Defence Science Journal, Vol. 3 , No. 2, April 1953, pp.118-128

DEFENCE RESEARCH IN CANADA*

By Dr. O. M. Solandt, Leader of the Canadian Delegation

In the chair : Sri H. M. Patel, Defence Secretary and Chairman, Defence Science Policy Board.

Introducing the speaker, the Chairman said that it was a great pleasure to him to introduce a very distinguished Defence Scientist who is the Chairman, Defence Research Board, Ottawa. Canadian experience in the field of Defence research is bound to have many lessons for India. The Canadian organisation was much bigger than the Defence Science Organisation in India, but it was nevertheless smaller than the Defence Research organisation in England or U.S.A. The Defence Science Organisation in India is a small one having a sanction for about 140 scientists. It has not been possible to recruit the required number of scientists not because it could not be done if an all-out effort was made, but for the desire to go slow, have problems to work at so that the scientist may not feel frustrated. Further there was the desire not to deprive other organisations where the scientists were doing good work to enrich the Defence Science organisation. The idea has been to go slow at first, select young men and to give them the necessary training either in India or outside. In Canada also, there was the problem of finding the required number of competent scientists. It would be of great help to know how this problem was tackled in Canada.

Dr. Solandt said that it was a great privilege to have the opportunity to speak on Defence research in Canada ; though it might appear to be an imposition to talk on this subject, he would do his best to tell what was being done in Canada as he felt there was a sincere interest in this subject in India. There was a surprising similarity between the problems encountered in Canada and in India, although there were some differences. The basic similarity was probably due to the fact that both countries with small scientific communities had to meet the great demands on the scientists for the development of their respective countries. The types of development and reasons for the need were very different in the two countries but there was a very severe competition for a relatively small number of scientists. So the problem in India, as in Canada, was to evolve an Organisation for Defence research which would be as economical as possible in trained scientific manpower and which could do effective work although small in size.

Dr. Solandt divided his talk into two principal sections—(1) an outline of the defence research organisation in Canada and (2) a few examples chosen at random of the way in which defence research could contribute towards the ordinary economic development of the

* Based on a lecture given by Dr. Solandt in the C.A.C.D.S. Conference. The lecture was illustrated by lantern slides.

country. The latter was an aspect of defence research that required emphasis and which would be of particular interest and importance to India.

Before the World War II, there was no organised defence research in Canada though quite a little was done on the individual initiative of some officers in the services. During the war quite a bit of research grew up in various places wherever the need arose, most of it under the general auspices of the National Research Council. After the war none of these wartime research agencies could have persisted because they were on a temporary basis and so a post war organisation was planned. At present the Defence Research Board is responsible directly to the Minister of National Defence for advising him on all matters related to research and to certain aspects of the development for all the three Services which will be mentioned later. The Board has not only its advisory functions, but it also operates laboratories. The Board is a peculiar organisation in that it is made up of equal proportion of Government officials and appointed members—to represent both science and industry in the country. This is a peculiar kind of organisation that was tried experimentally in Canada in the National Research Council and was so successful that it was tried again in the Defence Research Board. The official members of the Board were the chiefs of staff of the three Services, the president of the National Research Council, the Deputy Minister of National Defence—(it is better to call him the Defence Secretary) and a representative of the Department of Defence Production. Of the appointed members, four came from the universities and two from industry. As Chairman of the Board, Dr. Solandt was a member of the Chiefs of Staff Committee and took part in all their deliberations. Soon after the Board was formed an attempt was made to lay down certain broad policies to guide its subsequent work and the first one was regarding specialisation. With the relatively small scientific talent that was available for defence work, it was not possible to undertake research in all fields of defence science. In order to do good work it was essential to pick out a relatively small number of subjects of particular importance and interest to Canada; even for this the research facilities were not always adequate. There were some fields of defence science which were of great interest to the services on which no work was being done. Canada depended on getting the results of work in these fields from other friendly countries.

