War history of the Associate Committees of the National Research Council

National Research Council of Canada

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NATIONAL RESEARCH COUNCIL OF CANADA

WAR HISTORY
OF THE
ASSOCIATE COMMITTEES
OF THE
NATIONAL RESEARCH COUNCIL

OTTAWA

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PREFACE

This volume of the war history of the National Research Council contains reports on the work done by the Council's Associate Committees - with the exception of those on medical research - which were active during World War II. Because of the great amount of medical research, reports on the Associate Committees on Naval, Army and Aviation Medical Research have been issued in separate volumes.

The information given in regard to the individual committees is based on reports prepared by the various committee secretaries on the work done during the period of hostilities from 1939 to 1945.

In addition to the Associate Committee mentioned in this volume, there were others under whose auspices research problems were investigated in the laboratories of the Council during the war; reports of the work of these committees have been included in the war histories of the individual Divisions concerned. List No. 1 following this preface names such Associate Committees.

Several other Associate Committees continued to function during the war, but since their work was entirely of a peacetime nature, no war histories were written for them. The names of the committees in this group are given in List No. 2 following this preface.

LIST NO. 1

Associate Committees Reported in Divisional War Histories.

Aeronautical Research	reported by	Mechanical Engineering
Food Preservation	" "	Applied Biology
Photographic Research	" "	Physics and Electrical Engineering
Plant Breeding	" "	Applied Biology
Transshipment of Perishables	" "	Applied Biology

LIST NO. 2

Associate Committees For Which War Histories Not Written.

Asbestos	Geodesy and Geophysics
Corrosion	High Temperature Metals
Dental Research	High Voltage Systems
Field Crop Diseases	Industrial Chemists
Fish Culture	National Building Code.

A. GENERAL INTRODUCTION

Associate Committees were established by the National Research Council early in its history and the mechanism proved so useful that it has been continued and expanded into one of great strength and usefulness. This mechanism became well known during the war as a distinctive Canadian method of carrying on co-operative researches and the effectiveness of the system has received general commendation.

In the early days, the founder members of the National Research Council recognized the need for bringing experts together to discuss general subjects on which research might profitably be done in the national interest. When a subject of study was proposed, the usual practice was to select a group of the leading authorities in that particular field and invite them to come together for a discussion of the problem. Three questions were generally put to such groups: (a) What is the general situation in Canada in respect of the proposed studies? (b) What are the gaps in knowledge of it that could be filled by adequate research? (c) Where and by whom should such new research be undertaken?

Utilization of Canada's natural resources and the development of improvement of processes to this end were the chief objectives of the several committees.

It may here be noted that the successes achieved by the National Research Council through its Committees have been due to the whole-hearted support given to the Council by the hundreds of specialists who accepted invitations from the Council to serve, without remuneration, on the numerous Committees and to bring the wealth of their knowledge and experience to bear on the solution of the problems put before them. Co-operation has been the keystone in the arch of this organization, and has given strength and assurance to the Council in the pursuit of many useful lines of research. It is a pleasure to pay a well deserved tribute to Canadian scientists who have participated in this plan.

"At the outbreak of war, the work of the Associate Committees was immediately reviewed. Some Committees were engaged on peacetime problems that could be laid aside for the duration, and this was done in order that all available facilities might be directed toward the solution of war problems. Other Committees were engaged in long-term projects, such as plant-breeding, in which discontinuance would mean the loss of records secured over long years of patient research. This need was recognized and such work was continued. It was found that the activities of many Committees could be re-directed and applied to the study of war problems and full advantage was taken at once of such possibilities. The history of the Associate Committees of the Council is replete with examples of outstanding achievements and notable developments that did much to improve the weapons and equipment used by the fighting forces, and to promote the welfare, comfort and safety of the troops at sea, on lnad and in the air.

All Committees of the Council that were active during the war have been included in this record, but detailed reports have been made only on the work of those that were directly associated with the Council's war effort.

Much of the war work planned and directed by Associate Committees was carried on in the Laboratories of the Council; while references to such projects are made in this part of the war history, more complete information will be found in the several volumes describing the war activities of the laboratory Divisions.

Because of their great growth during the war, particularly through the three Service Committees, the work of the Medical Committees has been described in separate volumes - Aviation, Naval and Army Medical Research.

The Associate Committees referred to in this volume have been arranged in alphabetical order. The Special Committees are treated likewise.

B. ASSOCIATE COMMITTEE ON BALLISTICS AND FIRE CONTROL

Early in 1942, a great deal of scientific research and development in the field of ballistics and fire control was being carried out in Canada in various establishments. The suggestion was made that this might be co-ordinated by using the facilities of the National Research Council in the formation of an Associate Committee on Ballistics and Fire Control. Two preliminary meetings were held to discuss the problem and the location of various laboratories doing the work. Development work in the field covered was being done independently in various parts of the National Research Council, notably, the Division of Mechanical Engineering, and the General Physics Laboratory and the Radio Branch of the Division of Physics and Electrical Engineering. Work was also being done at the Ballistics Laboratory of the Artillery Proof and Experimental Establishment, Valcartier, Quebec (Inspection Board of the United Kingdom and Canada). Some special problems were also covered independently, in such groups as the Directorate of Artillery, and in the Department of Munitions and Supply and at the John Inglis Company's plant at Toronto. These were largely co-ordinated financially by the Army Technical Development Board but scientific co-ordination was more or less of an ad hoc nature.

At preliminary meetings it was decided to organize an Associate Committee of the National Research Council and the first meeting was held on 2 December, 1942. The membership was chosen from senior administrative officers of the departments concerned as follows:

Name	Representing
Major General A.E. Macrae (Chairman)	Department of Munitions and Supply
Dr. C.J. Mackenzie (ex officio)	National Research Council
Honorary Representative of the U.S. Ordnance Committee	U. S. A.
Honorary Representative of National Defence Research Committee	U. S. A.
Colonel W.W. Goforth	Department of National Defence

Name	Representing
Major J.E. Hahn	Army Technical Development Board
Brigadier G.B. Howard	Inspection Board
Mr. C.J. Klein	National Research Council (Mechanical Engineering)
Brigadier G.P. Morrison	Department of National Defence
Mr. C.S. Parsons	Department of Mines and Resources
Dr. D.C. Rose	National Research Council (Physics and Electrical Engineering)
Air Vice-Marshal E.W. Stedman	Royal Canadian Air Force
Captain R.W. Wood	Royal Canadian Navy
Chairmen of Subcommittees (ex officio)	
Dr. W.L. Webster (Secretary)	National Research Council

At the first and only meeting of the Committee, a comprehensive list of possible problems and where they should be carried out was studied. This list had been prepared by the secretary in consultation with the various members.

The Committee appointed two subcommittees one on "Ballistics" and the second on "Fire Control".

These two subcommittees each met once and studied in more detail the list of problems reviewed by the main committee. No definite action was taken in either subcommittee. It was apparent that most of the problems being undertaken were to meet an immediate requirement and, as such, were distributed about the various suitable establishments as fitted their capabilities. Except to recommend continued studies in ballistics and fire control, the Committee and subcommittees made no plans for longer range scientific work, probably for two reasons, - firstly, the membership personnel was too largely composed of senior administrative officers rather than scientists working in the field; secondly, because all available facilities and personnel in Canada seemed so fully occupied that widening the scope of work in this field seemed impossible. No further meetings were held.

C. CANADIAN GOVERNMENT PURCHASING STANDARDS COMMITTEE

The Canadian Government Purchasing Standards Committee was organized in June, 1934, for the purpose of preparing specifications for the use of government departments in the purchase of supplies. It is essentially a co-operative body, the National Research Council providing the nucleus for co-ordination of activities, and supplying the secretariat as well as the facilities for reproduction and distribution of specifications.

The Committee, in 1945, was composed of the Deputy Ministers of the Departments of Agriculture, Fisheries, Justice, Mines and Resources, National Defence (Air, Army, and Navy), National Health and Welfare, Post Office, Public Printing and Stationery (King's Printer), Public Works, Trade and Commerce, and Transport; the Under-Secretaries for External Affairs, and State; the Commissioner of Royal Canadian Mounted Police; and the Secretary of the Civil Service Commission. The President of the National Research Council was Chairman of the Committee. Mr. A.F. Gill acted as organizing secretary of the Committee from its inception until the outbreak of war, when the work was taken over by Mr. C.C. Weeks. Mr. Weeks left at the end of July 1941, and was succeeded by Dr. C.A. MacConkey, who was acting secretary from that date until the end of June, 1943. Mr. P.L. Pouliot acted as secretary until about the middle of August, 1943, when Mr. D. Wolochow took over the position of acting secretary. A subcommittee on Plans and Administration served as an advisory body, and as a committee on finance.

The work of the Committee was carried on through sixteen subcommittees and seven panels, as follows:- Subcommittees and Panels on Paitn and Pigments, and Soap and Detergents; Wartime Subcommittee on Petroleum and Associated Products; Subcommittee on Panel on Textiles; Subcommittee on Leather, Stationery Forms, Standard Testing Sieves, Paper Quality, Refractories, Wood Preservation, Chemicals, Road Materials, Solid Fuels, Rubber Products; Wartime Subcommittee on Wire and Cable; and Panels on Safety Glass, Fire Hose, Thermometers, and Hydraulic Fluids.

These subcommittees and panels drew their membership from government departments that are interested in a particular field, either as consumers or because they have technical knowledge of the materials concerned. Whenever necessary, advice and co-operation of industry was sought, and in the case of the Wartime Subcommittee on Petroleum and Associated Products, the industry was directly represented by two members.

The progress of the work of the Committee is perhaps best reflected by the demand for its specifications, the distribution of which increased steadily, as shown in the following table:-

Fiscal Year	Yearly Total	Monthly Rate
1940-41	5,200	430
1941-42	12,900	1,075
1942-43	13,900	1,160
1943-44	30,900	2,575
1944-45	36,200	3,020

The number of specifications on issue increased from approximately 150 at the outbreak of war to a total of 220 up to V-E Day. To keep these specifications up to date required, on the average, the revision and re-issue of about thirty specifications and the issue of approximately thirty amendments per year.

After the outbreak of the war as much of the work as possible has been carried out through correspondence; nevertheless, the number of meetings required increased so that during the fiscal year 1944-45 about fifty were held.

CANADIAN CO-OPERATIVE AVIATION FUEL EXCHANGE

The Aviation Fuel Exchange, organized in May, 1941, on the recommendation of the Associate Committee on Petroleum, had, in 1945 a total of 24 participating laboratories. Seven oil companies distributed in rotation three monthly samples to each of these. The results of the tests were compiled into detailed monthly reports, copies of which were sent to the participating laboratories and ten others interested. The exchange afforded the various laboratories an opportunity of comparing the performance of their octane rating engines and of estimating the accuracy of their other test work on aviation fuels. Data obtained on the reproducibility of the method for determining tetraethyl lead were made the basis of a special report.

CANADIAN CO-OPERATIVE LUBRICANT EXCHANGE

To fulfill a somewhat similar function in the testing of petroleum lubricating products, there was organized a

Lubricant Exchange, which commenced operation in September, 1944. A monthly sample was analysed by the twelve participating laboratories, who reported their results to the secretary. These were put together into a monthly report, copies of which were sent to the participating laboratories, and sixteen others interested.

COMMITTEE ON CHEMICAL WATER STANDARDS

The secretary was also responsible for the operation of the Committee on Chemical Water Standards. This was a joint committee of the Chemical Institute of Canada and the Canadian Public Health Association. Its activities were largely concerned with problems of water and sewage analysis and the development of improved methods. It worked in close co-operation with the Joint Editorial Committee on Standard Methods for the Examination of Water and Sewage, of the American Public Health Association and the American Water Works Association which publish Standard Methods of Water Analysis. Owing to the increased duties which devolved on its personnel after the outbreak of war, the activities of the Committee were restricted. It met annually however, and work was continued on a limited number of problems, among which may be mentioned the development of a satisfactory method of determining chromium compounds in water and sewage, a problem which came to importance as a result of growing war industry, and a method for determining fluorine in water.

D. ASSOCIATE COMMITTEE ON EXPLOSIVES

The Associate Committee on Explosives was established in 1942 to supervise and co-ordinate the Council's participation in the scientific development of high explosives and propellants. Quite early in the war, the Advisory Committee of Industrial Chemists established a Subcommittee on High Explosives and, under the leadership of this subcommittee, research on explosives was started in several universities. Out of this research came several new explosives or new processes for the manufacture of existing explosives.

Under the terms of reference for the Associate Committee on Explosives it was provided that this Committee should be responsible to the National Research Council for:

1. The formulation of general policy for and the correlation with other interdepartmental activities of the contribution of the National Research Council in the field of explosives.

2. The co-ordination of work and the determination of programmes carried out under its auspices and allocated to its subcommittees.

3. The approval of and assignment of priorities for projects to be carried out under its auspices and the determination of financial support therefor from the allotment of funds made available to the Committee by the National Research Council.

4. The selection of staff required for the work of the Committee.

It was further provided that the Associate Committee on Explosives would respect the agreement between the Department of Mines and Resources and the National Research Council which governed the maintenance and operation of the Explosives Testing Establishment on the Montreal Road site of the National Research Council. The Associate Committee on Explosives was to co-operate on matters of common interest with the Associate Committee on Explosives Testing Laboratory, which continued to be charged by the National Research Council with the duty of implementing that agreement.

The Associate Committee on Explosives was also to note the need for co-operation on matters of common interest with the Associate Committee on Ballistics and Fire Control.

The constitution of the Associate Committee on Explosives was as follows, subject to such revision as authorized from time to time by the National Research Council:-

Name	Representing
Brigadier G.B. Howard (Chairman)	Inspection Board
Dr. C.J. Mackenzie (ex officio)	National Research Council
Honorary Representative of the National Defence Research Committee	U.S.A.
Mr. J.R. Donald (or Dr. J.H. Ross)	Department of Munitions and Supply
Colonel W.W. Goforth	Department of National Defence
Major J.E. Hahn	Army Technical Development Board
Dr. O. Maass	Department of National Defence
Dr. E.W.R. Steacie	National Research Council (Chemistry)
Colonel F.E. Leach	Department of Mines and Resources
Chairmen of Subcommittees (ex officio)	
Dr. W.L. Webster (Secretary)	National Research Council

Subcommittees were established at the first meeting of the main Committee as follows:

Research Subcommittee

Terms of reference of this subcommittee were to:

(i) explore the science of high explosives and propellants and recommend to the Associate Committee on Explosives problems suitable for attack giving for each project submitted advice about its direction, an indication of its importance and of the facilities available at the location proposed, and estimates of additional special facilities needed, of the time necessary to complete the project and of financial requirements.

(ii) supervise all projects approved and allocated to it by the Associate Committee on Explosives; arrange to receive and examine progress and other reports submitted periodically by directors of projects; and transmit regularly such reports with appropriate comments and recommendations to the Associate Committee on Explosives.

This subcommittee was made up of representatives of the University of Toronto, McGill University, the Departments of Mines and Resources, National Defence, Munitions and Supply, the Inspection Board, Canadian Industries Limited, Shawinigan Chemicals and the National Research Council.

Development Subcommittee

Terms of reference of this subcommittee read as follows:

This subcommittee shall be concerned primarily with pilot plant and similar scale work and shall be responsible particularly for the development and activities of the Experimental Explosives Establishment to be organized at Valcartier. The subcommittee shall:

(i) within this competence explore and recommend to the Associate Committee on Explosives developments worth undertaking, giving for each project submitted any advice about its direction which may appear useful, an indication of its importance and of the facilities available for its prosecution, and estimates of additional special facilities needed, of the time necessary to complete the project and of financial requirements.

(ii) supervise all projects approved and allocated to it by the Associate Committee on Explosives; arrange to receive and examine progress and other reports submitted periodically by the directors of projects; and transmit regularly such reports with appropriate comments and recommendations to the Associate Committee on Explosives.

This subcommittee was made up of representatives of the Inspection Board, the Departments of National Defence and Munitions and Supply, the University of Toronto and the National Research Council.

Testing Subcommittee

Terms of reference:

This subcommittee shall be concerned primarily with co-ordinating activities of the Associate Committee on Explosives with those of the Explosives Testing Establishment and Associate Committee on Explosives Testing Laboratory. The subcommittee shall:-

(i) within this competence explore and bring to the attention of the Associate Committee on Explosives any question relating to the testing of explosives which that Committee may appropriately consider jointly with other agencies concerned.

(ii) maintain contact with and report progress regularly to the Associate Committee on Explosives on any project relating to the testing of explosives with which that Committee may be concerned.

Members of the subcommittee included representatives of the Inspection Board, the Department of Mines and Resources and the National Research Council.

The Subcommittee on Research and the Subcommittee on Development were later combined into a Research and Development Subcommittee.

At the third meeting of the combined Research and Development Subcommittee it was proposed that further subcommittees should be established to deal with technical problems in relation to research and development, and the appointment of the following subcommittees was recommended:

(a) Propellants
(b) Chemical Studies of High Explosives
(c) Physical and Mathematical Studies of High Explosives
(d) Incendiaries, Pyrotechnics, Smokes and Fuses
(e) Polymers
(f) Raw Materials
(g) Development of High Explosives Compositions

Personnel for these subcommittees were to be named later. Actually some of the proposed subcommittees were not formed, but Propellants and Polymers became quite active. The Propellants Subcommittee later (at its 12th meeting) became the Subcommittee on Propellants and Internal Ballistics.

The Polymer Subcommittee was formed to study the part that polymers could play in imparting useful physical properties to military explosives. It was noted that if a polymer happened to be explosive, the force of the composition might be maintained at a high figure. Nitroglycerine often exudes from cordite and the highly crystalline explosive used to replace nitroglycerine have only a limited compatibility with the guncotton. Plastic explosives usually consist of a granular explosive of low molecular weight "plasticized" with some inert substance. These were two instances in which suitable explosive polymers might be of value. There seemed to be no specific information from the Services as to what was wanted in the way of explosive polymers and this situation made it difficult to delimit the scope of the subcommittee's activities. This subcommittee continued to be active during the life of the main Committee.

A Pyrotechnics Subcommittee was established in January, 1944, to explore this field and to plan a line of attack. During the next few months several additional meetings were held.

Later, a Panel on Fundamental Properties of Explosives was formed and several meetings were held.

A summary of extra-mural research on explosives carried out in Canadian universities during the war will also be issued shortly; this volume contains a record of the principal research and development work carried out on the recommendation of the Associate Committee on Explosives, but since much of the material is still classified as "Secret", it cannot be included here. Reports of work done during the war, material for which is no longer classified, will also be published in the Council's Canadian Journal of Research in the near future.

E. ASSOCIATE COMMITTEE ON FORESTRY

The Associate Committee on Forestry was established in 1936 as the result of a conference held in the preceding year at the instance of the Woodlands Section of the Pulp and Paper Association and the Canadian Society of Forest Engineers.

Prior to the war, the Committee made a survey of forestry research in Canada and prepared a programme for the better co-ordination of work in this field. Attention was given to fundamental studies of silviculture and mensuration, forest products, forest economics, forest engineering, utilization of forest products and the general subject of education and public information on forestry subjects.

A booklet entitled "Farm Woodlots in Eastern Canada" was prepared and in co-operation with the provinces some 30,000 copies were distributed.

An extensive research was carried out on forest succession as influenced by fire, and a report was prepared.

Work was done on forest fire pumps, forestry hose, and fundamental studies were carried out on methods of determining fire hazard in the forests.

Close co-operation was maintained with forestry organizations and with the university forest schools in order to avoid duplication of effort.

General activities of the Committee during the war were reduced to a minimum but the work on forest tree breeding, which had been undertaken as a co-operative project and which was essentially a long-term study, was placed on a maintenance basis.

The following report deals with the accomplishments of the Subcommittee on Forest Tree Breeding in the period under review.

SUBCOMMITTEE ON FOREST TREE BREEDING

Introduction

The Subcommittee on Forest Tree Breeding is a co-operative body involving the Dominion Forest Service, the Dominion Department of Agriculture, and the National

Research Council. It was established in 1939 to administer work on forest tree breeding and propagation which had been started the previous year. The objective of the Subcommittee was to meet increasing forestry and agricultural requirements for rapid-growing, superior-quality, easily-propagated forest trees.

In 1938 the work on forest tree breeding and propagation, later to come under the Subcommittee, was placed on the footing of a comprehensive programme. The work centered mainly around hybridization in spruce, pine and poplar and vegetative propagation experiments in spruce.

The Subcommittee on Forest Tree Breeding was established in June 1939; when war was declared, the programme of the Subcommittee was in its early developmental stages and plans had been laid to make the following year (1940) a period of expansion, especially with respect to the establishing of a nursery, field laboratory and greenhouse at the new N.R.C. Annex, Montreal Road. But since the work had no direct bearing on the war effort, contraction rather than expansion took place. With the military disasters of May 1940, financial support was reduced to the point where the prospects of continuing the work were very poor.

The Subcommittee recognized the fact that, because of the long-term nature of the work and the potentially valuable breeding materials already on hand, an irretrievable loss would be suffered if the work were stopped. It was decided to make the most of what financial and other means remained and to proceed on a "maintenance basis". By utilizing an expropriated cottage and salvaged materials and equipment, a workable field laboratory and nursery was brought into operation at the N.R.C. Annex and, by doing double duty, the remaining personnel were able to carry the work forward at a reduced rate. The curtailment of automobile travel was a positive check on the field work and forced a great reduction of that essential phase.

Between the time of the first meeting of the Subcommittee (21 June, 1939) and April, 1945, fourteen meetings were held, all of which are duly recorded in Proceedings designated by meeting number. Prior to the establishment of the Subcommittee the deliberations were recorded in Proceedings of six "Conferences on Forest Tree Breeding and Propagation".

Reorganization of the Research Programme

The ninth meeting of the Subcommittee, held in June, 1942, was devoted to the reorganization of the research programme and special consideration was given to the relative emphasis to be placed on the various projects. The decisions of that meeting were the basis of the breeding and propagation programme in force during the last three years of the European war. The projects are briefly outlined below.

Production of Blister-Rust and Weevil-Resistant White Pine of Good Quality and Rapid Growth: This project, which was considered to be the most important, was divided into six sub-projects, with responsibility for each specifically assigned to one member of the Subcommittee.

Dr. C. Heimburger of the Dominion Forest Service was made responsible for acquiring native or exotic white pine and related stock, as seedlings, cuttings or seeds, which might be useful either for direct propagation or as parent material. He was to select promising types and individuals from this material and arrange for the testing for disease and insect resistance.

