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Research Council of Alberta

Thirty-fifth Annual Report

1954

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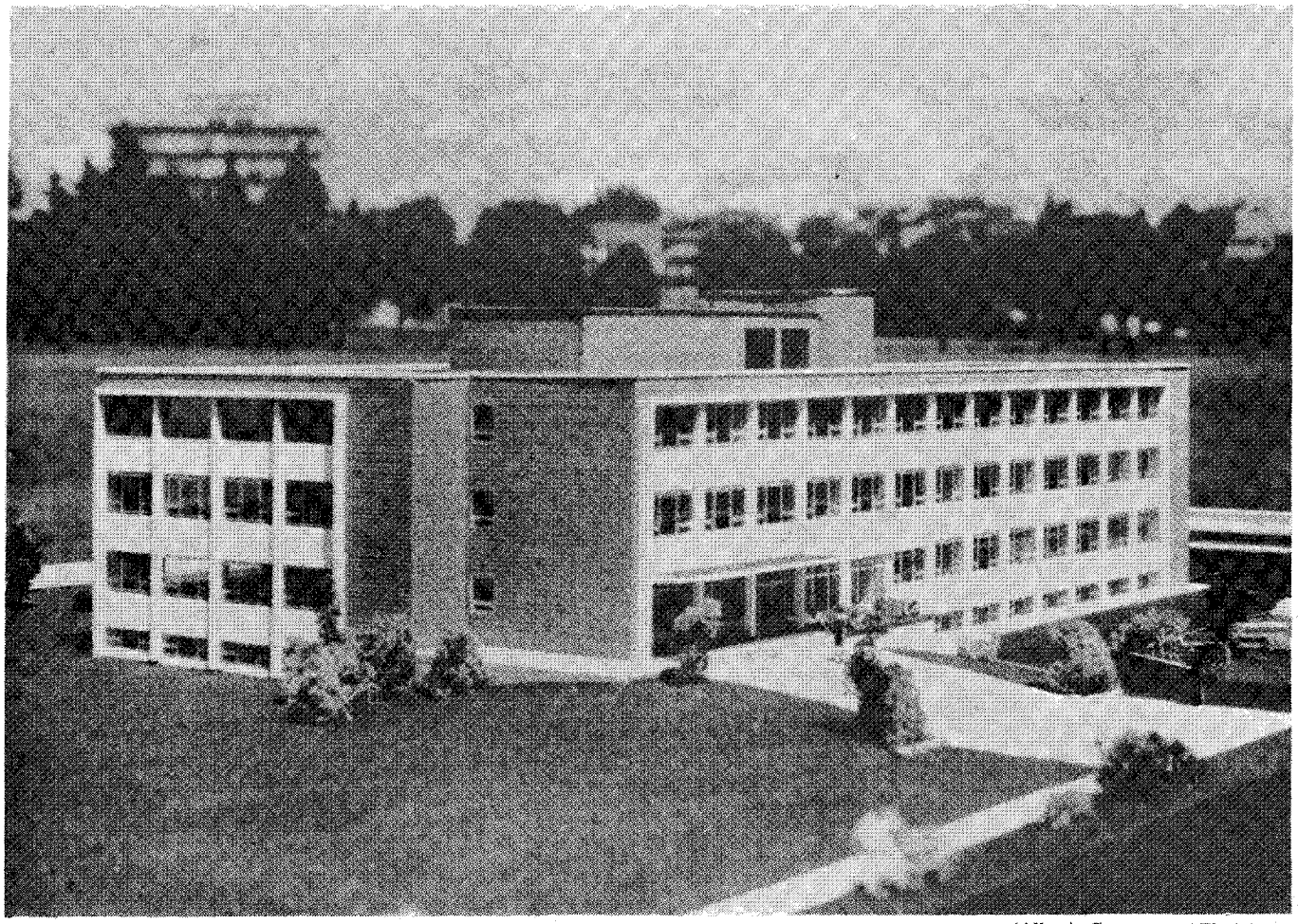

(Alberta Government Photo)

Model of Research Council Building currently under construction.

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FOREWORD

The following report, the Thirty-Fifth Annual Report of the Research Council of Alberta, was submitted in February, 1955, by Dr. N. H. Grace, Director of Research, to the Chairman of the Council, the Honourable G. E. Taylor, Minister of Highways and Minister of Telephones. 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

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*Appointed to Council October 19, 1954.

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

ANNUAL REPORT

1954

This report outlines the work of the Council for the calendar year 1954. Council's research program is concerned with the application of science to the development of the natural resources of Alberta. Consequently, the program includes such problems as soil surveys and soil classification, the irrigation of solonetzic soils, coal utilization studies including a study of the fundamental characteristics of coal, natural gas research, petroleum studies including work on the Athabasca oil sands, and basic geological research bearing on the above resources as well as on nonmetallic minerals such as clays. Council also provided assistance to developing industry through its section of Industrial Engineering Services, and valuable work was done by the Gasoline and Oil Testing laboratory.

Encouraging progress was made on the various research projects. The geological program was enlarged in an effort to meet an increasing demand for basic geological information. Likewise, increased emphasis was placed on the natural gas research program. During the year Council provided a subsurface drill which is proving helpful in providing information of value in soil classification, in problems bearing on irrigation, and in studies dealing with nonmetallic minerals.

In certain respects 1954 was a memorable year. The construction of the Research Council Building was commenced, and it is rapidly nearing completion. These new facilities will enable consolidation of most of the Council's scientific effort under one roof and this, undoubtedly, will contribute to the over-all effectiveness of the Council's endeavors. More specialized testing and investigational work on behalf of industry will also be possible.

On the whole, it was somewhat easier to obtain highly-trained staff than in the immediate past. Several pieces of modern laboratory equipment were acquired and, in this connection, special mention should be made of a double beam infrared spectrophotometer which is of particular value in studying the construction of the organic compounds occurring in oils or derived from coal. Purchase of this instrument was, in part, made possible by a National Research Council grant for fundamental research.

The program of basic research on coal was continued during the year. Investigations have included a study of the colloidal structure of typical Alberta coals by means of heat-of-wetting measurements; sorption of oxygen by coal at low temperatures; effects of an ultrasonic field on the solubility of coal in solvents; a study of the yields of low molecular weight by-products from the low-temperature carbonization of coal, including the use of catalysts; and a study of the constitution of humic acids derived from coal and possible uses for them. The paleobotanical program included a study of techniques for concentrating spores from shales and various kinds of coal as a step towards the objective of cataloguing plant microfossils of the uppermost Cretaceous and lowermost Tertiary formations of central Alberta. Applied research on coal was largely devoted to the question of surface dust on bituminous coal briquettes and the grindability of subbituminous coal. Analytical testing of coal has been continued.

Council's work on petroleum—formerly designated as oil sands research—has included geological studies as well as chemical and engineering phases. A geological party spent the summer in the oil sands area engaged in geological research and mapping. Work on the trace metals content of oils—particularly the content of vanadium, nickel, iron—contributed helpful information on the migration and accumulation aspect of the oils of western Canada. Recently, the study was extended to include magnesium since the occurrence of magnesium in crude oils appears to be related to the presence of chlorophyll in the living material from which the crude oils were formed. Fundamental studies were made on the properties of water-in-oil emulsions to provide information of potential value with respect to the storage and handling of "heavy oils" containing emulsified water. Studies on the chemical constitution of fractions from the "heavy oils" is continuing, with particular emphasis being placed on the sulfur compounds. Certain "heavy oil" fractions appear to have special merit as a briquet binder and for use in preparing metallurgical coke.

The Natural Gas research program has involved the construction of a new furnace—entirely modified from the preceding one—for studies on the formation of carbon black, and basic work has been continued on the partial oxidation of butane. The Gasoline and Oil Testing laboratory made a survey of the gasolines used in Alberta, handled a greatly increased demand for analytical services, made studies on dyes for use as a marker in Alberta gasolines, and continued research on the deterioration of aviation gasoline during storage.

The Industrial Engineering Services section was able to improve its service and widen its field of activity in keeping with the general diversification of industry in the province. The staff carried out investigations and conferred on many inquiries on a wide variety of raw materials. Technical advice and general assistance were made available to government departments, the general public and specific industries. It performed liaison work between the Division of Building Research of the National Research Council, the Central Mortgage and Housing Corporation, and several Alberta manufacturers of building products.

Geological work in the oil sands area has already been mentioned in connection with petroleum research. In addition, a Pleistocene research and survey program has been initiated in the Coronation district, an area which is of particular interest from the point of view of possible irrigation, and a preliminary map and report on the work will be issued shortly. Study and analysis of fine-grained minerals, such as those present in clays, have been continued with the aid of X-ray diffraction equipment. Mineralogical analyses of a number of clays from southwestern and west-central Alberta were completed. The study of bentonites was continued and a research investigation on the Bearpaw formation was started.

Council participates in the work of the Alberta Soil Survey, which is a joint effort of the Dominion Experimental Farms Service, the University, and the Research Council. The Council's portion of the program during 1954 included a reconnaissance survey of around 800,000 acres and an exploratory survey of about 400,000 acres, both being carried out in the Grande Prairie and Beaverlodge areas. Irrigation research in the Youngstown area—another co-operative effort of the three groups—was affected by unusually heavy rainfall. However, it was still possible to show certain beneficial effects from irrigation in relation to certain soil amendments and cultural practices. This

irrigation research project includes studies on the physical properties of solonetzic soils and is developing in close association with the Pleistocene research program. The subsurface drilling operations initiated during the year are proving helpful in matters relating to soil surveys and irrigation research as well as to geological studies on clays and other nonmetallic mineral deposits.

The Highway Research program continued field study of locations treated by various injection procedures during the previous winter and carried on various laboratory phases such as the setting times of chrome-lignen gel. It appears from the laboratory results that the chrome-lignen combination is as effective in reducing frost heaving as the plain lignosol—and perhaps even more effective—provided proper dispersion in the soil has been made.

The Biological Cycles project shows that the ten-year cycle is now at what is assumed to be its complete ebb, but with signs of recovery in certain places. During the year various phases of the earlier work were prepared for publication. Solar ultraviolet radiation measurements were continued. Council supported University work in Animal Science dealing with the "Hatchability of Turkey Eggs" and "Grass Silage".

During the year action was taken by Council on certain matters of common public concern. An Advisory Committee on Industrial Pollution was constituted in the hope that such a body may provide technical guidance at this relatively early stage in Alberta's industrial development and thereby aid Alberta in avoiding the pollution problems now faced by older industrial regions. Council staff have communicated with various Federal research officials and University personnel on the possibility of a scientific approach to the problem of hail damage. The committee appointed by Council to study the fluoridation of public water supplies has completed its task and submitted a report on its studies. This has been forwarded by Council to the Government of Alberta.

