Report No. 20

SEVENTH ANNUAL REPORT

OF THE

SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

1926

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The Scientific and Industrial Research Council of Alberta, formed in January, 1921, carries on its work in co-operation with the University of Alberta.

The personnel of the Council at the present time is as follows:

HON. J. E. BROWNLEE, Premier, Chairman.

H. M. TORY, President, University of Alberta.

J. T. STIRLING, Chief Inspector of Mines, Province of Alberta.

J. A. ALLAN, Geologist.

N. C. PITCHER, Mining Engineer.

R. W. BOYLE, Dean, Faculty of Applied Science, University of Alberta.

R. M. YOUNG, Canmore, Alberta.

EDGAR STANSFIELD, Honorary Secretary, Industrial Research Department, University of Alberta.

Requests for information and reports should be addressed to the Secretary, Industrial Research Department, University of Alberta, Edmonton, Alberta.

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UNIVERSITY OF ALBERTA,
EDMONTON, ALBERTA,
FEBRUARY 24TH, 1927.

HON. J. E. BROWNLEE,
Premier,
Edmonton, Alberta.

Sir :—

Under instruction from the Scientific and Industrial Research Council of Alberta, I herewith submit their Seventh Annual Report. This covers the work done under their direction during the year ending December 31st, 1926.

Respectfully submitted,

EDGAR STANSFIELD,
Honorary Secretary.

SEVENTH ANNUAL REPORT OF THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA

ORGANIZATION

In the organization of the University of Alberta the staff of the Research Council constitutes the Industrial Research Department, and the Research Council's laboratories are referred to as the Industrial Research laboratories.

In the organization of the Provincial Government the work of the Research Council is attached to the Executive Council.

PERSONNEL AND MEETINGS OF COUNCIL

Three meetings of the Council were held during the year. The personnel of the Council on December 31st was:

Hon. Alex. Ross, Minister of Public Works, Chairman.

H. M. Tory, President, University of Alberta.

J. T. Stirling, Chief Inspector of Mines, Province of Alberta.

J. A. Allan, Geologist, University of Alberta.

N. C. Pitcher, Mining Engineer, University of Alberta.

R. W. Boyle, Dean, Faculty of Applied Science, University of Alberta.

Edgar Stansfield, Honorary Secretary.

STAFF

The following changes in the permanent staff have been made during the year:

Eva Bowman Fisher commenced work as Geological Stenographer on January 1st, and resigned on July 9th.

C. J. Ferguson commenced work as Laboratory Assistant, Road Materials, on January 1st, and resigned on March 31st.

J. W. Sutherland commenced work as Fuel Analyst on May 1st.

J. H. Mooney commenced work as Laboratory Assistant on June 28th, in place of C. J. Ferguson resigned.

R. T. Hollies resigned his position as Assistant Research Engineer, Fuels, on July 31st.

W. P. Campbell resigned his position as Fuel Analyst on August 31st.

S. M. Blair, Assistant Research Engineer, Road Materials, was granted one year's leave of absence, dating from the 22nd of September.

J. C. Brennan resigned his position as Office Assistant on September 18th.

H. M. Kesner commenced work as Office Assistant on September 21st, in place of J. C. Brennan resigned.

Ruth MacLennan commenced work as Geological Stenographer on October 1st, in place of Eva B. Fisher resigned.

S. Zeavin and K. C. Gilbart commenced work as Assistant Engineers on November 15th, in place of R. T. Hollies and W. P. Campbell resigned.

The permanent staff on December 31st, 1926, was as follows:

EDGAR STANSFIELD, Research Engineer, *Fuels;*

K. A. CLARK, Research Engineer, *Road Materials;*

R. L. RUTHERFORD, Geologist, *Geology;*

W. A. LANG, Assistant Engineer, *Fuels;*

J. W. SUTHERLAND, Fuel Analyst;

S. ZEAVIN, Assistant Engineer, *Fuels;*

K. C. GILBART, Assistant Engineer, *Fuels;*

HAZEL M. WORTMAN, Accountant and Stenographer;

RUTH MACLENNAN, Geological Stenographer;

J. D. BAIRD, Laboratory Assistant, *Fuels;*

J. H. MOONEY, Laboratory Assistant, *Road Materials;*

H. M. KESNER, Office Assistant.

In addition to the above, Professors J. A. Allan and N. C. Pitcher, of the University of Alberta, members of the Council, are in permanent charge of the Council's research work in Geology and Mining Engineering, respectively. Associate Professor A. E. Cameron acts as secretary to the Council and has charge of the office staff.

Other members of the University staff have assisted from time to time; notably Prof. R. S. L. Wilson, who devoted considerable time throughout the year to work for the Council on the forest products of Alberta, with special reference to mine timber.

A number of other persons held summer or short term appointments under the Council:

In the Geology Division: L. S. Russell, field assistant in survey party; Geo. C. Haworth, cook and driver of survey car; G. J. Knighton, O. Inkster and A. K. Cox, draftsmen. C. E. White and L. S. Russell gave some assistance in the compilation of map data.

In the Road Materials Division: A. W. Drew, draftsman.

In the Forest Products Division: C. K. Muir, H. R. Webb, J. W. Porteous, H. M. Hunter and D. A. Hansen rendered occasional service.

LABORATORIES AND EQUIPMENT

The principal items of new laboratory equipment purchased or constructed during the year are as follows: A small Mashek roll press for briquetting coal, Ranarex CO_2 Recorder, Cenco rotary vacuum pump, Cambridge Thermo-Electric Pyrometer for measuring surface temperatures, a thermometer testing apparatus and ignition temperature of coal apparatus. Additions were also made to the library.

FUELS

The work of previous years was continued and some new investigations started under the supervision of Mr. Stansfield. Storage and screening tests were completed on one sample in storage.

Analytical work for the Provincial Mines Branch included analyses of 64 samples of coal, 52 of coal dust and 1 of limestone. Considerable work has been done on the standardization of methods of analysis for Alberta coals. The standard air drying apparatus was improved and also the method for determination of volatile matter.

The work on the Chemical Survey of Alberta coals was extended to include ultimate analysis. A method for the determination of the ignition temperature of the coal was standardized and the ignition temperature of a number of coals determined. Some work was also done relative to the determination of the maturity of coal.

The work on domestic heaters was continued during the year. The final tests to establish the accuracy of the hot air calorimeter, designed and built in 1925, were completed. A number of comparative experiments were run to determine the efficiency of a patented device for hot air stoves and furnaces. Details of the investigations are included in the appendix to this report, because they give interesting comparisons of coal and gas heating, as well as indications of the efficiencies to be obtained in the ordinary operation of a stove for house heating.

The records of the work on residence heating were restudied during the year and the information contained in them brought to a more systematic form.

The briquetting investigation was continued along the line of previous years, with special attention given to certain factors which influence the making of briquettes, namely, pressure, temperature of mixing and pressing, and effect of moisture. One hundred and thirty batches of briquettes were made, 38 with semi-anthracite coal from Cascade area, 30 with bituminous coal from Crow's Nest area, 41 with sub-bituminous coal from Coalspur area, 8 with carbonized lignite and 13 with blended coals. Eighty-five batches were made with asphalt (from different sources) as binder, 9 with soft coal tar pitch, 5 with hard coal tar pitch, and 31 with mixed binders (chiefly flour and crude McMurray bitumen).

A more detailed report of several branches of the work on fuels is given as an appendix.

GEOLOGY

The work of the Geological Survey Division of the Council is carried on in conjunction with the Department of Geology at the University of Alberta, under the direction of Dr. J. A. Allan. The palaeontological material obtained on field surveys is determined by Dr. P. S. Warren, and in return for this co-operation, Dr. R. L. Rutherford assists in teaching in the Department of Geology.

The office was open for ten months. The correspondence in connection with the mineral resources was about the same as the previous year. The drafting increased considerably, and temporary assistance was obtained for this purpose.

Two geological reports and two maps were published by the Council. One additional report was prepared by Dr. Allan and published with a soils report by the Department of Extension.

A black and white map of the Province of Alberta on a scale of one inch to sixty miles was prepared showing geological boundaries, and included in Report No. 16 of the Council.

One geological survey party under Dr. Rutherford spent about four months in two field areas. In Central Alberta an area between Edson and lake Wabamun was investigated, and in Southern Alberta a geological survey was made of a belt about ten miles wide along the Bow river between Cochrane and the front range of the mountains.

Dr. Allan did field work in the foothills between the Bow and Highwood rivers, and visited several other localities in the Province in connection with the study of the mineral resources. He also edited the reports and maps prepared by this division during the year.

A compilation of data on the mineral resources of Alberta was made for the Hon. H. Greenfield, who is in charge of the London office of the Alberta Government.

An appendix to this report gives the scope of the work carried out by the Geological Survey Division during the year 1926.

ROAD MATERIALS

Laboratory study of the Alberta bituminous sands was continued during 1926. Data from the examination of samples collected during 1924 field work on the bituminous sand deposits were completed for publication. Separation tests were made on samples specially collected in the fall of 1925.

A report covering the results of the 1924 field examination of bituminous sand exposures in Northern Alberta has been prepared and is ready for printing. This will be Part I of a general report on the work done to date on the Alberta bituminous sands. It contains detailed information about thirty-five exposures distributed throughout the bituminous area. This information includes thicknesses and field descriptions of the strata appearing in the exposures and complete analytical data for samples collected from such strata. These data are discussed to indicate the features of the deposit that are of practical importance, such as the variability of quality of the bituminous sand, the method of occurrence of the beds of rich commercial material, and the characteristics of locations where bituminous sand is likely to be found occurring in a manner favourable to commercial development. An historical review is given in an introductory chapter.

A number of samples of five hundred pounds or more were collected in 1925 from points distributed along a north-south section through the bituminous sand area. Tests made on these samples showed that the separation process which worked successfully on material from the neighbourhood of McMurray was generally applicable to bituminous sand from any section of the area. The results of these tests, as well as those of all previous work on the separation problem is being compiled to form Part II of the general report on the Alberta bituminous sands.

Heavy crudes and fuel oils are being handled commercially by the Dubbs cracking process units for gasoline manufacture. A sample of bitumen separated from the bituminous sands as well as a sample of Wainwright crude oil were sent to the Universal Oil Products Company, owners of the Dubbs Process, for test. A full report was received from this Company, and a summary is appended.

During August and September, Dr. Clark visited a number of centres in the United States to get in personal touch with activities that have a direct bearing on the study of Alberta bituminous sands. The preparation and use of Kentucky rock asphalt and California bituminous sand for pavement construction were given particular attention. The use of road oils for the treatment of earth and gravel roads by various State Highway Commissions were also noted. A number of petroleum refineries and research laboratories were visited to get into closer touch with developments in the oil industry which are creating a value for bituminous sand as a source of motor fuel.

The bituminous sand separation plant was not operated during 1926, and no experimental road construction was undertaken.

Brief accounts of the separation experiments, the report of the cracking tests and of Dr. Clark's observations in the United States are given in an appendix.

FOREST PRODUCTS

The work outlined in the 1923 report was continued during the year by Professor R. S. L. Wilson. Tests are still in progress on the suitability of lodge pole pine for mine timber under varied conditions, and additional results are being compiled. Further particulars of this work will be found in the appendix, and it is expected that publication of detailed results can be begun in 1927.

MISCELLANEOUS

In February Mr. Stansfield visited Lethbridge and read a paper to the Board of Trade on "Oil from Coal", and a paper to the Lethbridge branch of the Engineering Institute of Canada on "The Work of the Scientific and Industrial Research Council of Alberta".

Dr. Allan, Dr. Clark and Mr. Blair contributed a series of articles on oil topics to the special oil edition of the Edmonton Journal issued during February. An account of "Highway Researches in Alberta, Canada", by Dr. Clark, was published in the March issue of the Highway Research News, issued by the Highway Research Board of the National Research Council, Washington.

In July, Mr. Pitcher and Mr. Stansfield accompanied Dr. Allan and Dr. Rutherford to visit coal mines at Longview and Priddis, and also visited the Turner Valley.

A paper on "Alberta Bituminous Sands" by Dr. Clark was broadcast from the University Extension Department radio studio in July.

Dr. Clark presented a paper before the Canadian Good Roads Association at the national convention held in Edmonton during the last week of September.

In November Mr. Stansfield represented the Province at the International Conference on Bituminous Coal at Pittsburgh. He also visited the laboratories of the Bureau of Mines at Pittsburgh, the Bureau's experimental mine at Bruceton, and the laboratories and research residence of the University of Illinois.

Dr. Allan presented a paper to the Engineering Institute of Canada at Lethbridge in December on "Geological Problems on Spray Lakes Water Power Project".

Mr. Stansfield read a paper in December to the Calgary Board of Trade on "Oil from Coal".

Professors N. C. Pitcher and R. S. L. Wilson visited the Black Diamond Collieries of the Great West Coal Company during the course of the tests on mine timber.

FUELS DIVISION

By E. STANFIELD, R. T. HOLLIES, W. P. CAMPBELL, W. A. LANG
AND J. W. SUTHERLAND.

Professor N. C. Pitcher, Chief Mining Engineer, assisted with suggestions and advice with most of the work described.

R. T. Hollies was engaged almost entirely on furnace testing until he left at the end of July. W. P. Campbell acted as fuel analyst and later assisted with furnace testing until he left in August. W. A. Lang carried out briquetting tests and some laboratory investigations. J. W. Sutherland acted as fuel analyst after May 1st and carried out some special investigations. K. C. Gilbart and S. Zeavin assisted with laboratory investigations after their appointments in November.

COALS TESTED

The money available for the work of the year did not permit the procuring of any carload samples for storage and screening tests and for boiler trials, as in some previous years. Four tons of local coal were purchased for domestic heater tests. Coal already in stock was used for briquetting.