The second policy which was decided upon was to use the existing facilities wherever they were available to the best advantage. It was felt that it was a wise policy in a small country like Canada to avoid setting up a defence organisation to do work that was very closely related to research already being done by other organisations which catered for civilian needs. So the Defence Research establishments were limited to subjects which were peculiar to the Armed Services. Another basic policy was to try to put considerable emphasis on operational research, using this term in a rather broad way to include not only the conventional operational research but everything that had to do with general study of the peculiar defence problems of Canada and all weapon systems that might be evolved to meet these peculiar conditions. It could not be said that this was one

of the early formulated policies but it was evolved as work progressed. It was worth mentioning this because as the Defence Science Organisation in India matures, a good deal of time will have to be devoted to this kind of work than is the case with the other countries. This is because the other countries are concerned with first looking up their problems and doing research and development to meet them and to use finished equipment which will meet their requirements. In smaller countries very often one has to look to problems formulated carefully and to find out what equipment is available in the country; otherwise one will be forced to look to some other country and try to adopt either their equipment or situation until such time as the country can cope with the problems. The scientist could help a great deal in this kind of work and in India, as in Canada, there would be a considerable need for scientific help of this sort.

Dr. Solandt briefly described the way in which the Defence Research Board operated in Canada. The organisation had its headquarters in Ottawa. The headquarters scientific staff was organised as closely as possible along the lines of the staff in one of the Armed Services so that the headquarters scientific staff could work closely at all levels with the Services. It was through this staff that the Board got from the Services detailed knowledge of their requirements: it was not just a formulated statement of requirements but also what they were thinking about or worrying about and it was also through the contact of the two staffs that the Board got back not only the results of its research but also the results of any other scientific research which was relevant, and was available either in Canada or from other countries. Headquarters scientific staff was responsible after it got the requirements from the services for trying to place these requirements in suitable research agencies where a solution may be found. Attempts were made to use all the resources that were available in Canada and these resources could be roughly divided into four groups: first of all, the laboratories run by the Defence Research Board itself; second, a group of Government laboratories mostly federal, but some provincial also; thirdly, the universities and finally the industrial research laboratories.

Dr. Solandt described briefly each one of these resources, emphasis being placed on the laboratories of the Defence Research Board, with the aid of lantern slides. The laboratories in Canada stretched from Halifax on the east coast which was the main naval base, right across to Squiremouth, another naval base on the Pacific Coast and from Toronto in the south to Churchill in the north. The distances are comparable to distances in India; the distance from Halifax to Vancouver is something like 3,500 miles and from Toronto to Churchill about 1,200 miles.

The naval research laboratory is situated in Halifax just across the harbour. Dr. Keyston who came to India a couple of years ago to help establish naval research in India was the superintendent of the laboratory. This was a relatively small laboratory. Its new building was completed last year. The laboratory was located there because it had certain advantages. This laboratory was concerned primarily with the problems of anti-submarine warfare for the Canadian navy. Experimental vessels that were used for anti-submarine experiments were continuously available for the scientific work. Hydrophone

barges which are merely simple barges with small laboratories built on top with a big hole in the bottom through which hydrophone and other experimental equipment could be lowered into the sea were also available for anti-submarine work.

The Canadian Armament Research and Development Establishment was situated just outside Quebec city. It was an establishment which was concerned both with research and development on armament and explosives. The Canadian Arsenals Limited, a crown company, which manufactured weapons was also situated there. The establishment included a remarkably complete and flexible pilot plant for making small batches of explosives and propellants. One of the unique facilities in the establishment was an aeroballistic range or an enclosed range with buildings to house the instruments. This was a very interesting and useful tool for all sorts of ballistic studies and was one of the easiest and quickest ways of getting accurate measurements of drag.

Facilities were available for taking high speed photographs at Cardiff. The lecturer showed a picture of a projectile which was travelling probably at a speed of 4,500 ft./sec. in which the sabot and the shot were separating, projectile in front and the part sabot behind just after separation, could be seen. Yet another interesting use was the measurement of aerodynamic characteristics of any kind of rocket. Another useful device was the Reeds electrical analogue computer (REAC). It was an extremely valuable device for various ballistic calculations. It was particularly valuable for aerodynamic work.

In Ottawa, apart from other establishments, there was an organisation known as the National Aeronautical Establishment (N.A.E.). This was a new organisation which had been formed by taking the aeronautical research element out of the National Research Council. This element had been working for nearly 20 years. It was being expanded and new facilities were being provided to have a more adequate organisation for applied research and development on aircraft. New facilities were being built for flight research for the N.A.E. outside Ottawa. The new runway was completed and workshop buildings were under construction to house the flight research section. The buildings were virtually complete and it was hoped that they would be ready in the next few months. This formed a very important part of military research in Canada because of a growing aircraft industry. Canada was spending a little over half of her defence budget on the Air Force and consequently it was right that a large part of research and development effort was diverted towards aeronautical problems.