The research program of Council has been aided through the co-operation of government departments, the University and various organizations. Special mention may be made of the assistance of the National Research Council in making technical information available and for providing a grant-in-aid for fundamental research, and of the co-operation of the Federal Department of Mines and Technical Surveys in fuel investigations and of the Dominion Experimental Farms Service in soil surveys and irrigation research. The foregoing assistance and co-operation are gratefully acknowledged. The helpful services rendered by Council's Advisory Committees were much appreciated.

COAL

Introduction

In the Annual Report for 1953 attention was drawn to the need for a coal research pattern directed towards replacing steadily shrinking traditional coal markets by new outlets. Whilst a reversal of current trends—leading to a return to coal as a basic raw material for fuel and power generation—may confidently be expected within the foreseeable future, it was considered that major *new* uses would lie in the field of production of chemicals.

In accord with this thinking, which was felt to be justified by developments in the United States and elsewhere, Council embarked upon a more fundamental coal research program in which the emphasis was placed upon investigations designed to advance current knowledge of coal constitution and behavior. This re-orientation was continued and accelerated in 1954. The policy of keeping classical coal utilization schemes under continuous scrutiny and re-examination was maintained, and this applied research will be expanded when the new research laboratory with pilot plant is available.

Council accepts the implication that this change in policy places the larger part of its coal research program on a long-term rather than a short-term ad hoc basis. But it is convinced that a more complete understanding of the physical and chemical make-up of coal is an indispensable precursor to its most efficient utilization and the only basis upon which a long-term development program for coal can be built with assurance.

Analytical Section

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 purchased by the Federal Department of National Defence for the Army, Navy and Airforce, and of many miscellaneous samples obtained in other investigations of Council. In addition, because facilities for coal analysis were not readily available in Alberta, a number of samples of coal and briquettes were tested for commercial firms on a charge basis.

Two analytical procedures for coal analysis—the determination of the "capacity moisture" and the determination of the "volatile matter content"—are under advisement by both the International Standards Organization and the American Society for Testing Materials. Since Council has representation on both of these organizations and since it is considered important that the test procedures which will be adopted are applicable to Alberta coals, considerable test work has been done on them. The results were reported to subcommittee XXI of Committee D5, "Coal and Coke", of the A.S.T.M. in June, 1954.

Paleobotanical Section

With the establishment of the Paleobotany laboratory of the Council, examination of the enormous assemblages of plant fossils in the coals and shales of the province has begun. The objective chosen for primary attention is the cataloguing of all the plant microfossils of the uppermost Cretaceous and lowermost Tertiary formations of central Alberta. To this end, techniques have been developed for concentrating spores from shales and various types and ranks of coal by means of acid oxidation and alkaline extraction. When the catalogue of microfossils takes shape, it may be used increasingly as a standard for the correlation of spore-bearing coals and shales.

Besides this major project, work was done on techniques of thin-sectioning both coals and harder rocks and of peeling compression-fossils so that eventually it may be possible to relate microfossils and megafossils. A few field studies have been initiated with the hope of establishing standard geological columns in the horizons under consideration.

Physical Chemical Section

The survey of the colloid structure of a range of typical Alberta coals by means of heat-of-wetting measurements has been extended and virtually completed. The results—which will be reported in a paper now in preparation —confirm the existence of a catenary-type relationship between accessible inner surface and coal rank, and are likely to be of considerable value in kinetic studies of reactions between coal and organic liquids in ultrasonic fields. Further work has also been carried out to determine more closely the effects of compression and mild chemical pre-treatment of coal upon its colloidal structure. The data obtained from this study throw some light upon the course of physical maturation of coal and suggest that mild oxidation may, in certain instances, offer a means of improving the coking properties of indigenous coals.

In connection with the question of how coal behaves at low temperatures, more detailed measurements have been made of the sorption of oxygen by coal in the range –25° to –40°C. It has been found that sorption does not, as at ordinary temperatures or above, follow a simple exponential path: sorption obeying a law of the type $S=k^t$ (where S equals amount of oxygen sorbed, k=constant and t=time) appears to be restricted to a comparatively brief initial period and to be followed by several very clearly defined discontinua or "steps". Comparison of S/t curves obtained at various temperatures indicates that these discontinua occur at definite and quite reproducible points along the time-axis, but that their "height" tends to increase as the sorption temperature is lowered. Thus, whilst no discontinua are observable above about –30°C, they become progressively more pronounced at lower temperatures. The origin of the discontinua is at present uncertain, but it might be noted that they may be connected with either the presence of several minerals which oxidize at different rates or with a cyclic oxidation mechanism as postulated by Yohe et al.

Considerable progress during 1954 has also been made with a preliminary study of the behavior of coal when suspended in weak solvents (such as methanol) and exposed to ultrasonic irradiation at ordinary temperatures. Some difficulty was originally encountered in the development of a satisfactory transducer head assembly, but this has now been overcome and general performance of the experimental equipment is good. First experiments at 2 mc./sec. and ca. 2.8 kv., using a low-rank coal suspended in methanol, have shown greatly increased extraction rates (measured electrophotometrically) but no significant increase in the total amount of extractable material. It is possible that the failure to increase yields may be connected with the fact that the coal in question tended at this frequency to become more compacted: this phenomenon could be qualitatively demonstrated by means of X-ray powder photographs taken with the raw and ultrasonically-irradiated coal respectively, and it is currently being checked by means of density and surface area measurements. On the other hand, there is evidence that lower frequencies may induce reverse effects. For example, treatment of coal at 250 kc./sec.

and ca. 5 kv. seems to reduce "order" and compaction and thus to work in opposition to natural physical maturation processes. It has also been shown that very large increases in total yield of extract may be obtained by using mildly hydrogenated coal. An approximately tenfold increase in yield has thus been obtained by treating coal with nascent hydrogen (generated with hydrochloric acid from an intimate mixture of powdered coal and zinc dust), freeing the coal from excess acid and finally extracting it with methanol at 2 mc./sec. and 2.5 kv.

Finally, a carbonization program has been initiated to study means of increasing yields of low molecular weight by-products from coal pyrolysis. Preliminary experiments, using only a few grams of coal, have suggested several possible approaches (notably the use of traces of chain-reaction inhibitors), and a large-scale unit—embodying three electrically-heated vertical retorts of 2-lb. capacity each—has been designed and built. This unit and its accessory gear is expected to come into operation very shortly.

Organic Chemical Section

Council's program of organic coal research was organized during the year and a reasonably well-equipped laboratory established for the work. The infrared spectrophotometer, the high-pressure hydrogenation equipment, and the carbonization furnace that has been built in conjunction with the physical chemical section should make it possible to undertake virtually any problem of coal constitution from the viewpoint of organic chemistry.

A study of the low-temperature carbonization of Alberta coals was carried far enough with the laboratory apparatus at hand to indicate that the course of the carbonization can be modified profoundly by means of cracking catalysts. This may make it possible to increase markedly the yield of economically desirable chemicals such as benzene, toluene, naphthalene and phenol. It is hoped that the use of hydrogen transfer catalysts during the carbonization will contribute to the elucidation of processes involved in carbonization and possibly in coalification.

When organic material undergoes partial decomposition—either in nature or in the laboratory under certain conditions—a class of substances are produced which are known as the humic acids. These substances are the dominant organic material of soil and peat, and presumably are the key intermediate in coal formation. When coal is weathered or oxidized, humic acids are produced which apparently have the properties of the original humic acids. Therefore a study of these substances is fundamental to investigations on the organic chemical constitution of coal.

The investigations of the past year have resulted in the preparation of humic acids from various sources. These sources include coal oxidized by nitric acid, weathered coal, leonardite, black soil, and polymerized organic substances such as benzoquinone. The analyses of these prepared humic acids have demonstrated a marked uniformity of properties despite minor differences. The chief difference found has been the occurrence of a large number of nitro groups in humic acids prepared from coal oxidized by nitric acid. Recently, it has been found possible to separate humic acids prepared by nitric acid oxidation of coal into at least two distinct fractions by chromatography on powdered cellulose.

The humic acids upon acetylation in pyridine and acetic anhydride are converted into material closely resembling coal with respect to insolubility in

bases and certain organic solvents. The lowered solubility in organic solvents is surprising because acetylation should increase the solubility of the humic acids in organic solvents. This suggests that the essential difference between coal and humic acids is the presence of free hydroxyl groups in the latter which causes solubility in bases and certain organic solvents.

On the other hand, when the acetylation is carried out in the presence of zinc as well as pyridine and acetic anhydride, despite a greater amount of acetylation the material does not become insoluble and it is lighter in color. This fact suggests that the humic acids contain quinoidal groups which are responsible both for the color and solubility properties of the humic acids and to some extent of the coal itself. This theory has been further supported by preparation of oximes of humic acids which have some of the properties of the oximes of quinone derivatives. It is now felt that controlled degradation of chromatographically-fractionated humic acids will further extend our understanding of the humic acid molecule.

As a result of the discovery that oximes of humic acids were reducible at the dropping mercury electrode, it became necessary to study the polarographic behavior of the oximes of various quinones. This has resulted in a systematic set of data which will be offered as a paper to a suitable scientific periodical.

The humic acid content of a number of low-grade Alberta coals has been investigated. In response to information from a supplier of drilling and dispersing agents which suggested that humic acids were being used as tannin substitutes in drilling muds, the possibility of obtaining humic acids from low-grade Alberta coals, either directly or by oxidation, has been considered. Preliminary information suggests that Alberta could supply suitable material for such use.

Extractions were made on a number of coals with organic solvents, but this investigation has been discontinued until the high-pressure hydrogenator is in operation as it is proposed to use hydrogenation as a means of examining the fractions obtained directly by extraction or by subsequent chromatography of the extracts.

Attempts have been made to show the presence of molecular fragments in coal which could be identified as coming from definite constituents of the parent plant material. To date, no cellulose has been found in bituminous coals nor in one or two of the lower-rank coals. The presence of a phenylpropane nucleus in coal could not be detected by the simple nitrobenzene oxidation used on lignin, even though this type of structure has been shown by German workers to exist in lignitic coal by the isolation of propylcyclohexane in 30% yield from the hydrogenation of an ammonium nitrohumate prepared from a young lignite. Similarly, potassium hydroxide fusions, also used on lignin to produce aromatic fragments, gave negative results when tried on coal.