Provincial Inspectors of Mines submitted 64 coal, 52 coal dust, and 1 limestone samples for analyses. The coal samples came, 1 from Kootenay horizon, 40 from Belly River horizon and 23 from Edmonton horizon mines. Since this work was inaugurated, 824 coal samples have been received. Up to the end of 1925 the samples received had come from 112 separate townships. This number was increased during the year to 117. Samples were received during the year from forty-four mines not previously sampled; and samples from 268 mines in all have now been analysed.

STORAGE AND SCREENING

Tests were completed on the one sample in storage at the beginning of the year, and no new samples were placed in storage. The results obtained have been reported to the operators from whom the coals were obtained.

SAMPLING AND ANALYSIS

In the Annual Report for 1924, p. 16, it was stated that the quick heating method for the determination of volatile matter is to be used for coals retaining less than 10% moisture after standard air drying, and that the slow heating method is to be used for coals retaining more than 10%. It has since been found that some coals from Lethbridge area give trouble (lose weight by sparking) when treated by the quick heating method, although they retain less than

10% moisture when air dried; it has therefore been decided to use the slow heating method for all Lethbridge area samples. No other change in method was adopted during the year. The standard air drying apparatus was further improved by the installation, in April, of a simple air-lift pump to circulate the calcium chloride solution used to maintain the required humidity. The mechanical pump previously used caused trouble owing to corrosion, and the air-lift pump being made of glass, with no moving parts, is not corroded. The new system has the further advantage that the air used to lift the solution enters the apparatus duly moistened and any air leaks in the apparatus must be leaks outward.

A Dennstedt apparatus for the ultimate analysis of coal was set up and tested. Parallel tests can now be made with this and the more usual Liebig method as an extra check on the accuracy of the results. The Dennstedt apparatus, however, was not found to be as satisfactory as the Liebig.

Chemical Survey of Alberta Coals

This work was continued during the year and brought to such a condition that the approximate composition of the coals from all the important production areas is known and it is possible to predict, with reasonable accuracy, the coal to be expected in any new mine opened anywhere within a large area of the Province. The work in the past has only included proximate analyses and calorific values, not ultimate analyses. Towards the close of the year a more detailed survey was begun. The samples were submitted to both proximate and ultimate analyses, their ignition temperatures determined, curves prepared showing the relation between their calorific value and ash content, and other tests made. It is proposed to include in this work determinations of specific gravity and also of fusibility of ash.

Further progress was made with the tabulation and graphical presentation of the results obtained, for ready reference as required.

Ignition Temperature of Coal

Work was begun during the year on the ignition temperature of Alberta coals, along the lines of work by R. V. Wheeler on some English coals[1], and later by S. W. Parr on some Illinois coals[2]. Wheeler defines ignition temperature as "that temperature at which the coal begins to react with oxygen so rapidly that the ultimate appearance of flame is assured".

Different methods of determining this value may give different results, and for strictly comparable results, not only the method but the procedure must be closely specified and followed. In Wheeler's method oxygen is passed at a constant rate through a column of powdered coal, the temperature of which is gradually raised by an outside source of heat. One thermometer is placed with its bulb in the coal, another thermometer is placed with its bulb just outside the tube containing the coal. At the beginning of the experiment the outside thermometer, being nearer the heater, shows a higher

[1] R. V. Wheeler, Fuel in Science & Practice, October, 1924, p. 366.
[2] S. W. Parr & C. C. Coons, J. Indust. & Eng. Chem., February, 1925, p. 118.

temperature than that in the coal. When oxidation becomes notable the coal temperature rapidly rises and passes the temperature outside the tube. The temperature at the moment when both thermometers read the same is taken as the ignition temperature. The sharp rise in the temperature of the coal at this point is very marked, and rises as rapid as 100°C. in a minute have been observed. Neither Wheeler nor Parr completely specify all the factors, but variations in these were carefully studied and found to cause less difference than had been anticipated.

In the test as standardised in these laboratories, a tube of ½″ bore is used, the coal is ground, with repeated screening, until it all just passes a 200 mesh screen, it is dried in a current of natural gas, and 2½ cc. of the powdered coal taken for each test. This gives a column 1″ high in the tube. The oxygen is passed at the rate of 35 cc. per minute, and the furnace electrically heated so that the outside thermometer rises 10°C. per minute. Dried coal is used, as otherwise difficulty is experienced with high moisture coals.

The temperatures recorded in Table I indicate the relative ease of ignition of the different coals. As a further guide to the nature of the coal, each sample is oxidised by exposure to a current of air at 105°C. for six hours, and its ignition temperature then redetermined. It will be noted that in every case the ignition temperature is higher after oxidation.

TABLE I.—IGNITION TEMPERATURE OF COAL

Nature of Coal.	Ignition temperature Fresh coal.	Weathered coal.
Bituminous coal	212.5°C.	214.2°C.
Sub-bituminous coal	178.4°C.	188.5°C.
Domestic coal (1)	175.8°C.	187.1°C.
Domestic coal (2)	172.8°C.	190.8°C.

MATURITY OF COAL

Many investigators have employed the solvent action of caustic potash on coal as a measure of what might be termed the maturity of coal—the more mature the coal, the less it is acted upon. J. H. H. Nicolls of the Mines Branch at Ottawa[3] standardised the results obtained by matching the colour of the solution with standard colours. G. Charpy and G. Decorps[4] suggest titrating the potash solution with potassium permanganate which would appear to give more reliable results. The latter method, as published, appeared to be slow and unsatisfactory, but it was modified in these laboratories to give rapid results which could be closely duplicated. The value of this test to supplement the information given by ordinary analysis can not be settled until more results have been obtained, but it seems likely to prove useful. Other tests along similar lines are also being investigated.

DOMESTIC FURNACES

It was reported in the previous annual report, that a calorimetric method of testing the efficiency of a hot air furnace, from minute to minute, had been devised, and the proof of its accuracy

3J. H. H. Nicolls, Mines Branch Summary Report, 1916, p. 65.
4G. Charpy and G. Decorps, Comptes rend. 1921, 173 p. 807.

established. The final set of tests, employing an electric heater, were run between January 1st and April 14th, 1926.

The calorimeter is constructed as shown in Figure 1.

The principle of construction and operation is the same as that of a much smaller calorimeter described in the Third Annual Report, pp. 22-24. The new calorimeter is much larger than the old one and includes many improvements, notably the following. The hot air rising from the furnace to the calorimeter passes a series of spiral baffles to mix the air and bring it to a uniform temperature. It passes round an annular chamber before entering the temperature measurement box, in order that there should be no errors in the temperature measurements, due to radiation. The 10 semi-circular baffles attached to the cooling coil are replaced by 180 narrow sector baffles arranged in spiral form to offer little resistance to the air flow. The same precautions to avoid radiation errors are repeated to ensure correct temperature measurement of the gases leaving the calorimeter. No. 2B Wing Semplex exhauster fan of 2,100 cubic feet of free air per minute capacity is used to overcome the resistance of the calorimeter to the flow of air, and a set of 4 dampers provided to regulate the flow of air through the furnace casing. The temperature of the hot air entering the calorimeter is measured by two copper-constantan thermo-junctions, connected in series and the values recorded by means of a Leeds and Northrup recording potentiometer. The drop of temperature in the air in passing through the calorimeter is measured to within about 0.2°F. by means of 12 copper-constantan thermo-junctions. Six of these connected in series are placed in the entering air, and 6 connected in series placed in the exit air. These two sets are connected in opposition and the voltage recorded by a Leeds and Northrup calorimeter.

The water passing through the cooling coil is collected and weighed, instead of being metered as before. The rise in temperature of the water in its passage through the coils is recorded in a manner similar to that for the air described above. Five copper-constantan thermo-junctions, connected in series, are placed in the inlet water, and a similar set in the exit water. The Leeds and Northrup instrument, records the difference between the two temperatures.

The whole calorimeter is very carefully constructed to avoid air leaks, and jacketed to avoid heat losses. The details described can be seen in the sketch figure. The old calorimeter, referred to above, is used to measure the heat leaving the furnace in the flue gases. Its accuracy has been improved by weighing instead of metering the water, and by using thermo-junctions with Leeds and Northrup recording potentiometers to measure all the temperatures. Multiple differential, thermo-junctions are used here also to measure the rise in temperature of the water in its passage through the cooling coil.

The additions to the equipment during the year were as follows: A Ranarex CO_2 recorder, a Cambridge Thermo-Electric Pyrometer, for measuring the surface temperature of furnace casings, etc., and a thermometer testing apparatus. The latter, which was desgined by R. T. Hollies and constructed in our laboratories, is used for

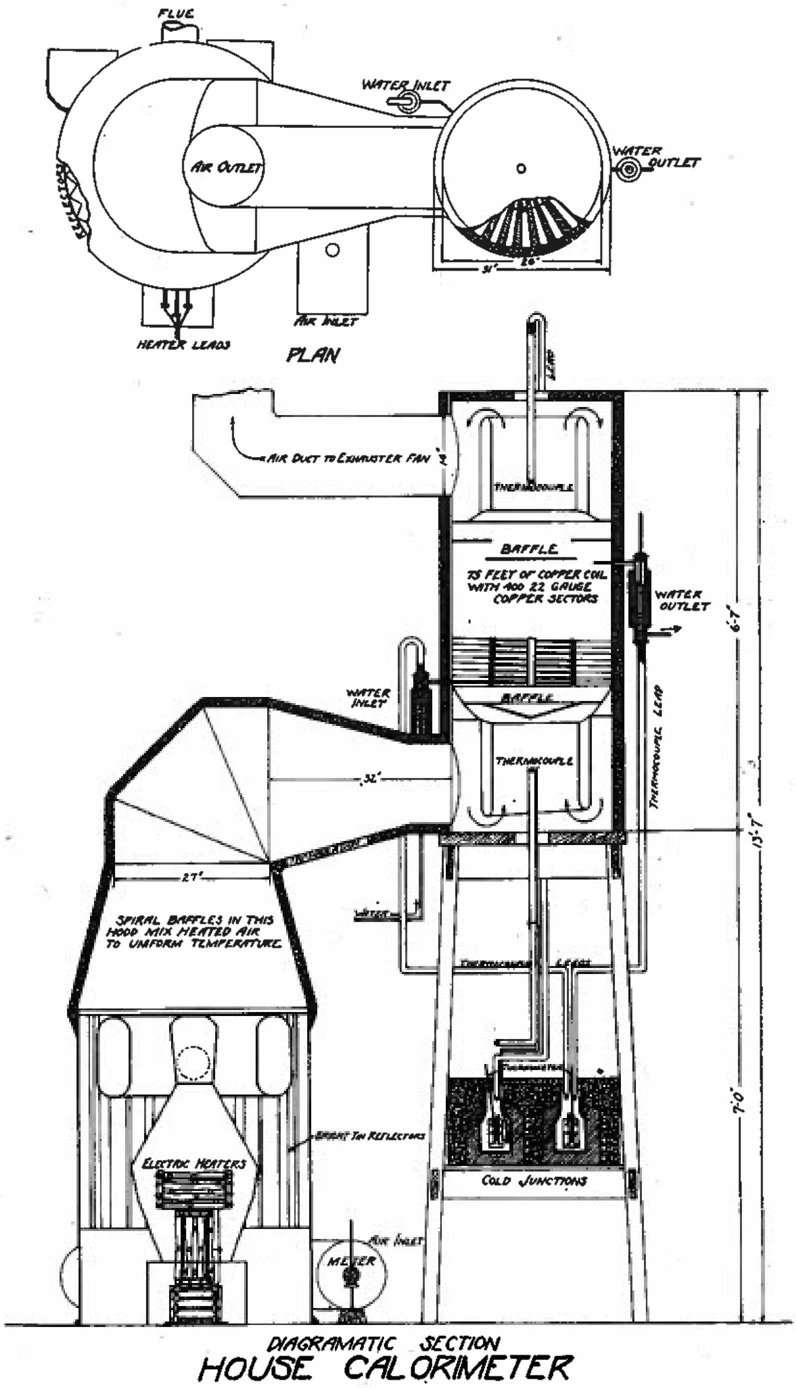

FLUE
WATER INLET
AIR OUTLET
WATER OUTLET
REFLECTORS
AIR INLET
HEATER LEADS
PLAN
AIR DUCT TO EXHAUSTER FAN
THERMOCOUPLE
BAFFLE
75 FEET OF COPPER COIL WITH 400 22 GAUGE COPPER SECTORS
WATER OUTLET
WATER INLET
BAFFLE
THERMOCOUPLE
THERMOCOUPLE LEAD
32"
27"
SPIRAL BAFFLES IN THIS HOOD MIX HEATED AIR TO UNIFORM TEMPERATURE
BRIGHT TIN REFLECTORS
ELECTRIC HEATERS
COLD JUNCTIONS
AIR INLET
METER
6'-7"
13'-7"
7'-0"
DIAGRAMATIC SECTION
HOUSE CALORIMETER

Figure 1.

standardising thermometers, and also thermo-couples, against thermometers standardised by the Bureau of Standards at Washington. The apparatus consists of an electrically heated, and mechanically stirred, oil bath. This bath is set inside, but insulated from, an outer oil bath likewise electrically heated and mechanically stirred. The temperatures can be accurately controlled by suitable switches and a rheostat. The inside heater is only used for rapidly heating the inner bath to the desired temperature, and is always switched off some time before any readings are taken.

A number of tests were made on a stove with an attachment (Blashill's superheater) designed to provide a longer travel for the flue gases and a greater radiation surface. Comparative tests were also made with a stove of approximately the same shape, though of a different make and without this attachment. It should be noted that the test stove was an experimental one which had seen considerable service and was in a somewhat leaky condition. The comparison stove was operated in such a way as to make the tests comparable, except for such differences as would be caused by the superheater. Higher efficiencies could have been obtained with the comparison stove.