The chemical laboratories were also located just on the edge of Ottawa. The chemical laboratory was one of the oldest ; it was started in 1940 under the National Research Council by the Army and it was taken over by the Defence Research Board on its foundation in 1947. It originally worked mainly on problems of chemical warfare, particularly the defensive aspects : respiration, protective clothing etc. More recently, it had been working on a variety of chemical problems for the Armed Forces. It had been housed in temporary quarters in Ottawa and new buildings were nearing completion.

The Defence Research Telecommunications Establishment was also located in Ottawa. Electronics was of very great importance to modern Armed Forces; not only radar but communications, navigational aids, proximity fuses, computers and all sorts of devices which depend on the successful application of electronic techniques. In Canada, a satisfactory organisation to meet particular needs had been devised. It consisted of three principal elements, the radar and electrical engineering division of the National Research Council which did most of the radar work for the services as well as for civilian needs, and the Defence research telecommunication establishments which consisted of two sections, both in Ottawa. The electronics laboratory which was concerned with communication and with other applications of electronics such as control system of guided missiles was actually located along the side of the Canadian Army Signals Development Establishment. The two organisations were interconnected to the extent that the scientists used the army signals workshops and the army signals depended on the scientists to do their more highly technical work.

Ottawa was the headquarters of the Operational Research Group. The Operational Research Group was organised as a separate establishment but was actually housed in the headquarters offices. It consisted of a main section which worked on problems of inter-service interest and which supplied scientists to work with sections that were in each of the three services and also in some of the major Commands, so that it was a highly decentralised organisation which pervaded the whole of the Armed Services. Also in Headquarters there was a small Scientific Intelligence Organisation which attempted to keep up to date on what was going on in science in potentially enemy countries and also a quite large scientific information service. Those who were working in Defence Science would realise that this was essential. In ordinary scientific work, one had only to subscribe to the good periodicals and occasionally read some of the review journals to keep pretty well uptodate with research in any particular field but as soon as one got into military work where classification existed, one found that one had to go after information. It did not just turn up on the desk and so one of the jobs of the scientific information service was to go after information that was needed by scientists in the course of their programmes.

The Defence Medical Laboratory was situated at Toronto. The name 'medical' was somewhat misleading because that laboratory by definition dealt only with healthy people. It was concerned with the problems of what one might call the occupational or industrial medicine of the Armed Forces. It was set up in Toronto so that it could be closely associated with the Institute of Aviation Medicine which was an organisation of the Royal Canadian Air Force which taught aviation medicine and also administered the various selection procedures. Naturally this laboratory had given priority to Air Force problems and worked on such aspects as oxygen supply, the effects of low pressures, high accelerations and so on. It also dealt with protective clothing problems for all the services, with food and nutrition, selection and training and, in fact, in general looked after the welfare of the man in the Armed Services who got caught up in many machines which other people were busy devising for his use. This

was considered to be a most important part of any defence research organisation because there was often a tendency, particularly if development was put in the hands of industry, on the part of those who developed equipment to forget the qualities of the man who would have to run the equipment. It was not unusual to find a better equipment devised which was excellent but required a person of such high skill and experience to run it that it was not possible to find such persons in any number particularly in wartime. It was hoped that the work of a laboratory such as the Defence Medical Laboratory would do much to improve the situation. The human centrifuge at the medical laboratory was a relatively new one. In fact, it was probably the first one operating in the North American continent. It had proved very satisfactory and had recently been brought uptodate by an addition of highspeed X-ray equipment and other devices and was regularly used both for research, selection and training.

At Churchill was located the northern experimental station operated by the Canadian army but the Air Force and the Navy also participate in it. The laboratory was housed in a good permanent building and was provided with a small permanent staff who worked on the problems of the adaptation of man to Arctic climate and also on operational research, on the problems that arose in connection with arctic operations. Churchill was a particularly suitable place for arctic trials because of its location. It had a very severe winter climate. The temperature did not go as low as in other parts of Canada but high winds were common with low temperatures and consequently from the point of view of the human being it had a more severe climate than was encountered in the mountains where the temperatures were often much lower. It also had the advantage of being on the tree line so that if one wanted to work on the arctic barrens one had to go north and if one wanted to work in the sub-arctic tree areas one had to go a few miles south.