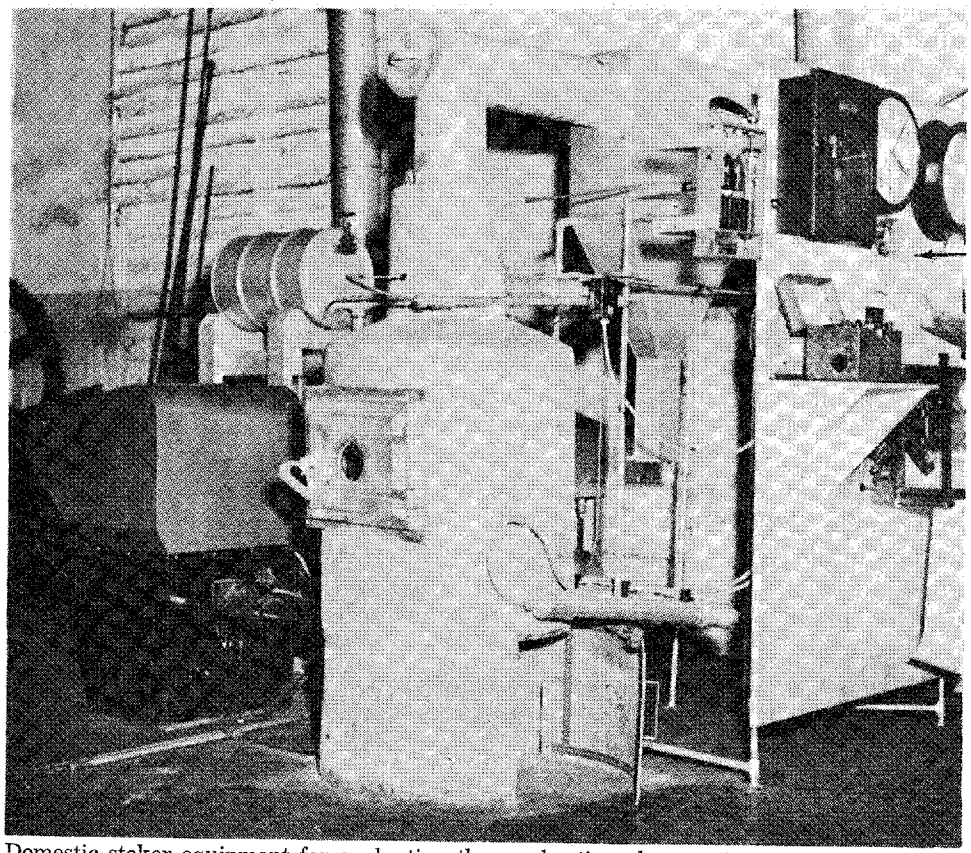
Samples of briquettes made in a commercial briquette plant from a bituminous coal and an asphalt and wheat flour binder were submitted for test. The asphalt was determined by extraction with toluene, while the percentage of wheat flour was determined by estimating the amount of pentosan in the original flour and in the finished briquettes. From the data, it was possible to calculate the percentage of flour used as a binder.

Applied Research Section

Two major projects were investigated by the section on applied research. One was a study covering the suppression of surface dust on bituminous coal briquettes. The other—a continuing investigation—is a study of the grindability of subbituminous coals.

During handling and transportation the surface of briquettes made from fine bituminous coal become covered with a fine film of dust which is objectionable to the consumer. Ways and means to eliminate this nuisance were considered. An acceptable solution should satisfy the following requirements: (a) prevent the dust film, (b) not change the original appearance of the briquettes, (c) not impair the combustion properties, and (d) be economically feasible.

A laboratory investigation was carried out in which a suspension of a paraffinic wax in water was used to surface-treat the briquettes. The suspension was made from dark raw wax and water emulsified in a homogenizer, with soap and casein as emulsifying agents. Preliminary tests indicated an amount of suspension equivalent to 4-7 pounds of wax per ton of briquettes would be required to give satisfactory coverage of the briquettes. Two methods for surface-treating the briquettes were then investigated in the pilot plant. In the first, the suspension was atomized onto the surface of the briquettes as they left the press, and in the second the suspension was atomized onto the rolls of the press immediately before they met to form the



Domestic stoker equipment for evaluating the combustion characteristics of Alberta coals.

briquettes, thereby squeezing the wax into the surface of the briquettes. The latter method appeared to give the most satisfactory results.

The investigation was then continued at a commercial briquetting plant in the province where a carload of briquettes were surface-treated by the second method. The surface-treated briquettes, when they came from the press, appeared superior to untreated briquettes, but the beneficial effect was lost subsequently due to dust collecting on the surface of the briquettes during transportation from the press to the railway car.

The construction of thermal power plants in Alberta utilizing pulverized subbituminous coal as fuel has emphasized the need for more authentic values for the "grindability index" of various coals, and also of the energy necessary for the pulverization. Currently, the "grindability index" of a coal is determined by the Hardgrove machine method according to A.S.T.M. Designation D 409-37T. Objections to this method have been listed from time to time, the most serious being that the results do not correspond to actual pulverization obtained in commercial equipment. This is especially true with subbituminous coals.

A small roll-crusher was designed and built, and preliminary tests made with it on a typical Alberta subbituminous coal. The indications are that grindability data, under well-defined and controlled conditions, can be obtained with this equipment. It is also anticipated that the power requirement for pulverization can be determined at the same time.

Miscellaneous

Visits were made to a number of coal mines and coal-preparation plants in the province. A member of the staff attended the annual meeting of the A.I.M.E. in New York and visited, en route, research institutions at St. Paul, Minn., Chicago, Ill., and Pittsburgh, Pa.; the annual meeting of the A.S.T.M. in Chicago; and the Dominion Coal Board Research meeting and the Mines Ministers' Conference in Winnipeg. Another member attended the Gordon Conference on Coal at New Hampton, New Hampshire.

Mimeographed Circular No. 17, "Performance of Typical Alberta Coals in a Rotating-Grate Domestic Stoker", was published.

PETROLEUM

In previous Annual Reports, the heading for this section of the work of the Research Council has been "Oil Sands". However, since studies on the Athabasca oil sands have inevitably led into the general field of petroleum, it would seem that the general term "petroleum" is now a more appropriate title.

Trace Metals in Crude Oils

Following the completion of the determination of the vanadium, nickel and iron trace metals in the McMurray oil and in the other typical Lower Cretaceous oils of Alberta, the study of trace metals in crude oils was extended to include oils produced from the other oil horizons of the western plains. Oils from the following horizons were examined: the Cardium sands of Upper Cretaceous age; the Viking sands of Lower Cretaceous age; the Ellis, Vanguard and Shaunavon sands of Jurassic age; the Madison group of Mississippian age; the Wabamun, Nisku, Leduc, Cooking Lake and Beaverhill limestones and dolomites of Devonian age. The sources of the oil samples ranged, geographically, from northwestern Alberta through Saskatchewan to Manitoba.

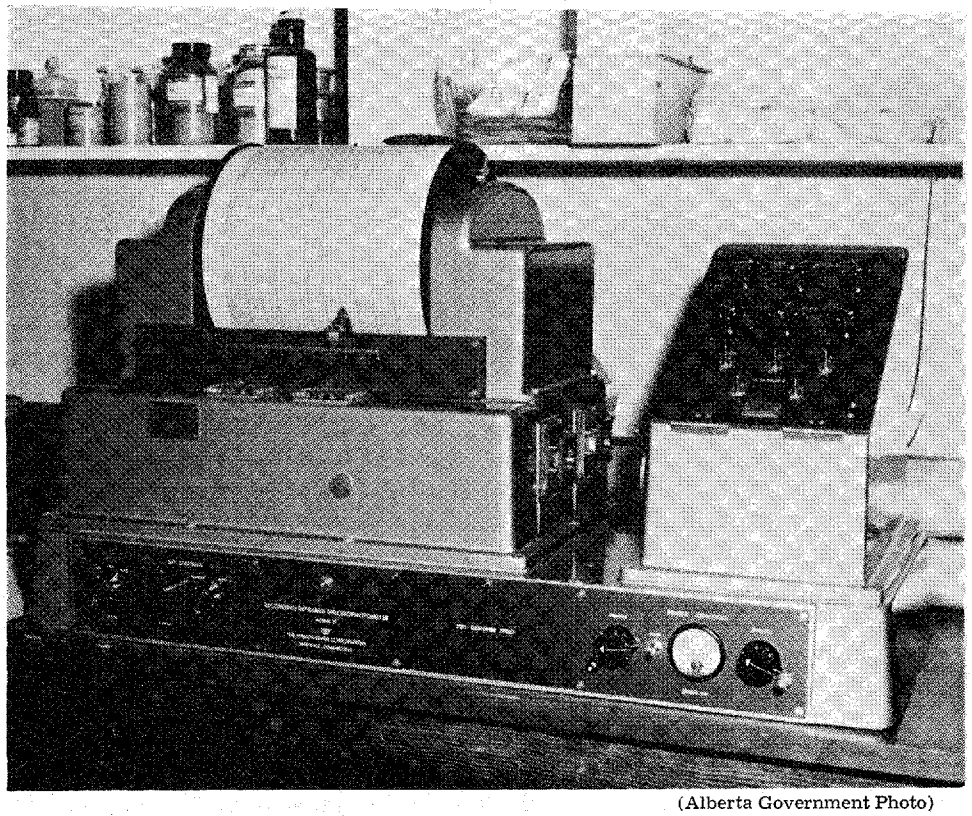
Results for the basal Cretaceous oils indicated that the vanadium-to-nickel ratio fell off as the A.P.I. gravity of the oils increased, and this was attributed to normal degradation and maturation of the oils. Oils produced from very much older horizons confirmed the maturation point-of-view, with ratios of vanadium-to-nickel of about 0.5 for Devonian oils as compared with about 2.8 for basal Cretaceous oils. Oils from the intermediate horizons—Jurassic, Permo-Pennsylvanian and Mississippian—were characterized by intermediate values for the vanadium-to-nickel ratios.

Trace metal results appeared to throw some light on the migration and accumulation aspect of western Canadian oils. There was considerable evidence that the Devonian oils fell into about three classes—more or less distinct—indicating that there were oils with histories that were more or less distinct. One Mississippian oil (the Coleville black oil) appeared to be a displaced Cretaceous oil, and the same was indicated for a Wabamun oil of Upper Devonian age (the Lac Ste. Anne oil). The most significant deviation from the general pattern of oils in western Canada appeared to be that of the Viking and Cardium oils. Both classes of oils showed a marked resemblance to the Devonian oils, although both were produced from Cretaceous sands. Considerable support was thus indicated for the hypothesis that these oils escaped and migrated from Devonian sediments in the near foothills region to the present-day traps in the region east of the foothills.

