22 NORTHERN AFFAIRS

SPECIAL AREAS OF ADMINISTRATION

REPORT 22: NORTHERN AFFAIRS

PUBLISHED BY THE QUEEN'S PRINTER • OTTAWA • CANADA FOR
THE ROYAL COMMISSION ON GOVERNMENT ORGANIZATION

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ACKNOWLEDGEMENTS

A number of project groups investigated various aspects of government administration in the North. Your Commissioners were assisted in the task of integrating this research by H. O. R. Hindley, M.A., Research Co-ordinator on the Commission's staff.

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Your Commissioners, in acknowledging the assistance and advice received, dissociate all those named above from any of the findings and conclusions contained in this report; for these, your Commissioners assume full responsibility.

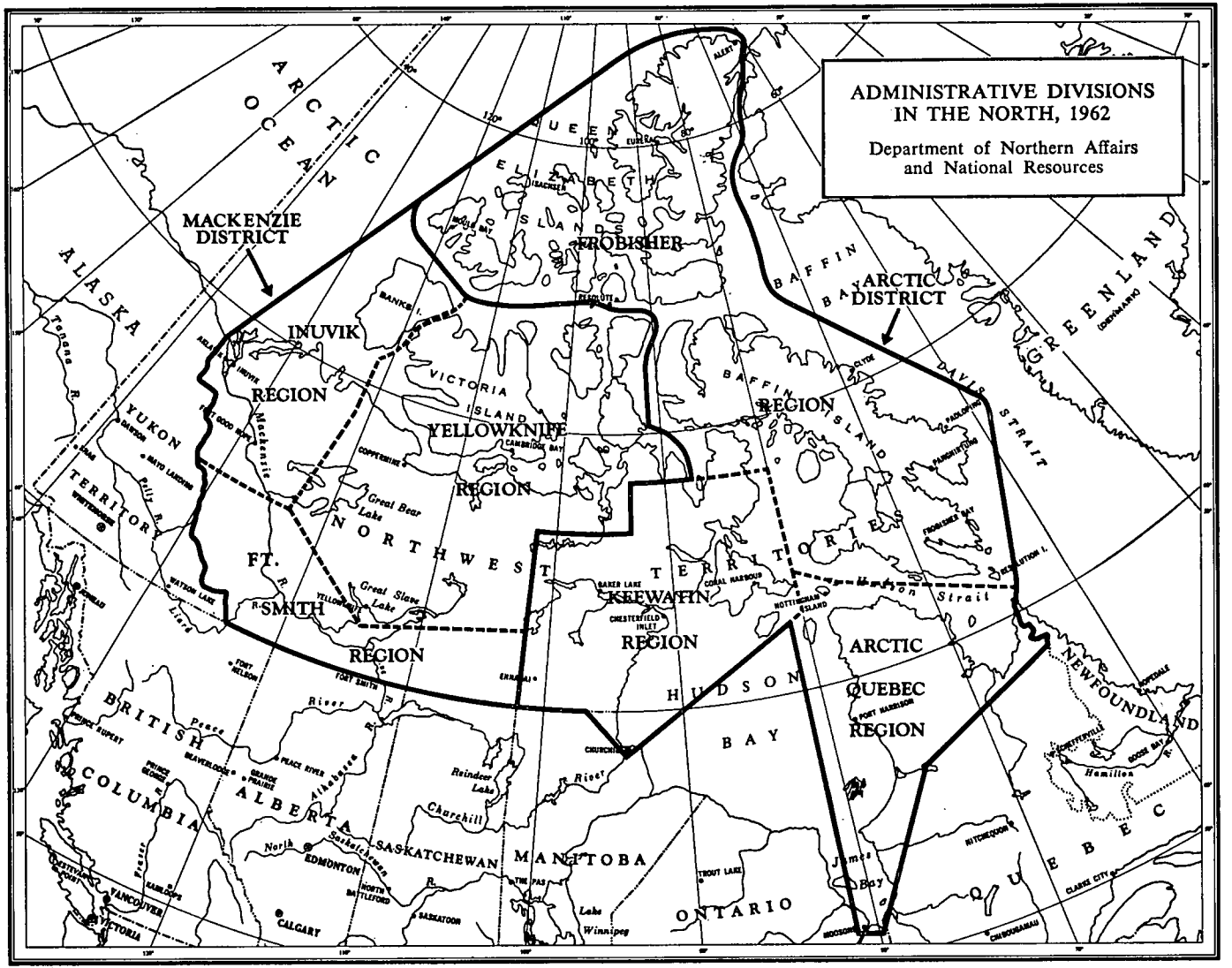
1

INTRODUCTION

In most of the preceding reports, and especially in the first and second volumes, the organization and methods of operation of the federal government have been appraised in the light of the economic, social and political conditions familiar to most Canadians. By and large, the findings and recommendations relating to the management of the public service and the organization of its supporting services have assumed a background of settled and productive communities, resting on a well-established economic base, served by transportation, communications and the other public utilities, and enjoying high standards of public order, health, education and welfare administered by experienced provincial and municipal authorities.

Throughout more than half the country, however, these conditions do not prevail. As a rough guide, the fifty-fifth parallel of latitude may be taken as the dividing line (see map). Beyond this lies the North, rigorous in climate, much of it barren in appearance, and containing in its vastness less than one-half of one per cent of the Canadian population: the Yukon Territory has 11,900 whites and 2,200 Indians in its 205,000 square miles, while the Northwest Territories, extending over 1,300,000 square miles, have a population of 8,900 whites, 5,300 Indians and 8,000 Eskimos.

Nevertheless, the writ of the federal government runs throughout it. It is not uninhabitable—as demonstrated by the presence there not only of Indians and Eskimos but also of a growing body of settlers. The barren face hides a wealth of minerals which the discoveries of recent years are only beginning to reveal. Its importance in the defence of Canada and North America, more


ADMINISTRATIVE DIVISIONS
IN THE NORTH, 1962
Department of Northern Affairs
and National Resources
MACKENZIE
DISTRICT
FROBISHER
ARCTIC
DISTRICT
INUVIK
REGION
YELLOWKNIFE
REGION
FT.
SMITH
REGION
KEEWATIN
REGION
ARCTIC
QUEBEC
REGION
ARCTIC OCEAN
ALASKA
YUKON
TERRITORY
NORTHWEST
TERRITORIES
BRITISH
COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
GREENLAND
HUDSON
BAY
BAFFIN
ISLAND
DAVIS
STRAIT
Hudson
Strait
Great Bear
Lake
Great Slave
Lake
Reindeer
Lake
Churchill
River
Peace
River
Mackenzie
River
North
Saskatchewan
River
Lake
Winnipeg
James
Bay
Hamilton
River
VICTORIA
ISLAND
BANKS
I.
PRINCE
PATRICK
I.
MELVILLE
I.
DEVON
I.
ELLESMERE
ISLAND
AXEL
HEIBERG
I.
EUREKA
ALERT
RESOLUTE
CAMBRIDGE BAY
COPPERMINE
BAKER LAKE
CORAL HARBOUR
CHESTERFIELD
INLET
NOTTINGHAM
ISLAND
FROBISHER BAY
PANGNIRTUNG
PANGNIRTUNG
RESOLUTION I.
CLYDE
EGEDESMINDE
(DENMARK)
WHITEHORSE
DAWSON
MAYO LANDING
WATSON LAKE
NORMAN
WELLS
FORT
NELSON
FORT
SMITH
ENNADAI
PRINCE RUPERT
BEAVERLODGE
GRANDE
PRAIRIE
PEACE RIVER
PRINCE
GEORGE
KAMLOOPS
VANCOUVER
VICTORIA
EDMONTON
CALGARY
NORTH
BATTLEFORD
SASKATOON
THE PAS
CHURCHILL
TROUT LAKE
PORT HARRISON
SEPTILES
GOOSE BAY
LABRADOR
CITY
NITCHEQUON
CHIBOUGAMAU
MOOSONEE

perhaps than anything else, has aroused the public to an awareness of its existence.

In their relative scale, the activities of the federal government in the North are not extensive. Of the federal public servants, scarcely more than one per cent are stationed in the North. Direct expenditures on northern administration and services account for little more than the same proportion of the federal budget. Because the costs of northern activities are seldom differentiated in government accounts from the cost of similar activities in the rest of the country, no precise figure can be given. The northern programmes of the Department of Northern Affairs and National Resources amount to roughly $30 million a year. Something more than this is spent by other departments—especially Justice, Transport, and National Health and Welfare—for the provision of services, the promotion of health and welfare and the maintenance of order in the North. But the total impact of the North on the federal government is much greater than these figures suggest. Heavy outlays are required by a number of operations undertaken in the North for the benefit, primarily, of the southern population, such as the meteorological service and, above all, defence activities. Almost every department and many of the other agencies are concerned with the North, and more than twenty departments and agencies employ full-time staff there. Ministers and senior officials constantly encounter special northern problems in the administration of federal programmes. For one department, Northern Affairs and National Resources, the development and administration of the North is its principal concern. Thus, in any study of the organization and operating methods of the federal government, northern affairs clearly require special consideration.

In all matters of federal administration, the North provides the exception to the general rule. Climatic conditions, and the lack of transport facilities and of commonplace materials and skills, conspire to create special construction and maintenance problems. The scarcity of local suppliers and service trades—amounting, in most areas, to a total lack—complicates the task of supply. The absence of a social infrastructure—roads, communications, utilities, and community services and amenities generally—presents problems not only for the administration of government but for the very maintenance of a civilized existence by administrators drawn largely from southern Canada.

The maintenance of order and the provision of public health, education and welfare services for the scattered population, much of it still nomadic, creates problems not found elsewhere in the country. Simultaneously, the impact of southern society—spreading from older settlements in the northwest, or appearing suddenly in defence installations, mining and mineral exploration camps, transportation centres, and the new administrative outposts of the

government itself—introduces forces of change and intensifies the problems of social development and adaptation. As the old patterns dissolve under this impact, they must be replaced by a new social and economic order; but for the immediate future at least, and in many areas for as long as can be foreseen, the patterns familiar in the south will remain unsuited to the needs of northern peoples. The immediate goal, in most of the North, must be a society that resembles neither that to which the native people have been accustomed nor that in which their administrators have been reared—and one, moreover, that is constantly changing. And, as far as possible, it must offer the Eskimos and Indians a life that sustains (and in some areas restores) their self respect, that satisfies their desire to be self-supporting, and develops within them the innate urge to better their own condition. Thus economic and social development must go hand in hand.

A fundamental complication for the federal administration in the North arises from the absence, throughout most of the area, of provincial and municipal government. Where provincial jurisdiction is involved—in Labrador and northern Quebec and between the fifty-fifth and sixtieth parallels west of Hudson Bay—the pace and direction of development for the economy and its supporting services rests largely with the provinces; but the social amenities and development of most of the population—Indians, Eskimos, and the Armed Forces, federal public servants and their dependants—are largely the responsibility of the federal government. North of provincial boundaries lie the Yukon and Northwest Territories, with their major areas in varying states of political development but all requiring the federal authorities to assume, in greater or lesser degree, the duties elsewhere borne by provincial and local governments.

It is, in fact, misleading to consider "the North" as a single entity. Even in the territories beyond the provinces, there is no uniformity. The Yukon is an area of established settlements, economically and socially developed, without the special problems of an Eskimo population. Its larger communities are served by road, rail and air services and communications, and are relatively close to one another. Above all, it is an area with a history, a sense of its own identity, and the will and capacity for a high degree of self-government. In the Mackenzie basin, the settlements are strung out over more than a thousand miles, linked by air and in summer by water, and with an access road to Yellowknife; further developments of both road and rail are now planned. The Indians and Eskimos in this area have, for some decades, been in close contact with southern ways. Thus, in many respects, its condition is rapidly approaching that of the Yukon.

Quite different circumstances prevail in the eastern parts of the Territories,

which are generally accessible only by air—or at coastal points by water in the short Arctic summers—with few scheduled services. There are no natural administrative centres of gravity and existing transportation and communication facilities make Ottawa the most convenient location for the management of activities in the region. On the other hand, it is in these areas that the major mineral discoveries—of metals, oil and gas—have been made in recent years, with implications for the future that cannot yet be assessed. Thus, in this region, the District of the Arctic, major resource developments may occur in the course of time, but the pace of these developments, and their probable effects beyond the localities immediately affected, cannot be foreseen.

Despite these major regional variations, however, the federal government is faced with problems of northern policy and administration that are common throughout almost the entire North. First, there are the special problems encountered in extending to the North the policies and programmes that apply throughout the rest of the country. Second, there are the problems associated with social, economic and political development.

On the latter score, the North presents, in effect, problems of underdeveloped areas and underdeveloped native peoples similar in many respects to those of current concern internationally. And the character of these problems has a direct bearing on both the development of policies for their solution and the design of administrative machinery.

Any programme dealing with underdeveloped areas and peoples must concern itself with three questions: what can be achieved? at what pace? and at what price? There must be, in short, a clear view of both the foreground to be traversed and the goals on the horizon, and a realistic schedule of progress. A casual disregard of the foreground can only cause the programme to founder before it is well begun; without goals there can be no sense of direction; impatience in the pace means that action is taken prematurely, and if the pace be laggard, the programme will be outstripped by events.

Your Commissioners are not concerned, within their terms of reference, with the direction or pace of federal programmes for northern development, but are necessarily interested in the administrative arrangements. If organization is designed too much to fit long-term goals or runs in its development too far ahead of events, it will be unsuited to the conditions in which it must work. If, on the other hand, it is related too closely to the here and now, or develops too slowly, it can become itself a brake on progress. In the three chapters that follow, the organization and practices of the several

departments and agencies are considered as a whole, and recommendations are submitted to improve the relationships among them.

Because the Department of Northern Affairs and National Resources has special responsibilities in the North, its organization and relationships with other departments is of particular relevance throughout the report. The responsibilities relating to the second part of its title—"National Resources" —are of interest in the present context only to the extent that they form part of its northern activities. Other aspects of its responsibility for natural resources must be discussed in a wider context, and are therefore left to the final report, *The Organization of the Government of Canada,* which appears in Volume 5.

2

TERRITORIAL ADMINISTRATION

North of the provinces, the geographic basis of administration for matters coming under the Minister of Northern Affairs and National Resources is the territorial division, with a Commissioner as administrative head. At present there are two such divisions: the Yukon Territory and the Northwest Territories. The latter is subdivided into two Districts—Mackenzie and the Arctic, each supervised by a District Administrator. The Commissioner of the Yukon is in Whitehorse, the territorial capital, and the Administrator of the Mackenzie in Fort Smith; the Commissioner of the Northwest Territories (a position held by the Deputy Minister of Northern Affairs and National Resources) and the Administrator of the Arctic are in Ottawa. The creation of a separate Territory of the Mackenzie, under a resident Commissioner, is now planned.

THE YUKON TERRITORY

Even before its acquisition by Canada in 1869, the Yukon Territory was an important outpost of the Hudson's Bay Company, bordering as it did another country—first Russia and after 1866 the United States. In 1898 it was designated a Territory and given a form of local government. The gold rush of that period brought an influx of people, with the result that the Territory had a population of over 27,000 in 1901. Thirty years later it had dwindled to 4,200, but since then it has increased progressively and is now around 14,000.

The present *Yukon Act* of the Parliament of Canada provides for the appointment by the Governor in Council of a Commissioner, to be the chief executive officer of the Territory. There is a Council of seven members, all of them residents of the territories, elected by the territorial communities for a term of three years. The Council sits separately from the Commissioner and presents bills for his assent; any ordinance approved by him may be disallowed by the federal government—the Governor in Council—within two years. Legislative powers of the Commissioner in Council include most matters that are of provincial jurisdiction in the south, including the creation of municipalities, the establishment of courts, the incorporation of companies, and the provision of education, health and social services. Unlike the provincial legislature, however, the territorial Council has no control over undeveloped Crown lands and natural resources, which are reserved as a federal responsibility.

The Commissioner in Council may impose direct taxation within the Territory, and may also—and does—impose a tax on furs shipped from the Territory. There is a statutory Yukon Consolidated Revenue Fund, but no tax may be imposed nor any appropriation made unless first recommended to the Council by message of the Commissioner. The Council may borrow for the purposes of the Fund and may authorize idle balances to be invested, but in each case the consent of the Governor in Council is necessary. The Yukon Territory has been treated as a province for the purpose of tax-rental agreements with the federal government and currently is receiving $475,000 annually under such an agreement. The Yukon Consolidated Revenue Fund is also credited with "any moneys appropriated by Parliament for the Territory as the Commissioner is authorized to expend by and with the advice of the Council". Finally, all accounts of the territorial government are subject to audit by the Auditor General of Canada.

As executive head of the Territory, the Commissioner is subject to direction by the Governor in Council and the Minister of Northern Affairs and National Resources, and directs a territorial civil service of about four hundred; the latter are not federal civil servants but are entitled, by federal law, to be brought under the *Public Service Superannuation Act*—a move which is now being made. The Commissioner also holds a federal appointment as Controller of the Yukon, in which capacity he is in direct control of about fifty federal civil servants of the Department of Northern Affairs and National Resources.

THE NORTHWEST TERRITORIES

The present system of government for the Northwest Territories really dates from 1905 when the Provinces of Alberta and Saskatchewan were created.

For legal purposes, the Northwest Territories consist of "all that part of Canada north of the 60th Parallel of the North Latitude, except the portions thereof within the Yukon Territory and the Provinces of Quebec and Newfoundland, and the islands in Hudson Bay, James Bay and Ungava Bay except those islands within the Provinces of Manitoba, Ontario and Quebec."

The chief executive officer is the Commissioner, who is appointed by the Governor in Council and traditionally is the deputy minister of the department responsible for northern administration. Like the Commissioner of the Yukon, he administers under instructions given by the Governor in Council or his minister. In 1905, provision was made for a Council of four. This was increased to six in 1921. Until after World War II, the members were civil servants. The Council now consists of nine members, of whom four are elected for three years by constituencies within the Mackenzie District; the others are appointed during pleasure by the Governor in Council—currently two are federal civil servants, two others are residents of Ottawa and one of Edmonton. The "seat of government" is Ottawa, but the *Northwest Territories Act* requires that the Council meet twice annually with one session at a place in the Territories designated by the Governor in Council.

The powers of the Council are akin to those of the Yukon Council but, unlike the situation in the Yukon, there is no special Consolidated Revenue Fund. Instead, there is a special account in the Consolidated Revenue Fund of Canada to which are credited all territorial revenues and moneys appropriated by Parliament for the purposes of the account. In the fiscal year 1961, charges to the account approximated $2,750,000. Under a tax rental agreement, the federal government paid $567,000 to the territorial government in 1961; practically all other federal expenditures in the North were charged directly to parliamentary votes, and consequently neither passed through special account nor were administered by the Commissioner in Council.

In the administration of the Northwest Territories, federal civil servants are used exclusively, except for the administration of liquor ordinances, which is done by territorial civil servants. Thus, federal civil servants must act in a dual capacity, federal and territorial. In Yellowknife, for instance, the Area Administrator, who is the federal mining Recorder and Lands and Forest Officer, is also responsible for the issue of car licences, business licences and game licences, all of which are territorial concerns. However, since the permanent executive head, for both purposes, is the person holding jointly the offices of Deputy Minister and Commissioner, no difficulties of divided loyalties arise.

Within the Mackenzie District, Regional Administrators have been ap-

pointed at Yellowknife and Inuvik; a similar office is provided for at Fort Smith but, pending the creation of a Mackenzie Territory, is occupied by the District Administrator.

As was noted earlier, the absence of any natural administrative centres in the District of the Arctic and the weakness of internal transportation and communication facilities will require, for some time to come, that Ottawa remain the focal point of administration. However, with the proposed division of the present Northwest Territories into two territories, the Department plans the appointment of District Administrators, initially at Churchill and Frobisher, with a Commissioner of the Arctic in Ottawa. In anticipation of this move, Regional Administrators have already been established in those communities; their offices will become the District centres. But no transfer of the office of Commissioner for the eastern Districts is contemplated, nor does it seem practical. A third region of the present District of the Arctic embraces that part of Arctic Quebec in which the Department of Northern Affairs has responsibilities among the Eskimo settlements; the regional office is now in Ottawa. Except for a few islands which lie outside provincial boundaries, this region is, however, excluded from the jurisdiction of the territorial council, and the continuing responsibilities of the federal government within the region appear to be uncertain.

In both Districts of the Northwest Territories, the existing organization has a top-heavy appearance. Under the District Administrators are the Regional Administrators already described; and below these again there is a division into Areas, each with its own Area Administrator. Thus, between the Northern Service Officer in the local community and the Commissioner responsible for territorial administration, there appear to be three intervening levels of authority. In fact, however, the present arrangement is in part temporary and in another aspect illusory. As noted, the Regional level merely anticipates the creation of the Mackenzie Territory and the greater devolution of authority over the eastern Arctic from Ottawa; with the accomplishment of these desirable changes, the Regional level of organization will disappear. Moreover, the duties of Area Administrators have been confined to essentially staff functions relating to general administration and financial matters. Consequently, functional direction of the work of Northern Service Officers in the communities will be provided directly from the District Offices.

ADMINISTRATION OF THE TERRITORIES

It is not for your Commissioners to put forward any opinion about the feasibility or timing of provincial status for the territories. But, as long as

territorial status is maintained, and indeed as long as natural resources in the territories are retained as a federal responsibility, it would be irrational to ignore the problems of territorial administration in any review of federal activities in the North. In the Yukon, there is a clear division, at least on paper, between the two, except that the Commissioner and a few of his administrative subordinates have dual responsibilities. In the other territories, it is evident that the establishment of a territorial civil service must be a gradual process and that it must be carefully planned to avoid creating separate positions for fractional jobs. With activities being on so small a scale in the past, it would have been carrying logic too far to distinguish too precisely between federal and territorial responsibilities in terms of officials.

Nevertheless, a continuation of the present system would seriously retard development, for the rigid application of federal standards to jobs in the North is bound to prejudice local recruitment. On the other hand, it is not to be expected that federal civil servants will be prepared to accept territorial status if it means abandoning their federal rights and burning their bridges behind them. There is no necessity to copy the Yukon exactly for the sake of a superficial consistency, provided that some better arrangement can be devised. Early steps should be taken to establish the framework of a territorial civil service for the projected Mackenzie Territory, and the classification and remuneration structure should be based on comparable provincial rather than federal standards, modified to suit northern conditions. Federal civil servants seconded to the territorial service, either temporarily or permanently, should be permitted to retain their status and superannuation rights, any differential cost being borne by the federal government. The application of a similar arrangement to the new eastern territory might be deferred for a few years in order to reap the advantage of experience gained in its implementation in the Mackenzie.

Amalgamation of Indian and Eskimo affairs in the North, as recommended in Chapter 3, will facilitate the integration of Indian education and welfare administration with corresponding elements of the territorial administrations. Much has been done already; there is no segregation in schools, and all child welfare is in the hands of the territorial welfare officers. There is no evident justification for different scales of relief for Indians and their cousins next door, and one Indian Agent of the Department of Citizenship and Immigration said that his responsibilities had by now been reduced to seeing that his Indians were treated no less favourably than their non-Indian neighbours. In the circumstances, proposals to extend the social service activities of the Indian Affairs Branch in the northern territories cannot be justified. Instead, the remaining work of the Indian Agents in the Northwest Territories

and the Yukon Territory should be taken over by the Territorial governments, with suitable reimbursement by the federal government.

We therefore recommend that: Agreements be negotiated with the territorial authorities for the assumption by them of the work of Indian Agents in the Northwest Territories and the Yukon Territory, and the staff of the Indian Affairs Branch be withdrawn from the territories as soon as the necessary arrangements can be put into effect.

One matter that is of provincial concern in the south seems likely, in the foreseeable future, to remain a direct federal responsibility in the territories: the control of undeveloped Crown lands and resources. However, the practice adopted in the Yukon, of appointing the Commissioner of the territory as the federal resources officer, serves to provide unity of direction at the top, and is essential if territorial and federal duties are to be borne jointly by northern officials. It is further suggested, however, that as the territorial public services develop, such joint duties might equally well be assigned to territorial officers, as a means of maintaining full flexibility in the use of personnel—and, incidentally, of developing among territorial staffs the experience as Mining Recorders and Lands and Forest Officers that would be required if, at some future date, control over lands and resources were to be surrendered by the federal government. As long as the Commissioner is held fully accountable, federal interests would be adequately protected. It will be evident from the foregoing that the recommendation in the report on *Real Property,* to the effect that the Department of Public Works be made responsible for the administration of federal lands, is not intended to apply to the undeveloped lands in the territories.

A factor that has hindered the devolution of responsibility to the territories is that the functions normally undertaken by a provincial government are not all under the control of the same federal department. The Department of National Health and Welfare and the Department of Justice are cases in point. In the report on *Health Services,* it is recommended that the health services in each of the territories be placed under a resident senior medical officer. Similarly, in the report on *Legal Services,* it is recommended that a resident legal officer be appointed to fulfil the functions of a provincial Attorney General in each of the territories. Clearly, neither the Department of National Health and Welfare nor the Department of Justice can abdicate its responsibilities overnight. Continuing guidance will be necessary during

the transition period, but the adoption of those recommendations will serve no practical purpose as long as direct control from Ottawa is retained. In each territory, the senior medical officer and the senior legal officer should therefore be directly responsible to and under the authority of the Commissioner.

Historically, the Royal Canadian Mounted Police have had a special connection with the North, where for nearly seventy years they were almost the only full-time representatives of government. A police officer administered the Yukon before the constitution of the Territory in 1898, and the reorganized Northwest Territories were almost exclusively administered by the police for about forty years after 1905. Notwithstanding the development of northern administration by the Department of Northern Affairs and National Resources, direct responsibility for law and order in the North has been retained by the Department of Justice. It is recognized that police services in the territories must be subsidized by the federal government to the extent of the larger part of the cost, but this circumstance does not require the total severance of police responsibility from the territorial administration. It is understood that the transfer of police responsibilities to the territorial authorities is now planned; the proposed appointment by the Department of Justice of legal officers to discharge the duties of territorial Attorneys General under the Commissioners would appear to facilitate this transfer. There would then be no discernible obstacles to the establishment of arrangements similar to those in the contract provinces, modified to suit the special conditions in the North, even if the territorial portion of the total cost has to be met, wholly or largely, by federal subsidy.

From the viewpoint of the many federal departments administering country-wide programmes involving agreements with the provincial governments, the great advantage of the territorial form of northern administration lies in the fact that formal federal-provincial arrangements devised in the south can be applied in the North in the form of agreements with the territorial Commissioners. This includes not only the various forms of co-operation to which reference was made in Volume 3, in the *General Introduction* to the reports on "Services for the Public", but also the federal-provincial fiscal agreements.

The concept of territorial government that has been evolving in recent years offers the great advantage of permitting maximum flexibility in the adjustment of relations between federal and local authorities, from the condition of almost complete federal tutelage in the District of the Arctic to something approaching provincial status in the Yukon. Similarly, it permits the adjustment of administrative machinery to the pace of social, economic

and political development in the northern communities—with progressively greater devolution of authority to territorial centres and progressively greater employment of northern residents in a territorial civil service. If, eventually, the state of development is reached at which provincial status becomes appropriate, one indispensable condition for effective provincial government will exist: a territorial public service experienced in the administration of all matters of provincial concern.

3

INDIAN AND ESKIMO DEVELOPMENT

Two separate departments—the Department of Citizenship and Immigration and the Department of Northern Affairs and National Resources—are now concerned with the education, welfare, and the economic, social and political development of Indians and Eskimos respectively. A third department, National Health and Welfare, administers health services for both groups.

At first glance, the two peoples seem to differ widely in character and geographic distribution. Over ninety per cent of the Indians live in the provinces, and a high proportion of these in the more southerly parts. On the other hand, the Eskimos are concentrated in the Northwest Territories and in the most northerly parts of Manitoba and Quebec. (Those in Labrador remain the responsibility of the Newfoundland Government under the terms of Union, and the federal government is not directly involved in their affairs.) Moreover, many of the Indians in the southern provinces are closely assimilated in their ways, if not in their status, to the populations around them. Among the Eskimos, only those who have been in close contact with the relatively new communities in the Mackenzie basin, or at such points as Churchill and Frobisher, have progressed significantly towards social assimilation, and most of these would still find the customs and attitudes of southern communities strange.

Section 91 of the *British North America Act,* 1867, assigns to the Parliament of Canada the legislative power with respect to "Indians and lands reserved for Indians", and, in 1939, the Supreme Court of Canada decided that, so far as Eskimos living in Quebec were concerned, they were within

the ambit of the phrase. However, for administrative purposes, the *Indian Act* declares that its provisions do not apply "to the race of aborigines commonly referred to as Eskimos". There is no special legislation applicable to these people, but the *Department of Northern Affairs and National Resources Act* places under the Minister of that Department all matters "over which the Parliament of Canada has jurisdiction" relating to Eskimo affairs, excepting those matters assigned to other departments and agencies.

Considered from the viewpoint of administration, however, the problems presented by the two races in the North are indistinguishable. Such variations in administrative needs as may exist are attributable to location rather than to inherent characteristics of the two groups. Throughout the North, both within the provinces and in the Territories, they live in similar conditions, and give rise to identical problems of adaptation and development.

The differences arising out of location are already felt within both the departments concerned. Their effect is most evident in the programmes relating to Indians, where the variation in degree of assimilation is greatest, but the Department of Northern Affairs and National Resources must also distinguish clearly between the problems of Eskimos in the Mackenzie basin and those in the Arctic Islands. The Indian Affairs Branch, as noted in the report on *Education Services,* is pursuing a determined policy of promoting the integration of southern Indians and of using provincial and municipal facilities wherever possible; in the report on *Health Services,* your Commissioners recommended, in effect, that the same policy be adopted in providing medical care. As this is progressively done, the federal government's responsibilities toward the southern Indians will become, in the main, a financial one—with, in some areas, additional concerns arising out of treaty rights and the supervision of reserves and trust funds. Consequently, for both groups the hard core of the task of development, including the direct provision of services, lies in the North.

The close relationship between the responsibilities of the two departments is reflected in the fact that in the third department principally concerned, National Health and Welfare, a single organization administers Indian and Northern Health Services. Equally striking is the manner in which the organization of the Indian Affairs Branch in the Department of Citizenship and Immigration parallels that of the Northern Administration Branch in the Department of Northern Affairs and National Resources, as they existed in 1961:

INDIAN AFFAIRS BRANCH

Administration Division
- Estimates
- Office Services

Agencies Division
- Accommodation and Works
- Transportation and Equipment
- Training and Management

Education Division
- Accommodation and Planning
- Equipment and Special Services
- Guidance and Adult Education
- Practical Arts
- Teachers Registry

Engineering and Construction Division
- Contracts
- Engineering
- Water and Sewage
- Heating and Plumbing
- Architectural
- Electrical
- Structural

Economic Development Division
- Research and Surveys
- Placement and Relocations
- Industrial Development
- Wildlife and Fisheries
- Handicrafts
- Finance and Loans

Welfare Division
- Field Welfare Services
- Public Assistance
- Housing
- Protection and Rehabilitation

Reserves and Trusts Division
- Band Trusts
- Reserves Registry
- Band Membership
- Estates and Land Holdings
- Land Sales and Leases
- Forestry
- Mining

NORTHERN ADMINISTRATION BRANCH

Administration Division
- Finances
- Office Services
- Housing
- Property
- Personnel Services

Education Division
- Schools and Hostels
- Curriculum
- Schools Services
- Vocational Education
- Vocational Training
- Adult Education
- Home Economics
- Industrial Arts

Engineering Division
- Administration
- Planning
- Site Planning
- Mechanical
- Architectural
- Electrical
- Structural

Industrial Division
- Area and Community Planning
- Industrial Promotion
- Co-operatives
- Field Projects
- Handicrafts

Welfare Division
- Family Services
- Linguistic Services
- Community Assistance
- Rehabilitation Services

Territorial Division
- Territorial Council Business
- Vital Statistics
- Municipal Affairs
- Fire Prevention
- Game
- Hospital Insurance
- Labour and Workmens Compensation

Resources Division
- Public Lands
- Lands and Forests
- Mining
- Oil and Gas

It will be noted that, except for the Reserves and Trusts Division of the Indian Affairs Branch, and the Territorial and Resources Divisions of the

Northern Administration Branch, the elements of the two are almost identical.

From the foregoing, it is clear that administrative arrangements relating to Eskimos and Indians should be based on the needs to be met rather than, as at present, on the distinction—in many areas meaningless—between racial groups. When this is done, the natural division becomes essentially geographic. As a first step, in all those northern areas in which the two groups present common problems, the welfare and development of both should be the responsibility of a single Minister.

We therefore recommend that: The responsibilities of the Minister of Citizenship and Immigration relating to Indians in the North be transferred to the Minister of Northern Affairs and National Resources.

Among the most immediate and pressing problems of northern administration are the economic welfare and social security of these scattered and largely indigent primitive peoples, whose numbers increase the more rapidly with every measure taken to protect them against the natural hazards of their environment. Between 1951 and 1961, the Eskimo and Indian population of the Yukon increased from 1,563 to 2,207, and that of the Northwest Territories from 10,660 to 13,233. The Eskimo problem is confined almost entirely to the northern and eastern areas, with overflows into Northern Quebec and Manitoba; there are fewer than fifty Eskimos in the Yukon Territory and relatively few in the Mackenzie basin. Statistics about the Indian population are misleading in considering social aspects, for they refer only to statutory Indians; a substantial number of others are of predominantly Indian ancestry and, in fact, follow the Indian mode of life. As the law relating to Indians now reads, it is possible for the elder children of a married couple to be technically "white" while the younger children are considered to be Indians.

In remote and primitive communities, it is nugatory to draw too fine a distinction between the administration of health, education, vocational training, economic development and social welfare, all of which interlock closely and extend even into the preservation of law and order. Community welfare must take all these factors into account, and successful community development or rehabilitation is possible only if they can be administered integrally. Moreover, any such programmes must take account, in both their planning and execution, of the gulf that separates the native peoples from the administrators—in outlook and temperament—and of the distrust with which the best-intentioned plans may be met. Nor is it enough to distribute benefits

as a form of dole. What is needed is a programme of economic rehabilitation and social development which the local people understand and in which they will co-operate—an object more easily stated than met.

Although outsiders can often analyze local problems more objectively and relate them to broader means of solution and longer time-scales than can the underprivileged themselves, remote control and a cautious paternalism are no substitutes for local enthusiasm and a local sense of responsibility, particularly if the outsiders are of a different culture and speak a different language from the group that is being helped. The planning must be done by persons with first-hand experience of the conditions to be met. And, equally, it must be administered at the point of impact with the community—by administrators with some power to adapt the plan as local circumstances require.

These principles are neither revolutionary nor new. In Canada, remarkable successes have been achieved along these lines among the Eskimos of Labrador by the Grenfell Association and, in recent years, among the Métis and Indians of Manitoba by the community development service of the provincial government. In the administration of the North, they have been adopted unreservedly for only eight years, and the results have only recently begun to appear in the development of co-operatives and other undertakings that provide a greater measure of local self-support.

In those eight years, the development of headquarters staff in the Northern Administration Branch has almost outstripped the pace of growth in the northern field force, reflecting the emphasis on planning. In the Welfare and Industrial Divisions of the Branch, the former with no more than nominal control over welfare activities in the Yukon, there were last year sixty-two positions in Ottawa and only eighty-five in the Northwest Territories. Moreover, your Commissioners have been critical, in their report on *Education Services,* of the disproportionate size of the Education Division headquarters staff of the Northern Administration Branch and of what appears to have been over-elaborate planning. The Department has reported that, in all divisions, the emphasis has now shifted from planning to implementation, with the result that the future growth will occur entirely in the field; in some divisions, a contraction of headquarters is expected.

Your Commissioners wholeheartedly endorse a change in this direction. At the same time, it is urged that there be a shift to the field of authority as well as staff. In the Estimates of the Northern Administration Branch for 1962-1963, provision was made for twenty positions carrying salaries of $10,000 a year or more in headquarters and only ten such positions in the northern territories. If the shift in emphasis from planning to operations is

to be effective, there must clearly be an upgrading of senior positions in the field, with a corresponding increase in the devolution of authority.

If field officers are to operate effectively in the North, they must work within a general framework of administrative direction that is suited to northern conditions and recognizes the greater need for improvisation. General regulations that may seem appropriate to federal administration in southern Canada may be preposterous in, say, Tuktoyaktuk. The Department does what it can within the limits of authority imposed upon it by legislation or Treasury Board regulation, but local officials lack the authority to use their discretion in, for example, balancing the saving in relief payments against the cost of marginally justifiable undertakings that would make employment, or in the use of obsolete or surplus material and equipment for purposes other than those for which its procurement was authorized. All too often, desirable but not strictly necessary local work could be done at almost negligible cost with local resources of people and material that would otherwise be going to waste but, when authorization is sought from Ottawa, the rigid application of unnecessarily high standards raises the estimated cost so high as to render the whole project unduly extravagant; the results are that the work remains undone and the relief payments continue, to the material and spiritual detriment of the community concerned and no real saving to the taxpayer at large.

We therefore recommend that: Consideration be given to relaxing the restrictive effect of federal regulations in the territories, within appropriate limits, and local officials be given specific direction and the requisite authority to make the best use of local human and material resources.

4

CO-ORDINATION OF FEDERAL ACTIVITIES IN THE NORTH

Northern conditions create special problems for the administration of the general programmes of the federal government. To meet these problems, special arrangements are necessary.

Until comparatively recently, except in the Yukon, the sole federal presence throughout the territories was the Royal Canadian Mounted Police. Now, however, defence programmes have taken the Armed Forces into the North in sizeable numbers; the Marine Services and Air Services of the Department of Transport—including the Meteorological Branch—have established posts as far as the Arctic Islands, as was seen in the report on *Telecommunications.* The Department of Public Works is building and maintaining wharves and dredging channels and harbours; Mines and Technical Surveys conducts the Polar Continental Shelf Project in addition to a wide range of surveying, mapping and charting operations. The National Harbours Board operates the harbour at Churchill, the Northern Transportation Company carries traffic on the Mackenzie, the Northern Canada Power Commission provides electric utility services to mines and settlements. And, as the northern communities spread, the federal services must follow: the Post Office, Unemployment Insurance Commission and National Employment Service, the Northern Services of the Canadian Broadcasting Corporation, to mention but several.