The tests are reported in some detail as they give interesting comparisons of coal and gas heating, as well as indications of the efficiencies obtained in the ordinary operation of an ordinary stove.

BLASHILL'S SUPERHEATER

Introduction.—This addition to a stove heater is patented by M. F. Blashill, of Biggar, Saskatchewan. It consists of an approximately crescent-shaped drum that fits around the body of a stove. The flue gases, after leaving the firebox through openings at the sides, pass through this drum before entering the flue pipe. This drum gives a stove a larger radiation surface and thus, presumably, a higher efficiency.

Figure 2 is a rough diagramatic sketch of the actual stove and drum as supplied for test by M. F. Blashill. It consists of a partial annular ring drum, D, mounted about the stove body, S, with a 1½″ air space, H_1, H_2, between the drum and stove. The products of combustion leave at the sides of the firebox through openings, C, into chamber, D. The gases pass over baffles E_1 and under baffles E_2, then up through F to the smokestack. A current of room air enters at H_1, and is warmed between D and S, and leaves heated at H_2, as indicated by the arrows in Figure 2.

This furnace was tested first by operating it on coal for a number of days at different rates and with different adjustments. Two or three days were taken up with preliminary runs, after which seven quantitative test runs were made. Comparative tests were then made with another stove of larger size and similar shape, but without the Blashill attachment. To further compare the two stoves, runs were made with both, using natural gas instead of coal as fuel. The particulars of the quantitative runs made are shown in Table II.

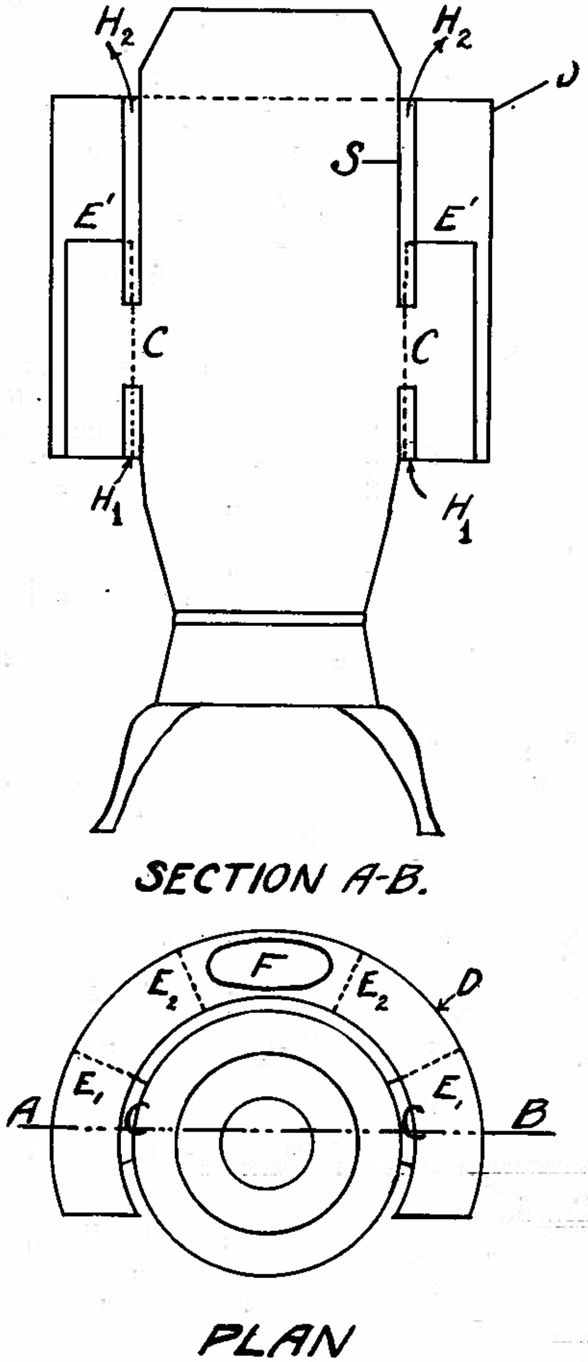


Figure 2.

The flues of each in turn were connected up by seven and one-half feet of stove pipe* to a calorimeter for measuring the sensible heat of the flue gases. This latter apparatus is referred to below as a flue calorimeter. The flue temperatures were taken at the entrance to the flue calorimeter. Two gas samples were taken from the stove pipe. The first of these was analysed by an automatic CO_2 apparatus. The second, which was taken by an automatic mercury sampler was later analysed in a Randall and Barnhard apparatus. Room temperatures were recorded on a Bristol recording thermometer and all other temperatures were recorded on a Leeds and Northrup recording potentiometer.

TABLE II.—SUMMARY OF TESTS ON STOVES

Test No.	Actual charge fired per firing. Lbs. coal	Data computed for three 4-hr. firing cycles: Rate of firing per sq. ft. of grate area per hr lbs. coal	Data computed for three 4-hr. firing cycles: Average CO_2 %	Data computed for three 4-hr. firing cycles: Average Flue Temp. °F.	Data computed for full test. Heat Losses. Chimney: Sensible heat in flue gases. %	Data computed for full test. Heat Losses. Chimney: Latent heat of steam. %	Data computed for full test. Heat Losses. Chimney: Unburned gases (estimated) %	Data computed for full test. Heat Losses. Ash Pit: Combust. in ash. %	Data computed for full test. Heat Losses: Total %	Data computed for full test: Eff. of stove and pipe, i.e., radiation (by diff.). %
Blashill's Patent Superheater—Coal Firing										
B 1	25	15.9	8.6	266	9.9	6.0	3.0	2.7	21.6	78.4
B 2	25	15.9	8.2	244	7.9	6.2	3.0	1.4	18.5	81.5
B 3	25	15.9	....	223	8.3	6.3	3.0	1.0	18.6	81.4
B 4	25	15.9	9.4	234	8.9	5.1	3.0	0.4	17.4	82.6
B 5	16	10.2	7.1	219	8.3	5.0	3.0	0.0	16.3	83.7
B 6	25	15.9	8.4	252	8.0	5.1	3.0	1.1	17.2	82.8
B 7	25	15.9	9.7	224	5.7	5.1	3.0	0.3	14.1	85.9
*McClary's Belle Oak Heater No. 36—Coal Firing**										
M.B.O. 4	38	16.5	15.3	373	11.0	4.8	3.0	1.1	19.9	80.1
M.B.O. 5	30	13.0	11.8	318	9.3	5.1	3.0	1.0	18.4	81.6
Blashill's Patent Superheater—Gas Firing										
		Cu. Ft. gas.								
B 8	....	98.5	6.9	162	4.9	9.5	0	....	14.4	85.6
*McClary's Belle Oak Heater No. 36—Gas Firing**										
M.B.O. 1	....	85.1	6.9	343	15.7	9.5	0	....	25.2	74.8
M.B.O. 2	....	116.0	7.4	489	20.0	9.5	0	....	29.5	70.5
M.B.O. 3	....	102.1	7.0	258	8.7	9.5	?	....	......	......

*The stove pipe connecting a stove to its chimney affords useful radiation surface in heating a room, and is, therefore, included as a part of the stove radiating surface.

*The efficiency of this stove was lowered because the CO2 percentage in the flue gases was adjusted to equal that obtainable with the Blashill stove, which was leaky.

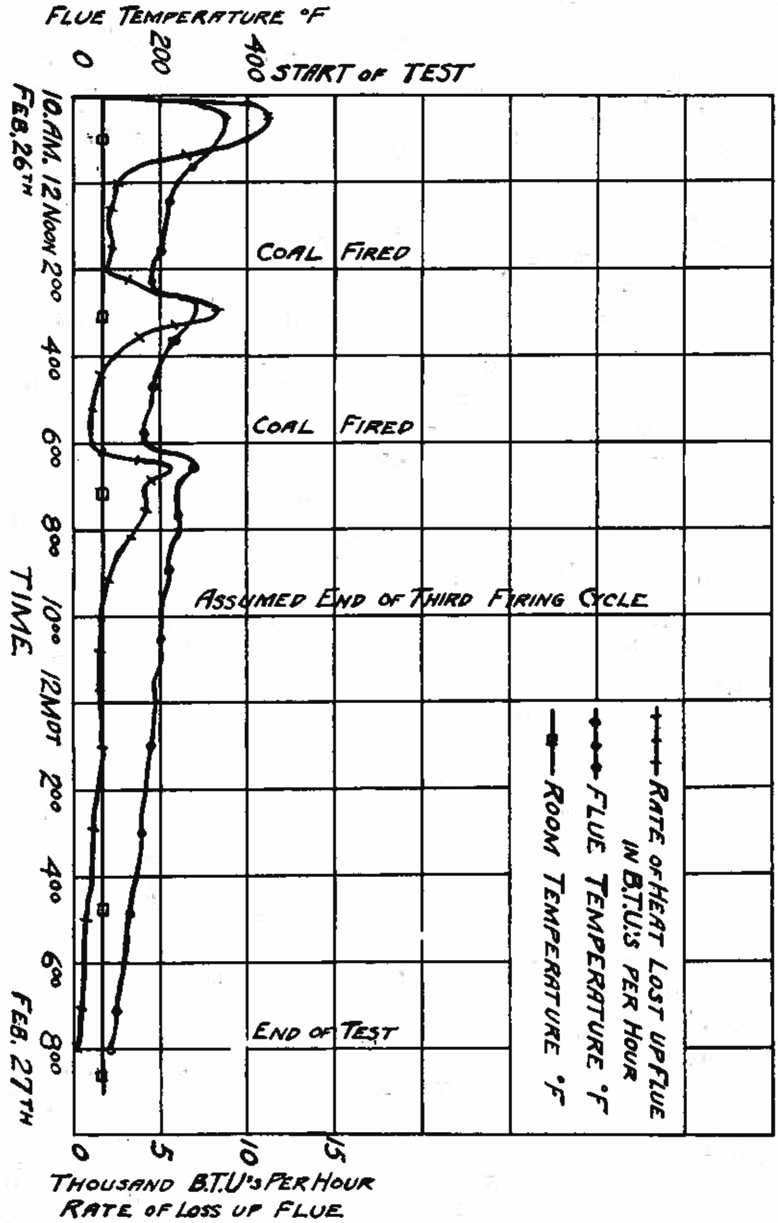


Figure 3.

Coal Tests.—The coal tests usually lasted 18 to 24 hours, and were carried out as follows: Each test began with a cold stove; a weighed amount of kindling and coal were ignited and drafts were left open for a few minutes until the first heavy smoke of the green coal passed off. The drafts were then closed and the fire left untouched until the next firing period, four hours later. Then the fire was cleaned and a second weighed amount of coal was put on, the drafts being open and closed as before. The third firing was carried out eight hours after the start, and the stove then left running undisturbed until the fire died out. The coal was sampled each time of firing and analysed in the laboratory in the usual way. The ashes from the ash pit were sampled and analysed at the end of each test. The firing times were normally 10 a.m., 2 p.m., and 6 p.m., the fire dying out between 3 and 9 a.m. the next morning, as shown by the recording instruments.

For the purpose of comparing the performance of the two stoves, the flue temperatures, CO_2, %, and rate of firing are given as the average for the three firing cycles, 10 a.m. to 2 p.m., 2 p.m. to 6 p.m. and 6 p.m. to 10 p.m.† The efficiency is reported as over the complete test, that is from cold start to nearly cold finish.

The total available heat supplied to the furnace was calculated from the weight of fuel burned and its determined heat values. The heat losses, such as unburned fuel in the ashpit, unburned gases up the chimney, heat carried by gases up the chimney and loss due to uncondensed steam were all determined or computed, as shown below, and expressed as percentage of the total heat. The efficiency of the stove and stovepipe, that is the heat given out to warm the room, was determined by subtracting from 100 the total of the above percentage losses. These losses are given in Table II.

Heat Losses.—Sensible heat of the flue gases was measured by the flue calorimeter as described in Third Annual Report and this report*. The heat value of the unburned combustible gases was found by calculation from the flue gas analysis and the coal analysis. The heat lost due to uncondensed steam (latent heat) from the water in the coal and the water formed by combustion of the hydrogen in the coal were calculated from the coal analysis. The ash pit losses were calculated from the ash analysis.

Gas Tests.—For the gas tests the grates were removed, ring gas burners introduced into the ash pit—two in the larger stove and one in the smaller. The fire pot in each case was partially filled with fire clay balls (artificial coal). The same testing equipment was used as before.

When making a test the gas supply was regulated by means of a calibrated gas meter and the air supply carefully adjusted with the assistance of the carbon dioxide recorder*. The stove was then allowed to heat up until all the conditions were steady, when a one-hour test was run.

The total available heat supplied to the furnace was calculated from the determined heat value of the gas and the volume of gas burned. The heat losses were measured as before, and the efficiency of the stove and stovepipe similarly computed.

SUMMARY AND CONCLUSIONS

Table II and Table III give a summary of the results of the tests.

†A third cycle was assumed, for purposes of computation, from 6 p.m. to 10 p.m., although no more coal was fired at the close of this period.

*Scientific & Industrial Research Council of Alberta, Third Annual Report, 1922, pp. 22-24. Seventh Annual Report, pp.

*In these tests the flue gas from the McClary stove was adjusted, for sake of comparison, to the same percentage CO2 as obtained with the leaky Blashill stove.