Dr. L. P. V. Johnson of the National Research Council was made responsible for the production of new forms by hybridization or by chromosome doubling, and for all genetical and cytological problems related thereto. He was to arrange for adequate testing of all promising material.

Dr. Johnson was also made responsible for maintaining the Disease Garden at the N.R.C. Annex. The facilities of this garden were made available to the members on approval of the transfer of material, and Dr. Johnson was responsible for reporting the results of disease garden tests to the member submitting the material.

Dr. N. H. Grace of the National Research Council was made responsible for the development of methods of vegetative propagation and related problems. In nursery phases of this work, he co-operated with Dr. Heimburger.

Dr. C. H. Riley of the Division of Botany of the Central Experimental Farm was asked to develop more expeditious methods of testing disease resistance. He also advised other members of the Subcommittee on pathological problems and undertook to make periodical examinations of the materials in the disease garden or otherwise under investigation for disease resistance.

The entomologist on the Subcommittee acted as advisor to the other members on entomological problems and was responsible for periodical examinations of the materials under test.

Other Projects: The following projects were also undertaken, with the responsibility for different phases assumed by various members of the Subcommittee as in the main project above:

a) Production of rapid-growing, high quality spruce for both pulpwood and lumber plantations in the accessible parts of the Eastern forest region.

b) Production of hardy, drought- and disease-resistant, high quality poplars for shelterbelt plantings on the Western prairies.

c) Production of rapid-growing, disease-resistant, high quality poplars for pulpwood, match stock, veneer, etc.

Consideration was also given to several minor projects which could not receive immediate attention due to lack of time and facilities. These included: production of high quality, rapid-growing hard pines; production of high quality, rapid-growing, easily propagated basswood; production of high quality, rapid-growing birch for veneer.

Progress During the War Years: In spite of substantial commitments to the war effort and the difficulties attendant upon a low priority rating in wartime, it was possible, with the co-operation of Subcommittee members in the Forest Service and the Department of Agriculture, to achieve gratifying progress in the forest tree breeding and propagation work during the war.

New spruce, pine, poplar, birch, ash and elm hybrids were added to the breeding material, new selections were made from the older hybrid populations and from native and introduced species in the test plots. New field-testing facilities were established on the prairies, for testing shelterbelt selections, and the disease garden (blister rust) at the N.R.C. Annex was greatly expanded to include a wide range of white pine materials. The vegetative propagation work resulted in devising methods for rooting spruce and pine cuttings. New forms of trees were produced through doubling the number of chromosomes by the colchicine treatment. Cytological observations were extensively made on colchicine-treated and hybrid materials. Nursery testing of all materials, whether hybrid, natural selection, introduced or colchicine-treated material, was carried out and the more promising types selected and established in test plantations under practical forest, wood-lot or shelterbelt conditions.

The following list of papers prepared for publication during the war years indicate specific instances of some of the wartime accomplishments of the National Research Council members of the Subcommittee.

REPORTS

Farrar, J. L. - Rooting of Norway spruce cuttings. Forestry Chron. 15: 152-163. 1939.

Farrar, J. L., and Grace, N. H. - Note on the propagation by cuttings of white pine and white spruce. Can. J. Research, C, 18: 612. 1940.

Farrar, J. L., and Grace, N. H. - Vegetative Propagation of Conifers. X. Effects of season of collection and propagation media on the rooting of Norway spruce cuttings. Can. J. Research, C, 19: 391-399. 1941.

Farrar, J. L., and Grace, N. H. - Vegetative Propagation of Conifers. XI. Effects of type of cutting on the rooting of Norway spruce cuttings. Can. J. Research, C, 20: 116-121. 1942.

Farrar, J. L., and Grace, N. H. - Vegetative Propagation of Conifers. XII. Effects of media, time of collection, and indolylacetic acid treatment on the rooting of white pine and white spruce cuttings. Can. J. Research, C, 20: 204-211. 1942.

Grace, N. H. - Vegetative Propagation of Conifers. I. Rooting of cuttings taken from the upper and lower regions of a Norway spruce tree. Can. J. Research, C, 17: 178-180. 1939.

Grace, N. H. - Vegetative Propagation of Conifers. II. Effects of nutrient solution and phytohormone dusts on the rooting of Norway spruce cuttings. Can. J. Research, C, 17: 312-316. 1939.

Grace, N. H., and Farrar, J. L.- Effects of talc dusts containing phytohormone, nutrient salts, and an organic mercurial disinfectant on the rooting of dormant taxus cuttings. Can. J. Research, C, 19: 21-26. 1941.

Johnson, L. P. V.- The breeding of forest trees. Forestry Chron. 15: 139-151. 1939.

Johnson, L. P. V.- A descriptive list of natural and artificial interspecific hybrids in North American forest-tree genera. Can. J. Research, C, 17: 411-444. 1939.

Johnson, L. P. V.- Relation of sunspot periodicity to precipitation, temperature, and crop yields in Alberta and Saskatchewan. Can. J. Research, C, 18: 79-91. 1940.

Johnson, L. P. V.- Studies on the relation of growth rate to wood quality in Populus hybrids. Can. J. Research, C, 20: 28-40. 1942.

Johnson, L. P. V.- Experiments on chemical control of damping-off in Pinus resinosa Ait. Can. J. Research, C, 20: 559-571. 1942. (with G. M. Linton).

Johnson, L. P. V.- The storage and artificial germination for forest tree pollens. Can. J. Research, C, 21: 332-342. 1943.

Johnson, L. P. V.- Sugar production by white and yellow birches. Can. J. Research, C, 22: 1-6. 1944.

Johnson, L. P. V.- A note on the production of Vitamin C by sprouting seeds. Sci. Agric. 25: 499-503. 1945. (with G. A. Young and J. B. Marshall).

Johnson, L. P. V.- Development of sexual and vegetative organs on detached forest tree branches cultured in the greenhouse. Forestry Chron. 21: 130-136. 1945.

Johnson, L. P. V.- Forest tree breeding. The New Trail, 3: 143-150. 1945. (This paper restates and brings up-to-date the subject of paper No. 1.)

Johnson, L. P. V. - A rapid squash technique for stem and root tips. Can. J. Research, C, 23: 127-130. 1945.

Johnson, L. P. V. - Effect of chemical treatments on the germination of forest tree seeds. Forestry Chron. 22: 17-24. 1946.

Johnson, L. P. V. - Reduced vigour, chlorophyl deficiency and other effects of self fertilization in Pinus. Can. J. Research, C, 23: 145-149. 1945.

Johnson, L. P. V. - Physiological studies on sap flow in the sugar maple, a Acer Saccharum Marsh. Can. J. Research, C, 23: 192-197. 1945.

Johnson, L. P. V. - Fertilization in Ulmus with special reference to hybridization procedure. Can. J. Research, C, 24: 1-3. 1946.

F. ASSOCIATE COMMITTEE ON GRAIN RESEARCH

INTRODUCTION

The Associate Committee on Grain Research was formed in 1926 when the cereal laboratories of the National Research Council, the Dominion Department of Agriculture, the Board of Grain Commissioners, and of the Universities of Alberta, Saskatchewan and Manitoba, joined forces to collaborate on grain studies. The work of the Committee was re-organized on a war basis at a meeting held in February, 1941. Committee staff at the Universities of Alberta and Saskatchewan were transferred almost entirely to war projects. In Manitoba, it was found best to transfer Committee staff from the University to the Board of Grain Commissioners' Laboratory, which had lost two senior chemists to war research in other Departments. Both the Department of Agriculture and the Board of Grain Commissioners maintained their long-term projects but were able to devote some time to projects arising out of war-time conditions. Reports on grain research by the National Research Laboratories appear in another volume of this series.

UNIVERSITY OF ALBERTA

In May, 1942, the Departments of Field Crops and Soils at the University of Alberta undertook to co-operate with the National Research Council in studying the production of 2,3 butanediol from grain. Two laboratories made isolations and carried on fermentations, while the third carried out the chemical determinations involved. During the last year of the work, the chemical work was largely done in the laboratories that were carrying on the fermentation studies. This report is a brief history of the work of each of the co-operating laboratories.

Studies on Bacillus Polymyxa in Relation to the Production of 2,3 Butanediol from Wheat

Isolation of B. polymyxa from Alberta Sources. In attempts to obtain strains of B. polymyxa which would produce high yields of 2,3 butanediol from wheat starch, numerous isolates were made from Alberta sources. The soil, the air, water, manure, sewage, decomposing grains, rotting vegetables and wood were explored as sources.

The soil and rotting wood proved to be particularly good sources and many isolates were obtained from widely separated parts of Alberta.

High Yielding Stains of B. polymyxa from Alberta Sources. Numerous strains of B. polymyxa capable of producing high yields of 2,3 butanediol were obtained from Alberta sources. A large proportion of these fell into a single group based on dye absorption and colony characters. Several of them compared favorably in ability to produce 2,3 butanediol, with the best yielding strains obtained elsewhere by other workers.

Selective Action of Environmental Factors on B. polymyxa. Pasteurization of source material proved useful in the selection of high yielding strains. Pasteurization also increased the yielding ability of individual strains of the organism. Different strains showed different degrees of tolerance to 2,3 butanediol, and the selective action of it and of certain salts, such as sodium acid phosphate, di-potassium phosphate and sodium acetate appeared to have value in the isolation of superior strains.

Special Properties of B. polymyxa. All isolates obtained from the soil, together with several from other sources, proved capable of rotting potato tubers when introduced through wounds under conditions of abundant moisture and high temperature. In fact, pathogenicity towards potato tubers appears to be general property of B. polymyxa. It can frequently be isolated from rotted potatoes and may be of some importance as a cause of decay of stored potatoes exposed to high temperatures, but it is unlikely that it is the cause of much damage to potatoes in the field, at least in Alberta.

Considerable variation in the color of potato slices rotted by different strains of the organism was noted. However, the variations did not appear to be consistent enough to be depended upon to differentiate strains.

All strains tested except one liquefied gelatin.

Though the organism is a spore-former, none of the strains studied were observed to produce spores when grown on a glucose-agar medium. However, spores were formed on wheat-peptone-agar.

Growth Factor Requirements of Different Strains of B. polymyxa. These studies were undertaken to determine the growth factor requirements of Alberta isolates in comparison with those from other sources. Biotin was found essential for the growth of all strains tested. No single growth factor nor any pair of growth factors induced growth in the absence of biotin. Improved growth over that obtained with biotin aline was induced when biotin plus any one of the following growth factors was present in the medium: thiamin, pantothenic acid, nicotinic acid and inositol. The addition of pantothenic acid, nicotinic acid and inositol singly to a medium containing biotin and thiamin, produced uniformly heavy growth of the bacteria, generally in excess of that obtained in the presence of biotin and any other single growth factor tested.

Nitrogen Compounds in Relation to the Growth of B. polymyxa. Some twelve out of seventeen amino acids used singly as sources of nitrogen supported growth of B. polymyxa on a basal synthetic medium containing other necessary nutrients and growth factors. Best growth was induced by di-alpha-alanine, d-glutamic acid, l-aspartic acid, dl-serine and l-leucine; fair growth by l-cystine, l-cysteine, d-arginine, dl-phenylalanine, dl-methionine, dl-valine, dl-isoleucine; whereas no growth was supported by d-lysine, l-histidine, l-tryptophane, l-proline, and l-tyrosine. No marked differences in amino acid requirements were detected between five strains of B. polymyxa tested.

When urea added to the aforementioned basal medium was tested as a source of nitrogen, no strains of B. polymyxa produced growth.

Two inorganic salts, namely potassium nitrate and ammonium sulphate were tested in a similar manner as sources of nitrogen. Out of six strains of B. polymyxa tested, none produced growth on the medium containing potassium nitrate, but two produced consistent growth on the medium containing ammonium sulphate. Moreover, a considerable number of strains were induced to use ammonium sulphate as a source of nitrogen by preculturing them in a medium containing glutamic acid as the sole source of nitrogen.

Effect of the Addition of Wheat-Grain Fractions to Wheat Starch on the Production of 2,3 Butanediol by B. polymyxa. The addition of any of the following wheat-grain fractions to wheat-starch increased the yield of 2,3 butanediol as compared with that produced from non-supplemented checks; wheat germ, bran, shorts, feed flour and flour.

Effect of the Addition of Nitrogen Compounds to Wheat Starch on the Production of 2,3 Butanediol by B. polymyxa. A form of liquid gluten apparently formed by enzymatic action at low temperature proved to be one of the most suitable sources of nitrogen for B. polymyxa in the fermentation of wheat-starch. Increasing the liquid gluten concentration up to 600 mg. of nitrogen per 100 cc. of medium caused a continued increase in yield of 2,3 butanediol.

Eighteen amino acids were studied separately but only one, namely l-cysteine induced a significant increase in the yield of 2,3 butanediol over the check. Since the other sulphur-containing amino acids, namely l-cystine and dl-methionine, failed to induce significant increases, it would appear that the -SH radical is in some way responsible for the improvement in yield effected by l-cysteine. Increasing the concentration of l-cysteine within certain limits increased the yield of 2,3 butanediol. While l-cysteine had a favourable effect on the fermentation of wheat-starch by B. polymyxa, it is interesting to note that it was not outstanding in its effect on the growth of this organism. It should also be noted that a number of amino acids, especially tyrosine, proline, and phenylalanine induced a marked depression in the yields of 2,3 butanediol.

Although ammonium sulphate alone did not seem to be a satisfactory source of nitrogen for B. polymyxa in wheat-starch fermentations, 2,3 butanediol analyses have indicated that it is utilized to some extent by the organism. Furthermore, in the presence of gluten, increased yields of 2,3 butanediol were obtained in wheat-starch fermentations as a result of the addition of small amounts of ammonium sulphate. However, the optimum amount of ammonium sulphate was lower where gluten was added to the medium than where it was absent, indicating that gluten is the preferred source of nitrogen.

Studies on Production of 2,3 Butanediol by Aerobacter Fermentation

The principal object of this investigation was the study of the Aerobacter type of bacterial fermentation. Various factors were studied and efforts were made to obtain optimum conditions.

All of the preliminary studies were made with pure dextrose as a substrate in order to learn as easily as possible the results of varied conditions and techniques. Later the fermentations were broadened to include washed-starch, flour, wheat mash, barley mash, potato mash and sugar beet molasses.

In the preliminary investigations, started in May, 1942, four organisms (pure cultures obtained from the N.R.C., Ottawa) were tested, using the technique suggested by a report from the Peoria Conference held in April, 1942. The best results were obtained with Aerobacter aerogenes (#199), and subsequent studies were carried out mainly with this organism, although many other organisms were isolated later and tested.

Method of Handling and Storing the Culture. The culture has been stored on agar medium suggested by the (Northern Regional Research Laboratory (N.R.R.L.)).

At first the culture was stored in the refrigerator (2°C) to prevent too rapid drying, but later it was stored in the incubator at 30°C and transferred every 10 days or two weeks.

It became apparent that the Aerobacter Aerogenes organism when stored on agar medium frequently undergoes a degenerative variation, losing part of its ability to utilize and ferment glucose to butanediol.

To obviate this degenerative tendency and maintain the culture in good condition, a modified "lyophile" method of drying the culture was tried.

Several strains of the organism having different fermentative ability were "lyophilized" at this laboratory. These cultures retained their viability when tested three to four weeks after drying. When tested again after eight months they would not grow when transferred to nutrient broth. Legume nodule bacteria dried at the same time produced active cultures when transferred to a liquid medium. This would indicate the lack of ability of Aerobacter aerogenes organism to remain alive over a long period in the dried state.

The inoculum medium generally used was that suggested by N.R.R.L., containing glucose, corn steeping liquor and calcium carbonate. No consistently better yields were obtained in the fermentation by shaking the inoculum than by non-shaking. Frequent transferring (daily) did not increase the rate of fermentation beyond a certain point that can be reached by keeping the culture in a relatively fresh condition by occasional transfers. For convenience usually 5-10% of a 24-hour inoculum is added to the fermentation medium and this practice appears to give satisfactory results.

Starch Media Hydrolysis. Starch is not fermented by the Aerobacter culture or at least only very slowly. Thus a starch medium must be hydrolyzed before becoming available. There are three recognized methods of hydrolyzing starch to sugar: (a) by the use of acid, (b) malt and (c) moldy bran. Only the first two methods have been tried here.

The acid hydrolysis method was first used. The best results were obtained with 0.2N acid at 110°C for two hours, and with both 0.1N and 0.2N acid at 121°C for either one or one and a half hours. However, the results were somewhat variable, and this method was discontinued in favor of the malt hydrolysis method. Distiller's malt gave better liquefaction and in some cases at least better saccharification than brewer's malt, though this is hard to measure accurately.

Fermentation. The initial percent sugar is very important in determining the percent 2,3 butanediol in the final liquor. In most fermentations the initial sugar concentration of the medium was about 10%.

A number of tests were run at various temperatures in order to determine the effect on yield and rate of fermentation. In the range 30° to 36°C no definite differences were found and temperature did not appear to be a limiting factor.

It appears that 46 hours is too short a period for the fermentation and that at least 72 hours is necessary to secure reasonable yields. Too heavy aeration is detrimental to the yields.

It is very necessary that the pH be carefully controlled in the fermentation. The range of pH at which the fermentation will be successful is from 5.0 to 6.5, with the optimum from 5.2 to 6.0. A buffer consisting of 0.8% of $CaCO_3$ and 0.8% of Na_2CO_3 gave the best returns.

Two salts, $MgSO_4 \cdot 7H_2O$ and KH_2PO_4, are very essential and must be added to the fermentation medium at the time of inoculation. However, the beneficial effect of these salts is not nearly as noticeable where malted solutions are used. Urea has been used as the source of nitrogen in nearly all the fermentations, and it has proved entirely adequate.

Aeration is apparently very important. In these experiments nearly all the variation among replicates in the same test can be attributed to ineffective control of aeration. No consistently successful fermentations were obtained until an easily controlled unlimited source of sterile air was made available.

Heavy aeration gives a fast rate of fermentation, where the culture is active, but a low butanediol yield. Under our conditions an aeration rate in the range from 250 to 500 cc. per litre per minute is optimum. This will give a fermentation time of from 48 to 60 hours with good yields.

To supply sufficient fresh sterilized air for a large fermentation would be difficult. In view of this fact, a series of 10 tubes was aerated in the following manner: air was introduced into the first tube at a constant rate; the exhaust air from the first tube was forced through the second tube through rubber tubing; this was repeated through the ten tubes.

The results were somewhat variable but there was no significant variation. Thus we can say that the air can be recycled through the fermentation medium at least nine more times without any loss of effectiveness.

It was quite generally believed that aeration produced a physical rather than a chemical effect upon the fermentation. Therefore, a series of experiments was planned using different gases as the aerating media in order to investigate and substantiate these conclusions. The gases used in these tests were air, nitrogen, hydrogen and carbon dioxide.

The results of this experiment show that the effect of aeration is primarily a physical one since in every instance the fermentation did go to completion (i.e., all the sugar was consumed) in a much shorter incubation period than when no aeration was employed. At the same time, there was an indication that aeration has a chemical effect which should not be overlooked. Aeration with gases other than air retarded the rate of fermentation very noticeably.

Foaming of the medium during aeration created quite a problem, especially when using high rates of aeration averaging around 500 cc. per minute per litre of medium. This tendency was greatest in malt hydrolysed products.

The use of oleic acid as an anti-foam agent gave glycol yields which, although slightly lower, were probably not significantly lower than those of the check. Lubricating oil gave more favorable yields and is also much cheaper to employ. Enzyme hydrolysis (trypsin) was quite effective and may have advantages in laboratory practice, yet its use commercially is questionable because of its high cost.

<u>Isolation and Study of New Organisms</u>. After making a preliminary survey of the literature on isolation technique and obtaining suggestions from other laboratories, the following method of isolation was adopted.

The contaminated materials (soils, fresh or rotting vegetables, etc.) were placed in 10 cc. of Peptone-Lactose or Peptone-Dextrose Bile Broth. Good gas production in this medium was an indication of an active culture. The mixed culture was then plated on either Difco Eosin Methylene-Blue Agar or on Difco MacConkey's Neutral Red Agar. By experience it was possible to select the correct organisms very easily. Finally the Voges-Proskauer test was used as the critical test for the presence of an Aerobacter culture.

In all, 341 cultures classified as Aerobacter types, were isolated and to these, yield tests were applied. Twenty of these cultures have averaged at least 2.50% glycol without aeration, which is between 50% and 60% of theoretical production based on the initial amount of sugar supplied. However, it was not felt that any one of these isolated cultures possessed any significant or distinct advantage over Aerobacter Aerogenes #199.

A Study of Weathered Wheat, Barley, Potatoes and Beet Molasses as Sources of Raw Material for the Fermentation. A comparison of glycol yields from unweathered fall-threshed samples of wheat and weathered spring-threshed samples showed that although the fall-threshed samples gave better results for the majority of samples tested, the average was only slightly higher.

The average yield of glycol from barley was 6.6% lower than from wheat. This may be explained by the fact that barley contains 6 to 8% less starch than wheat. However, since barley generally yields more starch per acre than does wheat, it would appear that barley could be used more economically in the fermentation than wheat.

A brief study was made concerning the utilization of potatoes as a carbohydrate source for Aerobacter fermentation. Although the investigation was very incomplete the results would indicate that this starchy material is not wholly satisfactory for this fermentation because complete saccharification of the cooked potato mash was difficult to obtain.

Some fermentation tests indicated that beet molasses can be utilized quite efficiently in Aerobacter fermentation. Yields ranging from 19.4 to 20.4 grams of butanediol together with 5.3 to 5.6 grams of alcohol were recovered from 100 grams of molasses containing approximately 55 grams of sugar. Molasses has also several factors in its favor. It can be fermented directly without first being hydrolyzed, and it is probable that beet molasses need not be sterilized prior to fermentation since several fermentations were made successfully without sterilization. Beet molasses should prove to be a good source of raw material for glycol production by means of Aerobacter fermentation, and may provide the basis for a small glycol production plant in Alberta. The approximate total yearly supply of beet molasses in Alberta is about 10,000 tons. At present price levels it is a cheaper source of raw material than wheat or barley.

Chemical Methods for Fermentation Products and Some Representative Results

Method. In the early stages of the work, the methods as outlined by other laboratories were used. During the first six months, some 2000 fermentation liquors were analysed. Approximately two-thirds of these liquors were from Aerobacillus fermentations, and the balance from

Aerobacter. The former were fermentations of wheat starch and ground wheat; the latter fermentations of hydrolysed wheat starch and pure glucose.

Essentially theoretical yields were obtained using Aerobacter fermentations of glucose, and a method of hydrolysing starch was worked out so that yields were almost as good as with glucose.