The special conditions that influence northern operations—climatic, geographic, economic, social and political—were identified in the prior chapters and their general effect was noted. For the organization and operat-

ing methods of the federal departments, two consequences stand out: the need for adapting the general standards and practices of administration that prevail throughout the rest of the country to suit northern conditions; and the need for special co-ordinating arrangements, both in Ottawa and among northern units.

GENERAL ADMINISTRATION

The task of adaptation applies to both the general aspects of management that were treated in the first volume and the management of the supporting services considered in the second. In considering, in Chapter 3 of this report, the administration of economic and social development, your Commissioners have recommended the relaxation of general regulations to permit and encourage the most effective use of the limited human and material resources now available in the North. This recommendation is clearly of equal relevance to the northern administration of all federal programmes.

If northern residents and natives are to play a growing role in the northern operations of the federal government, something more than a modification of personnel standards and regulations is necessary. Vocational training is proceeding and general employment opportunities are being enlarged by the development of natural resources and of new applications for local skills or new markets for local products. But there has been little concerted effort to fit the northern inhabitants for the government jobs that are available, as distinct from efforts to create special work for them. In view of the difficulty of recruiting people to work in the North and the high rate of turnover among those recruited, a more positive approach is needed.

Until very recently, any moves in this direction have been inhibited by the absence, through much of the area, of even the most elementary education, and initial efforts have had to be directed to remedying this deficiency. As general education and vocational training have developed, employment officers of the Department of Northern Affairs and National Resources have provided a placement service, seeking out job opportunities for the northern inhabitants among both private and public employers. Apart from its office in Whitehorse, serving the Yukon communities, the National Employment Service has no field units north of the provinces, most of the needs of northern mining and construction operations having, by their nature, to be met in southern centres. In a sense, it must remain the task of the Department of Northern Affairs to develop the northern peoples—by its education and vocational training programmes—to the point where a labour force emerges that is similar in character to that found in the south. As this occurs, and as northern employment opportunities are enlarged through the development of resources, the National

Employment Service can enter the territories to play its normal role.

In 1962, the Department of Northern Affairs established a training programme at Fort Smith to develop clerks and stenographers for its own territorial offices, but as yet no general training for public service employment is available. The Civil Service Commission has no offices north of Edmonton—for either recruiting or training purposes—and it is doubtful that conditions will justify any change in this regard in the foreseeable future. But if a territorial service is to be developed, Northern Affairs will clearly have to enlarge its own programme as circumstances warrant and, as this is done, its programme should be extended to meet a growing part of the needs of other federal departments—until such time in the more distant future as the assumption of this responsibility by the Civil Service Commission may be appropriate.

Although departures from the standards applied elsewhere in Canada may be necessary, uniformity of standards must nonetheless be maintained within the northern regions. From this arises, in part, the need for special co-ordinating arrangements—to ensure that northern allowances and pay scales, entitlement to leave, scales of rationing, housing standards including scales of furniture and household equipment, transportation privileges and the like are uniform among federal employees working under similar conditions. In this regard, it is noted that the Treasury Board has taken an early initiative and a high degree of co-ordination and uniformity of standards has been achieved.

SUPPORTING SERVICES

In the provision of supporting services for federal operations in the North, the general practices dealt with in the second volume of reports must again be modified to suit the special circumstances. In one case—the development of northern telecommunications—a special need was recognized in the relevant report. Your Commissioners have recommended that the Minister of Transport be made responsible for ensuring that the special needs of the various departments are met in a way that provides maximum integration and facilitates the development of a telecommunications network serving the general needs of the North and stimulating its development.

For the other supporting services, the general recommendations submitted in Volume 2 apply equally to the North, but the special conditions of northern operations must be recognized in their application.

In some respects, northern conditions accentuate the need for changes proposed earlier. For example, federal housing in Whitehorse, Fort Smith, Yellowknife and Inuvik is maintained by the Department of Public Works, while the maintenance of office buildings and certain storage buildings in

those centres is the responsibility of the Department of Northern Affairs, with the result that many skills and supplies must be duplicated. Nine departments maintain separate storage facilities in Fort Smith, further subdivided by branches in some cases; the Departments of Public Works, Transport and Northern Affairs all have permanent warehouses containing such common items as paint and standard hardware. In Churchill, vehicles are maintained, with independent facilities and personnel, by the Department of Northern Affairs, the Indian Affairs Branch, the National Harbours Board, the Royal Canadian Mounted Police and each of the three Armed Forces. In the relative isolation of the North it is all the more essential that there be integration in such matters as construction and real property management, supply and materials management, and the pooling of local vehicles or maintenance facilities—as recommended in the earlier reports.

Northern supply and construction are heavily dependent on the existence of strong administrative and engineering bases in the south. Because of the exceptionally brief shipping and building season, timing is of the essence; a delay of several weeks in any part of the supply or construction process can set programmes back for a year—with the only alternative being the use of costly airlifts. To cope with these circumstances, it will clearly be necessary for the two servicing departments most involved—Public Works, and Purchasing and Supply—to make special arrangements for ensuring that northern needs are met. For the Department of Public Works, in particular, this will require, within the design and engineering organization, a strong and distinct component specialized in northern construction, including a supervisory force within the territories.

At the local level, northern conditions may require some modification of the general arrangements proposed in Volume 2. In local purchasing and supply, for example, considerations of convenience and the desirability of encouraging northern commercial development require that local sources be used where possible in the better established northern communities. However, the relative weakness of local commerce would require the proposed Department of Purchasing and Supply to operate under conditions radically different from those familiar to its field staff in the provinces. This suggests that, for the time being, the Minister of Purchasing and Supply should delegate to the Minister of Northern Affairs the local purchasing function within the territories and, with it, the operation of common warehousing facilities. If this were done, it would permit the Department of Northern Affairs to develop small purchasing and supply components within the territorial services. Similar considerations apply to the disposal of surplus supplies in the North, for which the practices followed in the south are inappropriate; in

Fort Smith, for example, a small warehouse is filled with discarded furniture that has been awaiting disposal action for more than six years.

Responsibility for local building maintenance services might, in many localities, be delegated to the Minister of Northern Affairs and National Resources with the same objects in view. It is also noted that, within the Yukon, the territorial Engineering Department now undertakes, under contract, certain engineering work of the Department of Northern Affairs; this organization might well be used for the supervisory tasks of Public Works on the basis of similar arrangements.

CO-ORDINATION OF PROGRAMMES

The crucial importance of co-ordinating northern operations of the various departments and agencies is clearly illustrated by the difficulties of the construction cycle. Unless requirements for building and works are planned sufficiently ahead and close liaison is maintained between the requisitioning department and Public Works, the orderly development of northern operations becomes impossible and costs are pyramided. The same is true of supply requirements, which must be planned well in advance with deliveries to southern ports timed accurately for the annual sealift directed by the Department of Transport.

The same need for co-ordination is evident wherever the northern programmes of one department have a bearing on those of another. For example, at least five departments are engaged in operations on the Mackenzie River: Fisheries, Mines and Technical Surveys, Northern Affairs and National Resources, Public Works and Transport—to which should be added the Northern Transportation Company. In the summer of 1961, the Water Resources Branch of Northern Affairs was taking soundings in reaches being charted at the same time by the Hydrographic Service of Mines and Technical Surveys; meanwhile, Public Works and Transport had no option but to do their own charting in other reaches where dredging and aids to navigation were urgently needed. In part, this situation reflects a maldistribution of functions which would be corrected by recommendations made in the final report on *The Organization of the Government of Canada*. But no reallocation of tasks will eliminate the need for concerting the work of the various departments in the North.

Generally, in these isolated communities, officials of different departments are on good terms and do all they can to help one another within the limits imposed by the directions they receive from Ottawa. But if programmes are not co-ordinated in the planning stage, little can be done in their execution to eliminate absurdities.

Within the various departments, the officers directly concerned with northern operations generally appreciate the realities of northern operations. But, except in the Department of Northern Affairs and the Royal Canadian Mounted Police, too many senior officials have a limited appreciation of both the potentialities of the North and the limitations imposed by the climate, the isolation and the meagre facilities of all kinds that are available. The effect of this is evident in a jealous insistence on autonomy that leads inevitably to a waste of time and public funds.

With the post-war expansion of government operations in the North, the need for co-ordination was formally recognized, almost as soon as it assumed serious proportions, by the establishment in 1947 of the interdepartmental Advisory Committee on Northern Development. The stated task of the Committee is to advise the government on questions of policy relating to civilian and military undertakings in northern Canada, and to provide for the effective co-ordination of all government activities in that area. Since the formation of the Department of Northern Affairs and National Resources in 1953 the Deputy Minister of that Department has been Chairman of the Committee, and the secretariat has been incorporated in the Department.

The achievements of the Advisory Committee have fallen short of the original hope, although there has been some success in limited functional areas through the efforts of active subcommittees. The principal difficulty lies in the fact that the initiative in referring departmental plans to the Committee, in sufficient time to permit full assessment of their relevance to other projected activities and the adjustment of plans where appropriate, rests with the individual departments. Moreover, as its name suggests, the Committee can only advise. The Minister of Northern Affairs and National Resources has, it is true, a statutory responsibility to "co-ordinate" all government activities in the territories; but this carries with it no power to compel compliance with his wishes.

The solution of the problem, as of so many others, is dependent on collective action, with the Treasury Board taking the initiative. The only practical way to achieve coherence in federal activities is by examination of the mutual impact of programmes when they are submitted for approval. In the past, Treasury Board itself has been limited in this role by the weakness of long-term planning, which has meant that proposals relating to northern operations have had too often to be considered precipitately in order that seasonal shipping and construction deadlines might be met. With the adoption of recommendations submitted in the report on *Financial Management,* involving greater emphasis on forward planning, it should become possible for the Treasury Board to make more effective use of the Advisory Committee.

In exceptional cases, where operations are carried on exclusively in the North under a more-or-less autonomous agency, co-ordination can best be achieved by vesting responsibility in the Minister of Northern Affairs and National Resources. This is now done for the Northern Canada Power Commission (which has one plant in Field, B.C., to serve certain national parks, but is otherwise a purely northern undertaking). In the report on *The "Make or Buy" Problem* in Volume 2, your Commissioners noted the possibility that the Northern Transportation Company Limited might well be separated from its parent Crown company, Eldorado Mining and Refining Limited, in recognition of its status as a common carrier in the Mackenzie River system. Whether or not this is done, it is appropriate, in view of the area of its operations and its relevance to the development of the Mackenzie basin, that the company should be answerable to the Minister of Northern Affairs and National Resources.

We therefore recommend that: Ministerial responsibility for the Northern Transportation Company Limited be transferred from the Minister of Trade and Commerce to the Minister of Northern Affairs and National Resources.

CO-ORDINATION IN THE FIELD

For co-ordination in the North itself among the field units administering the various programmes, primary reliance must be placed on the general proposals already put forward in these reports, especially those relating to the supporting services, with such modifications as were suggested early in this chapter. For the rest, it will depend on the good sense of the officers concerned. The analogy between northern administration in Canada and the task of governing colonial areas cannot be carried to the point of vesting in the territorial Commissioners the all-encompassing powers of a colonial governor.

Nevertheless, it is not only natural but proper that the senior resident representatives of the Department of Northern Affairs should feel a general concern with all federal activities in their areas—in view of their general responsibility for the social and economic development of the North. In one respect, it may be appropriate that this general concern of Commissioners—or, in the eastern Arctic, of District Administrators—be recognized by the grant of special powers to intervene in the operations of other federal departments. This relates to the personal conduct of federal public servants in the area.

Service in the North involves peculiar problems of personnel manage-

ment which cannot be ignored. In isolated and remote communities, where a small handful of officials and their families must consort with each other, day in and day out, officially and socially, for long periods without a break, the significance of personality, character, and social attitudes is highly intensified. Many outsiders are ignorant of northern conditions until they arrive, and the serious strain imposed by isolation and totally unfamiliar surroundings often evokes quite unexpected reactions. It is therefore of the highest importance to make every effort to ensure that emotional stability, temperament and character are given due weight in selecting outsiders for northern positions. Since so many departments and agencies have little experience in the North, consideration should be given to the establishment of a panel of senior officers with northern experience, either active or retired, to screen southern candidates for northern positions and advise the department or agency concerned in making a suitable selection.

No screening process, however, can be infallible, and personality problems are bound to be encountered from time to time among public servants in the North. Moreover, the isolation of many northern posts not only contributes to the development of such problems but also intensifies greatly their disruptive effect within the local communities. If serious damage to morale and stability is to be avoided, both among the public servants and within the northern communities in which they live, such situations must be met more promptly than the normal processes of federal personnel administration permit.

In the light of these circumstances, it may be appropriate that each Commissioner have, in addition to his normal powers over territorial civil servants, the power to suspend temporarily any federal government employee in his territory and to require the parent department or agency to withdraw the employee, if the Commissioner considers this necessary. The power of temporary suspension should, in the eastern Arctic, be delegated to the District (at present Regional) Administrators. Being an extraordinary power, its use would clearly be justified only by extraordinary circumstances.

In all other matters involving other federal departments, the senior resident officers of the Department of Northern Affairs must rely on their own powers of persuasion in their dealings with northern officials, and on their access through the Department to the co-ordinating machinery in Ottawa. Only in this way can their general interest in all government activities within the territories be reconciled with the maintenance of departmental channels of authority and responsibility, which, with the one possible exception noted, is no less essential in the northern operations of the federal government than elsewhere in the country.

23 SCIENTIFIC RESEARCH AND DEVELOPMENT

SPECIAL AREAS OF ADMINISTRATION

REPORT 23: SCIENTIFIC RESEARCH AND DEVELOPMENT

PUBLISHED BY THE QUEEN'S PRINTER • OTTAWA • CANADA FOR THE ROYAL COMMISSION ON GOVERNMENT ORGANIZATION

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ACKNOWLEDGEMENTS

The detailed investigation of the scientific research and development activities of the federal government was undertaken by a Project Group under the direction of John A. Bilton, PH.D. F.C.I.C., Technical Manager, Textile Fibres Division, *Canadian Industries Limited*, Montreal.

A number of Project Officers were associated with this endeavour, and your Commissioners in recording their names below, wish to acknowledge the assistance received:

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Your Commissioners also benefitted from the views of an Advisory Committee, chaired by Gordon M. Shrum, O.B.E., PH.D., F.R.S.C., Chairman, *British Columbia Electric Company*, Vancouver. The members of the Committee were:

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A number of briefs and submissions bearing on this subject were considered and these are duly recorded in the final volume of your Commissioners' reports.

Your Commissioners, in acknowledging the assistance and advice received, dissociate all those named above from any of the findings and conclusions contained in this report; for these, your Commissioners assume full responsibility.

PART 1

1

INTRODUCTION

The conduct of scientific research and development is today universally recognized as having a profound effect on the development of nations and the well-being of their peoples. The extent and quality of the research effort not only influence the technical capability of the productive segments of the economy and the adequacy of defence mechanisms, but have broad implications for the health and safety of the people and the success of their adaptation to their environments. In any country, the output of highly skilled scientific personnel needed in increasing numbers is conditioned by the quality of continuing programmes of scholarly research in the educational institutions.

As a consequence of the series of dramatic scientific breakthroughs in the past twenty years there has been in Canada, as in all the mature economies of the world, a tremendous expansion in the scale of research activity. From negligible sums prior to World War II, the expenditures of leading nations have risen to over two per cent of their gross national product. In Canada the expenditure of $250 million in 1959 represented roughly three-quarters of one per cent of the gross national product.

As in the United Kingdom and the United States, the dominant element of this expansion was direct intervention by government, taking the form of massive expenditures for research and development in its own establishments as well as financial assistance to similar activities conducted by industry and elsewhere. The dimensions of this participation are exemplified by the fact that, in terms of annual operating costs, the programmes financed by the Government of Canada account for over three-quarters of the total research expenditures of the nation. The remainder was at the expense of industry, the universities, and provincial research organizations.

2

THE GROWTH OF GOVERNMENT

SCIENTIFIC ACTIVITY

The earliest instance of research and development undertaken by the Government of Canada shortly after Confederation is the formation of the Geological Survey, to explore the mineral resources of the country and undertake related scientific studies. Before the turn of the century, the opening of the West had led to the establishment of experimental farms for agricultural investigation. For many years, these and similar activities subsequently undertaken represented a very minor part of the over-all responsibilities of the departments which conducted them. For the most part, the programmes were related to resource development, the improvement of cereal grains, establishing standards and the analysis and testing of materials.

In 1916, the government recognized the growing need for encouragement of scientific research on a broad scale, as a means of stimulating the industrial development of the country. The Honorary Advisory Council for Scientific and Industrial Research, hereafter referred to as the National Research Council, was formed to recommend policies to the government, and to supervise the distribution of research grants to the universities and industry and the establishment of post-graduate scholarships in the sciences.

From 1916 to 1939 there was a slow but steady growth of scientific activity by the government. New programmes initiated by various departments were still on a modest scale, but annual expenditures had reached a total of about $5 million by the outbreak of World War II. A noteworthy change occurred between 1925-26 and 1930-31 when annual expenditures of the National Research Council increased from $139,000 to $550,000 to finance the opera-

tion by the Council itself of a series of laboratories in Ottawa. The Council's annual expenditures, increasing by 1938-39 to $880,000, thus brought into being a complex of scientific establishments without equal in the country. While grants to universities were continued on an increasing scale, they came to be exceeded (and still are) by the Council's expenditures on the operation of its own laboratories and research enterprises.

The war years, as might be expected, witnessed a substantial upsurge in the scale of government scientific activity. Expenditures increased sevenfold, reaching approximately $35 million in 1945. The National Research Council served as the government's principal agent in this growth, which reflected the development of nuclear energy and sophisticated armaments. Both of these activities have since separated from the Council, being today largely the concern of independent organizations, Atomic Energy of Canada Limited and the Defence Research Board.

This wartime expansion, impressive as it was, is overshadowed by the explosive growth of government scientific activities in the postwar years. Since 1945, annual expenditures of the federal government have increased from $35 million to over $220 million. All scientific agencies of the government, including many new ones, have stepped up their activities, increasing and diversifying very considerably their scientific and development effort. New laboratories have been built, the number of field stations greatly increased, and systems for gathering data extended to all parts of the country. A corresponding growth in the numbers and range of skills of scientific personnel has occurred. The earliest entrants in the field, the Departments of Agriculture and Mines and Technical Surveys, are today each spending in excess of $25 million annually. Other departments with important programmes include Fisheries, Forestry, National Health and Welfare, Northern Affairs and National Resources, and Transport.

It is worthy of note that almost the entire research activity of the government has been concerned with the physical and biological sciences. Research in the social sciences—anthropology, economics, political science, sociology, history, economic geography, etc.—has benefitted from no more than token federal support. The unbalancing effect on academic organization of concentrating support in the physical and biological sciences, coupled with the increasing demand for social scientists, is a matter of some concern to the universities.

The National Research Council, in common with the other agencies, has continued to grow, in spite of splitting off segments of its work to other bodies, and its current level of expenditure is approximately $35 million annually. A notable development of the past ten years was the growth in defence

research and development expenditures which, carried on by the Defence Research Board, the Armed Services themselves and the Department of Defence Production, today account for slightly more than one-third of the total research expenditures of the government.

Table 1—RESEARCH AND DEVELOPMENT—OPERATING EXPENDITURES

	1951-52	*1961-62*[1]
	($000)	($000)
Civil Departments		
Agriculture	11,303	25,346
Forestry	3,785	9,563
Fisheries	1,688	6,428
Mines and Technical Surveys	8,802	25,644
Northern Affairs and National Resources	1,345	3,498
National Health and Welfare	1,565	5,694
Transport	158	1,482
Veterans Affairs	287	389
	28,933	78,044
Defence		
Defence Production and Canadian Arsenals[2]	42	11,513
Defence Research Board	14,346	33,271
Armed Services[3]	32,000	32,157
	46,388	76,941
Other Agencies		
National Research Council	11,881	35,614
Atomic Energy of Canada, Ltd.	6,625	29,756
Atomic Energy Control Board	200	700
Other[4]	170	680
	18,876	66,750
Total[5]	94,197	221,735

[1] Based on estimates made early in 1961.
[2] Does not include research paid for and included with Armed Services or Defence Research Board.
[3] Air Force expenditures in 1951-52 are estimated. In 1952-53 they amounted to $23,430,000.
[4] Including Board of Grain Commissioners, Central Mortgage and Housing Corporation, National Film Board and the Post Office. Although discussed in this report, Polymer Corporation Limited and Eldorado Mining and Refining Limited are excluded from these figures.
[5] Estimated overhead and indirect support costs of two departments are not included. Amounts involved are $2,400,000 in 1951-52 and $7,600,000 in 1961-62.

Comprehensive data as to government expenditures over the years on scientific research and development are not available. Your Commissioners,

in the face of this deplorable lack, have had to assemble information from a number of sources. The growth in the past decade is illustrated in some detail in Table 1, showing expenditures made for the operation of the government's own research establishments and as grants-in-aid and scholarships.

Accompanying the more than two-fold increase in federal expenditures for scientific research and development in the past decade has been a considerably smaller proportionate increase in employment of professional scientific and supporting personnel. The total in these categories, excluding seasonal employment, has grown from 10,791 in 1951-52 to 17,915 in 1960-61. The special problems of accommodating this class of specialist personnel within the public service are referred to later.

3

PRESENT RESEARCH AND DEVELOPMENT ACTIVITIES

THE CANADIAN RESEARCH EFFORT

In the year 1959, the latest for which statistics are available, the country's total expenditures for the conduct of research and development (excluding scientific information services, data gathering and scholarships) amounted to slightly more than $250 million, about three-quarters of one per cent of gross national product. In comparison, the shares of gross national product devoted to this purpose by other leading countries is considerably greater—the United States more than three times as much, the United Kingdom two and a half times

Table 2—RESEARCH AND DEVELOPMENT EXPENDITURES

	Canada – 1959		United Kingdom 1958–59		United States – 1959	
	Millions of dollars	% of GNP	Millions of £ sterling	% of GNP	Millions of dollars	% of GNP
Total Expenditures[1]	251	.72	478	2.11	12,430	2.58
Financed by Government	154	.44	320	1.41	8,030	1.67
Performed by Government	126	.36	159	.70	1,780	.37
Financed by Industry	78	.23	144	.63	4,075	.85
Performed by Industry	97	.28	280	1.23	9,438	1.96

[1] Including universities, etcetera.

and Switzerland almost twice as much. There are also significant variations between Canada and other countries in the way these moneys have been spent and in the degree of participation of industry, as shown in Table 2.

In the three countries shown, the research and development financed by industry represents roughly one-third of the total of such expenditures of the nation. However, in terms of the actual conduct of research and development, industry in Canada in 1959 performed 39 per cent of the total compared with 58 per cent and 76 per cent in the United Kingdom and the United States respectively.

GOVERNMENT-FINANCED RESEARCH AND DEVELOPMENT

Turning now to the government-financed programmes in Canada in the year 1961-62, total operating costs amounted to over $229 million, including overhead. In addition, expenditures for land, buildings and facilities, which have in the past few years been running at between $30 million and $40 million, account for approximately $37 million, bringing the total of capital and operating costs in 1961-62 to $266 million. In the comments which follow, frequent reference is made to expenditure levels; in all cases these reflect only operating costs.

Figures quoted earlier dealt with the relative parts played by government and industry in the financing and performance of the nation's total research effort. A significant aspect of the government's scientific policies is the extent to which moneys are applied within its own establishments and to support research elsewhere, principally in the universities and industry. In Canada, the "in-house" scientific activities of the government have long claimed the lion's share of funds available. Table 3 demonstrates the dimensions of gov-

Table 3—FEDERAL RESEARCH AND DEVELOPMENT OPERATING EXPENDITURES BY PRINCIPAL SECTORS IN WHICH PROGRAMMES WERE CONDUCTED

	1952-53		*1961-62*	
	($000)	%	($000) (estimates)	%
Federal government laboratories and establishments	81.3	78	181.6	82
Industry	18.9	18	21.7	9½
Universities	4.4	4	17.7	8
Other, mainly provincial establishments	.2	—	1.2	½
	104.8	100	221.8	100

ernment support of outside research, and it will be observed that in the past decade the disparity has become even more pronounced.

The present federal apparatus for the conduct and financing of research and development embraces three broad groups of activity, with varying organizational forms. Departmental research is carried on by departments and allied boards in furtherance of the objectives of the departments themselves—in most cases related to resource development. Defence research is carried on by the Armed Forces and the Defence Research Board within the Department of National Defence, and by the Department of Defence Production. Research agency activities comprise the operations of separately established boards and corporations in research and development, mostly non-military and existing independently of any department of government.

As a result of differences in origin and organization, significant variation occurs throughout in the quality of direction, conditions of recruitment and remuneration of personnel, and degree of financial autonomy enjoyed by the various members of the government's research family. The resulting lack of consistency in performance and effectiveness which has persisted in the absence of any central policy is a matter for concern.

DEPARTMENTAL RESEARCH

In most of the departments referred to hereunder, research activities, in spite of the growth already described, remain but a minor function in relation to the total tasks of the department. As a result, science has been required to fit into an existing administrative framework not of its choosing, and related types of research are, if only because of their independent origins, often dispersed within the departments and even scattered among them. In Part 2 of this report such problems are reviewed in some detail and certain recommendations offered for their correction. There follows hereunder a brief description of the current activity of each department.

Agriculture

With an annual budget of slightly more than $25 million the department conducts research into problems of crops, animals, soils and a small group of related subjects. The professional staff exceeds 800, of whom one-half hold Ph.D. degrees; supporting staff and farm labourers each number about 900. The research programme is carried on in separate establishments known as research institutes, regional research stations, laboratories, and experimental farms.

The investigation disclosed that the quality of research is high and the

department has a record of important and tangible contributions to the agricultural community as a result of its research. From the point of view of organization your Commissioners are less satisfied, and Part 2 of this report refers to steps considered necessary to correct an excessive fragmentation of the research programme. In the absence of strong control mechanisms to unify the whole effort and make possible major policy decisions within the department, there was observed a lack of balance in effort applied in the several main fields of research. Thus the relationship of expenditures to the economic interests of the country have become unbalanced, principally through the devotion of a disproportionately low amount of effort to animal research and a preponderance to crops. As an indication of this imbalance, the country's cash income from the sale of principal farm products (1959) is compared hereunder with the research effort of the department.

	Cash Income		*Professional Man-Years Devoted to Research (1959)*	
	($000)	%		%
Crops	914,218	33	604	70
Soils	—	—	112	13
Animals and Animal Products	1,725,202	62	118	14
Other	168,673	5	29	3
	2,808,093	100	863	100

Fisheries

The research activities under this heading are shared by the Fisheries Research Board and the Department of Fisheries and comprise biology, fish culture, fishery technology and oceanography, covering both marine and fresh water fish. Annual operating costs of $6.4 million, supporting a professional staff of 218, represent about 25% of the total costs of the department (including the Board).

The biological stations are concerned with studies of the life histories and population dynamics of the principal food fishes, fish culture, and new fishing methods. Technological stations do research in preserving and processing fish and by-products and attempt to promote the efficiency of the fishing industry. Oceanography includes the study of biological, chemical, and physical aspects of the marine and fresh water environment of fishes and other important aquatic organisms. Canada's several international fisheries research obligations are generally carried by the Fisheries Research Board.

The work carried out is on the whole of high scientific quality, particularly in oceanography. Here again, as set forth in Part 2 of this report, your Commissioners' recommendations relate to improved organization and the desirability of combining within a single authority all research activities relating directly to Canadian fishing resources.

Forestry

In this new department, formed by severing the Forest Biology Division (entomology and pathology) from the Research Branch of the Department of Agriculture and the Forestry Branch from the Department of Northern Affairs and National Resources, the main emphasis has so far been on research and development of forest resources. Most of the budget is devoted to direct research; the direct research activities employ 308 professional scientists and a supporting staff of 506 (excluding some 360 seasonal employees), in experimental stations, regional laboratories and institutes spread from Victoria, B.C., to Newfoundland.

The department has been so recently formed that it may be premature to comment upon current problems, but it is observed that its establishment represents further fragmentation of a phase of biological research that is common to scientific research and development programmes in the renewable natural resources—agriculture, fisheries and forestry.

There is a lack of balance and consistency in the present organization, largely due to the different origins of the several divisions. The annual budget is divided approximately 50 per cent to forest entomology and pathology, in which the healthier and more stimulating atmosphere is found; 35 per cent covers expenditures of the forest research branch and 15 per cent the forest products research branch. In the latter branches, with insufficient competent scientists to sustain a serious programme, many of the programmes are of an *ad hoc* nature, with particular stress on industrial programmes.

Mines and Technical Surveys

The character of the activities of this department has changed considerably in the past two decades. It is now recognized as being largely scientific in purpose and it is the national centre for research in geological sciences, geography, mining, metallurgy, fuel technology, astronomy, oceanography and many branches of geophysics.

An annual budget, currently over $25 million, finances research activity in all of the five branches of the department, as well as the independent Polar Continental Shelf Project. Total professional staff numbers about 650 (seasonal employees omitted).

There is considerable variation in the size of the several programmes conducted by the department. The Mines Branch and Geological Survey together employ over 59 per cent of the scientific personnel but account for only 40 per cent of total expenditures on scientific activities. The Dominion Observatories, with a budget of $1.8 million, and the Polar Continental Shelf Project, spending $1.6 million, are followed by the small spenders, Geographical Branch, $.5 million, and Mineral Resources Division, $.4 million. The balance of the department's research and development expenditures, approximately $12 million, is represented by research and data-gathering in the Surveys and Mapping Branch. While in this branch true research is very limited in scope, the data-gathering activities provide the foundation of much of the research carried on by other branches.

The department is rapidly becoming one of the main research arms of the government but retains some traces of its non-scientific origins which are particularly noticeable in the Surveys and Mapping Branch, in some units of the Mines Branch, and in the central administrative and information divisions. Relations between scientists and the administrative staff of the department, although greatly improved, still leave something to be desired. The situation requires a more general acceptance of the fact that, while continuing to be responsible for certain important non-scientific activities, the department has also come to possess the attributes and responsibilities of a major scientific establishment.

National Health and Welfare

This Department provides $5.7 million to support research, mainly in public health and clinical medicine. Grants to universities and other non-government recipients, chiefly through the National Health Research Grants, absorb about $3.7 million annually, the remaining $2 million being spent on research carried on within the department by government research staff.

The programmes and grants of this Department represent roughly half the total expenditures of the government in the field of medical research. The subject is considered as a whole in the Commission's report on Health Services.

Northern Affairs and National Resources

The evolution of this Department, created ten years ago from the former Department of Mines and Resources—itself the successor of the long-established Department of the Interior—reflects the ending of federal responsibility for the natural resources of the prairie provinces and the growing awareness of the needs and potential of the North. Excluding forestry research expenditures, which are reported under the new Department of Forestry, research

and development expenditures have doubled in the past ten years.

Four out of the five main branches of the Department have a degree of interest in research but none is concerned exclusively with it. The annual budget, slightly over $3 million, is spent by the National Museum of Canada (botany, archaeology, zoology and ethnology); the Canadian Wildlife Service (biology, ornithology and mammalogy); the Northern Co-ordination and Research Centre (anthropology, sociology); and the Water Resources Branch (hydrology and data gathering).

The predominantly administrative activities of the Department create an atmosphere inimical to effective research. The lack of scientific leadership at the higher administrative levels and the inability of scientific staff to secure the resources needed for their work prejudice the effective conduct of research activity. Your Commissioners' detailed recommendations in Part 2 of this report reflect their conclusion that all research activity should be transferred from this Department to more appropriate and congenial environments elsewhere in the public service.

Post Office

A modest research programme is conducted by this Department for the purpose of mechanizing letter and parcel sorting, the largest project being the development of electronic sorting. Most of this work is contracted out and expenditures, which reached a peak five years ago of just under $1 million, have fallen sharply to a current budget of $132,000.

Transport

In its Meteorological Branch, with headquarters in Toronto, the Department of Transport conducts programmes of research and development relating to climatology, several divisions of meteorology and instrument improvement. Current expenditure of about $1.5 million is less than ten per cent of the total expenditures of the Branch, and research activities are overshadowed in more ways than one by important operating responsibilities. Facilities and housing arrangements are less than satisfactory and consideration should be given to the suitability of the Department as a location for the meteorological activities as a whole.

DEFENCE RESEARCH

Ten years ago, defence research accounted for about half the total government expenditures on scientific research and development. Today, at an annual level of about $77 million, the proportion is approximately one-third, which is significantly lower than in some allied countries. In the United King-

dom, for example, research programmes to meet the needs of the Armed Forces represent about three-quarters of all government expenditures on scientific research and development.

The proportion of the total defence budget devoted to research activities in Canada provides another indication of a less intensive approach to defence research than is found elsewhere. Present defence research expenditures in Canada account for but five per cent of the total defence budget, whereas in the United States about twenty per cent of the budget is so applied. A further important disparity exists in the manner in which defence research funds are spent in Canada as compared with the United Kingdom and the United States. While in both the latter countries only 20 per cent of the total is spent on basic and applied research, with the balance devoted to development, Canadian expenditures are divided approximately equally between research and development. As a result of devoting so small a proportion of the defence budget to research and development, coupled with the relatively small allocation to defence development from the limited funds available, the impact of defence activities upon industry has been very much less significant in Canada than in other countries. Thus in Canada defence development expenditures represent .08 per cent of gross national product compared with 1.3 per cent in the United States; on a per capita basis, Canada is spending on development $1.50 compared with £4 in Great Britain and $36.00 in the United States of America.

In spite of the several major disparities between defence research and development expenditures in the United Kingdom, United States, and Canada, there is conclusive evidence that some Canadian defence research programmes are making disproportionately high contributions to military science and technology. Substantial progress has been made in Canada in such diverse fields as hypersonic and plasma physics and anti-submarine warfare, upper atmospheric research, blast physics, etcetera, with comparatively small teams. Similar programmes are being pursued abroad with appreciably stronger scientific groups and the Canadian successes are due largely to the enthusiasm of the scientists and to the use of small select groups.

The Canadian programmes cover almost the entire range of the scientific disciplines and extend from bio-sciences and the behavioural sciences on the one hand to the physics of the upper atmosphere and atomic energy on the other. It is not surprising to note that the research and development effort as a whole is spread rather thinly. This condition is not necessarily unsatisfactory, for it is symptomatic of a very high degree of enthusiasm which should not be discouraged. It may also be regarded as a Canadian characteristic; even in the

universities there is a tendency to set targets which stretch resources to the limit—a not unhealthy condition.

The Several Agencies

Upon its formation in 1947, the Defence Research Board took over most of the defence research activities of the National Research Council. In its own establishments, with an annual budget of $33 million, it conducts defence research and a limited development programme. In contrast, the other agencies in this field undertake development but no research. Herein lies the key problem to the efficient organization and conduct of Canadian applied research and development activities. Applied research and development merge one with the other so intimately in practice that, to maintain a balanced and realistic programme, it is most unwise to separate them.

The Chairman of the Defence Research Board is equivalent in rank to the Deputy Minister of the Department of National Defence and to the Chiefs of Staff, which fact alone exemplifies the importance military science has achieved in Canada. Further, the Chairman of the Defence Research Board is a full member of the Chiefs of Staff Committee, and the Defence Research Board is generally recognized as a fourth arm of the Service, but it is as a fourth arm, rather than as the senior scientific authority of the Department, that the Board operates.

Although a major statutory function of the Board is to act as a defence research policy-advising body, with implied responsibility for the whole of such activities, that duty has never been assumed. Accordingly, the three Armed Services, each with its own development programmes and collectively spending about $32 million annually thereon, enjoy a great measure of autonomy and are virtually independent of the Defence Research Board. This lack of cohesion has important implications in the field of policy-making, a subject discussed in a later chapter.

The scientific development activities of the three Armed Services, of which the RCAF programme is the largest by a considerable margin, show little evidence of co-ordination. While present Service budgets, $32 million in total, are approximately equal to that of the Defence Research Board, special weapons programmes, notably the development of the "Arrow" as a manned supersonic interceptor aircraft, raised development expenditures to a peak of nearly $72 million in 1957-58.

An inherent difficulty in the organization of the Armed Services development efforts arises from the "tour of duty" procedure, under which officers are posted in different parts of the Service for three or four year tours of duty. In defence development programmes, frequent changes of command are not

conducive to efficiency. Sometimes, also, senior officers with limited scientific and engineering background or knowledge are posted to essentially defence development commands, purely on the basis of seniority. The early retirement age of senior uniformed personnel further reduces continuity in programme administration to an undesirable degree.

Active participation by the Services in defence development programmes is an obvious corollary of Service responsibility for defining needs, and for conducting proving and trials programmes and training activities. Today, less than ever, can the "user aspect" be supplied by civilian scientists and engineers. However, as a result of factors mentioned above and the rapid advances in science and technology, it is doubtful whether the Services are adequately staffed, from the standpoint of technological capability, to direct and supervise development programmes in the future. The most practical remedy lies in making the best use of the skilled personnel available by a proper co-ordination of the several agencies involved—a subject discussed later in this report.

Two other agencies are involved in the development side of defence scientific activities. Canadian Arsenals Limited, a Crown corporation engaged in munitions production, conducts development programmes initiated in the Defence Research Board and by the Armed Services, spending about $1 million annually thereon.

The activity of the Department of Defence Production in this field relates specifically to the development-sharing programme initiated with the United States in 1959. While it is premature to attempt to assess the long-term impact of this programme on the prospects of active participation by Canadian manufacturers in joint United States-Canada defence development and production projects, there is no doubt that an auspicious beginning has been made. Current expenditures are slightly over $10.5 million and the programme is broadening in scope; the volume already approaches that now contracted out to Canadian industry by the Armed Forces and the Defence Research Board under purely domestic programmes.

The Role of Canadian Industry

By far the most striking fact to emerge from a comparison of defence research expenditures in Canada, the United Kingdom and the United States is the astonishingly small degree to which Canadian industry shares in the programmes. Apart from joint U.S.-Canadian development-sharing projects promoted by the Department of Defence Production, the total of expenditures by way of extramural contracts with industry approximates $12 million annually, equal to 37 per cent of total defence development expenditures. In the United Kingdom 90 per cent of such work is contracted out and the sums spent with

industry, £175 million per annum, represent an expenditure on a per capita basis of over $10. In the United States a preponderant share of the $36 per capita spent on defence development is represented by contracts placed with industry. In comparison, the Canadian extramural costs with industry total but 55 cents on a per capita basis.

