Coal Research and Development in Canada — 1970

T. E. TIBBETTS, Research Scientist,
Fuels Research Centre, Mines Branch,
Dept. of Energy, Mines and Resources,
Ottawa, Canada

ABSTRACT

An unparalleled growth in the Canadian coal industry in 1970 coincided with increasing awareness by Canadians of their environment and their geography with its accompanying transportation factors. R and D on coal moved with greater emphasis toward solving problems in these areas as well as continuing with strong interest in coal preparation, carbonization, combustion, "weathering", spontaneous ignition, storage, exploration and geology. Long-range "basic" research was not forgotten in that work continued on coal-based carbons, coal chemistry and agrobiological uses for coal.

This paper reviews the status of these many areas of coal research at the beginning of the seventies and takes note of some of the more significant legislation and projects brought to the author's attention. No attempt is made to itemize or to describe in detail all the worthwhile projects, many of which are reported elsewhere.

INTRODUCTION

UNPARALLELED OPTIMISM AND ACTIVITY were the main features of Canada's coal industry as it entered the nineteen seventies. Production increased by 55 per cent in 1970; this was the largest percentage increase in a single year in the history of the Canadian coal industry[1]. Export shipments increased 220 per cent and there was a slight increase in imports. There was increased emphasis in 1970 on applied research and development in mining, beneficiation and utilization of western Canadian coals. In addition to new areas of research being opened, there was a continuation and expansion of projects initiated in the late 1960's concerned with fine coal beneficiation, carbonization, combustion, transportation, weathering, spontaneous ignition, storage, exploration, coal mine land reclamation and environmental aspects of coal mining, processing and utilization. It is significant to note, however, that the deferment of federal government coal research grants in 1970 has had a markedly deleterious effect on coal research at universities.

In 1970, the electric utilities and the iron and steel industries were major markets for coal and are expected to increasingly dominate the coal markets of the future. World shortages of high-quality coking coal, in particular, have intensified research toward the upgrading of lower-grade coals as well as exploration activity for new sources. The uncertainties of present off-shore energy sources and Canada's future requirements have spurred increased efforts by governments and industry in resource studies. Increased demands for electricity throughout the country and delays in nuclear programs have resulted in significantly increased utilization of coals of all types by the electric utilities. Accompanying this increased utilization have been increasing restrictions on sulphur content, occasioned by serious efforts to combat atmospheric pollution, and increasing transportation problems demanding economic solutions.

T. E. TIBBETTS is a research scientist with the Mines Branch, Department of Energy, Mines and Resources, Ottawa. He is a Member of The Canadian Institute of Mining and Metallurgy, has been Secretary of the Coal Division since 1965 and serves on several of its committees, including the Committee on Research. He is Secretary of the Canadian Advisory Committee on Coal Research, on whose behalf he has prepared this Review.

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EXPLORATION, GEOLOGY AND RESOURCE EVALUATION

Exploration for coal continued at a high level in Canada in response to an apparent world shortage of coking coal, in particular, and high-quality thermal coals.

In 1970, there were about twenty companies actively engaged in coal exploration concentrated in the southern and northern sections of the coal belt in Alberta and British Columbia[2]. Increasing use of new borehole logging techniques for small-diameter holes is reported. Considerable success has been reported in the use of the "Gamma Ray" and "Neutron Response" techniques by Master Exploration Limited in the Rocky Mountains Foothills, and other companies report some success with "High-Resolution Density" and "Long-Spacing Density" techniques. Increased use of the expanding drill for larger and more representative sample recovery is also reported. Experiments with several geophysical methods to determine subcrops of pitching seams were reported. These methods offer savings over trenching to bedrock by excavating methods.

The Geological Survey of Canada's Coal Research Section reports that coal rank studies in the Rocky Mountain Foothills Belt have shown that (a) coal rank increases regularly with stratigraphic depth, but not with geologic age, depth of mining or with degree of tectonic disturbance; (b) the coalification gradient varies between different coal areas, those with a low gradient containing more seams in the coking range than those with a high gradient; and (c) in the Canmore coalfield the coal rank as determined by reflectance can be utilized to correlate coal seams.

Petrographic evaluation of the Rocky Mountain Foothills coal by the GSC has shown that the Chamberlain seam of the Sukunka River area is a premium coking coal; and, as regards composition, the lower

Kootenay coals at Fording River and Line Creek have the same high content of inertinite (fusinite and semifusinite) as was previously noted in other parts of the Crowsnest coalfield. The petrographic study of the coals from Telkwa, B.C. showed that not two but three separate seams are probably represented by the Betty, the No. 3 and No. 4 seams. A correlation between the 5-Foot and McNiel seam has also been established.

GSC's study of the lignite deposit of Estevan showed (a) a greater variation in petrographic composition than was expected in such a relatively immature coal and (b) low contents of molybdenum, vanadium and uranium (1 to 10 ppm on total coal basis). The latter appeared to be highest in the parts of the seam adjacent to the roof and pavement, and the vanadium showed a concentration in the high-ash bands.