The occurrence of magnesium in crude oils is related undoubtedly to the presence of chlorophyll in the living material from which the crude oils were formed. Analytical procedures have been developed for the colorimetric determination of magnesium in crude oils using Titan Yellow indicator.

Sulfur in Crude Oils in Relation to Trace Metals Content

Determinations of the sulfur content of the above groups of crude oils showed that there was no close relationship between the sulfur content of an oil and its trace metals content. There was a very general trend that the higher the A.P.I. gravity the lower the sulfur.



(Alberta Government Photo)

Infrared spectrophotometer, being used for the study of the constitution of organic compounds occurring in petroleum or derived from coal.

Storage and Handling of Heavy Crude Oils

The handling of heavy crude oils is made difficult by the presence of sand and water in the oils as a result of normal production methods. The sand and water tend to settle out in storage vessels and interfere with handling techniques by fouling pipelines and wearing pumps excessively. A falling-ball instrument was designed for the study of the settling characteristics of solid particles in emulsions of water in heavy oils. Radioactive steel balls with geiger-tube detectors were used to measure the rate-of-fall characteristics of emulsions of water in pure mineral oils and in a heavy black crude oil.

The results showed that the presence of water in an oil retarded the settling of solid particles appreciably. For example, the presence of water to the extent of 40% (by volume) in a Grade 140 aviation lubricating oil resulted in a 39% reduction of the fall velocity at 70°F. of a ⅜-inch ball. Undoubtedly, the effect of the water was related to the existence of water-oil interfaces in the emulsion.

The presence of a small amount of water—of the order of 1%—showed the opposite effect with the fall velocity showing a slight increase over that obtained by dry oil. This effect, however, was limited to very low water concentrations and may have been caused by a simple "dilution" trend.

Considerable significance is attached to the observation that the rate-of-fall characteristics of solid particles in a heavy black crude oil containing a

large amount of surface-active material were essentially the same as those for a highly-refined lubricating oil.

McMurray Oil Field Bibliography

A bibliography of the published literature on the McMurray oil field was prepared.

Study of the "Heavy Oils" of Alberta

It was mentioned in the previous Annual Report that the bunker fuel produced during the partial cracking of oil-sand oil at varying temperatures and rates of heating was split up into a number of fractions by means of solvent extraction, and that a good start had been made in carrying out various analyses on these fractions. Molecular weight and carbon and hydrogen determinations had been completed on most of the samples at that time.

During the current year the determinations of sulfur, volatile content, swelling characteristics, specific gravity, softening point and penetration were carried out on many of the samples, and this work was extended to include other "heavy oils" in Alberta.

While the above work was in progress a lead was obtained regarding the preparation of a binder (for briquetting coal and for use in preparing metallurgical coke) which appears to have very desirable properties. A study is being made of possible source materials for preparing this binder and consideration is being given to methods of manufacture.

Sulfur in "Heavy Oils"

Knowledge of the manner in which sulfur is present in "heavy oils" is important, being both of fundamental interest and of importance to the refiner. Since the immense reserves of Athabasca oil-sands oil is a primary consideration, the initial study is being carried out on distillates prepared from it. Two such distillates have been used:

1. The product from a flash distillation which contained 4.37% of sulfur, and
2. The product from a slow distillation which contained 3.06% of sulfur.

A preliminary attempt was made to separate the sulfur-containing compounds—the mercaptans, disulfides, aliphatic sulfides, aromatic sulfur compounds, and the thiophenes—into groups according to their sulfur bondings by following the procedure outlined by the U.S. Bureau of Mines in Report of Investigations No. 3591, with modifications. The method did not prove satisfactory on the original distillates as only 36% of the sulfur was classified in the flash distillation product and 82% in the slow distillation product, the balance in each case being termed residual sulfur.

A much better resolution was obtained by redistilling the original distillates—first at atmospheric pressure up to a vapor temperature of 175°C., and then at reduced pressure—care being taken to avoid additional cracking. Three fractions of each original distillate were thus obtained, together with a residue. On analyzing these fractions it was determined that the distribution of the sulfur compounds in the product from a slow distillation was comparable to that from a flash distillation.

Even that procedure was not satisfactory as each fraction showed a substantial amount of residual sulfur whose resolution into its constituent group-

ings was not successful. This was due to the fact that the above-mentioned method for separating the sulfur-containing compounds was most unsatisfactory when applied to the higher-boiling components of the distillates, due to the apparent decreased sensitivity of the sulfur groups when present in large molecules.

Work is in progress to obtain a better separation of the sulfur groups by studying chromatographically-separated portions of the distillate fractions. Tests are being run using silica gel, alumina, and florosil as adsorbents.

Oil Sand Exploration

The Research Council continued, during the year, to serve as agent of the Department of Mines and Minerals in keeping in touch with the exploration work of companies operating in the Athabasca oil sands area.

Publications

During the year a paper titled "Vanadium, nickel and iron trace metals in crude oils of western Canada" was published in the Bulletin of the American Association of Petroleum Geologists.

The Encyclopedia of Chemical Technology requested an article titled "Tar sands", and a section of 13 pages under that heading is contained in Volume 13.

NATURAL GAS

Partial Oxidation of n-Butane

During the year major modifications were made in the reactor design and this was followed by the completion of the second experimental phase of the program. (A paper titled "The vapor phase partial oxidation of n-butane—effect of pressure, reaction time, and inlet gas composition" was published in the Canadian Journal of Chemistry. This was based on the first phase of the program.)

The first phase had indicated the need for:

(1) More complete temperature measurements throughout the entire reactor, and

(2) A reactor of the variable-length type which would permit mass velocity and reaction time to be investigated separately.

The new reactor incorporated these features. A series of tests were then carried out, noting the effect on the course and characteristics of the vapor phase reaction of the following variables: temperature, reaction time, and mass velocity. The data is in process of being analyzed.

The partial oxidation of butane, under the conditions employed in these tests, occupies an intermediate position between slow oxidations (carried out under less severe conditions and, nominally, isothermally) and flame combustion (where the reaction zone is essentially adiabatic, and temperatures are very high). However, basically, partial oxidation is a combustion-type phenomenon. It has a pronounced induction period (around 0.70 sec. in these tests), followed by a comparatively short reaction period (around 0.10 sec.) during which temperature peaks of over 100°F. higher than the ambient temperature were observed. The reaction temperature coefficient shows a sharp increase—almost a discontinuity—as the initiation temperature is raised from 700°F. to 725°F. Mass velocity had the anticipated effect on the induction period (i.e., higher mass velocities, with the resultant higher heat transfer coefficients, lengthened the induction period) but appeared to have no appreciable effect on product yields.

The availability of a mass spectrometer would be of great value to the natural gas program—especially the n-butane project. At present, considerable delays are involved when samples are sent away for analysis to an industrial firm having a mass spectrometer.

Carbon Black Research

The original carbon black pilot plant was completely dismantled and a new one built, since previous work had indicated the need for a number of changes. The new design incorporated the following changes:

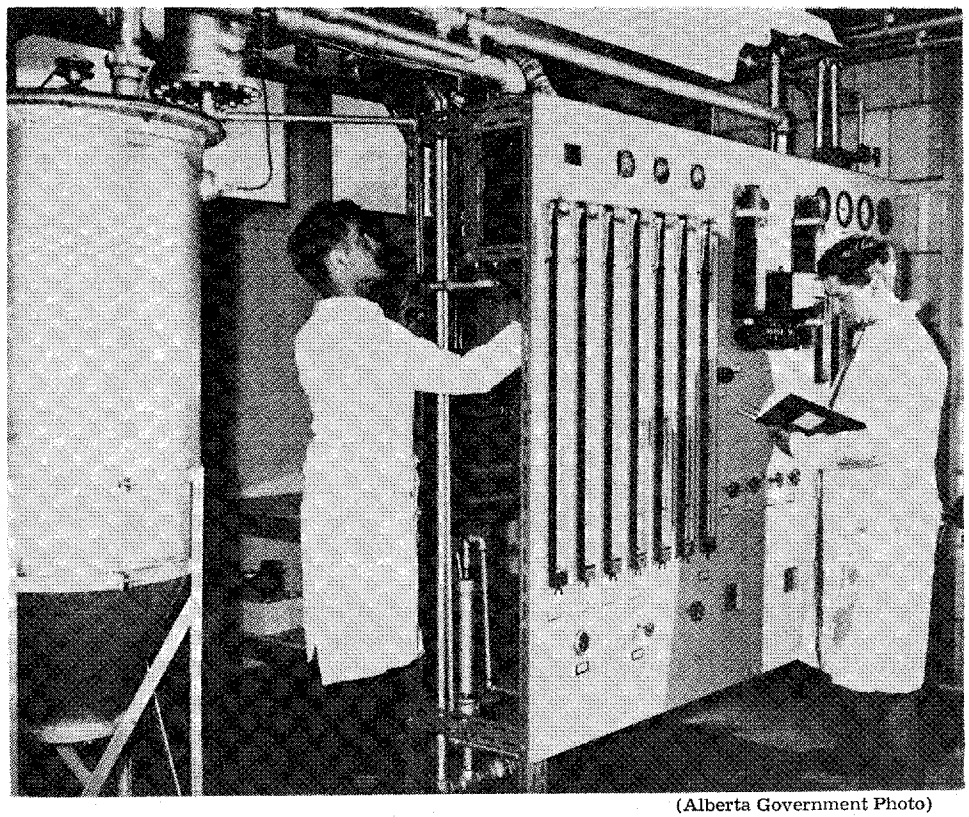
(1) Vertical mounting of the reaction tubes to avoid tube failure due to thermal shock,

(2) The use of a cylindrical shell-type construction and water cooling of all external surfaces,

(3) Revision of the air supply system,

(4) Modification of the carbon black gathering system and the adoption of a new sampling system, and

(5) In general, much more complete instrumentation.



(Alberta Government Photo)

Laboratory pilot plant for studying the production of carbon black from natural gas.

Thermally, the new furnace behaves very well and temperatures up to 2650°F. are obtained easily. Tube failure due to thermal shock has been eliminated. However, the problem of the plugging of the reactor tubes with carbon black persists. Diffusion of flue gas does help—with no diffusion, plugging occurs after about 15 minutes of operation; with diffusion, operation is possible up to an hour. It is hoped that higher space velocities and extension of the diffusing zone to a point outside the furnace wall may solve the problem.