Canadian industry's participation in defence research activity is reduced to nominal proportions, compared with its counterparts in the United Kingdom and the United States, not only by the factors referred to earlier—the small proportion of the Canadian defence budget devoted to research and development and the small scale of development effort in comparison with research—but by the conduct on an intramural basis of the greater part of the development work undertaken. The significance of these variations as they affect Canadian industry can be illustrated by pointing out that should defence spending in Canada conform in character to that of the United Kingdom and the United States, the total defence budget of $1,600 million should support development contracts for industry of between $150 million and $250 million.

The economic consequences to Canada are of major importance. A more adequate level of spending with industry would not only beneficially affect employment and tax revenues but, in the light of United Kingdom and United States experience, the resulting stimulation of industry would have lasting and far-reaching implications in terms of the industrial capabilities of the nation. Research and development carried on by manufacturers engaged on defence projects inevitably spill over to improve the technologies applied to production for civilian needs and for export. Canada, by following existing policies in its defence spending, may well be guilty of a costly neglect of opportunity to enhance its industrial skills and capacity.

This state of affairs has developed in the absence of proper policy-making machinery at the centre of government, a topic discussed in a later chapter. There are, however, several specific contributing factors worthy of mention.

Senior officers of the Armed Services display a marked lack of confidence in Canadian science and technology as a whole, manifested by a lack of interest and understanding by the Armed Services in a large part of the Defence Research Board programme. This attitude may stem from certain unhappy experiences, and may also derive in part from the growing need felt for Service self-sufficiency and minimal reliance on outside sources. That this lack of confidence is unwarranted is amply demonstrated by a record of first-rate achievement by Canadian science over the past few years.

Partly on this account, and partly as a result of excessive caution by inter-Service control committees which often amounts to inaction, few of the promising research projects have been carried through development and

prototype stages to eventual production for the Services. This does not reflect on the high standard of work which has been conducted by the Defence Research Board, but rather on the inability of the Armed Services to capitalize on it. This failure to pursue promising defence developments has had serious effects for Canada in the loss of valuable exports, of facilities for advanced technologies, and—more important—of some first-class scientists and engineers to other countries.

As the procurement agency for the Armed Services the Department of Defence Production is a necessary intermediary in arrangements between defence research establishments and manufacturers. While the advantages of interposing a civilian purchasing agency between the parties outweigh the resulting complications, your Commissioners are not satisfied that such complications are minimized, as they should be, by effective procedures and efficient organization.

Implementation of recommendations made in other reports on the future role of the central control agencies will afford a partial solution to this problem, but your Commissioners are of the opinion that there is need for a comprehensive review of existing purchasing, contracting and programming procedures in the interest of greater speed and flexibility.

Organization and Co-ordination

Part 2 of this report contains a description of the present organizational structure for defence research and suggestions for its improvement. The central policy governing the relationships between the several agencies is of transcending importance however, and your Commissioners' findings are discussed hereunder.

While co-ordination of basic research programmes is not important, and indeed is undesirable, some measure of co-ordination of applied research programmes is desirable, and co-ordination of defence development programmes must be regarded as essential. At present five government agencies have an initiating role in development programmes—the Defence Research Board, the Royal Canadian Navy, the Canadian Army, the Royal Canadian Air Force and the Department of Defence Production.

Notwithstanding the fact that the Defence Research Board's applied research programme is spread rather thinly in some areas, the aggregate output of research is impressive, and development programmes in hand, although small in number, show considerable promise. But the Armed Services (and more recently, the Department of Defence Production) are responsible for the bulk of defence development programmes and hence, by implication, for defence engineering. It is in this context that need arises for a careful selection

of projects and for adequate co-ordination of programmes. To achieve optimum results, development programmes may be supported by some basic research but must be closely correlated with applied research programmes.

It therefore appears advisable, in the interests of economy and effectiveness alike, to co-ordinate all defence programmes for applied research and development, including the new "development-sharing" programme, and to provide an effective environment for their conduct. In this area, as in many others, the traditional independence of the three Services gives rise to duplication and waste. Short of total unification of the Services, co-ordinating machinery represents the most likely means of gaining some of the benefits of integration. The urgently needed strength in defence development and engineering should be provided by the creation of a national defence research and development agency—a defence-engineering high command, backed by the resources of the present Defence Research Board establishments, Canadian Arsenals Limited and industry, and supported by the experience of the "development-sharing" groups in the Department of Defence Production.

To assist the new agency, which might appropriately be named the Defence Research and Development Board, and to ensure the optimum utilization of defence scientists, there is need for a strong defence science and engineering planning unit. The growing importance of the "development-sharing" programme requires that the Department of Defence Production be adequately represented. The principal duty of the unit would be to keep the Board adequately informed of defence research and engineering and related programmes in Canada and abroad, and to maintain a continuous assessment of the current potential of Canadian industry to undertake defence research and development.

Under the general direction of the Board, the laboratories, establishments and administrative staff of the existing Defence Research Board should be operated as a common facility available to and working in close partnership with each of the three Services. The actual conduct of development programmes, more an engineering than a scientific task, must remain the responsibility of the Services, but the proposed Defence Research and Development Board, on which each Service should be prominently represented, will play its major role in the planning area by promoting inter-Service co-operation and encouraging the Services to make the most effective use of the laboratories as a scientific facility available to all, with programmes chosen in response to individual requirements.

The role of the Department of Defence Production should remain substantially unchanged. Representation within the proposed defence research and engineering planning unit should ensure proper co-ordination of the "develop-

ment-sharing" programme with the development programme of the Department of National Defence, so that these two different types of demand on Canadian industry do not come into conflict.

We therefore recommend that:

1 A new agency, to be called the Defence Research and Development Board, be established in place of the present Defence Research Board, to be responsible for all the defence research and development activities presently undertaken in the Department of National Defence.

2 The proposed Board be responsible for advising the Minister of National Defence on all policy matters related to defence research and development.

3 The three Armed Services be prominently represented on the proposed Board.

4 A defence research and engineering planning unit be established under the general direction of the proposed Board.

5 Existing defence research establishments, to be known as National Defence Laboratories, be independently organized under a full-time senior administrative officer, and be operated on behalf of the three Services under the general direction of the proposed Defence Research and Development Board.

RESEARCH AGENCIES

This group of independently established organizations conducts basic and applied research and development in areas not specifically connected with departments of government and, for the most part, unrelated to defence science. In terms of annual operating research and development expenditure, two large agencies, the National Research Council and Atomic Energy of Canada Limited, together account for ninety-eight per cent of the total. Small but important programmes are conducted by operating agencies like Eldorado Mining and Refining Limited, Polymer Corporation Limited and Central Mortgage and Housing Corporation.

National Research Council

Reference has already been made to the founding of this body in 1916 as an advisory council and its embarkation on the active conduct of research in the mid-twenties. As the government's principal arm in scientific matters, it fathered research and development in defence science and atomic energy during the last war and in due course turned over these responsibilities to other bodies.

The Council remains the best known Canadian scientific agency, both at home and abroad, and it has built for itself an enviable reputation for the excellence of its work and the high quality of its professional personnel. Under strong leadership, in the absence of effective national policy-making machinery, it has been the most influential voice in the post-war growth of government science.

Broadly stated the activities of the National Research Council encompass the operation of eleven laboratories or establishments engaged in pure or basic research, applied research, and engineering; it makes grants-in-aid and awards fellowships and scholarships in support of scientific endeavour; it attends to most of Canada's international scientific interests and commitments; and it has responsibility for the newly formed Medical Research Council and Canadian Patents and Development Limited.

Though the range of its interests is broad, the Council does not attempt to cover the whole range of scientific endeavour in its own research and development activities. It does not generally deal with areas of research which are the special concern of government departments. It does not, for example, deal with geology, or mining, or comprehensively with metallurgy. It barely touches the oceans; although actively concerned with outer space, it does little with regard to meteorology; it has few dealings with the social sciences, even those such as anthropology, geography and psychology, which are closely related to the natural sciences.

In addition to its main functions, the National Research Council provides a wide range of supplementary services, including the publication of journals, dissemination of scientific information by various means, and the supervision of a large number of nation-wide technical committees.

The operating budget of the National Research Council currently amounts to $35.6 million, of which approximately one-third is disbursed as grants and awards (including those of the Medical Research Council). A broad division of current operating costs according to areas of activity is as follows:

Pure (basic research) divisions	$ 2.7 million
Applied research divisions	4.8 "
Regional laboratories (Halifax and Saskatoon)	1.5 "
Engineering divisions	12.5 "

As of March 31, 1961, staff consisted of 664 scientists and engineers, with supporting staffs of technicians and others numbering 1,819.

The work in the National Research Council laboratories is not assigned on a project basis, the emphasis being put rather on fields of research. The divisions are organized in sections, each of which operates more or less independently in a specified scientific field. The Ottawa laboratories are devoted to investigation in the fields of pure and applied chemistry, pure and applied physics, and applied biology. In Ottawa also, four engineering divisions are concerned with aeronautics, radio and electrical engineering, building research, and mechanical engineering. Regional laboratories at Halifax and Saskatoon slant their investigations toward local resources and economic interests of the Atlantic and Prairie Provinces respectively.

Because the National Research Council was built by scientists for scientists it has become to be regarded by government scientists in all branches as the ideal pattern of a government research agency. A favourable environment is created by freedom from vexatious control in money and staffing and a minimum of close direction of the individual research scientist. By contrast, in government departments, central controls of an absolute nature and non-scientific senior direction prove irksome to professional scientists. Means must be found to overcome this environmental disparity if a uniformly high degree of effectiveness is to be achieved throughout government scientific establishments.

This is not to suggest that scientific workers should be free to pursue their investigations without any direction at all. As indicated elsewhere fundamental research flourishes with minimal supervision of the individual but responsibility must be borne by the director of each scientific establishment for proper programming and the evaluation of priorities.

The governing body, the National Research Council itself, is made up (at the date of this survey) of four of its senior officers, an ex-President, thirteen members from Canadian universities, and one representative each from labour, industry, and a provincial research foundation. This reflects the intent when the National Research Council was established, essentially as an advisory board on national science policy, to make the Council broadly representative of the Canadian scientific community—a character which by reason of the changes since 1916 it can no longer properly claim. In its capacity as a board of directors supervising actual operations costing upward of $24 million per year, the Council is not appropriately constituted. In fact, its principal concern is with the disbursement of the grants-in-aid and scholarships which represent one-third of the annual expenditures of the organization. Some altera-

tion in the composition of the Council may be appropriate to the new responsibilities recommended later in this report.

Atomic Energy of Canada Limited

Atomic Energy of Canada Limited was incorporated in 1952 to take over the operation of the Chalk River research establishment of the National Research Council. Shortly thereafter the Corporation initiated a nuclear power reactor programme based upon experience with the heavy water natural uranium concept. Experimental reactors at Chalk River and a 20-megawatt nuclear power station at Rolphton have been followed by the construction of a 200-megawatt reactor at Douglas Point, Ontario, which will supply the Ontario Hydro-Electric system. A 40-megawatt reactor in Bombay was presented to India, under the Colombo Plan, for research purposes. Further development in the power reactor field will follow the completion of the Whiteshell Nuclear Research Establishment in Manitoba.

Having regard to the nature of Atomic Energy of Canada Limited, it is difficult to distinguish between research and development, but there is no doubt that the preponderant emphasis in its activities relates to the use of atomic energy in the development of electric power. Approximately twenty per cent of the work carried out in the Chalk River laboratories is devoted to fundamental research in the atomic energy field and the production of radioactive isotopes and source material for Cobalt 60 beam-therapy units.

The annual operating expenditures of Atomic Energy of Canada Limited have increased four-fold in the past ten years to a 1961-62 total of $29.8 million. Estimates for 1962-63 show a continuation of this upward trend with operating costs forecast at $32.1 million. Atomic Energy of Canada Limited realizes revenues of over one million dollars annually from commercial sales of isotopes and other products.

Within the past few years there has developed a close and growing relationship between industry and Atomic Energy of Canada Limited. Substantial responsibilities have been assigned to leading electrical manufacturers and nearly $8 million was provided in 1961-62 for research and development by universities, industrial firms and independent engineers.

The accomplishments of this organization are universally recognized and there can be no doubt that in the successes achieved Canada has received more for each dollar spent in the advance of atomic-energy technology than other leading countries. Concentration of effort in the power-reactor field has been a logical outcome of Canada's early participation in nuclear research. Almost entirely by reason of government leadership and finance, development has proceeded a very considerable distance. The ultimate vindication of these

efforts would be the assumption of initiative by industry and active promotion by it in world markets of the highly competitive product developed as a result of the research to date. Industry has appeared loath to commit itself to the responsibilities involved and it is at least open to question whether such a development can take place so long as Atomic Energy of Canada Limited, in its expanding operations, commands such a degree of leadership and wealth of management know-how.

Other Agencies

The dimensions of the smaller research and development programmes conducted by other agencies, independent of departments of government, are illustrated as follows:

	Operating Expenditures
	($000)
Eldorado Mining and Refining Limited (1961)	609
Polymer Corporation Limited (1960)	1,810
Central Mortgage and Housing Corporation (1961-62)	206

The research conducted by both Eldorado Mining and Refining Limited and Polymer Corporation Limited in their own laboratories is of commendable quality. The organization and operating research procedures of Polymer Corporation Limited are recommended as a model for study by industry. The research interests of Central Mortgage and Housing Corporation are entirely served by contracting out—about fifty per cent of the total to the Building Research Division of the National Research Council.

CO-ORDINATION OF GOVERNMENT RESEARCH ACTIVITY

This brief summary of activities in research and development illustrates the breadth of the government's existing interests and the diversity of the programmes financed. Three main divisions of the government spending agencies have been identified—the civil departments, the defence research group, and the independent research agencies.

Although the several units in these divisions are variously organized, there are often close similarities in the work they undertake and in the facilities and techniques employed. All draw on the same pool of university-trained scientists; all look to the government as the principal source of research funds; and, to a greater or lesser extent, all have relations with industries which are dependent on scientific research and development. While in many ways similar

in function, facilities and personnel needs, these diverse government bodies are not subject to any over-all scrutiny or supervision, nor is there available to the Prime Minister and his Cabinet any independent or disinterested adviser qualified to give counsel on their scientific policies or programmes and the priorities which should be accorded.

4

NATIONAL SCIENTIFIC POLICY

Few matters are of more fundamental importance to the peoples of the economically advanced countries of the world than the enunciation of wise and appropriate national scientific policies. What proportion of the nation's resources should be devoted to research and development and how the money available should be distributed to the various areas of scientific investigation are questions the answers to which may profoundly affect the health, the safety and the economic well-being of the nation.

There is no universally accepted pattern for arriving at these vital decisions. In both the United Kingdom and the United States, continuing efforts are being made to devise procedures that will permit top-level decisions to be founded on the judgment of the principal groups involved, including the professional scientists, the universities, the defence forces, industry, agriculture and medicine.

The ultimate responsibility is a heavy one and in a parliamentary democracy must be borne by the government of the day, the Prime Minister and his Cabinet. The fact that political leaders usually possess only a lay knowledge of scientific matters provides no grounds for escaping this onerous task. For good or ill someone must take decisions, and their consequences are so vital and far-reaching that they cannot safely be left to public servants or to any one of the several groups which have a special stake in some part of the scientific spectrum.

A recent President of the United States warned against some of the dangers of specialized influence on the shaping of national scientific policy. He en-

joined his fellow citizens to beware the "conjunction of an immense military establishment and a large arms industry". To this hazard he added "the prospect of domination of the nation's scholars by federal employment" and "the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite". A sub-committee of the United States Senate in June 1961 discussed the problem in the following terms:

> The President cannot afford to rely upon any one source of scientific advice. No single scientist, no one group, nor even the scientific community as a whole can be counted upon to foresee the unfolding course of research and technology... Scientists are professional experts... (they) often have strong opinions about the morality or political utility of developments in the laboratory. They are not exempt from the human tendency to allow these beliefs to color their technical judgments, and to become ardent pleaders for special causes. A President needs as much sales resistance in science and technology as anywhere else.
>
> Viewed from where the President sits, scientific counsel is inevitably parochial. It is only one of the many factors he must weigh in arriving at policies covering the full span of our national needs. Measured against the perspectives of the President's office, scientific counsel is therefore like economic and military advice and must in the same sense be subject to civilian control.

In the view of your Commissioners, the existence of suitable machinery for informing and assisting the Prime Minister and Cabinet with respect to major scientific policy decisions is of paramount importance. Such arrangements as exist on paper today are, because of their narrow compass, less than adequate. But the real concern of your Commissioners is that in fact they have been virtually inoperative and the whole post-war expansion of government scientific activity has proceeded on a piecemeal basis without adequate co-ordination. There has been no effective mobilization of advice and counsel from outside the public service and responsibility for the expansion of various activities has been borne by individual ministers without any evidence of their relation to national policy as a whole. It is not unfair to say that the scientific policy of Canada today is the result rather than the cause of growth in the many scientific activities undertaken by government.

CRITERIA IN THE FORMULATION OF POLICIES

The determination of what Canada can afford to spend, or what it cannot afford to refrain from spending, involves consideration of a number of different factors. The selection of the fields of research in which effort is to be applied should take into account the economic needs of the country, its geography (which influences health, resources, and defence needs), its industrial plant and capacity, the skills of its peoples and the educational facilities available for their enhancement; and last, but not least, its international obligations for co-operation in defence and other fields. The degree of effort to be expended in each field calls for the establishment of priorities and a careful

weighing of the claims of each for support against the potential economic and social value of the scientific gains which may result.

Here the questions arising may be of the greatest difficulty. For example, should Canada, in view of its geography, make a major effort to develop long distance transmission of power, or should the money be spent in developing atomic power reactors? Is the challenge of Canada's high rate of infant mortality sufficient to divert research funds from, say, marine biology? Does the expenditure of but five per cent of the research budget on human life and health represent a reasonable apportionment? Of all scientific activities supported by public funds, 82 per cent are conducted within the government's own establishments; is this warrantable, or does it reflect a tendency toward empire-building? Conversely, is the optimum degree of stimulation and support afforded to universities and industry by the expenditure therein of only 8 per cent and 9½ per cent, respectively, of the total scientific budget? These and many other similar questions are the raw material of the decision-making process.

EXISTING MACHINERY FOR POLICY DETERMINATION

The present organization for dealing with high-level decisions in the scientific and research field is composed of two statutory bodies and an advisory panel of senior civil servants.

Privy Council Committee

The Committee of the Privy Council on Scientific and Industrial Research was set up in 1916, under the same statute as the National Research Council, to provide at the highest plane of government a group of Ministers specifically charged with supervision of the nation's scientific research efforts. Broad duties were assigned to it by the *Research Council Act* and later, to a much more limited extent, by the *Atomic Energy Control Act*. The Committee, consisting of ten Ministers, has specific responsibility for the supervision and co-ordination of government research, and for the foundation of broad policies on government research and development expenditures. In 1947 its duties were amended to provide that it should scrutinize all new proposals of a scientific nature before final authorization by the appropriate authorities. This proved unworkable and the Committee now considers only major developments or new projects involving important changes in policy or expenditure.

The National Research Council

This body, formally entitled "The Honorary Advisory Council for Scientific and Industrial Research", is responsible for "advising the (Privy Council)

Committee on questions of scientific and technological methods affecting the expansion of Canadian industries and the utilization of the natural resources of Canada". When formed, the Council was broadly representative of Canada's scientific community, both governmental and private. Today it has a different character, consisting (in March 1962) of thirteen scientists from universities, four senior officers from its own permanent staff, one ex-president and a representative of each of industry, labour, and a provincial research council. The President of the Council is its chief executive officer, in which capacity he administers the laboratories and establishments of the Council. An executive committee consists of three permanent staff members of the Council and at least three others. The President reports on behalf of the Council to the Privy Council Committee.

Advisory Panel

An Advisory Panel for Scientific Policy was set up in 1949 to advise the Privy Council Committee on the formulation and conduct of government scientific policies. It consists of thirteen deputy ministers or deputy heads from departments and agencies having scientific responsibilities, together with the Clerk of the Privy Council and the Secretary of the Treasury Board. The President of the National Research Council is ex-officio the Chairman. This body, clearly non-scientific in character, should possess a fund of knowledge and experience with regard to the managerial problems of science within the government framework and some appreciation of the economic and financial aspects involved.

PRESENT WEAKNESSES

The foregoing pattern would appear to provide a reasonably workman-like approach, although it is subject to objection on the grounds of the poverty of provision for advice from non-government sources, apart from the universities. In practice, however, the system has failed to function as intended. The Privy Council Committee has met infrequently, and between 1950 and 1958 was not called together at all. The National Research Council has turned aside from its original duty of advising on broad national policy and has concentrated its efforts, albeit with conspicuous success, on the support of research and scholarships in the universities and, in a general way, on its own laboratories and establishments and the fields of science in which they operate. The Advisory Panel met formally fourteen times in its first ten years of existence and has since been convened only infrequently. Proposals for new scientific programmes have usually reached Cabinet on the recommendation of individual Ministers, via the Treasury Board, with support provided in some

cases by interdepartmental committees or recommendations from scientific and industrial groups outside the government. The Treasury Board has itself provided the principal review. In these circumstances, new programmes have depended for their adoption on the persuasive powers of Ministers concerned, on the weight of non-departmental support, and at times on an assessment by the permanent staff of the National Research Council.

In view of this evident breakdown of the system as designed, it is remarkable that science in the government has from some points of view flourished as never before. Budgets more than tripled in a decade; there were large increases in staff and facilities; and many new programmes were initiated. Advances in defence research, Canada's active part in the International Geophysical Year, large and expensive new schemes in aeronautics and oceanography, and the reorganization of agricultural research make it apparent that the failure to build on the basis of a cohesive programme has not inhibited the spending of public money.

It is against such a background of disjointed promotion that the Cabinet is called upon to approve plans for expansion of existing agencies and their programmes, or the creation of new ones. Too often, in the existing organizational vacuum, the decision for or against is made in fact by the Treasury Board, largely on the advice of its own staff. These officials, although possessing widely recognized ability, make no claim to scientific competence or foresight.

The missing element of expert appraisal has been compensated for in part by the presence of strong leadership in the National Research Council, the informal participation in policy-making of a succession of able presidents, and frequent consultation amongst scientists on a number of committees. While their contributions have had undoubted value, as part of the operating research group with a direct stake in one segment of it, they have not been wholly disinterested in the elaboration of government scientific policy.

THE REQUIRED STRUCTURE

The principal reasons for the failure of the existing organization to function as intended are, in the view of your Commissioners, three-fold.

a. The lack of a single Minister having responsibility for guiding Cabinet in the making of policy. A Committee of ten Ministers creates diffusion of responsibility and is hard to assemble, while its members are so concerned with their own departmental responsibilities that the devotion of time and study to scientific proposals must seem to many a formidable distraction. In essence, the Cabinet has lacked a "spark plug".

b. The lack of a secretariat. To permit adequate consideration of major problems of scientific policy at Cabinet level, a considerable amount of preparation and assembly of information is needed. Even a committee composed of scientists, faced with the choices involved in high scientific policy, would have to be provided with large volumes of background and statistical information dealing with matters not only of scientific but of economic and social significance.

c. The failure to distinguish between high policy as the embodiment of national aspirations in the whole field of science, and operating or administrative policy concerned with the running of a massive governmental apparatus. Both of these require great skills, discriminating surveillance, and advice from non-government sources, but the approaches are quite different and no common procedures will satisfy both needs.

For these reasons your Commissioners believe the correction of the present situation requires placing senior responsibility for scientific policy on a single Cabinet minister, creating a suitable secretariat to serve this minister and the Cabinet, and drawing a sharp organizational line between the functions of policy-making and the day-to-day operation of the government's laboratories and scientific establishments. While the demarcation of these separate fields must be clear and unequivocal, your Commissioners recognize that adequate two-way communication is essential between those concerned with policy and those engaged in the direction of research activities as such.

The Minister Responsible

The importance of the subject is of sufficient gravity to demand that, if a single minister is to carry the senior responsibility, none other than the Prime Minister should be considered. But, in view of the heavy responsibilities of that office, your Commissioners do not consider that such a course is practicable. The suggestion has frequently been made that a Department of Science should be created, following the precedent in the United Kingdom. This does not commend itself to your Commissioners, because scientific activity, like economic activity, pervades such a large segment of the public service that attempts to centralize scientific activity would impair the effectiveness of the many departments of which today it is an important part.

Whoever is chosen to bear this responsibility must have a specialist staff at his disposal. Moreover, the nature and importance of the function dictates the need for a minister who has a diversity of interests and frequent contacts with departments generally; in short, one who would not be a "special pleader" for some departmental activity.

In its report *A Plan for Management* the Commission recommends the establishment of a new portfolio, the President of the Treasury Board. This office, with responsibility for the general quality of administration in the public service, but without any departmental operating responsibility, seems to your Commissioners the best available choice to carry the responsibility for government science. Both tasks are of major importance and each reinforces the importance and influence of the office and its incumbent.

The Supporting Secretariat

In order to render effective senior supervision at the Cabinet level a secretariat, or Central Scientific Bureau, is required at the centre of government, operating under the direction of the President of the Treasury Board. It should be headed by a competent scientist of broad experience or by a proven administrator literate in science, who should have the status of a deputy minister and be known as the Scientific Secretary. A small but expert staff will be needed, possessing scientific, economic, financial, and statistical skills. Periodic rotation of key personnel with operating branches of government science will have evident advantage in preventing any tendency of the Bureau to become ingrown or static in its approach.

The duties of the Central Scientific Bureau will include the assembly of data and conduct of investigations and studies required in the field of scientific policy. In addition, a general and continuing scrutiny of all government scientific programmes should be maintained, and comprehensive information as to all facets of research and development conducted in Canada and elsewhere should be constantly available. The Central Scientific Bureau, with the aid of External Affairs and the National Research Council, should be responsible for the arrangements necessary to further the international relations of Canadian science. The Bureau should, however, direct no programmes of its own and have neither operating responsibility for nor authority over the conduct of government scientific establishments.

The Advisory Function

In order to mobilize the independent views and advice of knowledgeable groups both within and outside the government, a National Scientific Advisory Council should be established with membership drawn from the several scientific disciplines (in universities, government and outside research organizations), industry (management and labour), the Armed Services and the community at large. Care is needed to secure breadth of representation and freedom from domination by any group, which are essential in a body charged with advising on high policy. The Council will properly include in its mem-

bership prominent scientists in the government's employ and, to avoid embarrassment to them and possible conflict of interest, provision should be made that the Council and its committees should always be presided over, and committees at least fifty per cent manned, by members drawn from outside government service. The Council should be served by the Central Scientific Bureau, and the Scientific Secretary should be the secretary of the Council.

The Council should be called upon each year to review all government scientific programmes. All changes in emphasis or scope should be scrutinized and proposed expenditures as reflected in the Estimates should be considered by the Council before submission to the Treasury Board for approval. A report containing the Council's views and recommendations should be submitted to the President of the Treasury Board following each review. In addition, special meetings of the Council may be required from time to time to consider specific problems or proposals in respect of which policy decisions are urgently required.

We therefore recommend that:

1 The proposed President of the Treasury Board be designated as the Minister responsible for the scientific policy of the country and the co-ordination of existing activities in the field of research and development.

2 A Central Scientific Bureau be established to act as a science secretariat to the Cabinet under an officer to be known as the Scientific Secretary, reporting to the proposed President of the Treasury Board.

3 A National Scientific Advisory Council be established, with membership drawn from the scientific disciplines, the universities, industry and the community at large, to review and submit independent advice with respect to national scientific policy.

4 The Scientific Secretary act as secretary and the Central Scientific Bureau serve as a secretariat for the National Scientific Advisory Council.

5

THE FUTURE CONDUCT OF RESEARCH ACTIVITIES

A brief description of present research and development activities of each government department and agency has already been given. Part 2 of this report contains a more detailed commentary on existing establishments and recommends certain changes in organization and procedures. Several important considerations emerge, having general application to the organization and management of government research programmes. These, functionally separate and distinct from the policy and decision-making process referred to in the preceding chapter, are discussed hereunder.

ORGANIZATION OF RESEARCH

A notable feature of the growth in government scientific activity is that important research laboratories have evolved from two totally dissimilar origins, namely the departments of government and the National Research Council. There is today little difference in the type of activity in these laboratories but certain organizational inconsistencies persist. Varying degrees of autonomy and an uneven recognition of the need for scientific leadership are causes of dissatisfaction to many government scientists.

In terms of the purpose and objectives of individual programmes and the research areas in which they are carried out, three broad classes are discernible.

- Research in support of, or carried on in association with, the administrative or operational activities of departments; examples are mining, agriculture, forestry and fisheries.
- Research for which the government acknowledges a special interest or responsibility, although unconnected with direct operations; oceanography and astronomy are examples.
- Research unrelated to any specific practical objective but directed towards increasing general scientific knowledge, which may be described as pure basic research.

In order to create an orderly structure in which the various categories of research activity can be accommodated without overlapping or duplication, your Commissioners believe that certain principles should be applied in organizing the conduct of government research. A major consideration is that superficiality be avoided, hence no research activity should be undertaken unless a programme can be developed of sufficient dimensions to permit efficient operation on a continuing basis.

Research falling into the first category above should be gathered together into a research branch or unit attached to the department or agency concerned with the particular area, or at least into the smallest possible number of branches or units, if the area is diverse. These departmental units should be managed by competent administrators with good scientific qualifications and research experience.

Research in the second category, unrelated to any department, should be assembled in a group of national research establishments, each concerned with a particular area of research. Such establishments should operate under a central executive organization, but each should possess a considerable degree of autonomy in the scientific aspects of its operation. Specific proposals for organizational changes to bring this about are made in Part 2 of this report.

Pure basic research, carried out solely in the search for new knowledge, is usually separated according to discipline. In spite of an outstanding contradiction represented by the "pure" laboratories of the National Research Council, it is generally conceded that pure basic research is best done in the universities. Not only is the scholarly atmosphere and academic freedom conducive to scientific investigation, but the conduct of research within educational institutions has an important effect on the training of future scientists. These circumstances lead your Commissioners to the view that in the field of pure basic research government activity should not be increased, and the enlargement of existing, or the creation of new, laboratories of this type should be avoided.

MANAGEMENT OF THE RESEARCH ESTABLISHMENT

It is generally recognized that the scientific activities commonly described as research and development encompass in any single area of investigation a range of successive types of study. Fundamental or basic research, seeking mainly to expand the frontiers of knowledge, is succeeded by applied research which has as its object the achievement of a particular goal, such as a new process, technique, material or piece of equipment. Development is concerned with bringing forward to the production stage the fruits of applied research; it may involve actual construction of prototypes and be concerned with the perfection of production methods. Thus, the imposing array of new and useful products resulting from scientific advance owe their existence to a sequence of pure or basic research, followed by applied research and, finally, development in industrial plants.

Fundamental research undertaken within an establishment working towards a specific goal, or as part of a programme within a particular scientific area such as agriculture, which may be termed objective basic research, benefits from a feed-back of problems encountered in application and development. Conversely, the latter are extensively dependent on basic research to explain phenomena and to stimulate and suggest new approaches to practical problems. It follows that within a national research establishment the activities may cover the entire spectrum of investigation. In some cases the whole process will be a continuous one where the lines of demarcation between the various types of activity may be difficult to define.

The foregoing considerations applied to either departmental research units or national research establishments, each operating within a specific area of investigation, would render it appropriate in some cases that the research activities should cover the whole spectrum. Thus, it should be permissible for such organizations, when the need exists, to conduct either objective basic research at the one end or actual development to the point of commercial acceptance at the other. Such flexibility is needed if maximum effectiveness is to be achieved.

External contacts of research establishments have a special importance. First, the grouping of activities according to specific areas will facilitate the maintenance of close relations with the industries concerned. General contact and technical liaison should be provided for, in addition to co-operation with respect to programmes designed to assist industry. Secondly, the use of advisory committees to review activities and programmes in each area of research should be part of general policy. Expert independent judgment exercised periodically should serve as a beneficial stimulus as well as a safety

device, and has special relevance where funds are allocated for extra-mural research.

The direction of the scientific investigator and the degree of supervision to be provided present certain difficulties wherever research is conducted on a large scale. In basic research, where a particular subject is chosen for study by the individual scientist in response to his personal interests and curiosity, close supervision is impracticable. Someone must be responsible for seeing that the scientist continues to put forward his best efforts and that a tradition of keen and imaginative application to the task is maintained in each laboratory. But it is virtually impossible, in this field, to parcel out specific work assignments.

In the field of applied research and development, there is not the same case for granting the individual scientist freedom from supervision. In fact, there is abundant evidence that the existing tendency to preserve maximum freedom throughout the whole investigative spectrum has resulted in an inadequate level of supervision, planning and direction, sometimes with costly result. Programmes are in places diverse and thinly spread; others in their goals tend to be "off the target" in terms of the national interest; and, generally, motivation and purpose need to be strengthened by more specific direction and closer supervision. For fear of inhibiting the creativity of the scientists, specific projects in the applied field have been allowed to continue for years after they should have been terminated on practical grounds.

While there is evident need for autonomy in research activity, this cannot justify complete freedom of the staff from supervision and control by senior management. Senior scientific administrators should be given broad responsibility for the selection and direction of their research programmes, but departmental scientific programmes must harmonize with the general aims and purposes of departmental policy. Future planning should, equally, recognize this need.

Like other departmental and agency programmes, research and development programmes will be subject to annual assessment and review by the Treasury Board, assisted by the technical knowledge and experience of the proposed Central Scientific Bureau. To facilitate this assessment, and to provide necessary statistical data, the individual research establishments should accumulate their costs by meaningful sub-divisions of activity, according to the principal components of their programmes. Thus, expenditures for agricultural research should be broken down to show separately the costs of research into animals, soils, crops and other main divisions. In order to provide information required for purposes of policy-making, data similar to

those gathered by your Commissioners should be regularly provided by all research establishments and correlated on an over-all basis by the Central Scientific Bureau.

It has been pointed out that, while there is little distinction between the types of activity in various government laboratories, there is considerable dissimilarity in the administrative and environmental conditions under which research is conducted. The general view of scientists is that the National Research Council's laboratories provide a model environment in terms of facilities, employment and personnel practices, as well as in the degree of financial autonomy enjoyed. Any move towards uniformity throughout the public service should avoid diluting these standards and, rather, seek to establish equally favourable conditions wherever research is carried out. The importance of this subject is such as to prompt your Commissioners to observe that unless the recommendations contained in their report on *Personnel Management* are adopted, so as to grant all departments and agencies suitable authority over their manpower, no change should occur in the existing authority of the National Research Council over recruitment and promotion of scientific personnel.

Although present activity is widely scattered and is remarkably diverse in both its aims and its facilities, some technical needs are common to all units. Scientific information, such as reference services, bibliographies, abstracts and translations; the publication of research results; data processing and the compilation of statistics are illustrations of services generally required which might best be provided for all by a single agency. The development of such common service activity, to be conducted by the most suitable existing agency, should be an early concern of the President of the Treasury Board.

UNIVERSITIES AND OTHER RESEARCH BODIES

Financial support by the government has been a substantial influence in the development of research in Canadian universities. Grants-in-aid, scholarships and fellowships are provided by the National Research Council (to the largest individual amount), the Defence Research Board, the Department of National Health and Welfare, the Atomic Energy Control Board, the Fisheries Research Board, the Geological Survey of Canada, and others. Research contracts, on a relatively small scale, are placed with the universities by Atomic Energy of Canada Limited, the National Museum and the Department of Agriculture. Your Commissioners believe that more can be done, particularly in the exchange of scientists, and that the constantly expanding scope of scientific investigation affords opportunities for wider sharing of research

effort and contracting-out to universities on a substantially greater scale than at present. Some parts of the scientific apparatus of government exist in virtual isolation, not only from other government laboratories but from adjacent universities and other scientific establishments.

This lack of contact may well lead to loss of enthusiasm and a static type of research effort. A frequent manifestation is the use of an increasing proportion of the available funds for intramural activity, at the expense of outside agencies supported through grants, scholarships or contracts. To check these tendencies there should be a general policy requirement that a part of the funds of each agency should be devoted to the support of extramural programmes, and a minimum percentage should be established. Further, particularly in the case of the laboratories and establishments more remote from Ottawa, every effort should be made to create the closest possible links with universities nearby. The existence of a government laboratory staffed with professional scientists on the campus of a provincial university, living to itself with no participation in the academic life of the university, represents a form of waste which should not be tolerated.

In the future planning of research, account must also be taken of other research activities in Canada, in particular the expanding research programmes of provincially-financed bodies. The federal government's responsibility for the country's scientific effort is such that, in planning for the most effective performance in this important field, it cannot, on jurisdictional or other grounds, afford to ignore any substantial activity carried on by others. In this context, the periodic review of programmes by independent advisory groups must have regard to all federal programmes, whether they be conducted in the government's own establishments or contracted out to universities or other bodies, as well as scientific programmes financed from other sources.

RELATIONS WITH INDUSTRY

One of the original purposes of government in devoting money to research was to encourage and stimulate Canadian industry. From being a primary goal this has, over the years, been relegated to being little more than a minor distraction —a desirable but rather difficult task and certainly of less pressing urgency than other items on the programme. So in the year 1961-62 we find a total of just over $21 million, equivalent to nine and one-half per cent of the total government scientific expenditures, applied to finance research in industry. Of this meagre share, a large part represents business recently secured for industry by the Department of Defence Production under the production-sharing scheme entered into with the United States; and, of the balance, less than

$400,000 originates with other than the defence agencies and Atomic Energy of Canada Limited.

What are the reasons for this minimal support of industry by government departments and agencies? How sharp is the contrast between Canadian experience and developments in the United Kingdom and the United States?

Some people point to the fact that there are enterprises of magnitude which are not Canadian-owned. Because large industrial enterprises tend to concentrate their research activity in one place, at home, subsidiary plants in Canada are often deprived of opportunity to carry out research in this country and depend on the research efforts of their parent organizations, particularly in the United States. Thus, doubt is cast upon the research capability of Canadian industry. This point of view can certainly be substantiated in some cases, but in the matter of degree there has been a tendency seriously to under-estimate the research potential of the country's industry.

A factor, already referred to, tending substantially to limit the placing of development contracts with industry, is the general lack of confidence displayed by the Armed Forces in Canadian science as a whole, coupled with a possibly inordinate regard for science abroad.

More important, however, than either of the foregoing reasons is the nature of the evolution of the government's own programmes and the attitudes and motivation of its senior scientific personnel. All the factors influencing the "make or buy" decision in government have been present, accentuated by the fact that much of the expansion has represented exploration of new scientific territory in which no outside organization was already established. In the policy vacuum which has existed through most of the period of greatest expansion, industry has had no effective spokesman, and those most responsible for influencing decisions have been persons possessing neither industrial experience nor close knowledge of the operational problems of industrial research.