GSC has reported the recognition of seven spore zones in the Horton Group of the Atlantic Provinces, extending its known age from Lower Carboniferous to Middle Devonian.

Some of the recent exploration projects of GSC's Coal Research Section that were briefly mentioned in earlier reviews have now been completed and details have been published[3],[4],[5].

At the Research Council of Alberta (RCA), taxonomic studies of megaspores in Cretaceous rocks have been virtually completed; specimens representing the more important megaspore types have been photographed, and related areal and stratigraphic data have been compiled. A publication is being prepared that is expected to materially help better correlation of coal-bearing strata and coal seams in the central region of Alberta[6].

In early 1970, a preliminary estimate of the coal resources in western Canada was prepared by the Department of Energy, Mines and Resources[7]. Coal reserves of the three western provinces were estimated at approximately 119 billion tons of coal in place. The continuation of the resource study is concerned with not only the total tonnage available but also with the quality of the coals and with the suitability of present technology to mining the coals. In this connection, the Fuels Research Centre and the Research Council of Alberta have continued studies of coal resources.

In its role of contributing to the Mines Branch activity of providing up-to-date information on the chemical composition of Canadian mineral and energy resources, FRC conducted studies of samples from several properties, being explored and producing, from coalfields in British Columbia, Alberta, Graham Island, the Yukon and Cape Breton. Many of these evaluations, involving assessment of the coking potential as indicated by dilatometer and microscopic examinations, were related to areas of major exploration activity or active mine development. For example, FRC conducted an extensive sampling of the Harmer Ridge property of Kaiser Resources Limited and is following closely the development work at the new Lingan mine of DEVCO with collection and evaluation, at periodic intervals, of channel samples from the advancing coal face.

During 1970, FRC scientists collected and analysed coal samples from producing mines and from electric utilities in Nova Scotia, Alberta and British Columbia[8],[9]. FRC scientists authored a report on the ash analyses of Canadian coals determined over a five-year period[10].

A major function of the Coal Research Division of RCA lies now in the provision of basic information on geological settings, compositions, properties and processing characteristics of western Canadian coals to individuals and companies investigating mining opportunities in Alberta and British Columbia; also included are topics concerned with utilization of by-products accruing from processing or combustion.

In connection with RCA's long-range efforts to establish an inventory of strippable coal reserves in the province, last year's discovery of a subbituminous coal occurrence in the Fox Creek area has led to a study of the recoverable reserves and the quality of coal extractable by alternative mining methods. A full report on RCA's survey work in the region has been drafted. In efforts to trace the Ardley coal zone, considerable drilling was undertaken around Whitecourt and from Whitecourt into the Freeman River valley.

MINING

The Mining Research Centre (MRC) continued research programs, integrated with those of mining companies and universities, on ground control and mining systems engineering. A western office of MRC was opened in 1970 to study problems associated particularly with roof control and coal and gas outbursts in western Canadian coal mines.

Current studies at MRC involve an in-depth evaluation of the effects of quality and geological variations in roof strata on bolt performance as well as the determination of roof and bolt behaviour, and the variation in stress on the bolt with time. The development of measuring capabilities to measure pressure, permeability, sorptive capacity and coal strength are included in the study associated with coal and gas outbursts.

MRC carried out structural and fabric analyses of selected coal basins and individual mines to determine the effect of these geological impediments on the strength of and the stress within coal-bearing areas.

Development work progressed in the new Lingan mine by DEVCO. A slope, several hundred feet long, was driven with a DOSCO Roadway Cutter-Loader. Other collieries of the company were up-dated through the installation of improved mining machinery and roof supports, including a shearer and gate-end support system to mechanically cut the stall and brushing at the end of a longwall.

In Alberta, two 1100-volt longwall mining units were placed in operation. A methane monitor was installed to isolate the electric equipment when methane gas builds up. Master Exploration Limited experimented with a 3-foot-diameter twin auger for recovering coal from seams dipping up to 25 degrees from the horizontal. Problems associated with alignment, rock-partings, thrust faulting and tear faulting have been encountered. In its open-pit operations, Kaiser Resources have had encouraging results in testing a 22-cu.-yd. Le Tourneau front-end loader capable of digging coal from the solid and loading directly into 120-ton trucks. Kaiser's pilot project, in which a hydraulic monitor is being used to mine and deliver the top and up-pitch pillar coal from an underground mine, is yielding favourable results.

SAFETY, ECOLOGY AND ENVIRONMENT

Research associated with roof control and the control of gas outbursts has been outlined under Mining. Work on the control of methane emission that would reduce mining problems and increase mining efficiency and safety is being conducted.

During 1970, progress was made toward a final draft of The Canadian Coal Mine Safety Regulations which includes standards for respirable dusts.

The Canadian Explosives Atmospheres Laboratory of FRC conducted several research projects in the field of explosive atmospheres and the safety of apparatus operating in such atmospheres. Numerous investigations of electric-powered equipment for coal mines and of electric motors for coal mine equipment were carried out. Also examined were diesel-powered coal mining equipment, conveyor belting and fabric for mine ventilation ducts.

