Report No. 60

THIRTY-FIRST

ANNUAL REPORT

OF THE

RESEARCH COUNCIL OF ALBERTA

1950

EDMONTON
PRINTED BY A. SHNITKA, KING'S PRINTER FOR ALBERTA
1951

CONTENTS

The following report, the Thirty-First Annual Report of the Research Council of Alberta, was submitted in March, 1951, by Dr. Robert Newton, Director of Research, to the Chairman of the Council, The Honourable N. E. Tanner, Minister of Mines and Minerals. The Chairman submitted the report to the Premier of Alberta, The Honourable E. C. Manning, who tabled it in the legislature.

The offices and laboratories of the Council are situated in the buildings of the University of Alberta. Requests for information and reports should be addressed to the Secretary, Research Council of Alberta, University of Alberta, Edmonton, Canada.

MEMBERS OF COUNCIL

The Honourable N. E. Tanner, Minister of Lands and Forests and Minister of Mines and Minerals, Chairman.

The Honourable E. C. Manning, Premier of Alberta.

The Honourable Dr. J. L. Robinson, Minister of Industries and Labour.

President Andrew Stewart, University of Alberta.

Dr. Robert Newton, Director of Research.

*Mr. L. E. Drummond, Edmonton.

*Mr. J. E. Davies, Medicine Hat.

†Mr. R. J. Dinning, Calgary.

†Mr. O. C. McIntyre, Edmonton.

†Mr. R. D. Purdy, Calgary.

†Mr. F. V. Seibert, Edmonton.

*Retired as member of Council December 1950.

†Appointed as member of Council December 1950.

The Council operates under the Research Council Act of 1930 as amended 1943, 1945 and 1950.

The offices and laboratories of the Council are in the University of Alberta. The Secretary of Council is W. A. Lang.

TECHNICAL ADVISORY COMMITTEE

Dr. R. Newton, Director of Research, Chairman.

Dean R. M. Hardy, Faculty of Engineering, University of Alberta, Assistant Director of Research, Deputy Chairman.

Mr. J. E. Oberholtzer, Deputy Minister, Department of Industries and Labour.

*Mr. G. H. N. Monkman, Deputy Minister, Department of Public Works.

Mr. O. S. Longman, Deputy Minister, Department of Agriculture.

Mr. J. Crawford, Director of Mines, Department of Mines and Minerals.

Dr. K. A. Clark, Professor of Metallurgy, the University.

Dr. J. D. Newton, Professor of Soils, the University.

*Dr. O. J. Walker, Professor of Chemistry, the University.

Dr. P. S. Warren, Professor of Geology, the University.

Mr. W. A. Lang, Secretary of Council, Secretary.

*Retired from Technical Advisory Committee December 1950.

ADVISORY COMMITTEES

Constituted December 1950

---

1. *Fuel and Power,* Dr. K. A. Clark, Co-ordinating Chairman.

   A. Coal:

      Mr. W. A. Lang, Senior Research Chemist, Chairman.

      Mr. J. Crawford, Director of Mines, Department of Mines and Minerals.

      Prof. J. A. Harle, Department of Electrical Engineering, the University.

      Mr. W. C. Whittaker, representing The Western Canada Bituminous Coal Operators' Association.

      Mr. J. A. Davidson, representing The Domestic Coal Operators' Association of Western Canada.

   B. Petroleum and Natural Gas:

      Dr. K. A. Clark, Department of Mining and Metallurgy, the University, Chairman.

      Dr. G. W. Govier, Department of Chemical Engineering, the University.

      Prof. J. A. Harle, Department of Electrical Engineering, the University.

      Mr. J. S. Charlesworth, Gasoline and Oil Testing.

      Representative from Western Canada Petroleum Association, to be appointed.

2. *Industrial Projects.*

   Mr. J. E. Oberholtzer, Deputy Minister, Department of Industries and Labour, Chairman.

   Mr. R. Martland, Director, Industrial Development and Economic Research, Department of Economic Affairs.

   Mr. W. J. McGill, Alberta Representative, National Research Council, Technical Information Service.

   Prof. W. D. Gainer, Department of Political Economy, the University.

   Dr. O. J. Walker, Department of Chemistry, the University.

   Mr. B. W. Pitfield, representing the Canadian Manufacturers' Association.

   Mr. J. Gregory, Industrial Engineer.

3. *Surveys,* Dean R. M. Hardy, Co-ordinating Chairman.

   A. Geology:

      Dr. P. S. Warren, Department of Geology, the University, Chairman.

      Mr. M. B. B. Crockford, Petroleum and Natural Gas Conservation Board.

      Dr. R. D. T. Wickenden, Federal Geological Survey.

      Mr. W. H. A. Clow, Geologist.

B. Soils:

Dr. J. D. Newton, Department of Soils, the University, Chairman.

Mr. O. S. Longman, Deputy Minister, Department of Agriculture.

Mr. V. A. Wood, Director of Lands, Department of Lands and Forests.

Mr. W. E. Bowser, Federal Experimental Farms Service.

Mr. W. Odynsky, Soil Surveyor.

C. Highways:

Dean R. M. Hardy, Faculty of Engineering, the University, Chairman.

Mr. A. Frame, Highway Commissioner, Department of Public Works.

Mr. N. A. Bradley, representing the Prairie Road Builders' Section, Canadian Construction Association.

STAFF OF THE RESEARCH COUNCIL

The following held full-time appointments on the technical staff during the year:

Robert Newton (part), Director of Research, from September.

W. A. Lang, Senior Research Chemist, Coal, and Secretary of Council.

D. S. Pasternack, Senior Research Chemist, Bituminous Sands.

J. S. Charlesworth, Chemist, Gasoline and Oil Testing.

Wm. Odynsky, Soil Surveyor, Soils.

G. W. Hodgson, Research Chemist, Bituminous Sands.

Donald Quon (part), Research Chemist, Natural Gas, from May.

John Gregory, Industrial Engineer, Industrial Projects.

W. H. R. Clow, Geologist, Geology.

Edward Tipman, Asst. Chemist, Gasoline and Oil Testing.

Edward Sherlock, Asst. Research Chemist, Coal, to June.

T. E. Morimoto, Asst. Research Engineer, Coal.

M. R. Wardle, Asst. Research Chemist, Coal.

J. F. Fryer, Asst. Chemist, Coal.

J. L. Carveth, Asst. Research Engineer, Coal, from May.

L. G. Barrett, Asst. Research Engineer, Coal, to April.

Andrew Wynnyk, Asst. Soil Surveyor, Soils.

R. P. Stone, Asst. Soil Surveyor, Soils, May to December.

J. S. Groot, Draftsman-Compiler.

The following held full-time appointments on the non-technical staff during the year:

Miss K. S. Wark, Accountant-Librarian.

Miss S. M. Mackintosh, Technical Stenographer.

Miss P. A. Paterson, Stenographer, to September.

Mrs. N. A. Luck, Stenographer, from September.

R. M. Morison, Laboratory Assistant, Coal, to October.

R. C. D'Amur, Laboratory Assistant, Gasoline and Oil Testing, to June.

Leonard New, Laboratory Assistant, Gasoline and Oil Testing, from June.

H. R. Van der Meulen, Laboratory Assistant, Coal, from September.

Olaf Katzer, Laboratory Assistant, Coal, from November.

The following held temporary appointments during the year:

J. S. Powell, Laboratory Assistant, Coal, Jan. 18-Feb. 28.

W. R. Bruce, Research Assistant, Bituminous Sands, May 1-Aug. 31.

D. E. Duff, Asst. Field Geologist, Geology, May 1-Sept. 30.

M. D. Scheelar, Asst. Soil Surveyor, Soils, May 1-Dec. 31.

Wm. Wanat, Research Assistant, Natural Gas, May 15-Sept. 30.

D. B. Robinson, Research Assistant, Natural Gas, May 15-July 15.

John Markovich, Asst. Soil Surveyor, Soils, May 25-Sept. 20.

K. B. O'Neill, Asst. Soil Surveyor, Soils, May 22-Sept. 20.

K. S. Goodman, Asst. Civil Engineer, Highway Research, May 29-Sept. 20.

Alex Roshko, Technician, Highway Research, May 29-Sept. 18.

F. J. Disney, Cook, Soils, June1-Sept. 23.

V. N. MacDonald, Asst. Soil Surveyor, Soils, June 24-Sept. 20.

Miss N. B. Horne, Stenographer, July 1-Oct. 31.

C. K. Kehoe, Laboratory Assistant, Natural Gas, Aug. 1-Sept. 23.

The following members of the Faculty of the University of Alberta assisted in the work of the Council:

Dr. K. A. Clark, Bituminous Sands.

Dr. E. H. Gowan, Ultra-Violet Solar Radiation.

Dr. G. W. Govier, Natural Gas Research.

Dean R. M. Hardy, Highway Research.

Prof. J. A. Harle, Power Project.

Dr. J. D. Newton, Soil Survey.

Dr. Wm. Rowan, Animal Cycles.

President A. Stewart, Power Project.

Dr. O. J. Walker, Utilization of Straw.

ANNUAL REPORT

OF THE

Research Council of Alberta

1950

REPORT OF THE DIRECTOR OF RESEARCH

Organized industrial research under Government auspices in Alberta began in 1919. Inquiries in regard to iron deposits caused the Provincial Secretary, Hon. J. L. Coté, to ask Dr. J. A. Allan, Professor of Geology in the University of Alberta, for a report. The obvious usefulness of this report led Mr. Coté to appoint a committee of Provincial Government and University representatives to survey all the mineral resources of the Province and ascertain the possibilities of their development. This Committee met first on October 21, 1919. Progress was such that on January 6, 1921, the Government by Order in Council reorganized the Committee as the Scientific and Industrial Research Council of Alberta, and noted that "the work can best be continued in co-operation with the University of Alberta". Now, after thirty years, it seems appropriate to review briefly the history and progress of the Council's chief projects.

The Athabasca bituminous sands have been a major subject of investigation from the outset, both as road material and as a source of liquid fuel. Dr. K. A. Clark, in the report of the Council for 1920 described the sands as a natural deposit of road material, but recognized the importance of developing a process for separating the bitumen from the sand, to improve its availability and extend its uses. Early experiments showed that the sand could be used directly in road building, but the cost of transporting such bulky and heavy material was excessive. Gradually the hot-water process of separation was perfected, and finally proved in practice by the pilot-plant operations at Bitumount in the summer of 1949. In 1950, co-operative experiments in the National Research Laboratories demonstrated the feasibility of combining the hot-water separation process with the fluidized-bed cracking and distillation process, using the wet crude oil from the former process as feed stock for the latter process. Mr. S. M. Blair, of Toronto, the consulting engineer engaged by the Government of Alberta to survey the situation, has recommended the foregoing combination as the best available, and reports that by its use the economic development of the bituminous sand is immediately practicable. A number of details remain to be cleared by further investigation, but it is reassuring to know that if an emergency required Canada to become self-sufficient in oil, or to supply large quantities to allies in war, the bituminous sands could be developed quickly. Long-range research and experiment have paid off richly in this case.