The National Research Council, originally established to promote research in industry and in universities, has not been successful in its role as a promoter of industrial research. While industry has benefitted considerably from the scientific accomplishments of the National Research Council laboratories, particularly in several special areas, such practical steps as have been taken to encourage the conduct of research by industry itself have been ineffective. For this the rather academic orientation of the National Research Council and its preoccupation with basic research may be in part responsible.

Several new schemes have recently been put forward for assistance to industry in research and development. Your Commissioners entertain serious doubts as to their adequacy in character or scope. Based on the sharing by the

government of the cost of industrial research, they show few signs of any recognition of the hard facts of industrial operation today. A submission received by the Commissioners in June, 1962, from Air Industries Association of Canada, expresses views currently held by much of Canadian industry with regard to development contracts. Your Commissioners find themselves in agreement with the principles set forth:

The Industry considers that one problem in establishing an effective level of government research and development support is the lack of a senior planning policy making group in the government, responsible for establishing national research and development objectives and plans. There are many government agencies familiar with the problem but these agencies lack individual authority for making policy decisions or the responsibility for long range planning and co-ordination of the efforts of all interested government agencies, industry, Armed Services and government laboratories. An analysis of successful past efforts in gaining access to export markets shows that a product must be selected which is advanced but within the present capabilities of the industry. Financial support in the form of research and development funding is then necessary to achieve a competitive product.

What is required to achieve a competitive and healthy aircraft industry in Canada is the creation of an atmosphere favourable to research by the industry. This can only be achieved by a large increase in government support to research and development in the industry with favourable terms and a greatly increased co-ordination between industrial and government research and development planning. The recently announced DRB Applied Research Fund and the NRC Industrial Research Fund is a start but the level of funding is too low to be effective when compared with that of other countries and the required level of industry participation has been firmly set at the unrealistic level of 50%. The industry finds itself in competition with countries which support large development programmes in their aircraft industries and do so at levels up to 100%. At a time when the general level of activity in the industry is diminishing, the government could most effectively provide a stimulus by establishing an effective research planning group in control of a much larger research and development fund. If the increased funds were then released under terms which encouraged a higher level of industrial research the eventual result would be a stronger Canadian Aircraft Industry and one that is capable of realizing a greater share of the world aircraft market.

SENIOR RESPONSIBILITY FOR OPERATIONS

Organizational changes recommended in Part 2 of this report are directed, wherever possible, towards attaching research establishments to the operating department or agency most closely related to the research undertaken. The work of some laboratories and research establishments, however, bears no close relation to any existing department or agency; the largest of these is Atomic Energy of Canada Limited. Although each should have reasonable autonomy with regard to programmes, it would be logical to assign a measure of central administrative authority over these independent agencies to the National Research Council, whose President should have the rank and status of a deputy minister.

The selection of the minister or ministers who are to bear responsibility for the operations of the National Research Council and Atomic Energy of Canada Limited is a matter for governmental decision. Your Commissioners,

however, venture to draw attention to the substantial interest of the Department of Trade and Commerce in scientific development. In view of the relationship of research to domestic economic and industrial activity and to export trade possibilities, there is much to be said for involving the Minister of Trade and Commerce in responsibility for some substantial segment of government scientific operations.

CONCLUSION

In the foregoing discussion, and in the recommendations in Part 2, the central theme is the divorce of the operating organization from the formulation of government policy. The new structure recommended for the latter is not elaborate and is designed to fill the existing vacuum by providing all the pertinent data, backed by the advice and recommendations of independent advisers, as a basis for decisions by the Prime Minister and his Cabinet. Primary responsibility for government scientific policy is placed on a single senior minister, and provision is made for a scientific secretariat without which neither he nor any combination of ministers can effectively discharge this responsibility.

The improvements recommended in the operating organization are mainly changes in emphasis and grouping, together with clarification and simplification of administrative procedures. No major changes in physical plant or facilities are required.

In the matter of co-ordinating activities the creation of the recommended Central Scientific Bureau will fill a present gap. Without authority over any part of the conduct of research, the Bureau will maintain a scrutiny of continuing scientific activities throughout the public service, and will thus be able to render technical aid and informed advice to the Treasury Board in its annual assessment of all scientific programmes of departments and agencies. As a result, for the first time in many years, the scientific activities of the government will be susceptible to review as a whole.

PART 2

1

INTRODUCTION

1 The first part of this report was confined to giving an outline picture of federal research activities, and to discussing research problems and needs in general terms.

2 This part describes in greater detail the research programmes of various departments and agencies, and makes specific suggestions and recommendations based on the findings of the Commission.

3 It should be noted that the size or importance of any department or agency is in no way reflected by the scope or extent of its treatment in this part of the report. Indeed, several agencies are omitted altogether from discussion: Atomic Energy of Canada Limited and Polymer Corporation, for example, were found by your Commissioners to be well organized and efficient in the performance of their research roles, and for that very reason find no place in this survey.

4 The final sections are devoted to an examination of problems involving all research activities. They include a discussion of the relationship of government research to industry, and of the state of international research liaison.

2

RESEARCH IN GOVERNMENT DEPARTMENTS

AGRICULTURE

1 The Department of Agriculture conducts research in the areas of crops, animals, soils and engineering. The Department's research work also extends to systematics—chiefly insect and plant taxonomy—and includes some entomological projects directed towards insects affecting man. In general, the programme emphasizes the application of science to the problems of agriculture and achieves a satisfactory combination of the agricultural and the scientific points of view. As a result the quality of research is, on the whole, excellent. A great number of scientific papers of high quality is published, and there have been large and very valuable direct benefits to the Canadian economy. These include rust-resistant wheat, the Lacombe hog with a high feed-meat conversion ratio, soy bean varieties suitable for Canadian conditions, and measures for the control of insects and disease.

2 The Department has a professional research staff of high quality, whose academic qualifications have markedly increased in the last ten years. These scientists have been attracted partly by the independent status of the agricultural research officer, who is free, within reasonable limits, to plan and initiate his own projects, and partly by the strongly scientific orientation of the work. The research ranges over basic, applied, testing, and developmental phases. By far the greatest effort is devoted to the applied phase, although some scientists are allowed —or obliged—to continue their efforts on into the development stage.

3 The physical facilities are on the whole good, and the research is not generally hampered by lack of equipment.

4 The present Research Branch of the Department was created in 1959, with the object of co-ordinating the Department's scattered research groups. The reorganization constituted a major step forward; while centralizing administrative and common services, it retained and even extended the freedom of the research units to plan and execute their own research projects. Thus the first stages of implementation were logical steps towards a system of regional research laboratories,

each with a high degree of autonomy. However, once the preliminary reorganization had taken place, the Department appears to have accepted the initial reforms as final. Your Commissioners view this as a failure to obtain the full benefits inherent in the new organization. The present situation may be criticized on several important grounds.

5 First, not all research activities associated with the Department were included in the new Research Branch—for example, the Grain Research Laboratory of the Board of Grain Commissioners. The Animal Diseases Research Institute at Hull, Quebec, with branch laboratories at seven other locations across Canada, is in the Production Branch, although its activities are strongly oriented towards research.

6 Second, the reorganization did not include any major changes in the physical structure of the research programme. There are exceptions to this. Former "divisions" at Ottawa, with their research activities and personnel, were regrouped as "Institutes", and former Experimental Farm and Science Service units located in the same geographic area were united under a single director. However, this regrouping and consolidation still leaves nine research institutes, and forty-five research stations, laboratories and experimental farms reporting directly to the Director-General of Research. It is this cumbersome arrangement which has necessitated the employment of a Programme Directorate. This committee, comprising four directors (Animals, Crops, Soils, Entomology and Plant Pathology) and fourteen associate directors, has the task of advising the Director-General on the research programme. Clearly, an arrangement by which fifty-four units report to a single office, which is in turn advised by a committee of eighteen Branch scientists, cannot be a satisfactory permanent organization.

7 Third, many small units are still carrying on research in several different areas, classes and subjects. Lack of sufficient scientific staff in the various disciplines, inadequate research equipment, limited library facilities and insufficient professional contacts make it virtually impossible for such units to develop research programmes of acceptable quality. Productivity, measured either by scientific publications or by agricultural innovations, is much greater in research establishments of reasonable size. The remedy is to take the next major step in reorganization by consolidating small units into regional laboratories where a proper research environment can be created.

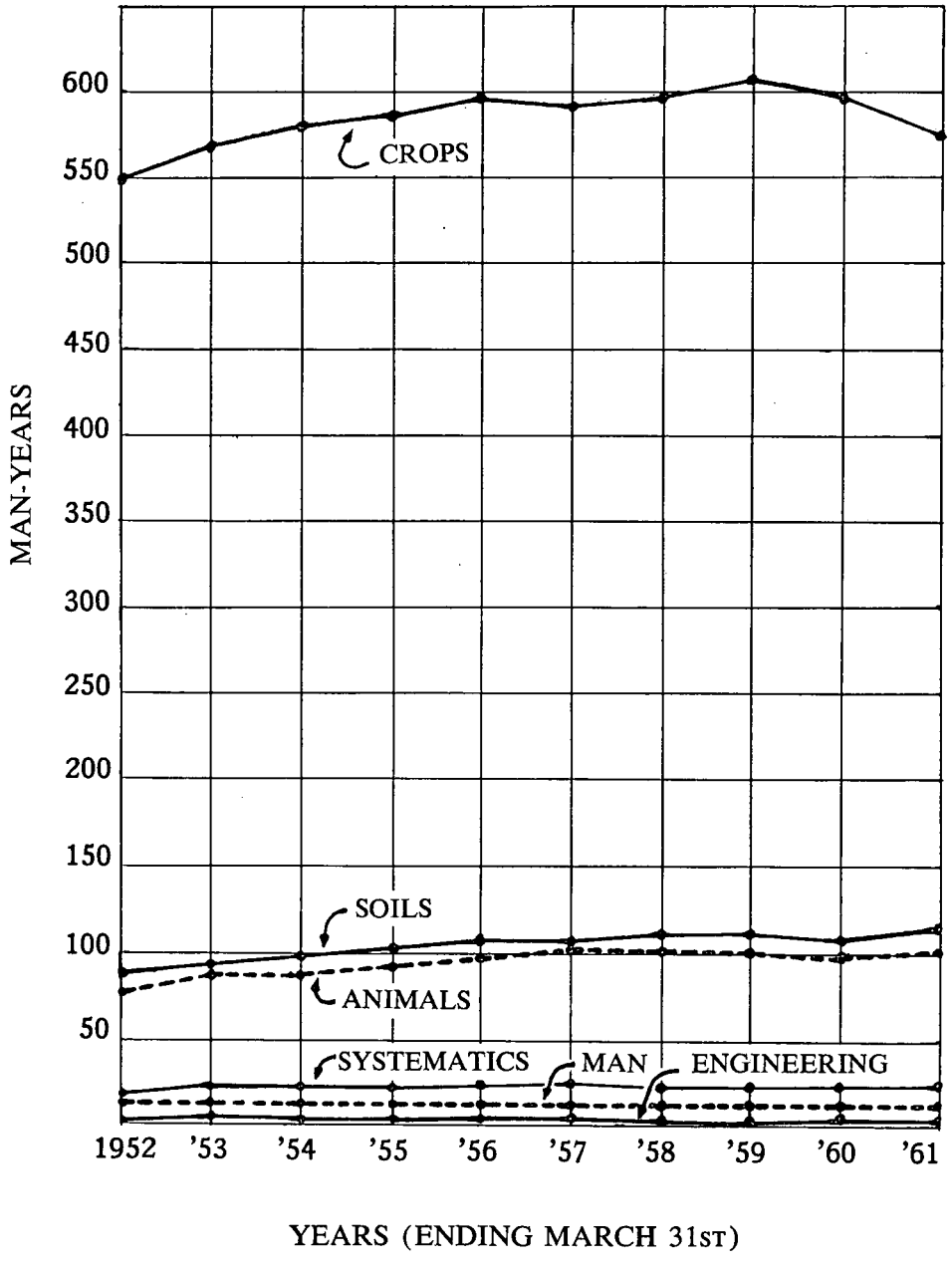
8 Agricultural research is undertaken in response to the needs of an industry and to aid it in efficiently producing marketable goods. Thus, while research projects should be initiated in the laboratory by the professional scientist, who is enthusiastic and close to the problem, the research programme as a whole must take account of the importance of the work in relation to agriculture and to economic factors such as market potential and resource scarcity. Chart 1 shows the present distribution of the number of man-years devoted to areas of research between 1950-51 and 1960-61, inclusive. It will be seen that very great differences exist in the amount of professional effort put into the major research areas.

9 To be effective and economical, Canadian agricultural research requires a well co-ordinated nation-wide organization. It must take into account complex environmental and economic factors extending over a wide geographical area. The paramount aim must be to improve the agricultural industry.

10 *We therefore recommend that:*

1 All research supported by the Department of Agriculture be administered by the Research Branch.

Chart 1—RESEARCH BRANCH—DEPARTMENT OF AGRICULTURE—AREAS OF RESEARCH IN MAN-YEARS



2 Regional laboratories be formed by consolidating present research units; they should be few in number and located in academic and research environments, and should supervise sub-stations and other units designed for applied research and development.

3 A development section be set up to ensure that research results of economic significance are carried to the point of commercial acceptance.

FISHERIES

11 Federal scientific research and development in fisheries is conducted by the Fisheries Research Board, and also by two units of the Department of Fisheries—the Fish Culture Development Branch of the Conservation and Development Service, and the Industrial Development Service.

12 Of these groups the Fisheries Research Board is the largest. It conducts both basic and applied research, with emphasis on the latter, and by means of a broadly based membership gives to fisheries research both scientific and industrial orientation.

13 The Board's research responsibility falls into three broad categories: fishery biology, fishery technology, and oceanography. At its biological stations studies are made of the life histories and population dynamics of the principal food fishes. These studies include fish cultural methods, exploration for unexploited stocks, new fishing methods, marine mammals and marine flora, and the over or under-exploitation of fish stocks. Recommendations based on these studies are made to the Department of Fisheries. The technological stations conduct research into methods of preserving and processing fish, and develop new products and by-products from fishery resources. Oceanography undertaken by the Fisheries Research Board includes study of biological, chemical and physical aspects of the marine and fresh water environments of fish and other important aquatic organisms. The Board also serves as the research agency for work arising from Canada's membership in six international fisheries commissions.

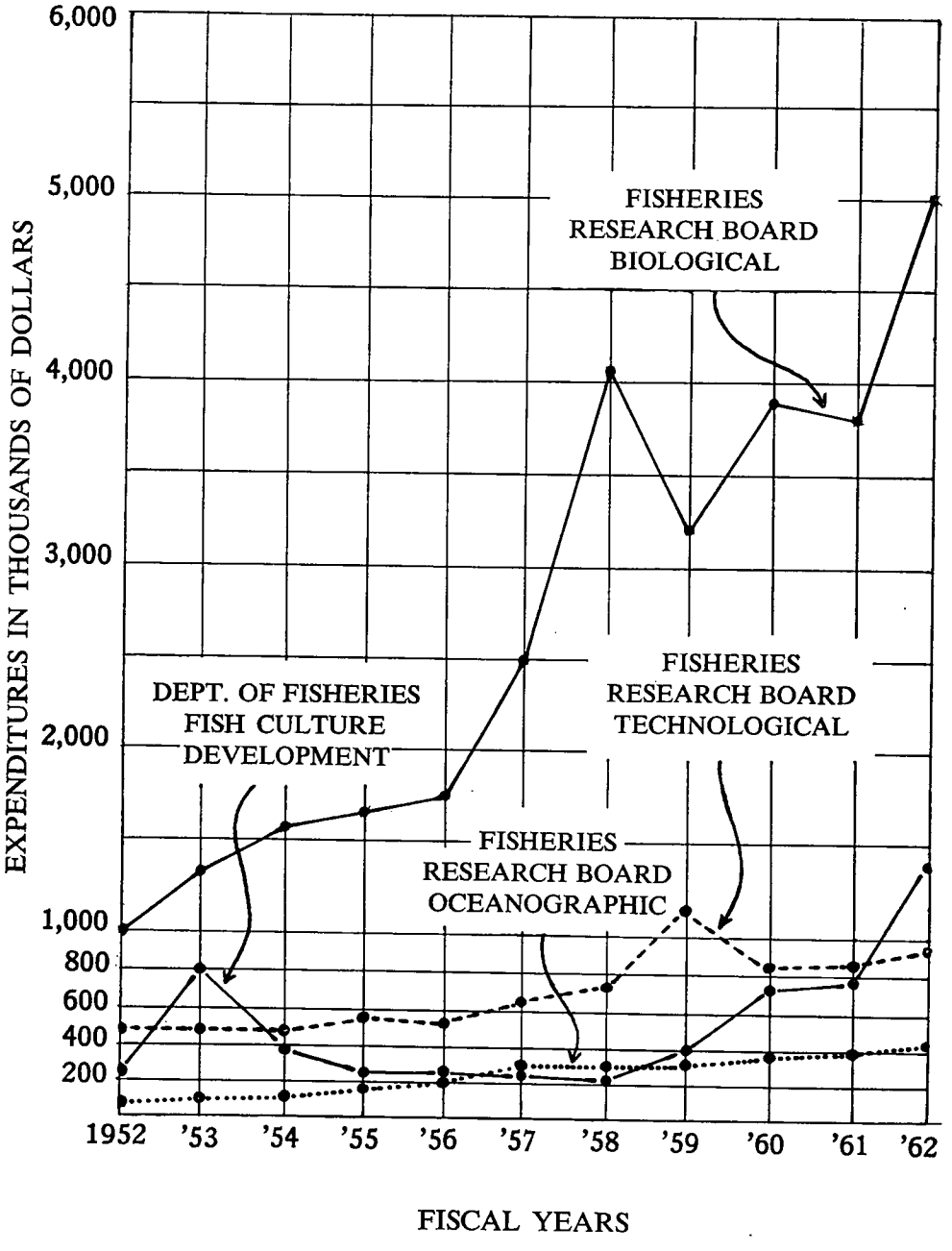
14 The Fish Culture Development Branch of the Department of Fisheries applies modern scientific findings to the problem of maintaining fish populations. The Branch does not undertake long-term research, which is the responsibility of the Fisheries Research Board.

15 The Industrial Development Service has as its primary objective the modernization of the Canadian fishing industry through the application of improved technology in all phases of operations, from the primary catching or harvesting function through the processing, transportation, storage and distributive phases, and the administration of related financial aspects. The Service encourages the fishing industry, provincial fisheries authorities and others to suggest and recommend areas of study and investigation, and to participate as far as is practicable in the developmental projects undertaken. The Service keeps in close touch with the results of fisheries technological developments both at home and abroad.

16 While the scientists in fisheries research have considerable freedom to initiate and conduct research programmes, there is some inconsistency in the allocation of budget funds (Chart 2) and sometimes a tendency to over-emphasize *ad hoc* problems of urgent practical nature at the expense of the long-term research programmes.

17 The wide geographic dispersal of research activities has brought about various organizational problems. Research projects developed in widely separated units of the Department of Fisheries are administered by

Chart 2—DEPARTMENT OF FISHERIES—FISHERIES RESEARCH BOARD



its regional offices. This makes co-ordination of the research programme difficult. Biological and technological units of the Fisheries Research Board are generally not located in the same geographic areas, and, when they are, there is little association or co-ordination of work.

18 Between the chief research groups there appears to be a similar lack of co-ordination in research planning, with little contact and discussion even at senior levels of administration. In many instances the stimulation and advanced knowledge resulting from basic and applied research are not closely co-ordinated by the Department with development and planning for the industry. The Fisheries Research Board is not in close touch with the departmental programme, a distinct disadvantage when planning its own research. There is also a danger that Board members, who serve without remuneration on a part-time basis, may be preoccupied with their private responsibilities and unable to give the research programme of the Board the necessary attention.

19 Some changes are required to develop a co-ordinated and effective research programme to improve the fishing industry, to add to scientific knowledge, and to be in harmony with a national research policy.

20 *We therefore recommend that:*

1 The areas of research now assigned to branches of the Department of Fisheries and to the Fisheries Research Board be brought under a single Research Branch of the Department.

2 The Fisheries Research Board, renamed the Fisheries Research Advisory Board, assume an advisory role and maintain a continuing scrutiny of all programmes of fishery research.

FORESTRY

21 Forestry research is conducted in three branches of the Department of Forestry: the Forest Research Branch, the Forest Entomology and Pathology Branch, and the Forest Products Research Branch.

22 The Forest Research Branch, with seven district offices and one experimental station, undertakes research into techniques of forest survey (mensuration, statistics, classification), forest management (tree farming, tree breeding), and forest protection (fire fighting). The Forest Entomology and Pathology Branch, with nine regional laboratories and one research institute, does research into techniques for controlling insects, disease and timber decay, and performs nation-wide forest insect and disease surveys. The Forest Products Research Branch is concerned with timber mechanics and engineering, plywood, wood preservatives, wood chemistry and physics, paints and other coatings, and the design of wooden containers.

23 The Department of Forestry has been operational only since 1960, when it was formed by transfer of units from other departments. For this reason no valid judgment can be made on the effectiveness of the new research organization, and your Commissioners restrict themselves to the following observations:

- The establishment of a Department of Forestry fragmented even more the biological research that could be shared in the work on renewable natural resources such as forestry, fisheries and agriculture.
- Research activities within the Department are conducted by three separate branches, each reporting independently to the Deputy Minister. There is little co-ordination of research effort among the three.
- The Forest Entomology and Pathology Branch has a healthy and stimulating

research atmosphere which is absent in the other two branches. A large part of the experimental programme of the latter has been of an *ad hoc* type; when more basic research has been attempted in these branches, a shortage of qualified scientists has reduced effectiveness.

- There is undersirable fragmentation within the Forest Entomology and Pathology Branch. Heads of sections report individually to the Director of the Branch, even when they are located near each other. The entomology and pathology sections are often located in different cities, or in different parts of the same city. Many laboratories are not located at research or academic institutions, with the consequence that scientific staffs are isolated. The separation of Forest Entomology and Pathology from the Research Branch of the Department of Agriculture (of which it was a part until 1960) undoubtedly removed it from access to many of the basic disciplines. If these are not developed within the Branch, the quality of its research may be seriously affected.

MINES AND TECHNICAL SURVEYS

24 The Department originally consisted largely of agencies that had regulatory responsibilities (for explosives, legal surveys, official time service, et cetera) and performed technical services, such as testing of ores and metals, and the preparation of topographical and geological maps and hydrographic charts based on official surveys. Its character has changed rapidly in the last two decades, and it is now one of the main research arms of the government.

25 There are five branches in the Department: Geographical, Geological Survey, Mines, Dominion Observatories, and Surveys and Mapping. The Dominion Observatories Branch is reviewed in another section of this report.

Geographical Branch

26 The immediate research programme of the Branch includes physical and socio-economic geography. Physical geography is divided into regional analysis and quantitative analysis. In northern Canada, this involves terrain analysis (physiography) and glaciology, and some of the work is carried out in collaboration with the Polar Continental Shelf Project. Socio-economic geography consists of regional analysis, land use, and urban studies. The pioneering work of the Branch on land-use is beginning to bear fruit in the programmes developed by the Department of Agriculture under the *Agricultural Rehabilitation and Development Act.* While the urban studies ceased in 1961, the basic studies of urban morphology are of continuing value to other interested bodies.

27 The Branch was largely responsible for the publication of a new Atlas of Canada and this, involving much original research, is a continuing responsibility. The Atlas has won world recognition as the best of its kind, and is the sort of undertaking that fits well into the Branch's formal responsibilities.

28 Research on the origin and distribution of sea ice is an important item both in the Branch's co-operative programme with the Polar Continental Shelf Project and in its normal activities. For more than a decade this work has proved to be of economic importance in the Gulf of St. Lawrence and may eventually be so in the Arctic. This matter is referred to at greater length in Chapter 6.

29 In 1961, the Branch was given responsibility for servicing the Canadian Permanent Committee on Geographical Names. The staff transferred to the Branch for the purpose are not professionally trained, and there is a risk that such accretions will dilute the research flavour of the organization.

30 The Geographical Branch was established in 1947 as the Geographical Bureau, with the aim of reviving federal interest in geographical research. Initiating a new agency in government is never easy; building it up to a size required for efficient operation is even harder. The Branch is still a small organization and has had exceptional difficulty in attracting and retaining personnel of the requisite quality.

31 The Branch suffers from two circumstances peculiar to geography in Canada: first, university departments have been opened at a remarkable rate in the past decade and have attracted most of the best qualified geographers; and second, high schools are now offering attractive positions to geographers with M.A. degree (the minimum qualification acceptable in the Branch) at salaries greatly in excess of those offered by the government. Thus the Branch finds it hard to compete for the small number of good geographers available.

32 The Branch has endeavoured to overcome its difficulty in building up an adequate professional staff by appointing a relatively large proportion of seasonal employees. These numbered fifty in 1961-62, in comparison with a permanent research staff of thirty. Practically all of those seasonally employed are recruited from universities, being either staff members or students. There is merit in this arrangement since it assists the Branch with its seasonal field programmes, particularly in the north, and also enables university personnel to obtain field experience. The Branch could be of further assistance to the universities by expanding its programme of grants-in-aid; the present allocation of $3,000 for this purpose could be substantially increased.

33 This, together with an immediate review of salary scales on a realistic basis, should go far to solving the Branch's manpower difficulties. There are signs that an increasing emphasis laid on geography by industry, planning, universities and high schools will soon begin to increase the number of qualified geographers available. The Branch should take steps to attract them.

34 In summary, the Branch was established with terms of reference calling for the development of a programme of high scientific content requiring original research by professionally qualified personnel. It has suffered certain vicissitudes in the form of staffing difficulties, leadership which has not always been sufficiently objective, and responsibility for certain non-scientific tasks which dilute the professional flavour of the organization. It has, nonetheless, achieved a considerable degree of success in certain of its activities. In view of the increasing importance of its work as part of the whole scientific programme of the government, every effort should be made to overcome existing deficiencies.

Geological Survey

35 The Geological Survey of Canada has long been the most active in field mapping. Emphasis continues to be laid on reconnaissance mapping, which is an essential first step in understanding the geological configuration of the country. In addition, field parties are employed in geophysical, geochemical and water supply studies, and in palaeontology, mineralogy and stratigraphy. The effort put into laboratory work has recently increased, while there has been a gradual reduction in scientific manpower devoted to field mapping.

36 One division of the Branch is organized on a regional basis and includes specialists on various areas of the country. The other four divisions are topical: that is to say, they are arranged not by areas but by the subject matter of the research undertaken. These are Fuels and Stratigraphy, Economic Geology, Petrological Sciences, and Geo-

physics. It is from these divisions that the initiative comes in formulating research programmes.

37 A systematic record is kept of all research projects, the date of their completion, and the resultant publications. One consequence is that all research projects are subject to continuous review and the activities of all staff members are known to all others.

38 At one time the Geological Survey was completely autonomous. There are signs that the proper desire to maintain an efficient and progressive organization may lead the Branch to becoming too self-contained. Some overlapping may be expected, which is not harmful unless it leads to competition for scarce personnel or to duplication of expensive facilities. There is a danger of this becoming significant in the Geological Survey Branch, which now maintains an independent library, separate map drafting facilities and increasingly elaborate chemical laboratories.

39 The Survey is an efficient organization, well staffed, with high scientific standards and an excellent national and international reputation. It has expanded rapidly and will no doubt continue to do so, particularly in areas related to geological field work. This is proper, but care must be taken not to duplicate or overlap the work of other existing government facilities.

40 Field work in remote areas of Canada can often be carried out most economically by pooling the resources of several agencies. There is a tendency for the Geological Survey to be unco-operative in such proposals, and to carry through its own plans by use of its own logistics and its own staff. It is in the common interest that the Survey Branch participate actively in co-operative field enterprises.

Mines Branch

41 The main purposes of the Mines Branch are to develop new and improved methods of processing ores, industrial minerals and fuels, and to seek new uses for Canadian minerals and metals. In recent years there has been a growing tendency to concentrate on basic and long-term research, which reflects a general trend throughout the Department.

42 It is not necessary to record in detail the extremely diverse programme of research carried on by the Branch's many laboratories and workshops. As of midsummer, 1961, the number of projects in hand was as follows:

Division	*Number of Projects*
Mineral Services	50
Physical Metallurgy	92
Fuels and Mining Practice	42
Mineral Processing Division	105
Extraction Metallurgy	43
Others	6

43 The Branch enjoys close relations with the mining industry and other industries in the area of its specializations. This is all to the good, but the Branch should not be considered as a source of free services where commercial research agencies are available. Were the Branch relieved of some of this work for industry, the staff would be freed for more fundamental studies of value to the country as a whole.

44 In contrast to the Geological Survey—with which parallels can fairly be drawn—the Mines Branch is not actively developing in the range and scope of its interests. The general pattern of its operations was set many years ago, yet some of its areas of interest are at the forefront of modern industrial innovation.

45 This lack of development may have been caused by undue emphasis given to more or less routine testing and problem-solving, or it may be an inherent difficulty faced else-

where by engineers rather than scientists. Whatever the cause, the work of the Mines Branch is sufficiently important to the national welfare that the effort should be to meet the demands of the modern age.

Surveys and Mapping

46 Most of the duties of this Branch relate to data-gathering and publications. The work forms the basis for field and other research by other branches of the Department and, in many cases, by other departments and independent scientists. However, research and development, in the narrower sense, are also part of the Branch's responsibility.

47 To understand the significance of any research done in surveying and mapping, it should be borne in mind that Canadian universities have for the most part neglected modern aspects of the science. Only one has a small department of surveying, and it is a recent innovation. None offers advanced instruction in cartography.

48 In the Surveys and Mapping Branch research is beginning. New techniques are being developed for processing survey data, and the Department's computer centre is proving useful. The Branch is aware, too, of the need to be in the forefront of developing new methods of survey, and has pioneered the use of new devices such as Shoran, the tellurometer, and the geodimeter, though it did not originate them. Even so, the best survey methods used today are time-consuming and costly; therefore new techniques are needed in the drafting, compilation and reproduction of maps. For research into these areas considerable expenditure is necessary. Yet no large sums are devoted to it, and there are no Canadian government research agreements, either with the universities or industry, to foster study of the problems concerned.

49 The pressure of demand is forcing changes but they are coming too slowly. A programme of research and development within the Branch is called for, and a research unit should be attached to the Director's office. This will entail the employment of professional staff with advanced degrees, which should influence the development of higher academic qualifications throughout the Branch. Research in the universities should be supported. A summer student programme should be established to encourage new members to enter the profession and the Branch. More help should be sought from private industry. There is in Canada a useful surveying industry which, partly owing to contract awards by the government, enjoys world-wide repute, particularly in photo-mapping. The industry is not at present in a position to give leadership in development through research, but could do so with contractual aid from the government. Canada has an opening for a small map-making and printing industry, but this too would need to be founded on research which the industry cannot at present provide.

General Conclusions

50 In spite of its growing preoccupation with research, the Department of Mines and Technical Surveys retains more than a trace of its non-scientific origins. This is noticeable in the Surveys and Mapping Branch, in some units of the Mines Branch, and particularly in the central services such as departmental administration, personnel, and the Editorial and Information Division. However, the whole Department now appears to realize that research is its main function and other activities must be subordinated to it. The objective of any administrative reforms should be purely and simply to increase the effectiveness of the research agencies and give them the maximum autonomy consistent with economy and the general welfare.

51 Consideration should be given to the co-ordinating responsibilities of a department engaging in widely dispersed research activi-

ties. Major facilities that could serve in common, such as libraries, data-processing units and workshops, should be shared, and the Department, taking account of the high costs of field programmes, should ensure that where possible these programmes are arranged on a co-operative basis by several branches and even with other departments. The Polar Continental Shelf project is an example of such co-operation, and is discussed elsewhere in this report.

NORTHERN AFFAIRS AND NATIONAL RESOURCES

52 This Department was formed about a decade ago from units of the large and complex Department of Mines and Resources. In its relatively short life, the northern responsibilities have been expanded rapidly and now overshadow those grouped under National Resources.

53 Of the five branches or equivalent units within the Department, all but one have a degree of interest in research, though none is wholly concerned with it. Discussed in some detail hereunder are the National Museum, the Wildlife Service of the National Parks Branch, and the Water Resources Branch. The Northern Administration Branch has a different function—that of caring for the Yukon and Northwest Territories. While it has depended on scientists from other departments for much of the intensive study of the north, it is now adding some research specialists to its own staff. Because of its implications for several government departments, northern research is discussed in a separate chapter.

Canadian Wildlife Service

54 Mammalogy and ornithology are the main research fields of the Service, with a small amount in limnology. The work is based in Ottawa, at various stations across southern Canada, and at several sites in the north. Field studies are carried on, usually in summer but to a lesser extent throughout the rest of the year.

55 Many of the research centres outside Ottawa are associated with universities. Close university ties are particularly necessary because academic training in wildlife biology is rare in Canada, so much so that the biologists needed by the Service are increasingly being recruited in the United States. There is little direct aid to universities through grants or research contracts, but use of student help in the summer provides some indirect assistance.

56 The Wildlife Service is a subdivision of the National Parks Branch but, while it provides some services in the National Parks, its responsibilities are nation-wide. At present, it is a small unit with a budget representing less than one per cent of the departmental total. It is a well-qualified, closely knit, active professional group, but is handicapped by being administratively part of a non-scientific branch of a department that is not primarily a research agency. The Wildlife Service and the Zoology section of the National Museum would form a logical unit, which would be more appropriately situated in an atmosphere congenial to scientific research and in a department with field and related activities throughout Canada.

57 *We therefore recommend that:*

> The Wildlife Service, with the addition of the Zoology unit from the National Museum, be transferred to the Department of Fisheries.

National Museum of Canada

58 The purpose for which the Museum is maintained has been officially stated as follows:

The main function of the National Museum of Canada is the dissemination of knowledge con-

cerning the natural history and human history of Canada. The Museum sends field parties each summer to collect material pertaining to the prehistory of Man in Canada, the cultures of aboriginal and immigrant races in Canada, and the animal and plant life in Canada, both living and prehistoric. On the basis of this material, scientific reports and popular accounts are written and museum exhibits are prepared.

59 The National Museum has a scientific staff of thirty-eight, of whom twenty-three are professionally trained. The proportion of support staff to scientific staff is low. There are sections specializing in botany, zoology, archaeology, and ethnology, with smaller units concerned with linguistics, folklore and musicology. There is a division into Natural History and Human History Branches, but this has little significance in practice.

60 The link between the scientific staff and the exhibitional-educational activities of the Museum is tenuous, and becoming more and more so. In fact, despite the implication in the quotation above, the scientists do not exist to contribute to the Museum exhibits, and most of them prefer to have no responsibility for them. Some types of exhibit are related to fields of science or human history not represented in the scientific staff. Technical advice concerning them is secured from other government departments active elsewhere. For one field (Botany) in which the Museum is scientifically active, the exhibit was prepared under the guidance of another department (Agriculture).

61 The scientific staff traditionally spend the summer season in the field and the rest of the year preparing reports, for eventual publication, although this system appears to be breaking down. In some cases they also have responsibility as curators for maintaining 'national' scientific collections in such fields as botany, archaeology and ethnology.

62 If a museum is to be more than a mere repository of objects of interest, it must have close ties with research related to its exhibits, but this does not imply that it must necessarily undertake the research itself. Under present arrangements, the small group of scientists at the National Museum tend to be cut off from the main stream of research in their respective disciplines and have limited scientific facilities. The scientific sections now gain nothing from being nominally associated with the exhibitions, to which they make few contributions of material or advice, and would be better placed in more congenial environments. For example, the Zoology Section should, as recommended, be associated with the Canadian Wildlife Service; and the Botany Section and the National Herbarium could be attached to the appropriate research institute of the Department of Agriculture.

63 Other sections have less obvious ties to particular government agencies, and their role should be to supply a national focus for the fruits of independent research in these subjects by universities and other non-government bodies. Indeed, the National Museum should itself be regarded in this light, and there is no doubt that the educational-exhibitional function would be strengthened by divorcing it from active research and reinforcing its ties with the relevant disciplines both inside and outside the government. In this central role, it would be inappropriate for the National Museum to be a branch of a government department. It could more appropriately be given some degree of independence, within the limits imposed by the provision of funds, under a Director General reporting immediately to a minister —a change that has been under consideration in the Department of Northern Affairs and National Resources.

Water Resources Branch

64 Research and development undertaken by the Branch include data collecting (flows and levels, sediment, evaporation, snow depth and water content, glacier ablations,

et cetera); the study or application of these (determination of hydraulic conditions and of hydraulic features, hydrometeorological aspects, and all phases of water conservation and control); and studies related to matters such as water conservation legislation, water power legislation, international river legislation, and an inventory of water power resources. The systematic hydrometric survey of Canada is the Branch's main responsibility. Extension of it to more remote areas and the demand for a greater variety of data have led to a steady expansion in the programme.

65 Snow surveys and observation of glaciers are undertaken to estimate in advance the water flow in certain rivers. The growing anxiety over flood damage in densely settled river valleys calls for new forecasting techniques and studies to obviate flooding. The continuous regulation of water levels in the Great Lakes is an important duty of the Branch, in collaboration with United States agencies. The earlier concentration on simple recording of data is passing—although this activity must continue and even expand. This trend compels the Branch to be more active in scientific research and development, and it faces urgent demands from many sources to expand and to put increased emphasis on fundamental studies.

66 In 1961 research and development occupied a staff of eighty-seven graduate engineers (eighty-six in 1951), one hundred and fifty-seven supporting personnel (one hundred and fifty in 1951) and eleven seasonal employees. This uniformity in numbers over a decade is in remarkable contrast to other research agencies. Almost all the professional staff are graduate civil engineers, but it was noted that only five have advanced degrees (Master's in hydraulics).

Water Resource Study in Other Agencies

67 To understand the present state of water resource study in Canada, it must be noted that the Water Resources Branch is far from being alone in the field. Jurisdiction is tenuous in some cases, and it is obvious that local authorities and the provinces have a large measure of direct or indirect interest in water resources. There is also some joint Canadian-United States responsibility. While there is widespread recognition of the need for greater research into water use, confusion exists as to the authority of the various levels of government to act.