Yields of diol from Aerobacillus fermentations were reasonably satisfactory. Some strains gave much better results than others, and modifying some of the fermentation conditions had a beneficial effect.

As the work progressed, it became obvious that many of the methods could be improved and, whenever time permitted, methods were critically studied. A rapid, simple, modified method for the estimation of 2,3 butanediol in fermentation liquors in the presence of sugar, alcohol, and acetylmethylcarbinol, was evolved. The method eliminated the periodate distillation and utilized direct titration following treatment with $CuSO_4$ and $Ca(OH)_2$. Results, using this method, were more consistent and satisfactory than with any other method used. This method was later modified so that diol and carbinol could be determined on the same sample.

A continuous extraction apparatus was developed by W.G. Corns for the extraction of diol and carbinol. It was based on earlier work by Fulmer, but embodied a number of modifications. Using this apparatus, it was possible to concentrate the two substances in ether. Fractional distillation was used to separate them. The final fraction of carbinol boiled at 142-144°C and the purified diol at 179-182°C.

<u>Yields of 2,3 Butanediol from Commercial Grades of Wheat</u>. A wide variety of wheat and barley samples were fermented to determine their suitability for use as a source of 2,3 butanediol.

Twenty-four average samples of wheat grades (1° to #6) were collected from the Saskatoon, Edmonton, Winnipeg, Calgary, and Moose Jaw inspection offices. Mashes of 8 and 15% were used and essentially a 72-hour fermentation. One strain of Aerobacillus was used for all fermentations and conditions standardized as completely as possible. It appeared that grade of wheat is not a significant factor in diol production.

Yields from Varieties of Wheat. Four varieties of wheat grown under comparable conditions were fermented under similar conditions, using 15% mashes. Garnet gave slightly higher yields of diol and alcohol than did Marquis, Red Bobs, and Reward. The differences, however, were small and of doubtful significance.

Yields of Wheat Grown at Different Stations. The source of comparable varietal samples did not appear to affect the glycol yield, despite wide variations in protein content of the samples.

Yields from Weathered Wheat. Comparable fall- and spring-threshed samples of wheat were fermented. The spring-threshed samples were damaged by frost and sprouting. No consistent differences were attributable to degree of weathering, and it was concluded that low-grade, poor quality wheat may be as satisfactory as high-grade wheat for this fermentation.

Yields from Barley. Three varieties of barley grown in 1942 at Edmonton, Bon Accord, and Athabaska were fermented. These represented high, medium, and low protein barley. There appeared to be significant differences in station yields, but only slight differences due to variety. The most significant result was found in the speed of fermentation. The barley fermentations reached completion in less time than did any fermentation with starch, wheat, or granular flour.

Yields from Wheat and Barley Compared. Two varieties of wheat and two of barley grown at Edmonton in 1942 were fermented, using two organisms with each. The average yield of diol from wheat was 0.1% higher than the average yield from barley, while alcohol yield from barley appeared to be slightly higher. When the difference in starch content of the wheat and barley was taken into consideration, barley produced diol more efficiently than did wheat.

UNIVERSITY OF SASKATCHEWAN

In 1939, prior to the outbreak of war, the Associate Committee on Grain Research decided that it would be advisable to expand and intensify research on oil seeds. This decision was taken primarily with a view to stimulating a greater interest in flax production with a consequent substitution of flax acreage for wheat acreage. It was felt, since high quality linseed could be produced in areas which were producing low quality wheat, that this move would be advantageous in raising wheat quality and also open up an export market for quality linseed.

With the beginning of the war in the fall of 1939, it immediately became evident that Canada, then a heavy importer of vegetable oils, would be faced with the problem of sharply increasing oil seeds production to cope with her own and British requirements. In the spring of 1940, arrangements were made to open an oil seeds laboratory at the University of Saskatchewan, equipment was placed on order and, in September, the laboratory began operation with a staff consisting of one professional and one sub-professional member.

At the time the laboratory was started the only oil seed being grown and processed in Canada on a commercial scale was linseed. However, as the war spread and a critical condition with respect to shipping arose, it became evident that a serious shortage of vegetable oils for edible purposes would develop. To meet these conditions the work of the laboratory was organized to provide information on the composition of linseed oil with a view to modifying it for use in the production of edible and soap products, studies to assist in the commercial handling of new crops such as sunflower seed for edible oils and rapeseed for marine engine lubrication, and assistance to plant breeders by providing testing facilities designed to increase production and quality of oils through improvements in varieties and cultural methods.

Linseed

The most urgent problem with respect to linseed was increased production. At the outbreak of war, Canada was producing less flax than was required to supply domestic peacetime needs. However, the crop was established, seed stocks were available and a domestic crushing industry was in operation. Under these circumstances, by the creation of suitable incentives, production could be markedly increased and no special research problems regarding production, handling and crushing would arise. Appropriate steps were taken and, during the war years, sufficient flax was produced to supply all domestic requirements and provide a substantial exportable surplus. This surplus, in addition to supplying allied nations, placed Canada in a more favourable position to bargain for more saturated vegetable oils required in the food and soap industries.

The work of the laboratory in this programme was to test new varieties of flax in an effort to increase yields and quality of oil. In addition, a study of the composition of linseed oil was undertaken to provide a groundwork of knowledge on which to approach the problem of adapting it for use in edible and soap industries.

Variety Testing. A marked interest in breeding of flax varieties was stimulated and the number of samples submitted for test increased considerably. Standard variety tests were run each year and data on 25 varieties from four to six stations was obtained. The results included oil content, nitrogen content of the oil-free meal, iodine value of the oil and 1,000 kernel weight of the seed.

In addition to the standard variety tests, about 100 new hybrids and selections were tested each year. If any of these showed promise they were included in subsequent variety trials for further testing.

While no new varieties were developed and distributed during the actual war years the programme of flax breeding was materially advanced. At the present time a number of the more promising varieties developed are being increased and, as soon as seed stocks are built up, will be released for distribution. These varieties show promise of giving higher oil yields and iodine values than varieties now grown and in addition are resistant to both flax rust and flax wilt.

Effects of Environment. As part of the Committee on Grain Research programme, an annual survey of the quality of Canadian linseed has been made in the Board of Grain Commissioners' Laboratory at Winnipeg. With a large increase in flax production, this survey was greatly enlarged and more samples tested each year. These samples represented commercial grain and little information on individual varieties could be obtained. To supplement this work, the oil seeds laboratory conducted tests on four varieties grown in replicated plot tests by the Saskatchewan Wheat Pool.

The results of this study showed that environmental and varietal effects were about equally important in determining the quantity and quality of oil produced from flaxseed. It was also shown that no simple method of determining flax quality could be developed from tests such as 1,000 kernel weight or nitrogen content. However it was found that iodine values could be determined on solvent extracted oil. Since extraction is necessary to secure quantitative data on oil content, a saving in the time required for testing samples was secured by using the extracted oil for the determination of iodine values by refractive index. This technique cut down the man hours for analysis and speeded up the testing of samples.

Statistical analyses of the data obtained on variety testing over a period of three years has shown that the main factors affecting the quality and growth of linseed appear to be climatic. The multiple correlation of mean seasonal temperature and rainfall with a number of flax properties gave the following correlation coefficients.

Multiple Correlation Coefficients of Flax Properties with Temperature and Rainfall

Yield per acre	836	Oil content	871
Straw length	689	Iodine value	700
Days of maturity	712	1,000 kernel wt.	588
Straw Strength	602	Protein in meal	877

High temperatures resulted in rapid maturity, low oil content, low iodine values and high protein content in the meal, qualities which are undesirable for quality linseed. High rainfall was associated with higher yields and longer straw.

In general these data indicate that for maximum production coupled with best quality, flax should be produced in areas having relatively low growing temperatures and high rainfall.

Composition of Linseed Oil. A study of 54 samples of oil from the varieties Bison, Redwing and Royal was made to determine the fatty acid constituents. It was found that on the average linseed oil contained 6.7% saturated acids, 24.2% oleic acid, 11% linoleic acid and 53% linolenic acid. Furthermore, the proportions of the various fatty acids could be estimated from iodine values by the following equations:

$$\text{Linolenic acid, \%} = 0.49 \text{ iodine value} - 37.93$$
$$\text{Linoleic acid, \%} = 0.05 \text{ iodine value} + 0.73$$
$$\text{Oleic acid, \%} = -0.48 \text{ iodine value} + 113.08$$

The results of this study show definitely that, for use in industries other than those based on drying properties, an oil having a low iodine value should be selected. Furthermore, iodine values bear a direct relation to the composition of the oil and as such have a definite interpretation in terms of oil quality.

The first study was made on pure samples of known varieties grown under experimental conditions. To check the validity of the results, commercial composite samples of the 1942 crop were secured. An analysis of these samples confirmed the previous work and proved that the results were applicable to flaxseed entering commercial channels.

Fractionation of Linseed Oil. In an attempt to break linseed oil into fractions to provide a superior drying oil and a low iodine value fraction for use in the edible and soap industries, studies on chromatographic adsorption, fractional crystallization and liquid extraction were undertaken.

The first two of these methods are laboratory techniques and are not applicable to commercial production. It was found that chromatographic adsorption was inadequate to study fractionation since it was impossible to recover more than 90% of the oil from the adsorbent. Fractional crystallization at low temperatures is, also, seriously limited since the fractions do not separate sharply by components.

Liquid-liquid extraction is a commercial technique which shows some promise applied to linseed oil. An extensive study of solvents showed that ethyl acetoacetate and furfural were about equally selective for unsaturated portions of the oil but furfural extracts a greater quantity. A laboratory extraction column was designed and constructed to investigate furfural extraction of linseed oil. The following table indicates the separations that have been obtained on a commercial sample of linseed oil having an iodine value of 185 units.

Solvent Extraction of Linseed Oil with Furfural.

Solvent ratio	% oil extracted	Iodine value extracted oil	Iodine value raffinate oil
2.84	40.5	201.4	174.6
4.40	61.9	202.3	160.9
5.95	74.1	201.1	143.3
8.75	89.2	193.8	112.6
10.60	94.9	189.7	96.3

If the data is plotted it will be observed that a 75% cut of linseed oil having an iodine value of 201 and a 25% cut having an iodine value of about 140 units can be obtained. This lower fraction has an iodine value comparable to western grown sunflower oil and but little higher than soyabean oil.

Further investigation on the composition of these fractions is being undertaken in the laboratory.

Sunflower Seed

Prior to the war, an extensive programme of experimental work on the breeding and culture of sunflower seed as an oil crop was underway in the Department of Forage Crops at the University of Saskatchewan and at the Central Experimental Farm at Ottawa. The oil seeds laboratory undertook to do the required testing for these organizations in the development of sunflowers as a commercial crop.

Variety and Cultural Tests. Each year, from 200 to 300 samples were submitted and tested in the laboratory. These samples consisted for the most part of selections and hybrids which appeared promising from data collected on their agronomic characteristics. In addition, numerous samples from dates of seeding tests, row and plant spacing tests, fertilizer trials, dates of harvesting tests, and breeding techniques were tested to provide information on the best cultural methods for growing this crop.

The major problem with sunflowers is to raise the oil content and yield of seed to a level which makes sunflower culture profitable. Tests conducted in the laboratory indicate that the use of hybrid seed similar to that used in corn production results in higher oil contents and field trials have shown improved yields.

In the seasons of 1943 and 1944 variety trials were conducted at Morden, Saskatoon, Brandon, Indian Head, Melfort, Scott, Swift Current and Lethbridge. The samples were analysed in the laboratory and the results indicate that improvements on the original Sunrise and Mennonite varieties have been made.

At the close of the war these hybrids were still in the development stage since the production of sufficient seed stocks and the hybridization techniques were not far enough advanced for commercial production.

Handling Problems. In view of the critical shortage of edible oils, the Agricultural Supplies Board decided in 1941 that the varieties Mennonite and Sunrise should be produced commercially in 1942 although it was realized that these varieties were not ideally suited to Canadian conditions. Since this crop was entirely new to the Canadian grain trade, several problems in connection with grading and handling arose.

The first major problem was that of safe moisture levels for storage. Since sunflower is late in maturing and its heavy stock and head have a high moisture holding capacity it was felt that much of the seed would be harvested too wet to store safely. The oil seeds laboratory undertook the problem of determining the maximum moisture at which seed could be stored without danger of heating.

To maintain definite moisture levels for storage periods it was necessary to determine the humidity of air required for equilibrium at fixed moisture levels. This problem was investigated and preliminary information obtained for studying the main problem. Using this data, samples of sunflower seed could be maintained at constant moisture levels for extended periods of time.

Respiration studies were used to determine the moisture level at which a marked increase in CO_2 production occurred. This point indicates active mold growth with resultant spoiling and "bin burning". It was found that at about 11.0% moisture no marked increase in respiration occurred. This same technique when applied to wheat showed no acceleration of respiration at 16.0% moisture. It is known that 14.5% moisture is a more reliable value for wheat under commercial conditions hence a value 1.5% lower or 9.5% was indicated for sunflower seed. This study also showed that hulled seed and broken meats required a lower moisture level than sound seed for safe storage.

This work served to establish a tentative moisture level for straight grade sunflower seed but was based on indirect measurement involving an arbitrary correction factor. Later results using a direct measure of heating in an adiabatic system confirmed this value. In the comparatively short storage period of 56 days, actual heating at a moisture level of 10.5% was demonstrated. When longer periods are involved and partially hulled and damaged seed are considered, it is evident that the value 9.5% is none too low.

As no data on commercially produced sunflower seed was available, a survey on the 1942 crop was undertaken. Samples were collected at the inspection office at Winnipeg by the Board of Grain Commissioners Laboratory and sent to Saskatoon for study. Data on oil content, kernel weight and bushel weight of the whole seed; oil content and nitrogen of the meats; and iodine value, acid value and refractive indices of the oil was obtained for both Sunrise and Mennonite varieties. A statistical study of these data showed that bushel weight was significantly associated ($r = .867$) with the total oil content of the seed. It was suggested that appropriate use of bushel weight would result in a marked improvement in the commercial grading of sunflower seed.

To obtain the data reported in this study it was necessary to dehull the sunflower seed. A laboratory huller was designed and constructed. Under test this huller handled 70 to 80 pounds of seed per hour with about 95% hulling and about 10% of broken meats. Good recovery of meats by a simple fanning operation was obtained. Test data showing equally good or better performance on oats was obtained.

Composition of Sunflower Oil. A number of samples of sunflower seed from the variety trials were submitted to intensive study of oil properties. Average values obtained were acid value 1.0, refractive index 1.47372, iodine value 140.6, thiocyanogen value 82.8, saturated acids 8.5%, oleic acid 17.5% and linoleic acid 69.0%. The statistical analyses of these data have not been completed as yet, but it is evident from graphical treatment that a relation exists between iodine values and fatty acid composition similar to that shown for linseed oil.

Fractional Crystallization of Sunflower Oil. To provide information on the glyceride structure of fats and oils and to develop a technique for studying induced changes in structure, an investigation of low temperature fractionation was undertaken. Sunflower oil was selected for this study since it contains only saturated, oleic and linoleic acids and is free from linolenic acid. This makes analysis less complex since the composition of fractions can be determined on small amounts of oil by means of iodine and thiocyanogen values. In addition, since no linolenic acid is present, the fractions are easier to handle and there is less danger of oxidation manipulation.

A sample of sunflower oil iodine value 138, was selected for study. From analysis this sample contained approximately 70% linoleic acid. On the assumption that the fatty acid radicals are distributed in a random manner on the glyceride molecules, the oil should contain about 30% of trilinolein; even on the basis of even distribution as postulated by Hilditch it should contain about 20% of the triglyceride. Fractional crystallization of the oil in acetone at 0°C to -70°C failed to yield fractions having iodine values below 69 or above 162. The theoretical iodine value for trilinolein is 173.2. Obviously this glyceride must be present in the oil but it is impossible to separate it by crystallization. A plot of iodine values against thiocyanogen values gave a straight line relation. This means that there must have been a constant proportion of oleic to linoleic acid in all the fractions. If the glycerides separated by molecular species the relation of iodine and thiocyanogen values would be curvilinear.

As a further check on this work, trilinolein of about 98% purity was prepared and mixed with the original sunflower oil. When this mixture was submitted to fractional crystallization it was found impossible to recover the added portion of trilinolein. In this case the relation of iodine and thiocyanogen values also proved to be linear. When samples were subjected to ester interchange reactions and then crystallized, the relation was still linear but some evidence of greater resolution by weights and iodine values was obtained.

These results indicate that low temperature fractionation of highly unsaturated oils fails to make separations of molecular species. It is therefore highly improbable that this technique will yield pertinent data on the glyceride structure of these oils.

Rapeseed

The British Admiralty specifications call for rapeseed oil in marine engine lubrication. Prior to the war this oil was imported from the Argentine, India or Europe. A critical supply situation developed early in the war and experiments indicated that rapeseed could be grown satisfactorily in Canada. Samples from a number of stations were submitted to the laboratory for analysis which showed oil contents ranging from 38 to 40% and iodine values of 101 to 104 units. In 1942 Black Argentine Rape was grown commercially to supply the requirements of our rapidly growing Canadian Navy.

Mustard Contamination in Rapeseed. Since the seed of wild mustard and rapeseed are similar in size, shape, and weight, it is impossible to separate these seeds with any cleaning equipment. Wild mustard is a very common weed and much of the rape produced was contaminated. At the request of the Oils and Fats Administration, the effect of this contamination on rapeseed oil was investigated.

Using the Texas specifications for rapeseed oil, it was found that pure mustard oil would meet all requirements with the exception of viscosity and iodine value. The viscosity was 198 secs. Saybolt while the specifications call for 212 to 240; the iodine value was 122.6 compared with a range of 97 to 103 in the specifications. Canadian grown rapeseed was found to have a viscosity of 232 secs. and an average iodine value of 102.3. It was computed that a 10% contamination of rapeseed with wild mustard would give values of 227 secs. and 103.2 units. This suggests that contamination of the order of 10% would have little injurious effect on the quality of rapeseed oil.

In assisting the Plant Products Division to obtain pure seed stocks of Argentine rape, a sample of Polish rape was located. Under test in the laboratory, the oil showed iodine value 113.5 units, viscosity 200 seconds, and saponification equivalent 182.5 as compared to range of 170 to 180 in the specifications. As a result of these tests, some 70 to 80 thousand pounds of this rapeseed was removed from commercial channels and certified Argentine rape for seed purposes was supplied to the growers of this material.

Variety Testing. Considerable variation in plant characteristics was noted in growing fields of Argentine rapeseed. It was found that iodine values ranged from 101.8 units to 106.2 units and that oil content varied from 32.6% to 41.3%. This suggests that by proper selection and breeding a marked improvement in the quality of rapeseed could be effected. This work is being undertaken by the Forage Crops Department at the University of Saskatchewan and the Oil Seeds Laboratory is collaborating in control testing of the selections and hybrids.

Miscellaneous Oil Crops

A small number of samples of soyabeans and safflower seed were submitted to the laboratory for test. Western grown soyabeans were found to be immature and low in oil content. This, together with unfavorable climatic conditions, made soyabeans unsuitable for western production.

Safflower seed was found to have a low oil content and in view of the shortage of crushing capacity and general unfamiliarity of the trade with this oil it was not recommended as a suitable war-time crop.

DOMINION DEPARTMENT OF AGRICULTURE

CEREAL DIVISION

High Vitamin Flours

In September 1940, the Canadian Public Health Association adopted a resolution urging the Dominion Government to increase the B vitamins of flour by the addition of wheat germ and not by the addition of one or more of the known individual components of Vitamin B. The Cereal Division was asked for a memorandum on the subject and through this contact was requested to explore the possibility of improving the vitamin content of wheat flour through natural means rather than through fortification with artificially produced vitamins.

The Department of Health and Welfare through its Advisory Council on Food and Nutrition, pursued the question, with the result that regulations were formulated for "Vitamin B White Flour", "Vitamin B Whole Wheat Flour", "Vitamin B White Bread" and "Vitamin B Brown Bread". All of these products were written into specifications for flour and bread for the Armed Forces operating in Canada. Several meetings were held with representatives of the milling and baking industries while commercial samples of flour and bread were checked periodically and advice given on the production of these products.

Thiamin in Canadian Wheat Flour. A paper entitled "Investigations on the Thiamin Content of Canadian wheat and flour" reported data on the thiamin content of commercial samples of Canadian Hard Red Spring Wheat taken from cargo samples ex Atlantic and ex Pacific as well as on samples taken at the mill. The data were based on samples collected during the crop year 1940 and 1941. Subsequently, data were obtained on the 1941 and 1942 crop wheat. These studies indicated that a wide range of thiamin in wheat was to be expected and that environment not only influenced the thiamin content of wheat in any one crop year but in different crop years. There was some evidence to show that a positive correlation between thiamin content and protein content exists.

Thiamin in Wheat Varieties. In a further paper, "The Thiamin Content of Canadian Hard Red Spring Wheat Varieties", it was demonstrated that significant differences existed between the thiamin content of different varieties of wheat grown under the same environment and that samples of Regent could be expected to give higher thiamin contents than Thatcher or Marquis.

Milling for High Thiamin White Flour. Examination of flour streams from two commercial mills showed a general progressive increase in the thiamin concentration with individual flour streams as the wheat advances through the milling process. The concentration in the bran, shorts and feed middlings was found to be high. Experimental milling tests designed to increase the thiamin content in white flour showed that the thiamin content could be increased by milling the wheat at a lower moisture content than that commonly used or through increased extraction. The flours, however, were less refined than when milled by the orthodox procedure. This pointed to the fact that mills could increase the thiamin content of white flour by locating certain high thiamin mill stocks and processing these further in order that much of their thiamin content could be incorporated into their finished flour.

Location of Thiamin in Wheat. Studies of the wheat kernel revealed that the thiamin was concentrated largely at the germ end of the kernel including the germ proper, while the germ itself (the yellow embryo), is very rich in these vitamins; those cells immediately surrounding the germ must also contribute substantially. Hinton and Allan Ward in England pointed to the scutellum and epithelial cells as being much richer than the embryo in thiamin and this was corroborated by the Cereal Division in tests made on Thatcher and Regent wheats of the 1942 crop.

The Utilization of Beef Dripping for Shortening Purposes

Surplus beef dripping accumulated in Army camps during the war and the Division undertook to study ways and means of making this type of fat more useful in the production of various types of baked goods. A report on this investigation was furnished to the Quarter Master General's Department of the National Defence.