GEOLOGY

Oil Sands Area

A complete section of the McMurray formation has been examined for oil saturation, grain size distribution and heavy minerals analysis. This work has shown—at least in the central area southwest of the Steepbank Devonian high —that there is a sedimentation break in the McMurray sand section. Oil saturation studies indicate that the glauconite zone or green sand overlying the McMurray formation has not a trace of oil, though the upper McMurray formation lying in direct contact with the green sand is saturated with oil. This indicates that oil impregnation took place before the deposition of the Clearwater shale which overlies the green sand.

Samples for mineralogical and microfaunal study of the Clearwater-McMurray contact zone were collected; this study is being made by a graduate student in the Department of Geology, University of Alberta.

An area in township 101, range 3, west of the 4th meridian had been previously mapped as the Athabasca series. Certain hypotheses as to the origin of the McMurray formation used the close proximity of this sand formation in the supporting evidence. It has been found that no Athabasca sandstone exists between the Firebag and Richardson rivers. Instead of the Athabasca sandstone, a series of quartzites and meta-sediments representing a folded and metamorphosed sedimentary series that has been intruded and replaced in part by simple pegmatite material has been mapped. Subsequent to the folding, the area was cut by minor quartz veins and quartz diabase dikes. The fold structures have a north or northwest lineation, parallel to the diabase dikes. This direction represents a major tectonic line and is parallel to the strike of the Paleozoic and Lower Cretaceous sediments in the lower Athabasca valley. The rock exposures on the Firebag river were mapped. Pleistocene material, previously mapped as "oil sands", now is considered to be reworked McMurray formation.

Rocks of the Waterways formation of upper Lower Devonian age outcrop along the Athabasca river. A similar carbonate sequence has been mapped in township 99, range 8, west of the 4th meridian. On the Marguerite river, northeast of the Firebag river, the Devonian rocks change from a fossiliferous lime carbonate through a thin sequence of soft grey shale to an iron sulfide rich rock. These iron sulfide rocks are most likely Middle Devonian in age and they rest on, or close to, the Precambrian Shield. In township 98, range 7, west of the 4th meridian, where the Firebag river alters its course from westerly to northerly direction, cliff sections of McMurray formation are exposed on the south bank. The exposures are between 10 and 40 feet thick, with little overburden. One measured section was 24 feet thick and consisted of oil-saturated McMurray formation, overlain by a thin section of sorted sand and gravel. As described by Ells—Mines Branch, Ottawa, 1924—these exposures along the Firebag river constitute a rich deposit of oil sand. Gravel beds with oil impregnation that are designated as McMurray on the Firebag river are considered by the current survey to be of recent origin. The oil-saturated sand has been found to migrate en masse, and flows over the outcrops that are saturated with ground water. The migrating sand envelops gravel-bars that are subsequently dissected, exposing oil-saturated gravel deposits that include granite-type boulders.

Areas in the Athabasca valley east of MacKay also were mapped. A plane-table survey was made—on a scale of 200 feet to one inch—of an outcrop of consolidated rock which is composed of quartz but had been previously described as quartzite. The detailed mapping shows the area to be compacted basal McMurray formation that has been cemented in part by lime cement. The total area is less than one-half square mile, in s.w.¼ section 32, township 94, range 10, west of the 4th meridian.

Pleistocene Survey—Coronation District

The summer was spent in mapping the glacial deposits of the Coronation district, Alberta. A relatively small area was chosen so that the geologists could thoroughly familiarize themselves with the geology of the area and examine some of the surficial deposits in detail. A preliminary map—showing glacial geology and bedrock outcrops—has been completed and will soon be printed as part of a preliminary report. The survey outlined several areas of sand and gravel, and the quality and extent of the gravel will be discussed in the report.

Although it was not the purpose of the report to study ground water, it was found that most of the fresh water in the area was obtained from sand lenses in the Bearpaw formation and small amounts from the glacial deposits. Water in the glacial materials generally occurs in perched water-tables above the relatively impermeable Bearpaw shales. As has happened in the past, dry weather results in the lowering of this perched water-table; consequently shallow wells are not reliable. While fresh water occurs in the Bearpaw formation in the area studied, it is believed that there is a fresh water and salt water interface downdip. This interface should be located and its fluctuation studied by a competent ground-water geologist as there is the possibility that strong pumping could bring the salt water interface closer to the surface and contaminate the wells.

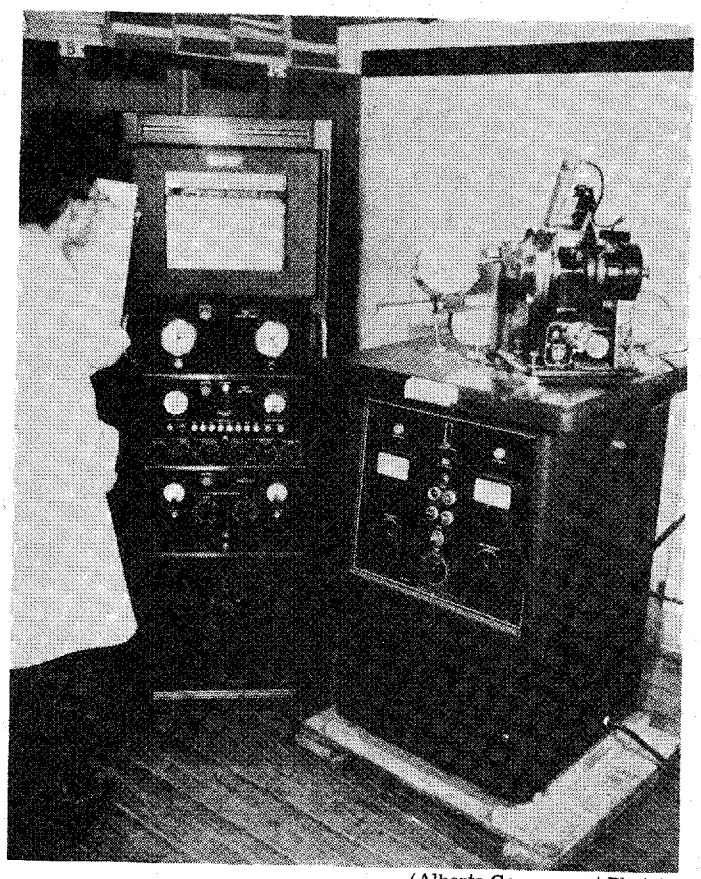
Drilling operations were carried out to determine the depth of drift in the area and to investigate the subsurface Pleistocene stratigraphy. If care and time are taken in locating the drilling sites, it is believed that the logs obtained would aid greatly in the study of glacial deposits and in ground-water exploration.

It was noted in the field that the surficial glacial till is often covered with a layer of sand with some gravel lenses. In many localities this sand thickens to a depth of five feet or more; however, in general, it is confined to the "A" soil horizon (the uppermost soil layer). This sand is important in soil classification and, consequently, its origin should be ascertained. Mineralogic and size analyses are being made on this upper sand and it is hoped that this will help to explain its origin.

A laboratory research program has been commenced to determine the amount of colloidal-sized quartz in certain of the soils and subsoils of Alberta and investigate its base-exchange characteristics. This work will be carried out in conjunction with the Council's soil section. It is believed that the colloidal-sized quartz found in soils was derived from underlying shales. The origin and transport of this colloidal quartz is at present also being investigated.

Clay Mineralogy

During the year, X-ray diffraction equipment was installed and placed in operation. This equipment permits identification of any crystalline mineral



(Alberta Government Photo)

X-ray diffraction equipment for identifying the crystal structure of minerals and of chemical compounds; currently being used for the study of minerals in clays.

or compound. A diffractometer attachment for the basic unit now in operation is on order. When it is installed, more rapid and quantitative diffraction analyses can be performed. The X-ray equipment will find its greatest use in the analysis of fine-grained minerals such as those present in clays.

Mineralogical analyses of a number of clays from southwestern and west-central Alberta have already been completed. None of the clays appears to be suitable for use in manufacturing high quality ceramic materials or refractory products. One clay which merits mention occurs in the Kootenay formation under the coal seam at the South Adanac strip mine south of Bellevue; it consists of illite and kaolinite, with the former predominating. (This composition is typical of many underclays or clays occurring under coal seams in the midwestern United States.) In the same area, other underclays containing kaolinite with small amounts of illite are very refractory and might provide the basis for a major industry. Although the clay occurring at the South Adanac strip mine is not present in commercial quantities and is not of high quality, its composition (by analogy with midwestern U.S. underclays) does suggest that prospecting of underclays in the Kootenay formation might uncover some valuable clay.

Of the clays tested to date, another feature which merits special mention is the large number which contain montmorillonite. This mineral swells greatly in water and is responsible for the unique properties of bentonite. It would be expected that this mineral could cause considerable trouble to road foundations.

The testing of bentonite samples collected during the summers of 1952 and 1953 has been completed. Although a sizeable number of pure bentonite deposits have been found in Alberta, they have so far, in their natural state, proved inferior to commercially-used materials both in the viscosity characteristics necessary for use in drilling fluids and in decolorizing ability. The results of these investigations will be published shortly.

During the past summer the clay research program was extended to include the Bearpaw formation: three composite sections in southern Alberta were examined and measured, fossils were collected, and samples taken for mineralogical study. Further work will involve a thorough study of this formation throughout the province, and will include complete mineralogical analyses of the shale which makes up the formation.

Publications

Council Report No. 67, "Glacial Geology, St. Ann Area", is currently being printed. Map 24 will accompany the report.

A paper on "Differential Thermal Analysis" was presented to the Annual General Meeting of the Canadian Institute of Mining and Metallurgy in April. This was subsequently published in the Bulletin of the Institute in August.

SOILS

The Alberta Soil Survey Committee is Council's advisory committee on soils and is responsible for planning the joint program conducted by the soil survey staff of the Canada Experimental Farms Service and the Research Council of Alberta through the chairmanship of the Professor of Soil Science of the University of Alberta. The irrigation research project on Hemaruka solonetzic (hardpan) soils at Youngstown involves the co-operation of the University Department of Soil Science, the Research Council, and the Canada Experimental Farms Service, with support from the Provincial Department of Agriculture.

Soil Surveys (Council Staff)

The Council's soil surveyors were engaged principally in the Peace River district of Alberta. They were mainly responsible for reconnaissance soil surveys of some 800,000 acres and exploratory soil surveys of approximately 400,000 acres during the season. The interval between traverses in the reconnaissance surveys is usually one mile, whereas in the exploratory work the information is usually obtained by pack horse surveys at irregular intervals, depending on availability of trails, but generally some miles apart.

