, comprising two boilers already on the bog, the wasteful steam engines which formed part of the two plants previously experimented with, and a high speed engine which was rented for the season. The two boilers were rated at 80 horsepower each and the engineer of the Committee had reason to believe that practically 160 horsepower would be available. A test, however, disclosed that only 110 horsepower could be developed, while the minimum required to operate the full capacity was estimated to be 150 horsepower. With 150 horsepower and a larger macerator the full capacity of the plant could have been delivered. Since both these elements are standard equipment and can be obtained in various sizes on the market, the ultimate capacity of the plant can readily be obtained by simply substituting a macerator and power plant of greater capacity.

COSTS

Based on the performance of the experimental combination plant and the estimated cost of an entirely new and remodelled plant, complete with an efficient power unit and larger macerator, the production and other costs of the finished peat per ton are estimated to be:—

	10 hour day	20 hour day
Production costs.....	\$2 00	\$2 00
Overhead charges.....	2 48	1 50

or a total cost of finished peat fuel, on board cars at siding of plant, of \$4.48 for a ten hour day for a season of 100 days, or \$3.50 for a twenty hour day during the same season. A total production of saleable fuel in the first case is 10,000 short tons and in the second, 20,000 short tons. Since, however, the overhead costs mount rapidly as the production decreases the Committee recommended that plants of this type should be

operated for twenty hours per day. The necessity for increasing the length of the working season by operating twenty hours per day will be readily appreciated, when it is realized that the considerable investment represented in plant is, under the most favourable conditions, lying idle practically two-thirds of the year. Thus the overhead would be distributed over the production of only one-third of the year, greatly increasing the cost. Working two shifts is equivalent to operating ten hours a day for 200 days. Night operation with this combined plant is entirely feasible; it was not the case with either of the others.

The foregoing costs are below that arbitrarily set by the Committee as the maximum price at which peat could be sold f.o.b. at plant and still compete with coal for domestic purposes. The most notable feature is the marked reduction in the total cost due to reduction in overhead, by operating for a season of two thousand hours instead of one thousand.

The important reductions in the final total cost will be attained by many improvements permitting of substantial saving in the construction of a new plant, and by the employment of a self-contained Diesel engine electric power plant. By using Diesel engines and electric generators, and operating all drives on the plant with electric motors, it is estimated that a saving of 85 cents per ton of saleable peat fuel will be realized, over that possible with the inefficient outfit employed this season. These figures assume the employment of this or some other equally efficient power plant. For a plant producing ten thousand tons, in 1,000 hours, a power equipment of 200 horsepower will be required. The following table recites the estimated costs of building an entirely new plant, with power, harvesting, loading equipment and other accessories. Overhead and administration charges are also shown.

TABLE OF NEW PLANT COSTS

	Capital cost	Interest	Depreciation	Administration
Power plant.....	\$25,000		10%—\$2,500	10% on \$100,000 for 20 hours daily operation
Peat plant.....	35,000	7%	20%—7,000	
Harvesting equipment.....	25,000		14%— 3,500	or
Buildings, equipment and miscellaneous.....	5,000		10%— 500	10% on \$50,000 for 10 hours daily operation
Total.....	\$90,000	6,300	13,500	\$10,000 or \$5,000.

MARKET

A good market has been developed for peat within the economical shipping radius of the Alfred bog. The demand is growing. The success of such a plant depends in a marked measure, however, upon the site chosen for manufacturing in its relation to points of consumption. This should be selected with a view to eliminating long rail hauls. The economic

limit depends not only upon freight rates, but on the price of other available competitive fuel. For example, the cost of anthracite to consumers has an effect upon the price at which peat fuel can be sold at the same point. It is the opinion of the Committee, that the price of peat fuel delivered to consumers should be in the neighbourhood of \$10 per ton if the bogs are strategically situated with respect to transportation facilities and within 100 miles of the market.

PLANT NO. 3, SMALL PEAT PLANT

When Plant No. 3, the small plant, was first designed, an attempt was made to combine the excavating and macerating units in a single machine, simple in design and inexpensive. Until the end of the season of 1921 efforts were made to perfect the original design, but the results were not satisfactory. Difficulties with the combined excavator and macerator were not completely overcome, and it was decided that other means of macerating must be found before this type of machine could be considered practical from a commercial standpoint. About this time the possibilities of the Swing Hammer Pulverizer were brought to the notice of the Committee and nothing further was done with No. 3 until this machine had been tested.

The Swing Hammer Pulverizer proved to be so superior to the type of macerator formerly used that it was decided to include it in the rebuilding of No. 3. This was carried out during the 1922 season. Construction, however, was only completed after the normal working season, and, therefore, no sustained demonstration was possible. The troubles which developed in the first design were overcome. The capacity of No. 3 plant should be not less than 1½ tons standard fuel per hour and in regular operation might exceed this. The cost of construction cannot be given at this time, as new drawings have to be prepared. It is, however, expected that it will not exceed \$5,000. A full description of the redesigned machine, with a discussion of its capabilities, and accurate figures of its cost, will be given in the final report of the Committee. Three men should be sufficient to operate it.

TORONTO, December 5, 1922.

(Sgd.) A. A. COLE,
Chairman,
Peat Committee.

(Sgd.) B. F. HAANEL,
Secretary,
Peat Committee.

(Sgd.) R. C. HARRIS,
Member,
Peat Committee.