Shortening Blends. Beef dripping is classed as a hard fat and by itself has little or no value in the manufacture of baked goods. Blends of salad oil--corn oil in this case--and beef dripping were made with from 5% to 30% of salad oil combined with from 95% to 70% melted beef dripping and creaming tests made on each blend. It was found that salad oil could be used up to 30% in the blend, but beyond this point the creamed mass broke down at a temperature of 75°F. At 75°F a mixture of 15% salad oil with 85% beef dripping appeared to give the best results. At 82°F the fat mixture was too soft, consequently a table was given indicating the number of pounds of salad oil to mix with beef dripping from 5% to 25% salad oil on the basis of 10 pounds of blended shortening. Adjustments could then be made in the salad oil percentages depending on the temperatures prevailing in the various camps.

In making the blends it was found that they must be cooled gradually and stirred repeatedly to prevent formation of hard and soft areas in the mixture. When the mixture begins to solidify frequent beatings were advocated. Over-beating produced large bubbles and foaming.

Baking Tests. Baking tests gave good results in plain cakes, chocolate cakes and pie pastry.

Stability of Blends. Samples of blends containing 10%, 15% and 20% salad oil held at room temperatures during June and July gave no visible signs of separation into their component parts or development of off-flavours. After two years' storage under refrigeration the blends remained good.

The Use of Sugars Other Than Sucrose in Bread-Making.

The baking industry has been a heavy user of sucrose but, during the war, restrictions were necessary on this commodity. Consequently, substitute sugars for sucrose were of considerable interest and bread is one product which can be made with substitute sugars. At the request of the Administrator of the Baking Industry, War Time Prices and Trade Board, an investigation was made on this subject and a report submitted to him.

Gassing Tests. Dough gassing tests were made using five different sugars at levels from 1/2% to 2 1/2% in relation to the weight of the flour used. From the standpoint of gas production, the sugars arranged themselves in the following order of value, viz., diastatic malt syrup, non-diastatic malt syrup, sucrose, glucose syrup and dextrose.

Baking Tests. Using a standard second patent bread flour the use of 1/2% of any of the sugars gave satisfactory gas production and any increase beyond this figure in sugar did not increase loaf volume using a straight dough procedure. Glucose syrup or dextrose could be used up to 2½% but diastatic malt syrup should not be used beyong 1% and non-diastatic malt syrup beyond 1 3/4% or sticky dough would result.

Dry Granular Yeast for Bread-Making

The Department of Munitions and Supply requested information on dry granular yeast in the production of bread. The product of one company was investigated. This particular product was produced to serve the same purpose as wet compressed yeast in the production of bread. It had the added advantage in that it could be stored in moisture proof containers for a long time without the necessity of refrigeration. Subsequently, it was used successfully by the Armed Services in places where fresh compressed yeast was not easily available.

Gassing Tests. Dough gassing tests recorded from sugarless doughs showed that the granular yeast gave a slightly lower gassing curve than the fresh compressed yeast used for comparison and the time required to reach its peak was longer. Added sugar to the doughs reduced the time difference although the fresh compressed yeast gave a slightly superior curve.

Bread Tests. Using a straight dough procedure, granular yeast and wet compressed yeast were compared in the production of bread. The granular yeast was used in the proportion of six ounces to sixteen ounces of wet compressed yeast. Fermentation progressed more slowly with the granular yeast and at panning the doughs with this yeast were slightly heavier than those with wet compressed yeast. When the doughs entered the oven, little differences were noted. The somewhat slower action of the granular yeast indicated that it required somewhat longer to get into its best condition. The dried granular yeast will serve the same purpose as wet compressed yeast in the production of bread and is capable of producing good bread in a short procedure.

Specifications for the Purchase of Supplies

The Cereal Division collaborated with the Department of Munitions and Supply and the Department of National Defence in the preparation of specifications for the purchase of cereal products for the Armed Services. Specifications were prepared for general purpose hard wheat flour, pastry flour, rye flour, cracked wheat, rolled oats, rolled wheat, pot barley, pearl barley, cream of barley, Vitamin B White Flour, Vitamin B Whole Wheat Flour, Vitamin B White Bread, Vitamin B Brown Bread, macaroni, vermicelli, noodles, rice, baking powder. Samples of bread and flour were checked periodically to see if they met the specifications.

Biscuits for the Armed Forces

The question of reserve ration biscuit was brought to our attention in 1940 by the Quarter Master General's Office of the Department of National Defence. The old ration biscuit specifications were reviewed and improved formulae were developed and suggested. At this time it was not considered advisable to change the specifications by the above Department owing to the extra cost.

Carrot Biscuit. Out of the investigation in respect to reserve ration biscuits formulae for the production of carrot biscuits were developed. While this type of biscuit was not adopted by the Armed Services, it was taken up by the Department of Indian Affairs and used for distribution to Indian children in the more northerly parts of Canada. About fifteen tons of these biscuits have been distributed annually since 1942. The original and later developed formulae are as follows:-

	Original	Second
Flour (soft wheat)	17 lbs.	60 lbs.
Soyabean flour (full fatted and debitterized)	25 "	20 "
Shortening (hydrogenated vegetable)	12 "	9 "
Mild powder (skim)	8 "	8 "
Sugar	10 "	11 "
Salt	2 "	1 3/4"
Carrots (finely pulped raw)	50-60 "	60 "
Oatmeal (finely ground)	--	20 "
Yeast (dried brewers non-bitter)	--	3 "
Baking powder	2+ "	6 "

Vitamin assays on above biscuits.

Original Formula:	Vitamin A (from carotene)	5120 I.U. per 100 gm.
	Vitamin B_1	81 " " " "
	Vitamin B_2	100 gamma " " "
Second Formula:	Vitamin A (from carotene)	4000 I.U. per 100 gm.
	Vitamin B_1	15 " " " "
	Vitamin B_2	310 gamma " " "

Later the addition of ground bone flour, thiamin and riboflavin were added to boost the calcium, vitamin B_1 and Vitamin B_2 content of each biscuit.

Linseed Oil Shortenings

Owing to the tight situation in regard to fats and oils which developed after Japan entered the war, considerable research was undertaken with linseed oil as a shortening, chiefly by the Ontario Research Foundation, the National Research Council and Macdonald College. The Cereal Division participated in this programme by testing a large number of samples submitted by the above institutions in bread and in pastry products. In addition, a deep frying procedure was developed using squares of air-dried bread and frying these in the particular shortening, at 220°C. Flavour reversion was the chief difficulty in producing satisfactory linseed oil shortening and our part of the programme dealt with the assessing of the different shortenings developed by the above institutions in this particular characteristic. See report of Fats and Oils Section, Canadian Committee on Food Preservation.

Gas Production in Flour Doughs

An apparatus was developed for the automatic recording of gas production in flour doughs. Subsequent studies using this apparatus indicate that, where gas production is maintained at high levels, fermentation time is not a critical factor in loaf volume determinations in experimental baking tests. Over a range of eighty minutes, maximum loaf volumes were obtained when high gas production was maintained.

Production of Butanediol from Wheat

From gas production graphs obtained on the automatic gas recording apparatus mentioned above, it seemed reasonable to suppose that a higher yield of butanediol would be obtained from grade five wheat and grade six wheat than from the number one northern and number two northern wheats.

In co-operation with the Division of Bacteriology, of the Department of Agriculture an investigation into the yields of butanediol from various grades of wheat was undertaken. Frozen wheat (grades five and six) and off grades of wheat and also elevator screenings were investigated against wheats of grades one northern and two northern.

It was demonstrated that it was economically advantageous to produce butanediol from lower grade wheats.

Ordinary Peacetime Investigations

The Cereal Division operates a laboratory for the evaluation of the milling and baking qualities of samples of wheat either grown at the various stations of the Dominion Experimental Farms System or in tests initiated by the Experimental Stations at locations in various parts of Canada. The bulk of these tests are plant breeders' varieties which are in the preliminary stages of development or have been advanced to the stage where rod row field trials are being conducted at more than one location. The breeding and testing of rust resistant, early maturing, and sawfly resistant hard red spring wheats, soft white spring and winter wheats provide the bulk of the material which is annually investigated. This work has been maintained during the war period.

BOARD OF GRAIN COMMISSIONERS FOR CANADA

GRAIN RESEARCH LABORATORY

As was pointed out in the Introduction, the Grain Research Laboratory took over in 1941 much of the essential peacetime work of the Associate Committee on Grain Research, thus freeing staff of other laboratories for war research. At about the same time, two senior chemists were also transferred to other Departments for war work, and four men enlisted in the Services. Since these experienced men could be replaced only with girls, the Laboratory operated with a reduced staff throughout the war.

The results of the continuing peacetime studies have been published each year in Crop Bulletins and Annual Reports issued by the Laboratory. Short accounts of those of the Laboratory's projects having a bearing on the war effort, or arising out of conditions created by the war, are given in the following sections.

Stored Grain Problems

An accumulation of large grain stocks in Canada occurred during the war years as a result of large crops and the wartime curtailment of shipping. These reserve stocks soon exceeded the normal storage capacity in Western Canada, and under these circumstances the Canadian grain trade built, between 1939 and 1941, temporary storage structures to house 174,000,000 bushels. The temporary storage structures varied in capacity from 30,000 bushel sheds at country points, to sheds with capacities of as much as 5,500,000 bushels at the Lakehead.

The storage of large quantities of wheat in temporary wooden sheds created problems which the Canadian grain trade had not previously encountered. Mite and insect infestation developed in these facilities, often associated with an excessive accumulation of moisture in the surface layers of the grain. This report summarizes the investigation of these problems and includes a note on the quality of wheat held in temporary storage.

Investigations of insect infestation in stored grain and related problems were conducted by the Board of Grain Commissioners' Entomologist, under the direction of the Dominion Division of Entomology, and in co-operation with the Grain Research Laboratory.

<u>Insect Infestation</u>. From 1939 to 1945, almost all reported cases of mite and insect infestation occurred in the temporary storage structures. Grain stored in these facilities was not moved for long periods of time, and thus provided opportunity for infestation to become established. Moreover, the tendency of grain to accumulate excess moisture in the temporary storage buildings because of structural defects and the phenomenon of "condensation" created conditions ideal for the development of infestations.

Grain mites, particularly Tyroglyphus farinae de Geer, were general in the temporary storage annexes from 1939 to 1942. Severe infestations occurred only in grain with moisture content of 13 percent or higher. Structural defects or condensation often created local areas of high moisture grain in which the mites became established. The incidence of mite infestation increased during the winter months and decreased in the summer. Although coarse grains are subject to this type of infestation, serious infestations were general only in wheat, since only wheat was stored in the temporary sheds.

The rusty grain beetle, Laemophloeus ferrugineus Steph., appeared in the temporary grain sheds in 1942 and, from then until the temporary storage program was terminated in 1945, proved to be a most serious pest of stored grain. Characteristically, the insect became established in a local area of "tough" grain from which the infestation spread. In many cases, the original nucleus of infestation occurred on the floor, and spread vertically through as much as 45 feet of grain. Grain heavily infested with the rusty grain beetle was invariably heated to a maximum temperature of about 110°F. The larva of the insect attacks the germ end of the wheat kernel, and there was a marked reduction of viability, and baking quality in infested wheat. The rusty grain beetle caused damage to grain in temporary storage on farms, and in temporary storage buildings, both on the prairie and at the Lakehead. Infestations often developed very rapidly, and in winter the cold surface grain above the resultant "hot-spot" often became moldy and spoiled by reason of the heavy condensation.

The grain weevils (Sitophilus oryzae L. and Sitophilus granarius L.) appeared in southern Manitoba during the emergency storage period. These primary grain pests had not previously been reported in commercially stored grain in Western Canada, but from 1942 to 1944 ten infestations occurred in this area, in temporary storage facilities.

The Indian meal moth, Plodia interpunctella Hbn., was the only insect to cause severe infestations in normal storage facilities. Several major infestations occurred in terminal elevators at Vancouver and on Georgian Bay, and minor infestations were quite common in the latter elevators from 1940 to 1945. The Indian meal moth infests only the surface layers of grain, where the larva consumes the germ ends of the wheat kernels, and spins a heavy webbing over the surface. Infestation reaches a peak in the late summer months when the larvae often migrate from the bins in enormous numbers.

The control measures developed to combat infestations in stored grain were fumigation, the use of contact insecticides, repair of structural defects, and moving and cleaning of infested grain. The fumigant chloropicrin was used almost exclusively, because of its high toxicity in small quantities and the safety factor conferred by its strong lachrymatory effect. In the temporary storage sheds, chloropicrin was applied either on the surface in the case of shallow infestations or probed into the grain in the cases of deep infestations. Spot fumigation of local "hot-spots" in large bulks of grain was used to hold infestations in check until unloading operations could be carried out. Contact insecticides, mainly 10 percent pyrethrum in odorless kerosene, were used to combat Indian meal moth infestations in terminal elevator facilities. Routine spraying with this material throughout the summer months gave satisfactory control. Turning and cleaning infested grain was practised wherever possible and served to break up "hot-spots", cool the grain and eliminate large numbers of insects.

<u>Effect of Insecticides on Wheat Quality</u>. Before applying any type of insecticide to commercially stored grain, laboratory tests were conducted to determine the effect of the insecticide on wheat with regard to grading and quality characteristics. All commonly used fumigants were tested in this way and most of them were found to have little or no effect on the wheat after aeration such as occurs in normal handling. A number of contact insecticides were tested in the same way and several were rejected because of their tendency to taint the grain.

<u>Sampling Methods</u>. The difficulty of obtaining information on the condition of wheat at depths was an important problem in maintaining the grain in good condition in the temporary storage sheds. Conditions of excessive moisture or insect infestation might develop at depths in the grain

and progress to serious proportions before being detected. To obtain information on temperature conditions in these large bulks, many sheds were equipped with vertical pipes to accommodate a thermometer or thermocouple at any given depth. Actual samples of grain were obtained with a variety of probing devices, of which the most commonly used was the torpedo probe, with enclosed thermometer. This was pushed into the grain by hand to a maximum depth of 20 feet. This type of probe was inadequate for sampling the Lakehead annexes where depths of 45 feet of grain were common. To meet this difficulty, the Grain Research Laboratory designed and constructed an auger type probe, capable of recovering samples at three foot intervals to depths of 80 feet in one operation.

Moisture Gradients. Early in the emergency storage programme it was found that, during winter and early spring, moisture tended to accumulate in the surface layers of wheat stored in the temporary annexes. Grain stored with an average moisture content of 12.5% might show a rapid increase to 16 or 17% moisture in the surface layers. This phenomenon provided ideal conditions for the development of mite and insect infestations and promoted deterioration due to the growth of moulds. Conditions pertaining in sheds showing this moisture gradient suggested that temperature differences between the central portion and the periphery of the grain mass promoted a translocation of water vapour from the warm central portion to the cold periphery where condensation occurred. This hypothesis was confirmed in the laboratory.

Quality of Wheat Held in Temporary Storages. In order to keep a close check on the quality of the large stocks of wheat held in terminal annexes at Fort William and Port Arthur in 1940, a project was planned by the laboratory to test samples annually for as many years as the grain remained in storage. Aside from the control aspect, such a study provided an excellent opportunity for obtaining information on the keeping quality of Canadian bulked grain.

Samples of the wheat, representing nineteen annexes, were taken at time of loading in 1940 and these were tested for milling and baking quality, dough properties, and viability. The following year, the storage situation at the head of the lakes had changed considerably. The comparatively small harvest in 1941 and the reduced production of No. 1 Northern created a shortage of this grade for export, and as most of the wheat in storage was One Northern, many of the annexes were emptied and refilled with grain from country points.

Additional annexes were partly emptied and replenished with new grain of the same grade and others were partly emptied and not refilled. Because of these changes, only four of the nineteen annexes sampled at time of loading could be sampled a second time and these were tested in exactly the same manner as the original samples. The emptying of the four annexes the following year made it necessary to discontinue the investigation. For the one year storage period for which comparable samples were available, the results obtained showed that milling and baking quality and physical properties of the doughs remained essentially unchanged, but slight deterioration in viability was indicated.

Oil Seeds Investigations

Western Canadian Flaxseed. The disruption of markets and transportation facilities, caused by the war, created increased interest in the expansion of flax production in Western Canada with the object of supplying domestic demands for linseed oil. Because of the importance of this problem, certain information on Western Canadian flaxseed which had been collected in the laboratory in pre-war years was compiled and published. The technical data reported dealt primarily with areas of production and the quality of flaxseed produced in different districts.

The results of the surveys made by the laboratory during the years 1934 to 1939 showed that the main flax-producing areas in Western Canada were: the Rosetown district in west-central Saskatchewan, the Red River Valley and the Portage Plains in Manitoba, a district south of Regina in Saskachewan, and the irrigation districts in Alberta. Production in the northern park belt was sparse and scattered but increasing.

In oil content and drying quality of the oil, there is appreciable inter-annual variations. Both quantity and quality of oil depend on environmental factors, and there are indications that oil of better quality can be obtained from flax grown in the park belt where rainfall is higher and protein content of wheat is generally average or lower. Grades of flax differ little in oil content and drying quality but appreciable differences exist between varieties. From a consideration of production, yields, prevailing prices, and returns per acre, it was concluded from the surveys that the outlook for Canadian flax production was favourable.

In the early years of the war a large increase in Canadian flax production occurred. The Laboratory continued its annual surveys and information on the oil contents and iodine values were made available to the Oils and Fats Administrator, and to all other interested persons, as early as possible each fall.

Vegetable Oils Survey. The occupation of the Phillippines and the Netherlands East Indies by Japan created a shortage of certain vegetable oils throughout the whole of North America, and this shortage was particularly severe in Canada which produced only linseed oil and a small amount of soyabean oil. As a result of this situation, a number of references were made to the Associate Committee on Grain Research asking for various investigations in the field of oils and fats. Plans for an expanded programme of research on oil seeds were discussed by the Committee, but with limited staff available it was considered unwise to make detailed plans without adequate information on many practical matters which might limit the application of research findings. It also appeared advisable to seek up-tp-date knowledge on the status of research on oil seeds by collecting new and unpublished information from various sources. The Chief Chemist of the Grain Research Laboratory was asked to collect this information for the guidance of the committee in outlining its research programme. General information was requested on the oils and fats situation in the United States and Canada, on the production programme for 1942, on crushing capacities, on demands for various types of oils, and on facilities in Canada for processing oils. Among the more specific requests, information was sought on the possibilities of using linseed oil in making shortening, on the problems which might have to be solved if Canada undertook to produce and use sunflower seed on a large scale, and on the possibilities of utilizing waste seeds from Canadian fruit and vegetable processing industries, and wild mustard from grain screening, for the production of vegetable oils. The survey was made during March and April 1942, and reports were submitted to the Committee under the following headings: I. General Information; II. Utilization of Flaxseed; III. Sunflower Seed; IV. Utilization of Waste Seeds from Canadian Fruit and Vegetable Processing Industries; V. Interim Report on Screenings.

The survey showed that the deficiency in vegetable oils in North America created by the loss of copra and palm oil areas would be offset in major part by increased production of soyabeans, cottonseed, peanuts and flax in the United States and by increased production of flax in Canada. Crushing capacity, however, placed a limitation on the amount of soyabean oil which could be produced in the United States and on the amount of linseed oil that could be processed in Canada.

The utilization of linseed oil other than in the drying industries had possibilities, but 10-20% of the oils used for soap could be linseed oil without creating serious difficulties. Research on the development of methods whereby a percentage of linseed oil could be used for shortening was suggested. In the paint industry, excellent progress had been made in developing substitutes for Tung and Perilla oil. Adequate information was found to be available on the hulling, crushing, refining, and processing of sunflower seed oil, and little work on sunflower seeds would be required, other than that dealing with production, harvesting and storage. Research on the agricultural phases had been in progress for some time and a new investigation on storage problems was begun immediately.

A survey of the possibilities of using canning wastes showed that none of these wastes, other than tomato seeds, was produced in sufficient quantity to merit serious consideration. When all available information on the drying, collection, and processing of tomato seed waste had been assembled, it was concluded that the project was not feasible from the practical standpoint.

Although considerable amounts of oil might be obtainable from the wild mustard accumulated in refuse screenings at Fort William and Port Arthur, it was considered improbable that it would pay to segregate and process these, owing to the relatively low oil content of the seeds and the poor quality of the oil. It was recommended, however, that some work should be done on this project.

<u>Oil Seeds in Western Canadian Grain Screenings</u>. Refuse screenings from cereal grains, shipped from Fort William and Port Arthur during the second quarter of the 1942-43 crop year, were examined for oil content. The samples were obtained by the Inspection Branch of the Board of Grain Commissioners and represented 190 carlots (approximately 4800 tons) of refuse screenings and 56 carlots (approximately 1400 tons) of flax refuse screenings.

Samples of wild mustard seed, obtained principally from carlot shipments of "black seeds", were also included in the study. The refuse screenings contained an average of 49 percent of weed seeds having an average oil content of 14.6%. The principal oil-bearing seeds found were: wild mustard, 8.8%; stinkweed, 2.9%; broken flax, 2.4%; hare's ear, 1.6%; and tumbling mustard, 0.9%. The amounts of total seeds and of individual species varied widely in different shipments.

The refuse screenings from flax contained an average of 75 percent of weed seeds and other small heavy material having an oil content of 21.4 percent. The principal oil-bearing materials found were: broken flax, 13.8%; wild mustard, 11.7%; stinkweed, 9.4%; hare's ear mustard, 5.0%; and tumbling mustard, 2.8%. Although, at the time the investigation was made, limited crushing capacity and man-power shortage made it unfeasible to produce oil from screenings, future possibilities merited consideration.

Protein and Starch Contents of Wheat

Owing to the large amount of alcohol required for war purposes, and the need for making much of this from cereal grains, information on the starch content of Canadian wheat was required. During prewar years, attention had been paid primarily to protein content and a large volume of data on protein was available as a result of annual surveys started in 1927. As protein content and starch content are inversely related, the possibility of using protein data to predict starch contents merited investigation. Reports of studies relating to starch content and a summary of a bulletin dealing with protein content are given in the following subsections.

Starch Content of Western Canadian Wheat. Two papers on this subject were published by the laboratory. The first dealt with the starch content of average samples of different grade representing carlot inspections at different points in the prairie provinces during 1942-43. The second dealt with the estimation of starch from protein data. The mean starch content for all samples was 52.5%, the maximum was 56.2% and the minimum 48.2%. The Garnet grades, No. 5 wheat, durum wheat, and Alberta Winter wheat were all high in starch content. Grades 1 to 4 Northern, which comprise the bulk of the wheat marketed in Western Canada, had an average starch content of 52.5%. For grades 1 to 3 Northern inspected at Winnipeg, Edmonton and Calgary, the correlation coefficient between starch and protein was -.918 and the prediction was: starch = 68.0 - 1.12 x protein ($\pm$0.76). The data for No.5

wheat were heterogeneous and yielded correlation coefficients of the order of -.7 which were too low for prediction purposes. By means of the above equation it was estimated that for the crops 1927 to 1942 the average starch content of Western Canadian wheat varied between 51.1 and 55.1% with a mean value of 52.7%.