68 There is no clear-cut responsibility for water resource study even within the federal government. For example:

- The National Parks Branch controls all aspects of waters within Park boundaries.
- The Territorial Governments control water used in placer mining.
- The Department of Agriculture is responsible for the Prairie Farms Rehabilitation Administration (now developing large irrigation and reclamation projects in western Canada) and the Maritime Marshland Rehabilitation Administration.
- The Department of Mines and Technical Surveys is active both in collecting data and in water management; the Geological Survey is concerned with ground-water studies, and the Surveys and Mapping Branch produces and distributes navigation charts, conducts tidal surveys and operates water level gauges on certain lakes.
- The Departments of Public Works and Transport are responsible for marine structures and aids to navigation, and have representation on various international Boards of Control.
- The Department of Transport is increasingly active—through responsibility for navigation—in icebreaking, maintaining the St. Lawrence ship channel, and in the supervision of canals. Its Meteorological

Branch is in charge of data gathering on precipitation and evaporation and for related research in connection with flood control, et cetera.

- The Departments of Fisheries, Health and Welfare, and Forestry, and certain Crown corporations and international bodies all exercise a degree of control over water resources in Canada, and so have an interest in related research and development.

69 The serious lack of co-ordination between the many agencies authorized to carry on research in water resources was apparent during the course of the inquiries of the Commission. Some of the inadequacies of water resource research could be overcome by a modernized Water Resources Branch, strengthened by the integration of some water resource groups from other agencies. For example, hydrometeorologists could be seconded from the Department of Transport; all hydrometric work could be done in the Branch, including that now undertaken by the Hydrographic Survey. The industrial water surveys of the Mines Branch could be transferred, as could various agencies concerned with water pollution.

70 The capacity to do high quality research in hydrology and related matters in Canada is limited by the lack of qualified scientists. It is rare for professional personnel in the Water Resources Branch to proceed beyond the Master's degree. There is urgent need to correct this situation.

71 Data-collecting needs to be improved in kind and quality. To make the results available for research and engineering purposes, there is need for improved techniques of data-processing. Present facilities for making data available to the public in the form now required are inadequate.

72 In order to place water resources on a sound basis in Canada, scientific hydrology must be established in the universities. This is essential in view of the fundamental importance of water—for power, industry, agriculture, fishing, domestic purposes and recreation. Leadership can come only from the federal level. A strong government research and development agency, equipped with modern laboratory facilities is a first requirement.

Conclusions

73 Research relating to water resources now suffers from excessive fragmentation. Although, as was seen, many departments and agencies are vitally concerned with the conservation, development and use of water resources, responsibility for research is to be found in three principal locations: the Department of Mines and Technical Surveys, the Meteorological Branch of the Department of Transport, and the Water Resources Branch of the Department of Northern Affairs and National Resources. Only in the first department is there a general orientation towards scientific research. Closer association of these activities in that Department would therefore be of undoubted benefit. It is noted, however, that the research aspects of the work of the Water Resources and Meteorological Branches cannot be dissociated from their other responsibilities. The broader question of the proper location of these branches is dealt with by your Commissioners in the final report in Volume 5.

DEPARTMENT OF TRANSPORT

Meteorological Branch

74 The Meteorological Branch of the Department of Transport has as its main responsibilities the observation and assembly of weather data, and the forecasting of weather, air and ice conditions in Canada and adjacent oceans. The Branch consists of six divisions: Forecast, Research and Training, Instrument, Basic Weather, Climatology, and Administration. Research and development are

primarily, but not exclusively, the responsibility of the Research and Training Division. This unit also provides in-service training for the large number of new recruits added to the staff in training each year, and this is its most demanding duty. Research is also conducted by the Climatology Division, and the Instrument Division undertakes the design and development of instruments employed in making observations. Some research is performed by individual staff members at forecast offices throughout Canada, with guidance from headquarters. The Branch is attempting to improve its research facilities and to attract specially qualified meteorologists to its research staff.

75 The main areas in which research and development are being carried out at present are listed hereunder:

- At Toronto Head Office:
  a. Instrument development
     Development of instruments and equipment for observing and recording temperature, wind pressure, humidity, ceiling, visibility, et cetera, over land, water and ice, at earth's surface and in the upper air.
  b. Physical Meteorology
     Application of methods of laboratory physics to study of the atmosphere; studies relate to ozone, radiation, air pollution, turbulence, energy budget and cloud physics.
  c. Dynamic Meteorology
     Study of the atmosphere in motion, including general circulation and the theoretical basis of numerical weather prediction.
  d. Synoptic Meteorology
     Study of the structure and state of the atmosphere and its changes with time for purposes of weather prediction—fronts, jet streaming, aircraft hazards—using the results of dynamic meteorology research and empirical techniques.
  e. Climatology
     Application of meteorological parameters to the Canadian economy, including micrometeorology, hydrometeorology, Arctic climatology, and research related to agriculture, forestry, construction and hydrology.
- At Central Air Office, Dorval Airport:
  Central Weather Analysis and prognosis
     Research designed to develop and evaluate techniques for forecasting weather over the whole of Canada from one location, includes use of numerical prediction methods.
- At forecast offices throughout Canada:
  a. Local forecast studies, mainly statistical, covering fog formation, ceilings, temperature, pressure, cloud formation, et cetera.
  b. Operational research in fields such as dynamic meteorology (jet streams and other upper atmosphere phenomena).

76 Growing demands for collaboration in agricultural research, hydrology, and ice observation and forecasting, are putting added strain on the research resources of the Branch, which have been inadequate for many years. The Branch has an insufficient number of able scientists to carry on all the necessary activities simultaneously. Operations have the first call on personnel, funds and facilities. There is also a problem in recruiting the right type of meteorologist. Outstanding research results can hardly be expected from meteorologists after they have been engaged for years on routine observing and forecasting on a shift basis. Yet the research positions are naturally attractive to such men, and seniority carries weight when appointments are made. There is at present no direct entry to research appointments for qualified scientists without routine meteorological operating experience, and scientists, interested mainly in research, are rarely attracted to ordinary meteorological vacancies.

77 Canada has pioneered in the design and development of instruments for making meteorological observations under severe climatic conditions and in remote locations. Some of these instruments, conforming to the essential high standards, are manufactured in the Branch's workshops from commercially made parts. Patents or other types of protection have rarely been secured.

78 The time would seem opportune to establish a modern centre for research and development in this increasingly important field. Better physical facilities are required, and also some reorganization of the staff with a strengthening of its scientific content. There is a well-established system of seconding Branch meteorologists, including those engaged in research, to other departments, and this has been more than justified. The scientific results achieved by the present small group of secondments is most encouraging; the time is approaching when this programme will need to be greatly extended.

79 The Canadian Meteorological Service, the third largest in the world, is a comparatively autonomous subdivision of a Department whose functions are predominantly operational and regulatory. From a research standpoint, this location is far from ideal. The small group of research scientists in the Branch are out of tune with typical departmental activities and administrative personnel. However, as was noted in connection with the work of the Branch relating to water resources, its scientific research activities cannot be dissociated from its other overshadowing responsibilities, and the general question of the proper location of the Branch must be left for consideration in your Commissioners' final report on organization.

3

DEFENCE RESEARCH AND DEVELOPMENT

1 Military scientific research in Canada has evolved in three stages. Up to World War II, military science was the sole responsibility of the Armed Services, and the amount of defence research and engineering carried out was almost negligible. A modest research programme was in hand at the National Research Council laboratories during the period 1936-39, which laid the foundations for the large-scale wartime defence scientific effort. During World War II the responsibility for defence research and development continued in the hands of the National Research Council. Since the formation of the Defence Research Board in 1947, defence research has been almost exclusively the responsibility of that body.

2 In addition to the research and development activities carried on by Defence Research Board establishments, development work is also undertaken independently by the Armed Services, and by Canadian Arsenals Limited, a Crown corporation established in 1945. The Department of Defence Production was given some responsibility in 1959 for stimulating defence development projects in the Canadian manufacturing industries. In theory, the Services specialize in development and the Defence Research Board in research, but in practice the line between the two is difficult to draw.

DEFENCE RESEARCH BOARD

Organization

3 The Chiefs of Staff Committee is responsible for advising the Minister of National Defence on defence policy, and this responsibility must include defence research and development policy. However, an essentially non-scientific body, such as the Chiefs of Staff Committee, cannot in fact be responsible for detailed defence science policies, and this was foreseen when the Defence Research Board was created. It was for this reason that the Board was given the responsibility for advising the Minister on defence research and development policy.

4 The Board comprises, in addition to the Chairman and Vice-Chairman, the Chiefs of Staff of the three Armed Services, the President of the National Research Council, the Deputy Minister of National Defence and,

at present, seven members appointed from the universities, two members appointed from industry, the Chief Scientist of the Defence Research Board and the Deputy Minister of Defence Production. The Board meets three times a year. It does not act as an advisory body on defence research policy, although the *National Defence Act* prescribes this as its main function. However, the Board does perform three important functions:

- It provides for joint consultations on defence scientific affairs between the Defence Research Board, the Armed Services, the universities and industry.
- Through its selection committee, it is responsible for professional appointments and promotions, and ensures that adequate standards are maintained.
- Through its standing committee on extramural research, it has established twenty-seven advisory committees and panels with membership drawn from government scientific agencies, the universities and industry. These bodies are responsible for screening all applications from the universities for Defence Research Board grants-in-aid of research, and several of the panels act in an advisory capacity in specialized fields of defence science.

5 The Chairman of the Defence Research Board also acts as its general manager. When additional responsibilities devolve upon the Board, there will be a need for some reorganization, and particularly for strengthening the executive functions. The Chairman of the Board should be responsible for advising the Minister on defence research and development policy, and for all the existing functions of the Defence Research Board (including international aspects of Canadian defence science and engineering) except the direct management of the actual research establishments. A senior administrator of the National Defence Laboratories should be appointed, who would be a member of the Board and have responsibility for managing the laboratories and associated headquarters directorates.

6 The organization chart (Chart 3) shows the Chief of Establishments as the executive officer responsible for the operation of the experimental establishments. In practice, there appears to be some overlap in the responsibilities of the Chief Scientist, the Chief of Personnel, the Chief of Establishments, and the Comptroller. There is clearly some difficulty in the interpretation of the terms of reference of these senior executives. The same problem arises in the definition of the respective roles of, and relationships between, the headquarters scientific directorates and the experimental establishments.

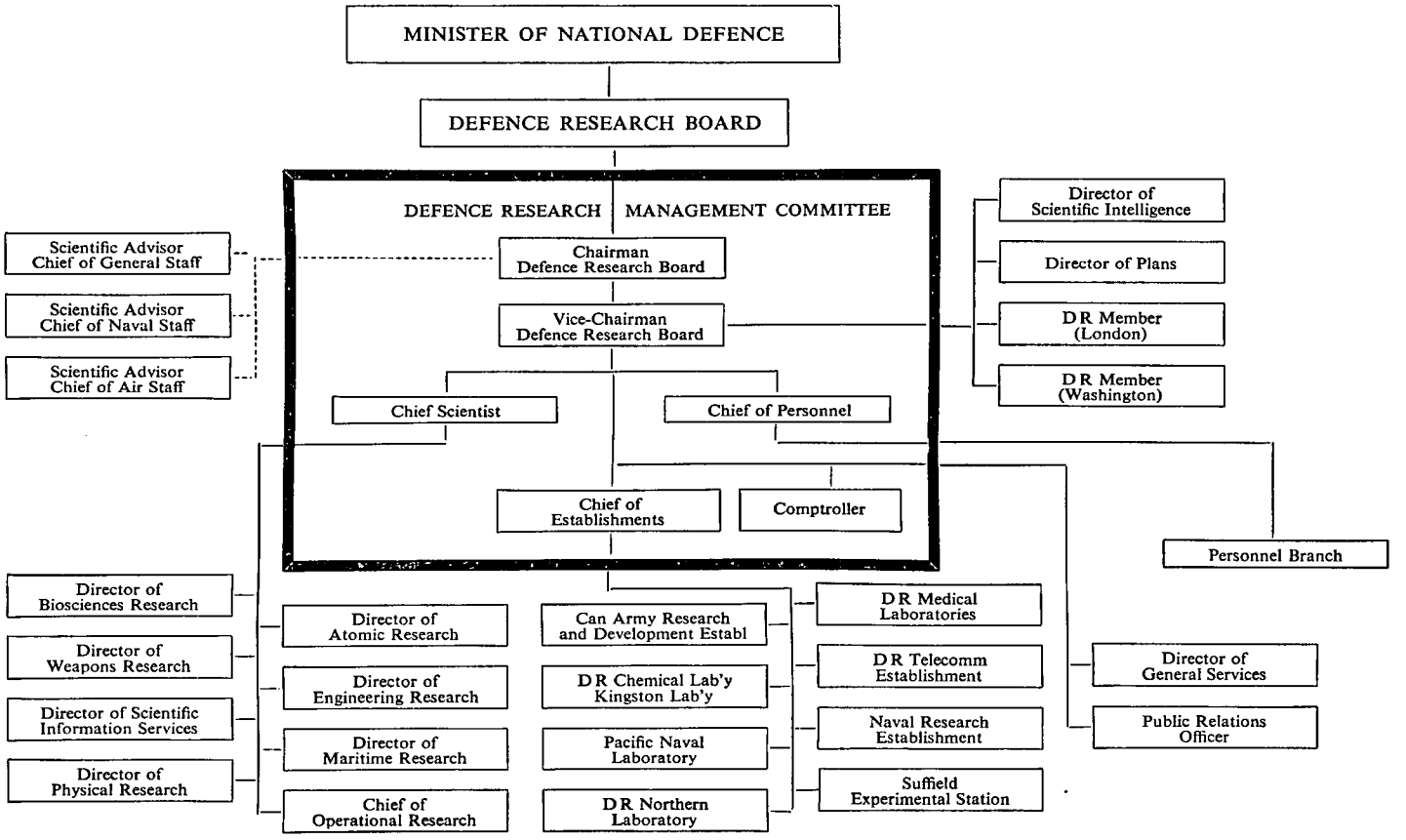
7 An operational research group, consisting for the most part of Defence Research Board personnel, is integrated into each of the Armed Services. In addition, the RCAF has established, under a senior Defence Research Board Scientist, a defence systems evaluation group. Apart from several small sections attached to operational units of the Services, these groups are based at National Defence Headquarters. Each group is carrying out effective analytical work. This aspect of the activities of the Defence Research Board has been highly praised by the Armed Services.

Research and Development Programmes

8 The magnitude and scope of defence research and development programmes and their security classification preclude a detailed description in this report of even the major projects. Comment is limited to certain aspects of the programmes.

9 The research programmes of the Defence Research Board Establishments appear to be balanced adequately between basic and applied research. There is particular emphasis on the latter, even at the expense of develop-

Chart 3—ORGANIZATION OF DEFENCE RESEARCH BOARD—SEPTEMBER 1961



ment work, because defence science is, almost by definition, applied research.

10 The research programme at the Canadian Armament Research and Development Establishment (CARDE), the largest Defence Research Board establishment, is particularly well-balanced, with the major effort in applied research. Some aspects of the research programme have attracted international interest. For example, CARDE hypersonic range facilities for the study of ballistic missile re-entry phenomena are among the most advanced of any in the NATO countries, and a considerable part of this programme is being financed by the United States Army Rocket and Guided Missile Agency.

11 An important aspect of CARDE is the close collaboration between the establishment and the Canadian Army. The future evolution of Canadian defence programmes may perhaps be patterned on the CARDE model, which has proved that joint development programmes can be effectively co-ordinated and executed. The research programmes at the Pacific Naval Laboratory and the Naval Research Establishment are to a large extent complementary, and it is suggested that the possibility of developing a co-ordinated programme, involving both establishments, should be studied. Canada has already made notable contributions to research in anti-submarine warfare, especially in connection with the development of Variable Depth Sonar; a well integrated naval research programme, with emphasis on no more than two or three major projects, should help to increase the country's contribution in this field.

12 Similarly, portions of the programmes at the Defence Research Chemical Laboratories and at the Suffield Experimental Station are complementary, especially in the fields of chemical and biological warfare. Since this area of research is closely co-ordinated with programmes in the United Kingdom and the United States, it may not lend itself to closer co-ordination with other programmes in defence research. At present, however, there are thirty-five projects in hand at the two establishments, and the selection of one or two major areas for study by comparatively large teams would appear to be a logical move.

13 Two sections of the Radio and Electrical Engineering Division of the National Research Council, Defence Sections I and II, are still concerned with defence research and development in radar and electronics. During the past twenty years these sections have made notable contributions to radar and electronics research. Nevertheless the continuance of this work within the National Research Council is anomalous, and it is suggested that consideration be given to the eventual transfer of the two defence sections to the Defence Research Telecommunications Establishment within the Defence Research Board.

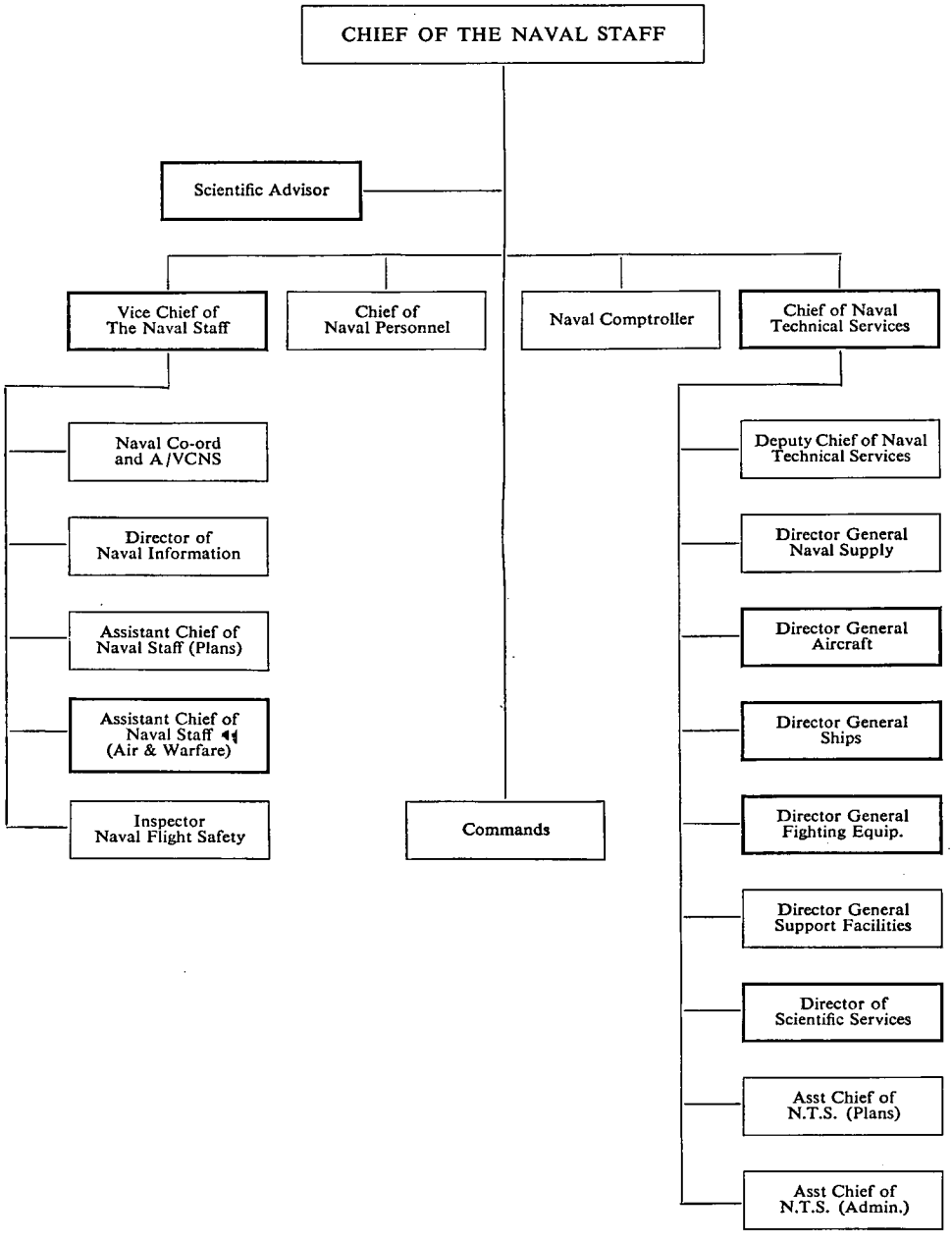
ARMED SERVICES DEVELOPMENT DIRECTORATES

Organization

14 The directorates principally involved in development work in the Armed Services are shown in the simplified organization charts 4, 5 and 6. While there is some attempt in the Army organization to co-ordinate development work within a single body (the Army Equipment Engineering Establishment), no like attempt appears to have been made by the Navy or Air Force.

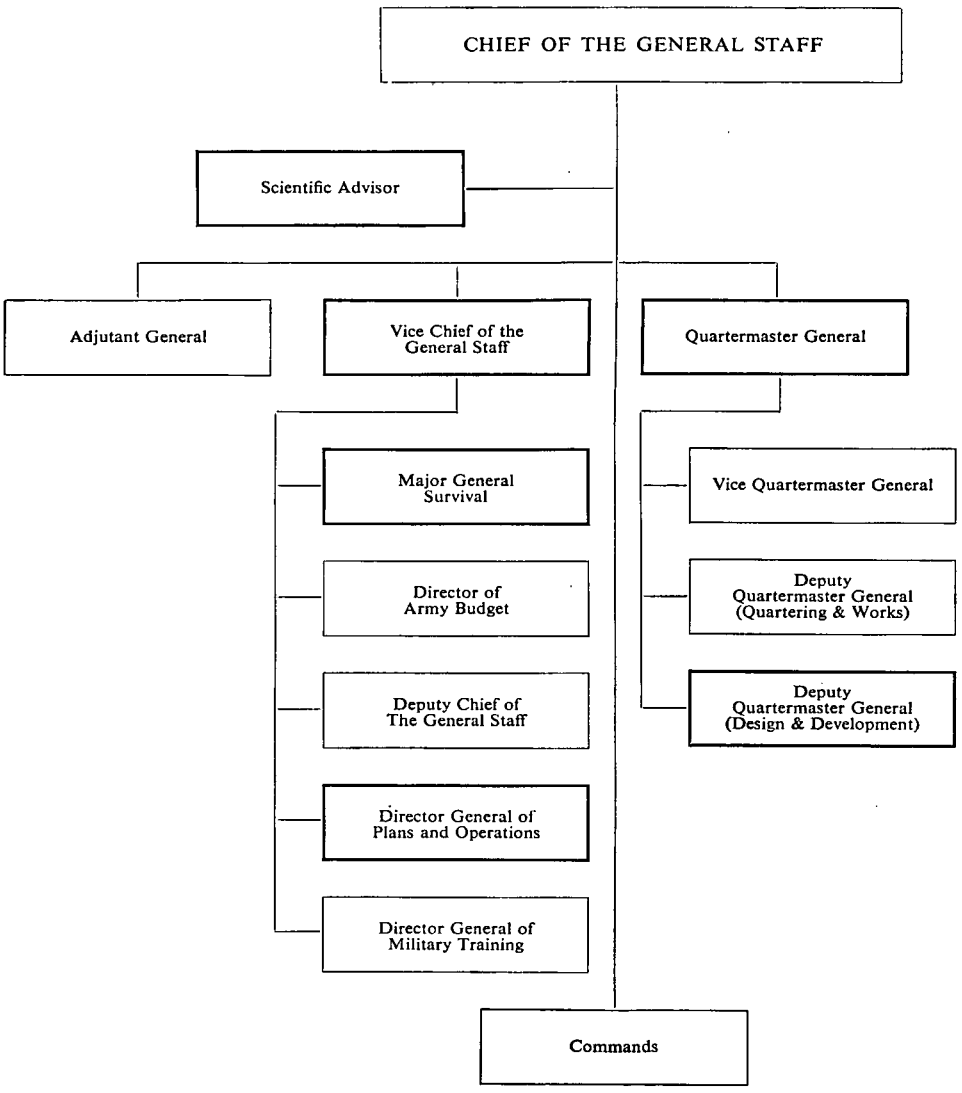
15 The Royal Canadian Navy development programmes, both 'in-house' and extramural, come under the Chief of Naval Technical Services. The Director of Scientific Services is also the Director of Maritime Research, Defence Research Board; on the one hand, he monitors the naval development programmes for the RCN and, on the

Chart 4—RESEARCH ORGANIZATION IN THE ROYAL CANADIAN NAVY



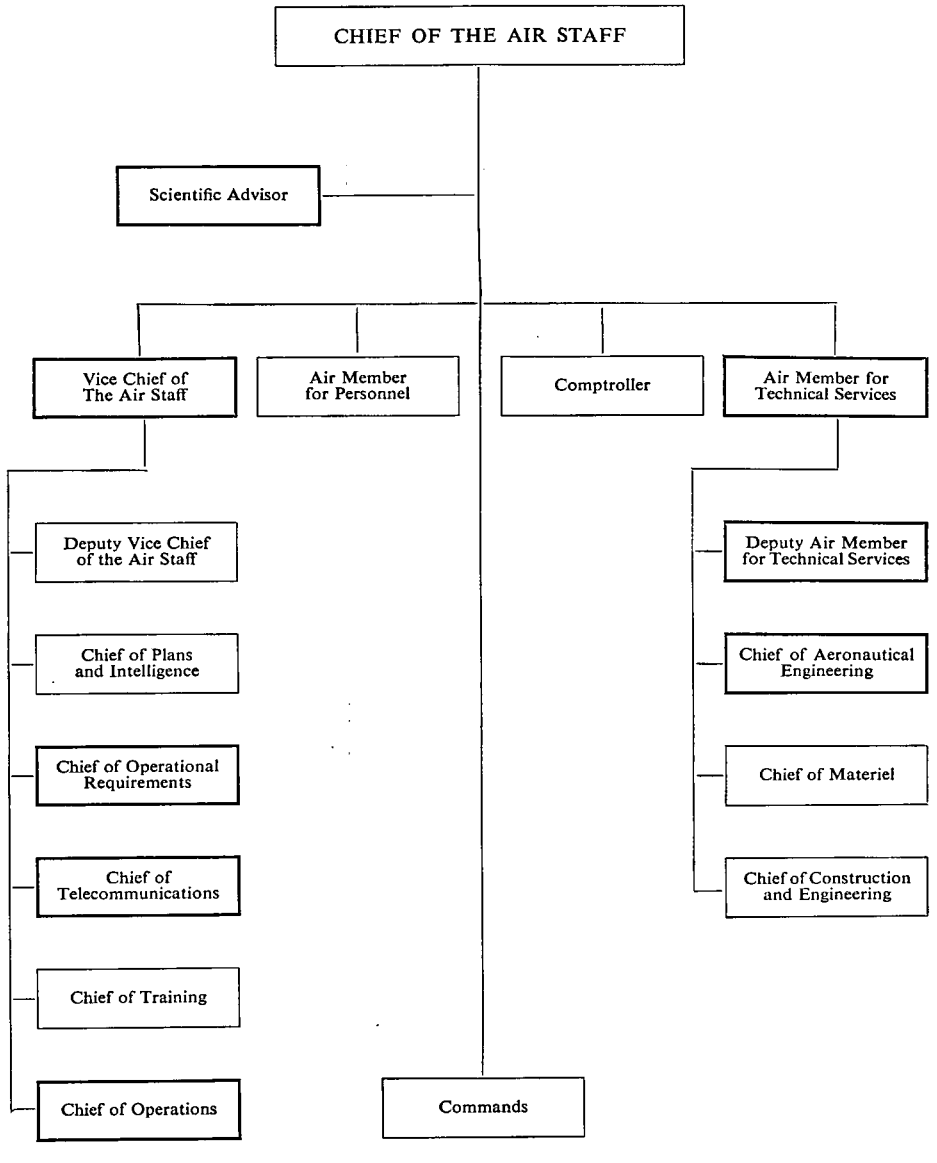
Heavy lines indicate RCN Branches and Directorates concerned with Research and Development Programmes.

Chart 5—RESEARCH ORGANIZATION IN THE CANADIAN ARMY



Heavy lines indicate Army Branches concerned with Research and Development Programmes.

Chart 6—RESEARCH ORGANIZATION OF THE ROYAL CANADIAN AIR FORCE



Heavy lines indicate R C A F Branches concerned with Research and Development Programmes

other, he advises on the technical aspects of programmes as a member of the staff of Defence Research Board.

16 The development programmes of the Army are the responsibility of the Deputy Quartermaster General (Equipment Engineering), who controls the two branches concerned with development—the Army Equipment Engineering Establishment and the Directorate of Equipment Engineering. The Army development programmes are planned and co-ordinated by the Army Research and Development Committee, whose chairman is the Deputy Chief of the General Staff. Examples of extreme fragmentation are the Directorate of Equipment Engineering comprising twenty-five sections, and the Army Equipment Engineering Establishment with forty-eight sections.

17 The RCAF development programmes have always been the largest in the Armed Services. The lack of co-ordination in the development branches and sections may be illustrated by the following examples:

- The Director of Systems Evaluation is responsible to the Chief of Operational Requirements, while the closely associated Operational Research Directorate is responsible to the Chief of Operations.
- The Director of Air Defence Systems Integration is responsible to the Deputy Air Member for Technical Services, while the Director of Radar and Data Processing is responsible to the Vice-Chief of the Air Staff through the Chief of Telecommunications.
- All RCAF development proposals pass through the office of the Assistant for Aeronautical Engineering Management, but this office constitutes a financial control, and has no responsibility, or indeed capability, for co-ordinating the development programmes.

Development Programmes

18 In spite of several important development programmes conducted jointly by the Armed Services and the Defence Research Board, approximately fifty per cent of the total national defence research and development expenditures is for projects that are not the direct responsibility of the Defence Research Board.

19 Several examples of undue overlapping and even duplication of development programmes have been noted. Three cases are outlined below:

- Electronic counter-measure programmes are being undertaken by various agencies and, although co-ordinated by a committee, the actual development work is being carried out in three independent laboratories—the National Research Council defence sections, the Instrument and Electronic Division of Canadian Arsenals Limited, and the Defence Research Telecommunications Establishment.
- The RCAF Directorate of Airborne Telecommunications is concerned with the development of some aspects of moored sonar buoy submarine detection and location systems, and with the magnetic detection of submarines (in conjunction with the National Aeronautical Establishment); associated programmes are in hand at the Defence Research Telecommunications Establishment, the Naval Research Establishment and the Pacific Naval Laboratory.
- There is little collaboration between Defence Research Board experts in digital data processing systems and the RCAF and RCN directorates concerned with such complex systems as the SAGE and corresponding systems for naval applications.

CANADIAN ARSENALS LIMITED

20 Canadian Arsenals Limited was formed as a Crown corporation in September, 1945.

Although its major function is the production of military stores and equipment to the order of the Department of Defence Production, the corporation has two other significant functions:

- The development of new military equipment for the Services.
- The development and planning of new manufacturing processes.

21 At present, except in one special electronic counter-measure programme, there is no mechanism for co-ordinating the corporation's work in defence development with that of other agencies, and the President and Board of Canadian Arsenals Limited are responsible to the Minister of Defence Production.

22 The Canadian Arsenals development programme is dependent, almost exclusively, on programmes initiated by the Armed Services and the Defence Research Board. During 1960-61 the combined development expenditures in the corporation's arsenals and the gun ammunition, small arms, filling, and explosives divisions amounted to only $76,000. Unless adequate funds are provided to support these vital development groups, they will rapidly become hopelessly out-of-date.

23 During the past decade, the Instruments and Electronics Division has been responsible for the major portion of the Canadian Arsenals development programme. It is a first-class group and has made important contributions to developments in radar, electronic countermeasures and air navigation systems. In spite of this impressive record, it remains difficult to state a case for the continuance of the Instruments and Electronics Division within the framework of a Crown corporation. The group is isolated and has no knowledge of future programmes, so that long-term planning is impossible. Two possibilities for the re-location of this work merit consideration. The development sections of the Instruments and Electronics Division might be incorporated with the Defence Research Telecommunications Establishment. The Canadian electronics and applied electronics industry has made great strides in research and development during the past decade, and it appears to your Commissioners that the existing electronics development programme of Canadian Arsenals Limited should be contracted out to private industry.

DEPARTMENT OF DEFENCE PRODUCTION

24 Since 1958, the Department of Defence Production has had responsibility for the conduct of the Canadian-United States defence production-sharing programme, initiated in that year. This responsibility in turn gave rise to the associated development-sharing programmes within Canadian industry. More recently, in January, 1961, the Department of Defence Production submitted a case for long-range industrial applied research planning for production-sharing. A committee of representatives of interested government departments was set up to review and to recommend the support of suitable development projects, and to monitor the financing and control of such programmes.

CONCLUSIONS

25 The ramifications of the foregoing survey amply reflect the complex state of defence research and development in Canada and should make one thing clear: the marked lack of co-ordination that exists both within and between the principal defence research and development agencies.

26 As has been stated, the principal intended function of the Defence Research Board was to co-ordinate defence research policy. That it has not exercised this function has been less damaging to Canada's defence contribution than the fact that it has not been responsible, either statutorily or in practice,

for the co-ordination of the development function. To a certain extent, basic and applied research require autonomy and a freedom for the individual scientist to go his own way. But if development policy is equally unco-ordinated, serious damage may result to the effectiveness of Canada's defence system.

27 In principle, the Department of National Defence Development Committee, under the chairmanship of the Chairman, Defence Research Board, is responsible for the co-ordination of the Armed Services development programmes which are covered by development votes. These votes apply mainly to Armed Services development contracts with industry, totalling some $12 million a year, as distinct from development programmes carried on by the Services within their own establishments. The Committee meets only once each year and deals almost exclusively with the extra-mural development budget proposals.

28 But although the Board approves the development contract demands of the Armed Services, it has no responsibility for the subsequent conduct of the work. It is also apparent that the Defence Research Board has not the manpower to devote adequate time to investigating the potential value of all development proposals. This is due mainly to the complex procedures involved in the processing of industrial development contracts. The average time taken by the Board to process Army contract demands is about three weeks, which must be regarded as insufficient for thorough investigations. However, for the majority of the Armed Services 'in-house' development programmes, there is in fact no scrutiny at all by the Defence Research Board of the scientific and technological merit of the projects. It would thus appear that the monitoring of the Armed Services development programmes by top-class defence scientists and engineers is limited. There is evidence of too hasty initiation of industrial development projects, giving rise to excessive numbers of amendments to development contracts and additional time-consuming processing procedures.

29 Two points remain to be made concerning defence science personnel. First, the defence scientist occupies a special position because his work is frequently subject to security regulations, which inevitably involve some restriction on the publication of his results. Accordingly, for the average defence scientist, career prospects in other scientific occupations, including for example university teaching and research, may be prejudiced. There is therefore some justification for giving the defence scientists special dispensations in the form of fringe benefits, such as attendance at summer schools, special travel grants, a liberal attitude towards those invited to give lecture courses at the universities, and permission to attend special graduate courses during hours of duty. There may otherwise be a tendency in the future for inbred characteristics to develop in the Defence Research Board.

30 Second, the Armed Services are encountering increasing difficulties in recruiting qualified scientific personnel. At present the career prospects of the majority of technical staff-officers, within the framework of the Armed Services, are not encouraging and are less attractive than those of the non-specialist. The Service environment is not conducive to excellence in high-level defence science and engineering; and the tour of duty requirement, which frequently means that an officer may spend only three or four years in an appointment before being posted to an entirely different field, is a further bar to the recruitment of the scientist or engineer. The basic character of the existing problems suggests that a special study dealing with the future role and career prospects of military technical staff would be fully justified.

31 The importance of the Defence Re-

search Board as the top-level defence research and development policy advisory body has been discussed in Part 1 of this report. From the standpoint of the conduct of defence research and development programmes, a strong central policy advisory body will become increasingly important in the future.

32 The large number of research and development groups and the correspondingly large number of projects in hand testify to the fragmentation in defence research and development programmes, reinforcing the view that the selection of projects, especially the Armed Services' development projects, is not well co-ordinated. The formation of strong groups to undertake projects of major importance, the elimination of other projects, and the statement of well-defined aims are all important requirements.

33 Because of increasing expenditure in defence development, the time is now ripe for the Defence Research Board to study the long-term aims and objects of Canadian defence research and development programmes, with a view to forming a long-term defence science policy and thereby minimizing the possibility of serious discontinuities.

4

THE NATIONAL RESEARCH COUNCIL

1 In Part 1 of this report your Commissioners discussed the constitution and role of the National Research Council and its relation to the government and to scientific research in general. In the following survey, consideration is given simply to the Council's internal research activities.

2 The organization of the National Research Council is shown in Chart 7. It consists of eleven scientific and engineering divisions, two of which are regional laboratories. The numbers of staff at January 1st, 1960, are given in brackets.

3 The divisions are each headed by a director who reports to the President. Each division includes a number of sections headed by senior scientists usually classified as Principal Research Officers.

RESEARCH PROGRAMMES

4 The work in the National Research Council laboratories is not assigned on a project basis. The emphasis is put rather on fields of research. The divisional sections each operate more or less independently in a particular scientific field. The following are brief descriptions of the scientific work of the divisions.