Coal has always absorbed more of the Council's attention and budget than any other product or project. Though coal mining ranks fourth among the industries of the Province (after agriculture, manufactures, and oil) it has had to face many difficulties, and needs all the help science can give. Its long-range potentialities, considering the amount of it within our borders, justify long-range investigations. By 1925 Professor Stansfield and his colleagues had published a compilation of analyses of Alberta coals from different areas, which laid the basis for a rational system of classification and marketing. This report was greatly expanded in 1944, under the title, "Coals of Alberta: Their Occurrence, Analysis and Utilization", a publication which has become a standard reference. Even this is due for early revision. Problems in coal preparation and processing have received their share of attention. Briquetting, low-temperature carbonization, and Alberta coals for domestic stokers, are among the subjects of recent publications. The current year saw further experiments on cleaning, balling, and briquetting, and studies on the constitution of coal, the latter of interest to chemical industry. Further modernization of the coal mining industry, based on operational research, seems desirable to meet competition by oil and gas, but limited markets and profits may not justify heavy capital outlays. Coal mining should be maintained as a matter of national policy, to avoid being caught short in an emergency. Coal has no adequate and universal substitute for meeting heavy power requirements.

Chemical analyses and physical tests of gasolines and other petroleum products, carried out for the Provincial Government in 1935 and 1936, as a basis for setting standard specifications, were followed in 1939 by the establishment of the Gasoline and Oil Testing Laboratory. Its work was supervised by Professor Stansfield, of the Council staff, but administered at first by the Department of Trades and Industry. During the period 1942-45, the laboratory was mainly occupied in testing for the Department of National Defence samples of aviation gasoline used by Air Force establishments from Fort William to the Pacific Coast. In 1943 the laboratory was taken over by the Research Council of Alberta, but continued its analytical and testing service for the administration of provincial gasoline standards. Co-operation is maintained with the Canadian Government Specifications Board and the National Research Council, through a representative of the laboratory on the petroleum committees of these bodies. A systematic annual survey of the gasolines sold in Alberta has been carried out for some years, and a survey of lubricating oils is now under way. Minor researches are done on problems submitted from various sources. The laboratory is becoming a centre for investigating and controlling Alberta petroleum products, and will become increasingly useful with the growth of the oil industry.

Geological survey work has been an important part of the Council's work from the very beginning. Dr. J. A. Allan's first and second annual reports on the "Mineral Resources of Alberta", for 1919 and 1920, mention the occurrence of the following minerals, though not all of them in significant amounts:

Bitumen	Iron	Phosphate
Building stone	Lead	Potash
Clay	Mica	Salt
Coal	Mineral springs	Sodium sulphate
Copper	Natural gas	Talc
Gold	Nickel	Zinc
Gypsum	Petroleum	

Thereafter work was devoted mainly to the geology of the coal areas, though one report is devoted to the water resources of the Peace River country, one to salt at Waterways, and one to soils. This year the Provincial Department of Mines and Minerals took over the responsibility for general surveys, and the Council switched to a survey of pleistocene deposits. These are, generally speaking, the deposits of the last million years, everything lying above "bed rock", and are of particular importance in connection with soil surveys and highway construction. Next year it is proposed to add an economic survey of non-metallic minerals, because of the industrial interest in limestones, sands, clays, bentonite, gravel, building stone, phosphate, and sodium sulphate.

Highway research has been assisted by the Council through grants for the past four years to Dean R. M. Hardy of the University of Alberta. With the growth in Provincial expenditures on road building, it became more important to insure the fullest possible use of science as an adjunct to this activity. Increasing volume and speed of traffic and increasing unit weight of loaded vehicles demand higher standards of highway construction. Detailed studies of subsoils, their moisture content and compaction, of aggregates, concretes, and asphalts, of the factors in stability of fills and hillsides, are required. The compaction studies have been completed, and a report is in preparation. Co-operation with neighboring provinces is secured through the Prairie Road Builders' Section of the Canadian Construction Association and the National Research Council. These bodies also give financial aid to the project.

Natural gas as a raw material for the production of industrial chemicals and liquid fuels has been investigated by the University of Alberta, Department of Chemical Engineering, with several grants-in-aid from the Council over the past twenty years. The late Dr. E. H. Boomer tried pyrolysis and also the Fischer-Tropsch synthesis, with some success. The new programme of work begun this year under the direction of Dr. G. W. Govier, Professor of Chemical Engineering, is aimed to test the newest conversion techniques. A group of Council staff prepared a report on "Natural Gas and its Relation to the Industrial Development of Alberta" for submission to the joint hearing of the Natural Gas Conservation Board in October, 1950. This report deals with the constituents of natural gas, the significance of natural gas as a power source and as a chemical raw material, the outlook for disposing of the liquid fraction (propane and butane), and with natural gas in relation to industrial growth in Alberta.

Soil surveys were carried on by the University of Alberta, with the help of a special annual grant from the Provincial Department of Agriculture from 1922 to 1931. The Research Council entered the picture in 1928, covering the expenses of northern exploratory surveys by members of the University Department of Soils from that year until 1931, and publishing two reports on this work. In

the depression years of 1932-34 very little was done, but in 1935 the Dominion Department of Agriculture, through the Prairie Farm Rehabilitation Act, began co-operative assistance which has been continued, through other channels, to the present. The Research Council renewed its assistance in 1945, and since then the entire programme has been carried forward by three co-operating bodies, namely, the University of Alberta, the Research Council of Alberta, and the Dominion Experimental Farms Service. The Professor of Soils in the University is chairman of a co-ordinating committee. There are three kinds of survey: exploratory, reconnaissance, and detailed. In exploratory surveys the men make observational traverses through substantial areas, taking soil samples whenever a change of soil type is noted. In reconnaissance surveys the traverses are not more than a mile apart and usually repeated, profile samples being taken at every soil change. In detailed surveys, as made in irrigation districts, every quarter section is examined carefully and sampled repeatedly. Alberta probably has more new land suitable for agricultural settlement than any other province, and soil surveys should keep pace with settlement demands.

Measurements of solar ultra-violet radiation, begun in 1932 by Dr. E. H. Gowan of the University Department of Physics, with daily readings made at noon, have since 1945 been placed on the basis of all-day records with the help of grants from the Council to purchase and operate the necessary equipment. Long-term records may possibly throw some light on the problem of biological cycles, particularly the alternate prevalence and scarcity of forms of wild life. The Council is also assisting Dr. William Rowan, Professor of Zoology, in the investigation of other possible factors, using the rabbit cycle as a test case. This baffling problem is of economic as well as scientific importance, affecting the fur industry and even the safety of human life in isolated northern districts where dependence is placed on wild game for food. The small grants-in-aid made by the Council to these two projects may easily lead to results of major importance.

The responsibility of the Council for answering technical questions submitted by industry or government agencies led to the appointment of an Industrial Engineer in 1945. Before that it had been necessary to farm out these questions to various members of the Council or University staff. The Industrial Engineer still consults these men as freely as necessary, but many of the questions can be answered by reference to appropriate literature. Sometimes they also involve minor investigations. As time permits he visits industrial concerns to ascertain their problems and offer help in appropriate cases. In short, he is a liaison officer between the Council and industry, helpful in industry as just indicated and helpful to the Council by keeping us in touch with the practical problems in need of solution. A large proportion of his time has been devoted to questions concerning the establishment of new industries, referred by the Department of Industries and Labour, the Industrial Development Board, and the Alberta Industrial Corporation.

The following reports on the current year's work in each of the projects reviewed above were prepared by the project leaders and the Secretary of the Council.

BITUMINOUS SANDS

The attention of Council staff concerned with bituminous sand studies was devoted, during the year, mainly to helping with the survey of bituminous sand development possibilities undertaken by the Board of Trustees of the Oil Sands Project. But in addition, laboratory work was done on several problems arising from the operation of the provincial government separation plant at Bitumount. The bituminous sand studies of the Council are in a state of transition. Hot water separation, which has been worked at for so long, is nearly completed. Workers are now getting orientated to other phases of the general problem.

Survey

Mr. S. M. Blair, Consultant Petroleum Engineer of Toronto, and Mr. E. P. Nelson, Vice-President of Universial Oil Products Company Ltd., visited Bitumount at the close of the 1949 season. The question in everyone's mind was what should be done with the separation plant and these prominent men from the oil industry were asked for an opinion. Their view was that what further to do with the plant could not be determined without first making a survey of development possibilities. The successful operation of the Bitumount plant had demonstrated that a technically feasible process for obtaining oil from the bituminous sands was available. There were well established processes for all other steps of a complete development. Open-pit mining was common practice. The oil industry had many refining methods. Transportation of oil by pipeline or otherwise was understood. The problem, then, was to choose from all available alternatives for each step in the complete development of bituminous sand and the delivery to market of saleable oil products, the best sequence of operations. The choice would be governed by the technical suitability of operations, the way they fitted together and their costs. A variety of useful results would come from the survey. One would be an answer to the question of whether bituminous sand development would be profitable now or in the immediate future. Another would be the finding of the weak spots in the sequence of development operations that stood in need of further study. Still another would be the realization of research problems and the order of their priority in laying out research programs. And, of course, the usefulness of the Bitumount site and plant in the carrying out of further studies would become clear.

The Board of Trustees of the Oil Sands Project agreed with the views of Messrs. Nelson and Blair. On recommendation from the Universal Oil Products Company, Mr. Blair was retained to undertake the survey.

A contract with Mr. Blair was completed in March. By its terms the provincial government undertook to make available to Mr. Blair any information pertinent to the survey that it possessed and he required. The government also agreed to provide the services of its technical employees with special knowledge of the bituminous sands as these services were needed. Work was got under way promptly. Obviously the staff of the Research Council of Alberta working on bituminous sands was involved.

When the contract with Mr. Blair was signed, Mr. Blair called for definite information about the bituminous sand deposit at a site

suitable for operations on the scale of 20,000 barrels of oil production per day. This could be given for one site only, namely the Mildred-Ruth Lake area that had been proved up by the core drilling of the Bureau of Mines. Results of this drilling had been published. Our Council made a detailed study of these data, delineated an exact square mile and worked out the average thickness of overburden, depth of bituminous sand and the average grade of sand. The best square mile was chosen. The average overburden depth was 32 feet. The depth of bituminous sand was 125 feet and its average oil content was 14.2% by weight. The quantity of bituminous sand available was sufficient to keep the projected plant supplied for 20 years. There were four adjacent square miles that were as favorable except that the ratio of overburden to bituminous sand was greater. With the grade of bituminous sand determined, the quantities of it needed to yield 20,000 barrels of oil per day by the processes to be considered could be calculated. This information was necessary for determining the size and estimating the costs of the various alternative plants.

General consideration of the development problem led to the conclusion that the bituminous sand oil would have to be destructively distilled to coke and a cracked distillate. The crude oil itself was far too viscous to transport by pipeline and was too low a grade of oil in any case. The cracked distillate on the other hand was a fluid oil, was free from heavy residuum and was an attractive "crude" oil from the refining standpoint except for its high sulphur content. There were three alternatives for going from bituminous sand to cracked distillate. One was hot water separation followed by the cleaning and drying of the wet separated oil by use of diluent as was done at Bitumount and then the coking of the dry crude oil by the conventional delayed coking procedure. The second was the cold water separation procedure of the Mines Branch, the drying of the wet diluted crude oil obtained by this separation process, the recovery of diluent from the diluted crude and then the conventional coking of the recovered crude oil. The third was the continuous retorting of the bituminous sand by the fluidized bed technique of the National Research Council, giving a cracked distillate directly. There was a fourth possibility that came to attention later. This was to separate oil from sand by the hot water process and then to charge the wet crude separated oil to the continuous fluidized solids coking plant.