Comparison of Methods for Determining Starch Content of Wheat. To obtain information on the most suitable method for routine determinations of starch in wheat, a comparative study was made of two chemical and three polarimetric methods: malt diastase with subsequent acid hydrolysis, the Rask procedure, the Lintner-Schwarcz method, and the Hopkins and the Clendenning modifications of the Mannich-Lenz methods. Mean values and standard errors (single determinations) for the five methods were: malt diastase with acid hydrolysis, 63.6 ±0.57; Rask, 62.2 ±0.48; Lintner-Schwarcz, 62.9 ±0.48; Hopkins, 63.3 ±0.31; Clendenning, 62.8 ±0.40.

The polarimetric methods are far simpler to use than the chemical methods, and of the former the Clendenning method is preferred. No preliminary washing is required, there are no frothing difficulties, filtering presents no problem, and one operator can make 24 to 30 tests a day. In the Hopkins method, washing is tedious and time-consuming and no more than 16 determinations a day can be made. The Lintner-Schwarcz method also requires preliminary washing to obtain satisfactory filtration and it is in the same class as the Hopkins method. The two chemical methods are long and complicated. In the Grain Research Laboratory, the Clendenning method has been adopted, chiefly because of its greater speed and ease of operation. It is not quite so precise as the Hopkins method and may be a little less accurate. But the relation between the two methods appears to be relatively constant over the starch range in which the laboratory is interested.

Variations in the Protein Content of Western Canadian Wheat. The study was based on twelve annual protein surveys of Western Canadian hard red spring wheat (1927-38) in which over one hundred thousand samples were collected and analysed. The bulletin which was published deals with the variations in protein content that occurred from district to district, from year to year, and from grade to grade, during the period indicated. The relation between protein content and yield was also examined as well as the effect on precipitation and other environmental factors.

Part I deals with the average geographic distribution of wheat of different protein levels, and the mean shows that zones of different protein ranges are distributed over Western Canada in a regular manner. Part II deals principally with the changes in the geographic distribution of wheats of different protein levels that occurred from year to year. In spite of wide differences between years, study of individual maps serve to confirm the general conclusion that protein content is generally highest in the south-central part of the prairies and tends to decrease towards the north, west and east. The maps show that soil is not the principal factor that governs the protein content of wheat; for the chemical and physical characteristics of the soil must have remained relatively constant from 1927 to 1938, and yet the protein level varied widely in almost all districts. Maps for each year, showing wheat yields and summer precipitation, are also presented in Part II and the latter provide ample evidence that rainfall has a major effect on both yield and protein: high rainfall increases yield and decreases protein content and low rainfall has the reverse effects. The total effect of environmental factors other than rainfall is, however, large enough in some years to upset the normal relations between rainfall, protein content and yield.

Part III summarizes the data as means and frequency diagrams for each year and province. The data show that the annual protein level for shipments of "survey" grades tends to fluctuate within ±0.5 units of a mean value of about 13.5%, but the variations from the mean of as much as 1.5 units can occur in very dry or in very wet years. During the 12-year period the surveys indicated a minimum protein level of 11.4% in 1927 and a maximum of 14.7% in 1936. Part IV presents similar summaries for grades, and there is good evidence to show that the mean protein content tends to decrease with grade from No. 1 Hard to No. 3 Northern. The data also show that the spread which can occur between the protein contents of the same grade in different years is about three times greater than the spread that normally occurs in any one year between the protein contents of Nos. 1 Hard and 3 Northern.

Miscellaneous Studies

Susceptibility of Biscuits to Insect Damage. During the war, hard biscuits of the type issued to the Armed Services for emergency rations were frequently stored for long periods, and infestation by insects sometimes caused spoilage. The extent of such spoilage was influenced by the suitability of the biscuits for insect development and survival, and development and survival depend on the moisture content and the ingredients of the biscuits. If these factors are favourable, the biscuits will resist insect attack. Flour and fat are both important components in ration biscuits and are used in relatively high proportions; the former is the main basic ingredient and is hygroscopic and the latter is not, hence the proportions used mush have an effect on the hydration capacity of the biscuits. In a study of the problem made by the laboratory, biscuits of suitable type, made from three grades of flour and three fat levels, were stored at three levels of humidity to determine the moisture equilibrium values. In addition, larvae of the confused flour beetle, Tribolium confusum Duv., were reared on the biscuits. The results obtained over a storage period of 113 days showed that increasing the fat content of the biscuits lowered both the initial and the equilibrium moisture content at all levels of relative humidity (25, 50 and 75%), and that flour grade exerted less influence on moisture content than did fat content. Aging the biscuits decreased their hydration capacity at high relative humidity and increased it at low relative humidity.

The rate of insect development and the percentage survival of the larvae reared on the biscuits were both adversely affected as compared with flour controls. Development was greatly retarded and mortality was high for larvae reared on both whole and ground biscuits. In a later study, it was concluded that destruction of thiamine during the baking process was responsible for the high resistance of the biscuits to insect attack. At the low level of survival and development attained by the Tribolium larvae on biscuits, high moisture content and biscuits made from a long-extraction flour favoured the insects, but biscuits of high fat content were somewhat unfavourable. A high fat content rendered the biscuits less susceptible to penetration by the larvae.

<u>Malts made from Wheat, Oats and Miscellaneous Seeds.</u> In connection with wartime research on fermentation, a study was made of malts obtained from wheat, oats, barley, rye and other miscellaneous seeds. Preliminary tests showed promising values for malts made from rye, wild and cultivated oats, wheat, barley, speltz and crested wheat grass seed. More extensive tests were made on wheat and oats. Samples of Garnet wheat, which is higher in amylase activity than any other Canadian wheat variety, gave values for liquefying or alpha-amylase activity ranging from 13 to 19 units. Although none of the samples of oats gave as high alpha-amylase as Garnet wheat, there was almost complete absence of beta-amylase in the malts. The mean alpha-amylase activity for the oat malts was 58 units.

Gluten Concentrates. As the use of wheat starch for alcohol production provided possibilities of preparing gluten as a byproduct, the laboratory re-opened studies on the preparation of gluten of unimpaired baking quality begun in 1936. Examination of samples of commercially prepared gluten showed that they were inferior in quality to the product made in the laboratory. This was not surprising because it seems reasonable to suppose that isolation by hand manipulation would have less drastic effect on gluten quality than methods of preparation used commercially. The superior quality of the laboratory-made product might also have resulted from the use of better source material of higher protein content and baking strength. Studies were therefore initiated in 1941 looking to an assay on the value of Western Canadian wheat for the preparation of dry gluten, and to possible improvement of commercially feasible methods of isolation and drying.

Comparisons of the relative merits of different methods for isolating gluten showed that the degree of impairment to gluten for fortifying the baking strength of flour depended on the following: the mechanical stress, as reflected by the granulation of the flour to which the wheat is subjected during grinding; the grade of the flour, which is the source material; the washing procedure, washing time, etc.; the extent to which the gluten is purified before drying; the method of drying; and the method used for reducing the gluten to powder.

One of the more difficult problems encountered was that of testing the isolated gluten to determine whether injury to quality had resulted from the processing, for it is not easy, if indeed it is possible, to establish the quality of the gluten prior to isolation. Failing this, the possible damage to quality during isolation cannot be determined with accuracy. Test baking with a low-protein flour fortified with different levels of gluten seemed most promising, and the results of such a study made with different base flours and different gluten concentrates were published. The study showed that the linear relation between loaf volume and protein content, expressed as a coefficient of regression, would serve as a useful tool for examining the quality of gluten, provided the protein and fortification levels covered sufficiently wide ranges. If several gluten concentrates are to be compared, each can be used to fortify one or more base flours at different protein levels, and the resulting data can be used to determine the regression coefficient for each gluten and the significance of possible differences between them. The essence of such a method is that a statistical analysis is used to obtain an objective and quantitative interpretation of the data.

As the work progressed it was considered necessary to attempt to develop a simple physical test that would show differences between glutens, rather than depend on a baking procedure that is time consuming and which requires considerable material. With this aim in view a mechanical device was designed and constructed in the laboratory, and a number of studies have been made with it. The device is known as the Stretchometer and it measures the extensibility and resistance to extension (toughness) of gluten.

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G. ASSOCIATE COMMITTEE ON INDUSTRIAL RADIOLOGY

This Committee had been preceded by a former Radiology Committee which dealt mostly with medical radiology, but the advent of the Associate Committee on Medical Research terminated the first Radiology Committee's existence. The present Committee, which deals with industrial radiology exclusively, was established early in 1939. Its primary objective was to provide X-ray inspection in the development of sound foundry technique and in the rejection of unsafe castings; in this way, it was to help establish on a firm base the production of trustworthy cast light-alloy aircraft parts in Canadian factories; later there was the application of radium radiology in inspection of cast steel parts of fighting vehicles, warships, etc.

The first major work of the Committee was to devise an Inspection Code which would provide acceptance standards against reduction in strength caused by common defects in castings. A first and provisional code, based on experiments in the Radiology Laboratories, was drawn up and submitted to various Committee members for trial in the factories with which they were associated; a later revision of the code, considered by the full Committee, was adopted. A request from the Royal Aircraft Establishment, England, was received asking the Committee to undertake studies of the effect of its Inspection Standards on service performance of aircraft castings; somewhat different methods were suggested to the Committee, but the work the Committee had already accomplished was a considerable contribution to this problem.

In 1940-41, a reduction in funds granted to the Committee made it impossible to continue the employment of a full-time physicist and laboratory workers to devote their whole time to the radiological investigations which the Committee required. In November, 1940, a suggestion was discussed that the National Research Council should consider offering industry the same kind of help in industrial spectroscopy as it had rendered in industrial radiology. It was also suggested that the National Research Council should call a conference of those concerned to discuss the utilization of this Committee's resources and the National Research Laboratories' equipment and facilities in assisting the manufacturer of heavy metal war devices. But these questions were left in the discussional stage. In September, 1942, the Committee and Laboratories suffered the loss of the services of the Secretary, Mr. Leslie Ball, who resigned to assume an important war position in the aviation industry in California. His place on the Committee, until its specific activities were suspended, was taken by Mr. A. Morrison, who in time became Acting Head of the Radiology Laboratories.

As the war intensified, the Associate Committee and its subcommittees could no longer meet, for so many of its personnel were moved to highly important war positions in various localities, some of them very distant, but the Laboratory technical staff kept in touch with Committee members as occasions required. The report on "Radiographic Inspection Procedure for Light Alloy Castings" was reprinted twice to meet the demands from war industry, and to respond to interest from laboratories in the United States. Throughout the war, following the policy originally established by the Committee, the Laboratories assisted the war effort in many ways, such as training of radiology personnel for industry, lending its own staff members to companies and government departments in emergencies, assisting in consultation and with technical advice.

H. ASSOCIATE COMMITTEE ON METALLIC MAGNESIUM

In 1937, two conferences on metallic magnesium were held under the auspices of the National Research Council. Representatives of the Department of Mines and Resources and the Department of National Defence were also present with Council officials.

At these conferences it was pointed out that there was then no production in Canada of metallic magnesium or of the compounds used for its production. It was also noted that there were available in Canada, as in most countries, large supplies of minerals containing magnesium which might serve as a source of compounds for producing the metal. It was recognized that metallic magnesium was important in both peace and war and that its production and use had increased rapidly in recent years in most of the major industrial countries of the world.

As a result of the conferences, it was agreed that methods for making metallic magnesium from certain compounds were well known and that the first step towards the production of metallic magnesium in Canada would, therefore, lie in the direction of preparing these compounds from the large available supplies of magnesium minerals in the Dominion.

The conferences agreed that the production of magnesium in Canada might be of importance in a national emergency and that there appeared to be a sufficient commercial objective to warrant establishment of such an industry. The conferences further recommended the formation of a Committee consisting of respresentatives of the Department of National Defence, the Department of Mines and Resources and the National Research Council to investigate the possibilities and methods of the production of metallic magnesium in Canada.

Such a Committee was accordingly established by the National Research Council in September. 1937. In the early years of the war, the strategic importance of magnesium as a war metal was soon recognized and the National Research Council was asked to attack the problem of its production.

A review of the literature was made and the possibilities of four different methods were investigated.

These methods were:

(a) Electrolytic

(b) Carbo-thermic

(c) Calcium carbide

(d) Silicon reduction of dolomite

Other methods had been suggested but it was thought they would not have any commercial possibilities.

Of the four methods studied in the Division of Chemistry preference was given to the one utilizing silicon reduction of dolomite, partly because dolomite is plentiful in Canada and partly because ferrosilicon is a lower-cost reducing agent (per equivalent) than calcium carbide. A heating method had been developed in the National Research Council which was apparently closely related to a process used in England for the production of metallic magnesium.

Using high silicon ferrosilicon of which a good supply was available in Canada, the laboratory obtained yields up to 90% in the reduction of calcined Canadian dolomite.

An experimental plant capable of producing about ten pounds of metal per day was built in the laboratories of the Division of Chemistry and operated for some time in order that the process might be studied and fully understood. Later a pilot plant was constructed by private interests, and subsequently a crown company was formed to produce metallic magnesium by the Pidgeon process.

Several plants were also built in the United States to utilize this process.

A full account of the experimental work leading to the development of the process is given in the volume on the War History of the Division of Chemistry.

I. ASSOCIATE COMMITTEE ON PARASITOLOGY

INTRODUCTION

The Associate Committee on Parasitology was appointed in 1932, under the chairmanship of Dr. H. M. Tory, to co-operate with interested bodies in investigations on animal parasites in Canada.

It opened negotiations with the Empire Marketing Board and Macdonald College of McGill University and, as a result, the Institute of Parasitology was established in 1932 at Macdonald College, under Professor T. W. M. Cameron as Director, to work under the supervision and advice of the Associate Committee. This arrangement continued until 1939, when the Dominion Department of Agriculture undertook to assist financially in this work. The Associate Committee was enlarged to give effect to the new arrangement and it continued to exercise direction over the scientific activities of the Institute.

The Committee at the outbreak of war consisted of the President of the National Research Council and the Principal of McGill University as joint-chairmen, with the Director of the Division of Biology and Agriculture of the Council, as Vice-Chairman. The other members were:

The Deputy Minister, Department of Agriculture
The Director, Science Service, Department of Agriculture
Dominion Animal Pathologist
The Veterinary Director General,
as representative of the Federal Department of Agriculture;
The Chief, Health of Animals Branch, Province of Quebec
The Provincial Zoologist, Province of Ontario
representing these two provinces;
The Vice-Principal, Macdonald College
The Secretary, " "
The Dean of Medicine, McGill University
The Director, Institute of Parasitology
The Professor of Animal Pathology
representing McGill University;
The Director, Imperial Bureau of Agricultural Parasitology, England.

The Secretary of the Council is Secretary of the Committee.

The scientific recommendations of this Committee are carried out by the Institute of Parasitology at Macdonald College.

ANIMAL PARASITOLOGY

Parasitology, as understood by the Associate Committee on Parasitology, referred to the animal parasites -- mainly to the so-called worms and the protozoa. As the major parasites of interest in Canada were the worms (or helminths), of the domesticated animals, particular attention was paid to these; however, parasites of man were not entirely neglected.

The helminths differ from the other causes of disease in one very important particular: they cannot multiply within the host. The young stages which these relatively complex animals produce must leave the body and undergo some essential development outside of the body before they become infective. This development varies for each species, but it usually requires very definite physical and chemical conditions.

Disease is usually due to numbers of parasites and, as each one must be taken into the body separately, a heavy infection can only follow gross exposure or gross contamination of pasture land or soil. Infection is usually by mouth, although in some species infective stages penetrate the unbroken skin. Infection is usually specific and in general the parasites of various animals are not interchangeable.

Accordingly, it is obvious that the parasites of animals in a country such as Canada are much more important economically than are those of man. However, parasites do exist in man in Canada, as they must in any country with a large rural population with defective sanitation, and so their study could not be completely neglected. Nor was it in the seven years preceding the outbreak of war.

The part played by human parasites in warm countries is very much greater than it is here and the main difference between tropical and temperate medicine lies in this fact -- partly because of defective sanitation in warm lands, partly because of temperature and humidity. Accordingly, when Canadian Servicemen moved into the warm lands of the Mediterranean, of Africa and of India, this Institute was prepared to undertake immediate instruction of medical personnel in these exotic causes of disease and their prevention, as well as to initiate research.

In 1939, however, the main requirement was food and it was decided to intensify and accelerate the work already begun on food animals. Cattle were not greatly infected by animal parasites but sheep were heavily parasitized and there was a prevailing belief that the roundworm of pigs was an important source of loss. It was known that poultry suffered heavily from coccidiosis (a protozoan disease of the intestine) and that it was a major hazard in poultry and egg production. These subjects were investigated serially because of shortage of staff.

Sheep Intestinal Parasites

In 1936, a survey of the parasitic diseases of sheep in Canada had been commenced and during the next two years several hundreds of animals were studied in great detail; this involved the examination of approximately two million worm parasites. As a result, the role which each kind played in the production of disease was clarified. Twenty-six species were found to occur in sheep and lambs in the Dominion but experimental observations on growth of infected lambs and a survey of graded animals in abattoirs showed that the nodular worm, the common stomach worm and the very small Trichostrongylus in the small intestines were largely responsible for the losses suffered by sheep breeders in Canada east of Manitoba.

These three nematodes have a very similar life-cycle. Minute eggs pass to the exterior with the droppings, a larval stage hatches from each and, after a period of growth, becomes infective for the sheep. It is swallowed as a contamination of the grass on which these animals feed and in a few weeks has become a mature, egg-laying adult. The worms, however, have very different parasitic habits. The stomach worm (Haemonchus contortus) lives in the true stomach where it feeds on blood and causes an anaemia, the severity of which depends on the numbers present. The nodular worm (Oesophagostomum columbianum), on the other hand, lives in the colon and does not feed on the sheep's tissues; however, after the young forms are swallowed, they develop for a while within the tissue of the large bowel, causing the production of nodules which not only interfere with the well-being of the animal but destroy the usefulness of the gut after slaughter. The minute Trichostrongylus worms live in the true stomach and duodenum of the sheep and are associated with a severe form of diarrhoea.

Studies were then commenced to determine the efficacy of various chemicals as anthelmintics and the place of copper sulphate, nicotine sulphate, tetrachlorethylene and arsenical preparations in the treatment of sheep in Canada, was determined. A minor project on the effect of prior fasting on the efficiency of anthelmintic drugs was then carried out; it was found that the common and often harmful practice of fasting sheep for long periods before dosing did not increase the efficiency of the treatments and recommendations were made accordingly.

The next and probably more important project was concerned with the ability of the free-living stages of the modular worm, stomach worm and Trichostrongylus to over-winter on pastures. It was shown that the nodular worm did not over-winter and the stomach worm was unable to do so in numbers sufficient to cause serious disease in lambs in the spring. Thus a system of prevention of the most serious parasitic diseases was founded on the theory that the removal of all adult nodular worms and stomach worms from a flock of sheep before they were turned to grass in the spring would prevent contamination of pastures and hence protect the lambs from serious infection during the grazing season. In a field test using four badly infected flocks in Frontenac County, Quebec, it was found that stomach worms could be eliminated by dosing the adult sheep with copper sulphate and nicotine sulphate <u>before</u> the pasture season. However, attempts to remove the nodular worms by colonic lavages with arsenical solutions apparently failed, as nodular disease appeared in a severe form in two of the flocks.

In 1939, the United States Department of Agriculture indicated the anthelmintic value of phenothiazine and a study was commenced at this Institute. After preliminary failures to remove nodular worms by injecting a suspension of phenothiazine into the colons, and partly satisfactory results from giving the drug mixed in feed, a means was invented of administering the drug in the form of large tablets made up of eighty per cent phenothiazine and twenty per cent of ingredients that caused rapid and explosive disintegration of the tablet into small particles in the stomach of the sheep. By increasing the speed of passage of the phenothiazine particles through the intestinal tract, it was found that a very highly efficient means of removing the adult nodular worms, as well as stomach worms, hookworms and several other species, had been developed. This method was promptly included in the previously devised preventive system and a special wartime grant form the National Research Council made it possible to devise a tablet press and obtain enough chemicals to launch a wide-scale field test of the system. In 1940, the tablets were patented on behalf of the National Research Council and a manufacturer was licensed to produce them so that they could be supplied by veterinarians and co-operatives to sheep farmers at a low price, for use by the farmers themselves.

It was found that in flocks owned by the Experimental Farms Service of the Dominion Department of Agriculture, two annual doses of the tablets in amounts that had been shown to be highly effective in critical tests in the Institute, had virtually eliminated nodular disease and the other harmful parasites had been reduced to insignificant levels. Results on private farms were apparently almost equally satisfactory, although exact figures on efficacy were impossible to obtain. The work done in co-operation with the Division of Animal Husbandry of the Central Experimental Farm stands as probably the first example of elimination of a helminthic disease from large flocks of animals by practical means.

The system has been widely adopted and in Nova Scotia, between 1940 and 1943, the number of Grade A lambs from the Antigonish area increased from sixteen per cent to sixty-eight per cent of the whole, due to the control of these parasites. The Department of Agriculture and Marketing of Nova Scotia has continued the work of controlling parasitic disease of sheep by the preventive system and figures are now available to show that parasitic diseases of sheep have changed from a major handicap in the production of meat and wool to a minor cause of loss in that Province.

The adoption of the system by the Quebec Department of Agriculture has resulted in a very large decrease in the incidence of nodular disease and stomach worm disease, although statistics are not available.

Special Studies on Phenothiazine

In connection with the work on sheep diseases, an investigation was undertaken of the details of the fate and effect of the drug in sheep, horses and other animals. This resulted in the first full understanding of the character and identity of the oxidized and excreted products of phenothiazine after it had entered the animal body. The toxic effect on horses was also demonstrated in detail for the first time, and the recommendations for use of the drug for horses in Canada were founded on this work.

The conjugated derivative of phenothiazine in sheep was first identified and later synthesized. It was found to be a new ethereal sulphate, potassium leucophenothiazone sulphate. This discovery made possible further work on the pharmacology of phenothiazine. The enzyme-inhibiting power of phenothiazine was also demonstrated and thus a start was made towards a probable explanation of the remarkable anthelmintic power of this chemical.