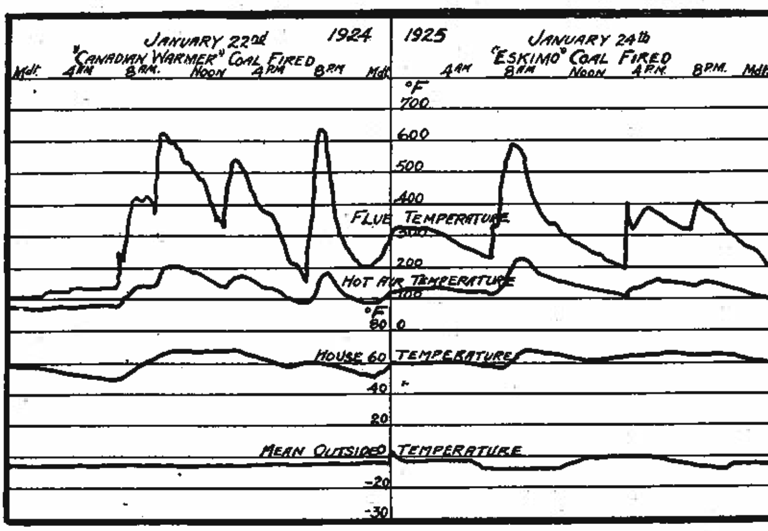


Figure 4.

In view of the importance attaching to flue temperatures, a chart (Figure 3) has been prepared showing this temperature throughout a typical test run. Another line on the same chart shows the rate of heat loss up the flue through the test. The extreme height of the curves when the fire was first lighted was largely due to the kindling used.

NOTE.—The Blashill heater supplied was an experimental one and was in a somewhat leaky condition. This explains the low CO_2 obtained with it.

RESIDENCE HEATING

No new tests were made during the year, but the several hundred circular charts obtained in the tests already described, were copied by means of the rectograph† on to a single roll of paper. Figure 4 shows a typical three days of operation when the residence was heated by a round pot furnace, too small for the house; also a typical three days with a large, rectangular fire box furnace (No. 220 Eskimo combination hot air furnace, for coal or gas). Similar coal was burned in both cases. These curves show clearly the steadier regulation obtained with the larger furnace. Similar curves for gas heating show, as might be expected, the very steady temperatures that can be obtained, even without thermostatic control.

†Sixth Annual Report of Council, p. 17.

TABLE III.—ANALYSES OF COAL AS FIRED AND ASHES PRODUCED

Tests on Blashill's Patent Superheater

Test No.	Size of Coal	Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Calorific value gross. B.T.U. per lb.	Combustible in ashes: % of ash produced	Combustible in ashes: % of Fuel fired
B 1	Egg	21.8	10.6	28.3	39.3	8,500	23.5	2.5
B 2	Egg	22.4	8.4	28.7	40.5	8,770	17.4	1.7
B 3	Lump	24.1	5.4	29.1	41.4	8,960	19.6	1.1
B 4	Lump	15.2	5.8	32.6	46.4	10,010	12.1	0.9
B 5	Egg	14.7	10.7	31.1	43.5	9,470	9.1	0.6
B 6	Egg	14.7	8.3	31.9	45.1	9,860	16.1	1.6
B 7	Egg	14.5	7.6	32.2	45.7	9,890	10.9	1.1
Tests on McClary's Belle Oak Heater No. 36								
M.B.O. 4	Egg	12.1	9.7	32.4	45.8	9,890	12.8	1.2
M.B.O. 5	Lump	15.1	5.2	32.8	46.9	10,150	18.8	1.3

BRIQUETTING

The briquetting investigations described in the previous Annual Reports were continued during the first half of 1926. The principal work was, as before, the study of the factors influencing the quality of the briquettes made from different coals using typical binders.

During the year 130 batches of briquettes were made. Of these batches 38 were made with semi-anthracite coal, 30 with bituminous coal, 41 with semi-bituminous coal, 8 with carbonized lignite, and 13 with blended coals; 85 batches were made with asphalt, 8 with soft coal tar pitch, 5 with hard coal tar pitch, and 31 with mixed binders.

Some tests were made with the Sheean-Gillen process. In this process sulphur is added to the asphalt binder to make a coking briquette out of non-coking coals. It was found that briquettes made from Edmonton lignite with this process were not strong when made, but that they did coke in the fire very satisfactorily. Comparative tests made with the process previously employed in this laboratory for non-coking coals—that is the admixture of ten per cent. of a good coking coal to the non-coking coal, and then the addition of binder as usual, to the mixture, gave a stronger briquette than the former when the same amount of binder was used, and that these briquettes also coked and behaved well in the fire. The coking properties were possibly not quite so good, although quite sufficient.

In January a new spring was received from Wm. Gibson & Co. and calibrated in the Civil Engineering laboratories by Prof. R. S. L. Wilson. The spring enabled appreciably higher pressures than heretofore to be used, and permitted more extensive tests upon the effect of pressure in briquetting.

A small commercial roll press, Mashek Engineering Co., Type Y 1, purchased from the Lignite Utilization Board of Canada, was installed in December, but not operated up to the close of the year. It has two shell rolls, 24″ diameter. Each roll has 3 rows of 42 pockets each, or a total of 126 pockets, and the rolls are driven at 9-10 revolutions per minute. It makes a pillow-shaped briquette of about 2 ounces weight, the weight depending on the density of the coal. That is, the press has a capacity of about 4 to 4½ tons per hour.

It is proposed to use this press to show the applicability of the results obtained with the plunger press to the more usual commercial type of roll press. Also to carry out some tests impossible with the other press. Meanwhile it is not proposed to publish the results at hand, although these can be supplied to interested parties.

GEOLOGICAL SURVEY DIVISION

BY JOHN A. ALLAN

INTRODUCTION.

During the first half of the year the data obtained in 1925 were compiled. Maps and reports were prepared and edited for publication. The writer had associated with him Dr. R. L. Rutherford, geologist, who conducted a field survey in two areas, as described below. He also prepared Report No. 15 and assisted with survey duties in the office. Dr. P. S. Warren, Associate Professor of Geology at the University of Alberta, examined and determined most of the palaeontological material obtained in the field. His assistance in this part of the work is deeply appreciated. Professor E. W. Berry, Johns Hopkins University, kindly assisted in determining and re-checking paleobotanical material from the Paskapoo formation in Alberta. L. S. Russell, who is making a special study of Paskapoo fossils, assisted in determining vertebrate fossils obtained in the field during the season. He also assisted in the drafting room, preparing charts and diagrams relative to the work of the division.

The drafting work involved has increased considerably, and temporary assistance was obtained from G. J. Knighton, O. Inkster, and A. K. Cox.

The correspondence relating to the divison is represented by approximately 1,000 letters received or sent. Requests were made for information on all the minerals that are known to occur in the rocks of this Province.

The number of requests for assistance in the finding of underground water supplies increases each year. A start has been made on the compilation of authentic data from the various water wells, and it is hoped that a detailed survey of the water supply can be undertaken by this division in the near future.

Over 100 samples and specimens were received with requests for information. Most of these were collected within Alberta. Ten samples of ores and rocks were received from a prospector in the Nahanni river district in the lower MacKenzie basin. These were examined, some of the specimens assayed, and the results forwarded to the prospector. The samples requiring chemical analysis were forwarded to Mr. J. A. Kelso, Director of the Industrial Laboratories of the University. These samples included chiefly clays, iron ochres, phosphate rocks, also a few that were supposed to contain metals and several placer gold samples.

In October the writer spent a day in Ottawa with Mr. F. H. Peters, Director Topographical Survey of Canada, and with Mr. A. Narroway, in charge of field surveys. Acknowledgement is made for the courtesies extended by the Director, and for the co-operation of the Topographical Survey of Canada with our division.

Valuable aerial photographic survey data were obtained while in Ottawa. The value of aerial photographs in geological survey investigations becomes more apparent each year. Over 300 aerial photographs of the district south of Whitecourt were obtained and have proven of great value to the geologist in the field. Detailed field use was made of aerial photographs taken by the Topographical Survey of Canada in the survey along the Bow river west of Cochrane.

During the month of December maps and data on the coal, petroleum and natural gas, salt, gypsum, clay, iron and other minerals were compiled and prepared for the Hon. H. Greenfield. to be used by him in the London office of the Alberta Government.

Field work was carried on by Dr. R. L. Rutherford in two areas, and occupied about four months. The first six weeks were spent along the Bow river between Cochrane and the front range of the Rocky Mountains. Two months were spent west of Edmonton between Edson and Wabamun. Notes on each of these areas are given below.

The writer spent some time investigating the foothills geology between the Bow and the Highwood rivers and the coal seams west of Priddis on the Highwood, in the foothills. Further data were obtained on the Ardley, Big Valley, and Carbon coal areas.

Acknowledgement is made of memoirs and maps from H. M. Geological Survey, England, received in exchange for our publications. Publications have also been received from the Department of Mines, West Australia; almost a complete set of the reports published by the Imperial Institute, Mineral Resources Department, London; and various Federal, Provincial and State Departments of Mines and Geological Surveys.

PUBLICATIONS FROM THE DIVISION IN 1926

Report No. 15: Geology of the Area Between the Athabaska and Embarras Rivers, Alberta, by R. L. Rutherford.

Map No. 11: In Three Colours. Accompanying Report No. 15, by R. L. Rutherford.

Five Structure Sections: In six colours. To accompany Geological Maps No. 8, Geology of the Red Deer Sheet; and No. 9, Geology of the Rosebud Sheet, by J. A. Allan and J. O. G. Sanderson. Distributed December 28th, 1926.

Geological Survey Division Report for 1925: By J. A. Allan. Appended to Report No. 16, Scientific and Industrial Research Council.

Geological Map of Alberta: In black and white. Scale 1″ to 6 miles. By J. A. Allan. This map is not numbered, but it accompanies Report No. 16.

The Relation of the Geology to the Soils of the Medicine Hat Sheet. By J. A. Allan. Accompanying Soils Report, Bulletin No. 14, School of Agriculture, University of Alberta.

Paskapoo Fossil Plant Localities of Alberta. By J. A. Allan and R. L. Rutherford. Transactions of the Royal Society of Canada, 1926.

On Fossil Plants from the Paskapoo Formation of Alberta. By E. W. Berry. Transactions of the Royal Society of Canada, 1926.

Mollusca of the Paskapoo Formation of Alberta. By L. S. Russell. Transactions of the Royal Society of Canada, 1926.

Fossil Ice Crystal Markings. By J. A. Allan and L. S. Russell. American Journal of Science, Vol. II, p. 494.

GEOLOGICAL SURVEY WEST OF EDMONTON

In 1922 a geological survey in the foothills was started at North Saskatchewan river. Up to date, the foothills belt has been examined north to Athabaska river. During the field season of 1925 the area lying between the Embarras and Athabaska rivers was examined. This area extends from the eastern edge of the foothills as far east as Edson. The results of this work are contained in geological report No. 15 by Dr. R. L. Rutherford.

In 1926 Dr. Rutherford commenced a survey at Edson and extended it to the east and north-east. As the surface in the inter-stream areas is covered with vegetation and recent deposits, most of the rock exposures in the area surveyed occur along the stream channels. Dr. Rutherford spent about two months in this area, beginning about the middle of July. The inclement weather during September prevented the completion of sufficient observations to warrant the publication of a report on this area. The results of this work will not be published until further observations are made, particularly to the south and east. Camp equipment and supplies were transported by automobile, and most of the traverses were made on foot.

The strata exposed along McLeod river were examined from a point near Edson north to Whitecourt, where the McLeod joins the Athabaska. A boat was used in making the traverse from McLeod river crossing to Whitecourt. The exposures along the Athabaska were examined from Whitecourt to a point about 12 miles east. The beds along the McLeod and Athabaska are in general flat-lying, and belong to the Edmonton and younger formations.

To obtain further data on these beds, observations were made along Pembina river from a point about 12 miles east of Sangudo, upstream past Evansburg for 12 miles, to the south boundary of township 52, range 7, west of the 5th Meridian.

The coal seam mined at Evansburg outcrops on the Pembina in sections 33 and 34, township 53, range 7. Several thinner seams occur in the lower strata, but no attempt will be made to correlate these with seams in other areas until further data are obtained.

The Lakeside Coal Company's collieries, situated near Wabamun village, were visited. The coal outcrops in section 4, township 53, range 5, on the south shore of Lake Wabamun and exposures of strata around the west end of the lake were also examined.

Following the above traverses, the balance of the season was spent in examining the rocks along North Saskatchewan river. These traverses along this river extended from the mouth of Mishow creek, in section 21, township 50, range 6, upstream to the end of the surveyed territory, which is the west boundary of township 47, range 7. Further observations on this stream will have to be made both to the east and west of the area examined before a correlation can be made between the strata exposed on Saskatchewan river and those exposed on the McLeod and Pembina rivers. The strata exposed along these three streams are all of uppermost Cretaceous and early Tertiary age. They are in general flat-lying and the exposures are often widely separated. In no case are there more than two hundred feet of beds exposed at one locality. Consequently, observations have to be extended over a large area in order to obtain data for determining the thickness and lithological character of the formations, and to correlate these formations in the different parts of the area.

BOW RIVER SECTION

Geological reports Nos. 6, 9, 11 and 15, published by the Industrial Research Council of Alberta, include the structure and stratigraphy of the foothills belt from the North Saskatchewan river north-west to the Athabaska river. The geology of the foothills from the International Boundary north to the oil fields of Turner Valley has been examined by various geologists, and somewhat disconnected structural details are included in various reports. Practically no field work has been carried out in the foothills between the Bow river and the North Saskatchewan. In order to correlate the results of the field work we have been doing in the last five years with the recognized stratigraphy of southern Alberta it was necessary to obtain the structural details in the foothills at some intermediate point. The Bow river section west of Cochrane was considered to contain data that might correlate the geology of the central foothills with that of south-western Alberta. For this reason a survey of a belt along Bow river, across the foothills west of Cochrane, was included in the field programme for 1926.