Mr. Blair called on those associated with the Bitumount plant, on the National Research Council and on the Mines Branch to provide him with as complete engineering data as possible about their process as applied to a plant of 20,000 bbl/day capacity. More specifically, he asked each party for a flowsheet of its process showing the size of vessels and general layout, power and utility requirements and complete heat and material balances. At Edmonton the superintendent for the Bitumount plant compiled all the pertinent records of the 1949 separation plant operation. Our Research Council decided on a flowsheet and arrangement of a separation plant of 33,700 tons bituminous sand per day capacity. Drawings of the plant layout were prepared showing size of storage hoppers, conveyors, vessels, etc., power requirements and quantities of materials to be handled through the plant. A heat balance was also worked out. All this work was based, as far as possible, on the actual results of the Bitumount plant. Similar compilations were made by

the parties at Ottawa. In their cases there was not a pilot plant operation to serve as a guide. However, the fluidized solids process of the National Research Council was so similar to a catalytic cracking plant that, with assistance from Universal Oil Products Company engineers, the work was accomplished with an adequate degree of accuracy. The National Research Council was, of course, able to supply accurate information about the yield of distillate from its process and its quality.

The compilations of engineering data on the three processes were passed to the Universal Oil Products Company. Its engineers worked out the capital costs, maintenance and operating costs, etc., and arrived at costs per barrel of distillate produced by the three operations or combinations of operations under consideration. The capital cost of the hot water separation plant was got by multiplying the cost of the Bitumount plant by the necessary factor to bring its capacity to that required and then taking the two-thirds power of this product. The Universal Oil Products Company engineers had plenty of cost data for conventional delayed coking plants and catalytic cracking plants and experience in designing such plants. Consequently they were able to estimate the capital costs of the fluidized bed coking plant and the conventional coking plants satisfactorily. There was difficulty in arriving at the capital cost of the cold water separation plant. However its general similarity to the hot water plant, the cost of which had been determined, and the description of it supplied by the Mines Branch made a reasonable estimate possible. These engineering costings, expressed in terms of cost per barrel of distillate produced, showed that the hot water process as carried out at Bitumount followed by conventional coking was the best of the three combinations studied. The cold water process was seen to be inherently more costly than the hot water process and it was followed by the same steps of drying the wet diluted crude, recovery of diluent and conventional coking of the dry crude oil. The capital costs for a fluidized bed plant working on a bituminous sand feed priced it away out of line.

The weak feature about the combination of hot water separation followed by cleaning and drying the crude oil by use of a diluent, recovery of diluent and then conventional coking of the dry crude oil was losses associated with the use of diluent. This consideration led to combining hot water separation to get rid of the great quantities of sand, with the fluidized solids bed coking plant using wet crude oil from the separation plant as a feed. The cost per barrel of cracked distillate was the lowest for this combination. The Universal Oil Products Company engineers were confident that the fluidized solids plant would work on a wet oil feed.

A meeting of all those actively engaged on the survey was held in July at Chicago in the Universal Oil Products Company offices. The costing results were presented and discussed. In the end it was mutually agreed that the hot water process combined with the fluidized solids continuous coker was the best way of proceeding from bituminous sand to cracked distillate. All technical questions and implications were reviewed thoroughly. It was most interesting and instructive to those from government research laboratories to note how the Universal Oil Products Company organization could bring knowledge and experience to bear on the questions that arose. Time and again when some particular matter was under discussion somebody from the organization with special knowledge and long

experience would be summoned to give consideration to the point and to express his judgment. The meeting continued for three days.

The high sulphur content (4%) of the cracked distillate puts it at a severe disadvantage as a "crude" oil. Ways of eliminating the sulphur were considered. It was judged that the best procedure was mild hydrogenation at moderate pressure. Hydrogenation is receiving widespread attention in the oil industry at the present time for various purposes. About the easiest result to accomplish through hydrogenation is sulphur removal. It is the least costly application of the process. A laboratory hydrogenation test on the cracked distillate brought its sulphur content down to 0.25%.

There is a difficulty about applying hydrogenation to the cracked distillate from bituminous sand oil. Samples of this distillate produced at the National Research Council contain vanadium in disconcerting quantities from the standpoint of catalyst poisoning. The indication is that it contains about 30 parts per million against a tolerance for vanadium of about 5 parts per million. Nobody seems to know much about how vanadium occurs in an oil—whether it is in the oil or in mineral matter held by the oil.

It should be interjected here that subsequent work showed that there was a practical solution to the vanadium trouble. Tests revealed that the vanadium was contained, mainly, in the heaviest hydrocarbons of the coker distillate. By fractionating the distillate and sending the heavy bottoms back to the fluidized solids coker for further coking, the vanadium content of the final distillate could be held to a low limit.

After the Chicago meeting the Canadian workers assembled in Toronto. Progress in the survey was reviewed. It was agreed that the National Research Council should operate its fluidized solids plant using wet separated crude oil as a feed and determine whether there was a difference in yield and nature of distillate as compared to feeding bituminous sand. The Mines Branch expressed willingness to undertake hydrogenation tests on the distillate to get information about the seriousness of the catalyst poisoning question. The opinion of hydrogenation workers in the States was that the answer to the question could be found only by trying and observing whether poisoning occurred. Edmonton members were assigned the responsibility of getting supplies of wet separated crude and some other wanted materials to Ottawa. This plan of action reveals a gratifying result of the survey. Workers in three government laboratories each partial to a competing separation process were in agreement on the combination of the hot water and fluidized bed processes and were enthusiastic about doing their part in pushing the survey through along this line. Our Council loaned one of its staff to the National Research Council.

The survey is concerned with operations other than those so far mentioned. One of these is the mining or excavating of the bituminous sand. Mr. Blair interested Fred Mannix and Co. of Calgary in this problem. This company has extensive experience with strip mining in Alberta. Two Mannix engineers flew to the Mildred-Ruth area and Bitumount in late June taking a member of our Council staff with them to acquaint themselves with the bituminous sand deposit. The company has prepared a report on an open pit development at the chosen site in the Mildred-Ruth Lake area and has calculated a cost per ton of bituminous sand delivered to a

separation plant. It has also made an interesting suggestion for a method of removing bituminous sand through tunnels driven below the deposit. There are unknowns involved in this scheme that can be determined only by experimentation. The scheme has attractive features, granted that it will work. Indicated costs are lower than open pit mining. Operations are underground where severe winter weather will not interfere. Any heavy overburden is of no importance. Sand tailings disposal is also provided.

The cost of transportation of oil from the Athabasca river to Edmonton is being studied by engineers of the Bechtel Corporation.

This brief review of the survey gives the highlights of procedure and progress. Time has elapsed since the writing of this summary. In this time Mr. Blair has reported to the government on the findings of the survey. These show that the total cost of producing a barrel of hydrogenated coker distillate and delivering it to the Great Lakes market is $3.10 and that its market value is $3.50. This means that the commercial development of the bituminous sands can be carried out at a profit now. Mr. Blair's report is being printed for distribution.

Laboratory Studies

Study of the Propane Extraction of Wet, Separated Crude Oil

It was thought, in the first stages of the survey, that propane extraction of the wet separated crude oil would be the best way to get a fluid, pumpable oil from the viscous crude that would be valuable as a refinery charging stock. Universal Oil Products Company made some extraction tests at Chicago. An apparatus was set up here and some extractions of the wet oil were made using pentane. The objective was mainly to get acquainted with the process and to know something about the complication of dealing with a water-in-oil emulsion. However, propane extraction dropped out of consideration. Making a cracked distillate from the crude oil was seen to be more advantageous.

Mechanical Arrangement for Feeding Sand from a Sand Tailings Receiver to a Sand Pump, Including an Automatic Control for the Sand Level in the Receiver

This problem arose from the operation of the Bitumount plant. There was persistent trouble with the tailings receiver, sand pump and tailings line. There was the added interest that a good solution to the problem would open the way for simplification of the separation plant; sand tailings could be pumped to waste directly from the separation cell.

The problem was worked at during the summer with success. A mechanically driven rake kept track of the level of sand in the receiver. As the sand level built up, more power was required to drive the rake through the sand. The increased power consumption gave a means of automatically regulating the flow of sand to the sand pump.

Separation of Sand Tailings and Plant Water by Use of a Driessen Cone

At the Bitumount plant a Dorr Thickener was used to clear the plant water of suspended mineral matter. This was a bulky piece of equipment. A Driessen Cone is an effective settler and it is small. Cones in place of thickeners would simplify the separation plant.

The Driessen cone that has been set up for cleaning fine coal was operated on a feed of sand tailings. Data on the performance of the cone on tailings were obtained.

Trace Metals in Separated Bituminous Sand Oil

Some spectrographic analyses for trace metals were made with the help of the Department of Physics. Results were in line with the ones obtained by Universal Oil Products Company.

In Situ Recovery of Oil from the Bituminous Sand Deposit by Application of the Hot Water Process down a Bore Hole

This idea was given a trial in the laboratory. A high pressure stream of hot water was directed against the surface of a packed column of bituminous sand at about 35°F. Results were discouraging. The stream tended to cut into the sand mass, dislodging chunks rather than causing it to disintegrate into clean sand and oil froth. Only the one trial was made so no definite conclusions can be drawn.

D.C. Antifoam in Wet Bitumen

Heretofore, wet separated oil could not be heated strongly for two reasons. When the temperature reached the boiling point of water, the wet oil foams in exaggerated fashion; also, the mineral matter in the wet oil cakes onto the surface of the heater soon reducing the transfer of heat to ineffectiveness. It was observed, following up a suggestion from the manufacturers, that the silicone products D.C. Antifoam A or D.C. 200, 350 cstks. fluid, stopped both the foaming and the caking. One part per million of the latter product was effective.

Examination of Bituminous Sand Oil Obtained from Exploratory Wells

The Bear Oil Co. supplied a core of bituminous sand from a well that was roughly 75 miles south of McMurray. A sample of viscous oil was obtained from the Shell Oil Co. which came from porous limestone immediately below the bituminous sands at a depth of about 2,000 ft. in a well located roughly 125 miles west of the Bear Oil Company's well. The oils from both wells were examined. The specific gravity of the Bear Oil Co. sample was 1.006; that of the Shell sample was 1.022. This is just about the range of specific gravities observed for oils in bituminous sands from outcrops along the Athabasca river. The sulphur contents of the two oils were about 5%. This is the sulphur content of oils from outcrops.

Asphaltene, Resins and Oily Constituent Contents of Bituminous Sand Oils

Several years ago bituminous sand oils from various locations and from various horizons at the same location were examined for their contents of asphaltenes, resins and oily constituents. This was done, also, for oil in weathered bituminous sand and for oil that becomes associated with sand tailings, very fine mineral matter and oil froth in the hot water separation process. During the past year further examinations have been made of oils collected at Bitumount. A report of this work has been prepared for publication.