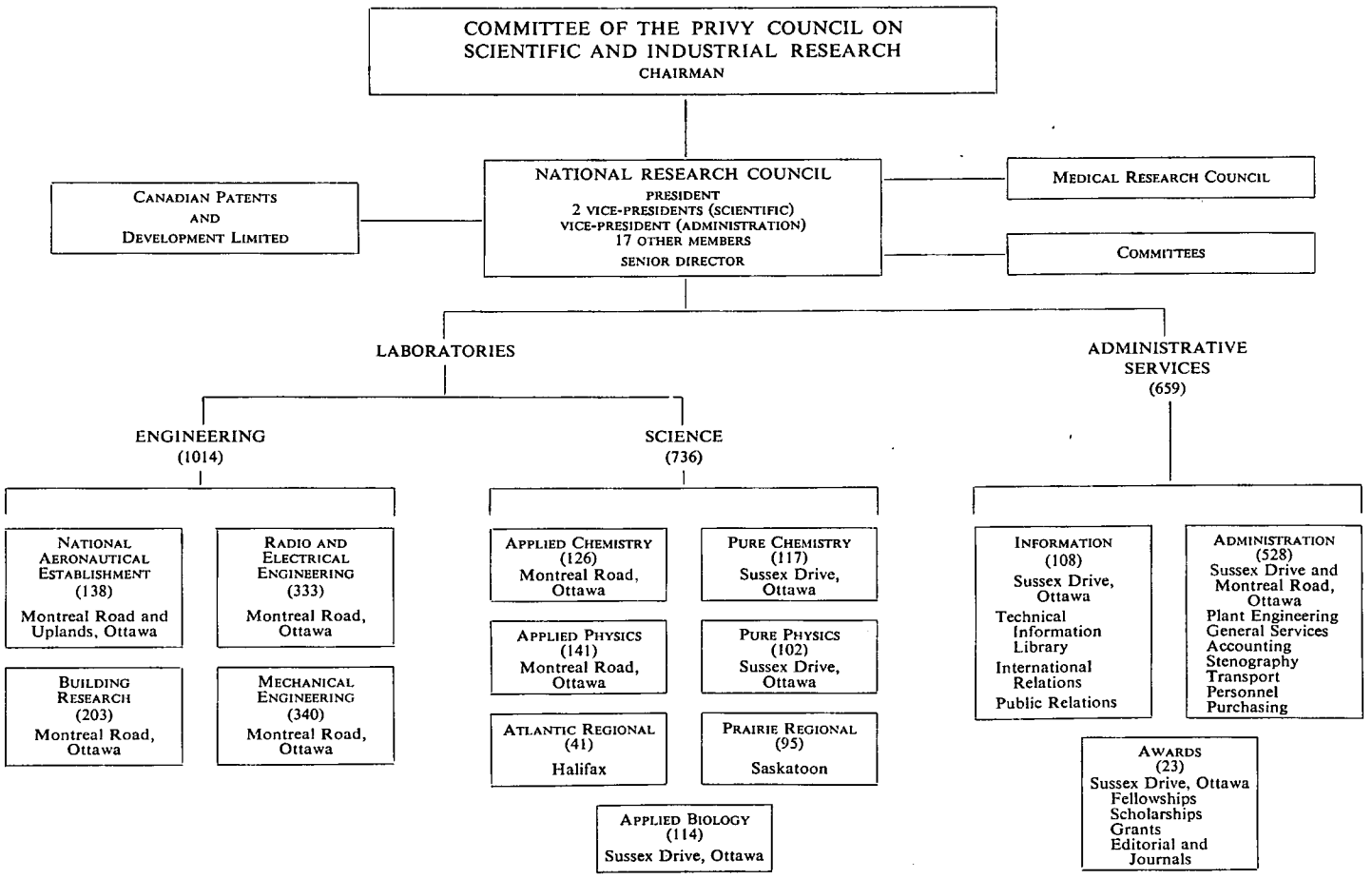
Building Research

5 The main function of the Division of Building Research is to provide a research service to the construction industry of Canada. It assists Central Mortgage and Housing Corporation on special technical housing research and provides the secretariat and necessary technical assistance to the Associate Committee on the National Building Code. The research programme of the Division includes work on all main building materials except wood, mechanical services for buildings, foundations and soil mechanics, all aspects of house design and construction, fire research and a variety of other services.

Mechanical Engineering

6 This Division works mainly in mechanics, hydrodynamics and thermodynamics. The mechanics activities include mathematical analysis and computation, instruments and

Chart 7—OGANIZATION OF THE NATIONAL RESEARCH COUNCIL



servo-mechanisms, and research on mechanical devices such as gears. The hydrodynamics research and development work is divided into hydraulics work pertaining to harbours and rivers and hydrodynamic aspects of naval architecture. The thermodynamics laboratories deal with further aspects of fluid mechanics and especially with the problems of reciprocating engines and turbines, with the characteristics of fuels and lubricants, and with the special cold weather and icing problems important in Canada.

National Aeronautical Establishment

7 The research programme of the National Aeronautical Establishment, which is concerned with problems of aerodynamics, aircraft structures and materials, and flight mechanics, is described in some detail in chapter 5.

Radio and Electrical Engineering

8 Roughly half of this Division's work consists of defence projects involving the development, production, and evaluation of new equipment. The rest of the research programme involves fundamental problems in electronics, electrical engineering, and radio science, as well as applied research in such fields as the application of electronics to navigational aids, instruments for inclusion in satellites, medical electronics, and long distance power transmission, with special emphasis on applications of interest to Canadian industry.

Applied Chemistry

9 The Division seeks to provide information needed in the development of Canada's natural resources and chemical industries. Much of the work concerns petroleum and corrosion chemistry.

Pure Chemistry

10 The Division is concerned with fundamental investigations in physical and organic chemistry. There are thirteen sections, twelve of which study long-term problems; the thirteenth prepares substances needed by the others. The work in organic chemistry includes investigation of the structure of alkaloids, studies of the infra-red spectra of steroids, the synthesis of porphyrins and of compounds labelled with isotopes. Other sections deal with chemical kinetics and photochemistry, the study of the ionization potentials of free radicals by mass spectrometry, Raman and infra-red vibrational spectroscopy, and the application of high resolution proton magnetic resonance techniques to the study of hydrogen bonding and other molecular interactions. Still others study aspects of surface chemistry such as the thermal properties of simple solids and imperfections in the bulk and the surface of alkali halide crystals, and the thermodynamics and stress-strain relationships associated with the absorption of fluids by active carbons.

Applied Biology

11 This Division's programme covers practical problems related to the national economy, and fundamental investigations in plant and animal physiology, microbiology, biochemistry and biophysics. Problems of preparing, preserving, and storing goods constitute a large part of the work. The Division is investigating the physiological and biochemical changes in mammals, birds and man in adapting to cold. Other fundamental work includes the structure and function of plant cells, the chemistry of proteins and lipoproteins, the composition and structure of carbohydrates and fats, and the metabolism of non-pathogenic micro-organisms that are important in the food and fermentation industries.

Atlantic Regional Laboratory

12 Practical and fundamental investigations related to the resources and industries of the Atlantic provinces are carried out. They include more efficient methods for dry-

ing plant materials, the problem of slime in the "white water" of Canadian pulp mills, basic chemistry in the fabrication of steel, and the processing of industrially important seaweeds.

Prairie Regional Laboratory

13 The Laboratory studies chemical, biological and engineering processes for turning agricultural crops into industrial raw materials or commercial products. For some time the Laboratory has studied major plant constituents such as carbohydrates, protein, starch, lignin and fibres. Attention is now being given to the minor components—such as phenols, flavonoids and terpenes, which are known to have fungicidal and germicidal properties—both individually and as they affect the processing and behaviour of the major constituents. The development of oil seed crops as alternatives to cereal crops constitutes an important part of the laboratory's work.

Applied Physics

14 The work is divided between research projects of potential practical value and development of the fundamental standards on which measurements generally are based. All the fundamental physical standards for Canada are housed and serviced in this Division, which now holds primary standards equal to any in the world in the fields of mass, length, time, electricity, temperature, light, and ionizing radiations. Industrial problems receive much attention, particularly calibration work and industrial noise abatement. Work is done in such fields as aerial mapping, rocket propellants and diagnostic radiography. The possible use of plasma motors to propel rockets in outer space is being investigated. The radiations group has made a study of the gonadal dose received by adults in diagnostic radiography, and has entered the field of radiochemistry to be able to measure radio-isotopes more effectively.

Pure Physics

15 The work is on long-range fundamental problems that do not have immediate application but advance knowledge generally and provide the basis for further progress in the applied fields. The Division's work includes fundamental studies on cosmic ray measurements using rockets flown to high altitudes; the electrical, thermal and mechanical properties of metals and semi-conductors; the spectra of atoms and simple molecules with a view to determining their structure; theoretical problems in atomic, molecular and nuclear physics; molecular and crystal structure; and identification problems for government laboratories.

The Laboratories

16 The National Research Council Laboratories represent the largest single research complex in Canada. Their activities, as already described, include pure and applied research in physics, chemistry, biology, and civil, mechanical, electrical and aeronautical engineering. Inevitably the programmes and organization are as much a result of past events and personalities as they are a matter of policy. The laboratories are recognized both nationally and internationally as doing research of the highest calibre. They have grown very rapidly during the past few years, from essentially a single establishment to a group of large research divisions, each with increasing independence.

17 Pure research is conducted by the National Research Council in two different environments. In the Pure Physics and Pure Chemistry Divisions it is conducted in relative isolation from the other activities of the Council, except as part of the scientific community as a whole. In the applied research and engineering divisions some pure research is also conducted alongside applied research, development, engineering and other activities. The conduct of pure research is the key to the attraction of top-quality creative

scientists, in which the National Research Council has been singularly successful. However, it has long been recognized that even pure research benefits from the feedback of problems from related applications, and that the best balance between pure research conducted in isolation and that conducted in proximity to applied research is a matter for continual review.

18 The physics, chemistry and biology divisions conduct pure and applied research of a kind and quality traditionally associated with the universities. They have an excellent record of scientific publication, which is actively encouraged, and have attracted and developed a number of outstanding scientists.

DIRECTION OF RESEARCH PERSONNEL

19 There is a deliberate policy of restraint from the direction of research, arising from an obvious and understandable fear of inhibiting the freedom of the creative scientists. The policy regarding the direction of research is summarized in the following paragraph extracted from a submission by the National Research Council to the Commission:

> Each Research Director is responsible for the scientific programme of his Division. He has the authority and responsibility to initiate work in a new field and to terminate work in another field. The Director in turn generally delegates full authority and responsibility to his Section Heads who are responsible for a special field within the spectrum of the Division's interests. As far as the basic research programmes are concerned it is the job of the Director to protect the scientists from outside direction rather than telling them what to do. The control by the Director, the President, and the Review Committee of the Council is largely indirect by way of encouragement, of criticism, etc.

20 The retention of this freedom is the most important single factor in the operation of research laboratories. The National Research Council has created an environment for research in its own laboratories which is unrivalled in academic freedom even by Canadian universities, where considerable emphasis is placed on teaching commitments. Indeed, the very success of the National Research Council in this regard may lead to the criticism that it has attracted to itself men who should be building up schools of scientific research in Canadian universities.

21 Restraint from direction has had further effects than those intended. The policy assumes that the majority of scientific staff have convictions about what they wish to do; that they are able to exercise critical judgment on their own work; and that they can maintain the sense of urgency necessary to a research environment. These assumptions may not be universally valid. The problem is to maintain an environment suitable for highly creative work and at the same time provide guidance and direction when needed.

22 Some quite senior personnel desire direction and guidance in the selection of their research, as distinct from its conduct, particularly in the form of clear statements of the policies, aims and objectives of their particular group. There is an evident reluctance in some places to seek such guidance in the face of the over-all policy quoted.

23 The policy neither to limit the scope of research nor, in some instances, to direct it, has resulted in a programme which is, in places, diverse and thinly spread. Sufficient attention has not yet been paid in every case to the selection of programmes that are either of fundamental scientific importance, of current scientific interest or, in applied research, of ultimate practical and economic significance. At the same time, insufficient stimulus appears to be given to a scientist to terminate a scientifically unproductive programme.

24 The age distribution of National Research Council scientists has become a matter for concern. The high influx of staff

in the late 1940's now reflects a peak in the age distribution at about thirty-eight. There is no obvious outlet for the forty-year-old whose creativity is generally regarded as passing its peak in this decade of life. In a university he would turn more and more to teaching and away from research. There are signs that some of the fragmentation of divisions is due to a desire to create senior positions for these men. Initial appointments by the National Research Council are for limited terms, succeeded by terms of increasing length before the appointment becomes discretionary. Advantage has not been taken of the existing regulations governing temporary appointments to enforce a healthy degree of turnover in the research staff. By far the greatest turnover is now among Post-Doctorate Fellows.

25 The Post-Doctorate Fellowship Scheme of the National Research Council is one of the most highly regarded fellowship schemes in the world. It provides a flow of high-calibre scientists and engineers who bring the benefit of training received in many parts of the world. They not only perform much useful work, but serve as a stimulus to the permanent staff. Since the scheme was started in 1950, over one thousand Fellows have passed through the National Research Council laboratories. It has also been extended to include appointments to Canadian universities and other government departments, although the numbers allocated to the latter do not yet approach those in the National Research Council. It has not yet been extended to industrial research laboratories.

26 Most Post-Doctorate Fellows come from outside Canada, and many return to their own countries after completing their Fellowships. The Post-Doctorate Fellowship scheme is *not* successful in attracting Canadians, who have so far represented only eight per cent of the Fellows. This is almost certainly due to the fact that the stipend offered is far more attractive to a scientist overseas than to a Canadian who has job offers at Canadian salary levels. As mentioned above, the greater part of the turnover of scientific staff is among the Post-Doctorate Fellows, and the age-distribution of the permanent staff is thereby unbalanced—the one possible disadvantage of an otherwise admirable scheme. One or two Divisions have a high proportion of Fellows; in one, the ratio of thirty-eight Post-Doctorate Fellows to twenty-two research staff implies a turnover of about one-third to one-half the research scientists every year. The Council might profitably re-examine the proportion of Post-Doctorate Fellows to permanent staff in each Division, from the point of view of its effect on the continuity of research.

27 The engineering divisions, which spend the greater part of the laboratory research budget, are undoubtedly a problem to an administration which has concentrated its effort so successfully on the support and encouragement of fundamental research. While the *ad hoc* selection of research programmes may be admirable if the sole responsibility of the division is to do pure research, it sometimes leads, even then, to excessive diversity. In an engineering division the results may be still more serious. The requirement for a large number of engineering staff, who have no counterpart in the science divisions, further accentuates the difference between the science and engineering divisions.

5

CO-ORDINATION OF NON-DEPARTMENTAL RESEARCH

1 Most research not related to departmental or agency operations is now undertaken by the National Research Council, the Defence Research Board and Atomic Energy of Canada Limited. However, some research in this category remains the responsibility of one or more departments and agencies. Four such areas of research are examined in this section, and certain principles for the organization of all non-departmental, civil scientific research will be enunciated.

2 The National Research Council has, as noted earlier, established an international reputation for general excellence. In the civil sector it now has responsibility for the lion's share of non-departmental research, if Atomic Energy be excluded. It might well take over all such research, thereby reducing the present fragmented nature of government research and placing non-departmental research activities in a sympathetic and expert environment. The effect of this and earlier recommendations would be to reduce to manageable proportions the number of agencies with research interests, and to provide the benefits which can best be derived from strong central supporting services and expert direction in a scientific environment.

3 Within the National Research Council, the engineering divisions tend to be self-sufficient, each including work that runs the gamut of activities from research to engineering. It appears certain that if the aims of these divisions were more clearly defined, their programmes would be more coherent and effective and their co-ordination with industry better developed. This is borne out by the experience of the Building Research Division.

4 At present, however, there is a widespread feeling that fundamental research is the only activity adequately recognized within the National Research Council. The recruiting and selection boards operate to some extent on this assumption. Much emphasis is placed on academic records and quantity of publications, both for recruiting and promotion. The engineering divisions engage in a great deal of pure and applied research, development, and engineering activities for which a wide variety of capabilities is needed.

But there is no corresponding variety of grades or of criteria for the selection of their professional staff. The various factors to be weighed when hiring a professional engineer may be quite different from those considered when appointing a research scientist. The problems of selecting and directing research programmes and those of personnel administration would be eased by having the engineering divisions report to the President through a separate channel from the science divisions, and by giving each unit a more independent status.

5 This would involve some changes in the organization of the National Research Council, which would not be dramatic. The Division of Building Research has already achieved a degree of independence unmatched by other units. The other divisions should be allowed the same autonomous status. In addition, some of the research units now placed in the departments should be brought within the National Research Council framework. These "satellites" would report to the Council through a new Vice-President, whose responsibility for their administration would be limited to the broadest aspects of financial and programme control.

6 The National Research Council's main operational responsibilities would be the management of its own pure and applied science laboratories, the scholarships and grants-in-aid programmes through which it has been largely responsible for the growth of research in the sciences and engineering at Canadian universities, and the provision of common administrative services.

7 No detailed plan of operation of the satellite system is outlined here, nor is any all-inclusive list proposed for the research areas that might be included. Four of these are discussed in some detail immediately hereunder: Oceanography, Astronomy, Aeronautics, and Space. Responsibility in these fields is now divided. Each is essentially non-departmental in character and would be well situated within the National Research Council as a semi-autonomous body.

ASTRONOMY

8 Several departments and agencies of the Canadian government are active in astronomy.

9 The Dominion Observatories Branch of the Department of Mines and Technical Surveys is a complex of astronomical and geophysical establishments. It is a true research organization with few other responsibilities.

10 There are seven divisions of the Branch, four concerned with astronomy and three with geophysical phenomena. These are: Positional Astronomy, Stellar Physics, Dominion Astrophysical Observatory (Victoria) and Dominion Radio Astrophysical Laboratory (Penticton) in the first group; and Gravity, Geomagnetism and Seismology in the second. Each division is administered scientifically as a separate laboratory and there is little or no interchange of personnel, although at small and remote sites some co-operative observation occurs.

11 The trebling of the cost of operations of the Dominion Observatories Branch in the past few years is attributable in part to extension of its work to distant places, particularly in the far north where costs are high. There have also been large expenditures on new equipment.

12 Research in radio-astronomy has also been carried out recently in the National Research Council (Radio and Electrical Engineering Division) and in the Defence Research Board (Defence Research Telecommunications Establishment). It has arisen out of interest in the electronic techniques rather than from a fundamental interest in astronomy. Research in radio-

astronomy requires expensive apparatus; the facilities of the Radio Astrophysical Laboratory in Penticton cost approximately $1 million. The National Research Council already has extensive facilities on a less favorable site in Algonquin Park and proposes to install there a larger telescope than that at Penticton. The Algonquin Park facilities also serve the University of Toronto, but it is doubtful whether their separation from the main body of astronomy in Canada can be justified on these grounds alone.

13 There is little to recommend the present administrative association of astronomy with geophysical activities or with the Department of Mines and Technical Surveys. It would be more logical to gather into the Dominion Observatories all federal work in astronomy and its closely related fields. This would require transferring to the Branch the radio-telescope facilities now maintained by the National Research Council and the Defence Research Board. The network of astronomical observatories thus created would form a logical administrative and scientific group.

14 *We therefore recommend that:*

> All federal astronomical research be consolidated in the Dominion Observatories Branch, which should become a national institute of astronomy within the National Research Council.

SPACE RESEARCH

15 Space research is intimately related to a wide range of other topics. Astronomy, aeronautics, and meteorology are obvious examples; and there are certain subjects connected not with outer space but with the upper atmosphere which are nevertheless classed as space research. Space research does not appear in the Estimates as a distinct item, but it is in fact being carried on in a number of government laboratories. The most important of these are in the Defence Research Board, the National Research Council and the Department of Transport.

16 It has been estimated that the non-military content of the above research involves directly some seventy people at a cost of about $2 million a year. Slightly less than half the research depends upon the use of the rocket-launching facility at Churchill, Manitoba, built by the United States Army as a contribution to the International Geophysical Year. Liaison has been difficult because of the divided responsibility for rocket launching and scientific research. It has been suggested that the new launching facility be operated by Canada, and that the National Research Council assume responsibility for it. Research in upper atmosphere and space physics is widely dispersed in departments and agencies and has suffered from the lack of a Canadian rocket facility. Should it be government policy to expand this research, Canada should take over the rocket-launching facilities at Churchill.

17 The Radio and Electrical Engineering Division of the National Research Council conducts a substantial amount of defence research which grew out of wartime work on radar. This defence research should be transferred to the Defence Research Board. With the advent of satellite communications and the necessity for radio control of rockets and for data telemetry, it is difficult to separate modern communications problems from space research. Space and Telecommunications Research would be a suitable major programme to succeed defence research in the Radio and Electrical Engineering Division. All non-military space and telecommunications research could be transferred to the Radio and Electrical Engineering Division of the National Research Council. This Division should be made responsible for the scientific operation of the Churchill rocket-launching facility. The research should comprise:

- All upper atmosphere research conducted by the Defence Research Board which is not of direct significance to defence, whether or not it involves the use of rockets.
- All upper atmosphere and satellite research now conducted in other divisions of the National Research Council, for example that on cosmic rays.
- The research now conducted in the Radio and Electrical Engineering Division on meteors and satellites and the operation of Minitrack instrumentation.
- Research on satellite communications on behalf of the Department of Transport, which should not be encouraged to set up its own facilities.

OCEANOGRAPHY

18 Before 1962, a number of government and other agencies had direct or indirect interest in oceanography. They kept in touch with one another through an informal Canadian Joint Committee on Oceanography, which included representation of all government agencies active in the field and of the universities that have departments of oceanography or related subjects. Increasing interest in Canada and abroad, together with the creation of official international organizations, made a more formal arrangement desirable. A major reorganization of federal government oceanographic activities was instituted on April 1st, 1962. The new arrangement had to take into account the following Canadian interests:

- *Defence*, particularly naval interest in anti-submarine warfare, and work of the Defence Research Board.
- *Fisheries*, including the Fisheries Research Board, concerned especially with marine biology.
- *Hydrography*, represented by the Department of Mines and Technical Surveys, and including the study of tides and currents, as well as charting.
- *Transport*, including several agencies in both Marine and Air Services.
- *The National Research Council*, with a variety of interests, including marine model studies.
- *Several universities*, notably British Columbia, Toronto, and Dalhousie.
- *Other groups* interested in such related topics as disposal of atomic waste, oil pollution, the study of submarine geology, and observations and forecasting of sea-ice.

19 From this diversity of interests and variety of organizational forms a new pattern was evolved. The system now in effect divides official responsibility for oceanography within the government between two main agencies, leaving certain additional subsidiary interests intact. The two main groups are the Department of Mines and Technical Surveys, which established a new branch to include both hydrographic surveying and physical oceanography and takes care of certain defence requirements, and the Fisheries Research Board, which is largely responsible for marine biology.

20 Other interests remain much as before, except for a strengthening of university work made possible by government assistance. A reasonably clear definition of the responsibilities of the different agencies has been prepared.

21 The Canadian Committee on Oceanography serves as a co-ordinating body, representing government and university organizations actively engaged in the work, and also advises the government on international oceanographic matters. Working groups on oceanography have been established on the east and west coasts of Canada, and on the Great Lakes.

22 A number of major new undertakings have been started which increase the capacity of Canadian oceanography to meet the demands being placed on it, both nationally and internationally. An oceanographic research institute is being built near Halifax, both to house physical oceanography research, largely under the auspices of Mines and Technical Surveys and the Fisheries Research Board, and to serve as a base for hydrographic activities and as regional headquarters for marine sciences. It will be administered by the Department of Mines and Technical Surveys. A similar station will eventually be built on the west coast. Aid to universities is being increased to enable them to carry on research and instruction in oceanography with a view to increasing the flow of trained scientists to government services.

23 The integration now taking place will bring problems which need intensive study. Integration, within the Department of Mines and Technical Surveys, of the traditionally distinct fields of hydrography and oceanography will require joint use of vessels and the gradual blending of personnel with distinct traditions. The hydrographic profession has, traditionally, been non-scientific, and university training has not been a normal qualification for it. Within the government service there is a growing separation of physical and biological oceanography. This is inherent in the division of labour between the Fisheries Research Board and the Department of Mines and Technical Surveys, which may make the work of university oceanographers more difficult, since it divides administratively what is to them a unified field.

24 There may be a relative weakening of non-governmental influence on the Canadian Committee on Oceanography and particularly on the Fisheries Research Board, due in part to the expansion of government activities and the overwhelming importance of government finance. Strengthening of university work and representation is vital to meet the great demand for new recruits to the profession.

25 The separation of physical oceanography and marine biology on the east coast (the one at Halifax and the other at St. Andrews) merits study. A similar division may arise on the west coast should a new oceanographic institute be built there. On scientific and related grounds, there is now little to commend the location of the marine biological institute at St. Andrews, New Brunswick. It could be transferred to the site of the oceanographic station at Halifax.

26 The Department of Mines and Technical Surveys is responsible for Arctic oceanography. This includes parts of the polar basin and the channels linking it with southern Canada. The Polar Continental Shelf Project has for the past three years contributed useful data on summer conditions, but no organization yet exists for securing corresponding information during winter.

AERONAUTICS

27 Although aeronautical research has a long and honoured tradition in Canada, dating from the early years of the present century, it was not until the period 1939-50 that the Canadian government first established aeronautical research facilities, within the Mechanical Engineering Division of the National Research Council. In 1950, due to the rapid development of aeronautical science and technology, and to Canada's interest in setting up aircraft development and production facilities in connection with defence requirements, the Cabinet authorized the creation of the National Aeronautical Establishment. Its terms of reference were: "The National Aeronautical Establishment will comprise laboratories and flight test

facilities for the conduct of research and experiments required for the development and operation of military and civil aircraft in Canada."

28 To co-ordinate the work of the National Aeronautical Establishment, the National Aeronautical Research Committee was set up, which reports to a sub-committee of the Privy Council Committee on Scientific and Industrial Research, as indicated in Chart 8. A Technical Advisory Panel was also established to advise the National Aeronautical Research Committee.

Organization

29 Chart 8 shows the general organization for aeronautical research and the relationships of the various interested units. It demonstrates that the National Aeronautical Establishment is essentially under dual control. The National Aeronautical Research Committee is responsible for matters of broad policy concerning the functioning of the establishment, while the Director is responsible to the President of the National Research Council for matters related to administration. This arrangement reflects the essentially interdepartmental and interagency character of the National Aeronautical Research Committee, the members of which are the Chairman of the Defence Research Board, the President of the National Research Council, the Chief of the Air Staff, and the Deputy Ministers of Defence Production and Transport. The membership of the Technical Advisory Panel is likewise broadly based.

30 Of continuing importance is the role of the National Research Council's Associate Committees concerned with aeronautics. These were set up to enable experts from the government service, the universities, and industry to discuss technical problems of mutual interest. They were never intended to advise on research and development programmes—this is the *raison d'être* for the Technical Advisory Panel.

31 Responsibility for the essentially defence aspects of aeronautical research rests with the Defence Research Board. Some important areas of aeronautical research are being investigated at the Canadian Army Research and Development Establishment, more particularly in the field of re-entry physics and the development of associated hypersonic range facilities. The Institute of Aerophysics, University of Toronto, which has been partially supported by the Defence Research Board, is recognized as an international laboratory for basic research in aerophysics. The Defence Research Board does not have extensive aeronautical laboratory or test facilities at its disposal, and use is made of the facilities of the Aeronautical Establishment, with which there is close co-operation.

32 The Directorate of Engineering Research (Defence Research Board) is responsible, among other activities, for monitoring Armed Services development contracts in aeronautical engineering, and for the development of special types of aircraft, such as vertical-take-off and short-take-off aircraft. However, the major responsibility for military aircraft development rests with the Directorate of Aircraft Engineering, RCAF. This directorate is one of four reporting to the Chief of Aeronautical Engineering. It is responsible for developing aircraft to the stage when flight tests are carried out and accordingly works in close association with the aircraft industry. At present, the professional staff totals only eighteen officers.

33 The Mechanical Engineering Division of the National Research Council is responsible for the propulsion aspects of aeronautical engineering.

34 The major expenditures involved in the creation of the National Aeronautical Establishment have arisen in connection with the 5-foot transonic-supersonic wind tunnel under construction at Uplands Airport.

Chart 8—AERONAUTICAL RESEARCH ORGANIZATION

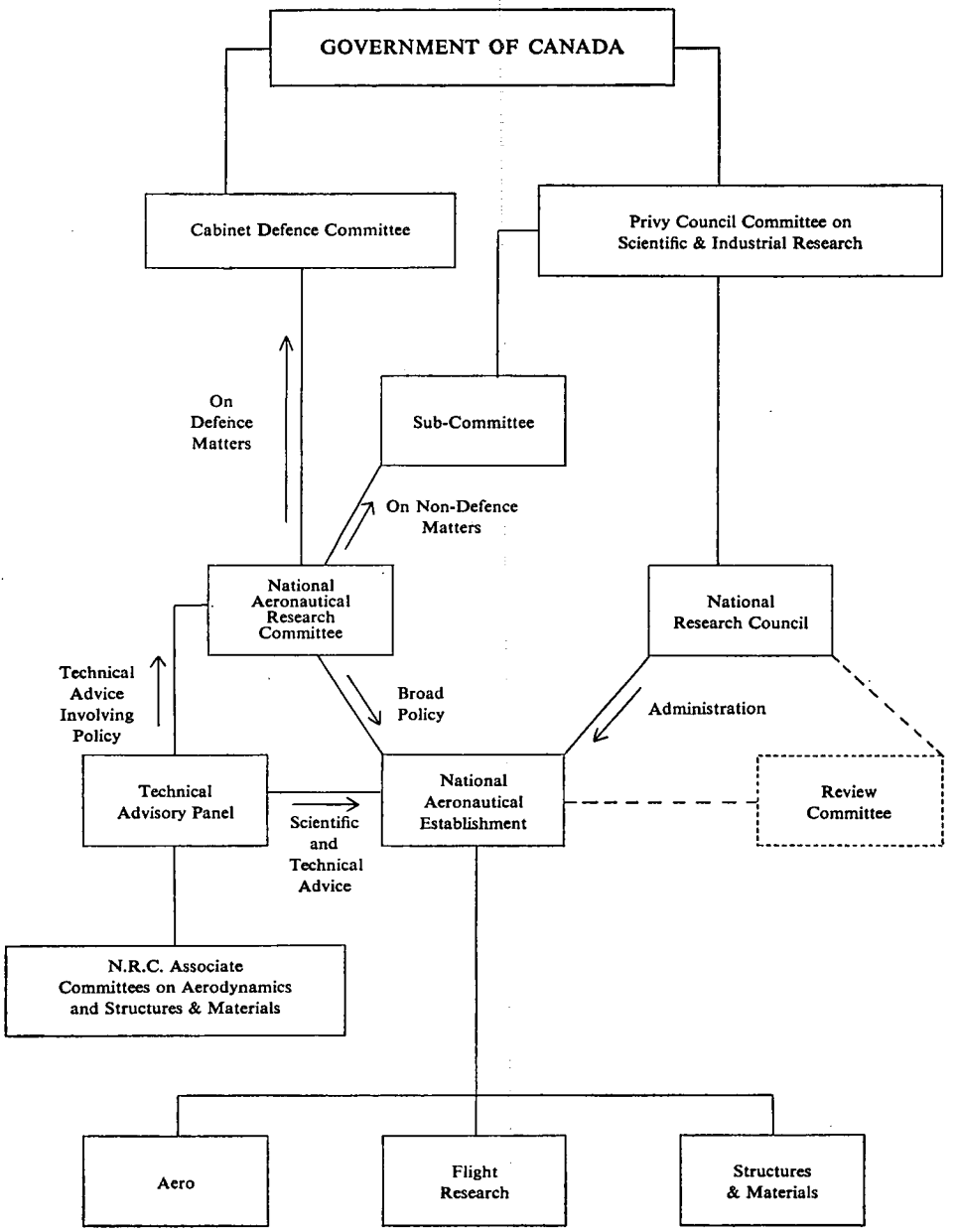


Table 4—APPROXIMATE DISTRIBUTION OF NATIONAL AERONAUTICAL ESTABLISHMENT PROFESSIONAL AND TECHNICAL STAFF AMONG SECTIONS, 1959-61

Section	*1959-60*	*1960-61*	*1961-62*
Aerodynamics	53	69	79
Flight Research	40	43	49
Structures	35	37	41
Service	16	15	15
Administration	3	3	3

Table 5—OPERATING BUDGETS OF THE NATIONAL AERONAUTICAL ESTABLISHMENT 1960-62

	Salaries	*Operations and Travel*	*Total*
	$	$	$
1960-61	1,002,000	344,000	1,346,000
1961-62 (estimated)	1,105,000	428,000	1,533,000

Although the National Research Council is the design authority and is responsible for the construction of the wind tunnel, the costs have been shared almost equally with the Defence Research Board. The fact that the Aerodynamics Section has at present the largest group of personnel is directly related to the building of the wind tunnel.

National Aeronautical Establishment Programme

35 The National Aeronautical Establishment programme is co-ordinated to a certain extent with the aeronautical research of the NATO nations through the NATO Advisory Group for Aeronautical Research and Development; close relations with nations of the British Commonwealth are maintained through the Commonwealth Advisory Aeronautical Research Council.

36 Although the 5-foot wind tunnel is the chief government aeronautical development project in hand, it is usually considered independently of the current National Aeronautical Establishment programme. Total expenditures to date have been approximately $9 million and the project has suffered from lack of co-ordination; at the time of review the tunnel was still not in operation after ten years' work, although similar facilities have been established in the United States in three to four years and at less cost. A detailed study of the wind tunnel project is beyond the scope of this Commission but nonetheless merits attention.

37 Several other topics are being investigated by the Establishment. The Aerodynamics Section is studying the aerodynamics of vertical take-off and landing; heat transfer problems in hypersonic flight; boundary layers, configuration optimization, and flutter research programmes in preparation for the 5-foot wind tunnel; and extension of the hypersonic work to include plasma jets and magneto-gas dynamics. The Structures Section is studying problems in structural analysis, dynamic plasticity, fatigue, non-metallic engineering materials, structural stability, and kinetic heating. The Flight Research Laboratory, which depends for its flight facilities (both men and machines) on the RCAF, is studying thrust augmentation, control systems for low-speed and hovering flight, slip-stream deflection and high lift devices applicable to vertical-take-off and landing and short-take-off and landing aircraft, stability, precipitation physics, air loads, and airborne magnetometry.

Programmes of Division of Mechanical Engineering (National Research Council)

38 Aeronautical research is carried out in the Gas Dynamics, Instrument, Low Temperature, and Engine Sections of the Division. Current activities include investigation of the behaviour of the vertical-take-off and landing fan, with special reference to the measurement of power, efficiency and air-

flow; experiments on vertical-take-off and landing aircraft models; control systems for the supersonic wind tunnel; aircraft noise; and air traffic control.

Programmes of the Directorate of Aircraft Engineering, RCAF

39 The work of this Directorate is closely associated with industrial programmes. Its responsibilities include modification of the CF 104 and CK 109 aircraft to Canadian requirements, development of the CC 106 transport aircraft, and special studies, including airworthiness.

40 In view of the fact that the total professional staff of the Directorate is only eighteen officers, of whom fourteen have professional engineering qualifications (four have higher degrees), it is clear that the development programmes can only be dealt with superficially, and it would be more appropriate to regard the Directorate as being responsible for specification rather than development work. For example, the design of a single military aircraft usually involves more than 100,000 professional man-hours.

Programmes of the Directorate of Engineering Research (Defence Research Board)

41 The programme of this Directorate, which is closely concerned with technological aspects of the Department of Defence Production development-sharing programme, is carried out in collaboration with industry and the universities. The six professionals in the directorate handle, in addition to aeronautics research and development programmes, such matters as hydrofoil development and land-vehicle mobility; the results achieved to date constitute a praiseworthy effort.

42 For example, the development of the Caribou aircraft has benefitted from encouragement by the Directorate. A large number of these aircraft are being exported to the United States and other countries. This project exemplifies the importance of pursuing development projects, especially novel ones, to their conclusion.

43 The major portion of the aeronautical research and development programme is concerned chiefly with the development of new propulsion units for short-take-off and landing and vertical-take-off and landing aircraft, and with the structure of these aircraft.

Co-ordination of Aeronautical Research and Development

44 The National Aeronautical Research Committee is the senior body in Canada for the formulation of government aeronautical research and development policy. However, when it was established in 1950, it was regarded essentially as the parent body of the National Aeronautical Establishment. The subsequent activities of the Technical Advisory Panel, the chief scientific advisory panel to the Committee, were concerned largely with the programme of the National Aeronautical Establishment. Moreover, the official organization chart implies that the Committee and the Panel are concerned solely with National Aeronautical Establishment affairs, to the exclusion of other government-sponsored programmes in aeronautical science and engineering.

45 Thus, although the National Aeronautical Research Committee is responsible for the formulation of policy for the National Aeronautical Establishment, there appears to be no single body for the co-ordination of the aeronautical research and development programmes carried out by, or sponsored by, the Defence Research Board, the RCAF, the Department of Defence Production, the Department of Transport and the National Research Council.

46 There is a small measure of co-ordination of programmes between, for example,

the RCAF Directorate of Aeronautical Engineering and the Defence Research Board Directorate of Engineering Research, through the medium of the Technical Advisory Panel. However, in practice, the Defence Research Board Directorate does not give advice to the RCAF in connection with aircraft development problems. Nor are the vertical-take-off and landing and short-take-off and landing programmes (supported by the Department of Defence Production, with the assistance of the Defence Research Board) co-ordinated effectively with similar programmes being undertaken by the National Aeronautical Establishment.

47 Your Commissioners see no justification for two large-scale government aeronautical establishments, one civil and one military. The National Aeronautical Establishment should suffice to handle both defence and civil programmes. If, as recommended in Part 1, the responsibility for all defence development programmes is vested in the Defence Research Board, the problem of co-ordinating the defence and civil aeronautical research programmes would be simplified. The National Aeronautical Research Committee is responsible for the formulation of policy and the co-ordination of government aeronautical research activities in Canada, and it should assume responsibility for co-ordinating the programmes of the Defence Research Board, the RCAF and the Department of Defence Production in this field.

48 The recent expansion in the membership of the Technical Advisory Panel to include two members from industry should serve to minimize, in the future, the possibility of comparatively large-scale aeronautical development programmes getting out of control. The Panel will also serve as a focus for the co-ordination of national programmes. The future collaboration between the National Aeronautics Establishment and the Canadian aircraft industry is considered to be of great importance, and it should be high on the list for discussion by the re-vitalized Technical Advisory Panel.

6

DEPARTMENTAL RESEARCH OF COMMON INTEREST

1 Several areas of research are of interest to more than one department. Some of these, discussed in the preceding chapter are not essentially related to operational activities, and accordingly it was recommended that they be consolidated within the framework of an enlarged National Research Council.

2 The research areas discussed in this chapter are related to departmental operations: the Polar Continental Shelf Project, Northern Research, and Ice Research. The first represents the best solution yet found to minimize duplication of departmental effort, and to take advantage of common services and a co-ordinated approach. There is no doubt that in future years more and more research programmes will require co-operation of several departments and agencies. It is essential that means be developed to prevent the waste and duplication now current in such programmes. No master plan suitable in every case is proposed in this chapter. Rather, in the context of each programme, suggestions are made which seem most suitable in the circumstances. Certain principles common to all such undertakings emerge.

POLAR CONTINENTAL SHELF PROJECT

3 This Project was organized to carry out a programme of survey and scientific research in the area of the continental shelf of the Arctic Ocean adjacent to and within Canada. In practice, the work has extended to some of the Queen Elizabeth Islands and shows evidence of expanding southward toward the mainland. The need for it arose in part from the United Nations Conference on Laws of the Sea in 1958, which allocated minerals within the continental shelf to the adjacent state, and in part from the lack of any detailed study of the northern continental shelf. It was decided to prepare a programme which would include all aspects of technical survey and research in the physical sciences within a single co-ordinated project. A steering committee was set up within the Department of Mines and Technical Surveys and a Co-ordinator appointed. The first summer field season was in 1959, and the work continues.