The field survey of this Bow river area was carried out by Dr. R. L. Rutherford between May 26th and July 6th. On account of the open character of this country the work was carried out most expediently by using an automobile for transportation. The area surveyed is ten miles wide and about thirty-five miles long. This section includes the structure from the western edge of the plains at Cochrane to the front overthrust of the Rocky Mountains. The details of this survey have been completed and are being printed as Geological Report No. 17 of the Scientific and Industrial Research Council of Alberta. A map (No. 12) on a scale of 1 inch to 2 miles and printed in nine colours with three structure sections accompanies the report.

The field data were plotted on a scale of 2 inches to the mile. Aerial photographs obtained from the Topographical Survey of Canada were used in determining the precise location of contacts and faults. These vertical photographs taken along Bow river proved most useful and valuable in the field.

The strata along the Bow section are very badly broken, but much new and valuable data have been obtained on the character and thickness of the upper Cretaceous formations. The section includes formations ranging in age from the uppermost Cretaceous and lower Tertiary represented by the Edmonton-Paskapoo formations at the east in the vicinity of Cochrane, down to the lower

Cretaceous, represented by the Blairmore formation at the front of the Rocky Mountains where the Paleozoic rocks have been thrust over the Jurassic and younger rocks.

Dr. Rutherford has been able to indicate certain stratigraphical horizons, chiefly on paleontological evidence, that will be useful and most valuable for further geological work in this part of the foothills of Alberta, north and south of the Bow.

A private survey was made by the writer early in 1926, before the survey along the Bow was started, of the geology in the foothills between the Bow and Sheep rivers. This information was useful in interpreting certain stratigraphical details along the Bow section.

PRIDDIS COAL AREA

Coal is being hauled by wagon from a small mine south-west from Priddis, a distance of six miles. The mine is located on Fish creek, on the north-west quarter of section 7, township 22, range 3, west of the 5th Meridian. The writer, accompanied by Messrs. Pitcher, Stansfield and Rutherford, made an examination of this prospect.

The coal seam is 5 feet 6 inches thick, and dips at 41° south-west. There is a sandstone roof and a shale floor. The coal occurs near the top of the Belly river formation. The stratigraphical position of this coal seam corresponds to the coal seam mined in the outer foothills on Highwood river in section 8, township 18, range 3, west of the 5th Meridian. The mine is entered on a slope. The coal is mined in blocky form, but on account of the structural deformation of the rocks there are numerous fractures in the coal. The coal is graded as sub-bituminous and an analysis made in the Fuels Division laboratories showed the following:

Moisture	6.7%
Ash	17.4%
Volatile	36.5%
Fixed Carbon	39.4%
Calorific Value—B.T.U. per lb.	12,470

There is another prospect near the northern end of the Pekisko coal area, in section 27, township 22, range 4, west of the 5th Meridian. Coal from this prospect has been used by one of the companies drilling for oil north of Bragg creek. This coal also occurs in the Belly river formation, and is very similar to that mined on Fish creek.

SURVEY OF SURFACE DEPOSITS

An examination of the surface geology and the relation of the various soil types in the Medicine Hat sheet was made by the writer in co-operation with Dr. F. A. Wyatt, Soils Department, University of Alberta. A report has been prepared entitled, "The Relation of the Geology to the Soils in the Medicine Hat Sheet." This report has been published as an appendix to the Soils Survey Report, Bulletin No. 14, School of Agriculture, University of Alberta, 1926.

The survey that has already been made on the surface deposits indicates that the types of soils in particular areas are very closely related to the character of the surface deposits, and the origin of these deposits. In most cases the surface deposits are of glacial origin or are glacial deposits that have been re-worked in post-glacial time. A similar report on the surface geology in the Macleod sheet appears as an appendix to Bulletin No. 11 prepared by F. A. Wyatt and J. D. Newton entitled, "Soil Survey of the Macleod Sheet."

COMPILATION OF DATA ON MINERAL RESOURCES

A request was received from the Hon. H. Greenfield for information on various mineral resources of Alberta. This information will be used in connection with the London office of the Provincial Government which, when opened, will be under the charge of Mr. Greenfield. The data already published on the various minerals were collected into separate files. The writer also prepared a short paper on the petroleum situation in Alberta at the present time, with an outline map of the Province showing the areas where geological conditions were most favourable for oil accumulation, and where special attention was being given by those drilling for oil. Additional data on the petroleum resources and on other mineral resources are being prepared by the writer for future reference, but these data will not be included in this report. Large scale maps showing the geology of Alberta, and also the coal areas of Alberta were prepared for Mr. Greenfield.

WATER SUPPLY

The underground water resources of Alberta have been investigated in a scientific way only in the south-eastern part. The problem of underground water supply is becoming more acute each year, and the number of requests for information on possible water horizons is increasing. Information is being gradually compiled by the writer on the water conditions encountered in wells in various parts of the Province, but it is hoped that more extensive consideration can be given to this problem in the near future. It is believed that valuable data can be obtained on possible water-bearing horizons in different parts of Alberta, when all available well data are correlated and when the surface geology and the sub-surface structure have been considered.

NATURAL GAS

BY JOHN A. ALLAN

In 1885 a well was drilled for water in the vicinity of Medicir Hat, and natural gas was encountered. In 1890 another well wa drilled in the Medicine Hat district in search for coal and a cor siderable flow of natural gas was obtained. This represents th beginning of natural gas development in Alberta. In 1894 th Canadian Geological Survey drilled a well at Athabaska. Severa pockets of gas were encountered, but no permanent flow was ob tained. In 1897 the Geological Survey of Canada drilled a well o the bank of Athabaska river, two miles above the mouth of Pelica river. An enormous flow of gas was encountered, and the flow wa so strong that it was not possible to deepen this well. Natura gas has been flowing from this well almost continuously since tha date. The well has been capped at least twice, but after a tim in each case the gas broke through the capping. Two other well were drilled in 1911 and 1913 respectively, within a radius of 20 feet of the Dominion Government well at Pelican, and gas wa obtained in both of these. The gas from the Dominion Govern ment well was allowed to burn for many years, and it is scarcel possible to estimate the volume of gas that has been wasted fron the drilling of these wells. In the summer of 1912 extensive drillin for natural gas was started at Medicine Hat, and before the end o that year the daily flow amounted to approximately 25,000,00 cubic feet.

These few introductory notes indicate the earliest chapter in th history of natural gas development in Alberta. Since 1912 severa hundred wells have been drilled in various parts of Alberta for nat ural gas and oil and in over 90 per cent. of these wells som flow of natural gas was obtained. Today it is estimated that ther are approximately 88 wells in Alberta that can be classed as ga wells. These are wells, each of which is capable of producing fron 3,000,000 to 50,000,000 cubic feet of gas per day. Scores of othe wells that have been drilled contained small flows of gas, but th quantity from each well is so small that it need not be taken int this consideration.

On the accompanying map there are shown eleven gas fields ir the Province of Alberta. These are distributed from the Interna tional Boundary line north to latitude 56, a distance of nearl 500 miles. The daily open flow of the wells in each field is give in the accompanying table. These figures have been taken fron various Federal Government publications. It is quite possible tha if the flow of gas in these fields was tested today it would b found that in some cases the flow had decreased slightly. On th other hand, there is also reason to believe that the flow in some o the wells has probably increased, so that the figures given ma be taken as fairly representative of the available natural gas in these particular districts. In the second column of the accompanying table is shown the approximate daily consumption of gas. This consumption is based on the figures that were available for the consumption in 1925. These data have been shown in graphical form on the chart accompanying this report.

The figures available indicate that in 88 wells in Alberta there is an available daily supply of natural gas amounting to 480,000,000 cubic feet. According to the most complete figures available, the amount of natural gas sold in Alberta in 1925 was 9,119,500,000 cubic feet. This represents an average daily consumption of 25,000,000 cubic feet. The marked discrepancy between the available supply and the daily consumption is shown graphically on the accompanying chart. It is important to note that although there is an enormous difference between the consumption and the daily capacity of these wells, it does not mean the difference represents the amount of natural gas that is being wasted. It is a fact that the most of the wells from which gas is being used have been capped, and there is therefore no important wastage from them.

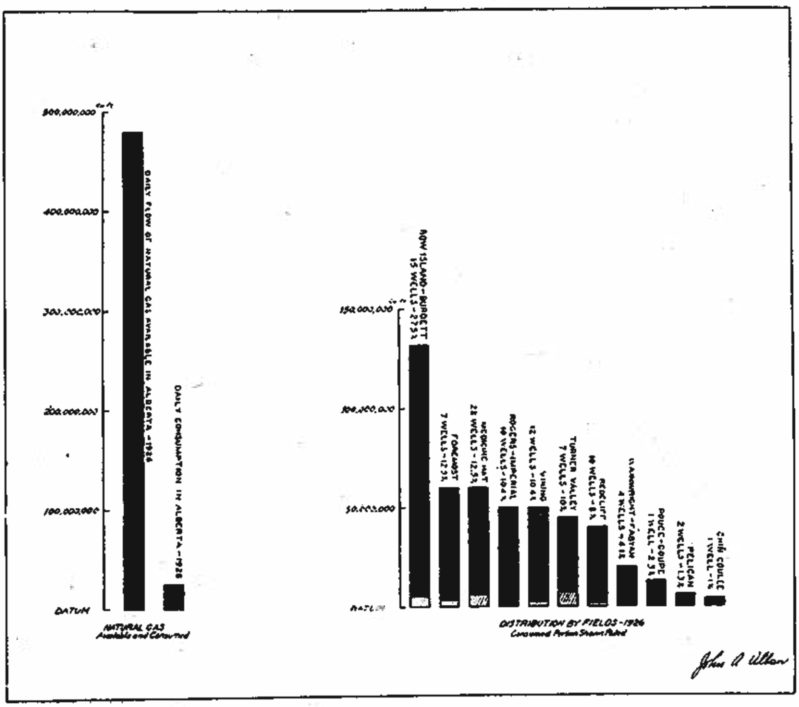
A considerable quantity of gas has been and is still being wasted in the Pelican district. No recent reports are available on the condition of the gas well at Pouce Coupe, but it is supposed to be adequately capped. The Rogers-Imperial gas well, near the Boundary, which is one of the largest gas wells on the continent, with a daily capacity of 50,000,000 cubic feet, is reported to be completely capped. There is always the possibility of any gas well that is capped breaking out at some future date.

The greatest wastage today is undoubtedly taking place in Turner Valley, where the average daily consumption amounts to about 7,000,000 cubic feet, whereas the daily production amounts to approximately 45,000,000 cubic feet. Most of the wastage in Turner Valley is necessary if exploration for petroleum continues. The rock pressure in the formation containing the gas in Turner Valley is enormous, and after the porous rock has been encountered it is almost impossible to hold back the gas flow completely. In the case of Royalite No. 4, the gas pressure on the well is retained at a safety point, and all of the naphtha is taken from the gas that is drawn off in order to retain that safety pressure. In this particular case less than one-half of the dry gas is sold for consumption in the field and in Calgary; the remainder is burned in the open and therefore lost.

It seems inevitable that if oil development is going to be permitted in Turner Valley a considerable wastage of gas must be expected for some time to come. If regulations were made which compelled the complete conservation of gas, it would be found almost impossible to encourage capital to come into the Province to develop petroleum resources. A comparison has been made with the way in which the gas has been handled in oil fields in other parts of the world, and particularly in the California fields. I would point out that in this particular case there was a great wastage of gas in the early stage of development, although today there is very little wastage because there is now a large population capable of utilizing all the gas produced. The maximum quantity of gas that could be used in Alberta today with its present population is negligible compared with the gas already available from wells that have been drilled.

In any discussion on the utilization of natural gas in Alberta, it is important to bear in mind the wide geographic distribution of these gas fields throughout the Province. It would appear to be disastrous to the development of our petroleum resources to have regulations compelling conservation of all gas. Nature has endowed this Province with an unusually enormous supply of natural gas over a wide geographic area. On the other hand, it is quite in order that regulations should require proper equipment to be used by the drilling companies in order to control any enormous flow of gas and to prevent the well from "running wild." It is just as important that such regulations should apply to water as to gas. One example might be cited: Wells were drilled in the Peace River district, and, due to lack of supervision, from at least two of these water and gas have been flowing for many years. These wells are now "running wild," and the chances are that this uncontrolled water has ruined the possibility of getting oil from at least the higher horizons in that district.

Attention is also drawn to the very important fact that the Dominion Government regulations apply only to Dominion Government lands, and these regulations do not apply to free-hold lands which include those lands held: (1) privately, (2) by the Canadian Pacific Railway Company, (3) by the Hudson's Bay Company.



Any regulation that is made to cover the development of petroleum or natural gas in Alberta should apply to all lands, irrespective of ownership.

It requires no further argument to emphasize the necessity of scientific investigations along chemical, physical and other lines, into the commercial utilization of these large mineral resources, keeping in mind the geographic distribution of the deposits.