The Role of Worm Parasites in the Production of Bacon Pigs

It had been known for some time that the commonest animal parasite of pigs was the roundworm, Ascaris lumbricoides. This parasite, which in its adult stage is twelve to fifteen inches long, lives in the small intestine and is identical with a similar parasite in man. It has a remarkable life-cycle. It lays eggs which are extremely resistant to adverse influences and which are distributed with the excrement. In this egg develops a minute roundworm which does not hatch until the egg is swallowed by the pig. It then migrates to the liver and the lungs before settling down in the intestine. Because of this, it was generally considered to be a major hazard in the production of bacon pigs.

A survey of Ascaris lumbricoides in pure-bred pigs in Canada, as they entered and progressed through the Advanced Registry Test Stations in Prince Edward Island, New Brunswick, Quebec, Manitoba and Saskatchewan, was commenced in 1940. From February, 1940, to July, 1941, each of 1,090 pigs was tested on entry to the Stations, at seventy days of age and at 84, 98 and 126 days of age, and finally just before shipment to the abattoir. It was found that seventy-five per cent of this population of pigs were infected with Ascaris at some period of their lives and that the majority of infections were acquired during the pre-weaning period. Only the heaviest infections, represented by over 10,000 eggs of Ascaris per gram of faeces, had a statistically significant effect upon the growth rates of the pigs. This work was then followed by an attempt to elucidate the relationship of nutrition to susceptibility to ascariasis, and thus to explain the reason for quite serious roundworm disease in other pig populations. Experiments extended over a two-year period revealed that pigs born of sows that were given balanced rations during pregnancy, and which were of normal size (over 2 lbs.) at birth, and were protected from iron deficiency and avitaminosis A, were highly resistant to ascariasis; no single case of roundworm disease occurred in such pigs even when they were exposed to quite heavy challenging doses of infective worm eggs. Pigs suffering from nutritional anaemia or avitaminosis A, or both, were, on the other hand, susceptible to ascariasis.

This work has resulted in a definite change in recommendations regarding parasite control and prevention by proper nutrition is now stressed over anthelmintic medication.

Coccidiosis of Chickens

Studies on coccidiosis were commenced in 1943 because it was the parasitic disease of outstanding importance to poultrymen in temperate climates. Projects on chemotherapy were conducted following the finding in Britain that one of the sulfanilamides, sulphamezathine, was effective in checking acute coccidiosis when given to chicks after artificial inoculation. This finding was confirmed and the work was extended in an effort to discover other effective drugs. Numerous experiments were conducted with various arsenicals and sulphonamides and it was found that a sulphonamide with a pyrimidine ring and one methyl group was very definitely coccidiostatic, as was its soluble sodium salt. Under experimental conditions, practically all infected birds can be saved when the drug is administered in feed or water at the commencement of intestinal haemorrhage. The practical application of this and related findings await further work which is at present going forward.

HUMAN PARASITOLOGY

It soon became evident that foreign and tropical service was bringing many new problems in human parasitology to the attention of Canadians. The most important tropical diseases are parasitic in nature or are carried by insect vectors, and the spreading of the war into the sub-tropical

Mediterranean region as well as south-east Asia and the immense amount of air travel in tropical lands involving Canada and Canadian personnel, made this subject one of very great medical interest.

The Director of the Institute was named Referee in Tropical Medicine and Parasitology to the Associate Committee on Medical Research and in this capacity he prepared a number of memoranda on control of insects, malaria, and so on. A considerable amount of diagnostic work was undertaken -- especially in malaria and amoebiasis -- for the three Services and Department of Veterans Affairs. Papers were prepared on the importance of tropical diseases to Canada, various surveys and other research projects were initiated.

Trichinosis

It had been shown that in the United States about seventeen per cent of the population harboured the Trichina worm. A survey made by the Director showed that in Canada less than 1.75 per cent were infected. Further surveys in pigs showed a much lower incidence than in the United States, probably due to the Federal regulation requiring the licencing of hog garbage feeders and the cooking of all such foodstuffs.

Pinworms

A survey was made by a member of the Institute staff which showed that in recruits entering the Canadian Army, in the following age groups, the rate of infection with the pinworm was as follows:-

18 to 21 years of age	----	19 per cent
Over 21 " " "	----	10 " "

This was on the basis of a single examination which had been shown previously to have an accuracy of about seventy per cent. Accordingly, the actual number of infections in adults may be presumed to be thirty per cent higher than these figures would indicate.

Intestinal Protozoa

A survey showed that approximately forty-seven per cent of the normal Canadian population harboured intestinal protozoa. Of these, however, only about two per cent were E. histolytica, the only pathogenic species. However, a survey of returned soldiers (in the Montreal area) showed that about seventeen per cent carried this parasite. This is the form which causes various intestinal disorders (including actual dysentery) and which may produce the very serious amoebic liver abscess.

While it is generally believed that E. histolytica is at least always potentially pathogenic, there is still some doubt. Moreover diagnosis is sometimes unsatisfactory, when sole reliance has to be placed on the demonstration of this minute parasite in the stool. Accordingly, investigations were commenced on the development of a suitable serological test. This work is still in progress but shows some promise of being of use. At the same time, it became obvious that a considerable number of parasitic diseases in man would be introduced into Canada by veterans and by internees from the tropics; preparations have therefore been made to maintain a stock of test antigens for Filariasis, Trichinosis, Schistosomiasis, Hydatid Cyst as well as Amoebiasis for post-war use while facilities for blood and faeces diagnosis, elaborated during the war period, will be maintained at least during reconversion.

Army Pregnancy Diagnosis Station

The Institute has housed the Army Pregnancy Diagnosis Station which has used the South African clawed toad as a diagnostic agent. The work has been carried out under the supervision of the Director by C.W.A.C. and R.C.A.M.C. technicians. This work does not properly come under the heading of parasitology, but owing to the fact that the first C.W.A.C. training centre was established at Macdonald College and that the Institute, because of its fish parasite investigations, had facilities for working with fresh-water animals, the Director General, Army Medical Services, requested that this arrangement should be made.

Since its inception some 3,000 tests have been made.

The toads have been imported from South Africa by air and as this test has considerable value in civilian as well as military life, it was thought desirable to undertake experiments with a view to increasing the stock. These experiments have been successful and a second generation of toads born in Canada has been obtained.

This work, like all the other diagnostic work carried out for the Services, has been entirely voluntary.

EDUCATIONAL WORK

Although the Council's Committees are not concerned with education as such, the obvious need for training of Service medical personnel in the exotic diseases encountered in a global war, made it essential that the only organization in Canada equipped with the necessary material and experience should be used partly for teaching purposes during the emergency.

In 1941-42, the Director was invited to assist in four short fortnightly courses in tropical medicine, organized by the Director of Hygiene of the Army and conducted at the Animal Diseases Research Institute at Hull. In August 1943, however, the first of a series of courses was given at the Institute. This was a fortnight's course, based on the curriculum drawn up in England as being suitable for Army Medical Officers proceeding to North Africa and Italy. Later, the R.C.A.F. seconded a medical entomologist for training at the Institute and he assisted the Director in the laboratory work.

The D.D.G., R.C.A.M.C., decided as the result of the experience gained in these courses that a fortnight's instruction was too little; in January of 1944, therefore, a series of five three-months' courses were given to Naval, Army and Air Force Medical Officers.

Of the thirteen weeks' instruction, eleven were given at the Institute, involving 450 hours' instruction each; the remaining two weeks were held in Montreal and were conducted by three professors of McGill University, and various specialists from outside the University.

The University instituted a Diploma in Tropical Medicine and arranged for the students attending the above-mentioned courses to spend three months in British Guiana and Trinidad studying the clinical aspects of the subject. As a result, these Medical Officers who were prepared for the Asiatic war theatre had a much better and more extensive training than that given either in the United Kingdom or the United States.

By June, 1945, it became obvious that time would not permit of this long training and a short course was devised, involving more lectures and less practical work. Only one such course was given, owing to the defeat of Japan.

In addition to instruction to medical officers, however, instruction was given to technicians of all the Services, as well as to those of the Department of Veterans Affairs, in the laboratory procedures necessary to diagnose malaria, dysentery and other exotic diseases. There were six such courses.

In addition, a short course of one week's duration in the methods of malaria control in the field was given to the R.C.A.F. at the end of July, 1945.

In all, this emergency teaching involved the Director in giving about 3,200 hours' instruction. This work was entirely on a voluntary basis and no charge was made to any of the Services.

J. ASSOCIATE COMMITTEE ON PETROLEUM

GENERAL ACTIVITIES OF THE COMMITTEE

Summary

Under the sponsorship of the Advisory Board of Industrial and Research Chemists, a meeting of the outstanding chemists of the Canadian Oil Industry was held in Toronto on the 17th. of April 1940 with Dr. O. Maass of the Advisory Board of the Industrial and Research Chemists acting as Chairman. Representatives of Canadian oil companies, of the War Supply Board and of the National Research Council attended.

The primary purpose of this first meeting was to discuss the production of high octane aviation fuels, toluene and acetone in Canadian oil refineries, so that the greatest possible production level could be maintained for the prosecution of the war.

After several meetings, this group became known as the Petroleum Committee of the Advisory Board of Industrial and Research Chemists which name through common usage became simple the Petroleum Committee. At its first few meetings, the Committee examined possibilities of producing toluene from Turner Valley crude oils, acetone in the Eastern refineries and the location of plants for the production of high grade aviation gasoline. A survey was made of possible locations of plants to manufacture aviation gasoline, blending agents, toluene, acetone and ethyl alcohol. Estimates were prepared on the possible output and the cost of manufacture of these products. These figures were referred to the Minister of Munitions and Supply and the British Supply Board for their information.

At the fourth meeting of the Committee, its aims were formalized as follows:

"The purpose of the Committee is to advise the Department of Munitions and Supply as to the possible production of certain strategic materials in Canadian Petroleum Refineries".

Early in 1941, close co-operation with other government departments was established through the National Research Council and the scope of the Committee was enlarged so that representatives of the three Armed Services could be included in its membership. Under these arrangements, direct contact was established between the Armed Services, government departments and industry. Problems arising in the Armed Services could then be referred directly to the Committee for solution by the members and the facilities they represented.

As the war progressed, the membership was further expanded to include direct representation of such government departments and sections as the Department of Munitions and Supply; the Oil Controllers' Office; the Directorate of Automotive Design; the Fuel Research Laboratory of the Department of Mines and Resources; the Gasoline and Oil Testing Laboratory of the National Research Council and the Engine Testing Laboratory of the National Research Council. This arrangement permitted very close co-operation between industry, government departments and the Armed Services in dealing with problems relating to the supply and use of petroleum products in Canada.

Towards the end of 1941, close liaison was established with Canadian Military Headquarters in London England, and contact was made with problems arising in the sphere of actual operations.

To assist in the speedy formulation of petroleum product specifications, two industrial members of the Petroleum Committee were nominated, late in 1942, to be members of the Canadian Government Purchasing Standards Wartime Subcommittee dealing with petroleum specifications. At the same time, serious consideration was given by the Committee to representation and co-operation with United States Committees dealing with similar problems. Closer liaison with the aircraft industry was established through the nomination of a mamber of the Petroleum Committee to membership in the Associate Committee on Aeronautics.

In February 1943, liaison with American and British bodies was established by the attendance at the meetings of the Committee of representatives of the Coordinating Research Council of the United States, the British Air Commission in Washington, and the British Petroleum Commission in Washington.

Due to the fact that the activities of the Committee had greatly expanded and had outgrown the original intention to act only as an advisory body to the Department of Munitions and Supply, tentative terms of reference were drawn up in June of 1943 and finally adopted in August. These covered all phases of the Committee's activities and formalized its position with government and industry. Under these terms of reference, the Committee now acted as an advisory body for the government and Military Services in all questions on the availability and supply of petroleum products, acted in a consulting capacity for test, development and research work, provided laboratory facilities from industrial and government laboratories for carrying on test and development work, studied wartime problems and made recommendations on research work to solve these problems if required and provided liaison on petroleum developments both to and from other countries.

These functions were ably carried out by the co-operation of the Committee with the Armed Services in their field tests at Camp Shilo, Camp Borden, Kapuskasing and Arvida. Information was received from British, American and Russian sources and provided on Canadian development to British and American sources. Close liaison was established with the Petroleum Board in Britain and the proceedings of the Committee were forwarded continually to the Coordinating Research Council.

Throughout 1944, the activities of the Committee were mainly directed to the solution of problems related to increasing the supply of 100 octane aviation fuel, service controls of lubricating oils, low temperature hydraulic fluids, low temperature fire control lubricants and cold weather tests carried out by the Armed Services. Late in 1944, when it became evident that the final prosecution of the war was only a matter of time, the Committee began to give thought to its continuation as a post-war organization. At the 43rd meeting held in October, 1945, this action was formalized by the Committee through the following motion: "It is recommended that the Petroleum Committee be maintained as an active Committee after the present war thus making it possible for the industry to continue co-operating with government departments and laboratories in advising the public and Military Services in problems relating to the availability, quality and application of petroleum products in peacetime". This recommendation was accepted and agreed to by the President of the National Research Council.

Another post-war aim of the Committee was the encouragement of research work on fundamental problems dealing with petroleum and its products in Canada at Canadian universities.

Just prior to V-E day, the Committee began to discuss the question of post-war research. A list of problems presented by the R.C.A.F. for post-war consideration was studied and a recommendation was made to the National Research Council that it support a research project on the fundamental mechanisms of oil deterioration in service.

By V-J day, the preliminary steps had been taken to set up the machinery to start research work on problems related to petroleum and its products for use in Canada.

Terms of Reference

As revised and finally adopted at the 33rd meeting held on the 4th of August, 1943, the terms of reference were as follows:

1. To advise the Government, in particular the Department of Munitions and Supply and the Department of National Defence in all questions relating to the availability and supply of petroleum products.

2. To advise the Canadian Military Services in questions relating to the availability, quality and application of the petroleum products required for satisfactory operation and maintenance of motorized and other equipment used by the Services.

3. To act in a consulting capacity and provide technical observers in tests, development work on research projects carried out by the Department of Munitions and Supply and the Department of National Defence and to provide laboratory facilities in Canadian refineries for the testing and development of motor fuels and lubricants.

4. To study wartime problems related to petroleum and allied products and, if it is judged advisable, recommend research on these problems by any interested organization.

5. To provide a liaison through which information on reports on petroleum developments in other countries may be secured and information and reports on Canadian developments distributed in other countries.

Membership

The membership of the Associate Committee on Petroleum consists of representatives from industry, government, the Armed Services and other groups directly interested in petroleum and its products. At the time of cessation of hostilities the Committee membership was as follows:

Dr. R. K. Stratford	Imperial Oil Company, Chairman
Mr. C. B. Veal	Secretary of the Coordinating Research Council, U.S.A.
Mr. G. K. Brower	Representative, Coordinating Research Council, U.S.A.
Mr. A.W.S. Thompson	British Air Commission, Washington.
Mr. H. B. Barton	McColl-Frontenac Oil Company.
Mr. R. O. Campbell	British American Oil Company.
Dr. D. M. Morrison	Shell Oil Company of Canada.
Mr. E. A. Smith	Canadian Oil Companies.
Mr. K. H. Cheetham	Allied War Supplies Corporation
Dr. W. A. Jones	Allied War Supplies Corporation
W/C J. M. Macoun	Directorate of Aeronautical Inspection, R.C.A.F.
W/C B. Rabnett	Directorate of Aeronautical Engineering, R.C.A.F.
Major F.A.G. Lake	Directorate of Mechanical Maintenance, Army.
Lt.Col. S. C. Sifton	Directorate of Supply and Catering, Army.
Mr. P. B. MacEwen	Directorate of Automotive Design, Army Engineering Branch, Department of Munitions and Supply.

Mr. R. L. Dunsmore	Imperial Oil Company.
Major Gordon McIntyre	Imperial Oil Company.
Lt.Cdr. W.A. Williams	Director of Fuels, R.C.N., H.Q.
Lt.Cdr. D.L. McGillivray	Naval Engineering & Construction Branch, R.C.N., H.Q.
Lt. W. G. Belfry	Directorate of Naval Stores, R.C.N., H.Q.
Mr. W. H. Rea	Office of the Oil Controller Department of Munitions & Supply.
Mr. P. V. Rosewarne	Office of the Oil Controller Department of Munitions & Supply.
Dr. T. E. Warren	Fuel Research Laboratories Department of Mines & Resources.
Dr. J. W. Broughton	Gasoline and Oil Testing Laboratory National Research Council.
Mr. M. S. Kuhring	Engine Testing Laboratory National Research Council.
Mr. J. H. Parkin	Director, Division of Mechanical Engineering, National Research Council.
Dr. A. Cambron	Division of Chemistry National Research Council.
Mr. G. T. Perry	Gasoline and Oil Testing Laboratory National Research Council Secretary.

DETAILED ACTIVITIES OF THE ASSOCIATE COMMITTEE ON PETROLEUM

Toluene

At the beginning of the war Canada faced a serious shortage of raw materials required for the production of aviation gasoline and explosives. The first efforts of the Committee were directed to alleviating this situation. The possibility of producing toluene from Turner Valley crudes was thoroughly investigated. Estimated production capacity and costs were prepared and submitted to the Minister of Munitions and Supply. The coal tar industry was also thoroughly investigated and costs prepared for toluene recovery. Due to the uncertainty of supply of this critical material from the United States, the Shell Oil Company of Canada was requested by the Committee to prepare estimated costs for a plant at Calgary to process Turner Valley crudes for the production of toluene. However, by the beginning of 1941, the production of toluene in the United States had reached a point where the situation was no lonter critical and it was agreed to drop further action on this phase of the Committee's activities. The question was again discussed immediately after Pearl Harbor which brought about the subsequent cutting off of supplies from the Dutch East Indies. Subsequent events however showed that further action was not necessary.

Acetone

The question of the production of acetone for the Eastern refineries was in a similar category to that of toluene. Supplies from exporters in the United States were uncertain at the beginning of the war and as a result the Committee carefully went into the question of costs and design of equipment for the production of this essential material. When it became apparent that there was sufficient supply available on hand to meet the needs of the explosive industry in Britain, Canada and the United States, no further action was taken.

Aviation Gasoline

The need for ever increasing quantities of high octane aviation gasoline was one of the problems that faced the Committee from its inception right up to the cessation of hostilities. Early in 1940, a survey was made for the location of plants to produce aviation gasoline and blending agents. Estimates were prepared on production and costs and were forwarded to the Minister of Munitions and Supply and the British Supply Board. Full thought was given to the problem of the complete utilization of Canadian crude stocks for aviation blends. At the same time, discussion centered around the need for alkylate plants and their location. As a result of this, a survey was made to obtain an estimate of the cost of production from a plant at Calgary and another to be located in the Eastern part of Canada. Polymerization and isomerization of the lighter refinery fractions was also considered as well as the use of benzol blends. To meet the increasing demands for aviation gasoline the Committee in July 1941 urged the Oil Controller to obtain surplus alkylate from the United States. As a result of the earlier survey, plans for an alkylate plant at Calgary were underway by August 1941. This plant was to utilize raw materials from the refineries of the Imperial Oil Company and the British American Oil Company located in that district.

During the early part of 1941, the Committee was still concerned with the supply of aviation gasoline and pointed out that this would shortly become critical. Proposals were made to the government urging it to plan on an expansion of the aviation gasoline programme. Estimates were prepared on the basis of feed stocks available at Montreal and Sarnia. In November 1941, a recommendation was made to the Minister of Munitions and Supply, Minister of National Defence for Air, the Oil Controller and Air Vice-Marshall Stedman of the R.C.A.F. that plants be set up at Montreal and Sarnia. Plants were finally erected and completed at Calgary and Montreal. Progress reports on production figures were reported to the Committee on these plants at each meeting up to the end of the war.

The supply of feed stock for the Montreal plant became critical in 1944 and the Committee studied the possibility of supplying feed stocks from points outside of Montreal.

The supply of cumene as blending agent for high octane aviation gasoline became very critical in 1942 and as a result the pulp and paper industry was investigated to determine the cost of producing para-cymene from sulphite liquors as a substitute for this essential blending agent; however, investigation showed that it would not be economical and this matter was dropped.

One of the outstanding accomplishments of the Committee was its work in the investigation of cracked gasolines for use in 87 octane gasoline supplied for training in the Commonwealth Air Training Scheme. Due to the large demands of the training scheme, base stocks that could have been utilized for the production of 100 octane fuel for operational flying were diverted to the production of 87 octane fuel for training. Since the cracked fuels did not have sufficient storage stability for blending into operation fuels, it was proposed to divert cracked stocks to fill the demands of the Air Training Scheme where long term storage stability was not critical. Through the co-operation of the National Research Council and the R.C.A.F., full scale engine tests were carried out at the Engine Testing Laboratory of the National Research Council and flight tests were made at Uplands Airport near Ottawa. Since these tests proved satisfactory, the use of cracked stocks was finally adopted for use by the Commonwealth Air Training Scheme. As a result of this work, the Canadian Government Purchasing Standards Wartime Subcommittee was able to draw up a specification to this type of fuel.

Further work was carried out at the Engine Testing Laboratory on catalytically cracked and re-cracked suspensoid gasoline right up to the latter part of 1944. Information on tests in Ram tanks both in Canada and the United States using these fuels was also presented to the Committee.

To make further stocks available for 100 octane aviation fuel a recommendation was forwarded to the Oil Controller and the Refining Committee to increase the 50% distillation point of motor transport fuels. This was adopted in May 1943. Again in June 1943 a recommendation was forwarded to the Canadian Government Purchasing Standards Wartime Subcommittee to have the 50% distillation point of 80, 87 and 90 octane fuels increased.

On the question of tetraethyl lead content, the Committee was kept fully informed at all times on developments in the United States and, in co-operation with the Canadian Government Purchasing Standards Wartime Subcommittee, aviation fuel specifications were designed so that they would be equivalent to United States fuels. Late in 1943, on the recommendation of the Committee, 87 octane fuel was lowered to 86 octane for supply to the R.C.A.F. with a resulting saving in stocks.

Right up to the end of the war, the Committee continued its efforts to increase the production of aviation gasoline from available stocks by any means which seemed practicable.

Lubricating Oils

One of the first problems confronting the Committee with respect to oils was the reclamation of used oils as a means of saving essential materials. The Armed Services were considerably interested in the possibility of oil reclamation due to the large volumes used. The Army went to considerable lengths with this question and requested the Committee to develop special tests to determine the usability of reclaimed oils. After considerable thought and effort on the part of the Committee, the conclusion was reached that due to the widely scattered locations of the various depots it would not be economical to collect all the used oils and reclaim them at one time or to set up reclamation units at the individual depots, particularly in view of the fact that there was considerable doubt regarding the quality of reclaimed products. This conclusion was upheld by the operation of an experimental unit installed by the Army. As a result, the problem was dropped from the Agenda of the Committee in June 1942.