Chemical and Physical Tests

Analytical work, on coal and related materials, included the analysis of channel samples of coal submitted for test by the Provincial Mines Inspectors, of samples from consignments of coal and of briquettes purchased by the Federal Department of National Defence; and of many miscellaneous samples obtained in connection with other investigations of Council. A number of mine dusts were tested to determine their explosion hazard. An attempt was made to improve the test procedure for determining the percentage of carbonates present in coal and in mine dusts. The results are still not as satisfactory as are desired. A study was made of the factors which may influence the coke button obtained in the Free Swelling Index Test. It was found that both the shape and the size of the button are dependent on the rank of the coal, the percentage of ash in the particular sample, the sizing of the powdered coal used in the test, and the degree to which the coal has been oxidized. The latter is an important factor, particularly in the case of coal mined by stripping operations.

Constitution of Coal

Humic acid studies, initiated in 1949, have developed into an investigation of the oxidation of low-rank Alberta coals. The effect of concentration of nitric acid upon the yield of water soluble acids, humic acids, and the amount of residue has been studied, and a number of the simpler degradation products have been isolated by chromatographic techniques, but only two compounds were definitely identified, namely, oxalic and picric acids. Alkaline permanganate oxidations of a subbituminous coal were carried out, with subsequent esterification of an ethanol soluble fraction of the acids produced. Four solid esters, whose properties are not those of the esters of the benzenecarboxylic acids, have been resolved from the mixture, and an attempt to discover something of the structure of these esters is being made, chiefly by means of spectrophotometric investigations. Other oxidation studies have included some preliminary work on the kinetics of the reaction between molecular oxygen and the humic acids, with particular reference to the destruction of the chromophoric groups of these substances, and a comparison of the ultraviolet absorption spectra of the humic acids generated by such reagents as nitric acid, molecular oxygen, and ozone.

Cleaning of Coal

The cleaning of coal investigation has been limited to treating the finer sizes of coal since this is one of the major problems facing the Alberta coal industry. The advent of strip-mining has increased generally the percentage of mineral matter present with the fines, and in many cases has increased the amount of fines being recovered. The market for fines of bituminous rank has been the railroads, but with the introduction of oil-burning and Diesel locomotives on the railroads, and with restrictions being placed on the amount of fines present in the run of mine coal purchased by the railroads, this market is diminishing. If new markets are to be found or the fines briquetted, then they should have a reasonably low ash content. Coal cleaning work has been done during the year

on three processes, the Stephens Adamson air sand, the Sy-vor, and Driessen cone.

The air sand coal cleaning model loaned to the Council by the Stephens Adamson Manufacturing Co. was used to test the cleaning of a High Volatile C Bituminous coal. The size of coal suitable for treatment with this apparatus was limited to $-\frac{1}{4}+\frac{1}{8}$ mesh. The cleaning efficiency effected by the model cleaner as calculated by the Yancey formula was 94%. The Driessen error area, calculated in terms of units rather than square centimeters, gave 18.9 units, while the Anderson efficiency, at the specific gravity of separation of 1.715, as given by the distribution curve, was computed to be 91.3 percent.

A laboratory model to test the characteristics of the Sy-vor process was built, and a considerable number of tests were made with it. The major difficulty found to be present with this apparatus was the classification of the feed material into its various sizes. This is inevitable with a process whch uses an upward current of water and often results in the finer sizes of mineral matter being floated and thus contaminating the clean coal.

A three-inch Driessen cone with ancillary equipment including heavy media tanks, pumps, magnetic separator, demagnetizing unit and screening equipment has been assembled and is now ready for operation. Tests have been made with the cone, when using water as a media, to determine the validity of Dahlstrom's capacity formula. These data are important in determining the throughput of the cyclone at different line pressures. Magnetite and water will be used as the heavy media for the preliminary work but it is hoped to use at a later period, materials which are available in Alberta for the media. Minus 10 mesh is the maximum size of coal that can be tested in the three-inch cone, but it is anticipated that results obtained will be applicable to a larger sized feed material in a commercial sized cone.

Complete float and sink separations, using organic liquids as heavy media, have been made on two coals and the fractions thus obtained analysed for moisture and ash. These data have been used to plot washability curves. They have also been used to evaluate various methods of showing efficiencies for coal cleaning processes.

Studies will be commenced shortly on the physical properties of heavy media for use in coal cleaning processes. Among the materials to be tested will be magnetic beach sand, loess, waste shale, limestone, etc.

Briquetting

The briquetting investigation was limited to a number of tests made on blended coals and to a further investigation of the properties of asphalt in relation to its use as a briquet binder. Imperial Oil Ltd. kindly assisted by supplying nine samples of asphalt and complete inspection data for them. The asphalts were made from Redwater oil.

The results of this investigation confirmed the previous finding that the most important property of a briquetting binder is its penetration over the range of temperatures to which the briquet will be exposed during handling, transportation and storage. A similar relationship exists between the softening point of briquetting

binders made from Redwater crude oil and the qualities of briquets made with these binders. This may be due to the relationship that has been found to exist between the penetration and softening point of asphalts from this crude oil. No differences were shown to exist between briquets made with asphalt from cracking coil tar stock, and asphalts made from straight run materials provided the softening temperatures and/or penetrations were similar. This may be a peculiarity of binders made from Redwater crude oil, and may not hold for binders made from different oils. The relationship between the softening point and penetration at any given temperature, which is generally much different for the straight run than for cracking coil asphalts even when made from the same source oil was not found to be the case in this investigation. However, this finding should be regarded as indicating an unusual characteristic of asphalts made from Redwater crude oil, rather than a characteristic of cracking coil and natural asphalts. It was observed that the softening point of the straight run binders tended to have a somewhat higher viscosity at 300°F. than did the cracking coil tar binders made from Redwater crude oil. This would ordinarily be expected, except that for asphalts from most sources, the points for the straight run asphalts would be widely separated from those for cracking coil asphalts.

A paper "The Briquetting of Alberta Coals" was presented at the Annual Meeting of the Canadian Institute of Mining and Metallurgy, Toronto, April 1950. The paper was published in the September 1950 issue of the Institute Bulletin.

Balling of Fine Coal and Asphalt.

An investigation of the balling of fine coal with asphalt was undertaken with the hope that a product might be prepared which would have a more desirable sizing than have briquets, for stoker and locomotive use, and also that the capital and operating costs for a plant to produce the fuel would be lower than those of a standard briquetting plant. The indications from the preliminary investigation are that the process and equipment should be relatively simple, and that power and binder are the major items of cost. The tests made have shown that fine coal (minus ¼ mesh) can be agglomerated into a sized product which is clean to handle, free running from storage bins, and which could be stored without disintegration or danger of spontaneous combustion. The sizing of the product obtained with present equipment depends to a considerable extent on the amount of asphalt that is used. The product ignites rapidly because of the coating of asphalt on the surface of the particles, and the increased volatile content ensures good combustion particularly of the lower volatile coals. The chemical properties of the product are a combination of those of the coal and of the asphalt. It seems likely from the preliminary work that an addition of a minimum of 8 percent of asphalt will be required if an appreciable upgrading in the coal sizing is made. This amount may make the product uneconomical for a railway fuel but probably not for a stoker fuel.

Visits

Visits were made to a number of stripping operations in the province. A member of the fuels staff attended the Research Meetings of the Dominion Coal Board in Ottawa, the Annual Meeting of the Canadian Institute of Mining in Toronto, the Anuual

Meeting of the Nova Scotia Mining Society in Kentville, and a coal conference sponsored by the Nova Scotia Research Foundation and the Department of Mines of Nova Scotia at Crystal Cliffs, N.S. Another member of the staff visited the Coal Research Laboratories at Penn State College, State College, Pa., Carnegie Institute at Pittsburgh, and the U.S. Bureau of Mines stations at Pittsburgh and Bruceton, Pa. Close liaison has been maintained with the Provincial Mines Branch, Department of Mines and Minerals; and Fuels Laboratory, Mines Branch, Ottawa.

GEOLOGY

Pleistocene Survey of the Edmonton Area

A preliminary survey of the Pleistocene deposits of the Edmonton area was conducted. The territory traversed is that of the Edmonton sectional sheet which includes townships 49 to 56 and ranges 15 to 27, west of the fourth meridian. This is an area of 3,744 square miles. Traverse of the area was made by automobile and foot. Information was obtained from river cutbanks, road cuts, building excavations, auger holes and wells.

The unconsolidated material lying above bedrock was studied. The deposits are of two kinds, the pre-glacial Saskatchewan sands and gravels and those of glacial origin. The Saskatchewan sands and gravels lie above bedrock and below the glacial mantle. Their age is not definitely Pleistocene but they are thought to belong to or be near that epoch. The Pleistocene epoch in Alberta was one of glaciation. Glacial remnants, in the Edmonton area, indicate that there were at least three ice advances. Till, gravel, sand and clays were deposited directly by the ice or in the pro-glacial lakes and channels.

Deposits of gravel, sand and clay were noted. These were not explored to determine the extent or suitability for economic development. Gravel exploration by private interests has been quite extensive in the Edmonton district. Clay and sand investigations have not been made in any detail. The clays of the district which would appear to be suitable for brick and tile wares are of common occurrence.

A preliminary report on this survey will be prepared during the winter months.

Geological Reports

A report on the survey of the Carbondale River area was prepared and will be published in the near future. The report on clays of the Cypress hills is also ready for publication.

Reconnaissance Trips

Several field trips were made to districts adjoining the Edmonton map area. During these excursions glacial deposits and geomorphology were noted. The experience thus gained aided greatly in deciding the mapping policy and the interpretation of the glacial features of the Edmonton area.

Pleistocene parties of the Geological Survey of Canada led by Dr. A. S. Stalker and Mr. B. Craig, were contacted. Discussion of methods and exchange of data with these parties was very beneficial to the work of the Council party.

GASOLINE AND OIL TESTING

The Gasoline and Oil Testing Laboratory continued its investigations of petroleum and associated products during 1950. Aviation fuels, motor gasolines, Diesel fuels, lubricating oils and other materials received attention. As in former years the largest volume of testing was carried out for the Dominion Department of National Defence and for various departments of the Government of Alberta. Some commercial testing of petroleum products was done.

A detailed report, Mimeographed Circular No. 9, entitled "Alberta Gasoline Surveys 1950" was printed for distribution. The report, based on the analysis of 200 retail samples, indicates the quality of motor gasolines sold in Alberta during the year. A study of the results shows that there were fewer failures than in the previous year and that octane ratings and tetraethyl lead contents had increased slightly.

The survey of automotive lubricating oils for sale within the province was continued. When it is completed, the results will be compared and studied in relation to the standard specifications for lubricating oils as set out by the Canadian Government Specifications Board.

Considerable time was devoted to various special projects. These included a study of antifreeze solutions; the suitability of one type of plastic compound considered for use as a petroleum product container; numerous requests for assistance in the solution of engine operating difficulties; the supplying of technical assistance in the revision of the Alberta Standard Specifications for Gasoline; and in the rewriting of the handbook of Petroleum Testing Procedures as published by the National Research Council.

Close liaison was maintained with the Petroleum Sub-Committee of the Canadian Government Specifications Board and with the Associate Committee on Petroleum Research of the National Research Council. The Research Council of Alberta has official representation on both of these committees.