Experimental establishment at Suffield in southern Alberta was set up as a joint field trials establishment with Britain early in the war and was taken over by Canada at the end of the war. It was suitable for trials of all kinds, but had been used mostly for field trials in chemical warfare, although there had been great many artillery and explosives trials done there. Its unique feature was a thousand square miles of open range area. That was a land in which the rainfall was so low that it was not possible to grow useful crops but there was just enough scrub grass on it to keep the dust low and it was an ideal area for field trials. The establishment was provided with hangars and an air strip from where aircrafts were flown for the experimental programme.

The Research Laboratory of the experimental station was 35 miles from the nearest town and that town had a population of only 15-20 thousands and at the time the laboratory was built, there was not a paved road between the town and the laboratory. It became necessary to provide housing for the research workers and their families. This, of course, was not done during the war when people were just forced to be separated from their families but soon after the war this small village was built which had a population of about 1,500. This showed one of the problems and difficulties that had to be faced in Canada.

As an example of the type of equipment used in Suffield, mention may be made of a steel platform from which a 25 pounder was being fired down at the ground to get accurate data on the fragmentation of the shell and the flight at the normal angle of descent.

While the laboratories described so far were either occupied or almost ready for occupation, the Seffic Naval Laboratory had only been just started and probably will be ready for occupation in about a year or so. This laboratory would be concerned with the problems of underwater warfare on the Pacific Coast. There the experimental ships would be taken into the fiords and sound velocity and other things measured in water.

Dr. Solandt next dealt with government laboratories. Mention was already made of the National Research Council. The atomic energy project of Canada—Chalk River Project—which Sir John Cockcroft started and ran for a long time, had now been split off from the National Research Council and was now operating as a crown company. It was devoted almost entirely to the peaceful applications of atomic energy but it did, naturally, as a byproduct of its other work, a good deal of work for the Services and particularly was responsible for advice on the design and development of radiation detection instruments both for the Services and for civil defence.

The Mines Branch, Department of Resources and Development, has a large metallurgical laboratory in Ottawa which does all metallurgical research for the Services. At present it administered quite a substantial programme on titanium research for the Defence Research Board. The Board also worked very closely with the departments of agriculture and transport.

It was felt in the very beginning that the success of the Defence Research Board would ultimately depend upon the quality of the graduates being turned out of the Canadian universities. The National Research Council was in general responsible for supporting research or at least for administering the federal funds that were available for the support of research in the universities. But it was felt that the Defence Research Board should accept some responsibilities for making certain that the universities were well-equipped for training people in a few special fields of interest to defence which would not otherwise have been covered. An example of this was aeronautics. At the end of the war, no university in Canada had an adequate wind tunnel. The only one in any university was built in 1923 and had a top speed of 70 to 80 miles/hour. It was felt that this was not adequate for the age of supersonic flight and so the University of Toronto was given the necessary funds to build a supersonic wind tunnel. It was a small tunnel, entirely designed for research, not suited to design and development work, but it was a nucleus around which had been built up an institute of aero-physics which trained four or five graduate students a year and supplied the Canadian need for well-trained supersonic aerodynamicists both in research and in industry and, of course, in the Air Force. Similar support had been given to work on oceanography because it was found that there was no oceanographist being trained and it was essential to have them for submarine research. In addition to these specific supports the Defence Research

Board also gave grants-in-aid to research in universities where professors wanted to do research of interest to defence, as for example in the instance of medical research. Most of the defence work was being done in the universities because this kind of work was suited to medical students and they hoped to undertake all the work that was needed on problems of blood transfusion, blood substitutes, healing of wounds and treatment of burns and so on. This work was financed in the universities from the grants given by the Defence Research Board or National Research Council. In all this work with the universities it had been very strongly felt that it was essential for the welfare of the scientific community and the country to try to keep the centre of fundamental research in the universities. That did not mean that other bodies should not do some fundamental research but the main fundamental research should be done in the universities. Dr. Solandt felt very strongly on this point because he felt sure that the only way of learning to do research was by doing pure fundamental research in which one was not seeking to solve any immediate problem. It was the experience of the speaker that people who were trained in that way always did better applied research than the people who started by learning to do applied research. The former had much more flexible minds and more fully understood the principles of research and seemed able to tackle new problems with greater enthusiasm and greater ingenuity.