With regard to the recovery of the aviation type oils used by the R.C.A.F., it was felt that it would be possible to re-refine these oils for motor transport use. As a result of the work of the Committee and the conclusions drawn, the Canadian Government Purchasing Standards Wartime Subcommittee drew up a specification to cover this material on the advice of the R.C.A.F. in December 1942. Full scale engine tests on a Cheetah 9 aircraft engine were run at the Engine Testing Laboratory at the National Research Council. On the basis of these tests, the re-refined oil was approved for motor transport use but not for general aircraft or operational use.

Towards the latter part of 1942, the Armed Services started to use heavy duty additive oils. The first problem encountered by the Committee was one of supply. Large amounts of this type of oil were used in changing over mechanized equipment from regular mineral oil to the heavy duty type and the Committee agreed to look into the possibility of reducing the amounts required. As a result, the Army was requested to look into their oil change procedure to see if it would not be possible to amend it so that the demand would not be so great. Since considerable experimental work was carried out in the United States with these types of oils, close contact was maintained with authorities there on this question.

As the supply of additives used to manufacture heavy duty type oils had to be imported from the United States, it was essential that every effort be made to conserve these materials. In May 1943, a letter was written to the Oil Controller pointing out the situation and requesting that the sale of heavy duty oils be restricted to essential users. By June 1943, the supply situation had become so critical that the Committee investigated the possibility of setting up the manufacture of additives in Canada. As a result, a preliminary survey was instigated to find what equipment and raw materials were required. The National Research Council was requested to obtain all available information in the United States through its liaison office in Washington. This information was received shortly afterwards and placed before the Committee. On the basis of this information and the increased production in the United States, it was decided that it would not be necessary to establish a source of supply in Canada. To increase the operating period of mechanized equipment using heavy duty oils, the Imperial Oil Company prepared a method of evaluating used heavy duty oils.

By the end of 1943, the Army had carried out field tests to try to determine an optimum period for oil change. The Shell Oil Company of Canada and the Imperial Oil Company carried out laboratory work on oil samples taken from each vehicle after 2,000 miles of operation.

Troubles which had been experienced with foaming in Ram tanks using SAE 50 grade heavy duty type oils were discussed and this was finally overcome by the manufacturers adding anti-foaming agents to the oil supplied to the Army.

Through the co-operation of the Department of Munitions and Supply's Army Engineering Design Branch, the Committee was kept posted on tests being run in Texas to determine the correct oil and filter elements change periods. To obtain further information on this subject, the British American Oil Company undertook to carry out in February 1944 laboratory tests on the deposits taken from the filter elements of the Texas tests. These field tests in Texas were completed in March 1944 and the final report on the work was to be made available to the Committee. To expedite the laboratory work on tests of the filter deposits, the Subcommittee on Performance Tests of Heavy Duty Oils was set up in August 1944. Some of the work on the filter elements was allocated to the Gasoline and Oil Testing Laboratory of the National Research Council and the remainder was to be completed in the laboratories of the British American Oil Company. The final combined report on the results of the laboratory and field tests was not issued by the time the war was over, although the report on the field tests had been prepared for some time.

Many problems dealing essentially with supply and specifications were dealt with in co-operation with the Armed Services and the Canadian Government Purchasing Standards Wartime Subcommittee over the period of hostilities.

Service problems, such as low temperature starting of engines and the question of dilution of crank case oils, were encountered and discussed. Recommendations were made to overcome the difficulties encountered. With regard to the question of dilution, the R.C.A.F. requested that a method of field testing be developed and in the early part of 1944, the Gasoline and Oil Testing Laboratory of the National Research Council devised a method using bubble tubes which gave an indication of the change in viscosity brought about by dilution. However, due to carbon and other deposits in the oils, this was not satisfactory and a field distillation procedure was developed and checked against an R.C.A.F. gravity check method at Kapuskasing during the winter trials.

Special Oils

Requirements for special types of oils for rust prevention were discussed and recommendations were passed on to the Armed Services and the Canadian Government Purchasing Standards Wartime Subcommittee so that specifications could be drawn up.

In September 1942, the Navy requested the Committee to consider the matter of supplying a petroleum fraction that would be satisfactory for use in the Langmuir Smoke Generator fur use as a smoke screen oil. Upon consideration it was found that the supply of this material would not be a serious problem.

In April 1944, an inquiry was received from the Army regarding a kerosene type vapourizing oil for use in lubricating small arms. After examination of the requirements, it was agreed that this could be readily supplied by the Canadian manufacturers.

Hydraulic Fluids

The problem of the performance characteristics of the hydraulic fluids at low temperatures came before the Committee early in 1943. Due to the scope of this problem the Subcommittee on Low Temperature Greases and Hydraulic

Fluids was set up in June 1943 to study low temperature greases and also take over the problem of hydraulic fluids. Further details on this work are given under the heading of the Subcommittee on Low Temperature Greases and Hydraulic Fluids.

Greases

During the war, the Committee was continually faced with problems calling for the application of specialized lubricants. The majority were satisfactorily solved in the laboratories of the petroleum industry. Very close co-operation existed on problems of this type between the Armed Services and industry and as a result of the work of these groups, the Canadian Government Purchasing Standards Wartime Subcommittee was able to draw up the necessary specifications to meet the varying demands.

Every attempt was made to keep the specialized greases and lubricants down to a minimum and those that were developed were made so that they would be equivalent to British and American greases designed for similar purposes. To accomplish this, close liaison was maintained with various bodies in these countries working along similar lines.

As with other petroleum products, the problem of supply and the question of meeting specification demands was always present and had to be dealt with as specific cases arose.

Problems dealing with low temperature characteristics of greases came under the jurisdiction of the Subcommittee on Low Temperature Greases and Hydraulic Fluids. Further details of this work are given under that heading.

With the increased use of amphibious landings in warfare, the Committee became interested in the use of greases that would resist salt water. While no actual work was being done by the Committee, all available information was obtained on wading greases, etc, for the information of the Committee and the Armed Services.

SLUDGE FORMATION IN MERLIN AIRCRAFT ENGINES

During 1941, the R.C.A.F. experienced considerable trouble with sludge formation in the lubricating oil used in Merlin engines. This problem was communicated to the Committee and after discussion was referred to the technical staff of the Imperial Oil Company. After examinations of 53 separate engines at their overhaul periods, and after considerable laboratory work on samples taken from these engines, the trouble was traced to ethylene glycol used in the coolant system of the Merlin engine. A method of detecting small amounts of glycol in lubricating oils was developed by the Imperial Oil Company and improved after consultation with the staff of the Gasoline and Oil Testing Laboratory of the National Research Council. This permitted an early check to be made in the field and allowed the necessary corrective steps to be taken.

LONG TERM STORAGE OF GASOLINE

Towards the latter part of 1942, due to the steel shortages, the question of additional storage tank accommodation for aviation gasoline came before the Committee. The question centered around the substitution of concrete tanks for steel tanks and the possible effect on the fuel. It was decided that it would be necessary for such tanks to have a gauge steel or rubber compound lining to prevent leakage. Steps were taken to secure information on the experiences of the British and Americans on similar type tanks. After this information was available and studied the Committee agreed to recommend the continued use of steel since it was shown that the actual steel requirements could be reduced below the original estimate.

MISCELLANEOUS ITEMS

In May 1942, the Department of Munitions and Supply requested a technical opinion on the practicability of utilizing the Alberta tar sands. After careful consideration the opinion was given that in spite of wild claims, a large amount of development work would have to be done to make the project economically possible and it was recommended that the investigation be deferred until after the war.

With regard to the work being carried out at the Fuel Research Laboratories, Department of Mines and Resources, on the hydrogenation of coal for the production of liquid fuel the Committee was kept informed of the progress of the investigation being made.

Towards the latter part of 1941, the Army requested advice and information on the use of suitable inhibitors for rust prevention for use in ethylene glycol that was being recovered from anti-freeze solutions. This work was undertaken in the laboratory of the Canadian oil companies and a report was issued giving the required information.

In July 1942, the Navy requested the Committee for information on a satisfactory method of collecting oil slicks at sea so that the origin could be determined. After considerable discussion, it was thought that a modification of a method developed by the American Petroleum Institute might be applied. The problem was referred to the Gasoline and Oil Testing Laboratory of the National Research Council. Further information was also obtained from the Shell Company of Canada through the Shell Development Company in the United States. A report was issued on the work done at the National Research Council in October 1943.

In December 1941, the Oil Controller's Office requested information regarding the usability of blown fish oils as a substitute for rapeseed oils for Naval use. The required information was obtained and forwarded to the Navy through the Committee.

The question of additives for gasolines to improve their performance characteristics was considered at several times. One of these known as "P.D." additive received considerable thought. Tests carried out in the United States for both the United States and British Government were observed and information on these tests was made available to the Committee. Due to the inconclusive evidence of these tests to show any specific improvement in performance, the subject was dropped.

In September 1942, the Committee discussed the possibility of using substitute fuels such as producer gas and propane for use in motor vehicles due to the possible critical shortages of gasoline. After considerable discussion, it was decided that at that time these products were impractical for use on this continent.

In December 1942, the possibility of utilizing shale deposits in the Maritimes as a possible source of aromatics was discussed. This was found to be impractical.

Early in 1943, in an effort to increase aviation gasoline supply, the Committee examined the possibility of obtaining aromatics from Fort Norman crudes. However, upon examination it was found that this was not a possible source of supply.

In 1942, the Army became interested in a simple method of deleading gasoline for use in gasoline fired cookers. Information and reports issued by the Ethyl Corporation on the same problem for the U.S. Army were obtained and forwarded to the Canadian Army.

In the early part of 1943, the Committee studied the use of "CS" or toluidiene for use in aviation gasoline blends as a means of increasing the production of 100 octane aviation fuel. As a result, through the co-operation of the R.C.A.F., full scale engine tests were carried out in the Engine Testing Laboratory of the National Research Council. The results of these tests conducted for the R.C.A.F. were made available to the Committee. Continued interest was maintained in this product until the use of "CS" was finally dropped in the United States late in 1944.

Early in 1944, the R.C.A.F. requested information on the possibility of manufacturing an aviation fuel of a 100/150 grade to meet an English specification. This fuel contained monomethyl aniline to increase the rich mixture performance characteristics. An experimental blend was made up and tested on the supercharged test engine at the Gasoline and Oil Laboratory of the National Research Council. Results of this test were forwarded to the R.C.A.F. for their information.

In May 1945, the Army reported that several engine failures had been experienced with motorized equipment operating with heavy duty type oils. These failures were caused by the deposition of a gummy material which caused the seizure of the moving parts after operation. Analytical work showed that this was caused by small traces of ethylene glycol in the crankcase, and was mainly experienced with only one type of additive.

CO-OPERATION WITH THE ARMED SERVICES ON FIELD TESTS

During the course of the war, the Army and the R.C.A.F. carried out several field service tests on motorized equipment. To assist with this work, the Committee supplied technical observers at some of these tests and through the co-operation of the Armed Services information and reports were made available for study to the Committee.

These reports covered work done on cold weather tests by the R.C.A.F. at Kapuskasing, Ontario, during February 1942, Army Tests at Camp Shilo, Manitoba, during the winter season of 1942-43; Army tests on armament equipment at Arvida, Quebec, during the winter season of 1943-44 and at Camp Borden, Ontario.

A lot of the work of the Subcommittee on Low Temperature Greases and Hydraulic Fluids was carried out in co-operation with these projects.

In connection with tests at Camp Shilo a separate Subcommittee on Cold Starting was set up and conferred with representatives of the Department of National defence, the Department of Munitions and Supply and all motor vehicle manufacturers.

SUBCOMMITTEE OF THE ASSOCIATE COMMITTEE ON PETROLEUM

Subcommittee on Cold Starting

At the 24th meeting of the Associate Committee held in October 1942, a group was formed to make recommendations on tests to be carried out at Camp Shilo during the following winter. This subcommittee was made up of representatives of the Departments of National Defence and Munitions and Supply, the Shell Oil Company of Canada, the Imperial Oil Company, the McColl-Frontenac Oil Company and the National Research Council.

After a preliminary meeting held on the 9th of October 1942 to discuss test programmes, a meeting was held in Toronto on the 3rd of November with representatives of the Army, Department of Munitions and Supply and the automotive industry at which time the programme for all tests at Camp Shilo was outlined and discussed. Later on in the same day, a separate meeting of the Subcommittee was held to discuss in more detail fuels and lubricants that were to be used during the tests.

During the progress of these tests at Camp Shilo, members of the Subcommittee were present as technical observers and reports on the progress of the work were made to the Associate Committee as the tests were carried out.

Subcommittee on Low Temperature Greases and Hydraulic Fluids

Low temperature greases, hydraulic fluids, buffer oils and rust preventative oils had been under consideration for some time by the Associate Committee and, by 1943, these problems had reached such proportions that it was found necessary to appoint a Subcommittee to study these problems as a group. At the 31st meeting of the Associate Committee held on the 2nd of June 1943, the formation of a Subcommittee on Low Temperature Greases and Hydraulic Fluids was approved. The terms of reference of this Subcommittee were to study and make recommendations on hydraulic fluids, buffer oils, rust preventative oils and low temperature greases to meet the performance requirements of the Armed Services. The Army, Navy and Air Force, the Imperial Oil Company, the McColl-Frontenac Oil Company, the Shell Oil Company and the National Research Council were represented on this subcommittee.

The first meeting of the Subcommittee was held on 9 June 1943. Three low temperature greases were studied for possible adoption; one being an American grease, one a British grease, and one a Canadian development of a British grease which had been tested at Camp Shilo. A programme of field and laboratory test work was drawn up to find out how these greases performed under summer and winter conditions. The programme consisted of the following:

a) Field Tests

The Army agreed to carry out tests in guns and instruments at summer temperatures. The R.C.A.F. undertook to carry out leakage and bleeding tests from aircraft bearings at summer temperatures. The Army Engineering Design Branch of the Department of Munitions and Supply agreed to operate tanks with these greases at summer temperatures.

b) Laboratory Tests

The Gasoline and Oil Testing Laboratory of the National Research Council undertook to carry out laboratory work to correlate with field results so that specifications could be written.

c) Cold Room Tests

The Army agreed to carry out tests on representative types of guns in cold rooms to obtain comparative results. The R.C.A.F. undertook to carry out tests on gun turrets as used in aircraft.

The requirements for hydraulic fluids were reviewed and their properties such as viscosity at -40°F, viscosity index and rubber swelling tendencies were studied.

Army requirements for rust preventative oils for use on the bright parts of guns were studied. Various oils were reviewed in the light of the criterion that they must perform satisfactorily in temperatures ranging from -40°F to +40°F.

Six meetings of the Subcommittee were held from its inception up to November 1944. During that time, field tests and laboratory work carried out at Kapuskasing, Uplands Airport, Imperial Oil Company, Sarnia and the National Research Council were studied. This resulted in the drawing up of a specification for a special grease which was finally issued by the Canadian Government Purchasing Standards Wartime Subcommittee. Other specifications which had been issued by the Canadian Government Purchasing Standards Wartime Subcommittee were revised and amended as a result of studies and recommendations made by the Subcommittee.

Further work done by the Subcommittee consisted of the study of the supply and testing of special greases for normal and low temperature operation of gun sight mechanisms; the utilization of alkylate bottoms for the manufacture of buffer oils, which were found to be inferior to other types of buffer oils; the testing of specially prepared greases at Kapuskasing by the R.C.A.F.; testing of experimental buffer oils for the Army for use at Arvida and Camp Borden; the study of special lubricants for mechanical time fuses in anti-aircraft shells; and cooperative development work coupled with bench tests by Research Enterprises Limited and field tests by the Army on lubricants for optical fire control instruments to perform satisfactorily from -40°F to +160°F. In the latter work, on optical fire control instruments lubrication was still under way at the close of hostilities.

In October 1944, at the 43rd meeting of the Associate Committee the name of the Subcommittee was changed to "The Subcommittee on Extreme Temperature Lubricants" and a recommendation was made that its activities should be continued to handle new problems in this field of lubrication.

Subcommittee on Performance Tests of Heavy Duty Oils

At the 42nd meeting of the Associate Committee, this Subcommittee was set up to assist with and make recommendations on the laboratory work required in connection with the examination of filter deposits of oils from the field tests conducted in Texas on Army motorized vehicles operating on heavy duty detergent type oils. The Navy, the R.C.A.F, the British American, Shell, McColl-Frontenac and Imperial Oil Companies and the National Research Council were represented on this subcommittee.

Up to the time of V-J day, no meeting of the Subcommittee had been held but most of the laboratory work had been carried out by the British American Oil Company with some of the work being done at the National Research Council. Prior to the end of 1945, two meetings of the Subcommittee had been held to discuss the laboratory results and a final report consisting of work done in the field and in the laboratory was under preparation.

POST WAR PETROLEUM RESEARCH

In October 1944, the Associate Committee began to take cognizance of the need for continuing research work of a fundamental nature in the petroleum field in Canada to ensure the country maintained its knowledge of petroleum developments to meet future emergencies. It was proposed that the main post-war function of the Committee would be to coordinate petroleum research and to act as an advisory and consulting body on problems related to this work.

The first steps in this direction were to support a long term programme designed to study the fundamental causes of oil deterioration.

At the time of the cessation of hostilities, a survey had been made of Canadian universities to determine the possibility of having fundamental research work done in their laboratories.

A subcommittee was formed to study these problems and also operational problems from the Armed Services. This group was required to make recommendations to the Associate Committee on the best means of carrying out this work and to coordinate research work throughout the country. The personnel of this Subcommittee included representatives of the British American Oil Company, the Department of Mines and Resources and the National Research Council.

Up to the end of 1945, two meetings of the Subcommittee were held and recommendations were made to the Associate Committee with regard to future policy of carrying out petroleum research. Recommendations were made for close international co-operation in this sphere of activities in the future.

K. ASSOCIATE COMMITTEE ON RADIO RESEARCH

The formation and work of this Committee, which were known only to a few, dates back to the early part of 1938 when the only radio work being done was of a confidential nature and for two government departments, namely, the Department of National Defence (Air) and the Department of Transport (Marine). Council had disbanded the old Associate Committee on Radio Research which had been formed in 1931, and in 1938 set up in its place two inter-departmental secret committees on radio under the auspices of which would be pursued confidential work on the cathode ray direction-finder, and the cathode ray air-compass. The small executive consisted of the President and Secretary-Treasurer of the National Research Council, ex officio, with the Director of the Physics and Electrical Engineering Division as chairman, and the Head of the Radio Section as secretary of the Radio Research Committee. The above two panels continued their work into the war period. There was added a third secret panel to the Committee, known as "Section III", in the autumn of 1939 and ratified by the Council in July 1940, to deal entirely with the secret Radar, then known as R.D.F.

Before the war, all the work of the Council's Radio Laboratories centred around the secret panels of the Research Committee, ionospheric observations and standard frequency equipment. Naturally, the Radio Committee was indirectly interested in the last two. In time, prototypes of cathode ray direction-finders and cathode ray air-compass were developed and complete details supplied for their manufacture. These instruments were produced by Sparton Manufacturing Company in London.

The ionospheric research, begun before the war, was dropped immediately war broke out, but was later resumed at the request of the British Admiralty through the Royal Canadian Navy. The laboratories constructed and operated two sets of apparatus, one at Chelsea near Ottawa, the other at Churchill on Hudson Bay. Another set of equipment was constructed and lent to American observers for an ionosphere station on Baffin Island. Another equipment was installed at an Army ionosphere station in September, 1944.

The Radio Standard Frequency Laboratory was in existence before the war and only a few additions were made to it during hostilities.

"Section III" worked intensively during the early part of the war until its functions were gradually merged into specialized committees organized under the Inter-Departmental Services and under the newly established National Research Council Radio Board.

On the formation of this Board, with its various special and ad hoc committees, there was no longer any necessity for the three panels of the Radio Research Committee and in November, 1944, it was recommended that the Committee should be disbanded; this was later done.

L. ASSOCIATE COMMITTEE ON SOIL AND SNOW MECHANICS

Late in 1944, the Chief of the General Staff of the Canadian Army was advised of work which had been started in England, by the British Army, on the problem of the trafficability of tracked vehicles (especially tanks) in muddy ground. The Director of Operational Research, and of Vehicles and Small Arms, of the Canadian Army investigated the need for studying this problem in Canada. The problem necessarily meant considering the inter-relation of soil mechanics and vehicle design; it was therefore discussed at the University of Toronto with Dean C. R. Young and members of his staff.

The matter was next discussed with Dr. C. J. Mackenzie, President of the National Research Council of Canada, who suggested that the problem was intimately associated with problems of peacetime transportation in Canada, especially if the corresponding action of tracked vehicles over snow was considered. Accordingly, a meeting of military and civilian personnel interested in the many phases of the broad question thus developed was held in Ottawa on 3 March, 1945. After full consideration, it was decided to recommend the institution of an Associate Committee on Soil and Snow Mechanics of the National Research Council.

The Committee was appointed in April 1945, with equal representation of military and civilian interests. It was made up of the following:

Prof. R. F. Legget, <u>Chairman</u>	University of Toronto, Toronto, Ont.
Dr. C. J. Mackenzie	National Research Council.
Prof. R. E. Jamieson	McGill University, Montreal.
Mr. G. J. Klein	National Research Council.
Col. G. M. Letson	D.V.S.A.(Army), Dept. of National Defence, Ottawa.
Dr. D. C. Rose	National Research Council.
Col. J. T. Wilson	Operational Research (Army) Hut No. 1, Cartier St.,Ottawa.

Mr. F. L. Peckover, <u>Secretary</u>	National Research Council
Dr. N. W. McLeod	Dept. of Transport, Ottawa.
Mr. N.C. Millman	Director General, Army Engineering Design Branch Dept. of Reconstruction and Supply, Ottawa.

Work was almost immediately started on some urgent projects. The first publication of the Committee was issued just before V-J day; it dealt with a proposed field testing device for checking the "trafficability" of soils. Work on some of the fundamental aspects of the major problem continued, and after V-J day, was turned to its civilian aspects. Close contact was maintained from the start of operations with corresponding committees in Great Britain and the United States, with complete interchange in information. It seems clear that Canada's main contribution will be in relation to the specific problem of over-snow travel.