4 The organization is flexible. During 1961 a total of about seventy persons were active on the Project, including twelve scientists

seconded from other agencies. It is expected that the permanent staff will remain small, and that the scientific staff will vary in size and character as the programme itself changes. The total cost attributable directly to the Project for the year 1961–62 is estimated at $1,572,000. Two university projects operating in the same general areas have received some assistance.

5 There has not been a continuous programme in all fields. The intention is to initiate programmes that appear necessary and terminate them when adequately covered. In this way there will be a continual change of emphasis. In 1961 programmes in progress concerned oceanography, hydrography, submarine geology, topographical surveying, aeromagnetic surveying, geomagnetism, seismic and gravity surveying, glaciology, geomorphology, and sea-ice studies. If it is shown that a long-term routine programme is justified, the present view is that this programme may eventually be assigned to a department.

6 The essential difference between this project and the traditional surveys of the various departments is that it is centrally planned and organized. There is a single headquarters and a single logistic and supply service. Scientists from various disciplines have been compelled by local circumstances to work together in the field, and to become familiar with each other's techniques and results. This interdisciplinary approach has obvious scientific advantages.

7 Nevertheless, there may be continuing problems due to the traditionally rigid division between scientific and technical disciplines. For example, the Geological Survey and the Hydrographic Survey have for decades been accustomed to working as distinct, closely knit units. As such they have planned their own field or office operations entirely independently, and publicity concerning the work has been harvested by the individual unit. Clearly such luxuries are not possible under the new arrangement. It is still uncertain whether the common interest in economy of operation, and the flexibility of programmes and staffing arrangements, can overcome the very strong departmental tradition of independence.

8 Because the Project, in its conception, staffing and administration, runs counter to strongly entrenched departmental and branch autonomy, a firm policy will be required to prevent it being taken over by the stronger of the existing branches of Mines and Technical Surveys. At present it is attached to the office of the Director-General for Scientific Services and will continue to need some such association to provide the necessary authority and independence.

ICE STUDIES

9 Study of ice is now of major scientific concern in Canada due to greatly increased activity in the far north in summer, the extension of winter navigation in eastern Canada, the need to understand the *régimes* of glacier-fed rivers in the west, and a general increase in interest in all aspects of the Canadian natural environment.

10 Ice studies carried on in Canada are of two main types: those concerned with ice in navigable waterways, and with ice on land. Several agencies have become interested in the scientific study of ice since World War II, and there has been a notable increase in the extent of the work during the past decade. Some co-ordination is provided by the Canadian Committee on Oceanography Working Group on Ice in Navigable Waters, and by a sub-section of the National Research Council Associate Committee on Geodesy and Geophysics that deals with glaciology. The main areas of interest and the active agencies are:

Ice in Navigable Waterways:

- Navigation—Royal Canadian Navy, Department of Transport (Marine Services), and private shipping interests.
- Fishing, sealing—Fisheries Research Board, and some provinces.
- Defence—Defence Research Board, RCAF, and other Services.
- Observation and forecasting for navigation—Department of Transport (Meteorological Branch and Marine Operations), Department of Mines and Technical Surveys (Geographical Branch).
- Origin and distribution of sea ice—Mines and Technical Surveys (Oceanographic Division and Geographical Branch).
- Historical distribution of sea ice and factors responsible for it—Department of Mines and Technical Surveys (Geographical Branch).

Land Ice:

- As a source of irrigation and industrial water—Department of Northern Affairs and National Resources (Water Resources Branch).
- Glaciology—Department of Mines and Technical Surveys (Geographical Branch).
- Building and related problems and foundation studies, including permafrost—National Research Council (Building Research Division).

11 Knowledge of the origins, distribution, movements and decay of ice in the sea is of great practical significance to navigation in Canadian waters, but continued improvement in this knowledge is impossible without basic research. Canada should be a major contributor to ice research but has not been in the past, largely because of a lack of a carefully planned and generally accepted research programme in the federal government; absence of agreement within the government on areas of responsibility; shortage of qualified scientists; and inadequacy of university training facilities. The few qualified ice scientists available have been scattered through several agencies and have worked without co-ordination. For example, the National Research Council Division of Building Research has for many years carried on a programme under its Snow and Ice Section and another under its Northern Building Section. Scientists with similar training and interests have been at work in the Geographical Branch of the Department of Mines and Technical Surveys, the Geological Survey of Canada, and the Defence Research Board. Most of the field glaciology, as well as glacial morphology and periglacial studies, have been carried out by the Geographical Branch. In recent years the Water Resources Branch of the Department of Northern Affairs and National Resources has carried on a glacier survey programme.

12 Study of ice in seas and lakes is of interest to many agencies, so that the danger of duplication and wasted effort is great. For example, some observation of sea-ice is undertaken by a unit of the Meteorological Branch of the Department of Transport, some by the same Department's Marine Operations Branch, and some by the Geographical Branch of the Department of Mines and Technical Surveys, although for different purposes. Research on the origins and distribution of sea-ice is of interest to the Meteorological Branch, the Geographical Branch, the Division of Oceanography of the Department of Mines and Technical Surveys, the Defence Research Board, and some others.

13 Large expenditures of public funds have been made to charter aircraft for ice observation. Some at least of this expensive direct observation could be avoided if the reasons

behind the changing distribution of sea-ice were understood; this can only be achieved as a result of basic research. Ice observation is not a routine matter, and techniques are not yet exact; in fact, considerable criticism has resulted from its imperfections in eastern Canadian waters in recent years. Ice distribution forecasts are said to be even less dependable.

14 The cause of these deficiencies is not hard to trace. Ice observation was first undertaken by the Meteorological Branch about five years ago without extensive experience or well qualified personnel. The whole undertaking still carries too many signs of being an *ad hoc* appendage to an otherwise efficient meteorological service. Training in meteorology provides little or no qualification for ice observation and forecasting. Most of the meteorological ice observers are technicians with little understanding of the complex problems of ice navigation. Better qualified oceanographers have not been actively interested until recently, and they are still few in number. The only government agency with long-term experience (about ten years) is the Geographical Branch. It has published a series of annual reports on ice conditions in the Arctic and the Gulf of St. Lawrence which have been well received by those planning commercial navigation in ice-filled waters. However, the Branch has been chronically short of qualified personnel in this field.

15 Sea-ice studies in the Canadian eastern Arctic and off the Atlantic coast should logically be closely co-ordinated with those conducted by Denmark in Greenland waters. Canadian scientists should also be familiar with the long-term research of Soviet scientists into the movement of polar ice, both within the polar basin itself and in the adjacent seas.

16 Increased interest in Canada in the science of hydrology has led to initiation of long-term studies of glaciers that contribute to stream flow in the mountains of Alberta and British Columbia. This is a matter of special interest to the western prairies. There is need to ensure the maximum of concentrated effort by available government scientists and a minimum of overlapping by several agencies.

Future Policy

17 To avoid duplication of effort and the consequent waste of personnel and finances, it will be necessary to correlate the work of all government agencies concerned with ice studies. This responsibility should be assigned to the proposed Central Scientific Bureau. In the various fields of study, specific responsibilities should be assigned.

18 The Geographical Branch of the Department of Mines and Technical Surveys should be recognized as the centre for glaciological research in the federal government. The limited work in this respect now carried on by the Geophysical Research Section of the Directorate of Physical Research, Defence Research Board, should be transferred to the Geographical Branch.

19 Research concerning ice in seas, lakes and rivers can, under present circumstances, best be undertaken through a division of responsibility as follows:

- Observation of ice distribution for tactical support of ships, the plotting of the data on maps, and short-term forecasting, at present in part a responsibility of the Meteorological Branch, Department of Transport, should probably be a responsibility of the Marine Operations Branch of that Department, since it is in direct contact with those using the information. Improvements are needed in the system of gathering and disseminating the information, since speed is essential. The continual shortage of meteorologists and technicians in the Meteorological Branch suggests that this agency should be relieved from a

growing burden of ice observation and forecasting.

- Analysis of ice distribution over longer periods, and the preparation of longer-term forecasts, which involve a more profound study of the physical forces at work, should be a responsibility of the Oceanography Institute at Halifax. Meteorologists from the present Halifax Ice Centre or elsewhere should be seconded there if needed. It should be the centre for government research into the factors influencing the origin, distribution and decay of sea-ice.
- Historical studies of ice distribution based on past records and on those secured from the Marine Operations Branch and the Oceanography Institute, with the recording function, should remain a responsibility of the Geographical Branch. For these purposes, periodical ice reconnaissance flights should be undertaken to record the state of the ice at specific times of the year and at specified locations, as part of a long-term study. Annual reports on sea-ice distribution in Canada should be produced by this Branch.

20 As in the past, fundamental ice research should be carried on at universities, aided by government grants. It should be closely co-ordinated with similar work in the National Research Council, but expansion in ice research should preferably take place at universities.

21 Ice observation and forecasting, and the study of its origins, are obviously best carried out in close relationship with other countries. Hence, emphasis should be laid on international co-operation in ice research and in the allocation of different spheres of scientific interest to the various countries concerned.

NORTHERN RESEARCH AND DEVELOPMENT

22 Research in northern Canada is carried on by several departments and agencies of the federal government, and by private organizations and individuals.

23 There is no agreed division of responsibility for scientific research between the Department of Northern Affairs and National Resources and other federal departments and agencies, and applications by the former for major research funds have been rejected because the National Research Council and other agencies were more appropriate.

24 Non-governmental research has a long history in the north. Individuals and university groups, both Canadian and foreign, as well as such organizations as the Arctic Institute of North America, have been active. An increasing proportion of funds for such work has come from government sources, some from the United States.

25 Since World War II federal departments and agencies have greatly expanded their scientific activities in the north. Among them are the Department of Mines and Technical Surveys (which has long had an interest), the Fisheries Research Board, the Defence Research Board, the National Research Council, the Department of Transport, and even the Department of Agriculture, whose far-ranging botanists have reached the shores of the Polar Sea. So diverse are these undertakings, and so tangled their lines of administrative responsibility, that nowhere could your Commissioners find a fully comprehensive report on their character, extent, use of manpower and total expenditure.

26 While all scientific departments have some interest in the north, Northern Affairs and National Resources has general and special interests, and its responsibilities must be borne in mind in any assessment of the research roles of government departments in the north.

Research Programmes

27 Apart from the Northern Co-ordination

and Research Centre, which carries on little direct research, two units of the Department of Northern Affairs and National Resources engage in some northern research. These are the National Museum and the Canadian Wildlife Service, whose programmes have been described. In addition, the Water Resources Branch may be expected to extend its general programme to the north at an increasing rate. It is commonly believed that the Northern Administration Branch does no research. In fact, some activities of the Industrial, Engineering, and Resources Divisions can be considered as research or development. Projects are of two main types: those directed to the solution of technical problems, for example housing and other construction, techniques for processing natural products, and surveys directed at community development; and studies in the social sciences made with a view to solving social problems.

28 No central records are maintained concerning northern research by other agencies except for a listing of permits issued to "scientists and explorers", and these are not required of government parties. Since detailed research data are not available, it is difficult to assess its extent, effectiveness, degree of co-ordination, economy of operation and general adequacy. From what is known, the research falls into the following main categories:

- Extension to the north of types of research long carried on in southern Canada by the Departments of Mines and Technical Surveys (Geological Survey, Dominion Observatories, Geographical Branch, et cetera), Transport (Meteorology), and Agriculture (Entomology and Botany), and by the National Museum (diverse sciences) and the National Research Council.
- Specific tasks related to economic or social developments, for example Department of Northern Affairs (regional planning, resources studies).
- Research of the type sponsored by the Arctic Institute (Devon Island research station), Defence Research Board (Lake Hazen Station), McGill University (Axel Heiberg Station), Northern Research and Co-ordination Centre, and smaller-scale undertakings by individuals.
- Co-ordinated area projects, of which the main example so far has been the Polar Continental Shelf Project.

29 Many agencies are at work independently and when several concentrate at one place there is a scientific research complex, which could be treated as a station or centre. Experience at Resolute Bay, where a variety of scientific work has been carried on since 1947, is illuminating. In October, 1961, when all summer activities of a temporary character had ended, the following Canadian government civilian agencies were engaged there in scientific work:

- Department of Transport—
  meteorological observations
  ozone research
  ice measurement
  temperature measurement at depth
  telecommunications
- Defence Research Board—
  telecommunications
  back scatter
  oblique incidence
  topside sounder
- National Research Council—
  cosmic rays
  Aurora studies
  spectrometer
  snow studies
- Department of Mines and Technical Surveys—
  seismology
  magnetism
  tidal gauging

30 This obviously represents a comprehensive programme of geophysical research.

While the projects may not be competitive with each other, there is no evidence that they are parts of a unified and systematic inquiry, or that they are even co-ordinated logistically.

Inter-departmental Co-ordination

31 Co-ordination of the multifarious northern scientific programmes is in theory the responsibility of the Department of Northern Affairs and National Resources. The Advisory Committee on Northern Development has the following terms of reference:

To advise the government on questions of policy relating to civilian and military undertakings in northern Canada *and to provide for the effective co-ordination of all government activities in that area.*

32 This Committee, under the chairmanship of the Deputy Minister of Northern Affairs and National Resources, consists of all Deputy Ministers and other equivalent officials whose departments are active in the north. The Committee maintains a small secretariat headed by a senior official of the Department of Northern Affairs and National Resources. Much of its work is done through a series of sub-committees dealing with transport, communications, construction, and scientific research.

33 The Scientific Research Sub-committee was formed in 1959 and has been relatively active. It has discussed major proposals concerning northern research, for example the plans to build and operate a scientific station at Inuvik near the mouth of the Mackenzie River. It has recommended grants to research organizations, such as the Arctic Institute. The Research Sub-committee does not, however, control routine scientific work conducted in the north by government departments, and has no authority to review budgets or other proposed expenditures on research.

34 The whole committee structure is advisory and lies outside the normal lines of administrative and financial responsibility passing from the departments through their ministers to the Cabinet. It consists of staff members of departments, whose first loyalty is to their own organizations. Such a committee system may be useful as a clearing house for information on forthcoming research. It can even provide a service by supporting the plans of a unit wishing to secure funds from the Treasury Board. What it cannot do is restrict the ambitions of its own members, or compel them to integrate their activities in the interests of long-term scientific planning, conservation of manpower, or economy of public funds.

Northern Co-ordination and Research Centre

35 The Centre was founded in 1954 to undertake research on northern subjects, to encourage northern research by non-government agencies, to co-ordinate departmental and interdepartmental northern research, and to collect and disseminate technical and scientific information on the north. The Centre reports through the Secretary of the Advisory Committee on Northern Research to the Deputy Minister of the Department. The total staff of sixteen includes personnel both of the Centre proper and of the Committee secretariat.

36 The Centre specifically has the obligation "to co-ordinate departmental and interdepartmental research in the north. . . . ." Had it been able to fulfil its co-ordinating role effectively, many current difficulties might have been avoided. The Centre has failed to meet expectations for several reasons:

- It received neither adequate funds nor sufficient personnel.
- Other agencies have preferred to develop their own facilities, for which funds and personnel have apparently been available.
- Neither government agencies nor the interested public have, to any considerable

extent, turned to the Centre for information, and it has not become the source of specialized information.

- The Centre's authority to undertake research itself, though circumscribed, has raised the fear among departments that it would compete with them in their own special fields.
- Little has been done to encourage non-government agencies to undertake research in the north.

37 The Centre has not been entirely unsuccessful. It exists as a possible nucleus of a much more effective organization, and has meanwhile maintained a departmental northern library and dispensed a small research fund, mainly in the field of anthropology, although in almost every case the topics selected could have been dealt with by another research unit of the government.

Re-organization of Northern Research

38 The present organization of northern research is clearly unsatisfactory. Most research to date has concerned the natural sciences, and has been generally limited to collection and correlation of data. There has been no serious attempt to plan an overall unified campaign, except for topographic and other mapping, including geology and some aspects of geophysics. In these cases the separate agencies directly concerned have made their own long-term or seasonal plans.

39 Until recently there has been relative neglect of the social sciences. Studies related to administrative planning, to the adaptation of the native peoples to changing conditions, to the effect of government and other policies upon the lives of such people, are now beginning to receive attention. It has become apparent, though, that qualified and experienced scientists are rare in these fields.

40 There are at present several ways in which northern research can be carried out. They are:

- Through the separate federal departments or agencies as a routine extension of work being undertaken in the south.
- By the Department of Northern Affairs and National Resources, because of its special responsibility for activities in the territories.
- Through some form of interdepartmental body; the Polar Continental Shelf Project is an example, although administered from the Department of Mines and Technical Surveys.
- By non-government organizations, such as universities or the Arctic Institute.

Whatever organization may be employed to undertake research in the north, a substantial portion of the costs will have to be borne from public funds.

41 In the past decade, the tendency has been for departments to expand their facilities and staffs in order to undertake large-scale northern research programmes. This is particularly true of the Departments of Mines and Technical Surveys, Transport, and Fisheries, but less so, as yet, of Forestry and Agriculture. A compelling factor driving departments northward is that in the provinces they survey resources on sufferance, for the *British North America Act* gives them no authority to do so. In the territories, federal writ is still effective. This tendency to run riot in the north was foreseen in the late 1940's, and an effort was made to stem it, first, as part of a general policy not restricted to research, through the medium of the Advisory Committee on Northern Development, and later through the Northern Co-ordination and Research Centre. In effect the Committee has been used by departments wishing to secure support for a particular policy or project before submitting it to the Treasury Board, but ignored when it seemed

likely to co-ordinate or curtail their own independent plans. In any event the Committee—and still more the Centre—lacks the necessary authority to make its views effective.

42 Such interdepartmental co-ordination as takes place is largely on a voluntary basis. Even when the Advisory Committee on Northern Development has approved a proposal, there is no assurance of success unless a particular department is prepared to provide the funds. On the other hand, a department can undertake northern research without raising the matter at any co-ordinating committee, so long as it can secure the funds from the Treasury Board, which has lacked disinterested advice on the best policies to follow in granting funds for northern research. As in other areas, the result has been that those departments able to make the most forceful submissions have been the most successful.

43 Thus there is nothing to encourage interdepartmental projects, and no mechanism is provided for assuring that an appreciable amount of northern research is done by non-governmental organizations. Nor is there the means for training the scientists needed to do the work—either inside the government agencies or elsewhere. Apart from the National Research Council grants, little or no public money for the purpose has passed from departments to universities or other research groups, even during recent years when northern research expenditures have increased enormously.

44 A system of departmental control of northern research has not led to the establishment of well-balanced permanent research centres anywhere in the north, although plans were approved in 1962 for a scientific station at Inuvik, where laboratories and other facilities are to be available to all departments and possibly to independent scientists. A grouping of separate research projects exists in a few places, but with no facilities for the unaffiliated scientist. The only truly interdisciplinary stations that exist have been built through private initiative, with the exception of the Defence Research Board International Geophysical Year centre at Lake Hazen, which was staffed largely from outside the government.

Conclusions

45 The present system is wasteful of money and personnel and does little to ensure that necessary research is being carried out. Certain conclusions are evident.

- Co-ordination of scientific work in the north and the determination of priorities should be the concern of the proposed Central Scientific Bureau.
- The Department of Northern Affairs and National Resources should not itself undertake scientific research in the north (assuming, of course, that the National Museum, Canadian Wildlife Service and Water Resources Branch are transferred elsewhere). The research needs of this Department can best be met by arranging for the work to be done by the appropriate department, or by securing on temporary secondment the services of scientists needed for specific tasks; an example would be the study of the economic geology of Arctic petroleum reserves, for which task the Department of Mines and Technical Surveys is equipped. Non-government research should be actively encouraged.
- Centrally administered northern research facilities would permit the greatest possible common use. These facilities, including scientific stations and permanent research stations, represent heavy costs in construction and maintenance and should be located to serve general interests rather than those of a single agency. It would be logical to assign the responsibility for administering such facilities to the Department of Northern Affairs and National

Resources. Its role should be one of service but not control, although it should be a requirement that the various departments and agencies make use of these services.

46 *We therefore recommend that:*

1 The Department of Northern Affairs and National Resources meet its northern research needs by contracting with other federal departments or private groups.

2 Facilities and services for research in the north be provided by the Department of Northern Affairs and National Resources.

7

THE PLACE OF INDUSTRY IN GOVERNMENT RESEARCH

1 In Part 1 of this report, attention is drawn to the small share of government research that has been allocated to private industry, a situation in striking contrast to that in Britain and the United States. Canadian government expenditures for research and development in industry are mainly concerned with defence and atomic energy. The federal government has recently inaugurated specific programmes designed to encourage industry to expand its own efforts in these fields and build up better facilities and larger research staff. These are outlined below.

2 The Department of Defence Production proposed support for a research and development programme in Canadian industry. It was recognized that Canada, a comparatively small country, faced special difficulties in trying to maintain an adequate defence industry in close partnership with the United States. A common policy on military operations and research, requiring integration of weapon development and production, had obviously curtailed the independent Canadian development of major military weapons systems. There was an urgent need to support the development capability existing in Canadian industry but likely to be lost through the cancellation of development programmes. Planning was necessary for a long-term programme of industrial development to build up Canadian capacity to meet United States-Canadian defence requirements.

3 An inter-departmental committee (The Department of Defence Production Development Committee) was set up to administer the funds on the basis of recommendations from its Advisory Groups in the fields of aeronautics, electronics and weapons. The main emphasis has been placed on identifying specific United States military requirements that could be met from existing Canadian capabilities which are not now fully employed. Except for certain unique Canadian projects referred to below, long-term plans have been designed to enable Canadian industry to compete with United States industry for United States military requirements.

4 Canadian industry has had limited success in the face of United States competition

for military research projects financed from the United States. It is difficult to make a convincing story about ability to undertake research when the industry has no record of previous success in the field. Greatest success has come from projects originated and financed in Canada that were sure of adoption in the United States if they could be successfully developed. Projects now being financed jointly by the Department of Defence Production and industry include the Caribou and VTOL aircraft, airborne navigation instruments, rocket research, etcetera.

5 Even when it is agreed that development of a United States military requirement is to be financed in Canada, procedural difficulties may sometimes remain. These include ownership and use of proprietary rights, monitoring of the project by United States authorities, security clearances, etcetera. However, the main difficulty has been to discover specific United States military requirements that can be dealt with by existing Canadian industrial facilities.

6 The status on November 30, 1961, of expenditures under Vote 72 to the Department of Defence Production is shown in Table 6.

Table 6—SUSTAINING TECHNOLOGICAL CAPABILITY—DEPARTMENT OF DEFENCE PRODUCTION VOTE 72

		Programme		*Actual Expenditures*	
	No.	*1961-62*	*Future Years*	*Cumulative FY 1959-60 1960-61*	*FY 1961-62 to date*
Awaiting Treasury Board approval in principle	1	$ 10,000	$ 29,750	—	-
Approved in principle by Treasury Board	7	475,000	5,920,000	—	—
Committed (DDP 85), Treasury Board authority to enter into contract, contract placed	43	8,465,067	7,556,748	$ 4,752,775	$ 1,432,219
TOTAL	51	$ 8,950,067	$13,506,498	$ 4,752,775	$ 1,432,219

7 In 1961 the Cabinet approved the establishment of an applied research fund, as part of a defence industrial research programme. The terms agreed upon were:

- that an industrial applied defence research programme be developed by the Department of National Defence in consultation with the Departments of Defence Production and Finance;
- that, subject to the programme thus developed, research areas and projects to be supported be selected jointly by the Defence Research Board and the Department of Defence Production;
- that the specific applied research projects be recommended to Treasury Board for approval prior to contracts being placed with Canadian defence industry;
- that funds for this programme provided in Defence Research Board estimates be identified and accounted for separately from other expenditures of the Board.

8 Initially, the practice was that when a company requested support for a research programme, the merit of the proposal and the capacity of the company to undertake the task were assessed by the Defence Research Board in consultation with the Department of Defence Production and the Treasury Board; following this, financial arrangements were made through the Department of Defence Production, resulting in a contract. However, the contract procedure was found to be, in certain respects, inappropriate to this type of programme, and in the fall of 1962 it was decided that henceforth assistance would be provided by grants rather than contracts. As a result, Defence Production is now involved only in the assessment of proposals. The success of this new arrangement cannot yet be judged.

9 A third source of research funds for industry has been provided through the initiative of the National Research Council. In 1961, a statement was submitted to the Cabinet on the necessity for federal government assistance to industry for research and development. It was subsequently agreed that financial assistance be made available for research by industrial firms in Canada on the following basis:

- the assistance would be on a matching basis, with industry contributing at least half the cost of any project;
- the general purpose of the scheme would be to establish a number of competent research teams in industry each year over a period of years, and the research and development projects submitted by industry should be judged on their merits with this general purpose in mind;
- that a sum of $1 million be provided for this purpose in the parliamentary grants to the National Research Council;
- that the programme be initiated by the National Research Council on an experimental basis after consultation with industry on matters of procedural detail;
- that decisions on the award of financial aid be made by committees competent in applied research and development and that, as necessary, the Council should establish committees of experts from departments or agencies of the government and from industry;
- and that rights arising out of the research projects would be the property of the company concerned.

8

THE INTERNATIONAL RELATIONS OF CANADIAN SCIENCE

1 The past fifteen years have seen an extraordinary growth of international science, in some cases through long-established organizations, in others through agencies of the United Nations such as UNESCO, and often by *ad hoc* arrangements set up to meet an immediate need, such as the International Geophysical Year.

2 Canada has, proportionately, carried an important share of the work involved. It has been host to many international meetings, and its scientists hold office in a diversity of organizations. Official delegations have attended numerous conferences (about one hundred invitations reach the Department of External Affairs each year), and many hundreds, possibly thousands, of other scientists in universities or industries have travelled abroad to attend conferences or to visit institutions and laboratories.

3 No formal organization exists to further these arrangements. Invitations may reach the government through diplomatic channels, or come direct to government departments or to the National Research Council. There is no recognized official routine for dealing with them. The Department of External Affairs includes no specialized unit to deal with science, nor does it send abroad scientific attachés to serve as permanent representatives. Scientific relations outside the country are certainly maintained after a fashion, but it would be impossible to provide a detailed and orderly statement of how it is done. Canada's ties with the United States are unique, and liaison with its research and development organizations is as close in many cases as that within the country. On the official level the National Research Council has found it useful to keep a staff member permanently in Washington, classed as an attaché in the Canadian Embassy. A comparable situation exists in London and is eventually to be extended to Paris. Similarly, the Defence Research Board maintains official representation in Washington and London.

4 From time to time Canadians are attached for longer or shorter periods to such specialized international bodies as the World Meterological Organization, the Food and

Agriculture Organization, and the World Health Organization. The official contact with such bodies is through External Affairs, which is advised by the appropriate government department or agency. Relations with UNESCO reveal another type of official international scientific contact. This organization is not exclusively scientific, so the matter of formal representation is more complex. The government has designated the Canada Council as its adviser in this case, and a National Commission has been set up to assist in the work.

5 Canada is also associated with other official international scientific agencies which are not world-wide in membership. Examples are the scientific committees of such bodies as NATO, as well as the British Commonwealth Scientific Committee.

6 At the non-official level the picture is infinitely more complex, due in part to the variety of ways in which the many international scientific bodies are constituted. Most of the larger ones are members of the International Council of Scientific Unions. The National Research Council is Canada's official representative on the Council itself, and in some cases also provides liaison with constituent unions. Although the International Council of Scientific Unions is specifically non-governmental, the National Research Council is able to represent Canada because its membership is made up of non-official scientists.

7 The National Research Council thus meets part of the need. It has responsibilities for advising the government on internal scientific matters, and its President has come to be regarded also as an adviser in external affairs. He is in fact, if not by formal appointment, scientific adviser to the Department of External Affairs, and has on his staff a specialist in international scientific relations. As the National Research Council does not include in its responsibilities all branches of science, other government agencies quite properly reserve the right to advise External Affairs on matters in their own specific areas of interest—for example, meteorology, geology, geography, agriculture, fisheries, forestry, and oceanography.

8 National Research Council funds provide aid to non-governmental delegates and other scientists to attend international meetings. They do not cover the cost of sending abroad staff members of government departments, and the Council does not necessarily select delegates to represent Canada at international conferences.

9 No mention has been made of scientific visits abroad for other purposes than attending official or other conferences. Yet these are perhaps the most important of all international contacts made by government scientists. There is a steady going and coming of members of departmental and agency staffs. The only central record is kept in the Department of External Affairs, which is responsible for maintaining a list of persons who travel abroad on official passports.

10 To provide continuing comprehensive scientific advice to the Department of External Affairs is far from easy. The National Research Council is understood to regard existing informal arrangements as satisfactory. This view is not generally held in government scientific departments, or in the scientific community at large.

11 *We therefore recommend that:*

> Co-ordination of official scientific activities abroad should be a responsibility of the proposed Central Scientific Bureau, with the aid of the Department of External Affairs and the National Research Council.

APPENDICES 1 TO 14

CONTENTS

These statistics cover scientific research and development activities of the departments and agencies of the government. Commercially-oriented Crown corporations such as Polymer Corporation and Trans-Canada Airlines are excluded. The detailed data on the operations and areas of research of individual departments and agencies used by the Commission's staff are not shown. Statistics in the form collected by the Commission are necessary for understanding and for future co-ordination of both the government's research effort and the formulation of policy.

These statistics are based on definitions similar to those used by Dominion Bureau of Statistics. The term "scientific research and development" is defined as investigations carried out in science and technology to derive new knowledge, or to apply new or present knowledge to produce new or modified products or processes. The following activities are included:

- Conduct of research and development including planning and administration.
- Collection of scientific data in support of scientific research and development.
- Scientific information in support of research and development.
- Scholarships and Fellowships.
- Research and development financed in whole or in part by the government through contracts, grants-in-aid or other such arrangements.
- Arrangements with outside organizations for technical services such as testing and evaluation in support of research and development.

Appendix 1 — TOTAL FEDERAL GOVERNMENT EXPENDITURES BY SECTOR DOING RESEARCH AND DEVELOPMENT

($ millions)

	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962
Current Expenditures											
Federal government	63.7[1]	81.3	89.8	101.0	114.0	113.1	124.0	135.8	142.4	159.6	178.7
Industry[2]	3.2[1]	18.9	16.8	23.6	31.7	45.2	53.1	47.6	12.6	13.4	21.3
Educational organizations (universities)	3.7	4.4	4.5	5.2	5.6	7.0	7.5	10.1	13.5	15.7	17.7
Other (provincial research councils, etc.)	0.3	0.2	0.3	0.4	0.4	0.6	0.6	0.6	0.8	1.2	1.2
Federal government testing and evaluation of R & D not included elsewhere	—	—	—	—	2.0	2.1	1.0	1.5	0.9	1.0	2.9
Sub-Total	94.2[1]	104.8	111.4	130.1	153.6	168.0	186.2	195.7	170.3	191.0	221.7
Capital Expenditures											
Federal buildings and works	13.3	20.2	15.4	15.3	18.5	26.4	26.4	28.1	31.8	33.8	36.2
TOTAL	107.5[1]	125.0	126.8	145.4	172.1	194.4	212.6	223.8	202.1	224.8	257.9

[1]Figures for the Royal Canadian Air Force were not available for 1951-52. An estimated $23.3 million is included in the total but not allocated by sector.
[2]Atomic Energy of Canada Limited Research Contracts are included in Federal government.

Appendix 2—FEDERAL EXPENDITURES BY KIND OF SCIENTIFIC RESEARCH AND DEVELOPMENT ACTIVITY

($ millions)

	1951-1952[1]	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962
Operating Expenditures											
Conduct of research and development:											
Total	63.9	97.2	103.0	119.7	143.1	155.4	171.7	178.2	153.0	171.9	199.3
Outside Government	(7.1)	(23.4)	(21.4)	(28.8)	(39.1)	(54.0)	(61.3)	(59.2)	(26.8)	(29.9)	(41.0)
Collection of scientific data	4.7	5.1	5.8	7.2	6.9	8.3	9.6	12.3	11.2	12.2	14.4
Scientific information	1.9	2.1	2.3	2.6	2.7	3.1	3.6	3.9	4.4	4.9	5.6
Scholarships and fellowships	0.3	0.4	0.4	0.6	0.8	1.2	1.4	1.3	1.6	2.0	2.4
Capital Expenditures											
Buildings and works	13.3	20.2	15.4	15.3	18.5	26.4	26.4	28.1	31.8	33.8	36.2

[1]Figures for Royal Canadian Air Force not available for 1951-52.

Appendix 3—TOTAL SCIENTIFIC RESEARCH AND DEVELOPMENT PROFESSIONAL AND SUPPORTING PERSONNEL[1]

	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961
Professional Personnel										
Bachelors	1,399	1,357	1,323	1,272	1,321	1,322	1,410	1,698	1,725	1,796
Masters	743	798	840	879	918	924	953	1,039	1,018	1,051
Doctorates	680	764	845	965	1,075	1,134	1,192	1,435	1,506	1,562
Total Professional[2]	3,161	3,661	3,806	3,987	4,239	4,371	4,520	4,717	4,788	4,923
Supporting Personnel[3]										
Technical Officers	234	234	223	223	241	239	253	240	261	285
Technicians	2,221	3,340	3,525	3,688	3,743	3,869	4,248	4,402	4,588	4,698
Craftsmen	1,678	2,123	2,119	2,153	2,509	2,573	2,758	2,683	2,696	2,740
Others	2,746	3,043	3,149	3,328	3,392	3,542	3,526	3,690	3,718	3,875
Total Supporting[4]	7,630	9,524	9,872	10,293	10,759	11,197	11,798	12,070	12,348	12,992
Seasonal Personnel	2,285	2,263	2,388	2,399	2,445	2,410	2,471	2,380	2,626	2,654

[1]Includes personnel engaged in research and development, scientific data collection, scientific information work and administration of scholarship and grants-in-aid of research.

[2]Total includes estimated number of officers of the Armed Forces who administer or do research and development but may or may not have degrees or the equivalent. Total includes also Atomic Energy of Canada Limited professional personnel not shown by degree.

[3]In some instances Technical Officers were included with Technicians.

[4]Total includes Atomic Energy of Canada Limited supporting personnel not distributed by category.

Appendix 4—TOTAL EXPENDITURES, OPERATING AND CAPITAL[1], BY FEDERAL GOVERNMENT ON SCIENTIFIC ACTIVITY 1951-52 TO 1961-62

($ Thousands)

Department or Agency	1951-1952			1952-1953			1953-1954			1954-1955		
	Operating	Capital	Total	Operating	Capital	Total	Operating	Capital	Total	Operating	Capital	Total
Agriculture	11,303	2,919	14,222	12,332	3,049	15,381	13,433	2,710	16,143	15,103	2,628	17,731
Board of Grain Commissioners	152	17	169	168	12	180	176	12	188	182	17	199
Forestry	3,785	26	3,811	4,461	350	4,811	4,572	418	4,990	4,890	106	4,996
Fisheries	1,688	325	2,013	2,044	880	2,924	2,276	521	2,797	2,748	246	2,994
Northern Affairs and National Resources	1,345	24	1,369	1,553	50	1,603	1,355	22	1,377	1,675	57	1,732
Mines and Technical Surveys[2]	8,802	337	9,139	9,730	389	10,119	10,918	234	11,152	12,926	1,351	14,277
Transport	158	—	158	165	—	165	188	—	188	192	—	192
St. Lawrence Seaway Authority	—	—	—	—	—	—	—	—	—	—	—	—
Post Office	—	—	—	39	—	39	242	—	242	301	—	301
National Film Board	17	1	18	27	2	29	31	1	32	26	7	33
Central Mortgage and Housing Corp.	1	—	1	2	—	2	3	—	3	1	—	1
National Research Council[3]	11,881	2,150	14,031	12,643	4,034	16,677	13,845	2,565	16,410	15,239	1,563	16,802
Atomic Energy Control Board	200	—	200	200	—	200	200	—	200	200	—	200
Atomic Energy of Canada Limited[4]	6,625	2,607	9,232	7,425	5,213	12,638	8,739	3,659	12,398	8,734	6,166	14,900
National Health and Welfare	1,565	29	1,594	1,985	49	2,034	2,749	579	3,328	2,540	561	3,101
Veterans Affairs	287	—	287	294	—	294	298	—	298	334	—	334
Defence Production[5]	—	—	—	—	—	—	—	—	—	—	75	75
Canadian Arsenals Ltd.[6]	42	—	42	22	—	22	52	—	52	47	—	47
National Defence excluding DRB[7,8]	31,900[10]	—	31,900[10]	33,249	—	33,249	31,909	—	31,909	29,638	—	29,638
Defence Research Board	14,346	4,846	19,192	18,485	6,207	24,692	20,419	4,649	25,068	25,336	2,527	27,863
TOTAL (Civilian and Defence)	94,197[10]	13,281	107,478	104,824	20,235	125,059	111,405	15,370	126,775	130,112	15,304	145,416
Overhead[9]	2,400	—	—	3,900	—	—	4,200	—	—	4,700	—	—

Appendix 4—TOTAL EXPENDITURES, OPERATING AND CAPITAL[1], BY FEDERAL GOVERNMENT ON SCIENTIFIC ACTIVITY 1951-52 TO 1961-62—Continued

($ Thousands)

Department or Agency	1955-1956			1956-1957			1957-1958			1958-1959		
	Operating	Capital	Total	Operating	Capital	Total	Operating	Capital	Total	Operating	Capital	Total
Agriculture	16,007	3,141	19,148	17,578	4,263	21,841	19,422	6,731	26,153	20,481	5,334	25,815
Board of Grain Commissioners	195	30	225	230	17	247	264	30	294	297	67	364
Forestry	5,426	160	5,586	5,671	1,124	6,795	6,051	2,621	8,672	6,624	1,352	7,976
Fisheries	2,855	825	3,680	3,630	1,225	4,855	4,347	2,203	6,550	4,687	1,652	6,339
Northern Affairs and National Resources	2,006	26	2,032	2,205	43	2,248	2,518	38	2,556	2,573	50	2,623
Mines and Technical Surveys[2]	12,910	2,644	15,554	15,035	1,400	16,435	16,481	627	17,108	19,777	3,958	23,735
Transport	227	—	227	272	100	372	419	25	444	443	13	456
St. Lawrence Seaway Authority	—	—	—	9	796	805	98	41	139	49	—	49
Post Office	485	—	485	681	—	681	274	—	274	217	—	217
National Film Board	23	9	32	25	18	43	28	7	35	29	1	30
Central Mortgage and Housing Corp.	—	—	—	1	—	1	9	—	9	38	—	38
National Research Council[3]	16,152	1,839	17,991	19,072	2,492	21,564	21,442	3,021	24,463	25,062	2,699	27,761
Atomic Energy Control Board	300	—	300	300	—	300	400	—	400	400	—	400
Atomic Energy of Canada Limited[4]	10,694	7,662	18,356	12,910	8,635	21,545	14,074	7,110	21,184	17,404	10,141	27,545
National Health and Welfare	2,569	533	3,102	2,784	234	3,018	3,279	80	3,359	3,605	161	3,766
Veterans Affairs	330	—	330	357	—	357	388	—	388	319	—	319
Defence Production[5]	—	230	230	—	3,999	3,999	—	1,892	1,892	—	409	409
Canadian Arsenals Ltd.[6]	44	—	44	15	—	15	20	—	20	40	—	40
National Defence excluding DRB[7,8]	51,344	—	51,344	63,948	—	63,948	71,976	—	71,976	67,352	—	67,352
Defence Research Board	31,785	1,405	33,190	23,294	2,071	25,365	24,755	1,966	26,721	26,303	2,222	28,525
TOTAL (Civilian and Defence)	153,622	18,504	172,126	168,017	26,417	194,434	186,245	26,392	212,637	195,700	28,059	223,759
Overhead[9]	5,000	—	—	5,400	—	—	5,700	—	—	6,300	—	—

Appendix 4—TOTAL EXPENDITURES, OPERATING AND CAPITAL[1], BY FEDERAL GOVERNMENT ON SCIENTIFIC ACTIVITY 1951-52 TO 1961-62—Concluded

($ Thousands)

Department or Agency	1959-1960			1960-1961			1961-1962		
	Operating	Capital	Total	Operating	Capital	Total	Operating	Capital	Total
Agriculture	22,066	6,903	28,969	23,954	4,058	28,012	25,346	5,911	31,257
Board of Grain Commissioners	320	41	361	355	84	439	408	49	457
Forestry	7,218	433	7,651	8,289	341	8,630	9,563	748	10,311
Fisheries	5,172	1,413	6,585	5,626	871	6,497	6,428	2,463	8,891
Northern Affairs and National Resources	2,891	84	2,975	3,466	31	3,497	3,498	96	3,594
Mines and Technical Surveys[2]	19,844	5,314	25,158	22,174	4,815	26,989	25,644	8,824	34,468
Transport	647	163	810	1,096	525	1,621	1,482	1,015	2,497
St. Lawrence Seaway Authority	143	—	143	20	—	20	—	—	—
Post Office	782	—	782	653	—	653	132	—	132
National Film Board	30	9	39	29	1	30	34	2	36
Central Mortgage and Housing Corp	50	—	50	51	—	51	106	—	106
National Research Council[3]	28,694	3,897	32,591	32,167	5,083	37,250	35,614	5,271	40,885
Atomic Energy Control Board	650	—	650	650	—	650	700	—	700
Atomic Energy of Canada Limited[4]	18,611	11,526	30,137	23,098	16,120	39,218	29,756	10,198	39,954
National Health and Welfare	4,426	264	4,690	5,339	162	5,501	5,694	148	5,842
Veterans Affairs	343	—	343	357	—	357	389	—	389
Defence Production[5]	1,851	6	1,857	2,902	—	2,902	11,464	—	11,464
Canadian Arsenals Ltd.[6]	20	—	20	20	—	20	49	—	49
National Defence excluding DRB[7,8]	29,341	—	29,341	30,588	—	30,588	32,157	—	32,157
Defence Research Board	27,151	1,797	28,948	30,130	1,786	31,916	33,271	1,443	34,714
TOTAL (Civilian and Defence)	170,250	31,850	202,100	190,964	33,877	224,841	221,735	36,168	257,903
Overhead[9]	6,300	—	—	7,000	—	—	7,600	—	—

[1]Capital is usually confined to buildings and works separately identified in the *Estimates* and *Public Accounts*.