The ecological importance of reclaiming lands disturbed by coal mining has been recognized in Canada and, in several areas, plans were made or put into effect to restore and revegetate such disturbed areas and mine dumps. Examples of such activity can be seen at Coleman Collieries Limited where, in co-operation with the Alberta government, the company is proceeding with a program initiated in 1969 to revegetate the old mine dumps in the Coleman-Blairmore-Hillcrest area. Some 450 acres of land, disturbed by strip mining, have been reclaimed by Calgary Power Ltd. at the Whitewood strip mine, near Lake Wabamun. The reclamation is a continual program to improve land that was once muskeg and swamp — to transform the jagged piles of soil and man-made cuts in the earth to contoured landscape that will later yield alfalfa.

The British Columbia government in 1969 enacted comprehensive legislation on the restoration and reclamation of lands affected by surface mining. The legislation provides for the deposit of performance bonds and the submission, approval and execution of a detailed plan of reclamation. The Faculty of Forestry, University of British Columbia, reviewed the progress during the first year of the legislation. A report[11] concludes that the reclamation proposals that were submitted were impressive in their stated intent and careful preparation. It suggests that surface mining operations have significantly greater environmental impact than is indicated by the area covered by the actual operations (76 square miles out of the total area of the province of 365,000 square miles) and that, in the absence of developed reclamation techniques, major research activity is essential. The report advocates the establishment of a provincial research agency to be financed jointly by the government and the mining industry.

In British Columbia, Kaiser Resources Limited has an active reclamation program involving hydro-seeding and tree planting in the low areas in the Michel Valley. Research and testing relative to elevations above 5,000 feet were continued at Kaiser's 2-acre nursery near Sparwood. A concentrated research reclamation program was continued at the Fording Coal property.

In eastern Canada, the federal Mines Branch and the Nova Scotia Department of Mines undertook a complete investigation of a burning coal mine dump at Springhill[12]. This smouldering bank located on the outskirts of the town is becoming an increasing hazard to the town environment. Information obtained from a drilling program indicated the presence of about 1.7 million tons of mineral and carbonaceous material, parts of which were as yet unaffected by heat and which offered an air pollution threat for many years to come. Separation of the various constituents of the waste bank and the recovery of coal and middlings products was shown to be technically feasible by 5-tph pilot testing at the Western Regional Laboratory. Samples yielded 20 to 30 per cent coal with ash contents of 18 to 26 per cent. The investigation indicated the probability, through the sale of valuable recovered products, of offsetting the costs of normal procedures, of extinction and control of the fires and of land reclamation that would involve moving, cooling, compacting and sealing the waste material.

It was estimated by the Mines Branch that the air pollutants emitted in Canada in 1970 would amount to 350 million tons; these would include both respirable and non-respirable sizes of metallic and hydrocarbon particulates and gaseous oxides of sulphur, nitrogen and carbon[13]. Realizing that new technology must be developed not only to control gaseous pollutants but also to prevent their formation at all by removal prior to combustion, the various research activities of the Branch related to mine environment, burning of fossil fuels and smelting of sulphide ores have been integrated under Environmental Improvement, an objective of the Mineral and Energy Resources Program (MERP). In 1970, projects under this objective, related to coal mining and combustion, included: the characterization of combustion source pollution in a research tunnel furnace; dispersion of pollutants from tall stacks by aerial probing; fixation, degradation and collection of pollutants before emission to the atmosphere; fuel and fuel additive evaluation; noise pollution from combustion processes; comparative dust measurements; clean-up of mine air; calibration of laboratory and field equipment; treatment of mine and plant liquid effluents; and development of sulphur dioxide absorbents.

At the Mines Branch's Metals Reduction and Energy Centre (MREC), studies on water recovered from coal cleaning were started with a view to select and improve, where necessary, conventional equipment best suited for the purpose of (a) the reconstitution of plant water and (b) the more complete clarification of the water prior to disposal in accordance with pollution regulations. Also, at this Centre, the heavy metals (mercury and cadmium) in effluents of the coal and steel industry were investigated.

The Research Council of Alberta made a study of probable environmental effects of coal mining and combustion in western Canada. A laboratory study of coal dust formation and suppression was planned.

In Saskatchewan, "The Pollution Prevention Regulations for the Mineral Industry, 1970" were passed by the Saskatchewan government. These regulations apply to the prevention and control of gaseous, liquid and solid industrial pollutants resulting from any process of the mining industry or from the development of any mineral resource, except the oil and gas industry. At the Saskatchewan Research Council, lignite, lignite char, lignite carbon and fly-ash have been tested in the treatment of sewage and industrial effluents (c.f. Carbon).

Also, in 1970, the Province of Ontario announced plans to restrict the sulphur content of fuels used in the province. To cope with sulphur in stack emissions, The Hydro-Electric Power Commission of Ontario collaborated with a group of United States utilities in a research program aimed at developing a suitable system for the removal of sulphur dioxide from stack gases.