Field work on the Grande Prairie sheet is now complete, and on over half of the Beaverlodge sheet. In addition, a portion of the relatively inaccessible area south of these sheets, consisting of townships 67 and 68 in ranges 1 to 9, west of the 6th meridian, has been traversed by exploratory survey parties. Since there are some areas of land suitable for agriculture in this region to the south it was deemed desirable to include all of townships 69, 68, and 67 in the published report of the Grande Prairie - Sturgeon Lake sheets and possibly in the Beaverlodge-Blueberry sheets. Checking of the accessible portions of the Grande Prairie - Sturgeon Lake sheets was completed in 1954 with a view to starting preparation for publication.

Various special projects were carried out, also, by the staff during the year. Several portions of the area adjacent to the Saddle hills were examined with members of the Department of Lands and Forests for the purpose of checking settlement and forest reserve boundaries. The senior soil surveyor made a correlation inspection tour of the Peace River district in Alberta and British Columbia with B.C. soil surveyors. The Chairman of the Alberta Soil Survey Advisory Committee inspected soil survey progress in the Peace River district and in southern Alberta, and visited the irrigation plot experiments on Hemaruka solonetzic soils at different times during the season.

The Soil Survey headquarters were moved to the new Agriculture Building during the fall.

Reports

1. "Exploratory Soil Survey Report of Portion of Valleyview-Whitecourt Area." This is a mimeographed report with hand-colored soil rating map. A limited distribution has been made.
2. "Soil Zones of Alberta." This is a map of the soil zones of Alberta as established by the Alberta Soil Survey, and is published under the auspices of the University Agricultural Publications Committee. The map was revised by Council's senior soil surveyor in February, 1954.

Other Projects of Alberta Soil Survey

For purposes of reference and interest the following brief discussion of other projects of the Alberta Soil Survey—conducted mainly by federal soil survey staff—is included in this report.

A detailed survey of approximately 70,000 acres of the St. Mary Irrigation Project was made in the area between Seven Persons and Medicine Hat. This completes the survey work on this project as at present delineated. A semi-detailed reconnaissance survey was made of approximately 75,000 acres on the Bow River Project near Vauxhall, and a reconnaissance survey of approximately 450,000 acres along the east side of the Edmonton sheet. Detailed soil surveys of the Fort Vermilion Experimental Station and of the Deadwood Illustration Station were made, and in the Tilley area approximately 60,000 acres were surveyed in detail as part of the program of gathering information regarding the more saline portions of the irrigated areas.

Irrigation Research on Solonetzic Soils

A large proportion of the projected Red Deer irrigation area consists of solonetzic soil and—since there has been practically no experience with this type of hardpan (Hemaruka) soil under irrigation—it was deemed necessary to carry out experimental work to see if this soil can be made to produce satisfactory crops under irrigation and maintain yields over a reasonable period, before spending large sums of money on irrigation development.

Experimental irrigation plots were established southwest of Youngstown in 1952, and the project is carried on co-operatively by provincial and federal workers. It was agreed:

(1) that the federal experimental plots at Youngstown should be used chiefly to study the consumptive use of water on Hemaruka soils under various cropping conditions, and

(2) that the provincial plots and experiments would be devoted mainly to studies of the physical characteristics of the soil and methods of correcting, if possible, the undesirable features of the soil when subjected to irrigation.

Brief descriptions of the studies on the provincial plots follow.

The "A" plots—each 16′ x 45′—were started in 1952 and treated as follows: (1) dry check, (2) irrigated check, (3) deep cultivation, (4) barnyard manure, (5) sulfur, (6) gypsum, and (7) krilium. One series of seven plots is used for continuous grain production, and two similar series for a grain and sweet clover rotation. Quadruplicate replication was obtained by using four ranges of each series of plots. Within each series the plots are randomized.

The "B" plots—each 40′ x 40′—were broken and seeded to barley in 1953. In the fall, these plots were cultivated according to the following treatment plan:

(1) deep cultivation—using a caterpillar and frost breaker and ripping the soil to a depth of 20 inches,

(2) deep plowing—using a caterpillar and breaking plow and plowing to a depth of 18 inches,

(3) alfalfa—continuous,

(4) shallow deep-cultivation, using farm machinery and farm tractor power,

(5) check—normal cultivation.

These treatments are used for dry land plots as well as irrigated, and the treatments are in quadruplicate.

TABLE 1

YIELD OF WHEAT

(bushels per acre)

Treatments on "A" plots	*1953*	*1954*
Manure	28.8	25.4
Sulfur	28.1	15.7
Krilium	22.8	20.3
Gypsum	29.3	18.3
Deep cultivation	23.6	18.8
Irrigated check	19.3	16.1
Dry check	12.7	9.9
	1954	
Treatments on "B" plots	*On irrigated land*	*On dry land*
Deep ploughing	22.1	16.5
Deep cultivation	22.3	12.3
Shallow deep-cultivation	14.2	6.5
Check	12.2	4.9

The average wheat yields obtained in 1953 and 1954 on the "A" plots, and the average wheat yields of the "B" plots in 1954, are shown in Table 1. It will be seen that the grain yields obtained from the "A" plots were rather similar in both years: the yields on the dry check plots were low in both years while manure gave relatively high yields. However, the higher yields are not very high by comparison with those obtained at Lethbridge on well-farmed irrigated land, and it will be important to know whether the continuation of the study shows that the yield level has been maintained, increased or decreased. The average yield obtained on similar soil on a nearby dry land farm was five bushels of wheat on stubble and eight to ten bushels on fallow. Some effects of type of cultivation on the dry land wheat yields of the "B" plots in 1954 are also shown in Table 1. It will be observed that deep cultivation had an important effect this year.

TABLE 2

YIELD OF SWEET CLOVER ON "A" PLOTS IN 1954

	Tons per acre	*Remarks*
Lowest plot yield	0.15	on deep cultivation
Highest plot yield	3.7	on dry check
Average plot yield:		
Deep cultivation	2.2	
Krilium	1.9	
Gypsum	1.9	
Irrigated check	1.8	
Sulfur	1.7	
Manure	1.7	
Dry check	0.9	

The yields of sweet clover obtained on the "A" plots in 1954 are shown in Table 2. Deep cultivation gave the highest average yield, but the yields were quite variable on the different plots.

TABLE 3

RAINFALL AT YOUNGSTOWN PLOTS

Period	*Rainfall in inches*
April 29 - May 31	2.20
June 1 - June 30	2.25
July 1 - July 31	1.67
August 1 - August 31	8.97
September 1 - September 17	2.27
Total	17.36

The year 1954 was unusually wet in the semi-arid region of southeastern Alberta. The rainfall record at the Youngstown plots from April 29th to September 17th is shown in Table 3. The very heavy August rainfall apparently came too late to be beneficial to dry land crops.

Ordinary surface irrigation is used on the "A" plots and on the federal plots, whereas sprinkler irrigation is used on the "B" plots. The sprinkler system provides uniform irrigation, enables information to be obtained regarding a method of irrigation which is now used rather extensively on rougher and higher lands, and supplies supplementary irrigation where the rainfall is moderately high; it is also used extensively on high-priced crops. Furthermore, the surface soil is left undisturbed and hence changes occurring in the physical and chemical composition of the soil can be more accurately determined.

Subsurface Investigations (Irrigation Research and Soil Surveys)

Council's subsurface drill was used to some extent on an irrigation soil survey near Medicine Hat and in the vicinity of Youngstown. Information regarding the character and stratification of the soil underlying the surface irrigation soil may help to determine the behavior of the soil under irrigation, and the possibility of alkali trouble. Interesting and useful information was thus obtained.

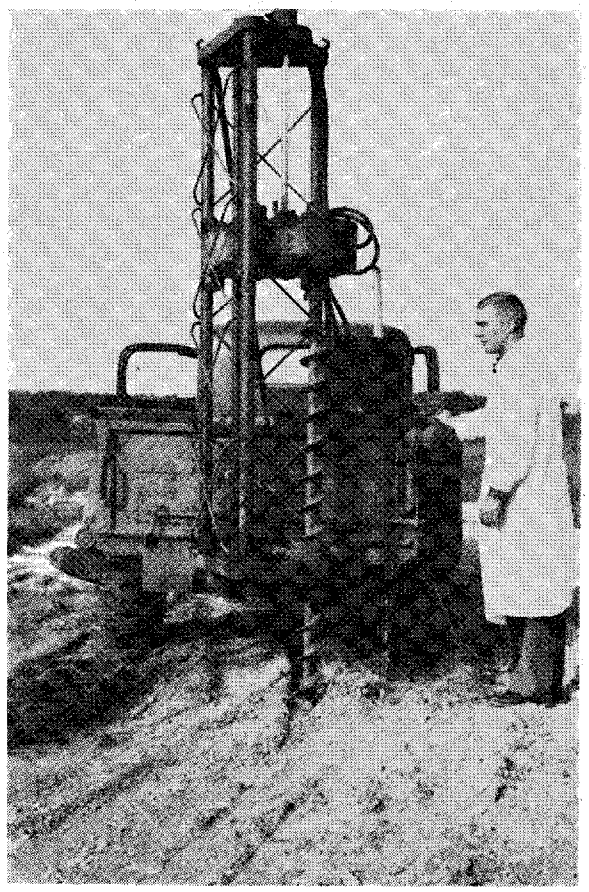
At the Youngstown plots observations made with the subsurface drill showed that the till averaged about 17 to 20 feet in depth, and that this glacial mantle was derived mainly from the underlying salty Bearpaw bedrock shale. Water penetration through the till and bedrock is slow. On the traverse north of Youngstown it was found that the permeable sandy profile extends down to a depth of 35 feet, with a perched water-table as high as ten feet from the surface. The introduction of irrigation in this area would possibly demand good management to prevent accumulation of alkali.

SUBSURFACE DRILLING

Investigation of the subsurface provides important information which is of great value in investigation of soils, in studying geological formations, and in assisting both the ceramics industry and work on irrigation. A mobile drill mounted on a power wagon enables rapid probing below the surface and is very satisfactory for such studies. Usually the drill worked to depths of about 50 feet, though greater depths were attained under favorable conditions if needed.