[2]Excluded are capital expenditures by the Department of Public Works on behalf of the Mineral Resources Division, the Mines Branch and Geological Survey of Canada.

[3]Expenditures by Medical Research Council on research grants are included with the National Research Council expenditures.

[4]In addition to the expenditure figures presented, the Commercial Products Division has spent about $250,000 annually on research and development activities.

[5]Funds provided by Department of Defence Production to develop research capability in industry.

[6]Excluding funds received for development from the Department of National Defence.

[7]Army expenditures have been estimated.

[8]Capital expenditures, by or on behalf of the three services were not available.

[9]Some departments did not take into account the costs of overhead and indirect support from other departments. This was the case with the Department of Mines and Technical Surveys and with each of the three Armed Services. Estimates were derived by determining the percentage which these costs were to intramural expenditures of those departments which did report and applying this to the expenditures of the departments not reporting.

[10]Includes an estimated $23.3 million for the Royal Canadian Air Force.

Appendix 5—SUMMARY OF OPERATING EXPENDITURES ON SCIENTIFIC RESEARCH AND DEVELOPMENT

($ Thousands)

	1951-1952			1952-1953			1953-1954			1954-1955		
	Civilian	Defence	Total	Civilian	Defence	Total	Civilian	Defence	Total	Civilian	Defence	Total
Total operating expenditures on scientific activity	47,809	46,388[1]	94,197[1]	53,068	51,734	104,802	59,025	52,380	111,405	65,092	65,021	130,113
Expenditures on activity performed by—												
Federal government	44,745	18,951	63,696	49,829	31,449	81,279	54,900	34,934	89,834	60,526	40,484	101,010
Industry	—	3,219	3,219	16	18,849	18,865	113	16,716	16,829	231	23,363	23,594
Educational organizations	2,743	931	3,674	2,993	1,436	4,429	3,741	730	4,471	3,983	1,174	5,157
Other organizations	321	—	321	230	—	230	271	—	271	352	—	352
Expenditures on research and development	40,847	23,101	63,948	45,451	51,734	97,185	50,584	52,380	102,964	54,648	65,021	119,669
Intramural	37,886	18,951	56,837	42,347	31,449	73,796	46,677	34,934	81,611	50,409	40,484	90,893
External	2,961	4,150	7,111	3,104	20,285	23,389	3,907	17,446	21,353	4,239	24,537	28,776
Expenditures for collection of scientific data	4,744	—	4,744	5,091	—	5,091	5,799	—	5,799	7,161	—	7,161
Intramural	4,744	—	4,744	5,091	—	5,091	5,799	—	5,799	7,161	—	7,161
External	—	—	—	—	—	—	—	—	—	—	—	—
Expenditures for scientific information	1,904	—	1,904	2,148	—	2,148	2,263	—	2,263	2,634	—	2,634
Intramural	1,904	—	1,904	2,133	—	2,133	2,213	—	2,213	2,571	—	2,571
External	—	—	—	15	—	15	52	—	52	63	—	63
Expenditures for scholarships and fellowships	314	—	314	378	—	378	379	—	379	649	—	649
Intramural	211	—	211	258	—	258	213	—	213	385	—	385
External	103	—	103	120	—	120	166	—	166	264	—	264

[1]Includes in the total, but not allocated, an estimated $23.3 million for the RCAF.

Appendix 5—SUMMARY OF OPERATING EXPENDITURES ON SCIENTIFIC RESEARCH AND DEVELOPMENT—Continued

($ Thousands)

	1955-1956			1956-1957			1957-1958			1958-1959		
	Civilian	Defence	Total	Civilian	Defence	Total	Civilian	Defence	Total	Civilian	Defence	Total
Total operating expenditures on scientific activity	70,449	83,173	153,622	80,760	87,257	168,017	89,494	96,751	186,245	102,005	93,695	195,700
Expenditures on activity performed by—												
Federal government	65,042	48,955	113,997	73,856	39,255	113,120	82,599	41,431	124,030	92,543	43,287	135,840
Industry	390	31,314	31,704	564	44,643	45,207	151	52,995	53,146	109	47,460	47,569
Educational organizations	4,646	924	5,570	5,683	1,297	6,980	6,107	1,367	7,474	8,727	1,417	10,144
Other organizations	371	1,980	2,351	648	2,062	2,710	637	958	1,595	626	1,531	2,157
Expenditures on research and development	59,957	83,173	143,130	68,114	87,257	155,371	74,909	96,751	171,660	84,541	93,695	178,236
Intramural	55,040	48,955	103,995	62,104	39,255	101,359	68,950	41,431	110,381	75,790	43,287	119,077
External	4,917	34,218	39,135	6,010	48,002	54,012	5,959	55,320	61,279	8,751	50,408	59,159
Expenditures for collection of scientific data	6,935	—	6,935	8,332	—	8,332	9,565	—	9,565	12,281	—	12,281
Intramural	6,930	—	6,930	8,317	—	8,317	9,536	—	9,536	12,253	—	12,253
External	5	—	5	15	—	15	29	—	29	28	—	28
Expenditures for scientific information	2,730	—	2,730	3,065	—	3,065	3,568	—	3,568	3,880	—	3,880
Intramural	2,660	—	2,660	2,984	—	2,984	3,488	—	3,488	3,803	—	3,803
External	70	—	70	81	—	81	80	—	80	77	—	77
Expenditures for scholarships and fellowships	827	—	827	1,249	—	1,249	1,452	—	1,452	1,303	—	1,303
Intramural	412	—	412	460	—	460	630	—	630	701	—	701
External	415	—	415	789	—	789	822	—	822	602	—	602

Appendix 5—SUMMARY OF OPERATING EXPENDITURES ON SCIENTIFIC RESEARCH AND DEVELOPMENT—Concluded

($ Thousands)

	1959-1960			1960-1961			1961-1962		
	Civilian	Defence	Total	Civilian	Defence	Total	Civilian	Defence	Total
Total operating expenditures on scientific activity	111,887	58,363	170,250	127,324	63,640	190,964	144,794	76,941	221,735
Expenditures on activity performed by—									
Federal government	98,182	44,231	142,413	111,377	48,252	159,629	127,278	51,417	178,695
Industry	940	11,667	12,607	766	12,662	13,428	383	20,919	21,302
Educational organizations	11,923	1,549	13,472	13,996	1,695	15,691	15,964	1,690	17,654
Other organizations	842	916	1,758	1,185	1,031	2,216	1,169	2,915	4,084
Expenditures on research and development	94,614	58,363	152,977	108,226	63,640	171,866	122,374	76,941	199,315
Intramural	81,911	44,231	126,142	93,734	48,252	141,986	106,880	51,417	158,297
External	12,703	14,132	26,835	14,492	15,388	29,880	15,494	25,524	41,018
Expenditures for collection of scientific data	11,226	—	11,226	12,192	—	12,192	14,431	—	14,431
Intramural	11,196	—	11,196	12,104	—	12,104	14,190	—	14,190
External	30	—	30	88	—	88	241	—	241
Expenditures for scientific information	4,442	—	4,442	4,932	—	4,932	5,626	—	5,626
Intramural	4,356	—	4,356	4,839	—	4,839	5,490	—	5,490
External	86	—	86	93	—	93	136	—	136
Expenditures for scholarships and fellowships	1,605	—	1,605	1,971	—	1,971	2,363	—	2,363
Intramural	719	—	719	697	—	697	728	—	728
External	886	—	886	1,274	—	1,274	1,635	—	1,635

Appendix 6 — DISTRIBUTION OF EXPENDITURES ON SCIENTIFIC ACTIVITY BY THE FEDERAL GOVERNMENT FOR SELECTED YEARS 1952-53, 1958-59 AND 1961-62 BY TYPE OF ACTIVITY, AND WHETHER INTRAMURAL OR EXTERNAL

($ Thousands)

Department or Agency	1952-1953														
	Total Scientific Activity			Conduct of Research and Development			For Collection of Scientific Data			For Scientific Information			For Scholarships and Fellowships		
	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation
Agriculture	12,332	12,238	94	12,115	12,021	94	—	—	—	217	217	—	—	—	—
Board of Grain Commissioners	168	168	—	74	74	—	81	81	—	13	13	—	—	—	—
Forestry	4,461	4,459	2	4,461	4,459	2	—	—	—	—	—	—	—	—	—
Fisheries	2,044	2,044	—	1,975	1,975	—	—	—	—	69	69	—	—	—	—
Northern Affairs and National Resources	1,553	1,552	1	971	970	1	459	459	—	123	123	—	—	—	—
Mines and Technical Surveys	9,730	9,710	20	4,129	4,109	20	4,472	4,472	—	1,129	1,129	—	—	—	—
Transport	165	165	—	107	107	—	55	55	—	3	3	—	—	—	—
St. Lawrence Seaway Authority	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Post Office	39	29	10	39	29	10	—	—	—	—	—	—	—	—	—
National Film Board	27	21	6	27	21	6	—	—	—	—	—	—	—	—	—
Central Mortgage and Housing Corp.	2	—	2	2	—	2	—	—	—	—	—	—	—	—	—
National Research Council	12,643	11,195	1,448	11,700	10,387	1,313	—	—	—	565	550	15	378	258	120
Atomic Energy Control Board	200	—	200	200	—	200	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada	7,425	7,425	—	7,425	7,425	—	—	—	—	—	—	—	—	—	—
National Health and Welfare	1,985	530	1,455	1,936	481	1,455	24	24	—	25	25	—	—	—	—
Veterans Affairs	294	293	1	290	289	1	—	—	—	4	4	—	—	—	—
Defence Production	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Canadian Arsenals Ltd.	22	22	—	22	22	—	—	—	—	—	—	—	—	—	—
National Defence	51,756	31,471	20,285	51,756	31,471	20,285	—	—	—	—	—	—	—	—	—
Armed Services	33,249	14,855	18,394	33,249	14,855	18,394	—	—	—	—	—	—	—	—	—
Defence Research Board	18,485	16,594	1,891	18,485	16,594	1,891	—	—	—	—	—	—	—	—	—
Total Defence	51,756	31,471	20,285	51,756	31,471	20,285	—	—	—	—	—	—	—	—	—
Total Civilian	53,068	49,829	3,239	45,451	42,347	3,104	5,091	5,091	—	2,148	2,133	15	378	258	120
GRAND TOTAL	104,824	81,300	23,524	97,207	73,818	23,389	5,091	5,091	—	2,148	2,133	15	378	258	120

Appendix 6—DISTRIBUTION OF EXPENDITURES ON SCIENTIFIC ACTIVITY BY THE FEDERAL GOVERNMENT FOR SELECTED YEARS 1952-53, 1958-59 AND 1961-62 BY TYPE OF ACTIVITY, AND WHETHER INTRAMURAL OR EXTERNAL—Continued

($ Thousands)

Department or Agency	1958-1959														
	Total Scientific Activity			Conduct of Research and Development			For Collection of Scientific Data			For Scientific Information			For Scholarships and Fellowships		
	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation
Agriculture	20,481	20,367	114	20,156	20,042	114	—	—	—	325	325	—	—	—	—
Board of Grain Commissioners	297	297	—	117	117	—	152	152	—	28	28	—	—	—	—
Forestry	6,624	6,608	16	6,624	6,608	16	—	—	—	—	—	—	—	—	—
Fisheries	4,687	4,595	92	4,574	4,486	88	—	—	—	88	88	—	25	25	—
Northern Affairs and National Resources	2,573	2,391	182	1,425	1,286	139	964	936	28	184	169	15	—	—	—
Mines and Technical Surveys	19,777	19,724	53	6,983	6,930	53	10,722	10,722	—	2,069	2,069	—	3	3	—
Transport	443	443	—	300	300	—	139	139	—	4	4	—	—	—	—
St. Lawrence Seaway Authority	49	27	22	49	27	22	—	—	—	—	—	—	—	—	—
Post Office	217	200	17	217	200	17	—	—	—	—	—	—	—	—	—
National Film Board	29	29	—	29	29	—	—	—	—	—	—	—	—	—	—
Central Mortgage and Housing Corp.	38	—	38	38	—	38	—	—	—	—	—	—	—	—	—
National Research Council	25,062	18,810	6,252	22,660	17,072	5,588	—	—	—	1,132	1,070	62	1,270	668	602
Atomic Energy Control Board	400	—	400	400	—	400	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada	17,404	17,404	—	17,399	17,399	—	—	—	—	—	—	—	5	5	—
National Health and Welfare	3,605	1,345	2,260	3,257	997	2,260	304	304	—	44	44	—	—	—	—
Veterans Affairs	319	303	16	313	297	16	—	—	—	6	6	—	—	—	—
Defence Production	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Canadian Arsenals Ltd.	40	40	—	40	40	—	—	—	—	—	—	—	—	—	—
National Defence	93,655	43,247	50,408	93,655	43,247	50,408	—	—	—	—	—	—	—	—	—
Armed Services	67,352	20,583	46,769	67,352	20,583	46,769	—	—	—	—	—	—	—	—	—
Defence Research Board	26,303	22,664	3,639	26,303	22,664	3,639	—	—	—	—	—	—	—	—	—
Total Defence	93,695	43,287	50,408	93,695	43,287	50,408	—	—	—	—	—	—	—	—	—
Total Civilian	102,005	92,543	9,462	84,541	75,790	8,751	12,281	12,253	28	3,880	3,803	77	1,303	701	602
GRAND TOTAL	195,700	135,830	59,870	178,236	119,077	59,159	12,281	12,253	28	3,880	3,803	77	1,303	701	602

Appendix 6—DISTRIBUTION OF EXPENDITURES ON SCIENTIFIC ACTIVITY BY THE FEDERAL GOVERNMENT FOR SELECTED YEARS 1952-53, 1958-59 AND 1961-62 BY TYPE OF ACTIVITY, AND WHETHER INTRAMURAL OR EXTERNAL—Concluded

($ Thousands)

Department or Agency	1961-1962														
	Total Scientific Activity			Conduct of Research and Development			For Collection of Scientific Data			For Scientific Information			For Scholarships and Fellowships		
	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation	Total	Intra-mural	Outside Organi-zation
Agriculture	25,346	25,206	140	24,934	24,794	140	—	—	—	412	412	—	—	—	—
Broad of Grain Commissioners	408	408	—	171	171	—	201	201	—	36	36	—	—	—	—
Forestry	9,563	9,552	11	9,563	9,552	11	—	—	—	—	—	—	—	—	—
Fisheries	6,428	6,231	197	6,312	6,125	187	—	—	—	88	88	—	28	28	—
Northern Affairs and National Resources	3,498	3,131	367	1,725	1,435	290	1,495	1,454	41	278	242	36	—	—	—
Mines and Technical Surveys	25,644	25,569	75	10,859	10,784	75	11,629	11,629	—	3,156	3,156	—	—	—	—
Transport	1,482	1,410	72	928	856	72	434	434	—	120	120	—	—	—	—
St. Lawrence Seaway Authority	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Post Office	132	56	76	132	56	76	—	—	—	—	—	—	—	—	—
National Film Board	34	34	—	34	34	—	—	—	—	—	—	—	—	—	—
Central Mortgage and Housing Corp	106	—	106	106	—	106	—	—	—	—	—	—	—	—	—
National Research Council	35,614	23,557	12,057	31,656	21,534	10,122	200	—	200	1,473	1,373	100	2,285	650	1,635
Atomic Energy Control Board	700	—	700	700	—	700	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada	29,756	29,756	—	29,706	29,706	—	—	—	—	—	—	—	50	50	—
National Health and Welfare	5,694	1,994	3,700	5,170	1,470	3,700	472	472	—	52	52	—	—	—	—
Veterans Affairs	389	374	15	378	363	15	—	—	—	11	11	—	—	—	—
Defence Production	11,464	—	11,464	11,464	—	11,464	—	—	—	—	—	—	—	—	—
Canadian Arsenals Ltd	49	49	—	49	49	—	—	—	—	—	—	—	—	—	—
National Defence	65,428	51,368	14,060	65,428	51,368	14,060	—	—	—	—	—	—	—	—	—
Armed Services	32,157	21,766	10,391	32,157	21,766	10,391	—	—	—	—	—	—	—	—	—
Defence Research Board	33,271	29,602	3,669	33,271	29,602	3,669	—	—	—	—	—	—	—	—	—
Total Defence	76,941	51,417	25,524	76,941	51,417	25,524	—	—	—	—	—	—	—	—	—
Total Civilian	144,794	127,278	17,516	122,374	106,880	15,494	14,431	14,190	241	5,626	5,490	136	2,363	728	1,635
GRAND TOTAL	221,735	178,695	43,040	199,315	158,297	41,018	14,431	14,190	241	5,626	5,490	136	2,363	728	1,635

Appendix 7—AVERAGE EXPENDITURE ON SCIENTIFIC ACTIVITY WITHIN THE FEDERAL GOVERNMENT PER PROFESSIONAL EMPLOYEE—1951-52 TO 1960-61

($ Thousands)

Department or Agency	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961
Agriculture	13.7	14.2	15.3	16.7	17.4	19.1	20.9	21.9	23.5	25.8
Board of Grain Commissioners	15.2	16.8	16.0	18.2	19.5	19.1	22.0	22.8	24.6	27.3
Forestry	15.6	18.3	18.3	18.9	20.5	20.9	21.8	22.7	25.6	26.8
Fisheries	11.4	14.2	14.8	18.3	18.4	21.9	23.8	23.6	26.2	25.2
Northern Affairs and National Resources	11.2	12.8	12.8	14.7	15.8	16.1	17.0	17.4	17.9	20.2
Mines and Technical Surveys	18.9	19.6	21.7	25.4	24.4	28.9	30.8	35.0	31.8	33.5
Transport	6.0	5.3	5.6	5.8	6.3	6.8	9.7	10.0	11.1	15.3
St. Lawrence Seaway Authority	—	—	—	—	—	—	—	—	—	—
Post Office	—	—	—	—	—	—	—	—	—	—
National Film Board	17.0	22.0	25.0	11.0	7.6	8.3	9.3	9.6	15.0	29.0
Central Mortgage and Housing Corp.	—	—	—	—	—	—	—	—	—	—
National Research Council	21.3	22.2	21.7	22.6	22.9	25.2	28.1	28.2	29.0	30.8
Atomic Energy Control Board	—	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada	32.1	29.1	31.2	26.3	30.5	33.7	32.2	36.0	35.9	43.1
National Health and Welfare	7.1	11.2	15.9	13.4	12.4	11.9	15.5	13.5	18.5	14.1
Veterans Affairs	—	—	—	—	—	—	—	—	—	—
Defence Production	—	—	—	—	—	—	—	—	—	—
National Defence	32.1	33.0	34.9	38.0	40.8	31.1	32.3	33.1	34.8	38.9
Armed Services	29.5	26.8	27.1	28.2	29.0	27.8	29.0	29.1	28.6	32.7
Defence Research Board	33.4	41.6	46.0	51.1	54.5	34.8	36.1	37.8	42.4	46.0
Total Defence	29.2	30.8	32.7	35.6	38.3	24.3	30.4	31.3	33.1	37.0
Total Civilian	17.8	18.8	20.0	21.2	21.9	29.0	26.0	27.6	28.3	30.7
GRAND TOTAL	20.1	22.2	23.6	25.3	26.8	25.8	27.4	28.7	29.7	32.4

Appendix 8—FEDERAL EXPENDITURES ON INTRAMURAL RESEARCH AND DEVELOPMENT

($ Thousands)

Department or Agency	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962
Agriculture	11,271	12,238	13,336	14,995	15,890	17,457	19,316	20,367	21,912	23,818	25,206
Board of Grain Commissioners	152	168	176	182	195	230	264	297	320	335	408
Forestry	3,782	4,459	4,566	4,881	5,417	5,665	6,045	6,608	7,194	8,266	9,552
Fisheries	1,688	2,044	2,276	2,748	2,830	3,596	4,309	4,595	5,071	5,504	6,231
Northern Affairs and National Resources	1,345	1,552	1,353	1,598	1,916	2,040	2,316	2,391	2,582	3,052	3,131
Mines and Technical Surveys	8,792	9,710	10,893	12,901	12,885	14,995	16,441	19,724	19,791	22,121	25,569
Transport	158	165	188	192	227	272	419	443	647	1,044	1,410
St. Lawrence Seaway Authority	—	—	—	—	—	9	30	27	23	20	—
Post Office Department	—	29	135	74	95	117	191	200	39	50	56
National Film Board	17	22	25	22	23	25	28	29	30	29	34
National Research Council	10,177	11,195	12,008	13,084	13,488	15,332	17,613	18,810	20,112	21,927	23,557
Atomic Energy Control Board	—	—	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada Ltd.[1]	6,625	7,425	8,739	8,734	10,964	12,910	14,074	17,404	18,611	23,098	29,756
National Health and Welfare	452	530	909	782	784	861	1,181	1,345	1,518	1,739	1,994
Veterans Affairs[2]	286	293	296	333	328	356	372	303	332	354	374
Canadian Arsenals Limited	42	—	52	47	44	15	20	40	20	20	49
National Defence											
Armed Services	(5,948)[3]	(14,855)	(15,920)	(17,229)	(18,617)	(18,737)	(19,924)	(20,583)	(19,864)	(21,362)	(21,766)
Defence Research Board	(12,961)	(16,594)	(18,962)	(23,208)	(30,294)	(20,503)	(21,487)	(22,664)	(24,347)	(26,870)	(29,602)
Total Defence	18,951[3]	31,449	34,934	40,484	48,955	39,255	41,431	43,287	44,231	48,252	51,417
Total Civilian	44,745	49,830	54,900	60,526	65,042	73,856	82,599	92,543	98,182	111,377	127,278
GRAND TOTAL	63,696[3]	81,279	89,834	101,010	113,997	113,111	124,030	135,830	142,413	159,629	178,695

[1]Includes some research and development contracts with industry.
[2]Veterans Affairs funds may go, in part, to scientists associated with the universities.
[3]Excluded are expenditures for development made by the RCAF.

Appendix 9—FEDERAL EXPENDITURES ON RESEARCH AND DEVELOPMENT BY INDUSTRY

($ Thousands)

Department or Agency	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962
Fisheries	—	—	—	—	—	—	—	70	77	56	60
Department of Transport	—	—	—	—	—	—	—	—	—	52	47
St. Lawrence Seaway Authority	—	—	—	—	—	—	68	22	120	—	—
Post Office Department	—	10	107	227	390	564	83	17	743	603	76
National Film Board	—	6	6	4	—	—	—	—	—	—	—
National Research Council	—	—	—	—	—	—	—	—	—	55	200
Atomic Energy of Canada Ltd.[1]	—	—	—	—	—	—	—	—	—	—	—
Defence Production	—	—	—	—	—	—	—	—	1,851	2,902	11,464
National Defence											
Excluding Defence Research Board	(2,765)[2]	(18,394)	(15,989)	(22,409)	(30,747)	(43,149)	(51,094)	(45,238)	(8,561)	(8,195)	(7,476)
Defence Research Board	(454)	(455)	(727)	(954)	(567)	(1,494)	(1,901)	(2,222)	(1,255)	(1,565)	(1,979)
TOTAL	3,219[2]	18,865	16,829	23,594	31,704	45,207	53,146	47,569	12,607	13,428	21,302

[1]Excludes contracts, mostly with industry, which amounted, in year for which information was obtained, to $3,129,722 in 1959-60; $4,767,572 in 1960-61; and provision for $7.8 million in 1961-62 of which $4.7 million was spent.

[2]Excludes development contracts in 1951-52 by the Royal Canadian Air Force.

Appendix 10—FEDERAL EXPENDITURES ON RESEARCH AND DEVELOPMENT BY UNIVERSITIES

($ Thousands)

Department or Agency	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962
Agriculture[1]	—	—	—	—	—	—	—	—	—	—	—
Forestry	3	2	6	9	9	6	6	16	24	23	11
Fisheries	—	—	—	—	25	34	38	22	8	7	33
Northern Affairs and National Resources	—	—	—	—	9	25	13	20	15	15	—
Mines and Technical Surveys	10	20	25	25	25	40	40	53	53	53	75
Department of Transport	—	—	—	—	—	—	—	—	—	—	25
Central Mortgage and Housing Corp.	—	—	—	—	—	—	—	—	—	—	—
National Research Council	1,417	1,316	1,670	1,990	2,493	3,355	3,512	5,956	8,265	9,648	11,420
Atomic Energy Control Board	200	200	200	200	300	300	400	400	650	650	700
Atomic Energy of Canada Ltd.[2]	—	—	—	—	—	—	—	—	—	—	—
National Health and Welfare[3]	1,113	1,455	1,840	1,759	1,785	1,923	2,098	2,260	2,908	3,600	3,700
Veterans Affairs[4]	—	—	—	—	—	—	—	—	—	—	—
Defence Research Board	931	1,436	730	1,174	924	1,297	1,367	1,417	1,549	1,695	1,690
GRAND TOTAL	3,674	4,429	4,471	5,157	5,570	6,980	7,474	10,144	13,472	15,691	17,654

[1]Extramural research grants classified as grants to "other organizations".
[2]Atomic Energy of Canada Limited makes some minor contracts with the universities for research.
[3]Some of these funds go to organizations not closely associated with the universities.
[4]Veterans Affairs funds for research may go to scientists associated with the universities.

Appendix 11—FEDERAL EXPENDITURES ON RESEARCH AND DEVELOPMENT BY OTHER ORGANIZATIONS

($ Thousands)

Department or Agency	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962
Agriculture[1]	32	94	97	108	117	121	106	114	154	136	140
Forestry	—	—	—	—	—	—	—	—	—	—	—
Fisheries	—	—	—	—	—	—	—	—	16	59	104
Northern Affairs and National Resources	—	1	2	77	81	140	189	162	294	399	367
Central Mortgage and Housing Corp.	1	2	3	1	—	1	9	38	50	51	106
National Research Council	287	132	167	165	171	385	317	296	317	537	437
Veterans Affairs	1	1	2	1	2	1	16	16	11	3	15
National Defence											
Total—Three Services[2]	—	—	—	—	(1,980)	(2,062)	(958)	(1,531)	(916)	(1,031)	(2,915)
Departmental Total	—	—	—	—	1,980	2,062	958	1,531	916	1,031	2,915
GRAND TOTAL (Civilian and Defence)	321	230	271	352	371	648	637	626	842	1,185	1,169

[1]Extramural research grants, mainly to universities.
[2]Navy Testing and Evaluation of Research and Development for other Agencies (not included in grand total).

Appendix 12—PROFESSIONAL AND SUPPORTING PERSONNEL ENGAGED IN SCIENTIFIC ACTIVITY WITHIN THE FEDERAL GOVERNMENT, 1952-53, 1958-59 AND 1960-61

Department or Agency	1952-1953								
	Bachelors	Masters	Doctorates	Total Professionals	Technicians[5]	Craftsmen	Others	Total Supporting	Seasonal
Agriculture	330	331	196	857	384	249	882	1,515	443
Board of Grain Commissioners	3	2	5	10	17	3	6	26	—
Forestry	105	81	57	243	205	—	163	368	393
Fisheries	49	55	39	143	110	10	93	213	82
Northern Affairs and National Resources	91	18	12	121	36	77	123	236	25
Mines and Technical Surveys	319	69	107	495	602	135	312	1,049	1,136
Transport	7	21	3	31	2	1	3	6	—
St. Lawrence Seaway Authority	—	—	—	—	—	—	—	—	—
Post Office	—	—	—	—	—	—	—	—	—
National Film Board	1	—	—	1	3	—	—	3	2
Central Mortgage and Housing Corp.	—	—	—	—	—	—	—	—	—
National Research Council	154	96	188	438	—	—	—	778[2]	200[7]
Atomic Energy Control Board	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada[1]	—	—	—	255	287	890	279	1,456	17
National Health and Welfare	15	10	22	47	21	—	14	35	—
Veterans Affairs	—	—	—	—	—	—	—	—	—
Defence Production[1]	—	—	—	1	—	—	—	—	—
Canadian Arsenals Ltd.	58	7	2	67	81	1	1	83	—
National Defence[3,4]	—	—	—	952	1,644	599	1,166	3,765[2]	65
Total, Three Services[1,3,4,6]	—	—	—	554	1,065	300	24	1,745[2]	—
Defence Research Board	157	108	133	398	579	299	1,142	2,020	65
GRAND TOTAL (Civilian and Defence)[1,3,4]	1,289	798	764	3,511	3,392	1,965	3,042	9,533[2]	2,263

Appendix 12—PROFESSIONAL AND SUPPORTING PERSONNEL ENGAGED IN SCIENTIFIC ACTIVITY WITHIN THE FEDERAL GOVERNMENT, 1952-53, 1958-59 AND 1960-61—Continued

Department or Agency	1958-1959								
	Bachelors	Masters	Doctorates	Total Professionals	Technicians[5]	Craftsmen	Others	Total Supporting	Seasonal
Agriculture	231	336	361	928	448	441	997	1,886	489
Board of Grain Commissioners	4	—	9	13	29	3	8	40	—
Forestry	97	109	84	290	275	—	175	450	393
Fisheries	62	58	74	194	206	15	171	392	191
Northern Affairs and National Resources	82	36	19	137	60	30	114	207[2]	31
Mines and Technical Surveys	318	71	169	558	782	191	364	1,337	1,192
Transport	13	27	4	44	18	1	7	26	1
St. Lawrence Seaway Authority	—	—	—	—	—	—	—	—	—
Post Office	—	—	—	—	—	—	—	—	—
National Film Board	2	1	—	3	2	—	—	2	1
Central Mortgage and Housing Corp	—	—	—	—	—	—	—	—	—
National Research Council	132	119	336	587	—	—	—	1,052[2]	200[7]
Atomic Energy Control Board	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada[1]	271	64	148	483	380	1,212	556	2,148	24
National Health and Welfare	24	31	44	99	52	—	64	116	—
Veterans Affairs	—	—	—	—	—	—	—	—	—
Defence Production[1]	—	—	—	4	—	—	—	—	—
Canadian Arsenals Ltd	60	9	2	71	95	3	2	100	—
National Defence[3,4]	—	—	—	1,306	2,295	787	1,232	4,314	58
Total, Three Services[1,3,4,6]	—	—	—	707	1,520	441	29	1,990	—
Defence Research Board	238	176	185	599	775	346	1,203	2,324	58
GRAND TOTAL (Civilian and Defence)[1,3,4]	1,534	1,037	1,435	4,717	4,642	2,683	3,690	12,070[2]	2,580

Appendix 12—PROFESSIONAL AND SUPPORTING PERSONNEL ENGAGED IN SCIENTIFIC ACTIVITY WITHIN THE FEDERAL GOVERNMENT, 1952-53, 1958-59 AND 1960-61—Concluded

Department or Agency	1960-1961								
	Bachelors	Masters	Doctorates	Total Professionals	Technicians[5]	Craftsmen	Others	Total Supporting	Seasonal
Agriculture	195	301	425	921	579	501	986	2,066	476
Board of Grain Commissioners	4	1	8	13	29	3	9	41	—
Forestry	93	119	96	308	297	—	209	506	368
Fisheries	76	53	89	218	216	14	191	421	170
Northern Affairs and National Resources	93	32	26	151	76	17	133	228[2]	31
Mines and Technical Surveys	362	87	204	653	863	185	410	1,458	1,295
Transport	27	36	5	68	34	1	16	51	7
St. Lawrence Seaway Authority	—	—	—	—	—	—	—	—	—
Post Office	—	—	—	—	—	—	—	—	—
National Film Board	1	—	—	1	1	—	—	1	—
Central Mortgage and Housing Corp	—	—	—	—	—	—	—	—	—
National Research Council	162	125	337	624	—	—	—	1,122[2]	200[7]
Atomic Energy Control Board	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada[1]	323	72	140	535	480	1,214	619	2,313	46
National Health and Welfare	32	38	53	123	77	—	77	154	—
Veterans Affairs	—	—	—	—	—	—	—	—	—
Defence Production[1]	—	—	—	6	—	—	5	5	—
Canadian Arsenals Ltd	56	8	1	65	88	3	2	93	—
National Defence[3,4]	—	—	—	1,237	2,243	802	1,223	4,268	61
Total, Three Services[1,3,4,6]	—	—	—	653	1,443	451	29	1,923	—
Defence Research Board	231	175	178	584	800	351	1,194	2,345	61
GRAND TOTAL (Civilian and Defence)[1,3,4]	1,655	1,047	1,562	4,923	4,983	2,740	3,875	12,722[2]	2,654

[1]Professional personnel classified by degree not available. Column totals include only data shown.
[2]Supporting personnel classified by categories given—not available for the Army or N.R.C.
[3]Armed Services personnel not classified by degrees.
[4]Army professional and supporting personnel estimated for 1951-52 to 1957-58.
[5]Includes technical officers. [6]Persons with rank of officer classified as professional personnel. [7]Estimated.

Appendix 13—RATIO OF TECHNICIANS TO PROFESSIONAL PERSONNEL ENGAGED IN SCIENTIFIC ACTIVITY WITHIN THE FEDERAL GOVERNMENT FOR SELECTED DEPARTMENTS OR AGENCIES—1951-52 TO 1960-61[1]

Department or Agency	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961
Agriculture	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.5	0.5	0.6
Mines and Technical Surveys	1.1	1.0	1.1	1.1	1.0	1.1	1.1	1.1	1.1	1.1
National Research Council	—	—	—	—	—	—	—	—	—	—
Atomic Energy of Canada	1.1	1.1	1.0	0.9	1.0	1.0	0.9	0.7	0.8	0.9
Defence Research Board	1.2	1.4	1.5	1.6	1.2	1.2	1.2	1.2	1.3	1.4

[1]Technical officers included with technicians.

Appendix 14—RATIO OF SUPPORTING PERSONNEL (INCLUDING TECHNICIANS) TO PROFESSIONAL PERSONNEL ENGAGED IN SCIENTIFIC ACTIVITY WITHIN THE FEDERAL GOVERNMENT FOR SELECTED DEPARTMENTS OR AGENCIES, 1951-52 TO 1960-61[1]

Department or Agency	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	1957-1958	1958-1959	1959-1960	1960-1961
Agriculture	1.8	1.7	1.7	1.8	1.8	1.9	2.0	2.0	2.1	2.2
Mines and Technical Surveys	2.1	2.1	2.2	2.2	2.2	2.3	2.4	2.3	2.2	2.2
National Research Council	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.7	1.7	1.8
Atomic Energy of Canada	5.8	5.7	5.3	4.8	5.1	5	4.8	4.4	4.2	4.3
Defence Research Board	4.4	5	5.1	4.8	4.1	3.8	3.8	3.8	4.0	4.0

[1]Technical officers included with technicians.

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