TRANSPORTATION

The export market for western Canadian coal, some 4.4 million tons in 1970, could rise to more than 16

million tons a year by 1975[1]. There are increasing prospects of shortages of imported coal from the United States for the central Canadian steel and thermal-electric power industries requiring these industries to look seriously at the great coal resources of western Canada. A major factor in these forecasts is the economical transportation of coal over imposing distances. This was emphasized in 1970 when, due to shortages of United States coal, Saskatchewan lignite was used for the first time in significant quantities by The Hydro-Electric Power Commission of Ontario in two of its Southern Ontario generating stations.

In 1970, studies were conducted into the feasibility of large-volume movements of western Canadian coal to the metallurgical and electric utilities of Ontario. The use of unit trains for the transport of coal across the prairies is being looked at. Ontario consumers of western coal, because of its low sulphur content, are pressing hard for the lowering of the prevailing high transportation charges on western Canadian coal.

At the Research Council of Alberta, work on paste slugs for pipeline transmission continued in 1970. Construction of a new 1-in.-diam. instrumented laboratory test loop was undertaken. This facility will center its initial experiments on paste slugs of subbituminous coals and bituminous coking coals. Results of the 1967 field trials with capsules and slugs have been publicly released at an international conference on hydraulic movement (Hydro Transport I, Coventry, England, September 1970)[14]. Detailed proposals for a second phase of the program designed as a follow-up on the 1967 trials were submitted to SPRDA (The Solids Pipeline Research and Development Association) and CTC (Canadian Transport Commission).

As a result of interest expressed by Ontario Hydro and a number of western Canadian coal producers in coal slurry transport, RCA resumed work on coal-oil slurries with a view to accumulating more complete data on slurry stabilities and separation. Initial experiments were concerned with settling velocities as functions of the oil carrier and the entrained coal of the slurry. Whether the type of coal entrained in the slurry affects slurry stability, energy requirements and de-oiling is being studied.

Paste-slug compression measurements made in 1969 were transcribed to computers, and quadratic equations were fitted to two seemingly distinct regions of the compression curves. No reasonably direct relationship between the curve parameters and the measured paste characteristics have so far been found.

The Western Regional Laboratory (WRL) did work sponsored by two major companies interested in the transportation of coking coal by pipeline. Coal slurries, containing high contents of clean coking coal in a finely divided form, were dewatered, without thermal drying, by means of oil agglomeration of the fines followed by mechanical dewatering.

Cascade Pipelines Limited announced their intention of constructing a pipeline to move a slurry of coal and water from the Elk River basin to Roberts Bank (500 miles). In 1970, at the Metals Reduction and Energy Centre (MREC), extensive testing was done in the technical-scale coke oven to evaluate the effects of the physical conditioning of coking coal for pipelining, the physical and chemical interactions during pipelining, and the subsequent coal recovery from the slurry on the coking properties of the coal.

In 1970, nine committees were set up by the Canadian Coal Producers, Transporters and Consumers Research and Development Group (CCPTCRDG) for the purpose of proposing a number of research and development coal programs, to be sponsored by the federal Department of Industry, Trade and Commerce (PAIT etc.). Under one of the projects, coal transportation studies, MREC conducted preliminary research on control of dust loss from moving trains.

COAL ANALYSIS

As in previous years, RCA and FRC completed much routine testing of coals and coal products[15]. To meet growing industrial needs for analyses, commercial test laboratories, particularly in western Canada, became more involved in coal analyses. With a view to ensuring consistent high precision and accuracy of analyses, these laboratories have participated in standardizations of procedures with all major coal laboratories. This is directed by FRC.

Several of RCA's research projects have required the development of special analytical techniques or of modified procedures and, in most instances, these have centered on adaptation of gas chromatographic methods. Tests designed to yield specific information on rates of "weathering" of western Canadian coking coals, tests on the composition of pyrolysis products of fresh and oxidized coal, and tests to determine the connection between loss of caking properties and build-up of oxygen-bearing functional groups in coal during "weathering" have been undertaken.

RCA, FRC and MREC have maintained close liaison with The International Standards Organization and The American Society for Testing and Materials, and staff members of these organizations have actively worked on several ASTM subcommittees and with the Canadian Advisory Committee on ISO/TC/27 in the continuing interest in the standardization of test methods.

At FRC, examination of the fine structure of coal and coke by scanning electron microscope and by electron probe was pursued.

Further work at MREC on the applicability of Arsenazo III as indicator for determining sulphur in coal by the oxygen-flask method has shown that this method was comparable in accuracy to the Eshka method and was applicable to Canadian coals over wide ranges of sulphur and ash contents. Experiments have also indicated its applicability to determining total sulphur in coke and coke-oven tars. Investigation was started on applying the titration part of the method to determine trace amounts of sulphate ion in water. A paper on "Analysis of Total Sulphur in Canadian Coals by a Modified Oxygen-Flask Method Using Arsenazo III", by S. M. Ahmed and B. J. P. Whalley, was submitted to *Fuel* (London) for publication[16]. Methods of analysis for mercury in coal and in coke-oven tars using dithizon and a spectro-photometer are under study at MREC.