The Alberta Soil Survey made use of the drilling equipment for several phases of its program, including study of the leakage of irrigation canals. Permeability studies were made in the Youngstown area where co-operative research is continuing on the irrigation of solonetzic soils. Council's program of Pleistocene geological research was greatly assisted by the drilling equipment which determined depth to bedrock and provided other information; in co-operation with the Geological staff of the University, a preliminary map of the glacial geology of the Coronation district was developed. The drilling operation also provided information on the clay deposits in the Cypress Hills area which may be of value to the ceramics industry.

Considerable use of the drill is planned for the ensuing year. The application of this type of equipment should prove increasingly helpful in the programs on soils, geology (including ground-water studies), and nonmetallic minerals such as clays. This should greatly increase the scope of the work accomplished and the over-all efficiency of operation.



Subsurface drill, being used for soil classification and in studies dealing with irrigation research and glacial (Pleistocene) geology.

HIGHWAYS

The program of Highway Research which has been undertaken is a continuing project which requires the carrying on of investigational work over a number of years before final conclusions may be drawn and full use made of the accumulated data. The program has the following objectives:

1. To determine the fundamental nature of the phenomenon by which migration of soil moisture to the frost line is prevented by lignosol;
2. To determine whether other chemicals may be equally suitable in preventing frost heaving and development of frost boils;
3. To treat one or more severe frost-heaving locations on Alberta's main highways;
4. To treat black soil-drift material so as to make it satisfactory for use in rebuilding highway embankments.

Through the co-operation of the Railroad Division of Mannix Limited it was possible to observe the injection techniques used at three locations using lignosol and chrome lignosol, and to take observations on the results of those treatments. The three locations were as follows:

(a) At Mile 50 on the main line of the C.N.R. west of Edmonton (about 200 feet treated),

(b) On No. 2 Highway 3.2 miles south of Ponoka (150 feet treated), and

(c) At the R.C.A.F. Station at Currie Barracks, Calgary (2,000 square yards of concrete pavement treated).

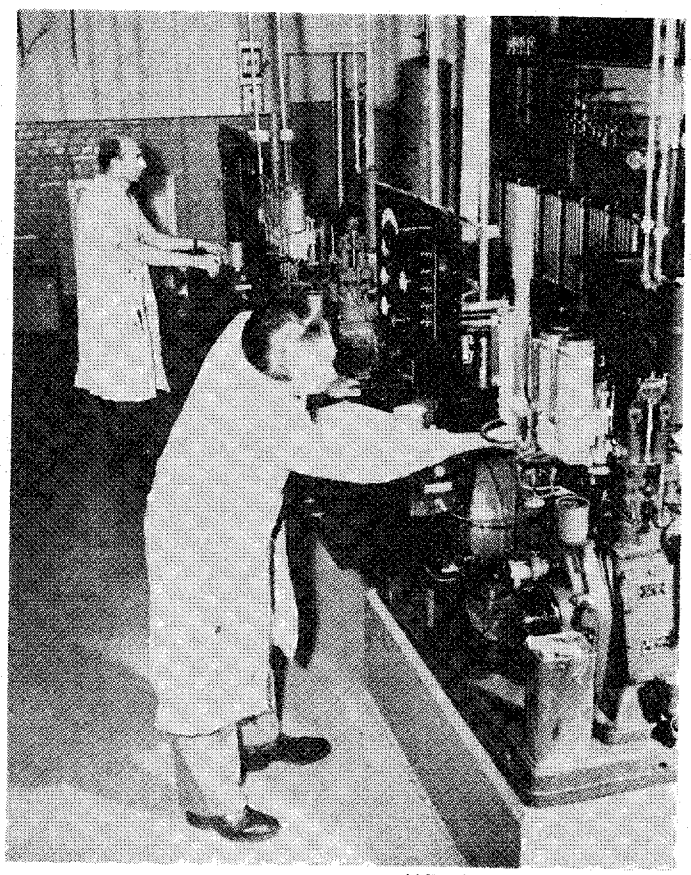
Careful records were kept of the amount of chemical injected and of the ground levels from the time of injection until summer. Since the injections were made in January and February after a considerable amount of heaving had taken place, it will not be known definitely until after the freeze-up this winter as to the effectiveness of the treatments. Readings taken after the freeze-up may decide the practicability of the method when using those injection techniques. In any case, valuable information was obtained concerning the winter weather conditions under which it is practical to proceed with a frost-prevention treatment using lignosol or chrome lignen.

A considerable amount of laboratory work was done on the setting times of the chrome-lignen gel with various proportions of chrome salts, lignosol and water. These tests have provided data from which it is possible to estimate, with a reasonable degree of accuracy, the proper proportions of the chemicals to use under various field conditions. Laboratory studies also indicated that the chrome-lignen combination was equally as efficient as the plain lignosol in preventing frost heaving, provided proper dispersion throughout the soil was secured. It may even have been somewhat better. A laboratory study was started on the injection of lignosol and chrome lignen by the process of electroosmosis .

Field trials showed that the chrome-lignen combination could be injected by means of the pressure grouting technique just as readily as the plain lignosol solution. The only hazard with the chrome lignen is that the gel may set up too quickly unless the proportions are properly controlled. It was not proved conclusively that the proportions of chrome lignen used in the field trials were sufficiently satisfactory to ensure that the gel set up properly in the soil, hence additional work must be done on this point. Data from an injec-

tion made at the Edmonton Curling Club in October, 1954, may provide some information in this connection. It should be mentioned, however, that a much greater percentage of chrome salts were used in the trial at the Curling Club than had been used by Mannix Limited.

It was not found possible to attempt work on the treatment of black soil drift during the year due to the unavailability of qualified staff.



(Alberta Government Photo)

Engines used for determining the octane rating of motor and aviation gasolines.

GASOLINE AND OIL TESTING

The year 1954 followed the trend of preceding years in showing a further marked increase in the volume of analytical work performed by the Gasoline and Oil Testing laboratory over the amount carried out the year before. As in other years, this testing was done for the Department of National Defence, for departments of the Alberta Government, for industrial firms, and for other sections of the Research Council.

While analytical testing represented the bulk of the work, other activities —of a research nature—took up a considerable proportion of the time. The purple dye used by the Alberta Government for some years for the marking of petroleum products, under the provisions of the Fuel Oil Tax Act of Alberta, had not proved too satisfactory since its solubility was comparatively poor. The marking systems used by the governments of Saskatchewan and New Brunswick were studied, and visits were made to various dye manufacturers in order to discuss the problem with them directly. As a result of this, a new dye was recommended for use in Alberta and it has proved much superior to the former dye. A detailed report on this problem was made to the Deputy Provincial Secretary who had requested the investigation. Further assistance was given to the Department of the Provincial Secretary in the local handling and packaging of the dye. For this purpose, standard measuring devices were constructed and calibrated in the laboratory. These have to be checked and adjusted periodically since dye shipments from the manufacturer are not consistent in their bulk density.

The study of the deterioration of aviation gasoline during storage was continued during the year. This is a continuing project started two years previously for the Defence Research Board. The third set of samples, untouched for two years, were opened and tested. This project will continue for at least another year.

A Gasoline Survey for 1953 had been made, and the results distributed early in 1954 as Mimeographed Circular No. 16. This report covered the winter months of 1952-53 and the summer months of 1953. The results of the Winter Survey of 1953-54 and the Summer Survey of 1954 have been compiled, and Mimeographed Circular No. 19, containing this information, will be distributed early in 1955. These surveys tend to indicate the general quality of the gasolines on the market.

A tabulation of humidity data expressed in grains water vapor per pound of dry air for nine barometric pressures from 22 in. to 30 in. and for forty-six air temperatures from 55° to 100°F. has been completed. These psychrometric tables are being submitted for publication. Many thanks are owed to the Computation Laboratory of the Gas Turbine Division of the A. V. Roe Canada Ltd. for using their I.B.M. Electronic Calculator to calculate some 400 pages of data in approximately 12 hours. With normal methods of calculation, around four months would have been required.

Close liaison was maintained with the Petroleum Specifications Committee of the Canadian Government Specifications Board and considerable work was carried out on behalf of a subcommittee of that group dealing with test methods. Numerous test methods were reviewed and the findings made available for the Canadian "Schedule of Methods of Testing Petroleum and Associated Products". A complete detailed index to the Schedule was prepared.

INDUSTRIAL ENGINEERING SERVICES

In keeping with the general diversification of industry in Alberta, this section increased its service during 1954 by widening its field of activity. This was made possible by an increase in its staff the previous year.

Many and varied were the items on which information was requested during the year. The section investigated and conferred on inquiries from representatives of industry and prospectors on raw materials such as the following: silica sand, salt, limestone, iodine, bromine, iron ore, "Hydrofrac" sand, lime, marl, potash, talc, low-grade bentonite, clays, gypsum, etc. Other investigations included lightweight aggregate, hydrogen, coal-tar pitch, sulfuric acid, alginic acid, trout eggs, polyethylene, polyvinyl chloride, and rock wool ore. Valuable contributions to the economic activity in Alberta result from conferences on subjects such as the above-mentioned. As an illustration, the preliminary information and advice supplied by this section contributed to the formation of the Peace River Glass Company.

Diverse technical advice is constantly being requested by the government, the general public, and by specific industries. A close contact is maintained with the Provincial Marketing Board who inquire about specific proposals. Meetings held with a group of poultry producers discussed improvements in quality methods. Engineering advice was given to a company on heat treatment failure. Liaison work was carried out between the Division of Building Research of the National Research Council, the Central Mortgage and Housing Corporation, and several Alberta manufacturers of building materials. Individuals received advice and comment on the worth of their inventions, and a small amount of consulting work was performed when other specialists were not readily available. Through the year 978 visits were made to industries, which resulted in 600 inquiries (as compared with 222 in 1953); 54% of these inquiries were handled locally while the remainder were referred to the Technical Information Service of the National Research Council.

The section advised and assisted on matters pertaining to the Research Council Building which is currently under construction. Apparatus has been designed for, and advice given to, some other sections of the Council. The subsurface drill was fitted up by a member of its staff.

This section has been helpful to Council in some phases of public relations. Interviews between industrial, financial and technical interests have been arranged. Representatives visiting Edmonton from large chemical firms and industries of Canada, the United States, Britain, Italy, Germany, etc., have been taken through industrial plants in the Edmonton area, and conferences, talks and special interviews for these visitors have been arranged. Members of the staff have taken part in speaking tours.

The national conference of the Technical Information Services across Canada—previously always held in Ottawa—was this year convened in Edmonton. Technical Information Service personnel from Halifax, Montreal, Toronto, Ottawa, Winnipeg, Edmonton and Vancouver attended. The National Research Council has been working co-operatively with the Research Council of Alberta, the Ontario Research Foundation, the Nova Scotia Research Foundation, and the British Columbia Research Council to make the Technical Information Service as effective as possible.