HIGHWAY RESEARCH PROJECT

Work was continued during the summer on compaction studies on new road construction. A somewhat more detailed study was made on one job in the Edmonton area than had been conducted on the projects studied during the previous two seasons. This was done for the purpose of verifying the conclusions reached from the results on the seven projects previously studied. A final report on the compaction studies conducted during the four seasons from 1947 to 1950 is in process of preparation.

Preliminary investigations were made to determine the reasons for asphalt paving cracks that appear to be unassociated with overloading of the road structure consisting of pavement supporting gravel base and sub-soil. That is, they develop where there is no evidence of overloading of the road by traffic and in fact may occur at locations of very light traffic. They are of importance from the maintenance point of view because they permit water to penetrate the pavement foundation which may in due course result in rapid deterioration of the surface. The initial studies were undertaken, as a matter of convenience, on the roads on the University of Alberta campus and also on the city streets of Calgary and

Edmonton. These have shown that in some cases the cracks originate in changes in volume of the gravel and soil supporting the pavement, but in others they originate in the asphalt surface.

As a result of the initial work a more detailed program has been planned for the present winter period. This will involve both laboratory and field measurements of the volume changes occurring in asphalt paving mixtures, gravel base courses and also sub-soils under various conditions.

Higher standards on highway construction are resulting in deeper earth fills being placed to reduce grades and to maintain longer sight distances. This has resulted in a greater incidence of slides occurring on side hills along which such fills are placed or in the fills themselves. Two locations of unstable hillsides have been investigated in detail for the purpose of assessing the soil conditions that accompany such instability.

General observations during the four seasons that this project has been under way have indicated the importance of sub-soil moisture variations as well as sub-soil moisture migrations on the behaviour of highways in service. Little information is available on seasonal moisture variations and on the conditions resulting in sub-soil moisture migration. It was therefore suggested to the other organizations financially supporting the highway research project that a co-operative study on this problem should be undertaken by the Civil Engineering Departments of the three Universities in the Prairie Provinces. Grants were provided for this purpose to the Universities of Manitoba and Saskatchewan in addition to that previously given to the University of Alberta by the Prairie Road Builders' Section of the Canadian Construction Association. Work was commenced on this problem in Saskatchewan during the summer and preliminary work is now under way in Alberta on the instrumentation for the program that will be undertaken here.

The Research Council of Alberta grant for this project was augmented again this year by grants from the Canadian Construction Association, the Prairie Road Builders' Section of the C.C.A., and the National Research Council. These additional grants have enabled the scope of the project to be expanded considerably from what would have been possible with the Research Council of Alberta grant alone. The interest of these organizations has also greatly increased the attention which the results of the work have received throughout the highway construction industry.

NATURAL GAS RESEARCH PROGRAM

Considerable effort was expended in acquiring background knowledge in the general field of natural gas utilization. This involved detailed study of the literature and a trip by a member of the staff to research laboratories in the United States working in the petrochemical field. As a result of these studies two technical articles are being prepared for early publication, one on the general subject "Natural Gas as a Chemical Raw Material" and the other a more detailed survey of one specific process "Carbon Black from Natural Gas".

On the experimental side, three projects are currently under investigation:

Project 1—The Catalytic Pyrolysis of Natural Gas in a Fluidized Bed.

Project 2—The Gas Phase Partial Oxidation of Butane.
Project 3—The National Research Council Pidgeon Process for Producting Carbon Black from Natural Gas.

The last two projects form the basis of graduate M.Sc. theses by two students in the Department of Chemical Engineering. Equipment for these projects is now largely constructed and the collection of experimental data will begin early in 1951. Equipment for Project 1 will be completed in the spring of 1951 by which time also a few preliminary runs will be made.

Project 1.—A Study of the Catalytic Pyrolysis of Natural Gas in a Fluidized Bed

Background

Because pyrolysis represents one of the simplest unit processes involving natural gas, many investigators have studied the reaction. This research has gone into two main paths—produce unsaturated reactive gases such as acetylene and ethylene which might be suitable for further synthesis or to produce aromatics directly, notably benzene. About twenty years ago the Research Council of Alberta sponsored a project on the pyrolysis of Alberta natural gas, the work being carried out by Boomer and Gishler. At that time, the main interest was in the effective utilization of Turner Valley gas which was being flared. Because of the unreactivity of the methane, and the disappointingly low yields, pyrolysis processes in general have had little commercial success.

At the present time, however, there is a critical shortage of benzene in America, and one possibility is its production from natural gas. Furthermore, the use of new reaction techniques, developed since the earlier experiments, justify a re-evaluation of the industrial potentialities of pyrolysis.

Objectives

The purpose of the present research is to investigate the kinetics and yields of the pyrolysis of natural gas, leading to aromatic products. The latest reaction techniques—fluidized bed operation, autothermic process—will be used, together with recently developed catalysts.

Technical Considerations

There is considerable doubt as to the mechanism of the decomposition and polymerization reactions leading to the formation of the aromatic ring. One possibility is the formation of the free radical ($—CH_2—$) as a primary produce, which in turn polymerizes to ethylene, and finally to benzene. Because of the many competitive reactions, temperature level and time of contact are both of prime importance. Since the process is endothermic, heat transfer and temperature control problems have been major stumbling blocks. Furthermore, it has been difficult to find a catalyst which will direct the reaction towards formation of aromatics and yet not catalyze the complete decomposition to carbon and hydrogen.

Experimental Approach

The pyrolysis will be carried out in a refractory tube reactor (3 feet long, 1.5 inches in diameter), heated electrically and with control to temperatures of 1200°C. It is planned to concentrate first on the heat transfer aspect of the problem. Fluid-

ized bed operaion should make possible a uniform controllable temperature. The autothermic reaction technique (i.e., supplying the heat for pyrolysis by burning part of the hydrocarbon with an incomplete supply of oxygen, the latter being mixed with the hydrocarbon feed before entering the reactor) may help solve the heat transfer difficulties. The first experiments will be carried out with inert carriers, but later on, various catalysts will be tried. Both the tarry products and the aromatics will be analysed by fractional distillation.

Progress

The overall reaction system has been designed and the essential parts ordered. Construction has been started but has been hampered by lack of personnel (at present there are no students working on this project) and delays in acquiring the necessary apparatus. However, the equipment should be in working order, and preliminary tests conducted before the end of the present fiscal year.

Project 2.—A Study of the Kinetics and Yields of the Gas Phase Partial Oxidation of Butane

Background

At the present time in Alberta, there is a surplus of butane produced from the Gas Conservation Plant at Devon, this butane being available at very low prices. Experience in the United States has been that the liquified petroleum gas fraction (propane and butane) is a more reactive and more versatile raw material than the whole natural gas for direct chemical synthesis. For that reason, it has found increasing use in chlorination, nitration and partial oxidation reactions. There are two commercial plants in the southwestern United States producing methanol, formaldehyde, acetaldehyde, and acetone from the partial oxidation of butane. The Canadian consumption of these products (which is, to a large extent, imported from the United States), appears to be large enough to warrant serious consideration of the establishment of a small chemical plant in Alberta. However, before any sound economic evaluation is possible, more must be known about the reaction itself. Naturally the companies involved are reluctant to divulge any operating details.

Objective

The objective is to obtain fundamental reaction rate and yield data on the gas phase partial oxidation of butane affected by reaction conditions such as temperature, pressure, gas composition and space velocity. Future studies call for the investigation of the reaction in a catalytic fluidized bed.

Technical Considerations

Superficially (disregarding mechanism), the partial oxidation reaction may be represented as:

$$\text{hydrocarbon} \xrightarrow{O_2} \text{alcohol} \xrightarrow{O_2} \text{aldehyde} \xrightarrow{O_2} \text{acid} \xrightarrow{O_2} CO_2 + H_2O$$

Unfortunately the first step is the hardest and requires the greatest activation energy. In other words: it is easier to oxidize an alcohol to an aldehyde or even an acid to carbon dioxide and water, than to oxidize the original hydrocarbon. The degree of oxidation is therefore very difficult to control—those reaction conditions severe enough to oxidize the hydrocarbon also tend to push the reaction

to undesirable end products (carbon dioxide and water). The time of contact and the temperature are especially important variables. This problem is common to nearly all paraffin hydrocarbon reactions—how to initiate the reaction and yet stop it before it goes to completion. The exothermic nature of the reaction adds to the difficulty of effective temperature control.

Experimental Approach

Of the reaction variables to be controlled, the temperature is the most difficult to handle. To obtain any kind of uniformity in the temperature, the high heat of reaction must be dissipated rapidly. A bath of boiling liquid (an aromatic compound called aroclor), surrounding the reactor, will act as a constant temperature, high capacity heat reservoir. To give a high surface to volume ratio, the diameter of the reactor (to be made from stainless steel to minimize the wall reaction) must be kept small. Furthermore, in order to assure high heat transfer coefficients, the gas flow must be kept turbulent, requiring high gas velocities (and high Reynolds numbers). For the contact times typical of this reaction, this means that the reactor will be fairly long. To meet all these requirements, the reactor will consist of a 6-foot length of ¼-inch stainless steel pipe, wound in the form of a coil, the latter being immersed in a bath of boiling liquid. Thermocouple wells, spotted along the length of the reactor, will enable the temperature and hence the progress of the reaction to be followed. Provision will be made to stop the reaction by quenching the gas immediately after it leaves the reactor. The organic products will be absorbed in an aqueous solution and analysed by fractional distillation followed by chemical methods. The analytical work in this project will be difficult and time-consuming.

Progress

The reaction system has been designed and about half built. Practically all the equipment had to be ordered or fabricated outside the department, resulting in long delays. However, it is expected that the apparatus will be in operation by January, 1951. Although the instrumentation, which includes pressure gauges, temperature recorders, and pressure flow meters, will be quite complete no automatic controls will be incorporated into the design at the present time. The reactor has been designed to cover the pressure range from 0-300 psia, temperature range 250-500°C. and contact times 1-5 seconds. It is believed that the commercial operation of the partial oxidation process falls within these limits.

Project 3.—A Pilot Plant Evaluation of the N.R.C. Pidgeon Process for Producing Carbon Black from Natural Gas

Background

In the last few years, there has been an increased interest in the possibilities of producing carbon black from Alberta natural gas, stimulated by the local availability of the raw material and by the recent drive to reduce American imports. At the present time, the entire Canadian consumption of carbon black, approximately 50,000,000 lbs. per year worth some $4,000,000, is imported from the United States. The rubber industry, located in Eastern Canada, uses about 90% of this carbon black.

There are three proven industrial processes—the channel, the thermatomic, and the furnace. The channel process, which accounts

for over half of the total production, gives a high quality carbon black, suitable for compounding natural rubber. However, the yields have been very low, of the order of five per cent of theoretical. The thermatomic and furnace processes, although giving much higher yields, produces a black of a different qualtiy suitable for compounding synthetic rubbers. The unsettled state of the rubber industry, and hence of the carbon black industry, is one of the major deterrents to the immediate establishment of carbon black plants in Alberta. However, the situation should stabilize and long term prospects for a carbon black industry in Alberta are reasonably good.

Another factor is the policy of the Alberta government. This policy which operates through the Petroleum and Natural Gas Conservation Board would prohibit the installation in Alberta of any natural gas consuming industry which does not make reasonably effective use of the natural gas raw material. It is understood that the Conservation Board takes the view that channel black plants with their low conversion efficiency do not represent efficient utilization of the gas. The policy, however, is not one which automatically prohibits carbon black manufacture but which will require carbon black production by an efficient process.