PREPARATION

To meet the specifications on coal for export to Japan, mine operators in western Canada continued extensive installations or modifications of coal beneficiation plants. Among these are the new preparation plants of Cardinal River Coals Limited and McIntyre Porcupine Mines Limited where heavy media, froth flotation and either thermal or mechanical drying is used. Difficulties, at Kaiser Resources Limited's new preparation plant, associated with excessive fine coal and oxidized coal led to study and modification of the facilities.

At the Western Regional Laboratory, the integration of coal-cleaning and dewatering facilities was completed on a pilot-plant scale. A major contribution toward the development of this process was made by the installation of a pilot plant for the mechanical dewatering of coal slurries, resulting either from the cleaning stage in the existing compound water-cyclone circuit or from other sources. The drying characteristics of a variety of coals were determined with special reference to their size distribution, the solids content of effluent or of slurry, the coal's affinity to different oils, and the effects of conditioning time and centrifugal acceleration on the free-water content of the finished product. The pilot-plant studies provided information on the dewatering characteristics of screens and centrifuges handling coal-effluents and slurries that had been conditioned with small amounts of oil. The ash reduction that results from the affinity of oil for coal is an additional advantage of oil-assist dewatering over thermal drying. As has been noted under Transportation, WRL was active on coal preparation work related to pipeline transportation.

Low-quality coal often means that ash and sulphur are finely disseminated in the coal structure and very fine grinding is required to liberate them from the carbon. The use of chemical pyrite depressants, and the use of bacteria to selectively oxidize the pyrite to the soluble sulphate form, coupled with agglomeration, are potentially valuable means of removing pyritic sulphur from coal. The National Research Council of Canada conducted projects on the spherical agglomeration of coal fines with a view to upgrading them, in particular desulphurizing them[17].

Also at WRL, a beneficiation process for upgrading lignite has been developed. It consists of simultaneously washing to reduce ash content and leaching to remove sodium salts, using a calcium additive for ion exchange. The removal of sodium salts leads to control of ash fusion temperature. Prevention of spontaneous self-ignition of processed lignite and charred lignite is currently being studied.

CARBONIZATION

With the great increase in exploration of Canadian coking coal resources has come increasing demands on the facilities available to evaluate the coking properties.

At MREC, an 18-in movable-wall oven was commissioned in 1970 and operated sporadically pending final standardization. A new 12-in movable-wall coke oven is being erected and will eventually replace the original unit, which has operated continuously since 1961. Also under consideration is a request from the coal industry to locate additional and adequate testing facilities in western Canada for the evaluation of coking coals. Such facilities would alleviate the work load on the facilities in Ottawa and provide more time for the essential long-term research. At MREC, a petrographic laboratory was set up to conduct maceral analyses of those component coals associated with evaluation studies done for the coal and steel companies. The microscope is regarded by this group as useful for the visual examination of coke, particularly specially prepared cokes which cannot be evaluated by standard techniques.

In 1970, MREC continued its studies on form coking in cooperation with the Canadian Carbonization Research Association. This program was undertaken to develop and operate laboratory and small-scale test equipment for investigating the application of form coking to Canadian coals and for identifying the important parameters. Where possible, these parameters and the properties of the resultant cokes would be correlated so that the potentialities of particular Canadian coals for form coking and associated processes could be assessed. A vertical, sand-filled retort for simultaneously carbonizing several coal briquettes under precisely monitored temperatures and under controlled conditions of atmosphere has been built and calibrated. On different coals, the effects of gas pressure, static pressure (head of sand) and the influence of volatile matter during coking are under investigation. The coke quality is characterized by mechanical strength tests and by petrographic techniques. To aid in form coke studies, a fluid-bed macro-differential thermal analyzer, for a 10-g sample, has been designed and built and is being tested for the scanning of thermal-indicating physical and chemical reactions involved in the treatment of coals and chars prior to final carbonization.

A coke reactivity test is under development at MREC using the reaction between coke and carbon dioxide. The rate of flow of carbon dioxide to the coke bed will be adjusted to give a predefined composition of the reaction gases and that rate of flow will be taken as a measure of the reactivity. The composition of the reaction gases will be monitored with a gas chromatograph.

At RCA, gas chromatographic studies of tar formation between 350°C and 550°C have confirmed that small amounts of nitric oxide will significantly alter the formation kinetics and yields of tar components having low molecular weights. Also at RCA, studies were initiated to yield specific information on rates of weathering of western Canadian coking coals. Also, a preliminary investigation into the composition of pyrolysis products of fresh and oxidized coal at 500°C has been undertaken. In progress are efforts to explore the connection between loss of coking properties and build-up of oxygen-bearing functional groups in coal during "weathering".