Research in industry in Canada was till recently surprisingly backward when one considers the size of industry in Canada. But this was understandable because so much of the Canadian industry began as branches of either American or British industry and really Canada's industry was part of the North American industrial complex and naturally only a relatively small part of the research was done in Canada. But since the war there had been a marked change and many firms were building up research laboratories in Canada and it had been found possible to get first class research and development done in industry. The most spectacular job of research and development or rather all development that had been done in the Canadian industry was the design and development of the C.F. 100 jet fighter and the engine which it needed. It was just going into production now and the first squadron of them was just being formed. That was a fighter that was designed to the Canadian Air Force requirements which were laid down just after the war. It was then felt that Canada did not have any especial requirement for a very long range all-weather jet fighter. At that time no other Air Force felt the need for the long range or the all-weather characteristics that the Canadian Air Force felt so essential. Since then other countries had become interested but as yet there was no other aircraft just quite as good, for this purpose, as the Canadian one had proved to be. Though in Canada they were most hopeful of their success it was too early to be sure of it.

Industry was also doing some important pioneering work in ship design. Here again there was close co-operation with the U.K. and, in fact, the new escort vessels that are being produced in Canada are really a joint R.N.—R.C.N. venture. The Canadian industry was also greatly strengthened in radar and electronics since the war and it was now possible to get very competent design work done on almost any kind of radar or electronic equipment in Canada.

CONTRIBUTION OF DEFENCE SCIENCE TO THE CIVIL LIFE OF THE COMMUNITY

Dr. Solandt gave a few examples of research that had been done in the laboratories of the Defence Research Board, universities or industry under the auspices of the Board which had been initiated for purely military purposes but yet were likely to pay substantial dividends to the civil life of the community. One of the examples was in the field Ionospheric research. In northern Canada they had the very doubtful asset of the north magnetic pole. Roughly arranged round the north magnetic pole was a belt in which the aurora was seen vividly. In this field the radio communication conditions were very different from those found in any other part of the world and presented certain unique complications and difficulties. It was obvious that good and reliable radio communication was essential to any modern military operation whether on the ground or in the air or at sea. It was equally obvious that good communications, good reliable radio and navigational aids and so on were absolutely essential to the development of a country like northern Canada where transport was almost entirely by air. So research aimed at solving the problems of communication in the aurora belt would be of just as great a value to the civil development of the country as it would be to defence. This was absolutely essential to defence, whereas the civilian development of the country could get along without it and so it was natural that this work received its impetus from the Services and that the scientists of the Defence Research Board had concentrated quite a lot of their effort in this field. This was a good example of the kind of specialisation that Canada had undertaken ; the Canadian team on this work in the radio-physics laboratory was comparable in size to the teams in the same field in Britain and the United States. This was so because the Canadian interest in the problem was very much greater than that of any other country in the world. There was no other country in the world which had as much difficulty in this field because owing to the magnetic pole being well down in Canada, the area of difficult transmission came well into the inhabited areas whereas in Russia it extended only up to the very northern parts of Siberia. The ionospheric observing station at Resolute Bay in the Arctic was on the Cornwallis Island. It was situated well north of the Arctic Circle and was the most northerly of the Canadian observing stations. It was one of the series which sent in the reports to the radio-physics laboratory in Ottawa where they were analysed and sent on to other similar centres in the world. As a result of this work Canada had just started a radio frequency prediction service which would be available not only to the services in Canada but to all the airlines and to other people to operate communications in the north.

One of the Universities had set up a light radar antenna to try to study the reflection of radar from the aurora. This would probably be of considerable importance in the operation of radar for both military and civilian use because if reflections were obtained from the aurora then they had to be differentiated from those obtained from the aircraft.