A process developed some fifteen years ago on a laboratory scale by Dr. Pidgeon of the National Research Council appears to offer the advantages of high conversion efficiency and at the same time to give a carbon black of quality intermediate between that produced by the channel and the furnace processes. The present project therefore was conceived to permit an evaluation on a pilot-plant scale of this interesting laboratory process.

Objectives

The primary objective is to obtain an engineering evaluation, on a pilot-plant scale, of the laboratory-scale carbon black process developed by H. M. Pidgeon of the National Research Council. This would involve the use of commercial size refractory tubes, calculation of heat balances, evaluation of the carbon black produced, and possible use of recycle in the gas feed. A secondary objective is the collection of fundamental reaction rate data on the gas phase thermal decomposition of natural gas under controlled conditions.

Technical Considerations

The thermal decomposition of methane to carbon and hydrogen is characterized by its endothermic reaction times. The manner in which large amounts of heat are transferred to the natural gas at high temperature levels distinguish the processes from one another. In both the channel and furnace processes, part of the natural gas burns with an incomplete supply of air in a diffusion flame, the heat of combustion serving to decompose the excess natural gas. The thermatomic process is a cyclic process in which the brick checkerwork in the furnace serves as a heat reservoir, storing up heat in this combusion period (premixed natural gas and air), and releasing that heat in the production period (pure natural gas). Furthermore, if the carbon black particles are kept in an atmosphere of natural gas at high temperatures for too long a period of time, the particle size increases, resulting in a lower quality of carbon black. The channel process quenches the reaction by means of cold channel irons located immediately above the flame. The quenching

in the other two processes is not nearly as effective, and consequently furnace blacks are much larger in particle size.

If one tries to decompose natural gas in an externally heated tube (in effect the thermatomic process conducted at a uniform temperature), the carbon deposited on the inner surface of the tube acts as an insulating barrier, effectively reducing the heat transfer.

In the Pidgeon process a pressure differential is maintained between the inside and outside of the tube, permitting inward diffusion of the burnt fuel gases. This diffusion is said to prevent carbon deposition on the wall. High yields (up to 60%) and good quality of carbon black are claimed.

Experimental Approach

A furnace with a heating capacity of 200,000 BTU/hr. is being built and it is hoped that temperatures up to 1500°C. can be reached. The refractory tubes used will be 36 inches long, and 1, 2, or 3 inches in diameter. The furnace will be operated under a slight pressure to permit diffusion of the flue gas into the tube. The gas will be quenched by water immediately on leaving the furnace and the carbon black collected in glass cloth filters. The variables to be investigated include the properties of the carbon black, temperature, time of contact, and inlet gas composition. With data from a unit of this size, it should be possible to make a much better economic evaluation of the industrial possibilities of this process.

Progress

The unit has been designed and is in the construction stage. The biggest delay has been in obtaining the refractory tubes. The furnace is being built here at a substantial saving in costs. Operation should commence by January, 1951. With the introduction of Leduc oil field gas into the City of Edmonton distribution system early next spring, it will no longer be possible to obtain lean natural gas from the city gas mains. Consideration is now being given to two possible solutions to this problem. One of these would involve the building of rather extensive storage facilities in the laboratory and the establishment of a shuttle service to bring suitable gas from the nearest source, which is at the East Edmonton Regulator Station of Northwestern Utilities Limited. The other possibility being explored is that of moving the pilot plant to a temporary location immediately adjacent to the Northwestern Utilities East Edmonton Regulator Station.

Visits to American Research Laboratories

Seven research centers—located in the Chicago area and in the southwestern United States—were visited. The latest research developments and the topics discussed included: the gasification of hydrocarbons to produce synthesis gas (Institute of Gas Technology); autopyrolysis of ethane (Universal Oil Products); the nitration and chlorination of paraffins (Department of Chemistry, Purdue University); the Fischer-Tropsch synthesis and the separation of the water soluble chemicals produced (Stanolind Oil and Gas Company); the measurement of the thermodynamic properties of hydrocarbons (U.S. Bureau of Mines, Bartlesville Station); the Schoch process for producing acetylene from hydrocarbons (Bureau of Industrial Chemistry, University of Texas); and the production and uses of helium (U.S. Bureau of Mines, Amarillo Station).

It is believed that the contacts made and the information gathered on this trip will be valuable not only in carrying out the present projects but in the formulation of future research.

SOILS

During the year a joint report was prepared outlining all the previous work of the Soil Survey by projects. It had been suggested by officials of the Dominion Soil Survey that henceforth all survey work be reported on a project basis. Accordingly, the following is a progress report of all projects under way in 1950.

Irrigation Surveys

Bow River Project (Dominion, assisted by Research Council).

This project of nearly 100,000 acres was completed this summer. It extends from Ronalane to north of Medicine Hat.

This area is a mixture of shallow Chin and Maleb loams with a small percentage of Hemaruka loam and Cavendish sandy loam. Much of it is very rough topography and unsuitable for irrigation. The rating is not yet completed, but it is thought that the actual acreage of fair or better irrigable land will be small.

Two staff members of the Research Council spent two weeks on this project to gain experience in detailed surveys.

Carmangay Project (Dominion)

The Carmangay project along the Little Bow drainage was surveyed this year. Part was a re-survey and part a proposed extension. In all approximately 23,000 acres were covered. The bulk of the area is a sandy loam to loamy sand with a fairly high lime parent material. The area is badly drifted, there are numerous silt bars in the area, and much of it is of irregular topography. The overall rating will not be very high. This work was requested by the Water Resources branch of the Province of Alberta since the farmers in this district want to form an irrigation district.

William Pearce Project (Dominion, assisted by Research Council)

This project of approximately 1,000,000 acres consists of an area to be irrigated by diverting some of the water of the Red Deer river. A preliminary survey of the area was made in July by two members of the Dominion staff and one of the Research Council. A party of five Dominion men moved to the area in August and surveyed about 100,000 acres. There are about 900,000 acres to be completed and a considerable amount of analytical and field experimental work to be done before these soils can be satisfactorily rated.

Since it has been requested that as much of this work as possible be completed next year, the Research Council personnel will assist with this work during at least part of the coming season.

Reconnaissance Surveys

Brazeau-Rocky Mountain House Sheets (Dominion)

Approximately 400,000 acres were mapped in this area. Considerable checking and correlating were done on previously completed work. There are approximately 1,000,000 acres yet to be surveyed in the area north and west of Olds and along the Pembina river west of the Saskatchewan river. Black, degraded black, grey

wooded, "brown-grey" podsolic and brown podsolic soils occur in this area.

McLennan and High Prairie Sheets (Research Council)

Checking and correlation was completed in this area this summer. The work was facilitated in parts of the area through the use of recently completed roads made by oil companies for their seismic crews. Approximately 1,750,000 acres have been surveyed, and much of this winter will be devoted to the preparation of the maps and report of this area.

Sturgeon Lake and Grande Prairie Sheets (Research Council)

Approximately half of the Sturgeon Lake sheet (400,000 acres) was completed this year. Much of the area is not accessible by roads and progress has been slow. Oil survey lines have been used wherever possible. Two of the new 2-mile sectional sheets have been considered as a mapping unit in order to economize on the costs of publication. Consequently there remain some 1,400,000 acres yet to be surveyed to complete this project. During part of the coming summer it is planned to complete the Sturgeon Lake and possibly make a start on the Grande Prairie sheet. These sheets comprise an area extending from near Valleyview to just beyond Grande Prairie. They lie immediately south of the published Rycroft-Watino area and west of the completed High Prairie area, and will include all of township 69 instead of just the northern half indicated on the sectional sheets.

Exploratory Surveys (Research Council)

Exploratory traverses were made of an area lying north and west of Blueberry Mountain and of an area lying north of Hotchkiss. The "Blueberry Area" consists of all or parts of townships 81 to 84 in ranges 7 to 12 inclusive west of the 6th meridian. The area is south and west of the Peace river and has recently been made fairly accessible through the construction of roads by the oil companies. This area has long been under consideration as a possible site for clearing operations, and of late there has been a growing demand to have it made available for settlement purposes. The area is now being subdivided, and it was found that most of it has suitable soils and a large proportion of it has a light tree cover. The soils in the suitable portions are degraded black and grey wooded clay loams that have few to no stones and a level to undulating topography. Low, ill-drained areas and beaver meadows are of common occurrence throughout the area. In those portions unsuited for settlement the soils are grey wooded loams to heavy loams that have stones and are often gravelly. The topography is quite variable and there is often a fairly heavy tree cover consisting of mixed stands of poplar, spruce and pine. Some excellent patches of second growth pine are found in township 83 range 7 and if this area were withheld from settlement it might serve as an excellent source of pine for reforestation purposes, or as a future timber reserve.

In the area, extending west to the Pouce Coupe river, there are approximately 370,000 acres of land. It is tentatively estimated that over half of this area is suitable for settlement purposes and that approximately 100,000 acres of desirable land have a light tree cover that could be cleared very economically. A tentative map and report of this area have been submitted to the Department of

Lands and Forests to serve as a possible guide for subdivision and settlement purposes. On the map, an attempt was made to delineate the areas of heavier tree cover and those whose soils were believed unsuited for arable purposes.

The "Hotchkiss Area" has about 100,000 acres of suitable arable land in townships 94 to 96 inclusive and ranges 20 to 23 inclusive west of the 5th meridian. The soils in this area are mostly degraded black clay loams that have few to no stones and a level undulating topography. For the most part the tree cover is fairly light and consists of variable stands of second growth poplar and fairly extensive willow flats. Most of the cover has been fire killed. West and north-west of this area the soils are grey wooded loams that are often stony and sometimes gravelly. The topography is quite variable and consists of the long slopes and benches associated with the Hawk hills. The tree cover is generally fairly heavy consisting of a mixed stand of poplar, spruce, and pine, much of which is green.

Recommendations have been made to the Department of Lands and Forests, that should the need arise, the present settlement boundaries might be modified to include most of townships 94 to 96 in ranges 20 and 21, township 94 range 22 and the south half of township 95 range 22. The remainder consisting of the north half of township 95 and all of township 96 in range 22 and townships 94 to 96 in ranges 23 to 25 inclusive might continue to remain unavailable for settlement purposes.

Other Activities

Miscellaneous

(a) The Alberta Land Clearing Board meets once a month throughout the year to consider problems arising on the Land Clearing Project and to approve the work completed each month on the project. The Senior Research Council Surveyor has attended these meetings whenever possible.

(b) A new area, consisting of some 30,000 acres, was outlined and proposed as a possible site for future clearing operations in the vicinity of Valleyview. These additional areas are required to complete 100,000 acres contracted for in the Alberta Land Clearing Project.

(c) The Senior Research Council Surveyor spent two weeks in Calgary supervising the printing of the Soil Map of the Rycroft and Watino sheets.

(d) Several days were spent by the Senior Research Council Surveyor with the Superintendent and Assistant Superintendent of the Beaverlodge Experimental Station to familiarize them with the classification of some of the areas now being surveyed, and to assist them in the selection of sites for substations near Nampa, Donnelly and High Prairie. Three possible sites were located.