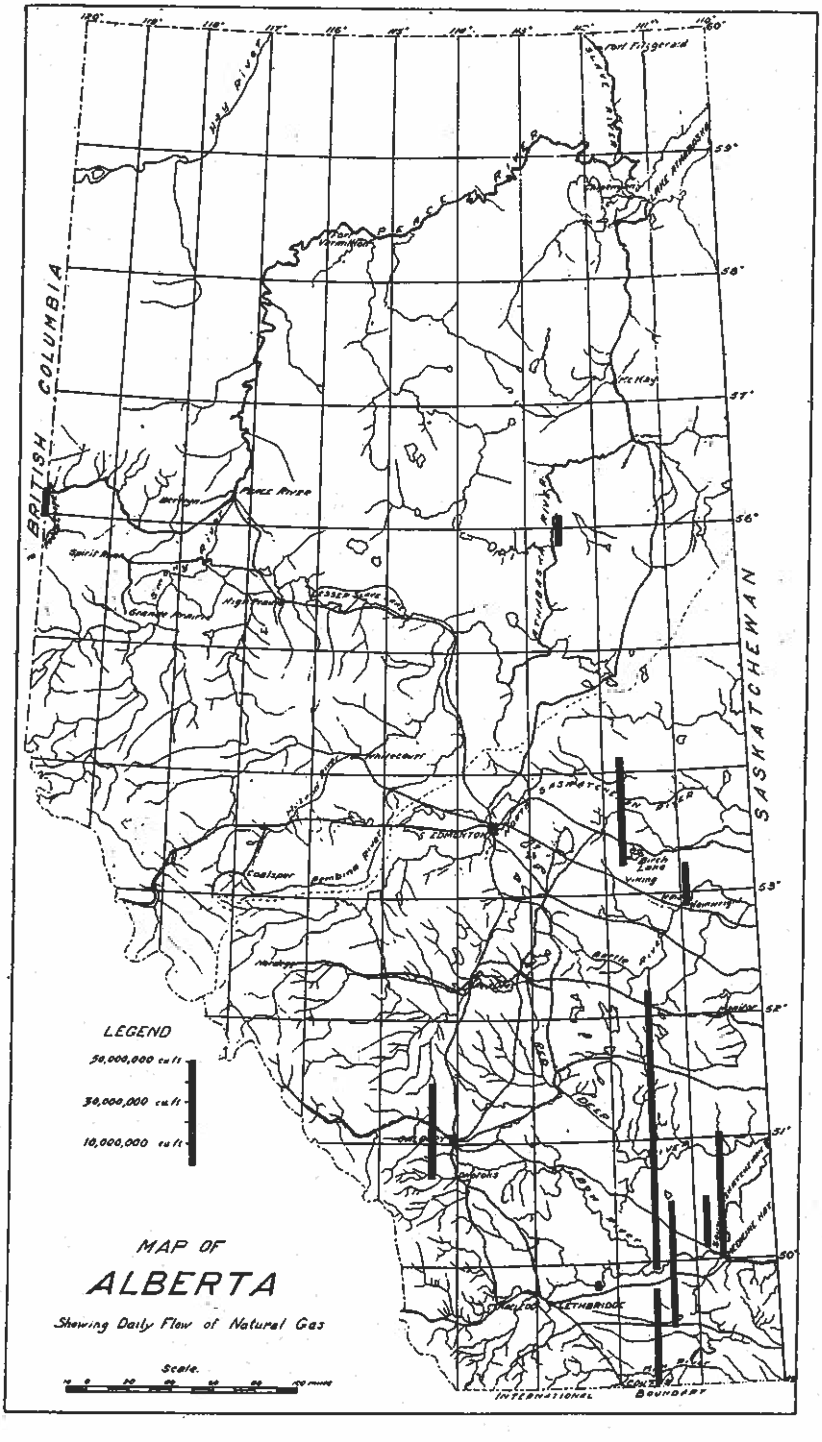
The accompanying graph, table and map indicate the valuable gas resources in Alberta that are already available.

TABLE IV.—NATURAL GAS, ALBERTA

(Figures are based on published data, 1925)

No.	Field.	Daily Open Flow of Gas (Approx.)	Daily Consumption (Approx.)	No. of Wells.	Percent. (Open Flow)
1.	Bow Island-Burdett	132,000,000	5,000,000	15	27.5
2.	Chin Coulee	4,000,000	....	1	1.0
3.	Foremost	60,000,000	3,000,000	7	12.5
4.	Rogers Imperial	50,000,000	....	1	10.4
5.	Medicine Hat	60,000,000	6,000,000	28	12.5
6.	Redcliff	40,000,000	1,500,000	10	8.0
7.	Turner Valley	45,000,000	7,000,000	7	10.0
8.	Viking	50,000,000	2,500,000	12	10.4
9.	Wainwright-Fabyan-Irma	20,000,000	....	4	4.1
10.	Pouce Coupe	13,000,000	....	1	2.3
11.	Pelican	6,000,000	....	2	1.3
				88	100.0

Total daily capacity of wells	480,000,000 cu. ft.
Gas sold in Alberta in 1925	9,119,500,000 cu. ft.
Approximate daily sales	25,000,00 cu. ft.


BRITISH COLUMBIA
SASKATCHEWAN
PEACE RIVER
Peace River
Fort Vermilion
Fort Fitzgerald
Lake Athabasca
McKay
Spirit River
Grande Prairie
High Prairie
Lesser Slave Lake
Whitecourt
Edmonton
Saskatchewan River
Birch Lake
Viking
Wainwright
Coalspur
Pembina River
Battle River
Red Deer
Calgary
Okotoks
Bow River
Medicine Hat
Lethbridge
International Boundary
LEGEND
50,000,000 cu. ft.
30,000,000 cu. ft.
10,000,000 cu. ft.
MAP OF
ALBERTA
Showing Daily Flow of Natural Gas
Scale.

ROAD MATERIALS DIVISION

BY K. A. CLARK AND S. M. BLAIR

Progress was made during 1926 in the study of the separation of bitumen from the bituminous sands. The applicability of the separation process to bituminous sand from all sections of the deposit was demonstrated. Further information was gained about best operating conditions for the process.

Important information was obtained relative to the possible use of the bitumen separated from the bituminous sands, and also of Wainwright oil, as crudes from which to manufacture gasoline. Samples of each oil were sent to the Universal Oil Products Company, owners of the Dubbs Cracking Process, and a comprehensive report received. The company stated that both oils can be handled in commercial Dubbs cracking equipment. The yield of cracked gasoline from the bituminous sand bitumen would be between 40% and 50%; that from the Wainwright oil would be about 55%. The gasoline from both materials has high anti-knock qualities.

Dr. Clark visited a number of places in the United States during August and September and made observations on the use of bituminous sand and its products as road material. California bituminous sands, the Kentucky rock asphalt industry, and road oil practises in a number of the States were studied in particular.

BITUMINOUS SAND SEPARATION

The separation work of previous years had all been done on bituminous sand from the southern part of the bituminous sand area. While it was a reasonable assumption that the process would work equally well on material from any other section, positive evidence was desired. Consequently a supply of material for separation studies was collected from a number of exposures along the Athabaska river as far as the northern limit of the area. One sample was taken from Ells river at a point about eight miles north-west of the Athabaska river at McKay. The samples were obtained by blasting into the face of the cliffs for a distance of about three feet to reach fresh sand, free of any weathering effect. Several hundred pounds were collected from each point. The samples were taken during September when the weather was getting cold. This condition tended to prevent the material from drying out during the time that elapsed between excavation and testing in Edmonton.

The location and general characteristics of the bituminous sand samples are given in Table No. V.

No difficulty was met in separating the bitumen from any of the five samples. The results of the tests are given in Table No. VI. These samples show almost a full range of variability in regard to fineness of sand and specific gravity of bitumen. Consequently it can be asserted with confidence that the separation process is applicable to all grades of fresh, unweathered bituminous sand from any section of the deposit.

Approximately eighty additional runs were made on the supply of bituminous sand collected and considerable information about the effect of conditions of operation of the separation process was obtained. The following general indications were noted.

1. The concentration of silicate of soda solution used for treatment was not studied. It was kept constant at 3% throughout most of the test runs. A number of runs with samples Nos. 3 and 5 were made, however, in which silicate of soda solution of 0.3% concentration was used. As good a separation resulted as with the more concentrated solution. This concentration corresponds to the use of 1.2 pounds of silicate of soda per ton of bituminous sand treated.

TABLE No. V.

Characteristics of Bituminous Sand Samples for Seperation Tests. (Four samples from exposures on Athabaska river; one from exposure on Ells river.)

Sample No.	Location of Point of Sampling	Composition of Sample, %			Screen Analysis of Mineral Matter, %				Specific Grav. of Bitument Content 25°-25°C.
		Bitumen	Mineral	Water	Retained on Mesh 48	Retained on Mesh 100	Retained on Mesh 200	Passing Mesh 200	
1	8 miles below McMurray....	16.0	83.0	1.0	....	17	76	7	1.020
2	20 miles below McMurray....	11.1	88.0	0.9	9	69	18	4	1.022
3	Ells river, 12 miles upstream	......	......	0.6	....	4	69	27	1.008
4	35 miles below McMurray....	13.9	84.5	1.6	61	33	3	3	1.013
5	55 miles below McMurray....	12.7	86.3	1.0	....	4	86	10	1.013

TABLE No. VI.—RESULTS OF TESTS.

Tests were run on 17 lb. batches of bituminous sand in laboratory separation plant. Bituminous sand treated with 20% of 3% silicate of soda solution. Treatment temp. and temp. of plant water 85° to 95°C.

Sample Number	Composition of Separation Products				Tailings
	Bitumen		Mineral Matter %	Mineral Matter Dry Basis %	Bitumen Content %
	Water %	Bitumen %			
1	22.5	75.1	2.4	3.2	1.5
2	21.0	87.0	2.0	2.2	0.6
3	28.2	70.3	1.5	2.1	0.8
4	21.1	77.1	1.8	2.3	0.5
5	16.9	80.3	2.8	3.4	0.6

Values for sample 1 are the average for 9 separation runs.
Values for sample 2 are the average for 3 separation runs.
Values for sample 3 are the average for 3 separation runs.
Values for sample 4 are the average for 4 separation runs.
Values for sample 5 are the average for 3 separation runs.

2. The conditions of plant operations must be adjusted to each type of bituminous sand treated to get the best separation results.

3. The temperature at which the bituminous sand is treated with silicate of soda solution and the temperature of the water in the separation boxes of the plant have a marked influence on the efficiency of the separation. The best temperatures lie within the range of 75° to 85°C.

4. Various salts dissolved in the plant water have a tendency to reduce the water content of the separated bitumen. The water content has been reduced in this way from 20 or 30% to less than 10% without sacrifice of cleanness of bitumen and of tailings.

5. Many miscellaneous observations suggest that the separation process depends on the properties and behaviour of bitumen emulsions of the water-in-oil and oil-in-water type and the inversion of the former to the latter.

CRACKING TESTS ON MCMURRAY BITUMEN AND ON WAINWRIGHT CRUDE OIL

The outstanding feature of the petroleum refining industry during the past few years has been the development of the "Cracking" process. By means of this process, gasoline is being manufactured from oils which have no natural gasoline content. Such rapid progress has been made in the commercial application of the process that now almost any grade of crude oil can be used for the making of cracked gasoline.

The handling of heavy crudes in commercial cracking plants is a quite recent development. It has been the practice for a good many years in many of the large refineries to crack a portion of the petroleum distillates, such as kerosene and gas oil into gasoline. But serious practical difficulties have been met in treating residual fuel oils and heavy crudes in the same way. Economic conditions have provided incentive for mastering the difficulties, however. Residual oils which the refineries can sell as fuel oil only at a price which will compete with coal prices are a cheap raw material for gasoline manufacture, if satisfactory equipment for cracking them can be devised. An accompaniment of the solution of the problems of cracking heavy fuel oils is, obviously, the solution of the cracking of heavy crudes. Marked progress has been made with the problem.

The Industrial Research Council has been following the trend of developments and during the year arranged for commercial cracking tests on a sample of bitumen produced by its separation plant, and on a sample of Wainwright crude oil. Several of the owners of cracking processes were invited to examine these heavy Alberta oils. The Universal Oil Products Company, owners of the Dubbs Process, accepted the invitation, carried out tests, and submitted a detailed report. A summary of their findings follows:

BITUMEN FROM THE BITUMINOUS SANDS

About ten gallons of the crude bitumen produced by the separation plant during 1925 was sent for test. The company reported the following analysis of the material received.

Crude Water-in-Oil Emulsion.

Specific Gravity	1.018
Water Content	20%
Mineral Matter	(Not stated, but about 7%)

Dehydrated Crude.

Specific Gravity	1.031
Sulphur Content	5.1%

Distillation Tests.

100 c.c. charge) Initial boiling point—350°F. (superheated) End boiling point—658°F.		(600 c.c. charge) Initial boiling point—285°F. End boiling point—597°F.		
Per cent. Over	Temp. °F.	Per cent. Over	Temp. °F.	Baume Gravity (A.P.I.)
5	460			
10	540	10	465	30.2
15	490			
20	505	20	583	29.6
25	572			
30	590	30	590	26.9
35	605			
40	608	40	563	27.1
45	655			
50	640	50	597	26.6
55	638			
60	618	60	585	27.0
65	595			
70	585			
75	583			
77	658			

Remarks.

2% over at 410°F.
23% over at 572°F.
77% distilled.
25% coke (by weight).
2.5% water.

1.5% water.
3.1% over at 410°F.
13% over at 572°F. (A.P.I. 29.8).
40% Pitch bottoms.

A laboratory cracking test was made on a quantity of dehydrated bitumen with the following results:

Laboratory Cracking Analysis of Dehydrated Bitumen.

Charge	6,000 ccs.
Sp. Gr.	1.031
Pressure	90 lbs. per sq. in.

Products of Cracking Run.

	% Raw Oil
Pressure Distillate (Baume A.P.I. 38.8)	56.0
Residuum	None
Coke, Gas and Loss	42.3
(Coke—5.24 lbs.)	
(Gas—37.85 cu. ft.)	
Water	1.7

Composition of Pressure Distillate.