RCA submitted a paper for publication in *Fuel* discussing some of the structural changes which coals undergo during interaction with excited hydrogen species and outlining the principal features and routes of the over-all reaction between hydrogen and coals[18].

CARBONS

Concern over air and water pollution, and new anti-pollution legislation has stimulated interest in coal-based carbons as pollution control media. Therefore, Canadian laboratories are intensifying R and D on such materials.

In Alberta, a company has been incorporated for the purpose of exploiting RCA's R and D on activated carbons, and final plans for a manufacturing plant, to be located in Lethbridge, have been developed. The plant will have an initial capacity of 1-2 million lbs/yr. A notable feature of the plant will be a relatively cheap fluid-bed reactor which is expected to furnish granular as well as powdered activated carbon.

Technical and other difficulties forced postponement of planned industrial trials of sized coke as a water filtration medium in Saskatoon's water treatment plant[19].

Laboratory tests at RCA have followed up a U. S. Bureau of Mines report that aerated activated carbons facilitate the oxidation of Fe^{++} to Fe^{+++}, a topic

which bears on the disposal of acid ferruginous mine effluents. Batch flow tests with aqueous solutions of ferrous iron have shown that oxidation occurs rapidly and that spent carbon columns can be fully regenerated by periodic back-flushing with tap water. A first paper on the results of the laboratory studies was prepared and arrangements were made for a small-scale test at a mine site in the summer of 1971.

In its studies of various aspects bearing on the preparation and properties of oriented synthetic graphites, RCA has done some preliminary carbonization experiments with anthracene and anthracene derivatives containing heterocyclic oxygen. X-ray diffraction patterns of chars prepared from these compounds at 750°C indicate quite significant ordering of graphitic layer-planes, but also suggest that orientation is a function of oxygen concentration and of the location of oxygen in the precursor molecule. It is believed that this line of enquiry will eventually explain why some coals can be easily electro-graphitized and why others merely furnish disordered carbons while subjected to such high-temperature processing.

The Saskatchewan Research Council has evaluated lignite, lignite char, lignite carbon and fly ash for their roles in purifying domestic sewage. The reliability of the experimental program was improved by using a standard synthetic sewage of definite composition containing dextrose, beef extract and peptone. Although the mixture simulates domestic sewage fairly well, the components were studied individually as well as mixed in order to determine where the strengths and weaknesses of the treatments lie. The chemical oxygen demand (COD) was chosen as an indicator of the degree of purification. The beef extract, which is largely protein, was effectively removed by lignite char; peptone, which consists of amino acids, was removed fairly effectively by the fly ash. Dextrose was the most difficult component to remove and was removed meagerly by all adsorbents. The main contribution of fly ash is an improvement in filterability of treated waters. The studies indicate some merit in a mixture of adsorbents with which fly ash is included for the treatment of domestic sewage.

With the present concern over phosphate pollution in domestic sewage, it was imperative that some testing of phosphates be conducted. Fly ash was less efficient by two orders of magnitude than lime, but the filterability was much better than with lime. This indicates that lime and fly ash might be used together.

COMBUSTION

Canadian Combustion Research Laboratory has broadened its research on air quality as part of FRC's activities under the Environmental Improvement objective of MERP.

The atmospheric dispersion factors project of this laboratory, relating to the dispersion of smoke plumes from large coal-fired thermal power plants, continued. This project, which was initiated in 1969 with the collaboration of the Ontario Air Management Branch, the Canadian Meteorological Service of the Ministry of Transport and others, has been formalized as an MOT-EMR five-year Interdepartmental Research Program. In this program, it is planned to proceed to the far north as instrument development for arctic conditions permits. The second aerial probing of plumes from the Lake View Plant of Ontario Hydro was completed and the data obtained forms the basis of a paper presented before the World Energy Conference at Bucharest in July 1971[20].

Initial light-up with a research burner of the flame research tunnel furnace at FRC was realized. This facility will be used to investigate burner performance, combustion aerodynamics and mechanisms of pollutant formation.

Committees were set up by the Canadian Coal Producers, Transporters and Consumers Research and Development Group to support combustion studies on coal middlings and low-rank coals.

COAL CHEMISTRY

In connection with studies of coal chemistry and constitution, RCA has continued efforts to isolate and characterize the components of mixed alkyl-substituted aromatic acids in which the alkyl groups appeared to contain up to four carbon atoms; these acids result from treating coal with acqueous hypohalite solutions. So far, a quantitative separation has been limited to acetic and propionic acids. By chromatographing the remaining acids as their methyl esters, it has been possible to define four groups which all contained more than two carbon atoms in their alkyl chains. It is tentatively concluded that coal contains one n-propyl group for every structural unit having a molecular weight of 1500, that at least one n-butyl group is shared by three such units and that the alkyl-substituted aromatic acids comprising the non-distillable portion of the product mixture support the contention that coal derives mainly from lignin.