(e) During the latter part of August a representative of the Dominion Soil Survey Headquarters staff and representatives of the Saskatchewan and British Columbia Dominion staffs accompanied the Head of the University Department of Soils and the Senior Dominion and Provincial Soil Surveyors on an inspection and correlation trip through the Peace River district. "Judah" soils were identified as a type of degraded black and not as brown forest. Various, "brown-grey" podsolic and brown podsolic soils were identified in British Columbia.

Collection and Preparation of Monoliths

Representative soil profiles are collected for demonstration, exhibition and reference purposes. Formerly they were displayed in boxes, but now they are trimmed, fixed with plastic and mounted on plywood boards. Twenty-five monoliths were collected this year: eleven from the northern part and fourteen from the southern part of the province. These monoliths are now being fixed and mounted.

Laboratory Analysis

Approximately 250 samples were collected and brought in for analysis. One hundred of these are from northern Alberta while the remainder are from the irrigation district and from the Brazeau-Rocky Mountain House sheets. The analytical work is done during the winter months by both Dominion and Research Council soil surveyors. Determinations are made of the following: pH, total phosphorus, nitrogen, silica-sesquioxides, carbon, mechanical analysis, water-soluble salts and potash. Most of the analyses are done as part of the regular reconnaissance survey projects. The silica-sesquioxide, water-soluble salts and potash analyses are in the nature of special projects and concern selected profiles. Additional analytical work and experimentation may be attempted to determine the movement of salts in some of the irrigation samples.

Reports

1. The Rycroft-Watino report was completed and the report is being distributed.
2. The Red Deer report was completed and is in course of publication.
3. A start has been made on the High Prairie-McLennan report and maps.

Staff

The Research Council had a soil survey personnel of eight men in 1950. Three of these were on permanent appointment, one on temporary appointment, three were student assistants and one a field cook. Of the student assistants only one was available for part-time work during the winter months on an hourly basis.

The Dominion Experimental Farms Service had a personnel of nine men and a stenographer. Three of the men were on permanent appointment, three on temporary appointment and three were student assistants. Two of the latter were available for part-time work during the winter months.

ULTRA-VIOLET SOLAR RADIATION

The accumulation of records with the Thorium photocell (wave-length range 0.29 to 0.367 microns) has continued. There have been no interruptions and the accuracy of the ballistic recorder has been good.

A study is being made of the relative response at different wave-lengths of the three photocells which have been used in the investigation. When complete these can be multiplied at corresponding wave-lengths by the relative erythemal curve to get relative biological response. Finally, use of the tungsten in quartz standard lamp to get the relative energies will make possible the

calculation of a factor, which multiplied into the weekly or monthly total charge, should give the biological equivalent in Erythavitons, a unit suggested by Luckiesh.

The gaps in the records of 1947 and 1948 (due to photocell difficulties) are being studied and a fair estimate made of the quantities that would have been measured. When this is done, and the above mentioned factors have been calculated, it will be possible to list weekly or monthly, and yearly totals of biologically effective radiation from September 1946. This may be available by the spring of 1951, and after that an annual compilation of the figures should be easy.

BIOLOGICAL CYCLES

In the spring of 1950 a deserted rat ranch half a mile from the Cooking Lake highway and 24 miles from Edmonton was secured for a rabbit enclosure. The total area, about 4½ acres, is surrounded with heavy animal-proof fencing. This is a perfect rabbit patch and will be used to maintain a series of observations on its rabbit population as a guide to two series of feeding experiments which will run concurrently with animals kept in small pens. One series is situated within the city limits of Edmonton, the other is at Anzac, south of McMurray.

During the year pregnancy records were obtained on scores of rabbits in the Anzac district through the kind co-operation of Mr. J. D. Waring. In addition he conducted a unique series of observations on the winter movements of rabbits by keeping a precise record of rabbit tracks over a specified area, systematically visited after every snowfall.

The collection of grouse material during the summer and especially during the hunting season has resulted in a great deal of valuable information which is now being compiled. To date there have been no indications of epidemics either among rabbits or grouse, but rabbits still remain comparatively scarce animals over large areas of the Province. As far as birds are concerned, the cycle seems to be running true to form, and it is expected that it will be two years before the crash hits. Samples of other animals, suspected of being diseased, are being checked in the government's veterinary laboratory.

INDUSTRIAL PROJECTS

The work of the Industrial Projects section included the following main lines of activity:

Assistance to Government Departments

(a) The Industrial Development Board of the Province of Alberta in their promotional activities are confronted with numerous inquiries and in this connection invite the assistance of the Industrial Engineer in drafting their replies. Assistance has been rendered the Board in such fields as Metallizing, the Pin Industry, Cosmetics, the Leather Industry and others. A list of industrial possibilities in Alberta was prepared for the Director of the Board on his recent trip to Eastern Canada and the United States.

(b) Attendance at meetings of the Industrial Development Board in a technical advisory capacity at Edmonton and Macleod. Questions are handled at the meeting or are investigated in more detail and reported on at a later date.

(c) Participation in the Advisory Committee in investigating for the Alberta Industrial Corporation the advisability of extending loans to such applicants as the Alberta Briquetting Corporation Ltd., Western Cement Limited and to concerns interested in manufacturing Asphalt Conduit and Asphalt Planking.

(a) Making periodic inspections of those industries to whom financial assistance was given by the Alberta Industrial Corporation and reporting on them to the Corporation.

Assistance to Private Industry

The Industrial Projects section maintains a technical information service to deal with numerous inquiries received from industry and individuals. Information is drawn from personal experience, the office files, from surveys of the literature available at the University and from the Technical Information Service of the National Research Council in Ottawa. About one hundred such requests were handled during the year.

Plant Visits

As opportunity permits, different existing plants are visited from time to time. In this way a better knowledge of industry and its operating personnel is obtained. Problems are viewed at first hand and possible technical assistance rendered.

General Reports

In addition to supplying information upon request a number of reports were prepared on the feasibility of establishing certain industries in the province. These included paint and varnish making, the alkali industry, the utilization of sodium sulphate and gypsum and the coal carbonization industry.

LIST OF PUBLICATIONS
of
RESEARCH COUNCIL OF ALBERTA
EDMONTON, ALBERTA

ANNUAL REPORTS OF COUNCIL

No. 3 (for the calendar year 1920); pp. 36. **(Out of print.)**
No. 5 (for the calendar year 1921); pp. 86. **(Out of print.)**
No. 8 (for the calendar year 1922); pp. 64. **(Out of print.)**
No. 10 (for the calendar year 1923); pp. 76. **(Out of print.)**
No. 12 (for the calendar year 1924); pp. 66. **Price 35 cents.**
No. 16 (for the calendar year 1925); pp. 65. **Price 35 cents.**
No. 20 (for the calendar year 1926); pp. 53. **Price 25 cents.**
No. 22 (for the calendar year 1927); pp. 49. **Price 25 cents.**
No. 24 (for the calendar year 1928); pp. 53. **Price 35 cents.**
No. 25 (for the calendar year 1929); pp. 65. **Price 35 cents.**
No. 26 for the calendar year 1930); pp. 76. **Price 35 cents.**
No. 27 (for the calendar year 1931); pp. 53. **(Out of print.)**
Nos. 28, 29 and 32 (for the calendar years 1932-1934); pp. 90. **Price 35 cents.**
No. 33 (for 1935); pp. 43. **Price 35 cents.**
Nos. 37-43 (for 1936-1942). Not published.
No. 44 (for 1943); pp. 14. **Price 5 cents.**
No. 45 (for 1944); pp. 18. **Price 5 cents.**
No. 47 (for 1945); pp. 21. **Price 5 cents.**
No. 50 (1946); pp. 28. **Price 5 cents.**
No. 51 (1947); pp. 28. **Price 5 cents.**
No. 54 (1948); pp. 27. **Price 5 cents.**
No. 55 (1949); pp. 26. **Price 5 cents.**
No. 60 (1950); pp. 39. **Price 5 cents.**

REPORTS—FUELS

No. 10A (1923); COMBUSTION OF COAL FOR THE GENERATION OF POWER, by C. A. Robb. **(Out of print.)**

No. 14 (1925); pp. 64. ANALYSES OF ALBERTA COALS, with 18 maps and 2 charts. By E. Stansfield, R. T. Hollies, and W. P. Campbell. **(Out of print.)**

No. 35 (1944); pp. 174. COALS OF ALBERTA—THEIR OCCURRENCE ANALYSIS AND UTILIZATION, by Edgar Stansfield and W. Albert Lang. In six parts. **Price $1.00.**

Parts I-V—Occurrence, classification, production, special tests, general properties, preparation, utilization and combustion. **Price 50 cents.**

Part VI—Analytical and technical data by coal areas. **Price 50 cents.**

No. 46. ALBERTA COALS AND AUTOMATIC DOMESTIC STOKERS. Edgar Stansfield and Colin A. Genge. **Price 20 cents.**

REPORTS—ROAD MATERIALS

No. 18. THE BITUMINOUS SANDS OF ALBERTA, by K. A. Clark and S. M. Blair.
Part I (1927)—Occurrence, pp. 74. **Price 25 cents.**
Part II (1927)—Separation, pp. 36. **(Out of print.)**
Part III (1929)—Utilization, pp. 33. **Price 25 cents.**

No. 53 (1949); THE ROLE OF VERY FINE MINERAL MATTER IN THE HOT WATER SEPARATION PROCESS AS APPLIED TO ATHABASKA BITUMINOUS SANDS, by K. A. Clark and D. S. Pasternack; pp. 22. **Price 15 cents.**

No. 57 (1950); DETERMINATION OF VISCOSITIES AND SPECIFIC GRAVITIES OF THE OILS IN SAMPLES OF ATHABASKA BITUMINOUS SAND, by S. H. Ward and K. A. Clark; pp. 21. **Price 15 cents.**

No. 58 (1951); THE COMPONENTS OF THE BITUMEN IN ATHABASCA BITUMINOUS SAND AND THEIR SIGNIFICANCE IN THE HOT WATER SEPARATION PROCESS, by D. S. Pasternack and K. A. Clark; pp. 14. **Price 15 cents.**

REPORTS—SOIL SURVEY DIVISION

No. 23 (1930); PRELIMINARY SOIL SURVEY ADJACENT TO THE PEACE RIVER, ALBERTA, WEST OF DUNVEGAN, by F. A. Wyatt and O. R. Younge; pp. 33 and colored map. Scale 1 inch to 4 miles. **Price 50 cents.**

No. 31 (1935); PRELIMINARY SOIL SURVEY OF THE PEACE RIVER-HIGH PRAIRIE-STURGEON LAKE AREA, by F. A. Wyatt; with colored map. Scale 1 inch to 4 miles. **Price 50 cents.**

No. 56 (1950); SOIL SURVEY OF THE RYCROFT AND WATINO SHEETS, by Wm. Odynsky and J. D. Newton; pp. 84 and 2 maps.