		% Pressure Distillate	% Raw Oil
Gasoline (Navy End Point[1])		64.8	36.3
Baume Gravity (A.P.I.)	50.8		
Initial boiling point	114°F.		
End boiling point	437°F.		
Gas Oil		31.5	17.6
Baume Gravity (A.P.I.)	16.6		
Loss		3.7	2.1

[1]Gasoline meeting the U.S. Government specification for motor gasoline.

Chemical Nature of the Gasoline.[2]

Unsaturated Hydrocarbons	27.2%
Aromatic Hydrocarbons	24.7%
Napthene Hydrocarbons	12.3%
Paraffin Hydrocarbons	35.8%
Aromatic Hydrocarbon Equivalent	33.2%
Ricardo's compression Ratio	5.85

Coke and Gas Formation.

Coke—Lbs. per gal.	2.5
Lbs. per bbl.	105
Gas—Cu. ft. per gal.	18.0
Cu. ft. per bbl.	756

The following comments were made on the tests:

"The dehydrated bitumen produced 25% of coke by weight by simple Engler distillation. Hence, the only logical operation for gasoline production from this oil is no-residuum operation; that is, the production of coke, gasoline and recycle stock only, the gas being understood".

"36.3% of N.E.P. gasoline has been obtained from the cracking of the dehydrated bitumen, making in addition 17.6% of gas oil or pressure distillate bottoms. Recycling of this gas oil will make an additional 11% of gasoline based on the original dehydrated bitumen, which will bring up the ultimate yield from the cracking of the bitumen to between 45 and 50%. This may be obtained in a single operation by removing end point gasoline from the cracking still".

"The cracked distillate may be readily treated into marketable gasoline by the use of the simplest acid and plumbite method". (A brief description of the treatment procedure is given in the report.)

"The cracked gasoline is very high in anti-knock properties, having an aromatic hydrocarbon equivalent of 33.2; that is, the motor equivalent of a straight run Mid-continent gasoline containing over 25% of commercial benzol in admixture. The gasoline is highly superior to the average motor fuel in anti-knock qualities".

WAINWRIGHT OIL.

Several hundred barrels of crude oil were obtained from the British Petroleums Company in 1925 for a practical road oiling experiment. About twenty gallons from this supply was also sent to the Universal Oil Products Company for test.

The Company reported the following composition for the oil received:

Crude Water-in-Oil Emulsion.

Specific Gravity	1.000
Water Content	36%
Mineral Matter	(Not stated but about 7%)

Dehydrated Crude.

Specific Gravity	.9682
Baume Gravity (A.P.I.)	14.6
Flash point (Cleveland)	240°F.
Fire point (Open cup)	290°F.
Viscosity, Furol, 77°F.—412 seconds.	
Sulphur Content	2.18%

Sulphur Content 2.18%

[2] c.f. Ind. & Eng. Chem. 18, 354 (1926) for method of Igloff and Morrell for estimating the various groups of hydrocarbons.

Distillation Tests.

(100 c.c. charge) Initial boiling point—413°F. (800 c.c. charge) Per cent. Over	Temp. °F.	Initial boiling point—375°F. End boiling point—680°F. Per cent. Over	Temp. °F.	Baume Gravity (A.P.I.)
5	510			
10	535	10	544	31.6
15	565			
20	610	20	578	27.8
25	640			
30	655	30	612	27.3
35	675			
40	685	40	560	28.9
45	695			
50	700	50	630	30.9
55	705			
60	710	60	620	30.0
65	715			
70	720	70	607	30.1
75	725			
80	625	80	596	30.8
84	725			

Remarks.

15.7% coke (by weight).
17% over at 572°F.
84% distilled over.

0.5% over at 410°F.
17% over at 572°F.
20% coke and pitch bottoms.

A laboratory cracking test was made on a quantity of the dehydrated crude oil with the following results:

Laboratory Cracking Analysis of Dehydrated Wainwright Crude.

Charge	6000 ccs.
Baume Gravity (A.P.I.)	14.6
Pressure	150 lbs. per sq. in.

Products of Cracking Run.

	% Raw Oil
Pressure Distillate (Baume A.P.I. 40.4)	68.3
Residuum	None
Coke, Gas and Loss	31.7
(Coke—3.22 lbs.)	
(Gas—22.56 cu. ft.)	

Composition of Pressure Distillate.

		% Pressure Distillate	% Raw Oil
Gasoline (Navy End Point)		60.6	41.4
Baume (A.P.I)	50.7		
Initial boiling point	115°F.		
End boiling point	440°F.		
Gas Oil		35.6	24.3
Baume (A.P.I.)	21.3		
Loss		3.8	2.6

Chemical Nature of the Gasoline.

Unsaturated Hydrocarbons	16.3%
Aromatic Hydrocarbons	28.3%
Naphthene Hydrocarbons	18.8%
Paraffin Hydrocarbons	36.6%
Aromatic Hydrocarbon Equivalent	36.2%
Ricardo's Compression Ratio	5.95

Coke and Gas Formation.

Coke—Lbs. per gal.	1.5
Lbs. per bbl.	63
Gas—Cu. ft. per gal.	10.7
Cu. ft. per bbl.	450

The following comments were made on the tests:

"Qualitative analysis of the dissolved and suspended matter in the water of the crude Wainwright oil shows that the greater portion of the solids obtained from the evaporation of this water is silica and organic matter. In addition to iron compounds and sodium chloride, some calcium and magnesium chlorides were found present. Unless the crude is completely dehydrated before cracking, which is not likely, the two latter salts will offer the probability of corrosion owing to the hydrochloric acid formation by hydrolysis of these salts at elevated temperature. This matter can be taken care of, however, in the same manner that we are at present handling Smackover crude at Houston".

"The test upon this oil was made upon a non-residuum basis owing to the low A.P.I. gravity. Satisfactory results could be obtained making a liquid residue while producing cracked gasoline, with a reduced gasoline yield, however, as compared with no-residuum operation".

"A yield of 41.4% of N.E.P. gasoline was obtained from the cracking of the dehydrated oil. The crude cracked distillate removed from the cracking still contained 35.6% of gas oil, or pressure distillate bottoms, in addition to the gasoline, which, based back upon the dehydrated crude, is 24.3%. The recycling of these cracked distillate bottoms will permit the formation of a minimum of 15% of gasoline based on the dehydrated crude which brings the ultimate yield of gasoline from this crude in excess of 56%. This, of course, could be carried on in one operation".

"The cracked distillates may be readily treated into marketable gasoline by the use of the simplest acid and plumbite method".

"The cracked gasoline has very high anti-knock properties, being equivalent to the cracked gasoline from our Smackover crude in that respect. This cracked gasoline is the equivalent in anti-knock properties of any gasoline which is now being produced commercially in any part of the world. Stated in terms of a Mid-Continent gasoline and benzol mixture, the cracked gasoline from the Wainwright crude is equal to a Mid-Continent straight run gasoline containing in admixture therewith 28% of commercial benzol".

Answers to Specific Questions.

The following questions were asked the Universal Oil Products Company when the samples of separated bitumen and Wainwright crude oil were sent for test:

1. What would be the nature and value of the residue from these oils after cracking?

2. What effect will the water and mineral matter contents of these crude oils have on the handling of them in commercial cracking equipment?

3. What would be the approximate cost of cracking these crudes and refining marketable products?

The answers given are as follows:

1. "Regarding the nature and value of the residues: where a coke is the only residue, it may be used for fuel purposes, being very high in quality in that respect. The coke formed from the cracking of these oils has a very high calorific value, being between fifteen and sixteen thousand B.T.U.'s per pound. The ash in the coke from the cracking of Wainwright crude will depend upon the extent to which the salt water has been removed before cracking, but under any circumstances this coke will be highly superior to coal as a fuel. As the mineral matter in the bitumen is a variable, the ash in the coke will vary likewise. In the event that the operation is of the liquid residue type, a liquid fuel of any desired characteristics may be produced. Coke will also be a product of this type of operation".

2. "The question of water and mineral matter in the oil will not affect the commercial cracking of same to any extent which would prevent consideration of cracking. In the event that it is too costly or too difficult to remove the water and mineral matter by pre-treatment, a heat exchanger may be used in conjunction with the cracking unit. Further than this, the question resolves itself to design of the cracking plant so as to obtain the velocity required to prevent settling of the mineral matter in the tubes. The question of the removal of water is one that has been definitely settled upon a commercial scale, and the Dubbs Process is today handling charging stocks direct containing several per cent. of water together with mineral matter, such as salts of the various kinds present in the Wainwright crude".

3. "The present cost of refining the cracked distillates as outlined above will be between 25 and 30 cents per barrel of gasoline product. The cost of refining depends mainly upon marketing conditions, *e.g.*, the question of meeting specifications such as water-white color, doctor sweet, and negative corrosion gasoline. When these specifications are not rigid, it may be reduced beyond that shown above, but this cost is based upon a product meeting all of these specifications. This figure does not include the cracking of the charging stock which will be in the neighbourhood of 50 cents per barrel".

BITUMINOUS SANDS, ROCK ASPHALTS AND ROAD OILING IN THE UNITED STATES

Progress of work in the United States on bituminous sands and rock asphalts for pavements, and the use of road oils for surface treatment of gravel and earth roads has been reported in articles appearing in the technical literature. Much of this work bears in a practical way on the problem of development of the Alberta bituminous sands, and has been followed by the Research Council in connection with its own studies. During 1926 Dr. Clark was sent to the United States to make first-hand observations. His detailed report is in the files of the Council. Some general comments are offered in the following paragraphs.

Bituminous sands similar in composition and bitument content to those of Alberta occur in California. Considerable quantities of the material have been excavated at Santa Cruz and Carpenteria and used for constructing pavements. The practise has been to mix the bituminous sand with approximately an equal quantity of extra mineral aggregate consisting of crushed sandstone, sand and stone dust and to heat the mixture in heated, rotating mixers. The added material cuts down the bitumen content in the final product to between 7% and 10% and helps to bring the general composition into conformity with standard pavement practise. In general, pavements made from bituminous sand have given excellent results. Many of them have been in service for fifteen and some for thirty years. Failures have been due, in most cases, to overheating during the heating and mixing process. This operation must be performed with great care and control of it has been dependent upon the experience and good judgment of the operator. The first asphalt pavements in California were made with bituminous sand, but refinery asphalt, produced in large quantity and at low price as a result of petroleum developments in the State, has displaced bituminous sands almost completely. Specifications for pavement work are still drawn up to permit the use of bituminous sand, but because of the greater cost of this material and the uncertainties of results from known methods of handling it, contractors decline to use it. Refinery asphalt of uniform quality and the well worked-out, easily controlled standard pavement plant have claimed the market for asphalt pavements.

Bituminous sands, sandstones or limestones occur in several other states. Their story is much the same as that of the bituminous sands of California except that in some instances efforts to revive their use as a road material are meeting with considerable success. In this connection, the rock asphalts of Kentucky are of particular interest.

The quarrying and preparation of rock asphalt has grown into a thriving industry in Kentucky during the last few years. The largest producer is the Kentucky Rock Asphalt Company, which operates a quarry and mill of 1,000 tons daily capacity at Kyrock, near Bowling Green. The Ohio Valley Rock Asphalt Company has a smaller plant at Summit, a short distance from Louisville. There are several other companies. The asphalt rock is a friable sandstone containing from 5% to 10% of bitumen. A review of the behaviour of early pavements made from Kentucky rock asphalt showed that those which had given good service had been made with material containing about 7% of bitumen, so the producers hold the bitumen content of their product close to this value. The rock asphalt is blasted down like rock in an ordinary quarry. The fragments are sorted over, blended to give an average bitumen content close to 7%, loaded into cars and sent to the mill. The judgment of the quarrymen in choosing material is checked constantly by laboratory tests and becomes sufficiently accurate. In the mill, the mineral bond of the sandstone is broken down and the material is reduced to a bituminous sand. The milling also smooths out the bitumen content to a uniform value within permissible limits. The final product is a ready-made pavement aggregate. No heating is done in its preparation. It is prepared, shipped and rolled down to pavement at ordinary out-door temperatures. Uniformity of product is the watchword of the industry, and is achieved by systematic sampling and analyses all the way through the manufacturing process from the prospecting of fresh quarry rock to shipment of carloads of finished product. The result is that the product of the reputable companies makes uniformly satisfactory pavements. It has excellent selling qualities. It is not a cheap material; but it is a good one and very convenient to use. The fact that no pavement plant is needed in handling it and that it can be unloaded from the cars, raked out on the road base and rolled without heating has a wide appeal. Numerous cities and towns lie within reasonable rail-hauling distance. The sales departments of the industry are succeeding in selling huge quantities of the rock asphalt.

The success of efforts in the United States to use bituminous sands and rock asphalts as paving material encourage the belief that equal success can be achieved with Alberta bituminous sand. Particular attention, however, should be given to difficulties encountered and special features differentiating American and Alberta conditions in arriving at conclusions about what course should be taken in development work here. The method of handling Kentucky rock asphalt is not directly applicable to our bituminous sand. The bitument content of our material is too great to allow of its being used alone as a pavement aggregate. Sand or stone must be added to it. To do this involves a mixing and heating operation which California experience has demonstrated to be attended by danger of damage to the bitumen and to lead to lack of uniformity of results. Our bituminous sand as found lacks the selling qualities possessed by rock asphalt. The buyer is not saved the necessity of using a pavement mixing plant and heat in handling the material. He must provide himself with as costly and troublesome equipment as is required for standard asphalt pavement work. In order to offer as saleable a product as the Kentucky rock asphalt, an Alberta industry would have either to undertake the blending of the bituminous sand with extra material to a final ready-made pavement mixture of constant, uniform quality and with cold laying properties, or to extend its organization and sell, not paving material, but finished pavement. Regarding the marketing possibilities, it should be remembered that the Alberta bituminous sands are not located in the midst of a populous region supporting many thriving cities and towns.