Also at RCA, results of a laboratory enquiry into the suppression of caking properties by boron trifluoride have been analyzed and a paper has been prepared[21]. It appears that the loss of caking propensities can be directly associated with limited molecular degradation of pyrolytically generated chloroform-soluble matter and consequent reduction in the amount of "plasticizer" capable of existing in the coal at temperatures between 350 and 450°C. Preliminary experiments on destruction of caking properties by atmospheric oxidation ("weathering") indicate a similar mechanism.

AGROBIOLOGICAL USES OF COAL

In a paper published in *Soil Section*[22], it is shown that nitrogen-enriched coal prepared by oxidative ammoniation is, in effect, agrobiologically inert. This represents the completion of a cooperative study on the subject by RCA and the University of Alberta.

RCA is also investigating the agrobiological properties of humanides, the physiological effects of humic acids on plants, and the effects of coal, oxidized coal and humic acids on soil structures.

The Saskatchewan Research Council has evaluated the stimulation of root initiation and plant growth by coal-derived humic compounds. Photographs of root systems of geranium slips in various media gave convincing evidence of enhanced growth as a result of additions of humic extracts. Besides the greater abundance of primary and secondary roots in the humate solution, there was also conspicuously greener foliage on the slips in these solutions. More quantitative data are being sought. At the present time, rates of root elongation are being determined as well as the total root development. The latter is assessed by a recognized procedure of counting the number of fibres in randomly selected areas of the flattened root system. The quantitative aspects of the study are being performed for the purpose of obtaining more convincing information about the growth stimulation of humates than that presented pictorially.

COAL CONFERENCES

The 22nd Canadian Conference on Coal was held in Vancouver, September 29—October 2, 1970. Conference proceedings were published. Future coal conferences were scheduled in Ottawa, September 19-22, 1971 and in Edmonton, September 22, 1972.

The Coal Division of The Canadian Institute of Mining and Metallurgy held technical sessions at the Annual General Meeting of the Institute in Toronto, April 20-22, 1970. Papers from this meeting are being published in the *CIM Bulletin.*

The North American Fuel Technology Conference was held at the University of Ottawa, May 31—June 4, 1970. Proceedings of the conference were published.

Papers on coal were included in the program of The Mining Society of Nova Scotia meeting at Ingonish in June, 1970; some of the papers are being published in the *CIM Bulletin.*

PAPERS PRESENTED AT COAL CONFERENCES IN 1970

1. The Canadian Institute of Mining and Metallurgy — Coal Division, and The Mining Society of Nova Scotia

"Developments in Coal Mining, 1969", H. Zorychta, Department of Energy, Mines and Resources, Elliot Lake, Ontario (CIM).

"Fibrous Dust — Its Measurement and Control", G. S. Rajhans, Occupational Health Service, Public Health Division, Department of Health, Toronto, Ontario (CIM).

"Tyndalloscope Experiences Under Mine Working Conditions", R. B. Fermor, Safety and Ventilation Services, Quebec Mining Assoc. Inc., Val d'Or, Quebec. (CIM)

"Diffusional Analysis of Seam Gas Emission in Coal Mines", Prof. I. McC. Stewart, Head, Department of Chemical Engineering, University of Newcastle, N.S.W., Australia. (CIM)

"The Emission of Gas From Coal", Prof. T. H. Patching, Department of Mining and Metallurgy, University of Alberta, Edmonton, Alberta. (CIM)

"Canadian Mining in the Seventies", A. E. Boone, Director of Planning, Joy Manufacturing Co. (Canada) Ltd., Galt, Ontario. (CIM)

"In-Situ Analysis of Coal by Borehole Logging Techniques", D. R. Reeves, General Manager, Instrument Division, BPB Industries Limited, East Leake, Leicestershire, England. (CIM)

"The Planning of a Modern Coal Mine", V. Greensmith, Cape Breton Development Corporation, Sydney, Nova Scotia. (MSNS)

2. 22nd Canadian Conference on Coal

"Ocean Transportation", J. F. Cunningham, President, Gibson Transportation Limited, Vancouver, British Columbia.

"Coal by Unit Train on the Burlington Northern", George R. Powe, Assistant Vice-President, Burlington Northern Railway, St. Paul, Minnesota, U.S.A.

"Coal Mining Safety and the New British Columbia Legislation", A. R. C. James, Department of Mines and Petroleum Resources, Province of British Columbia, Victoria, British Columbia.

"The Development of a New Mining Town", L. G. Price, Manager of Coal Division, and R. A. Hislop, Divisional Controller, McIntyre Porcupine Mines Ltd., Grand Cache, Alberta.

"Controlling Health Hazards in Coal Mining", Dr. C. R. May, Director, Division of Industrial Health Services, Province of Alberta, Edmonton, Alberta.

"United States Coal — The All-Purpose Energy", Geo. Fumich, Director, Office of Coal Research, United States Department of the Interior, Washington, D.C., U.S.A.

"Modern Mine Management", Gerald Blackmore, Vice-President, Coal Division, and J. V. Greensmith, Cape Breton Development Corporation, Sydney, Nova Scotia.

"Coal Deposits of Western and Northern Canada", B. A. Latour, Staff Geologist, Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, Calgary, Alberta.