M. ASSOCIATE COMMITTEE ON SUBSTITUTE FUELS FOR MOBILE INTERNAL COMBUSTION ENGINES

The threatened shortage of liquid fuels for cars, trucks, tractors and motor boats caused the Dominion Government, in November 1941, to consider seriously the possibility of providing suitable fuels from sources other than petroleum. Accordingly, the National Research Council was asked to investigate the various alternatives that might be made available for this purpose. A conference was held at Ottawa on December 1st, 1941, which was attended by representatives of the National Research Council, Dominion Forest Products Laboratory, Department of Mines and Resources, Department of Munitions and Supply, R.C.A.F., Dominion Oil Controller, and University of Toronto.

After considerable discussion, a committee was appointed "To consider substitute fuels for mobile internal combustion engines and to report to the Conference at a later date". Members of this Committee were:

Mr. J. H. Parkin (Chairman)	National Research Council.
Mr. L. Coderre	Deputy Minister of Trade & Commerce.
Mr. A. Bedard	Deputy Minister of Quebec, Department of Lands & Forests.
Professor E. A. Allcut	University of Toronto.
Mr. G. Godwin	
Mr. E. S. Malloch	Department of Mines & Resources.
Dr. C. Greaves	Forest Products Laboratories.
Colonel E. C. Thorne	Department of National Defence.
Mr. P. V. Rosewarne	Department of Munitions & Supply.
Mr. B. N. Torell (Secretary)	National Research Council.
Professor R. H. Patten	McGill University.

A summary was drawn up, in tabular form, comparing the relative merits of synthetic gasoline from coals, coal gas, benzol and other liquid by-products from coal, propane, methane, hydrogen, alcohol, acetylene, ammonia and producer gas made from coal, wood, coke or charcoal. The committee also obtained advice and assistance from other sources in considering the possibilities of some of these fuels and made a study of the available literature. The report of this committee was considered at a second conference held in Ottawa on February 7, 1942, and the following recommendations were made and subsequently adopted by the Conference:-

(a) That a small committee be formed immediately to arrange for the testing of producer gas units made in Canada and of a few imported models, to determine their practicality and suitability for different engines.

(b) That the production of alcohol be considered in relation to its use as a fuel substitute and also to its increasing importance as a solvent in the manufacture of munitions and supplies. Consideration should be given to the production of alsohol from wheat. The Conference is convinced also that investigations toward the utilization of such materials as wood and waste sulphite liquor should be encouraged. (It was found subsequently that all available alcohol was needed for munitions.)

SUBCOMMITTEE ON PRODUCER GAS

The Subcommittee on Producer Gas held its first meeting on May 4, 1942. Test procedures and facilities, availability of producers in Canada, estimates of costs and personnel required, were discussed at that meeting, and arrangements were made to visit Quebec, Duchesnay, Three Rivers and Montreal, to see gas producers in operation, to investigate possible charcoal supplies and to enquire into the availability of suitable test apparatus. These visits and conferences took place May 12-14, 1942, and it was ultimately decided that (a) no producer gas plant was available in Canada, that was developed sufficiently to serve as a war emergency unit; (b) the charcoal production of the Province of Quebec could be expanded usefully to serve as an emergency fuel supply; (c) the facilities offered by McGill University, Montreal, were the most suitable for the work of the committee; and (d) other necessary work could be done at the National Research Laboratories and the Forest Products Laboratories, Ottawa, which were situated a little more than 100 miles from Montreal.

By July 13, 1942, the preliminary work was sufficiently advanced to justify a Progress Report, which was sent by the Chairman to the Hon. C. D. Howe, Minister of Munitions and Supply, from which the following excerpts are taken:-

"The use of solid fuels such as charcoal, wood or coke, for producing a fuel gas in the requisite quantities while the vehicle or boat is moving has many advantages, and some disadvantages,....... The idea is not new, as it was applied in Great Britain during the First World War (1916), but its application has expanded rapidly during the last few years.

"Latest advices indicate that there are about 500,000 vehicles using this method of propulsion, in Europe alone. Great Britain and Australia have spent large sums on testing programmes during the past five years and have evolved designs that are most suitable for their fuels and local conditions. Advantage is being taken of the information available from them to shorten the Canadian programme and to devise a Canadian emergency producer that will be suitable for immediate use with the various fuels that are obtainable in different parts of the Dominion, and that will be as economical as possible in the metal and labour required for fabrication.

"Attempts are also being made to secure examples or drawings of European types so that advantage may be taken of European experience, more particularly in the use of wood fuels.

......

"A serious disadvantage is the loss of power in an engine of standard design when changed from gasoline to producer gas. This loss, which may be from 40 to 50 per cent, is not serious in lightly loaded machines, but may be important to transport vehicles that are heavily loaded and operate on strict time schedules. A supercharger has been obtained and will be used in some of the tests to increase the volumetric efficiency of the engine so that this loss may be reduced to the smallest amount, or possibly may be avoided altogether".

The use of producer gas involves both fire and poisoning hazards, and a special study was made of European experience in these matters. As a result, the Second Report included suggested safety regulations in connection with the design, manufacture, operation and maintenance of producer gas units. It was evident also that, in any large-scale programme, some programme for training the drivers and service men would have to be arranged and put into operation as, where accidents occurred, the prevalent causes had been carelessness and laxity in the enforcement of safety regulations.

By September 1944, all obtainable producer plants had been tested and reported upon, the condition of emergency had passed, and enough information was available to enable a producer gas programme to be put into effect at short notice. The testing plant was dismantled, therefore, on September 30, 1944 and, at a meeting held on February 7, 1945 (the sixteenth meeting of the Sub-Committee) it was decided to distribute the available gas producers for service tests by various organizations who had asked for them.

In so large and diversified a programme, minor questions constantly arose and, frequently, answers had to be found before satisfactory progress could be made. New apparatus for sampling dust and gases, for gas analysis, and for testing cleaners and filters had to be devised. Comparisons had to be made on the same apparatus working under winter and summer conditions, respectively; the effects of wear and vehicle overhaul had to be investigated and allowed for; ideas and suggestions received from outside sources had to be explored; test courses and hills had to be surveyed, and winter test schedules were disrupted by bad weather or adverse road conditions. In addition to these minor matters, the following major investigations were carried out:-

(1) A Canadian specification for sampling, grading and testing wood charcoal was drawn up and adopted. Particular attention was paid to methods of testing for moisture and hardness, respectively, and the results were given in the First and Second Reports. The various designs of charcoal kilns, their capacities, number available and ease of construction in wartime, were studied, the continuous production of charcoal on conveyors was investigated, and various devices for crushing and sizing were inspected.

(2) Gas producers employing the "cross draft" system have nozzles ("tuyeres") to admit the air to the hottest part of the fire. These tend to burn away rapidly unless they are water cooled (as in Great Britain) but the freezing hazard makes the use of water cooling undesirable in Canada. Many refractory materials and special steels were tried, but the only material that lasted for a reasonable time, without liquid cooling, was copper. This metal was not easy to obtain in wartime.

(3) The correct mixture of gas and air for combustion under all operating conditions is an important factor and the controls provided must be simple and effective. Several comparisons were made between mixing devices of different makes, and some new ones were designed and tested with promising results.

(4) Although some producer gas plants can be started in one or two minutes in moderate weather, starting in cold weather is difficult, and therefore motor heaters are used in Sweden to keep the engine warm overnight. There is no "approved" device available in Canada for this purpose and, after a survey of the literature, the Committee made preliminary experiments resulting in a design of heater that appears suitable for this purpose. Details are given in the Second Report.

(5) In view of the difficulty and expense of making the large series of road tests described in these reports, an attempt was made to devise a procedure whereby the probable road performance of a vehicle could be predicted from stationary tests made in the laboratory. The analysis indicated that, if certain characteristics of the vehicle are known, its probable performance on any particular fuel can be predicted with reasonable accuracy and the most desirable gear ratio can be calculated for a given set of working conditions.

This account is a brief outline of the work of the Committee on Substitute Fuels during the two and a half years of its active operation, much of the detail work having necessarily been omitted from the description. Although the war emergency programme did not materialize, the natural exhaustion of petroleum reserves may compel the use of substitute fuels within a few decades unless some new method of producing power is developed. If any national emergency arises, moreover, producer gas may assume vital importance as the only readily available substitute for liquid fuels. European countries have already experienced this condition, and there are over 700,000 vehicles now operating on producer gas in various parts of the world. This investigation, therefore, has a definite post-war significance and it is hoped that the knowledge and experience gained in the use of substitute fuels will not be lost to Canada.

N. ASSOCIATE COMMITTEE ON SURVEY WORK

This Committee, originating early in 1933, carried on its work under five subcommittees and, between meetings of the full Committee, under a small executive. The activities of the subcommittees may be envisaged from their names, namely, (1) Mapping Methods, (2) Photography - aircraft and cameras, (3) Photography, (4) Survey Instruments, and (5) Survey Museum.

All these subcommittees were active before the war, but mention may be made particularly of the work done, under subcommittees 1 and 2, on the design and construction of the stereoscopes and special plotters for use in mapping, by Mr. R. H. Field, Head of the Metrology Laboratory, and Colonel (later Major-General E. L. M. Burns of the Geographical Section, General Staff, Army. Work on survey instruments with some attention to the Survey Museum, and some work on aerial photography before the war, proceeded continually. In time, the war became the cause of suspending temporarily much of the work of the Survey Committee, but at times in the war use was made of the special instruments which had been devised and developed under the Committee's auspices. As the war grew in intensity, there was a great outburst of work in aerial photography undertaken by the Optics Laboratories of the Division of Physics and Electrical Engineering in co-operation with the Photographic Section of the R.C.A.F., and under the auspices of the Canadian Joint Photography Committee. Also, there was much work in the design and standardization of new military precision instruments, viz. clinometers, range finders, position finders, done directly by the Metrology Laboratories of the Council. Although the Associate Committee on Survey Work itself became inactive early in the war, the useful work which it had begun was carried on intensively under different and specific auspices.

During the war, this Committee lost quite a number of its original members through death, retirement and change of official position. Late in 1944, consideration was given to the question of the reconstitution of the Committee to get ready for the post-war period. This reconstitution was discussed at a meeting of those members who were left on the old Committee, in November,

1944. Re-establishment of the Associate Committee then took place so that it could play its proper role in an extensive survey programme which the war had already initiated. A working subcommittee of the Associate Committee was appointed to be immediately responsible for the detailed technical work undertaken.

O. ASSOCIATE COMMITTEE ON SYNTHETIC RUBBER RESEARCH

Order-in-Countil P.C. 2659, dated April 13, 1944, authorized the "Minister of Munitions and Supply, acting through Polymer Corporation Limited, to enter into Buna Rubber Cross-license Agreements, in the name of and on behalf of His Majesty, with Standard Oil Development Company and Jasco, Incorporated and with other companies". This Order-in-Council also ordered "that funds in the amount of $113,000. be provided to the National Research Council for expenditure to be conducted by it or under its auspices or direction on research in the synthetic rubber field".

President Mackenzie of the National Research Council met with Mr. Berkinshaw and Mr. Nicholson (President and General Manager respectively) of Polymer Corporation, together with technical representatives from the two organizations, first at Toronto in June, 1944, and then at Sarnia on July 5, 1944. At the July 5th meeting it was decided to set up an "Associate Committee on Synthetic Rubber Research" of the National Research Council to plan and coordinate a programme of research on synthetic rubber. This Committee, as organized by President Mackenzie during the summer of 1944, had the following membership:-

Dr. C.J. Mackenzie (Chairman)	National Research Council.
Mr. J.R. Nicholson	Polymer Corporation Limited.
Dr. J.L. Huggett	St. Clair Processing Company.
Mr. E.R. Rowzee	Canadian Synthetic Rubber Limited.
Mr. George Hooker	Dow Chemical of Canada.
Dr. Norman S. Grace	Dunlop Tire & Rubber Goods Company.
Dr. G.S. Whitby	University of Akron, Akron, Ohio.
Dr. A. Cambron	National Research Council.

Dr. L. Marion	National Research Council.
Dr. N.H. Grace	National Research Council.
Mr. S.G. Nicholls	Asst. Deputy Rubber Controller.
Dr. W.H. Cook	National Research Council.
Dr. E.W.R. Steacie	National Research Council.
Mr. W.B. Wiegand	Columbian Carbon Company, New York.
Mr. F.L.W. McKim (Secretary)	National Research Council.

The following Terms of Reference were approved by the Associate Committee at its first meeting in September, 1945:-

"The main functions of the Committee are:

1. To plan and coordinate a programme of research, the main object of which is to extend into the post-war years, the usefulness of the large industry which has been set up in wartime to produce synthetic rubber in Canada.

2. To initiate and supervise research on the reaction mechanism in butadiene-styrene copolymerization and in other polymerizations and the properties of the resulting polymers at various stages of the reaction.

3. To initiate and supervise research on the chemical and physical properties, including molecular structure, of Buna S and other polymers.

4. To initiate and supervise research on the compounding and processing properties of Buna S and other polymers and to arrange for service tests.

5. To determine how the research facilities of government, industrial and university laboratories can best be utilized in this field.

6. To advise as to the correlation and distribution of all available research information on polymerization.

7. To co-operate with the Plant Research and Development Committee at Sarnia in planning programmes and evaluating results."

The general policy of the Committee is to build up a strong research group at Sarnia to provide a nucleus and "spark plug" for the whole Canadian synthetic rubber research programme and to encourage, financially and otherwise, the participation in the research programme of university research groups, provincial research organizations and private industries.

In addition to the research programme being carried out at Polymer Corporation (which includes the operation of a $300,000. pilot plant) and at the National Research Council, Ottawa, assisted research grants were made to professors in six universities to aid them in carrying out fundamental research in the synthetic rubber field.

Among provincial research organizations, the Ontario Research Foundation, which had done considerable work on synthetic rubber before the formation of the Associate Committee, was prevented from co-operating with the Associate Committee because of its inability to find suitable personnel to do the work. Among private industries, Shawinigan Chemical Company and Dominion Rubber Company indicated their willingness to co-operate in any way the Associate Committee would suggest, but particularly from the point of view of the utilization of their products or potential products in the Sarnia plant.

Since the Associate Committee on Synthetic Rubber Research was organized only in 1944, major achievements along the lines of improved synthetic rubbers and other high polymers still lie in the future. It is hoped, however, that the co-operation of government, university and industrial research laboratories will lead to the development and production in Canada of new or improved synthetic rubbers. In addition to the importance in this country's domestic economy of an independent source of rubber, this would afford substantial returns from the sixty million dollar war investment at Sarnia.

ADDITIONAL COMMITTEES AND SUBCOMMITTEES ON WHICH THE NATIONAL RESEARCH COUNCIL HAD REPRESENTATION

P. SPECIAL COMMITTEE ON APPLIED MATHEMATICS

In September, 1939, Professor J.L. Synge of the University of Toronto wrote to General McNaughton offering the services of members of the University's Department of Applied Mathematics for war research. This offer was accepted, and in February, 1941, work on the impedance of antennae in wave guides was undertaken by a group consisting of Professors J.L. Synge, A.F. Stevenson, L. Infeld and V.G. Smith. This group, informally known as the Toronto group, issued five reports between November, 1941, and October, 1942, under the heading of University of Toronto, Radiation Theory; the titles of these reports are given at the end of this section.

During the summer of 1942, it was realized that the position of the group was ill-defined and Professor Synge discussed the matter with the Acting President of the National Research Council, Dr. C.J. Mackenzie. The result was the formal establishment, in October 1942, of the Special Committee on Applied Mathematics, composed of the following members:

Prof. J. L. Synge, University of Toronto (chairman)

Prof. A. F. C. Stevenson, University of Toronto

Prof. L. Infeld, University of Toronto

Prof. W. H. Watson, McGill University

Prof. J. W. Campbell, University of Alberta

Dean D. Buchanan, University of British Columbia

Prof. V. G. Smith, University of Toronto (secretary)

Dr. W. J. Webster, National Research Council.

The purpose of this Committee was to provide whatever assistance mathematics had to offer to the physical research workers working on war problems, particularly in the field of radar research. It continued to function until after V-J day, and issued eighteen reports, a list of which is given at the end of this section.

In June, 1943, when Professor Synge became Head of the Department of Applied Mathematics of Ohio State University, Professor Watson succeeded to the chairmanship of the Committee. In this year, too, Mr. J. M. Manson replaced Dr. Webster as the National Research Council representative on the Committee.

Since the work of the Committee was almost entirely mathematical in character, the reports themselves constitute its chief accomplishments. A list of these reports is given below.

REPORTS

University of Toronto, Radiation theory reports.

Infeld, L. - Influence of the width of the gap upon the theory of antennas. June, 1942.

Infeld, L. - The resistance of a circular wave guide in the case of an E_{01} wave. Oct. 1942.

Infeld, L., Stevenson, A.F.C., and Synge, J.L. - Radiation from a source inside a perfectly conducting wave guide of rectangular section. Nov. 1941.

Synge, J.L. - H-waves and vibrating membranes. July, 1942.

Synge, J.L. - The general problem of antenna radiation and the fundamental integral equations. Application to an antenna of revolution. August, 1942.

Reports of Special Committee on Applied Mathematics

Campbell, J.W. - Apparatus for investigating the stability of a liquid-filled shell. Ballistics Report No. 2.

Chien, W.Z. - The buckling of a cylindrical panel under axial compression. Mechanical Report No. 1.

Chien, W.Z. - Resistance of antennae of various shapes and positions in rectangular and circular wave guides. Report No. 5.

Chien, W.Z. - The reactance, matching conditions, and matching resistance of a circular wave guide in the case of an E_{01} wave. Report No. 6.

Chien, W.Z., Infeld, L., and Pounder, J.R. - On the matching of a rectangular wave guide with a thin antenna (Numberical). Report No. 7.

Infeld, L. - The impedance of a circular wave guide in the case of an E_{01} wave. (With an appendix by V. G. Smith). Report No. 2.

Infeld, L. and Pounder, J.R. - The impedance of a rectangular wave guide with a thin antenna. Report No. 8.

Pounder, J.R. - The matching problem for a rectangular wave guide and the sensitivity of the matched guide. Report No. 10.

Pounder, J.R. - Theoretical impedance of a longitudinal slot in the broad face of a rectangular wave guide (Numberical). Report No. 14.

Smith, V.G. - Spark gap pulsing circuits. Report No. 1.

Stevenson, A.F. - A general method for calculating the impedance of an antenna in a wave guide of arbitrary cross-section. Report No. 4.

Stevenson, A.F. - Theory of high-Q cylindrical cavity resonators. Report No. 9.

Stevenson, A.F. - Preliminary report on the theory of rectangular slots in rectangular. Report No. 11.

Stevenson, A.F. - Theory of slots in rectangular wave guides. (Part I.). Report No. 12.

Stevenson, A.F. - Theory of slots in rectangular wave guides. (Part II.). Report No. 13.

Synge, J. L. - The theory of antenna reception. Report No. 3.

Synge, J. L. - Momentum-theory of armour penetration. Ballistics Report No. 1.

Weinstein, A.W. and Chien, W.Z. - The buckling of a clamped cylindrical panel under axial compression. Mechanical Report No. 2.

Q. PANEL ON TUBERCULOSIS

In 1938, a Panel on Tuberculosis was appointed under the Council's Associate Committee on Medical Research, primarily for the purpose of making an independent study of the records of tuberculosis vaccination in Montreal, with a view to determining to what degree, if any, vaccination by mouth at birth afforded subsequent protection against the disease. This study was undertaken before war broke out, but most of the work was done during the war.

The work of the Panel involved an examination of the detailed records of about 1500 vaccinated and control children living in contact with positive sputum cases of tuberculosis, a critical study of all phases of the investigation, and a statistical analysis of the results obtained. The results of this investigation to the end of 1938 were published, and those of the succeeding four years were compiled but not published. In both cases it was clear that vaccination afforded substantial resistance to tuberculosis, but not by any means complete immunity. Both morbidity and mortality were reduced to a marked degree.

Subsequently the Panel was called upon to plan and analyze two other investigations involving vaccination against tuberculosis. One of these was of the student nurses and hospital attendants in Saskatchewan institutions, where all were under the best of medical care and frequently checked by X-ray examination to determine whether they showed symptoms of tuberculosis. There were no deaths from the disease in either the vaccinated or unvaccinated group, but the proportion of cases of tuberculosis developing among the unvaccinated nurses and hospital attendants was several times as great as among those vaccinated. The results were accepted as proof of the value of the vaccine, and vaccination has now been adopted as regular practice in the institutions in question. A paper embodying the results of this investigation will shortly be published.

A second test of vaccination against tuberculosis, of exceptional interest from the experimental point of view, is one being conducted amongst the Indian children in Saskatchewan. Because of the unusual degree of medical control and the stable habits of the Indians, it has been possible to carry out here an experiment which is probably unique in the similarity of its experimental and control groups. A further important factor is that Indians are far more susceptible to tuberculosis than are the white population. At present, this experiment has not yet been in progress long enough to permit a final conclusion, but the results to date point to an effect from vaccination substantially the same as that of the other two investigations noted above.

REPORTS

Hopkins, J. W. - BCG vaccination in Montreal. Am. Rev. Tuberc. XLIII, 581-599, N.R.C. 986, May 1941.

R. WOOL

Several years prior to the war the National Research Council's Associate Committee on Wool, working with the Dominion Department of Agriculture and other organizations, was active in projects for the development of new breeds of sheep suitable for the ranges of western Canada, as well as several related investigations. Studies of the fleeces of experimental and other flocks were made in the National Research Laboratories.

By agreement between the Department of Agriculture and the Council, the Associate Committee on Wool turned over its major projects to the newly formed National Sheep Committee, and especially to that Committee's Subcommittee on Wool. It was agreed at that time that the Department of Agriculture would support work involving the ownership of animals, and the Council would assume responsibility for wool research. In carrying out this plan, a member of the Council's staff was named chairman of the Subcommittee on Wool and a member of the executive of the National Sheep Committee, and the Council was also given additional representation on the Subcommittee on Wool.

The work carried out in the National Research Laboratories on behalf of the Subcommittee on Wool is very briefly dealt with in a report on textile research in the Division of Chemistry. To this it may be added that the Subcommittee on Wool has been the most active of the several subcommittees of the National Sheep Committee, and during the war held six meetings. On several occasions the Subcommittee met at Toronto, where the members spent some days on each occasion in the warehouse of the Canadian Co-operative Wool Growers, studying the fleeces of experimental flocks from western Canada and certain of the pure-bred flocks of the east. One meeting was held at Lethbridge, Alberta, where a major breeding experiment is being carried out at the experimental station of the Dominion Department of Agriculture. The work of the Subcommittee is being closely correlated with that of the Subcommittee on Breeding, in order that in the experimental breeding programme full consideration may be given to both mutton and wool. As a result of the work of these subcommittees, the objectives of the sheep growing industry are becoming more clearly defined.