The Research Council has maintained that the key to the development of the Alberta bituminous sands is separation of the bitumen. Observations made in the United States support this contention, and make it appear that even for pavement work separated bitumen from our deposits rather than the bituminous sands themselves offers the best chances for success. Separated bitumen sold as paving material could be handled in the same way as refinery asphalt by methods and equipment familiar to all construction engineers. The difficulties of getting equipment which will mix and heat bituminous sand and added material without danger of overheating, would not be met. Economies in production, and especially in shipment to point of sale, would be made. All bituminous sand mined could be put through a separation plant, not all of it could be used for pavement constructin—one-third of the rock asphalt quarried in Kentucky is discarded. The weight of bitumen is about one-seventh of that of the bituminous sand from which it is separated. With an initial rail haul of 300 miles before the first possible market is reached, freight charges are a controlling factor. Separated bitumen would enter the market with much the same selling qualities as its refined asphalt competitor. If it could be sold at a more favourable price, it would win out in the competition. The chances of producing the bitumen at a favourable price are good. No local petroleum industry is supplying the Alberta market with low-price asphalt. It is now known how to separate the bitumen from the bituminous sands, and indications are that the cost of operation will be low.

Production of separated bitumen has the further advantage that the market open to it is much broader than that created by demand for pavements. If one looks ahead a few years into the future of Alberta and the Western provinces, and then observes what has taken place in the older parts of Canada and the United States in highway construction methods, it is easy to predict what the major demand for bituminous materials in Western Canada is going to be. It will be for road oils of suitable qualities for surface treatment of thousands of miles of gravelled main highways. Highway improvements follow the same lines everywhere. Gravel roads are built as a first expedient for giving large mileage of all-weather surface at low cost. Next, the gravel is surface treated to protect it against the ravages of modern motor traffic. Finally, the gravel is replaced by pavement as traffic grows to a volume that is too great for low-priced types of construction. Today, Western Canada is in the gravelling stage of highway improvement. Tomorrow, it will be faced with the necessity of bituminous surface treatments. Separated bitumen from our bituminous sand deposits can enter the market for road oils which this development will create. Bituminous sands, as such, cannot.

The maintenance of earth roads by oil treatment offers possibilities of a still broader market for separated bitumen. The earth road, of necessity, will remain prominent in the prairie provinces for many years to come. Similar conditions are met in the United States. The State of Illinois uses many millions of gallons of road oil each year for maintaining earth roads. North Carolina has developed an effective method of oiling earth roads and veneer-surfacing them by an application of bitumen covered with sand. Several of the Eastern States have found that heavy sand road conditions can be corrected by admixture of the sandy soil with asphalt. The same sort of work is done by the counties of California. And in this connection it is interesting to note that natural heavy California crude oil very similar to the bitumen in our bituminous sands is proving particularly suitable for this work, as well as for other road work of higher type. There seems little doubt but that experimental study would bring out a wide field of usefulness for separated bitumen for earth road maintenance and improvement in Alberta and result in a large demand for it as the need of such improvement becomes sufficiently pressing.

Observations in the United States have brought out some practical points in connection with the direct use of our bituminous sands as a pavement material. Further, they have confirmed the judgment of the Research Council that maximum application of the Alberta bituminous sands to road construction needs in Western Canada will be secured by producing a sand-free bitumen from the bituminous sands, and that establishment of a separation plant is the key to the situation.

FOREST PRODUCTS OF ALBERTA

MINE TIMBER

BY R. S. L. WILSON, *Professor of Civil Engineering*

The series of tests on mine booms and props of lodge pole pine mentioned and described in previous annual reports has been continued during 1926. (See 1923 Annual Report, pages 74 to 75; 1924 Annual Report, page 66; and 1925 Annual Report, pages 62 to 65.)

Figure 5 shows in diagrammatic form the structural tests completed to the end of 1926, and thereby the present stage of the investigation of lodge pole pine.

Inspections of the timber at the mine were made during 1926 in the months of February, May and October.

In February the timber of Series I at "Return Air" was becoming punky; the timber of Series II had fungus, but was not yet punky. At "Dead Air" the timber of Series I had become punky to a depth of ¼ inch, and the timber of Series II was not punky, but was thoroughly infected with fungi. The location in the mine was changed from "Dead Air" conditions to "Return Air" condition in the summer of 1925, due to requirements arising from the operation of the mine.

At "Intake Air" all timbers appeared to be in perfect condition.

In May, at "Return Air,,' the timber of Series I was found to be more thoroughly infected than that of Series II, and there were a few booms of Series I found broken. The timber of Series II, unpeeled, was becoming punky while the peeled showed no punkiness.

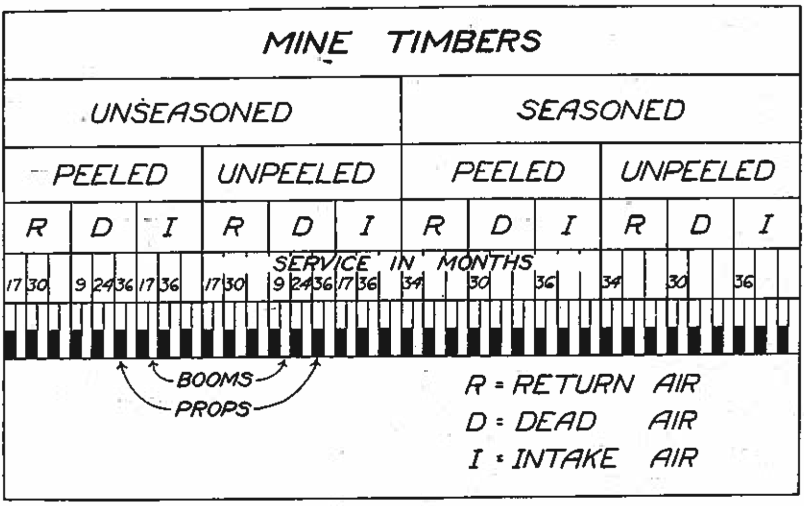


Figure 5.

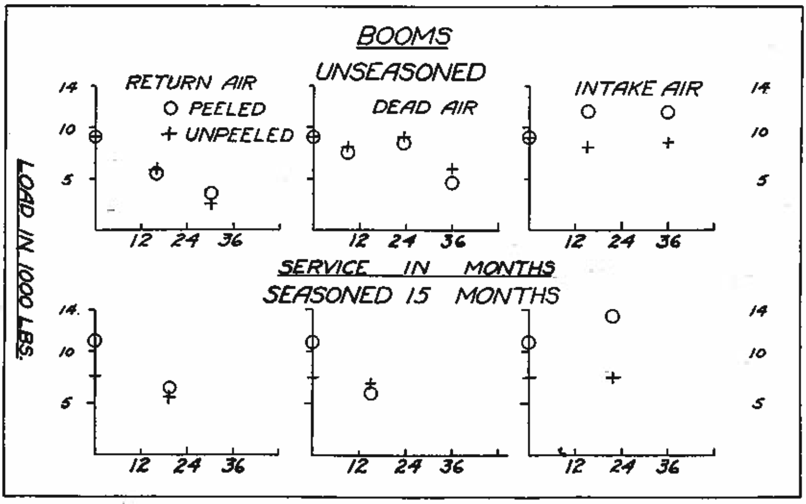


Figure 6.

At "Dead Air" (this name is retained although there is really a circulation) the timber was found in the same apparent condition as on the previous inspection.

At "Intake Air" every piece was still clean and sound.

In October, at "Return Air" the timber of Series I was apparently still fairly good, while the timber of Series II showed but little change.

At "Dead Air" and "Intake Air" practically no change could be noted.

Figures 6 and 7 show the results obtained from the tested batches of booms in graphical form. It will be noted that *completed* observations are available only for the timber booms, green peeled, and green unpeeled, placed at "Dead Air".

Each plotted point is the representative of a batch of 10 or more booms which had diameters ranging from 4.8 to 7.8 inches at the smaller load point. The bending tests were made by imposing a load which was equally divided among two load points spaced 30 inches from the points of support which were 90 inches apart. The ultimate load is the total load carried by the boom just before rupture.

The section modulus at the smaller third point is calculated from the formula:

Section Modulus=0.098 times the vertical diameter squared, times the horizontal diameter.

The rate of variation of ultimate load with section modulus is calculated by statistical method for each batch giving a regression coefficient which is applied to the difference between the average section modulus for the batch and the section modulus for a 6-inch diameter boom, thus obtaining an adjustment which is then applied to the average ultimate load for the batch in order to obtain the representative value of ultimate load for the batch.

This adjusted ultimate load is necessary for the fair comparison of results from all the batches on the basis of similar sizes of booms (*i.e.*, 6 inches diameter).

A complete discussion of the analysis of observed data is not offered here, as final results from all the tests are not yet available.

A consideration of the graphs of Figure 6 will show some interesting tendencies. Ordinates show adjusted ultimate loads and abscissas show actual periods of service.

Peeling of timber placed green in any location other than "intake air" is apparently worthless. Rate of deterioration is greatest in "Return Air". The difference in rates of deterioration at "Return air" and "Intake air" invites a study of the effects of preservative treatment since "Intake air" is about ideal in its effects on timber.

Now, refer to Figure 7 showing effects of seasoning on peeled and unpeeled timber. It is apparent that seasoning effects on strength are beneficial only when the timber is first peeled. For this lot of timber cut in December the whole benefit from seasoning appears to be concentrated in the short period February to May.

Again refer to Figure 6 showing the graphs of Series II (seasoned 15 months) results. There are batches for two more periods of service for each graph still to be tested, so any tendencies noted here must be regarded as very tentative indeed.

There seems to be no lasting strength value whatever in seasoning unless possibly in "Intake Air" peeled booms. The reduction of weight may be of value under some circumstances.

It may be remarked that prop test results tend to confirm the tendencies noted about the boom test results.

Studies are not yet complete and must cover other characteristics, such as "deflection", "age", "moisture", and infection due to fungi.

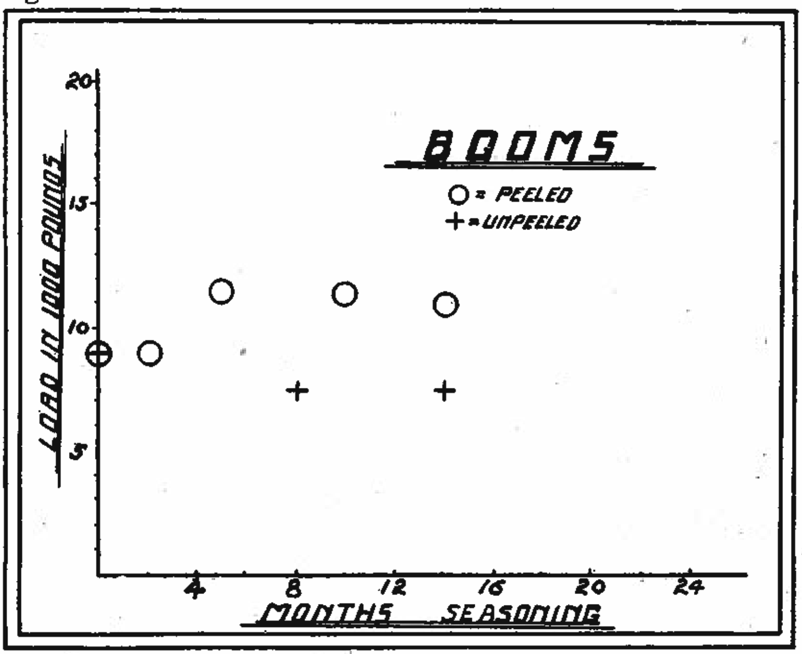


Figure 7.

LIST OF PUBLICATIONS

OF

THE SCIENTIFIC AND INDUSTRIAL RESEARCH COUNCIL OF ALBERTA.

EDMONTON, ALBERTA

ANNUAL REPORTS OF COUNCIL

No. 3 (for the calendar year 1920); pp. 36. **Price 5 cents.**

No. 5 (for the calendar year 1921); pp. 86. **Price 35 cents.**

No. 8 (for the calendar year 1922); pp. 64. **Price 35 cents.**

No. 10 (for the calendar year 1923) with 4-color map of Alberta coal areas; pp. 76. **Price 50 cents.** Map No. 6 only, **15 cents.**

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No. 16 (for the calendar year 1925); pp. 65. **Price 35 cents.**

No. 20 (1926); pp. 53. Reviews the work done during 1926 under the auspices of the Research Council. This includes a continuation of the chemical survey of Alberta coals, begun in 1925, their use in domestic furnaces and for residence heating; geological investigations of the section west of Edmonton and the Bow River section; compilation of data on mineral resources, water supply and natural gas; possible utilization of bitumen from the bituminous sands and Wainwright crude oil for oil and gasoline; a continuation of the study of Alberta trees for use as mine timber.

REPORTS—FUELS

No. 10A (1923); COMBUSTION OF COAL FOR THE GENERATION OF POWER, by C. A. Robb, Professor of Mechanical Engineering, University of Alberta. Multigraphed copies only. **Price 50 cents.**

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Part III—Utilization (in preparation).

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By Dr. J. A. Allan, Professor of Geology, University of Alberta.

No. 1 (1919); pp. 104—A summary of information with regard to the mineral resources of Alberta.

No. 2 (1920); pp. 138+14. Supplements the information contained in Report No. 1.

No. 4 (1921); GEOLOGY OF THE DRUMHELLER COAL FIELD, ALBERTA; pp. 72, and 6-color map (Serial No. 1). **Price $1.00.**

No. 6 (1922, Part I); GEOLOGY OF THE SAUNDERS CREEK AND NORDEGG COAL BASINS, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 76, and 2-color map (Serial No. 2). **(Out of print.)**

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