REPORTS—GEOLOGICAL SURVEY

No. 1 (1919); FIRST ANNUAL REPORT ON THE MINERAL RESOURCES OF ALBERTA, by J. A. Allan; pp. 104. **Price 25 cents.**

No. 2 (1920); SECOND ANNUAL REPORT ON THE MINERAL RESOURCES OF ALBERTA, by J. A. Allan; pp. 138+14. **(Out of print.)**

No. 4 (1921); GEOLOGY OF THE DRUMHELLER COAL FIELD, ALBERTA, by J. A. Allan; pp. 72, and 6-color map (Serial No. 1). **(Out of print.)**

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.)**

No. 7 (1922, Part II); AN OCCURRENCE OF IRON ON THE NORTH SHORE OF LAKE ATHABASKA, by J. A. Allan and A. E. Cameron; pp. 40; two maps (Serial Nos. 3 and 4). **(Out of print.)**

No. 9 (1923); GEOLOGY ALONG BLACKSTONE, BRAZEAU AND PEMBINA RIVERS IN THE FOOTHILLS BELT, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 48, and 6-color map (Serial No. 5). **(Out of print.)**

No. 11 (1924); GEOLOGY OF THE FOOTHILLS BELT BETWEEN McLEOD AND ATHABASKA RIVERS, ALBERTA, by R. L. Rutherford; pp. 61 and 8-color map (Serial No. 7). One inch to two miles. **(Report out of print, map available.)**

No. 13 (1945): GEOLOGY OF RED DEER AND ROSEBUD SHEETS, by J. A. Allan and J. O. G. Sanderson; pp. 109. Two geological maps in 8 colors. Scale one inch to three miles. Serial No. 8 Red Deer Sheet and No. 9 Rosebud Sheet, now out of print. Replaced by Map No. 9A, combination of Maps No. 8 and 9. Scale one inch to four miles. **Price 75 cents.**

Map No. 10 (1925); GEOLOGICAL MAP OF ALBERTA, by J. A. Allan. In 14 colors. Scale one inch to 25 miles. **(Out of print.)**

No. 15 (1926); GEOLOGY OF THE AREA BETWEEN ATHABASKA AND EMBARRAS RIVERS, ALBERTA, by R. L. Rutherford; pp. 29 and 3-color map (Serial No. 11). One inch to two miles. **(Report out of print, map available.)**

No. 17 (1927); GEOLOGY ALONG BOW RIVER BETWEEN COCHRANE AND KANANASKIS, ALBERTA, by R. L. Rutherford; pp. 46 and 9-color map (Serial No. 12). Scale 1 inch to 1 mile. **Price 50 cents, or map alone 25 cents.**

No. 19 (1928); GEOLOGY OF THE AREA BETWEEN NORTH SASKATCHEWAN AND McLEOD RIVERS, ALBERTA, by R. L. Rutherford; pp. 37 and 3-color map (Serial No. 13). Scale 1 inch to 3 miles. **Price 10 cents.**

No. 21 (1930); GEOLOGY AND WATER RESOURCES IN PARTS OF PEACE RIVER AND GRANDE PRAIRIE DISTRICTS, ALBERTA, by R. L. Rutherford; pp. 80 and 6-color map (Serial No. 14). Scale 1 inch to 4 miles. **(Out of print.)**

No. 30 (1934); GEOLOGY OF CENTRAL ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 41 and 10-color map (Serial No. 15). Scale 1 inch to 10 miles. **(Out of print.)**

Map No. 16 (1937); GEOLOGICAL MAP OF ALBERTA (Coloured), by J. A. Allan. Scale 1 inch to 16 miles. **(Out of print.)**

Map. No. 17 (1939); GEOLOGICAL MAP OF ALBERTA (Black and white), by J. A. Allan. Scale 1 inch to 32 miles. **Price 5 cents.**

Map No. 18 (1940); COAL AREAS OF ALBERTA, by J. A. Allan. Scale 1 inch to 20 miles. **Price 25 cents.**

No. 34 (1943), in five parts by J. A. Allan; pp. 202. **(Out of print.)**

Part I—General Geology of Alberta, pp. 37, and geological map No. 17, scale 1 inch to 32 miles. **Price 50 cents.**

Part II—Rock Salt Deposit at Waterways, pp. 19. **(Out of print.)**

Part III—Geology of Alberta Soils, pp. 87. **(Out of Print.)**

Part IV—Relief Model of Alberta and its Geological Application, pp. 9. **(Out of Print.)**

Part V—Coal Areas of Alberta, pp. 36, and Map No. 18, scale 1 inch to 20 miles. **Price 75 cents.**

No. 48 (1946); GEOLOGY AND COAL OCCURRENCES OF WAPITI-CUTBANK AREA, ALBERTA, by J. A. Allan and J. L. Carr; pp. 43 and map (Serial No. 19). Scale 1 inch to 3 miles. **Price 50 cents.**

No. 49 (1947); GEOLOGY OF HIGHWOOD-ELBOW AREA, ALBERTA, by J. A. Allan and J. L. Carr; pp. 75 and 6-color map (Serial No. 20). **Price $1.00.**

No. 52 (1949); GEOLOGY OF RIBBON CREEK AREA, ALBERTA, by M. B. B. Crockford; pp. 68 and 5-color map (Serial No. 21). **Price 50 cents.**

No. 59 (1951); GEOLOGY OF CARBONDALE RIVER AREA, ALBERTA, by W. H. A. Clow and M. B. B. Crockford; pp. 70 and 11-color map (Serial No. 22). **Price 50 cents.**

No. 61 (1951; CLAY DEPOSITS OF ELKWATER LAKE AREA OF ALBERTA, by M. B. B. Crockford; pp. and 2-color map (Serial No. 23). **Price 50 cents.**

REPORTS—RURAL ELECTRIFICATION

No. 36 (1944); pp. 107. RURAL ELECTRIFICATION IN ALBERTA, by Andrew Stewart. (Not available for distribution.)

Appendix I (1944); pp. 77. (Not available for distribution.)

Appendix II (1944); pp. 115 with maps. (Not available for distribution.)

CONTRIBUTION SERIES

This series comprises papers submitted to technical societies or journals by members of the technical staff. They are not available for general distribution; but can be consulted in the original publication cited.

No. 1—Fuel Investigations of the Research Council of Alberta (1919-1940), by W. A. Lang. Trans. Canadian Institute of Mining and Metallurgy, Vol. XLV, 1942, pp. 27-44.

No. 2—Humidity Data Expressed in Grains Water Vapour per Pound of Dry Air, by Edgar Stansfield. Canadian Journal of Research, A 21, 1943, pp. 51-55.

No. 3—Alternative Fuels for Motor Vehicles, by W. A. Lang, The Engineering Journal, August 1943, pp. 449-454.

No. 4—Hot-Water Separation of Alberta Bituminous Sand, by K. A. Clark, Trans. Canadian Institute of Mining and Metallurgy, Vol. XLVII, 1944, pp. 257-274.

No. 5—Some Physical Properties of a Sample of Alberta Bituminous Sand, by K. A. Clark, Canadian Journal of Research, F 22, 1944, pp. 174-180.

No. 6—Purification of Silica Sand—Alberta Tar Sands Suitable for Glass Manufacturing, by E. O. Lilge, Canadian Chemistry and Process Industries, Vol. XXIX, July, 1945, pp. 480-482.

No. 7—Bituminous Sands of Alberta, by K. A. Clark, The Oil Weekly, August 13, 1945, pp. 46-51.

No. 8—Asphaltic Road Oils from Alberta Bituminous Sand, by K. A. Clark, Canadian Chemistry and Process Industries, Vol. XXIX, September, 1945, pp. 616-618.

No. 9—Research and the Coal Industry in Canada, by W. A. Lang, Trans. Canadian Institute of Mining and Metallurgy, Vol. XLIX, 1946, pp. 51-62.

No. 10—Recent Work of the Research Council of Alberta, by E. Stansfield, Bulletin Canadian Institute of Mining and Metallurgy, No. 406, February, 1946, pp. 121-128.

No. 11—Some Recent Conceptions of Coal Structures, by A. McCulloch, Canadian Chemistry and Process Industries, November, 1947.

No. 12—Elimination of Water from Wet Crude Oil Obtained from Bituminous Sand by the Hot Water Washing Process, by K. A. Clark and D. S. Pasternack, Part I—Continuous Settling at Atmospheric Pressure, Part II—Continuous Settling Under Pressure; Evaporation. Canadian Chemistry and Process Industries, January, 1948 and November, 1947.

No. 13—The Oil-Sand Separation Plant at Bitumount, by K. A. Clark, Western Miner, August, 1948.

No. 14—The Fuel Reserves of Alberta, by W. A. Lang, Trans. Canadian Institute of Mining and Metallurgy, Vol. LII, 1949, pp. 15-22.

No. 15—Geology of Kootenay Coal Measures in Southwestern Alberta, by M. B. B. Crockford, Bulletin Canadian Institute of Mining and Metallurgy, No. 443, March, 1949.

No. 16—Oldman and Foremost Formations of Southern Alberta, by M. B. B. Crockford, Bulletin American Association of Petroleum Geologists, Vol. 33, April, 1949.

No. 17—The Athabaska Tar Sands, by Karl A. Clark, Scientific American, May, 1949.

No. 18—Low Temperature Carbonization of Alberta Subbituminous Coal, by J. Gregory and A. McCulloch, Industrial and Engineering Chemistry, Vol. 41, May, 1949, pp. 1003-1011.

No. 19—Graphical Studies of the properties of Alberta Coals, by A. McCulloch and E. Sherlock, Fuel, Vol. XXVIII, No. 6, June, 1949, pp. 135-141.

No. 20—A Classification of Alberta Coals, by E. Sherlock, Fuel, Vol. XXVIII, No. 12, December, 1949, pp. 276-281.

No. 21—(1950); Fuel Investigations at the Research Council of Alberta, by W. A. Lang, Chemistry in Canada, March, 1950.

No. 22—(1950); The Briquetting of Alberta Coals, by W. A. Lang, Trans. Canadian Institute of Mining and Metallurgy, Vol. LIII, 1950, pp. 500-508.

No. 23—(1950); The Hot Water Washing Method for the Recovery of Oil from the Alberta Tar Sands, by K. A. Clark, Canadian Oil and Gas Industries, September, 1950.

MIMEOGRAPHED CIRCULARS

No. 1 (1947); Significance of General Laboratory Tests on Fuels and Lubricants, by J. S. Charlesworth.

No. 2 (1947); Alberta Motor Gasoline Surveys 1939-1947, by J. S. Charlesworth and E. Tipman.

No. 3 (1947); Preliminary Report on the Ceramic Importance of Clay and Shale Deposits of Alberta, by M. B. B. Crockford.

No. 4 (1948); Alberta Gasoline Survey 1948, by J. S. Charlesworth and E. Tipman.

No. 5 (1948); Poplar Market Survey, by A. Stewart, A. R. Brown and D. E. Armstrong.

No. 6 (1919); Occurrences of Common Salt in Alberta, by M. B. B. Crockford.

No. 7 (1949); Geology of Peace River Glass Sand Deposit, by M. B. B. Crockford.

No. 8 (1949); Alberta Motor Gasoline Surveys 1949, by J. S. Charlesworth and E. Tipman.

No. 9 (1950); Alberta Motor Gasoline Surveys, 1950, by J. S. Charlesworth and E. Tipman.

No. 10 (1950); Natural Gas in Relation to the Industrial Development of Alberta—Submission Prepared for the Joint Hearing of the Petroleum and Natural Gas Conservation Board of the Province of Alberta, October, 1950. (Not available for distribution.)