"Exploring For Coking Coal", J. J. Crabb, Exploration Manager, Crows Nest Industries Ltd., Fernie, British Columbia.

3. North American Fuel Technology Conference

SESSION 1: UTILIZATION AND CONSERVATION OF FUELS RESOURCES

"Energy Conversion and Fuels Reserves", M. A. Elliott, Corporate Scientific Advisor, Texas Eastern Transmission Corporation, Houston, Texas, U.S.A.

"Fuels for Electric Power Generation", E. H. Manny, Esso Research and Engineering, and A. R. Crawford, Esso Mathematics and Systems, Linden, N.J., U.S.A.

"Fuels for Transportation", R. C. Amero, Gulf Research and Development Co., Pittsburgh, Pa.. U.S.A.

"Non-Energy Uses for Fuels", G. Alex Mills and John Tosh, U.S. Department of the Interior, Bureau of Mines, Washington, D.C., U.S.A.

SESSION II: TRENDS IN FUEL SCIENCE

"Objectives in Fuels Research", N. Berkowitz, Head, Coal Research Division, Research Council of Alberta, Edmonton, Alberta, Canada.

"The Aerodynamics of Flames", R. Cheradame, Centre d'Etudes de Recherches des Charbonnages de France, Paris, France.

"Turbulent Flames in Rotating Flow Systems", John Beér, Head, Department of Fuel Technology and Chemical Engineering, University of Sheffield, Sheffield, England, and W. Leuckel, Senior Investigator, International Flame Research Foundation, IJmuiden, Holland.

"High Intensity Combustion", T. D. Brown, University of Sheffield, Sheffield, England, and V. I. Hanby, Research Fellow, University of Sheffield, Sheffield, England.

"Effect of Inorganic Matter on Combustion", H. R. Hoy and J. D. Watt, BCURA Industrial Laboratories, Leatherhead, England.

SESSION III: NEW APPLICATIONS OF FUELS TECHNOLOGY

"Advanced Heat Processes", G. Whittingham, Head, Fuel Oil Section, Technical Services Branch, BP Trading Limited, London, England.

"New Fuel Developments in Metallurgy", J. H. Flux, British Steel Corporation, Midland Group, Research and Development Department, Rotherham, Yorkshire, England.

"Agricultural Uses of Fuels", D. Panar, D. Panar Associates Engineering Ltd., Edmonton, Alberta, Canada.

"New Directions in Power Generation",
Part I — MHD:
S. Way, Consultant, Westinghouse Research and Development Centre, Pittsburgh, Pa., U.S.A.
Part 2 — Fuel Cells:
D. L. Keairns and D. H. Archer, Chemical Engineering Research, Westinghouse Research and Development Centre, Pittsburgh, Pa., U.S.A.

SESSION IV: THE EFFECT OF FUELS ON THE ENVIRONMENT

"The Engineering Approach to Environmental Control", W. J. Moroz, Director, Center for Air Environment Studies, Pennsylvania State University, University Park, Pa., U.S.A.

"Behaviour of Hot Plumes Under Stable Conditions", Betsy Woodward Proudfit, Sign X Laboratories, Inc., Essex, Conn., U.S.A.

"The Problem of Sulphur in Fuels", J. R. Garvey, Bituminous Coal Research Incorporated, Monroeville, Pa., U.S.A.

"Incineration of Wastes", Richard B. Engdahl, Battelle Memorial Institute, Columbus Laboratories, Columbus, Ohio, U.S.A.

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Plans Announced for AIME's 101st Annual Meeting

THE AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS (AIME) will hold its 101st Annual Meeting in San Francisco, February 20-24, 1972. The San Francisco Hilton, the St. Francis Hotel and the Fairmont Hotel have been designated as the headquarters for the five-day event. The Annual Meeting coincides with the 56th Annual Meeting of the Woman's Auxiliary, AIME, which will have its headquarters at the San Francisco Hilton.

The 101st Annual Meeting is offering a comprehensive technical program encompassing the latest technological developments in mining, metallurgy and materials science. The program will include 10 All-Institute sessions, 37 sessions scheduled by the Society of Mining Engineers of AIME and 46 sessions planned by The Metallurgical Society. There will be more than 400 technical papers presented to the over 4,000 expected guests.

Prior to the meeting, two Short Courses are being offered by the Society of Mining Engineers of AIME and The Metallurgical Society of AIME. The SME course, which is titled "Financial Analysis in the Mining Industry", and the TMS offering on "Technical Economics for Metallurgists and Miners" are both two-day courses commencing on February 18, 1972.

For the social enjoyment of the attendees, a one-day field trip to The Geysers in Northern California has been scheduled for February 24, along with a seven-day Post-Meeting tour of Hawaii from February 24 to March 3, 1972.

To be placed on the Advanced Mailer list, contact Alexander R. Scott, AIME, 345 East 47th Street, New York, New York, 10017. The Mailer will include the complete program of paper presentations and housing and pre-registration forms.