The mosquito was responsible for one of the worst problems of life in northern Canada, a problem which was not unknown in India. The season for mosquitoes was very short in the Arctic but they made up for the lost time during the month or two in which they were active and they were sufficiently severe to seriously interfere with any outdoor activity. The Defence Research Board co-operated with the Deptt. of Agriculture to study the types of mosquitoes and the possible methods of control. It was obvious that the methods of chemical warfare would be applicable for the control of the insects and so the Board had at its Suffield experimental establishment a section of the Deptt. of Agriculture which dealt with entomological problems. The Defence scientists supplied them with all the knowledge and experience of methods of administering chemicals to insects and actually did many of the experiments for them. The Defence scientists had not only done this but had done experiments to control other biting flies ; they had done extensive experiments on the control of grasshoppers and of the spruce blood worm, the most important insect which was rapidly killing the spruce—forests in some parts of Canada. Dakota aircrafts were employed for spraying D.D.T. to destroy the spruce blood worm. During the course of experiments in one summer the effective technique of chemical warfare against these insects was devised. A commercial company was now using the same technique to attack these worms over almost the whole province of New Brunswick. Here was an example of a direct civilian benefit coming from purely military research, that too from a branch of military research which was then abhorred by many people.

The Naval Research Establishment at Halifax had been working for a long time on the problems of corrosion of ships and they were among the pioneers of the application of different kinds of protection to ships including the installation of magnesium anodes. One of the Canadian cruisers had been fitted with magnesium anodes to prevent corrosion to its bottom. This work had been very successful and had already been extensively applied to the protection of civilian ships particularly in storage.

Dr. Solandt then gave an amusing example of the way research sometimes went wrong. Nearly everybody in Canada was interested in clothing and particularly in cold weather clothing and the Board's chemical laboratory which at that time did not have any special responsibility for clothing got interested in the problems of Arctic clothing and they thought that the best thing to do was to try to duplicate Eskimo clothing. Though many others had thought of this idea they had decided that it was not possible to get enough caribou skin to clothe an army. Eskimos made their clothing almost entirely from these skins. The chemists said that it was easy to produce a synthetic substitute and they worked for some time at this and with the help of industry were able to produce nylon fabrics which were specifically designed to duplicate the physical properties of the skin. This was a very beautiful-looking snowwhite material prefabricated into arctic suits—again copying the design of the Eskimos' suit. The Armed Forces tried it extensively and they did not like it at all. The only people who liked it were those who were on survival courses, who were dumped out in the Arctic from a parachute and had to exist for several days in the open. They thought it was fine because they were living in conditions in which the Eskimos lived. The Eskimos

and the other people who really lived in the north and a few very experienced Arctic travellers thought that it was wonderful; so they had succeeded in meeting the requirements of a very small market but missed meeting the requirements of the Armed Services.

Most people either had experienced or had seen the results of motion sickness. Anyone who can do something to solve the problem of motion sickness would be a benefactor not only of the Armed Forces but also of mankind in general. Now in the Board's Medical research laboratory one of the research workers felt that motion sickness must in some way be related to the head movement and so he set up a gadget to measure the head movement in a swing. The person who was subjected to this experiment was made to wear a helmet which had a metal bar on top of it and a wire coil around him and by measuring the induced currents in the coil it was possible to measure the head movements without restraining his head at all. He was put on a swing and was swung till he got sick; his head movements were measured while he was being swung. Graphs relating to the head movement of a person who had never been air sick or sea sick inspite of his extensive travel and another person who was occasionally sick and also of a person who was always sick were shown. There was a remarkable relationship between the freedom of movement of the head relative to the body and the incidence of air sickness. This was tested statistically by measuring relative amplitude of movement of the head on a large number of people under controlled conditions on the swing and seeing when they got sick. The hypothesis was found to be statistically sound and its soundness was being tested by actual trials in flight.

A simple head dress had been devised and it was tested with troops who were used to flying but who still got sick at times. In properly controlled experiments it had been shown that the simple head dress did quite significantly reduce the incidence of air sickness. It was not suggested that it was a complete answer to the problem of motion sickness but it did illustrate that it was defence research which had produced very interesting fundamental scientific results and also information of great value to the civilian population.

Dr. Solandt concluded by reiterating that in Canada the scientists who were doing defence research felt that defence research was essential to the strength of the free world and that unless they remained strong they would not remain free. He was sure that everyone would be very happy indeed in doing ordinary scientific research devoted to improving the lot of mankind but defence scientists may feel happy that their research did produce the sort of civilian benefits to which he referred. He hoped that his talk would convince those who doubted whether defence research could contribute towards the ordinary economic development of the nation. Expenditure on defence research often yielded results of real value to the nation.