BIOLOGICAL CYCLES

The ten-year cycle is now at—what is assumed to be—its complete ebb, but with signs of recovery apparent in places. Snowshoe rabbits have been virtually unobtainable. Specimens of upland game birds and rabbits combined, submitted to the Provincial Veterinary Laboratory for post-mortems from October to October for the years 1951-52, 1952-53, and 1953-54, numbered 380, 110, and 24 respectively, even though the collecting effort was about the same in the three periods. In the face of decreasing supply it is possible that the collecting effort was even greater. The replies to the annual questionnaires indicate clearly that the scarcity is province-wide (the chart shown in the Annual Report for 1953 is of interest in this connection). Saskatchewan and Manitoba appear to have a similar scarcity.

To illustrate the current scarcity one need only mention that in the Athabasca district in November, 1952, on favorable spots, rabbits occurred at the incredible rate of 35,000 to the square mile, with road counts producing up to 120 to the mile. Eighteen months later (April, 1954) over the same plots, only one rabbit was seen during several hours of tramping and only one during 315 miles of driving, with a total count of two grouse. The situation is substantially similar in the Fort McMurray area: an observer at Anzac has not seen a dozen rabbits during the past twelve months, while surveyors who spent the summer in the bush did not see any at all. In view of this scarcity of rabbits it has been impossible to stock the Cooking Lake enclosure or the experimental hutches. A series of five papers on this work have been accepted for publication by the Canadian Field Naturalist. Two short papers on the correlation between weather and animal numbers over the past three years are also ready for publication.

Acknowledgments

This investigation owes much to the co-operation received from the Provincial Game Department, the Provincial Veterinary Laboratory and numerous collaborators.

ANIMAL SCIENCE

The following two investigations in the Department of Animal Science of the University have been supported by the Research Council.

Factors Affecting the Percentage Hatch of Turkey Eggs

The experiments conducted this year were designed to investigate:

(1) the effect of the carriage of the tom on fertility and hatchability, and

(2) the possible effect of breeding on reproduction performance.

The results obtained indicated that the use of upstanding males in the breeding pens resulted in an increase in the fertility of the eggs produced as compared to pens in which front-heavy males were used; hatchability of fertile eggs was apparently not influenced by the selection of the males. A comparison of the productive performance of imported stock (which had been selected for good reproductive performance) with University of Alberta stock indicated that the imported stock produced at a higher rate; however, the fertility and hatchability of fertile eggs of the imported stock was not superior to that obtained with University of Alberta stock in pens headed by upstanding toms. It is proposed to compare the performance of breeders fed the breeding ration, with and without the addition of certain of the known vitamins.

Grass Silage Project

Trench silos made available in 1953 were refilled in July, 1954, using forage and treatments similar to those employed the previous year. An attempt was made to obtain improved quality and yield of silage by: (a) more thorough packing, (b) distributing the grain more uniformly by blowing it in with the forage, and (c) covering the silos with a removable plywood roof.

A number of samples of fresh forage and silage were subjected to chemical analysis. Most of the analytical procedures are time-consuming. Preliminary analytical studies indicate:

(1) That very significant losses of carotene probably occur in silages that, on the basis of appearance, may be classified as good. For example, after approximately eight months the carotene level in the silage from one of the trench silos was found to be only 6% and in the other 31% of that in the original forage ensiled. If results of this nature were confirmed they would cast considerable doubt on the reliability of silage of good green color as a source of carotene.

(2) That the butyric acid content of a silage may drop with age. For example, in samples taken two, four and eight months after the forage was ensiled the following levels of butyric acid were found:

	Butyric acid content (% on dry basis)		
	At 2 months	At 4 months	At 8 months
Trench silo 1	6.6	0.8	0.4
Trench silo 2	9.1	0.6	2.3

Obviously, the results for silo 2 suggest a sampling or other error, but nonetheless if the trend indicated by these results is real it would be a matter of significance, because determination of the butyric acid content of silage is recommended as a method of estimating palatability and general quality. The

thumb rule used is that silage containing 2% butyric acid or less is satisfactory. On this basis—and assuming that the above analytical results are reliable—it is evident that, in practice, butyric acid determinations could lead to very different conclusions regarding the palatability of a given silage.

SOLAR ULTRAVIOLET RADIATION

A report on the solar ultraviolet measurements made in Edmonton since 1946 was prepared and sent to Rome for presentation to the Radiation Section of the International Union of Geodesy and Geophysics in September. The report contained some critical comparisons of the three methods being used in Alberta for different ranges of the solar ultraviolet. It showed a set of comparative curves, including the total solar radiation for the years 1952 to 1954 during which the three methods have all been in continuous use.

The study of solar ultraviolet radiation is continuing, as recommended by the World Meteorological Organization referred to in the Annual Report for 1953. This includes a comparison of the photocells.

The Meteorological staff at the Airport have been most helpful in enabling the measurements to be made as completely as possible.

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.**
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DR. D. R. STANLEY	Consulting Sanitary Engineer, D. R. Stanley and Associates, Edmonton
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MRS. B. W. BISHOP		Stenographer
MRS. B. JOHNSON*		Stenographer
MISS L. M. READ		Stenographer
MISS J. POWERS		Clerk
MISS D. P. CRAIG		Stenographer
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J. C. WOOD	B.Sc. (Alta.), Ph.D. (McGill)	Research Chemist
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E. J. JENSEN	M.Sc. (Copenhagen)	Research Engineer
J. F. FRYER	B.Sc. (Alta.)	Chemist
W. DAMMEYER		Technician
J. F. VANELDIK		Laboratory Assistant
C. ASCHER*		Laboratory Assistant
H. L. HANSEN		Laboratory Assistant
W. KRIKKE		Laboratory Assistant
PETROLEUM		
K. A. CLARK	M.A. (McMaster), Ph.D. (Illinois)	Consultant
D. S. PASTERNACK	B.Sc. (Queen's), Ph.D. (McGill)	Senior Research Chemist
G. W. HODGSON	M.Sc. (Alta.), Ph.D. (McGill)	Senior Research Chemist
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MISS K. G. TANNER	B.Sc. (Alta.)	Assistant Research Chemist
T. A. GOODWIN		Laboratory Assistant
GASOLINE AND OIL TESTING		
J. S. CHARLESWORTH	B.Sc. (Alta.)	Senior Chemist
E. TIPMAN	B.Sc. (Alta.)	Chemist
MISS G. M. RYMER	B.Sc. (Alta.)	Assistant Chemist
MISS J. WEBSTER		Laboratory Assistant
W. R. REED*		Laboratory Assistant
G. E. NICHOLSON*		Laboratory Assistant
W. DRISCOLL		Laboratory Assistant

*Resigned

NAME	DEGREE	CLASS TITLE
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D. QUON†	M.Sc. (Alta.), Sc.D. (M.I.T.)	Senior Research Engineer
H. W. HABGOOD	M.Sc. (Queen's),) Ph.D. (Michigan)	Senior Research Engineer
W. K. SCHMIDT	Dipl. Chem. (Frankfurt)	Research Engineer
C. C. LEE*	M.Sc. (Sask.), Sc.D. (M.I.T.)	Research Chemist
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H. A. SPENCER	B.Sc. (Sask.))	Mechanical Engineer
G. S. CRAWFORD	B.Sc., B.A. (Sask.)	Ceramic Engineer
GEOLOGY		
G. A. COLLINS	B.Sc. (Toronto), M.Sc. (Washington U., St. Louis)	Geologist
P. J. S. BYRNE	M.Sc. (Alta.), Ph.D. (Illinois)	Clay Mineralogist
L. A. BAYROCK†	M.Sc. (Alta.)	Assistant Geologist
L. G. BARTLETT		Technician
M. DENNINGTON		Laboratory Assistant
SOILS		
W. ODYNSKY	M.Sc. (Alta.)	Senior Soil Surveyor
A. WYNNYK	M.Sc. (Alta.)	Soil Surveyor
A. M. F. HENNIG*	B.Sc. (Alta.)	Assistant Soil Surveyor
J. D. LINDSAY	M.S.A. (Brit. Col.)	Assistant Soil Surveyor
J. J. CODY*	B.A. (Earlham College, Indiana)	Assistant Soil Surveyor
D. J. BELL		Assistant Soil Surveyor
H. O. RITCHIE		Technician
IRRIGATION AND SOLONETZIC SOILS		
A. L. MATHIEU	M.Sc. (Alta.)	Assistant Soil Surveyor
HIGHWAYS		
K. A. MILLIONS*	B.Sc. (Alta.)	Assistant Research Engineer
HATCHABILITY OF TURKEY EGGS		
MISS R. O. A. RENNER	M.Sc. (Alta.)	Research Assistant

†Part time
*Resigned

SHORT TERM AND/OR SUMMER STAFF

J. G. ATKINSON - Laboratory Assistant, Coal
W. N. McKAY - Assistant Research Chemist, Natural Gas
E. J. MORIN - Research Assistant, Natural Gas
C. P. GRAVENOR - Geologist
G. M. ARCHIBALD - Field Assistant, Geology
R. M. REEVE - Field Assistant, Geology
F. E. PARKINSON - Field Assistant, Geology
MING P. LEE - Assistant Chemist, Soils
R. J. MILLER - Field Assistant, Soils
R. L. THOMAS - Field Assistant, Soils
A. W. GOETTEL - Field Assistant, Soils
F. J. DISNEY - Cook, Soil Survey
K. C. STEWART - Operator, Drilling Project
R. W. WILSON - Field Assistant, Highway Research
MISS M. L. LONG - Laboratory Assistant, Gasoline and Oil Testing
D. G. R. BLAIR - Analytical Assistant, Grass Silage Project

The following staff members of the University of Alberta co-operated in the work of the Council:

DR. E. H. GOWAN - - - -	Ultraviolet Solar Radiation
DR. G. W. GOVIER - - - -	Natural Gas Research
DEAN R. M. HARDY - - -	Highway Research
DR. J. D. NEWTON - - -	Soil Survey, and with Dr. J. A. Toogood, Irrigation of Solonetzic Soils
DR. W. ROWAN - - - - -	Biological Cycles

The Council supported University work on the following projects in Animal Science:

1. Hatchability of Turkey Eggs, under the direction of Dr. D. R. Clandinin and Dr. A. R. Robblee.
2. Grass Silage, under the direction of Dr. L. W. McElroy.